Identifying and Prioritizing Target Regions to Conduct Outreach Activities to Improve Safety and Mobility of Aging Population

Final Report

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DISCLAIMER

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the State of Florida Department of Transportation.

METRIC CONVERSION TABLE

U.S. UNITS TO SI* (MODERN METRIC) UNITS

LENGTH

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
in	inches	25.400	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.610	kilometers	km
mm	millimeters	0.039	inches	in
m	meters	3.280	feet	ft
m	meters	1.090	yards	yd
km	kilometers	0.621	miles	mi

AREA

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
in^2	square inches	645.200	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.590	square kilometers	km^2
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.470	acres	ac
km^2	square kilometers	0.386	square miles	mi^2

VOLUME

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
fl oz	fluid ounces	29.570	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3

NOTE: volumes greater than 1,000 L shall be shown in m^3.
*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

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Ms. Gail M. Holley, Safe Mobility for Life Program and Research Manager at the FDOT Traffic Engineering and Operations Office, served as the Project Manager for this project.

16. Abstract

Florida leads the nation with over 20% of the population age 65 years and older, and this percentage is expected to continue to grow. As part of the strategies to improve the safety and mobility of the aging population, this research project developed a Geographic Information System (GIS)-based approach to identify and prioritize target regions to conduct outreach activities to support the Florida Department of Transportation's Safe Mobility for Life Program. The specific research objectives include: (1) identify and prioritize target regions; (2) recommend specific outreach activities at the target regions; (3) develop an approach to quantify the impact of outreach activities; and (4) develop procedures to conduct the analysis annually.

This research used four types of data: (1) crash data involving aging road users; (2) socioeconomic and demographic data; (3) roadway geometric characteristics data; and (4) infrastructure-related data. The crash data involving aging road users were collected for five years from 2014 through 2018 from the Florida Department of Highway Safety and Motor Vehicles (FLHSMV); socioeconomic and demographic variables were extracted from the Florida Geographic Data Library (FGDL); roadway geometric characteristics data were extracted from the Florida Department of Transportation (FDOT) 2020 GIS shapefiles; and infrastructure-related data (i.e., transit stop data) were extracted from the Florida Transit Data Exchange (FTDE) Portal of the Florida Transit Information System (FTIS).

The GIS-based approach was used to identify and prioritize target regions that benefit the most from the outreach activities. An optimized hot spot analysis was used to determine the hot spot locations for crashes involving aging road users and those involving aging non-motorists, and the analysis was conducted separately for urban and rural counties. The hot spots that were statistically significant at a 99% confidence level for total crashes involving aging road users and crashes involving aging non-motorists were identified as the target regions for conducting outreach activities. Furthermore, the spatial relationship between crashes involving aging road users and the built environment indicated that freeway roadway density, sidewalk proportion, and bus stop density were associated with more crashes involving aging road users. On the other hand, non-freeway State Highway System (SHS) roadway density and median household income were associated with a decrease in the likelihood of crash occurrence.

Specific outreach activities were recommended at the identified rural and urban target regions using certain criteria based on crashes involving aging road users, crash severity, demographic variables, roadway geometric characteristics, and infrastructure-related data. Based on the selected performance measure, i.e., the number of crashes involving aging road users, the simple before-after evaluation method was recommended to quantify the impact of outreach activities at the target regions. This research also provided step-by-step procedures to repeat the analysis annually.

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EXECUTIVE SUMMARY

Being a popular retirement destination in the country, Florida leads the nation with 20% of its population of age 65 and older. This proportion is higher than the national average of 16% and is expected to grow. Over 27% of Florida's population is expected to be over the age of 65 by the year 2030. With this significant increase in the older population, it is obvious that the number of aging road users will increase. As per Florida's 2017 Aging Road User Strategic Safety Plan, aging road users include drivers, transit riders, motorcyclists, passengers, operators of non-motorized vehicles, bicyclists, and pedestrians who are over age 50, with a special focus on the 65 years and older age groups. As such, the Florida Department of Transportation (FDOT) has been proactively addressing the specific needs of Florida's aging road users through its *Safe Mobility for Life (SMFL) Program.*

Reaching out to the target population in the entire state and conducting outreach activities for the safety improvement of the aging road users is a challenge, especially with a large state and limited resources. Therefore, it is essential to identify and prioritize regions with above-average crash rates involving individuals age 65 years and older. In addition to targeting regions that experience a disproportionately high crash rate involving aging road users, it is also important to proactively identify regions based on the built environment. Regions with certain land use, demographic, and socioeconomic characteristics may be perceived to be "less safe" and more prone to crashes involving aging road users, and hence, may need specific countermeasures.

The primary goal of this research was to develop a Geographic Information System (GIS)-based approach to identify and prioritize target regions to conduct outreach activities to improve the safety and mobility of the aging population. The specific objectives include:

- identify and prioritize target regions,
- recommend outreach activities at the target regions,
- develop an approach to quantify the impact of outreach activities, and
- develop procedures to conduct the analysis annually.

Identify and Prioritize Target Regions

Target regions are areas that experience a significant number of crashes involving aging road users. Identifying and prioritizing the target regions is crucial, especially in safety improvement plans, because it is not possible to conduct outreach activities in the entire state or county. A GIS-based approach was used to identify and prioritize target regions based on the total crashes involving aging road users and crashes involving aging non-motorists. These target regions were identified separately for the urban and rural counties. In this research, all hot spots that were statistically significant at a 99% confidence level for total crashes involving aging road users and crashes involving aging non-motorists were identified as the target regions for conducting outreach activities.

There were 2,592 urban target regions based on total crashes involving aging road users. These urban target regions were in Broward, Clay, Collier, Duval, Lake, Lee, Manatee, Marion, Miami-Dade, Sarasota, Palm Beach, Pasco, Pinellas, and Sumter counties. On the other hand, 1,285 urban target regions were identified based on the crashes involving aging non-motorists. These urban target regions were in Brevard, Collier, Duval, Hillsborough, Leon, Marion, Miami-Dade, Palm Beach, and Pinellas counties.

There were 190 rural target regions based on total crashes involving aging road users. These rural target regions were in Flagler, Glades, Hardee, Highlands, Okeechobee, Putnam, and Walton counties. A total of 120 rural target regions were identified based on the crashes involving aging non-motorists. These rural target regions were in Flagler, Hardee, Highlands, and Putnam counties.

The spatial analysis results indicated that freeway roadway density, sidewalk proportion, and bus stop density were associated with more crashes involving aging road users. This indicates that the higher the freeway density, sidewalk proportion, and bus stop density, the higher the likelihood of crash occurrence. On the other hand, non-freeway State Highway System (SHS) roadway density and median household income were associated with a decrease in the likelihood of crash occurrence. This indicates that the higher the median household income and the higher the non-freeway SHS roadway density, the lower the likelihood of crash occurrence.

Recommend Outreach Activities at the Target Regions

In this research project, the existing outreach activities being conducted by the FDOT's SMFL Program and Coalition were recommended at different target regions. Note that outreach activities were recommended at the target regions based on specific criteria. General outreach activities were recommended at all target regions that meet the following criteria (termed as the *base criteria*):

- Urban target regions with at least 6.2 total crashes involving aging road users per year per mile of the SHS roadway network.
- Rural target regions with at least 0.39 total crashes involving aging road users per year per mile of the SHS roadway network.

Note that these values were based on the 85th percentile of the total number of crashes involving aging road users per year per mile, and were termed as the *base criteria*.

Other specific outreach activities were recommended at the target regions with the following criteria (*Note: Total crash rate is based on only crashes involving aging road users*.)

Higher Proportion of Crashes Involving Aging Drivers:

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year
- At least 79% of total crashes involve aging drivers

For rural areas:

- Total crash rate is at least 0.39 crashes per mile per year
- At least 77.4% of total crashes involve aging drivers

Higher Proportion of Aging Drivers and Fatal and Serious Injury (FS) Crashes:

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year
- At least 79% of total crashes involve aging drivers
- At least one FS crash per year

For rural areas:

- Total crash rate is at least 0.39 crashes per mile per year
- At least 77.4% of total crashes involve aging drivers
- At least one FS crash per year

Higher Proportion of Crashes Involving Aging Non-motorists:

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year
- At least one crash per year involving aging non-motorists

For rural areas:

- Total crash rate is at least 0.39 crashes per mile per year
- At least one crash per year involving aging non-motorists

Higher Proportion of Intersection-related Crashes: Left-turn Crashes:

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year
- At least 23.7% of total crashes are intersection-related
- At least 5.1% of total crashes are left-turn crashes
- At least one signalized intersection

For rural areas:

- Total crash rate is at least 0.39 crashes per mile per year
- At least 31.3% of total crashes are intersection-related
- At least 4.4% of total crashes are left-turn crashes
- At least one signalized intersection

Higher Proportion of Intersection-related Crashes: Right-turn Crashes:

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year
- At least 23.7% of total crashes are intersection-related
- At least one right-turn crash per year
- At least one signalized intersection

For rural areas:

- Total crash rate is at least 0.39 crashes per mile per year
- At least 31.3% of total crashes are intersection-related
- At least one right-turn crash per year
- At least one signalized intersection

Higher Proportion of Roundabout-related Crashes:

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year
- At least one roundabout-related crash per year

For rural areas:

- Total crash rate is at least 0.39 crashes per mile per year
- At least one roundabout-related crash per year

Higher Bus Stop Density:

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year
- At least 1.16 bus stops per mile

For rural areas:

- Total crash rate is at least 0.39 crashes per mile per year
- At least one bus stop

No or Low Bus Stop Density:

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year
- Up to 1.16 bus stops per mile

For rural areas:

- Total crash rate is at least 0.39 crashes per mile per year
- No bus stop

Approach to Quantify the Impact of Outreach Activities

Program evaluations are crucial in safety analysis as they help agencies determine a program's impact and identify potential areas for improvement. The design of a program evaluation is highly dependent on the program's characteristics, goals, and objectives. Even though evaluating the impact of outreach activities is very important, it is difficult compared to evaluating the traditional engineering-related safety countermeasures. This research recommends step-by-step procedures that can be used to quantify the impact of the outreach activities. Selecting the appropriate evaluation tools will help agencies estimate the program's impact and identify potential areas for improvement. Based on the selected performance measure, i.e., the number of crashes involving aging road users, the *simple before-after evaluation* method was recommended to quantify the impact of outreach activities at the target regions.

Develop Procedures to Conduct the Analysis Annually

The process of conducting outreach activities at the target regions to improve the safety and mobility of the aging population is not a one-time process. This research project documents the step-by-step procedures to repeat the analysis annually. These procedures intend to provide support and guidance to transportation practitioners to repeat the analysis every year. In summary, the steps are divided into five parts:

- Collect data
  - Crash data
  - Roadway geometric characteristics data
  - Infrastructure-related data
  - Socioeconomic and demographic data

- Process data
  - Derive explanatory variables
  - Derive response variables
  - Identify urban and rural counties
  - Create polygon shapefiles for urban and rural census block groups (CBGs)

- Identify target regions
  - Conduct hot spot analysis for urban and rural counties
  - Identify urban and rural target regions

- Recommend specific outreach activities at the target regions
  - Identify potential crash types that specific outreach activities could potentially reduce
  - Develop criteria to recommend specific outreach activities at the target regions
  - Develop a process to evaluate the impact of outreach activities

- Quantify the impact of outreach activities
  - Conduct before-after evaluation

Implementation Strategy

The process of identifying and prioritizing target regions can be repeated every year using the most recent five years of crash data and the most recent SHS roadway network. The identified target regions can easily be incorporated in FDOT's *eTraffic,* a GIS-based website that displays various layered information on the state-maintained system, including SMFL features, traffic signals, mid-block crosswalk (MBX) treatments, and intersection control evaluation (ICE). However, variables such as bus stops and the proportion of sidewalk miles need to be updated every few years (e.g., five) to capture any changes associated with these variables.

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LIST OF ACRONYMS/ABBREVIATIONS

AAA	American Automobile Association
AARP	American Association of Retired Persons
AICc	Akaike Information Criteria (corrected)
ALFA	Assisted Living Federation of America
ARUSSP	Aging Road User Strategic Safety Plan
AOTA	American Occupational Therapy Association
Bike ISI	Bicycle Intersection Safety Index
CARS	Crash Analysis Reporting System
CBG	Census Block Group
FDOT	Florida Department of Transportation
FDR	False Discovery Rate
FGDL	Florida Geographic Data Library
FHP	Florida Highway Patrol
FHWA	Federal Highway Administration
FLHSMV	Florida Department of Highway Safety and Motor Vehicles
FS	Fatal and Serious Injury
FSU	Florida State University
FTDE	Florida Transit Data Exchange
FTIS	Florida Transit Information System
GIS	Geographic Information System
GTFS	General Transit Feed Specification
HCL	High Crash Location
HIA	High Incident Area
ICE	Intersection Control Evaluation
ISI	Intersection Safety Index
KDE	Kernel Density Estimation
MassDOT	Massachusetts Department of Transportation
MBX	Mid-block Crosswalk
NHTSA	National Highway Traffic Safety Administration
NKDE	Network Kernel Density Estimation
PSI	Potential for Safety Improvement
Ped ISI	Pedestrian Intersection Safety Index
PEDSAFE	Pedestrian Safety Guide and Countermeasure Selection
PSA	Public Service Announcement
PRSA	Pedestrian Road Safety Audit
PBCAT	Pedestrian and Bicycle Crash Analysis Tool
RRFB	Rectangular Rapid Flashing Beacon
ROI	Return on Investment
RSA	Road Safety Audit
SAFE	System Analysis & Forecast Evaluation
SDOT	Seattle Department of Transportation
SHS	State Highway System
SPFs	Safety Performance Functions
SHSP	Strategic Highway Safety Plan
SMFL	Safe Mobility for Life Program and Coalition

SSO	Single Sign-On
STRIDES	State Traffic Roadway and Intersection Data Evaluation System
TNC	Transportation Network Company
TRCC	Traffic Records Coordinating Committee
TTI	Texas A&M Transportation Institute
UBR	Unified Basemap Repository
USCB	United States Census Bureau
VIF	Variance Inflation Factor
WWD	Wrong-Way Driving

CHAPTER 1
INTRODUCTION

1.1 Background

The population is aging in the United States (U.S.). By 2050, the older population, age 65 years and older, in the U.S. is estimated to be almost twice the aging population estimates from the year 2012 (Ortman et al., 2014). Being a popular retirement destination in the country, Florida leads the nation with 20% of its population age 65 years and older, higher than the national average of 16%, and this percentage is expected to grow (Bureau of Economic and Business Research [BEBR], 2019). Over 27% of Florida's population is expected to be over the age of 65 by the year 2030 (Florida Assisted Living Federation of America [ALFA], 2014). With this significant increase in the older population, it is obvious that the number of aging road users will increase. As per Florida's 2017 Aging Road User Strategic Safety Plan (ARUSSP), developed by the Florida Department of Transportation (FDOT), aging road users include drivers, transit riders, motorcyclists, passengers, operators of non-motorized vehicles, bicyclists, and pedestrians who are over age 50, with a special focus on the 65 years and older age groups (Florida Department of Transportation [FDOT], 2017).

Since the U.S. is considered a mobile society, older adults drive for different reasons, such as volunteer activities, gainful employment, social and recreational needs, and cross-country travel (American Geriatrics Society & Pomidor, 2016). Thus, the miles traveled by older drivers are expected to increase in the future. According to a National Transportation Research Group (National Transportation Research Group [TRIP], 2018), the increase in the number of 65 years and older licensed drivers between 2012 and 2016 was 14%, while the increase in traffic fatalities involving at least one driver age 65 years and older was 41% in the same period. Note that traffic fatalities involving older drivers do not necessarily mean that the older drivers were at-fault. Older drivers experience declining vision, memory loss, slowed decision-making and reaction times, exaggerated difficulties when dividing attention between traffic conflicts and other important sources of motorist information, and reductions in physical strength, flexibility, and general fitness (Brewer et al., 2014).

Pedestrians in general, and older pedestrians in particular, are most vulnerable in traffic crashes. They bear a greater risk of severe injury in crashes with vehicles because they, unlike drivers, are generally not shielded. This vulnerability is even more pronounced for older adults because of the decline of sensorial, cognitive, perceptual, and physical abilities. In 2017, 5,977 pedestrians were killed in traffic crashes in the U.S, and about 20% of all pedestrian fatalities were people age 65 or older (National Highway Transportation Safety Administration [NHTSA], 2019). Florida is among the states with a high percentage of older pedestrian fatalities, accounting for about 21% of all older pedestrian fatalities in the country (NHTSA, 2019). Moreover, according to the Florida Department of Highway Safety and Motor Vehicles (FLHSMV), the number of older pedestrian fatalities increased by 35% between 2017 and 2018, an increase from 110 fatalities in 2017 to 148 fatalities in 2018.

In a proactive response to this inevitable surge in aging road users, the Federal Highway Administration (FHWA) published the *Older Driver Highway Design Handbook* in 1998, the

Highway Design Handbook for Older Drivers and Pedestrians in 2001, and the *Handbook for Designing Roadways for the Aging Population* in 2014. Also, an educational program, *CarFit*, was established by the American Society on Aging and jointly developed by the American Automobile Association (AAA), American Association of Retired Persons (AARP), and the American Occupational Therapy Association (AOTA). The *CarFit* program was designed to help older drivers find out how well they fit their vehicles, recommend actions that can improve their fit, and promote conversations about safety and mobility. It also provides information and materials on resources that can enhance their safety as drivers and increase their mobility in the community.

Several states have taken actions to improve the mobility and safety of aging road users. In 2016, Texas developed a guide for safer road design for older pedestrians in Victoria, Texas. The report focused mainly on the importance of walking, analysis of crashes involving older pedestrians, principles for road design for older pedestrians, key issues with road rules affecting older pedestrians, and recommendations for the general infrastructure and operational treatment to improve road safety for older pedestrians (Mantilla & Burtt, 2016). Also, in 2017, Texas A&M Transportation Institute (TTI) authored a report on how transportation impacts the aging population and documented the policies and programs that promote healthy aging through transportation (Ettelman et al., 2017).

In 2017, the Seattle Department of Transportation (SDOT) developed the Age-Friendly Street Design Toolkit that addresses pedestrian lighting, obstruction-free walking areas, crossing, design of social spaces, traffic calming, and transit amenities. Age-friendly strategies include reducing traffic speeds, improving pavement markings and signs for enhanced visibility and safety, building out an all ages and abilities bicycle network separated from vehicles, improving access to transit, and improving transit shelters (Seattle Department of Transportation [SDOT], 2017). In 2019, the Massachusetts Department of Transportation (MassDOT) conducted a study on identifying the contributing factors and communities with high risks of crashes involving older pedestrians using ten years of statewide crash data (2006-2015). The study also provided recommendations for leveraging the state's age-friendly efforts to accelerate the implementation of countermeasures. Some recommendations included raising public awareness about older pedestrian safety, prioritizing infrastructure improvement, and increasing the visibility of crosswalks (Dugan et al., 2019).

1.2 FDOT's Efforts

FDOT has been spearheading the efforts to improve the safety and mobility of the aging population in the state of Florida by implementing several safety-focused countermeasures since the early 1990s, including increased visibility, increased pedestrian features at intersections, countdown pedestrian signals, advanced street name signs, etc., to compensate for the natural changes that occur as people age. The agency continues to implement these countermeasures in accordance with the FHWA guidelines for designing for the aging population (Brewer et al., 2014). In addition to engineering improvements, FDOT has been proactively addressing the specific needs of Florida's aging road users from several avenues. The main focus is to educate aging road users, expand transportation choices and promote community design features to meet the mobility needs of the aging road users and to develop and distribute resources and tools to support safe skills and encourage early planning to safely transition from driving (FDOT, 2018, 2019, 2020).

In 2004, the FDOT State Traffic Engineering and Operations Office established the Safe Mobility for Life (SMFL) Program to improve the safety and mobility of Florida's aging road users. The program focused mainly on the engineering changes on the State Highway System (SHS) to better accommodate aging road users. Implemented engineering changes included increasing lane and edge line pavement marking widths to six inches, placing larger lettering on guide signs, installing refuge islands, considering slower walking speeds at signalized intersections, installing advanced warning signs, etc. In addition to focusing on the engineering improvements, the SMFL Program worked with the Department of Psychology at Florida State University (FSU) to conduct human factors studies with younger (21-35), middle-aged (50-64), and older adults (65 years and older) (Boot et al., 2013, 2014; Charness et al., 2011, 2012, 2017). The study results enabled FDOT to better understand the changes that could benefit all age groups. The program has also developed and distributed tip cards to help educate road users on infrastructure improvements that may confuse some aging road users, such as roundabouts and countdown pedestrian signals.

In 2009, FDOT partnered with the FSU Pepper Institute on Aging and Public Policy to establish the statewide SMFL Coalition (FDOT, 2017). The Coalition's goal is to improve the safety and mobility of aging road users in Florida by achieving a reduction in the number of aging road user fatalities, serious injuries, and crashes, while maintaining their safe mobility and connection to the community (Safe Mobility for Life Program and Coalition [SMFL], 2020b). The goal will be achieved through developing and distributing educational materials, resources, and information that are beneficial to the aging population and support the goals and objectives as outlined in Florida's ARUSSP. Some of the outreach activities include organizing and/or supporting safety and mobility events, such as *Keys to Achieve Safe Mobility for Life Workshop, CarFit, Safe Transit for Life Event, Safe Biking for Life Event in partnership with the University of Florida*, and *Safe Walking for Life and Stop on Red events in partnership with Alert Today Florida*, etc.; and distributing education materials through the SMFL Resource Center at the Pepper Institute. The materials distributed include tip cards on *Flashing Yellow Arrow*, *Right Turn on Red*, *Florida's Guide to Safe Mobility for Life,* etc. The SMFL Coalition website also provides educational materials through external links that are more helpful for aging road users, including *CarFit, Find a Ride Florida*, etc. These outreach activities have proven to be crucial in educating Florida's vulnerable population groups, particularly the aging population, about safe transportation practices.

In 2010, the Florida ARUSSP was developed and updated in March 2017. Florida's ARUSSP is incorporated under Florida's Strategic Highway Safety Plan (SHSP) within the Aging Road Users emphasis areas (FDOT, 2017). The ARUSSP focuses on improving the safety, access, and mobility of Florida's aging population, and reducing fatalities and serious injuries by addressing areas critical to the needs and concerns of the target population (FDOT, 2017). Based on data review and National Highway Traffic Safety Administration (NHTSA) Guideline No. 13 (NHTSA, 2014), the ARUSSP identified the following six focus areas: (1) program management, data, and evaluation; (2) aging in place; (3) outreach and advocacy; (4) licensing and enforcement; (5) prevention and assessment; and (6) transitioning from driving. These focus areas help in promoting the safety and mobility of Florida's aging road users. The ARUSSP tracks the number and rate of fatalities and serious injuries involving drivers age 65 and older on an annual basis. In addition, the plan also includes specific performance measures for each of these focus areas. Furthermore, the program annually identifies ten urban and ten rural priority counties that have the highest rate of crashes involving individuals age 65 and older compared to the population age 65 years and older using a three-year average crash rate. These priority counties receive special attention for program and project delivery, including engineering improvements, material distribution, and outreach events.

The SMFL Coalition uses an innovative approach to balance safety and mobility to help Floridians maintain independence and remain active in their community even after they transition from driving. The Coalition developed and/or supported some of the resources that helped Florida achieve a reduction in traffic-related fatalities and serious injuries involving aging road users. These programs include *Florida's Guide to Safe Mobility for Life*, a free guide designed to help Floridians learn how to continue to safely drive while sharing information to help prepare and plan to meet their mobility needs after transitioning from driving. The guide contains helpful state and local information and resources related to promoting safe mobility for life, the impact of aging on driving, whether it is safe to drive, keeping safe while driving, and retirement from driving (SMFL, 2018). *CarFit* safety events have been held statewide to promote safe driving conversations and provide community safety and mobility resources for older drivers. The events were conducted in such a way that a team of trained volunteers assists the older drivers with items such as a clear line of sight over the steering wheel, proper *Safety Belt* use and fit, and safe positioning of mirrors to minimize blind spots. The Coalition also supported programs such as *Find-a-Ride Database*, *Aging Road User Survey*, and *Aging in Place* to promote the safety and mobility of aging road users.

In 2019, the FDOT State Traffic Engineering and Operations Office established the State Traffic Roadway and Intersection Data Evaluation System 2020 (STRIDES 2 Zero) initiative. The program aims to leverage departmental data to evaluate the safety and mobility of roadway facilities, providing a traffic operation database for engineering analysis and reports, and applying state-of-art predictive analysis tools to monitor safety and operational performance before and after implementing engineering countermeasures. The program also used a data-driven approach to identify engineering countermeasures to improve safety and mobility for the SHS. The System Analysis & Forecast Evaluation (SAFE) is the first program developed under the STRIDES 2 Zero initiative to increase the accuracy of crash predictions for improving the operational and safety performance of the SHS. In addition to improving prediction accuracy, the program also tracks the progress and supports business decisions through a Return on Investment (ROI) analysis of changes to the SHS roadway network.

The 4 Es of traffic safety (Engineering, Education, Enforcement, and Emergency response) play a crucial role in the steady decline in fatality and injury rates over the past few years. *Engineering* countermeasures are the foundation of any traffic safety improvement program as they help prevent crash occurrence and reduce the severity when crashes do occur. Engineering countermeasures pertaining to improving the safety of aging road users include pedestrian countdown signals, curb extensions, complete streets and road diets, improved street lighting, etc.

Education countermeasures provide road users with increased knowledge of safety actions and traffic rules and guidelines. Education is critical, especially to aging road users, because they experience the decline of sensory, cognition, physical abilities, and sometimes memory. Education countermeasures include the development and distribution of educational materials such as tip cards on *Flashing Yellow Arrow, Right Turn on Red,* etc.; educational safety events such as *CarFit, You Hold the Keys Workshops,* and education through social media campaigns, newsletters, and videos. Note that while developing educational material, it is important to include human factors studies to account for the specific need of the aging road users and all other age groups in the design (Charness et al., 2017).

Enforcement countermeasures focus on enforcing road users to follow the traffic rules and guidelines. These countermeasures include tickets or citations to the drivers and pedestrians who violate the traffic rules; for instance, red-light running, speeding, etc. *Emergency response* countermeasures improve safety through the deployment of emergency medical services to the scenes where crashes occurred to reduce the severity of crashes and prevent the occurrence of secondary crashes.

Reaching out to the target population in the entire state and conducting the outreach activities for the safety improvement of the aging road users is a challenge, especially with a large state and limited resources. Therefore, it is essential to identify and prioritize target regions that have above-average crash rates involving individuals age 65 years and older. In addition to targeting regions that experience a disproportionately high crash rate involving older road users, it is also important to proactively identify regions based on the built environment. Regions with certain land use, demographic, and socioeconomic characteristics may be perceived to be “less safe” and more prone to crashes involving aging road users; and hence, may need specific countermeasures. Furthermore, the focus has to be not only on the target regions where the outreach activities need to be conducted but also on the type of the outreach activities. For example, it may be more effective to distribute the *Right Turn on Red* tip cards at signalized intersections where pedestrian crashes are more prevalent and where the built environment demands more attention from the aging road users.

The Coalition has developed the methodology to identify and prioritize the top ten urban and rural priority counties. These counties were selected using a five-year average rate of crashes involving individuals age 65 years and older for every 1,000 individuals age 65 years and older in urban and rural counties. The counties that experienced above-average crash rates were identified as the priority counties. The Coalition has also developed a methodology to identify critical intersections in Florida for crashes involving aging road users as well as all age groups. The Coalition team implemented geospatial analysis at the statewide level and evaluated critical intersections based on two criteria: number of crashes within the search radius and the occurrence of fatal and serious injury (FS) crashes. These criteria were used to develop a score for each intersection and rank the intersections by different geographical levels (e.g., top 10 intersections statewide, top 20 intersections by district, top 10 intersections by county, and top 20 intersections for urban and rural counties).

In summary, the Coalition has been doing a great effort in developing the methodology to identify and prioritize the top ten urban and rural counties based on the five-year average rate of crashes involving aging road users. However, it is worth noting that regions with certain land use, demographic and socioeconomic characteristics may be perceived to be “less safe” and more prone to crashes involving aging road users; and hence, may need specific countermeasures. This research project developed a Geographic Information System (GIS)-based approach to identify and prioritize target regions to conduct outreach activities to improve the safety and mobility of the aging population. The developed methodology considers the effects of the built environment (i.e., land use, roadway characteristics, socioeconomic and demographic characteristics) on the safety and mobility of the aging population.

1.3 Research Goal and Objectives

The main goal of this research project was to develop a GIS-based approach to identify and prioritize target regions to conduct outreach activities to improve the safety and mobility of the aging population. The specific objectives include:

- Identify and prioritize target regions.
- Recommend outreach activities at the target regions.
- Develop an approach to quantify the impact of outreach activities.
- Develop procedures to conduct the analysis annually.

1.4 Report Organization

The rest of this report is organized as follows:

- Chapter 2 entails a comprehensive synthesis of the literature on the methods used to proactively identify and prioritize target regions for conducting outreach activities, the strategies adopted by agencies to select the type of outreach activities, and the approaches used to quantify the impact of outreach activities.

- Chapter 3 discusses the data used to achieve the research goal and objectives. Specifically, the chapter describes, in detail, the types of data used, data sources, descriptive statistics of the crash data, and data processing steps on the built environment.

- Chapter 4 focuses on identifying and prioritizing target regions. It first presents the approach used to identify and prioritize target regions. It further discusses the spatial relationship between crashes involving aging road users and the built environment.

- Chapter 5 presents the recommended specific outreach activities at the target regions. It first documents the existing outreach activities being conducted by the SMFL Coalition. It further discusses the criteria used to recommend specific outreach activities at the target regions.

- Chapter 6 discusses the approaches used to quantify the impact of outreach activities. It first presents the existing approaches used to quantify the outreach activities. It further recommends and documents a procedure to quantify the impact of outreach activities.

- Chapter 7 documents a step-by-step procedure to conduct the analysis annually.

- Chapter 8 summarizes this research effort.

CHAPTER 2
LITERATURE REVIEW

This chapter presents a synthesis of previous studies that focused on the methods used to proactively identify and prioritize target regions for conducting outreach activities, the strategies adopted by agencies to select the type of outreach activities, and the approaches used to quantify the impact of outreach activities. The first section of this chapter presents the existing methods used to identify and prioritize target regions. The strategies adopted to select the type of outreach activities are presented next. The last section presents previous literature that documented the approaches used to quantify the impact of the outreach activities.

2.1 Identify and Prioritize Target Regions

Identifying and prioritizing the target regions is crucial, especially in safety improvement plans, since it is not possible to conduct outreach activities in the entire state or county. Researchers have investigated various methods to identify and prioritize locations that cause concern for safety improvement. These methods include GIS-based analysis, Kernel density estimation (KDE), intersection safety indices (ISIs), perception surveys, citizen input and advocacy, high crash or reactive approach, and systemic or proactive approach. The details of these methods are described in the following sections.

2.1.1 GIS-based Analysis

The availability of geographic coordinates for crashes has resulted in the ubiquitous use of spatial analysis in GIS platforms for displaying the locations and density of crashes on maps. This method can provide the most probable factors that contribute to the crashes, and these factors can be used to develop countermeasures that can prevent crashes from occurring in the future. On the other hand, crashes with no geographical coordinates may not be mapped and therefore are excluded from the analysis. Most of the studies have conducted spatial analysis in ArcGIS to identify and prioritize the regions that have a high potential for safety improvement. Dunckel et al. (2014) used the GIS application, and the pedestrian crashes in Montgomery County, Maryland, from 2004-2008 to create a county-wide GIS collision map. This collision map was used to identify high incident areas. Each roadway segment was reviewed for a high concentration of pedestrian crashes (i.e., clusters) to create a GIS-based collision density layer. Segments with a high concentration of pedestrian crashes were selected for further analysis (Dunckel et al., 2014).

Natarajan et al. (2008) applied a GIS-based tool to identify and prioritize high crash locations (HCLs) that require safety improvements. The locations were categorized into different groups based on features such as roadway functional classification and area type. The critical crash rate for each group was determined based on the average number of crashes within the group, and the locations with crash rates higher than the critical crash rate of the group were classified as the HCLs (Natarajan et al., 2008). Dugan et al. (2019) performed a spatial analysis to identify high older pedestrian crash hot spots in Massachusetts. The study further conducted multivariate spatial analyses to understand population health and environmental factors associated with older pedestrian crash rates and identify essential effective countermeasures.

Ragland et al. (2003) developed the candidate zones of the pedestrian injury collision using GIS software. Zone analysis, a systematic method that focuses on crash clusters in a concentrated geographic area, was performed to identify and prioritize crash clusters. Two candidate zones were selected, linear-single streets and area zones (i.e., neighborhoods with crash clusters), and the zones with high clusters of pedestrian-injury collisions were selected for further analysis (Ragland et al., 2003). Dai et al. (2012) applied spatiotemporal clustering techniques using ArcGIS software to identify clusters of injured pedestrians and investigate the influence of personal and environmental factors on pedestrian injuries. The clusters of pedestrian injuries were searched in both space and time, and were detected using the Bernoulli model in SatScan software (Dai, 2012).

Lee et al. (2015) used the GIS-based approach to identify the locations and the contributing factors for pedestrian crashes per crash location ZIP code area and pedestrian crashes per residence ZIP code area (Lee et al., 2015). The hot zones were identified by considering the potential for safety improvement (PSI) as the performance measure. The PSI was calculated as the difference between the expected and the predicted number of crashes. The PSI can effectively identify zones experiencing more pedestrian crashes than other zones with similar characteristics. Steenberghen et al. (2010) identified the hot spot's location through network distance weighted clustering of crashes and developed the dangerous index for selecting the most hazardous locations. The dangerous index was derived from the weighted crash frequencies within the influence distance along the network. The locations having higher dangerous index were considered the most hazardous locations and were taken into consideration for further safety analysis (Steenberghen et al., 2010).

The GIS-based analysis requires crash data with geographical coordinates for displaying the locations and mapping crash densities. This approach can provide the most probable factors that contribute to the crashes, and these factors can be used to develop countermeasures that can prevent crashes in the future. On the other hand, crashes with no geographical coordinates may not be mapped and therefore are excluded from the analysis.

2.1.2 Kernel Density Estimation

The KDE methods are often used in visualizing and analyzing spatial data, with the objective of understanding and potentially predicting event patterns. These methods have a wide variety of applications such as risk assessment, damage analysis, and traffic crash analysis (Ahola et al., 2007; Anderson, 2009; Chimba et al., 2018). Some researchers have used traditional planar KDE that estimates the density in two-dimensional space where traffic collisions are weighted based on the Euclidean distance (Erdogan et al., 2008; Flahaut et al., 2003). Others have used network-based kernel density estimation (NKDE) to identify the pedestrian crash hot spots (Okabe et al., 2009; Xie & Yan, 2008). Network-based kernel density estimates density in a one-dimensional space where distance is calculated along the road network because traffic collisions are considered a network-constrained phenomenon (Loo et al., 2011). Moreover, other researchers used KDE followed by a built-environment audit to identify the pedestrian crash hot spots and the associated environmental factors contributing to the crashes (de Andrade et al., 2014; Schuurman et al., 2009).

Bíl et al. (2013) used the standard KDE to identify hazardous locations based on traffic crash clusters. Statistical significance testing was used to determine the most dangerous cluster locations for further safety consideration (Bíl et al., 2013). Dai & Jaworski (2016) used NKDE and an environmental audit to identify and prioritize the pedestrian crash hot spots and assessing the built environment that contributes to pedestrian crashes in DeKalb County, Georgia. The top ten hot spots based on the density of the pedestrian crashes within the search distance of 100 meters were selected for further analysis. Another study (Yao et al., 2018) used NKDE to identify the pedestrian crash hot spots. The hot spots were determined by assigning the threshold value for crash density to three standard deviations from the mean value. More recently, Chimba et al. (2018) used the GIS kernel density technique to identify the high concentration of pedestrian crash clusters in Davidson and Hamilton counties, Tennessee. The spatial analysis identified pedestrian crash clusters within census block groups (CBGs) with a high population who walk to work and CBGs with a high number of housing units with no vehicles.

In summary, KDE improves proximity measures and enables the density to be estimated at any point on the map surface. One of the drawbacks of this method is it suffers from bias, particularly near the boundaries of the estimated density (Zambom & Dias, 2012). This approach requires crash attributes data, roadway characteristics data, traffic characteristics data, and land use information.

2.1.3 Intersection Safety Indices (ISI)

The pedestrian and bicycle ISI (Ped ISI and Bike ISI, respectively) are a set of models that enable users to identify intersections that should be the greatest priority for undergoing pedestrian and bicycle safety improvements. Using observable characteristics of an intersection crossing or approach leg, the tool produces a safety index score, with higher scores indicating a greater priority for an in-depth safety assessment (Natarajan et al., 2008). This method enables the practitioner to prioritize and proactively address sites that are most likely to be a safety concern for pedestrians and bicyclists (Carter et al., 2007). This method uses variables that indicate a higher probability of risk for pedestrians and bicyclists to identify which crosswalks and intersection approaches have the highest potential for hazards within a particular jurisdiction. An in-depth evaluation at each priority site can be conducted to determine which countermeasures would be appropriate to address safety problems.

This approach can be used to predict the extent of risk in places where crash data are not available based on the risk at other similar locations (Carter et al., 2006). However, this method is applicable only for intersection-related crashes. This approach requires data on intersection control, intersection geometric characteristics, traffic characteristics, and the type of land use adjacent to the intersection.

2.1.4 Perception Surveys

Perception surveys are designed to capture the perceived risk of road users rather than the actual or measured risk. In this method, a subset of pedestrians and drivers are surveyed and asked to determine those locations they perceive as hazardous. The perceived hazardous locations are further investigated for potential safety improvement. This method does not need any set of crash data. On the other hand, locations with very little pedestrian activities may not be identified as hazardous. Also, the burden of administering the survey and processing the information makes surveying regularly difficult (Natarajan et al., 2008).

2.1.5 Citizen Input and Advocacy

This method utilizes citizen comments and concerns to identify hazardous locations. Locations with many complaints from road users and the local community are a good indication of potentially dangerous locations. Data required are records of all citizen input about hazards to pedestrians and bicyclists. Using detailed information from the citizen inputs, it is possible to identify the nature of the hazard, the exact sequence of incidents that led to a crash or a near-miss, and to determine the type of safety treatment required at a particular location. On the other hand, citizen comments and concerns are often biased toward personal experiences (Natarajan et al., 2008).

2.1.6 Reactive Approach

This method is based on an observed or historical crash pattern that had occurred at particular locations. It relies on the assumption that crashes that occur at a location will continue to occur unless a change is made. However, history and statistical trends have demonstrated that crashes tend to shift spatially, and a high crash location may tend to experience fewer crashes in the future (Gelinne et al., 2017). This approach requires crash data, roadway characteristics data, and traffic volume data. In some cases, an index may be developed to integrate other conditions, such as lack of sidewalks, into the process of identifying these locations of concern. Some studies (Fitzpatrick et al., 2018) used this approach to identify the locations with high pedestrian crashes. This method provides more attention to locations with higher crashes based on the historical crash data; however, the locations where crashes increase over time may not be included in the analysis.

2.1.7 Systemic Approach

This approach, also termed as risk-based or proactive, is data-driven and network-wide, and could be adopted for identifying and prioritizing sites with the highest PSI, based on specific risk factors. It addresses not only the locations with prior crash occurrence but also locations with a similar roadway or environmental crash risk characteristics (Thomas et al., 2018). It uses statistical models such as safety performance functions (SPFs) to determine the expected number of crashes at locations within a particular region. These estimates can be used to prioritize the sites that may potentially require safety improvement. This approach is considered more proactive than those that focus only on treating specific locations with crash history. SDOT (2016) used a systemic approach to identify high-risk locations associated with pedestrian crashes in Seattle, Washington State. This approach allowed the practitioner to look beyond crash data and incorporate other variables such as roadway characteristics, land use, bicyclist, and pedestrian volume data to identify risk factors that are associated with crashes involving pedestrians. Natarajan et al. (2008) used the risk assessment models to identify and prioritize the target regions for pedestrian and bicyclist safety improvement.

Similar to other approaches, this method also requires crash data, roadway geometric characteristics data, traffic volume data, and land use data. One of the main advantages of this method is that it can predict the extent of risk in places where crash data are not available based on the risk at other similar locations. On the other hand, this method provides more attention to the locations with a higher crash rate than those locations with a lower crash rate.

2.1.8 Summary

This section discussed the existing methods used to identify and prioritize target regions for safety improvements. All the above-discussed approaches except the perception survey and the citizen's inputs and advocacy method require historical crash data, roadway characteristics data, traffic characteristics data, and land use information. The perception survey and the citizen's inputs and advocacy method require survey records and citizen's comments, respectively. The approaches requiring spatial analysis require geographical coordinates of the crash data for mapping. Table 2-1 summarizes the strength and weaknesses and data requirements for each method.

Table 2-1: Summary of Methods Used to Identify and Prioritize Target Regions

Method	Advantages	Disadvantages	Data Requirements
GIS-based Analysis	• Identifies factors that contribute to crashes • Provides information to select the type of countermeasures	• Crashes with no geographical coordinates may not be mapped and therefore excluded from the analysis	• Crash attributes • Roadway characteristics • Traffic data • Land use data
Kernel Density Estimation	• Improves proximity measures • Enables the density to be estimated at any point on the map surface	• Biased particularly near the boundaries of the estimated density	• Crash attributes • Roadway characteristics • Traffic data • Land use data
Intersection Safety Indices	• Can predict the extent of risk in places where crash data are not available based on the risk at other similar locations	• Limited to only intersections	• Intersection control • Intersection geometric characteristics • Traffic data • Land use data
Perception Surveys	• It is possible to identify the nature of the hazard and the exact sequence of incidents that led to a crash or a near-miss	• Biased towards personal experiences • Location with little pedestrian activity may not be identified	• Records of surveys
Citizen Input and Advocacy	• It is possible to identify the nature of the hazard and the exact sequence of incidents that led to a crash or a near-miss	• Biased towards personal experiences • Location with little pedestrian activity may not be identified	• Records of all citizen's inputs
Reactive Approach	• Use the existing crash data to prioritize high crash locations	• Provides attention to higher crash locations based on the history of the crash data	• Crash attributes • Roadway characteristics • Traffic data
Systemic or Risk-based Approach	• Can predict the extent of risk in places where crash data are not available based on the risk at other similar locations	• Provides attention to locations with higher crash rates compared to those locations with lower crash rates	• Crash attributes • Roadway characteristics • Land use data

Note: GIS = Geographic Information System.

2.2 Strategies Adopted to Select the Type of Outreach Activities

One of the most critical elements of a safety plan is to match the identified safety problems and community concerns with specific countermeasures and programs that address those problems. Plans that identify problems are not complete if they only include an extensive list of all possible countermeasures (Gelinne et al., 2017). Policies, campaigns, enforcement strategies, and design solutions should be tailored to the identified safety problems based on an analysis of available data and further diagnosis. Several strategies have been recommended and used to determine the type of specific countermeasures or outreach activities to be selected based on the factors that influence the crash occurrence risk.

The countermeasures or outreach activities to be selected range from engineering, education, and enforcement. Engineering countermeasures help to prevent crash occurrence and reduce severity when a crash does occur. On the other hand, education and law enforcement outreach plans increase the knowledge of safety actions for road users in selected high crash emphasis areas, increase compliance with existing laws, and coordinate with local law enforcement and engineering efforts on the safety of the road users. Furthermore, the combined engineering, education, and enforcement approach could produce the most benefits in reducing traffic fatalities and injuries. The strategies that have been adopted to select the appropriate type of countermeasures or outreach activities to specific target regions include: field reviews and road safety audit, pedestrian road safety audit, Pedestrian and Bicycle Crash Analysis Tool (PBCAT), Pedestrian Safety Guide and Countermeasure Selection (PEDSAFE), and statistical test and modeling results.

2.2.1 Field Reviews and Road Safety Audits

A road safety audit (RSA) is the formal safety performance examination of an existing or future road or intersection. It qualitatively estimates and reports on potential road safety issues and identifies opportunities for improvements in safety for all road users (Federal Highway Administration [FHWA], 2006). RSAs involve an independent multidisciplinary team of professionals who review a particular location and identify environmental, behavioral, and other factors that might be contributing to crashes and conflicts (Gelinne et al. 2017). Also, with a focus on pedestrians, pedestrian road safety audits (PRSAs) use a similar methodology as RSAs to select potential types of countermeasures for pedestrian safety improvement. Dunckel et al. (2014) used a data-driven PRSA at targeted high incident areas (HIAs) in Montgomery County, Maryland, to determine the most effective engineering countermeasures for each target area to improve pedestrian safety.

2.2.2 Pedestrian and Bicycle Crash Analysis Tool (PBCAT)

PBCAT is a crash-typing software used to analyze crashes in selected zones, based on the information associated with crashes between motor vehicles and pedestrians or bicyclists. The PBCAT can link each crash type with a set of possible causal factors, and each possible causal factor is linked to a set of potential countermeasures to produce reports and select the most effective countermeasures (Harkey et al., 2006). A study conducted in San Francisco, California, used the PBCAT to select the most effective countermeasures for the safety improvement of pedestrians and bicyclists (Ragland et al., 2003).

2.2.3 Pedestrian Safety Guide and Countermeasure Selection System (PEDSAFE)

PEDSAFE is an online system that helps practitioners select countermeasures to improve pedestrian safety and mobility. PEDSAFE provides the user with a list of possible engineering, education, or enforcement treatments to improve pedestrian safety and mobility based on user input (Harkey & Zegeer, 2004; Zegeer et al., 2013). Natarajan et al. (2008) adopted PEDSAFE in Virginia to match the causal factors of hazards with several potential countermeasures.

2.2.4 Statistical Test and Modeling Results

This is the data-driven approach that relies on the significance of the factors that contribute to crash occurrence. The countermeasures are then selected based on the significant factors at a given confidence level. For example, suppose one of the significant factors contributing to the crash occurrence was the absence of lighting. In that case, the countermeasure to be implemented should be improving the lighting conditions of the particular location. Several studies have used this method to select the type of countermeasures to improve pedestrian safety (Dunckel et al., 2014; Lin et al., 2019).

2.3 Approach Used to Quantify the Impact of Outreach Activities

Quantifying the impact of the selected outreach activities is essential to determine whether the selected and implemented countermeasures or outreach strategies were effective in improving safety. Several studies used post-deployment evaluation (e.g., before-and-after evaluation studies) to quantify the impact of outreach activities (Dunckel et al., 2014; Gelinne et al., 2017; Natarajan et al., 2008; Ragland et al., 2003; Sandt et al., 2016; Van Houten et al., 2013; Van Houten & Malenfant, 2004). Dunckel et al. (2014) used the data-driven approach to quantify the impact of the deployed outreach activities in Montgomery County, Maryland. Ragland et al. (2003) used surrogate evaluation measures to assess the impact of the deployed countermeasures in San Francisco, California. The study used video-recorded observations of pedestrian and driver behavior (e.g., pedestrian/vehicle conflicts and pedestrian crossing time) and intercept surveys of pedestrians at target intersections. Van Houten et al. (2013) examined the effects of a one-year high-visibility pedestrian right-of-way enforcement program on yielding to pedestrians at uncontrolled crosswalks in the City of Gainesville, Florida. The evaluation involved some areas which received enforcement and some of which did not receive enforcement.

Sandt et al. (2016) used a pre-post design with a comparison group to examine the effect of high-visibility enforcement activities and low-cost engineering treatment components of the "Watch for Me NC" intervention. *Watch for Me NC* is a multi-faceted, community-based pedestrian safety program that includes widespread media and public engagement in combination with enhanced law enforcement activities (Sandt et al., 2016). Van Houten & Malenfant, (2004) used the multiple baseline design to determine the effectiveness of the enforcement component of the *Courtesy Promotes Safety* program without its engineering components in increasing drivers yielding to the pedestrians and changes in yielding behavior produced by enforcement at uncontrolled crosswalks and untreated crosswalks controlled by traffic signals. During baseline, data were collected at crosswalks along two major corridors. Treatment was introduced first at selected crosswalks without traffic signals along one corridor. A week later, enforcement was shifted to crosswalks along the second corridor. Results indicated that the percentage of drivers yielding to pedestrians increased following the introduction of the enforcement program in each corridor and that these increases were sustained for a year with minimal additional enforcement.

2.4 Summary

This chapter focused on the detailed review of the existing literature on the approaches to proactively identify and prioritize target regions, the strategies to select the type of outreach activities, and the approaches used to quantify the impact of the outreach activities. Table 2-2 summarizes the literature reviewed.

In summary, the approaches used to identify and prioritize target regions include:

- GIS-based analysis
- Kernel density estimation
- Intersection safety indices
- Perception surveys
- Citizen input and advocacy
- Reactive approach
- Systemic approach

Strategies adopted by agencies to select the type of countermeasure include:

- Field reviews and road safety audit
- Pedestrian and bicycle crash analysis tool
- Pedestrian safety guide and countermeasure selection
- Statistical test and modeling results

Finally, post-deployment evaluation was used by different agencies to quantify the impact of outreach activities.

Table 2-2: Summary of Selected Literature

Study	State/ Region	Approaches to Identify Target Regions	Strategies to Select the Type of Outreach Activities	Approaches to Quantify the Impact of Outreach Activities
Dugan et al. (2019)	Massachusetts	GIS-based Analysis	Multivariate Spatial Analysis	NA
Lin et al. (2019)	Florida	GIS-based Analysis	Statistical tests and Modeling	NA
Thomas et al. (2018)	Washington	Proactive Approach	NA	NA
Fitzpatrick et al. (2018)	NA	Reactive Approach	NA	NA
Chimba et al. (2018)	Tennessee	GIS-KDE	NA	NA
• Loo et al. (2011) • Yao et al. (2018)	Shanghai	GIS-NKDE	NA	NA
Gelinne et al. (2017)	NA	• Reactive Approach • Proactive Approach	PRSA	Post-deployment Evaluation
Dai & Jaworski (2016)	Georgia	GIS-NKDE	NA	NA
Sandt et al. (2016)	North Carolina	NA	NA	Post-deployment Evaluation
SDOT (2016)	Washington	Proactive Approach	NA	NA
Lee et al. (2015)	Florida	• GIS-based Analysis • PSI	NA	NA
Dunckel et al. (2014)	Maryland	GIS-based Analysis	PRSA	Post-deployment Evaluation
de Andrade et al. (2014)	Parana	GIS-KDE	NA	NA
Bíl et al. (2013)	Moravia	GIS-KDE	NA	NA
Van Houten et al. (2013)	Florida	NA	NA	Post-deployment Evaluation
Dai (2012)	Georgia	• GIS-Based Analysis • Spatial-temporal Clustering	NA	NA
Schuurman et al. (2009)	Vancouver	GIS-KDE	NA	NA
• Okabe et al. (2009) • Xie & Yan (2008)	Tokyo	GIS-NKDE	NA	NA
Natarajan et al. (2008)	Virginia	• GIS-based Analysis • Risk Assessment • Perception Surveys • ISI • Citizen Input and Advocacy	PEDSAFE	Post-deployment Evaluation
Van Houten & Malenfant (2004)	Florida	NA	NA	Multiple-baseline Design
Ragland et al. (2003)	California	GIS-based Analysis	PBCAT	Post-deployment Evaluation

Note: GIS = Geographic Information System; ISI = Intersection Safety Index; KDE = Kernel Density Estimation; NA= Not applicable; NKDE = Network Kernel Density Estimation; PBCAT = Pedestrian and Bicycle Crash Analysis Tool; PEDSAFE = Pedestrian Safety Guide and Countermeasure Selection; PRSA = pedestrian road safety audit; PSI = potential for safety improvement; SDOT = Seattle Department of Transportation.

CHAPTER 3
DATA

This chapter discusses the data variables and their sources needed to identify and prioritize target regions for improving the safety and mobility of the aging population. Data used in this research project include: crash data, roadway geometric characteristics data, socioeconomic and demographic data, and transit stops data. Also, this chapter presented the descriptive statistics of the crash data, and data processing steps on the built environment.

3.1 Data Requirements

The following types of data were required to achieve the research goal: (1) crash data involving aging road users; (2) roadway geometric characteristics data; (3) socioeconomic and demographic variables; and (4) infrastructure-related data. Crash data involving aging road users were extracted from FLHSMV. Socioeconomic and demographic variables were extracted from the Florida Geographic Data Library (FGDL). Roadway geometric characteristics data were extracted from FDOT's 2020 GIS shapefiles. Infrastructure-related data, i.e., transit stops data, were extracted from the Florida Transit Data Exchange (FTDE) Portal of the Florida Transit Information System (FTIS). The following subsections discuss each of these data variables and their sources.

3.1.1 Crash Data

Crash data involving aging road users in the entire state of Florida for the years 2014 through 2018 were used in this research project. The following specific crash-related attributes were included in the analysis:

- crash severity,
- crash location,
- crash type,
- time of the crash,
- lighting condition,
- weather condition,
- age and gender of the people involved in the crash,
- alcohol and/or drug involvement, and
- type of aging road users involved in the crash (driver, passenger, and/or non-motorist).

Crash data are available from the following four sources, and are discussed below. Note that Table 3-1 discusses the pros and cons of using these four crash data sources:

- Florida Department of Highway Safety and Motor Vehicles (FLHSMV)
- Crash Analysis Reporting System (CARS)
- Signal Four Analytics database
- Unified Basemap Repository (UBR)

Florida Department of Highway Safety and Motor Vehicles (FLHSMV)

The FLHSMV is the state's official repository for crash records. The Florida Traffic Crash Reports are completed by filling in the blanks with the required information obtained from an investigation of the event. The investigating officer is required to select and enter a value in the appropriate data field (Florida Department of Highway Safety and Motor Vehicles [FLHSMV], 2019). The following crash attributes can be obtained from the database: type of person involved in the crash, crash severity, lighting condition, crash type, and information about individuals involved in a crash, such as gender and age. The FLHSMV crash database provides detailed information of all people and vehicles involved in the crash, and includes crashes reported through both long- and short- forms. However, FLHSMV does not provide crash coordinates for mapping. In other words, this database does not include the latitude and longitude information of crash locations.

Crash Analysis Reporting System (CARS)

The CARS database is developed and maintained by the FDOT State Safety Office. The database can be accessed through the Single Sign-On (SSO) GIS Web Portal. The database includes all crashes reported on long-form reports, and are also geo-located. However, CARS data has a latency of 1-2 years. Furthermore, crashes that occur on off-system roads, and those reported on short-forms are not available in the CARS database.

Signal Four Analytics

Signal Four Analytics is a web-based geospatial crash analytical tool developed and hosted by the GeoPlan Center at the University of Florida that provides crash data with numerous crash attributes. It includes crash data for the most recent 10-year period provided by the FLHSMV and citation data since 2011 provided by the Florida Highway Patrol (FHP). This database includes crashes reported through long- and short-forms and crashes that occurred on private roads and in parking lots. Signal Four Analytics database provides crashes with their respective geographical coordinates (i.e., latitude and longitude information) for mapping.

Unified Basemap Repository (UBR)

FDOT's UBR is maintained by the Florida Traffic Records Coordinating Committee (TRCC). The UBR system provides separate shapefiles for crashes on on-system and off-system roads. The on-system crash database includes crashes recorded in the long-form crash reports that occurred on Florida's SHS. On the other hand, the off-system crash database includes crashes recorded in the long-form crash reports within the state of Florida that did not occur on the SHS. This off-system database includes crashes on the public road network and excludes crashes in parking lots, private property, and private roads.

In this research project, the crash data were extracted from the FLHSMV database. Since crash data from FLHSMV does not include latitudes and longitudes of crashes, the Signal Four Analytics database was used to extract the specific crash coordinates.

Table 3-1: Crash Data Sources

Database	Pros	Cons
FLHSMV	• Includes both long-form and short-form records of crashes • Provides detailed information of all people involved in the crash	• Does not provide coordinates for mapping the crash records
CARS	• Location is accurate • Large datasets can be requested directly from the FDOT State Safety Office	• Includes only long-form crashes and crashes that occurred on the state roads • The availability of data has a latency of 1-2 years
Signal Four Analytics	• Includes both long-form and short-form records of crashes • Includes crash records from all roads and parking lots with their geographical coordinates • Crash data is updated on a nightly basis	• Location is not always accurate
UBR	• Location is accurate • Shapefiles are available • Crashes are separated on on-system and off-system roads	• Includes only long-form crashes and crashes that occurred on public roads • The availability of data has a latency of 1-2 years

Note: CARS = Crash Analysis Reporting System; FDOT = Florida Department of Transportation; FLHSMV = Florida Department of Highway Safety and Motor Vehicles; UBR = Unified Basemap Repository.

3.1.2 Roadway Geometric Characteristics

The following specific roadway characteristics were included in the analysis:

- Freeway roadway miles
- Non-freeway SHS roadway miles
- Sidewalk miles

These data were extracted from FDOT's 2020 GIS shapefiles. FDOT's GIS shapefiles include data on the functional classification, which included the SHS network and the presence of the sidewalk.

3.1.3 Socioeconomic and Demographic Variables

Socioeconomic and demographic characteristics include age, gender, education, income, number of people and vehicles in each household, and older population. These variables were extracted from the 2015 FGDL with selected fields from the year 2014 through 2018. The CBG is the smallest geographical unit for which the U. S. Census Bureau (USCB) publishes sample data. The attributes included in Florida's 2015 CBGs are total population, gender, age, income, total households, and transportation mode.

3.1.4 Transit Stops

Information on the location of transit stops in Florida was extracted from the FTDE Portal of the FTIS. The FTDE is a web-based system used for the sharing of planning-related spatial data of the Florida fixed-route transit agencies. These include General Transit Feed Specification (GTFS) and GIS shapefiles. The variables available in the FTDE database include transit stop location (i.e., latitude and longitude) and the associated transit agencies. The final *Transit Stops* shapefile included 44,939 transit stops within the state of Florida that were manually verified.

3.2 Descriptive Statistics of Crash Data

Crash data for the entire state of Florida for the years 2014 through 2018 were extracted from the FLHSMV database. More than eight million people (8,636,545) were involved in a total of 3,690,264 traffic crashes that occurred from 2014 through 2018 in Florida. Of the 3.69 million traffic crashes, about 18.6% (i.e., 687,675) involved aging road users. Also, about 10.8% (i.e., 871,011) of the 8.04 million people involved in traffic crashes were aging road users. Aging road users were found to account for 19% of all traffic fatalities during the analysis period. Table 3-2 provides the statistics involving people younger than 65 years and 65 years and older by injury severity. Note that non-traffic fatalities and crashes with unknown injury severity were excluded from the analysis.

Table 3-2: Severity of People Involved in Traffic Crashes by Age Group

Age Group	Fatalities Count	Fatalities %	Serious Injuries Count	Serious Injuries %	Minor Injuries Count	Minor Injuries %	No Injuries Count	No Injuries %	Total Count	Total %
Age < 65	12,026	80.9%	90,430	87.2%	1,003,104	88.8%	6,068,328	89.3%	7,173,888	89.2%
Age ≥ 65	2,840	19.1%	13,288	12.8%	126,501	11.2%	728,382	10.7%	**871,011**	10.8%
Total	**14,866**		**103,718**		**1,129,605**		**6,796,710**		**8,044, 899**	

Note: Minor injuries include possible injuries and non-incapacitating injuries.

Table 3-3 provides the statistics of aging road users involved in crashes by severity. Aging motorcyclists and non-motorists involved in crashes were found to sustain more severe injuries compared to other aging road users (i.e., drivers and passengers). More specifically, about 5.2% of the aging motorcyclists and 6.4% of the aging non-motorists involved in crashes resulted in fatalities, while a relatively low 0.2% and 0.3% of the aging drivers and the aging passengers involved in crashes resulted in fatalities, respectively. These statistics indicate that aging motorcyclists and aging non-motorists are more vulnerable compared to aging drivers and aging passengers.

Table 3-3: Severity of Aging Road Users Involved in Traffic Crashes

Category	Fatalities Count	Fatalities %	Serious Injuries Count	Serious Injuries %	Minor Injuries Count	Minor Injuries %	No Injuries Count	No Injuries %	Total
Drivers	1,598	0.2%	8,975	1.3%	88,610	13.1%	577,662	85.4%	676,845
Passengers	514	0.3%	2,741	1.5%	31,673	17.%	147,795	80.9%	182,723
Motorcyclists	254	5.2%	981	20.2%	2,446	50.4%	1,170	24.12%	4,851
Non-motorists	728	6.4%	1,572	13.7%	6,218	54.3%	2,925	25.6%	11,443

Note: Minor injuries include possible injuries and non-incapacitating injuries.

Table 3-4 presents the distribution of crashes involving aging road users by crash severity for the years 2014 through 2018. Of the 687,675 crashes that involved aging road users, 2,257 (~0.3%) resulted in fatalities. In general, over the years, crashes involving aging road users were found to be on an increasing trend.

Table 3-4: Statistics by Crash Severity and Year

Year	Fatal Count	Fatal %	Serious Injury Count	Serious Injury %	Minor Injury Count	Minor Injury %	No Injury Count	No Injury %	Total
2014	378	0.3%	2,013	1.7%	17,450	14.8%	98,142	83.2%	117,983
2015	429	0.3%	2,125	1.7%	18,894	14.9%	105,651	83.1%	127,099
2016	479	0.4%	2,182	1.6%	20,517	15.1%	113,122	83.0%	136,300
2017	483	0.3%	2,136	1.5%	20,827	14.3%	122,307	83.9%	145,753
2018	488	0.3%	2,039	1.3%	21,048	13.1%	136,965	85.3%	160,540
Total	**2,257**	**0.3%**	**10,495**	**1.5%**	**98,736**	**14.4%**	**576,187**	**83.8%**	**687,675**

Note: Minor injuries include possible injuries and non-incapacitating injuries.

Table 3-5 provides the statistics by crash severity and age group. As expected, the proportion of fatal crashes was found to increase with age. Crashes involving 85 years and older people were found to have a higher proportion of fatalities compared to other age groups. Figure 3-1 shows the FS crashes by age groups. Although the frequency of FS crashes seemed to be on a decreasing trend as people age, the proportion of FS crashes were found to be on an increasing trend.

Table 3-5: Severity of Aging Road Users Involved in Crashes by Age Group

Age Group	Fatalities Count	Fatalities %	Serious Injuries Count	Serious Injuries %	Minor Injuries Count	Minor Injuries %	No Injuries Count	No Injuries %	Total
65 - 69	737	0.2%	4,441	1.4%	44,541	14.5%	256,952	83.8%	306,671
70 - 74	616	0.3%	3,369	1.5%	32,047	14.2%	189,246	84.0%	225,278
75 - 79	480	0.3%	2,330	1.5%	22,326	14.5%	129,215	83.7%	154,351
80 - 84	434	0.4%	1,667	1.7%	14,736	14.9%	81,833	82.9%	98,670
≥ 85	573	0.7%	1,481	1.7%	12,851	14.9%	71,136	82.7%	86,041
Total	**2,840**		**13,288**		**126,501**		**728,382**		**871,011**

Note: Minor injuries include possible injuries and non-incapacitating injuries.

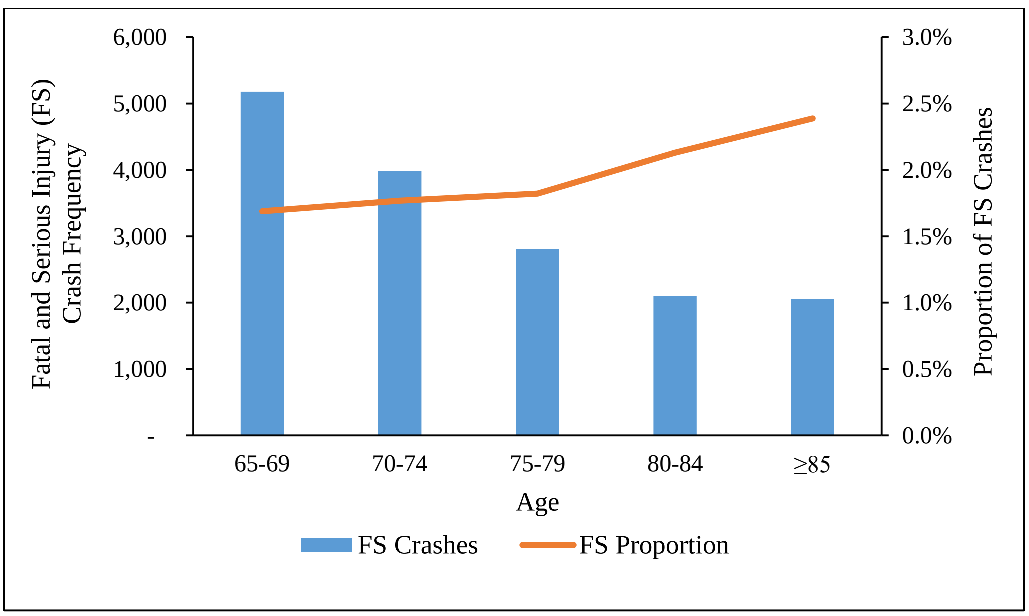


Figure 3-1: Distribution of FS Crashes by Age Group

Table 3-6 provides the distribution of crash severity involving aging road users by crash location. More than 60% of all crashes were found to be non-intersection-related. As expected, these crashes were found to be less severe compared to intersection-related crashes. Of the 2,651 crashes that occurred at roundabouts, only one crash resulted in a fatality and the proportion of serious and minor injury crashes were also very low compared to the crashes at other locations.

Table 3-6: Statistics by Crash Severity and Crash Location

Crash Location	Fatal Count	Fatal %	Serious Injury Count	Serious Injury %	Minor Injury Count	Minor Injury %	No Injury Count	No Injury %	Total
Not at Intersection	1,281	0.3%	5,445	1.3%	51,967	12.2%	366,746	86.2%	425,439
Intersection	929	0.4%	4,826	2.1%	44,375	19.3%	179,526	78.2%	229,656
Roundabout	1	0.0%	26	1.0%	175	6.6%	2,449	92.4%	2,651
Other	46	0.2%	193	0.7%	2,194	8.0%	25,145	91.2%	27,578
Unknown	0	0.0%	5	0.2%	25	1.1%	2,321	98.7%	2,351
Total	**2,257**		**10,495**		**98,736**		**576,187**		**687,675**

Note: Minor injuries include possible injuries and non-incapacitating injuries.

Table 3-7 provides the distribution of crash severity involving aging road users by lighting conditions. Overall, more than 75% of all crashes occurred during the daytime. Again, as expected, crashes were found to be more severe during dark conditions (both lighted and not lighted) than during daytime. Fatal crashes comprised 1.9% of the crashes that occurred during dark-not lighted conditions and 0.6% of the crashes that occurred during dark-lighted conditions. In comparison, a relatively low 0.2% of the crashes that occurred during daytime conditions were fatal.

Table 3-7: Statistics by Crash Severity and Lighting Condition

Lighting Condition	Fatal Count	Fatal %	Serious Injury Count	Serious Injury %	Minor Injury Count	Minor Injury %	No Injury Count	No Injury %	Total
Dark-Lighted	358	0.6%	1,028	1.7%	10,018	16.7%	48,609	81.0%	60,013
Dark-Not Lighted	309	1.9%	579	3.6%	3,328	20.8%	11,778	73.6%	15,994
Dark-Unknown Lighting	2	0.4%	12	2.3%	74	14.4%	426	82.9%	514
Dawn	27	0.5%	144	2.6%	1,004	18.4%	4,267	78.4%	5,442
Daylight	1,267	0.2%	7,579	1.5%	73,078	14.1%	437,433	84.2%	519,357
Dusk	59	0.4%	266	1.8%	2,511	16.8%	12,083	81.0%	14,919
Other	6	0.1%	10	0.1%	99	0.9%	11,262	99.0%	11,377
Unknown	229	0.4%	877	1.5%	8,624	14.4%	50,329	83.8%	60,059
Total	**2,257**		**10,495**		**98,736**		**576,187**		**687,675**

Note: Minor injuries include possible injuries and non-incapacitating injuries.

Table 3-8 provides the distribution of crash severity involving aging road users by weather conditions. More than 70% of all crashes occurred during clear weather conditions. As expected, crashes were found to be more severe during adverse weather conditions (e.g., fog, smog, smoke, etc.) than during clear weather.

Table 3-8: Statistics by Crash Severity and Weather Condition

Weather Condition	Fatal Count	Fatal %	Serious Injury Count	Serious Injury %	Minor Injury Count	Minor Injury %	No Injury Count	No Injury %	Total
Clear	1,501	0.3%	7,324	1.5%	68,373	14.2%	404,700	84.0%	481,898
Cloudy	369	0.4%	1,663	1.8%	14,689	15.9%	75,513	81.9%	92,234
Rain	132	0.3%	578	1.4%	6,714	16.3%	33,817	82.0%	41,241
Fog, Smog, Smoke	14	1.2%	45	3.9%	238	20.8%	847	74.0%	1,144
Other	12	0.1%	8	0.1%	96	0.9%	11,094	99.0%	11,210
Unknown	229	0.4%	877	1.5%	8,626	14.4%	50,216	83.8%	59,948
Total	**2,257**		**10,495**		**98,736**		**576,187**		**687,675**

Note: Minor injuries include possible injuries and non-incapacitating injuries.

Table 3-9 provides the distribution of crash severity involving aging users by road surface condition. More than 80% of all crashes occurred on dry road surface conditions. When the proportion of fatal crashes were considered, crashes on wet road surfaces were slightly more severe.

Table 3-9: Statistics by Crash Severity and Road Surface Condition

Road Surface Condition	Fatal Count	Fatal %	Serious Injury Count	Serious Injury %	Minor Injury Count	Minor Injury %	No Injury Count	No Injury %	Total
Dry	1,779	0.3%	8,665	1.6%	79,337	14.4%	461,120	83.7%	550,901
Wet	235	0.4%	915	1.4%	10,568	16.3%	52,982	81.9%	64,700
Other	14	0.1%	38	0.3%	205	13.0%	11,760	97.9%	12,017
Unknown	229	0.4%	877	1.5%	8,626	113.0%	50,325	83.8%	60,057
Total	**2,257**		**10,495**		**98,736**		**576,187**		**687,675**

Note: Minor injuries include possible injuries and non-incapacitating injuries.

Table 3-10 provides the distribution of crash severity involving aging road users by alcohol involvement. Only a little over 1% of these crashes involved alcohol/drugs; however, as expected, these crashes were more severe than those that did not involve alcohol/drugs.

Table 3-10: Statistics by Crash Severity and Alcohol/Drug Involvement

Category	Fatal Count	Fatal %	Serious Injury Count	Serious Injury %	Minor Injury Count	Minor Injury %	No Injury Count	No Injury %	Total
Alcohol/Drug	233	2.7%	418	4.9%	2,160	25.3%	5,716	67.0%	8,527
None	1,796	0.3%	9,200	1.5%	87,980	14.1%	523,254	84.1%	622,230
Unknown	228	0.4%	877	1.5%	8,596	15.1%	47,217	83.0%	56,918
Total	**2,257**		**10,495**		**98,736**		**576,187**		**687,675**

Note: Minor injuries include possible injuries and non-incapacitating injuries.

In summary, the key findings from the descriptive statistics of the crash data involving aging road users for the years 2014 through 2018 were as follows:

- Aging road users account for 11% of all road users involved in traffic crashes.
- Aging road users comprised 19% of all traffic fatalities.

- About 2,257 (~0.3%) of all crashes involved aging road users resulted in traffic fatalities.
- About 5.2% of the aging motorcyclists involved in crashes resulted in fatalities.
- About 6.4% of the aging non-motorists involved in crashes resulted in fatalities.
- Crashes involving aging road users were found to be on an increasing trend from 2014 through 2018.
- Crashes involving 85 years and older people were found to have the highest proportion of fatalities compared to other age groups.
- Intersection-related crashes were found to be more severe compared to crashes at other locations.
- Crashes that occurred during dark conditions were found to be more severe compared to daytime conditions.
- Crashes that occurred during adverse weather conditions were found to be more severe than those that occurred during clear weather conditions.
- Crashes that occurred on wet road surface conditions were found to be more severe than those that occurred on dry road surface conditions.
- Alcohol/drug-related crashes were found to be more severe than those crashes that did not involve alcohol/drugs.

3.3 Data Processing

As discussed in the earlier sections, the following data were retrieved:

- Crash data involving aging road users for the years 2014 through 2018
- Roadway characteristics data
- Signalized intersections data
- Socioeconomic and demographic data
- Roadside infrastructure data
- Transit stops data

The data were retrieved from the following data sources:

- Crash data: FLHSMV and Signal Four Analytics
- Roadway characteristic data: FDOT's GIS shapefiles
- Signalized intersections data: FDOT's *eTraffic*
- Roadside infrastructure data: FDOT's GIS shapefiles
- Transit stops data: FTDE

3.4 Summary

This chapter discussed the data variables and data sources needed to identify and prioritize target regions for conducting public outreach activities for improving the safety and mobility of the aging population. Table 3-11 provides the list of potential influential variables and their data sources considered in this research.

Table 3-11: List of Potential Influential Variables and their Sources

Data Variables	Attributes	Data Sources
Crash Data	• Crash severity • Crash time and location • Type of road users (drivers, passengers, and/or non-motorists) • Road surface condition • Lighting condition • Weather condition	• FLHSMV • Signal Four Analytics
Roadway Geometric Characteristics	• Freeway roadway miles • Non-freeway SHS roadway miles • Sidewalk miles	• FDOT's GIS Shapefile
Signalized Intersections	• Signalized intersection control characteristics	• FDOT's *eTraffic*
Socioeconomic and Demographic Variables	• Total population • Median household income • Aging population	• 2015 FGDL
Transit Stops	• Location of transit stops	• FTDE

Note: FDOT = Florida Department of Transportation; FGDL = Florida Geographic Data Library; FLHSMV = Florida Department of Highway Safety and Motor Vehicles; FTDE = Florida Transit Data Exchange; GIS = Geographic Information System: SHS = State Highway System.

CHAPTER 4
IDENTIFY AND PRIORITIZE TARGET REGIONS

This chapter discusses the approach used to identify and prioritize target regions for improving the safety and mobility of the aging population. The first section presents the data variables used to identify and prioritize target regions. The details of the hot spot analysis were present next, and the last section discusses the spatial relationship between crashes involving aging road users and the built environment.

4.1 Data

This subsection discusses the unit of analysis and different data variables (i.e., response and explanatory data variables) used to identify and prioritize target regions for conducting public outreach activities to improve the safety and mobility of the aging population. The analysis was conducted at the macroscopic level, and the CBG was used as the analysis unit. The data variables used in the analysis include:

- *Crash data*: Five years (2014-2018) of crash data involving aging road users were extracted from the FLHSMV. The latitudes and longitudes of crashes were extracted from the Signal Four Analytics database.

- *Socioeconomic and demographic variables:* These variables were extracted for each CBG from the 2015 FGDL with selected fields from the year 2014 through 2018.

- *Roadway geometric characteristics:* These variables were extracted from FDOT's 2020 GIS shapefiles.

- *Infrastructure-related variables:* Information on the miles of sidewalk was extracted from FDOT's 2020 GIS shapefiles. Transit stop data were extracted from the FTDE Portal of the FTIS.

The details of these variables and data sources were provided in Chapter 3.

4.1.1 Census Block Group (CBG)

The CBG was used as the unit of analysis. It is the smallest geographical unit for which the USCB publishes sample data. The state of Florida consists of 11,442 CBGs. Of these, 92 CBGs had zero total population and 141 had zero miles of the roadway network. These CBGs were not included in the analysis. The final analysis included 11,209 CBGs. The response variables included:

- total crashes involving aging road users per year per mile of SHS roadway network within the CBG, and
- crashes involving aging non-motorists per year per mile of non-freeway SHS roadway network within the CBG.

The following explanatory variables were aggregated for each of the 11,209 CBGs:

- total population density (i.e., total population within the CBG per area of the CBG),
- proportion of aging population (i.e., aging population within the CBG per total population within the CBG),
- median household income,
- non-freeway SHS roadway density (i.e., total miles of non-freeway SHS roadway network within the CBG per area of the CBG),
- freeway roadway density (i.e., total miles of freeway roadway network within the CBG per area of the CBG),
- proportion of sidewalk (i.e., total miles of sidewalk within the CBG per total miles of non-freeway SHS roadway network within the CBG), and
- bus stop density (i.e., the number of bus stops within the CBG per total miles of non-freeway SHS roadway network within the CBG).

4.1.2 Response Variable

Total crashes involving aging road users were aggregated for each of the 11,209 CBGs. In other words, crashes involving aging road users that occurred within 150 ft from the CBG boundary were identified and assigned to the CBG. The response variable included total crashes involving aging road users per year per mile of the SHS roadway network within the CBG and crashes involving aging non-motorists per year per mile of the non-freeway SHS roadway network within the CBG. Table 4-1 provides the descriptive statistics of the crashes involving aging road users.

Table 4-1: Descriptive Statistics of Crashes Involving Aging Road Users (65+)

Variable	Minimum	Maximum	Mean	Standard Deviation
Total crashes involving aging road users per year per mile of SHS roadway network within the CBG	0.00	322.22	10.05	12.25
Crashes involving aging non-motorists per year per mile of non-freeway SHS roadway network within the CBG	0.00	14.88	0.14	0.34

Note: CBG = census block group; SHS = State Highway System.

4.1.3 Explanatory Variables

The explanatory variables were divided into the following three categories:

- Socioeconomic and demographic variables
    - density of total population,
    - proportion of aging population, and
    - median household income.

- Roadway geometric variables
    - density of non-freeway SHS roadway network, and
    - density of freeway roadway network.

- Infrastructure-related variables

- proportion of sidewalk, and
- density of bus stops.

Table 4-2 presents the list of the explanatory variables used in the analysis.

Table 4-2: List of Explanatory Variables

Category	Variable	Description
Socioeconomic and Demographic Variables	Total Population Density	Total population per area of the CBG
	Aging Population Proportion	Proportion of aging population within each CBG
	Median Household Income	Median household income for each CBG
Roadway Characteristics	Freeway Roadway Density	Total miles of freeway roadway network within the CBG per area of the CBG
	Non-freeway SHS Roadway Density	Total miles of non-freeway SHS roadway network within the CBG per area of the CBG
Infrastructure-related Variables	Sidewalk Proportion	Total miles of sidewalk within the CBG per total miles of non-freeway SHS roadway network within the CBG
	Bus Stop Density	Total number of bus stops per total miles of non-freeway SHS roadway network within the CBG

Note: CBG = census block group; SHS = State Highway System.

4.2 Hot Spot Analysis for Urban and Rural Counties

An optimized hot spot analysis tool in ArcGIS was used to identify and prioritize target regions for conducting public outreach activities for improving the safety and mobility of aging road users. This method was used separately for urban and rural counties. Note that the definition of rural counties follows Section 288.0656 of the Florida Statutes:

- A county with a population of 75,000 or less
- A county with a population of 125,000 or less which is contiguous to a county with a population of 75,000 or less

The state of Florida consists of 36 urban counties and 31 rural counties based on the 2018 population data. Figure 4-1 presents urban and rural counties.

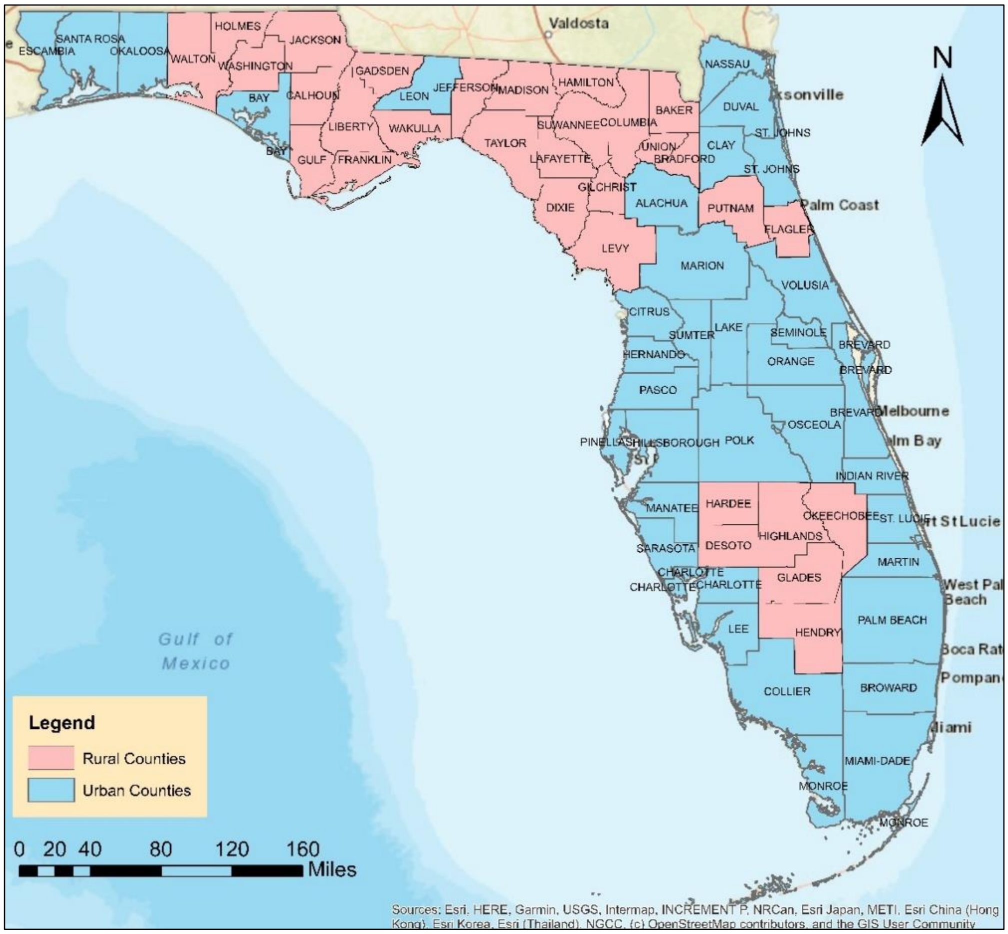


Figure 4-1: Urban and Rural Counties

4.2.1 Optimized Hot Spot Analysis

Optimized hot spot analysis executes the hot spot analysis (Getis-Ord Gi*) tool using parameters derived from the characteristics of the input data (ESRI, 2020b). This tool aggregates the input features (points or polygons) into weighted features. The tool utilizes the distribution of the weighted features to identify an appropriate scale of analysis automatically that yield optimal hot spot analysis results. The tool used a fixed distance band which is the distance that determines which features are analyzed together to assess local clustering (ESRI, 2020b). The distance band is one of the most important parameters in the hot spot analysis as it can directly determine the number of neighbor points to be evaluated as part of a possible cluster. The optimized hot spot analysis was conducted using the spatial statistics tools in ArcGIS v10.6, and the following fields were specified during the analysis.

Input Features

This represents the input data set, i.e., point or polygon feature class for which hot spot analysis will be performed. In this research, the polygons with 11,209 CBGs were used as the input features. These polygons consist of the response variables (i.e., total crashes involving aging road users per year per mile of SHS roadway network within the CBG and crashes involving aging non-motorists per year per mile of non-freeway SHS roadway network within the CBG) and explanatory variables (i.e., total population density, proportion of aging population, median household income, non-freeway SHS roadway density, freeway roadway density, sidewalk proportion, and bus stop density).

Analysis Field

This is the numeric field to be evaluated to determine the hot spots. The analysis field can be crash rate, crash frequency, etc., depending on the objective of the analysis. With an analysis field, the optimized hot spot analysis tool is appropriate for all data (points or polygons), including sampled data yielding accurate and reliable results (ESRI, 2020b). In this analysis, the response variables were specified and used as the analysis field to be evaluated to determine the hot spots.

Scale of Analysis

This represents the spatial extent of the analysis neighborhood determining which features are analyzed together to assess local clustering (ESRI, 2020b). Since crashes are random events and the analysis field consists of crash rates, it is not possible to specify and justify the scale of analysis. The optimized hot spot analysis tool used a fixed distance band which is a distance preset by the tool that determines which neighbors to include in the analysis (Mashinini et al., 2020). The selected distance, which requires at least eight neighbors for each feature, ensures that the scale of analysis does not change and remains consistent throughout the study area.

Output Features

The output features created automatically with the tool consist of GiZscore, GiPvalue, the number of neighbors, and the Gi-Bin. The Gi-Bin field reported in the output features was automatically adjusted for multiple testing and spatial dependence using the False Discovery Rate (FDR) correction method to identify statistically significant hot spots and cold spots. To be statistically significant hot spots or cold spots, a feature (i.e., CBGs) had to have high or low values and be surrounded by neighbor features (i.e., CBGs) with statistically significant high or low values, thus forming clusters. Features in the +/-3 bins (i.e., features with a Gi-Bin value of either +3 or -3) are statistically significant at a 99% confidence level; features in +/-2 bins reflect a 95% confidence level; features in +/-1 bins reflect a 90% confidence level; and features with 0 for the Gi-Bin field are not statistically significant. Note that the negative value indicates statistically significant cold spots, and the positive value indicates statistically significant hot spots.

4.2.2 Results of the Hot Spot Analysis for Urban Counties

The hot spot analysis was conducted separately for total crashes involving aging road users and those crashes involving aging non-motorists for urban counties. The analysis results were used to identify and prioritize urban target regions for conducting public outreach activities to improve the safety and mobility of the aging population.

Hot Spots and Cold Spots Based on Total Crashes Involving Aging Road Users

As stated earlier, the Gi-Bin field reported in the output features was automatically adjusted for multiple testing and spatial dependence using the FDR correction method to identify statistically significant hot spots and cold spots. Figure 4-2 presents statistically significant hot spots and cold spots at a 99%, 95%, and 90% confidence level for total crashes involving aging road users. There were 4,823 output features (i.e., CBGs) that were statistically significant based on an FDR correction for multiple testing and spatial dependence.

Of the 4,823 CBGs, 3,083 were hot spots and 1,740 were cold spots. As shown in Figure 4-2, the hot spots were mostly clustered in Miami-Dade, Broward, and Palm Beach counties. Other counties with significant hot spots included Clay, Collier, Duval, Lake, Lee, Manatee, Marion, Pasco, Pinellas, Sarasota, and Sumter. Note that the hot spots results show the locations and neighbors with a higher number of total crashes involving aging road users per year per mile of the SHS roadway network within the CBG. Figure 4-2 also shows that cold spots were mostly clustered in Brevard, Broward, Hillsborough, Leon, Polk, Seminole, and Volusia counties. Note that the cold spots present the locations and neighbors with a lower number of total crashes involving aging road users per year per mile of the SHS roadway network within the CBG.

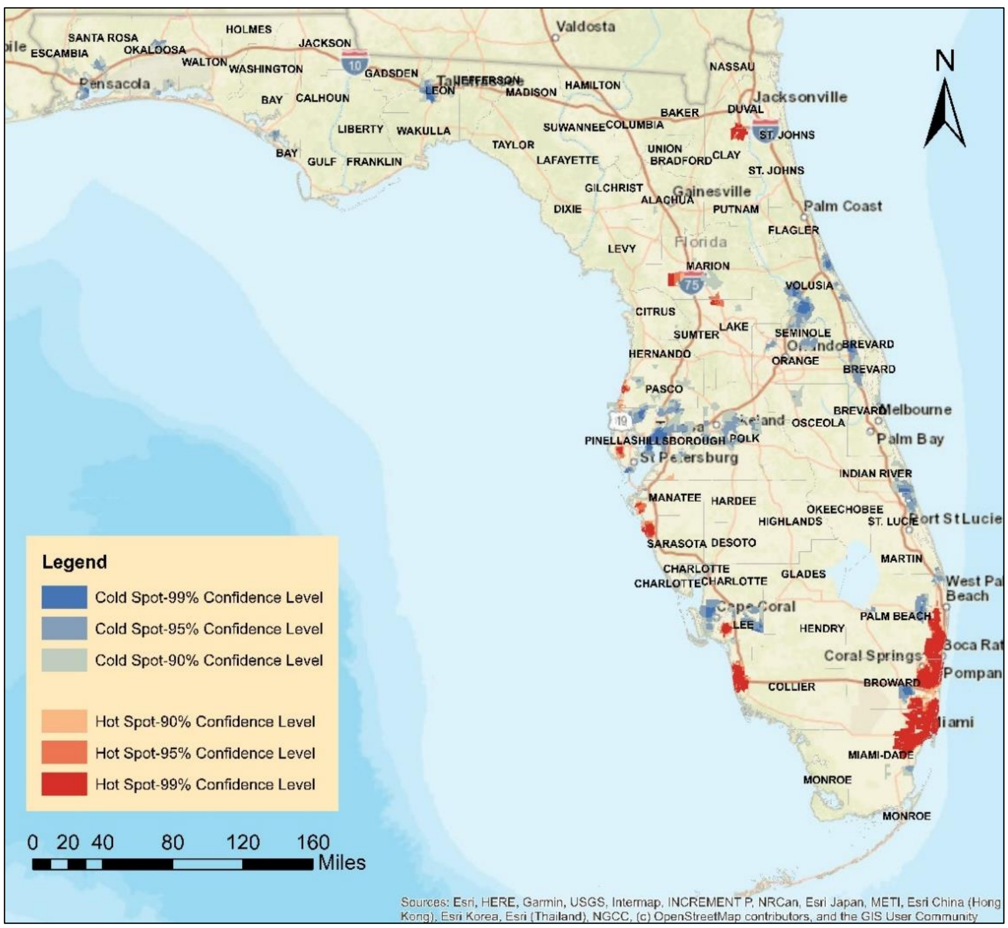


Figure 4-2: Urban Hot Spots and Cold Spots for Total Crashes Involving Aging Road Users

Hot Spots and Cold Spots Based on Crashes Involving Aging Non-motorists

The hot spot analysis for crashes involving aging non-motorists (pedestrians and bicyclists) was performed based on the number of crashes involving aging non-motorists per year per mile of non-freeway SHS roadway network within the CBG as a specified field of analysis. As presented in Figure 4-3, the results indicated 2,307 statistically significant output features (i.e., CBGs) as the hot and cold spots based on an FDR correction for multiple testing and spatial dependence. Among the 2,307 CBGs, 1,687 were hot spots, and 620 were cold spots. The hot spot clusters were in the following counties: Brevard, Collier, Duval, Hillsborough, Leon, Manatee, Marion, Miami-Dade, Palm Beach, Pinellas, and Sarasota. Figure 4-3 also shows that cold spots were mostly clustered in Alachua and Broward counties.

Figure 4-3: Urban Hot Spots and Cold Spots for Crashes Involving Aging Non-motorists

4.2.3 Urban Target Regions

Urban target regions are areas that experience a significant number of crashes involving aging road users in urban counties. As stated earlier, the hot spot analysis was used to identify urban target regions. Since it is not possible to conduct outreach activities in the entire county, the hot spots that were statistically significant at a 99% confidence level for total crashes involving aging road users and crashes involving aging non-motorists were identified as the urban target regions for conducting outreach activities.

Urban Target Regions Based on Total Crashes Involving Aging Road Users

Of the 3,083 CBGs that were identified as hot spots, 2,632 CBGs (85.4%) were statistically significant at a 99% confidence level. These CBGs were selected as urban target regions based on the total crashes involving aging road users. The urban target regions were in Broward, Clay, Collier, Duval, Lake, Lee, Manatee, Marion, Miami-Dade, Sarasota, Palm Beach, Pasco, Pinellas, and Sumter counties. Figure 4-4 presents the urban target regions based on total crashes involving aging road users. Such target regions give the priority list that can be used for improving the safety and mobility of the aging population. Table 4-3 summarizes the list of urban target regions for total crashes involving aging road users.

It is worth mentioning that FDOT's SMFL Coalition has identified the following ten urban counties as priority counties in 2020: Alachua, Bay, Broward, Duval, Escambia, Leon, Miami-Dade, Monroe, Orange, and Osceola. The results from this study show that about 74% of the urban target regions were consistently found within the priority counties identified by the SMFL Coalition. Note that the SMFL Coalition updates the urban and rural priority counties every year (SMFL, 2020a).

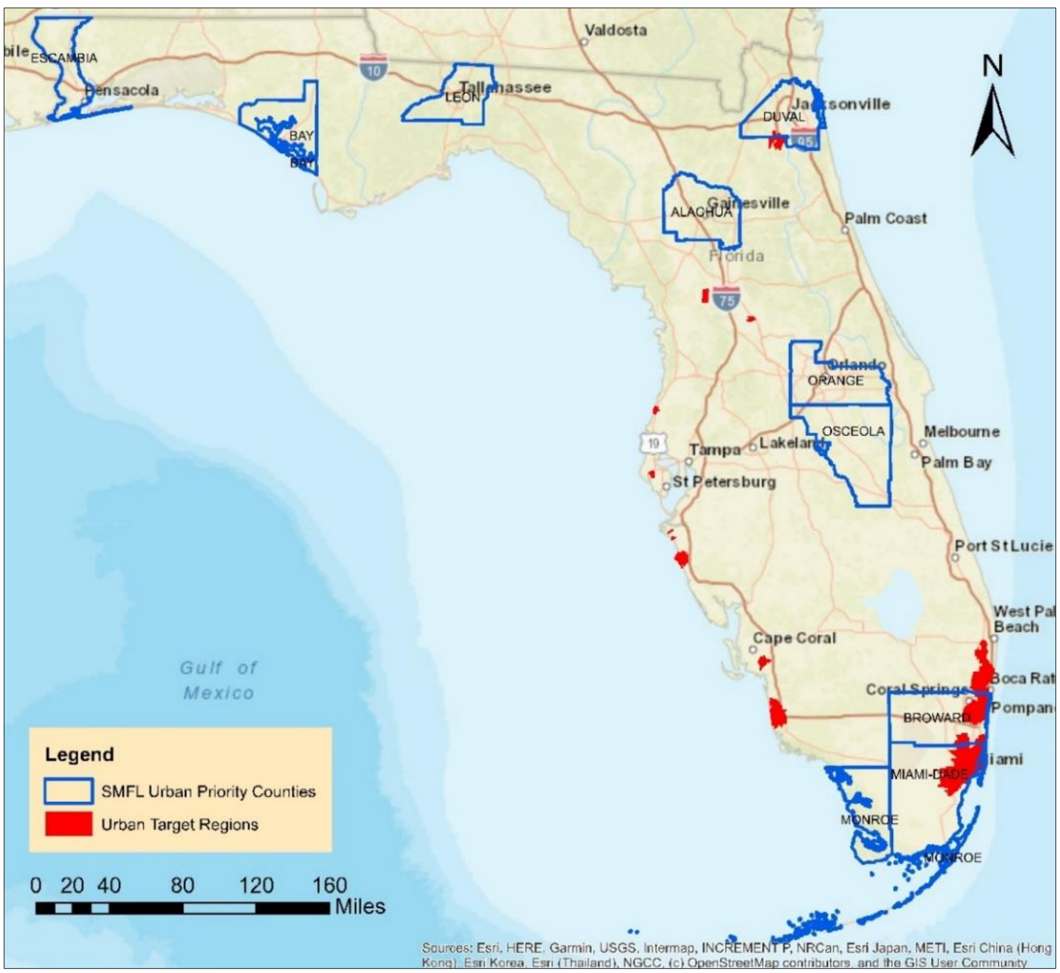


Figure 4-4: Urban Target Regions Based on Total Crashes Involving Aging Road Users

Table 4-3: Urban Target Regions for Total Crashes Involving Aging Road Users (65+)

FDOT District	County	CBG Total	CBG Target Regions	CBG Proportion[a]	Total Area (sq. mi.)	Target Regions (sq. mi.)	Area Proportion[b] (sq. mi.)
1	Collier	187	112	59.9%	2,304.96	88.7	3.8%
1	Lee	499	42	8.4%	1,212.37	23.14	1.9%
1	Manatee	207	18	8.7%	892.75	7.18	0.8%
1	Sarasota	248	70	28.2%	725.28	36.11	5.0%
2	Clay	78	29	37.2%	643.55	37.93	5.9%
2	Duval*	486	11	2.3%	918.46	9.42	1.0%
4	Broward*	927	595	64.2%	1,322.81	208.60	15.8%
4	Palm Beach	867	375	43.3%	2,383.18	172.19	7.2%
5	Marion	173	1	0.6%	1,662.65	19.69	1.2%
5	Sumter	41	8	19.5%	579.82	7.13	1.2%
5	Lake	148	4	2.7%	1156.96	2.09	0.2%
6	Miami-Dade*	1541	1307	84.8%	2,431.16	359.33	14.8%
7	Pasco	305	6	2.0%	868.46	8.28	1.0%
7	Pinellas	704	14	2.0%	608.13	7.70	1.3%
Total	**14**	**6,411**	**2,592**	40.4%	**17,710.53**	**987.49**	**5.6%**

Note: *represents Safe Mobility for Life Program and Coalition (SMFL) urban priority counties; proportion[a] is the ratio of the number of CBGs in the target region to the total number of CBGs within the county; proportion[b] is the ratio of the area of the target region to the total area of the county; CBG = census block group; FDOT = Florida Department of Transportation; sq. mi. = square miles.

Urban Target Regions Based on Crashes Involving Aging Non-motorists

Among the 1,687 CBGs that were detected as hot spots, 1,285 were statistically significant at a 99% confidence level. These CBGs were selected as the urban target regions based on crashes involving aging non-motorists. The urban target regions were in Brevard, Collier, Duval, Hillsborough, Leon, Marion, Miami-Dade, Palm Beach, and Pinellas counties. Figure 4-5 presents the urban target regions based on crashes involving aging non-motorists. Table 4-4 summarizes the list of urban target regions for total crashes involving aging non-motorists. Note that about 79% of the urban target regions based on the crashes involving aging non-motorists were found within the SMFL urban priority counties.

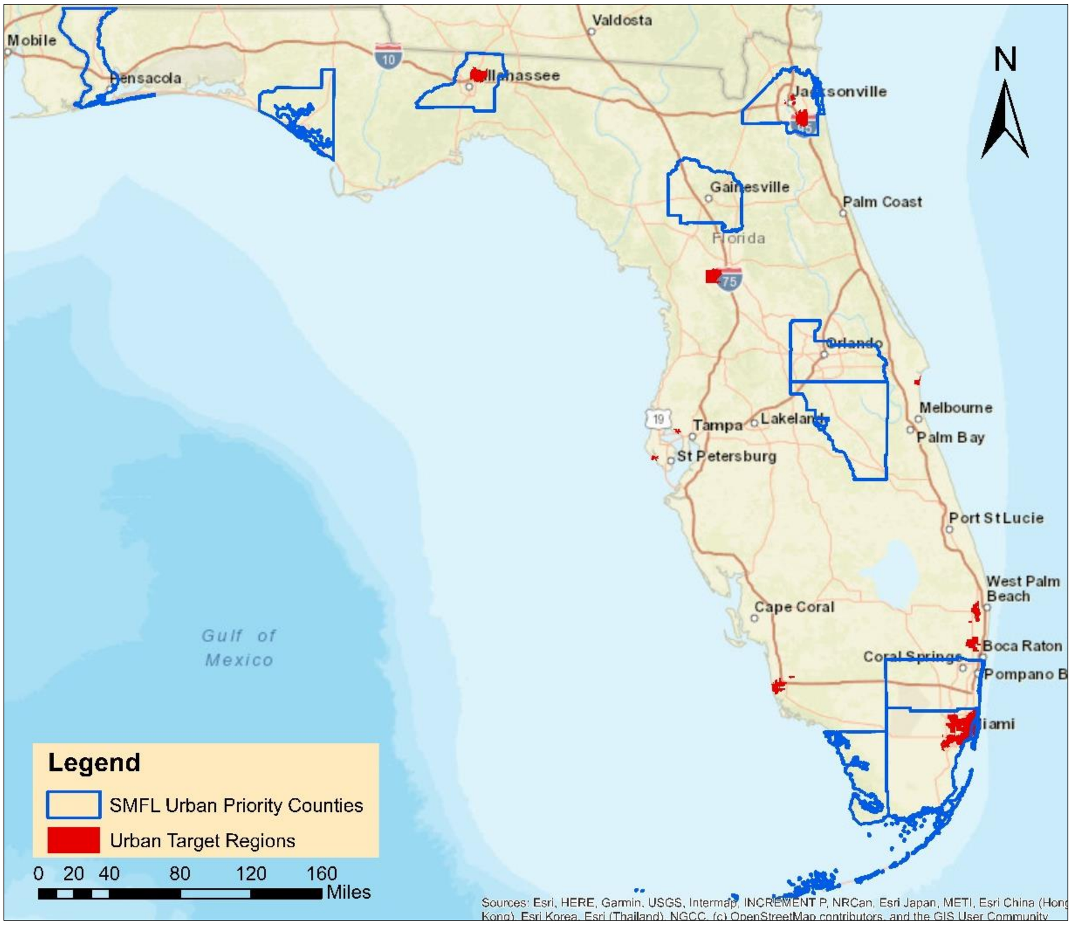


Figure 4-5: Urban Target Regions Based on Crashes Involving Aging Non-motorists

Table 4-4: Urban Target Regions for Crashes Involving Aging Non-motorists (65+)

FDOT District	County	CBG Total	CBG Target Regions	CBG Proportion[a]	Total Area (sq. mi.)	Target Regions (sq. mi.)	Area Proportion[b] (sq. mi.)
1	Collier	187	44	23.5%	2,304.96	37.15	1.6%
2	Duval*	486	52	10.7%	918.46	50.89	5.5%
3	Leon*	175	21	12.0%	701.79	44.71	6.4%
4	Palm Beach	867	116	13.4%	2,383.18	64.04	2.7%
5	Brevard	314	8	2.5%	1,557.02	7.52	0.5%
5	Marion	173	10	5.8%	1,662.65	48.80	2.9%
6	Miami-Dade*	1541	1,009	65.5%	2,431.16	225.75	9.3%
7	Hillsborough	852	16	1.9%	1,265.72	5.00	0.4%
7	Pinellas	704	9	1.3%	608.13	6.28	1.0%
Total	**9**	**5,299**	**1,285**	**24.4%**	**13,833.07**	**490.14**	**3.5%**

Note: *represents Safe Mobility for Life Program and Coalition (SMFL) urban priority counties; proportion[a] is the ratio of the number of census bock group (CBGs) in the target region to the total number of CBGs within the county; proportion[b] is the ratio of the area of the target region to the total area of the county; CBG = census block group; FDOT = Florida Department of Transportation; sq. mi. = square miles.

4.2.4 Results of the Hot Spot Analysis for Rural Counties

As stated earlier, the optimized hot spot analysis tool in ArcGIS was used to identify and prioritize rural target regions for conducting public outreach activities. The analysis was conducted separately for total crashes involving aging road users and those crashes involving aging non-motorists.

Hot Spots and Cold Spots Based on Total Crashes Involving Aging Road Users

The statistically significant hot and cold spots were identified after automatically adjusting the reported Gi-Bin field in the output features for multiple testing and spatial dependence using the FDR correction method. Figure 4-6 presents statistically significant hot spots and cold spots at a 99%, 95%, and 90% confidence level for total crashes involving aging road users in rural counties. There were 273 statistically significant output features (i.e., CBGs) based on an FDR correction for multiple testing and spatial dependence. Of the 273 CBGs, 213 were hot spots and the remaining 60 were cold spots. As presented in Figure 4-6, the hot spots were mostly clustered in Flagler, Hardee, Highlands, Okeechobee, Putnam, and Walton counties. Figure 4-6 also shows that cold spots were mostly clustered in Gadsden, Gilchrist, Holmes, Madison, and Washington counties.

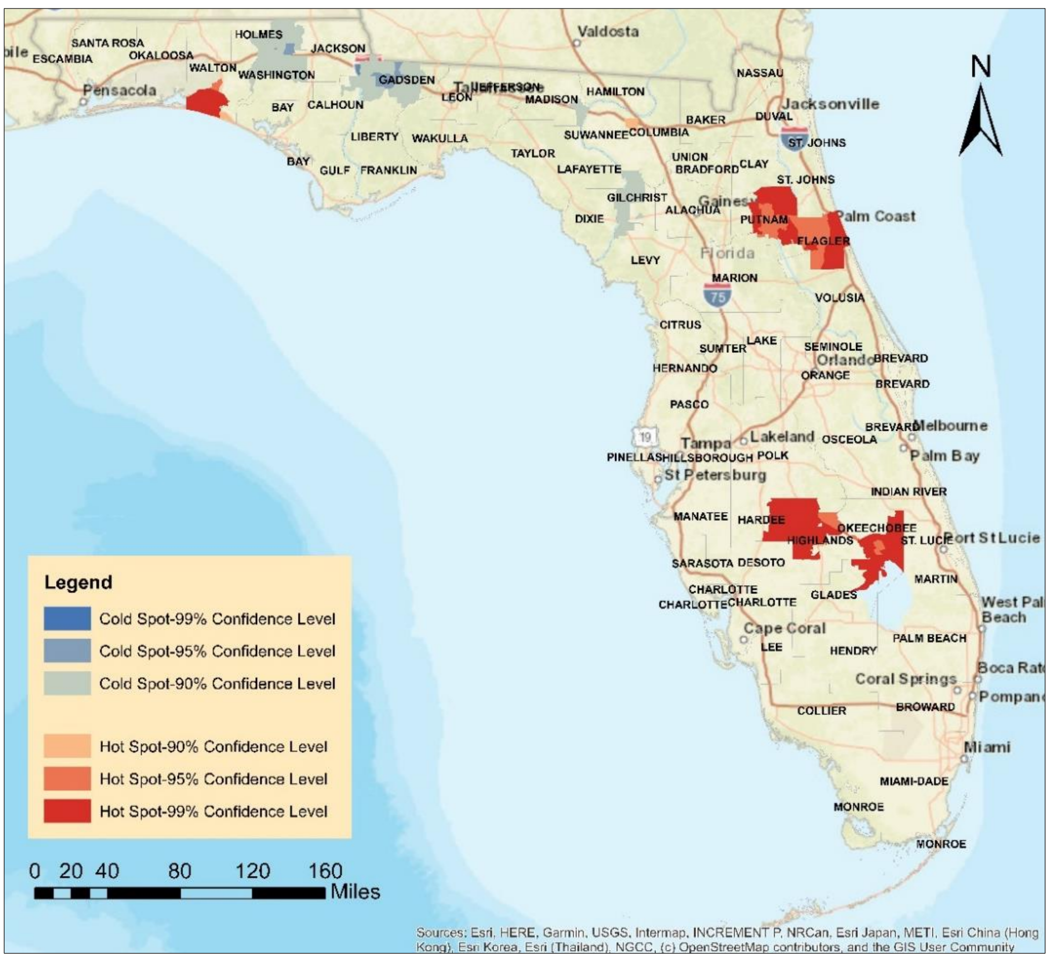


Figure 4-6: Rural Hot Spots and Cold Spots for Total Crashes Involving Aging Road Users

Hot Spots and Cold Spots Based on Crashes Involving Aging Non-motorists

The hot spot analysis for crashes involving aging non-motorists was performed based on the number of crashes involving aging non-motorists per year per mile of the non-freeway SHS roadway network within the CBG. As shown in Figure 4-7, there were 124 statistically significant CBGs based on the FDR correction for multiple testing and spatial dependence. Of the 124 CBGs, 122 were hot spots and two were cold spots. The hot spots were clustered mostly in Flagler, Hardee, and Highlands counties, while the cold spots were clustered in Bradford, Clay, and Gilchrist counties.

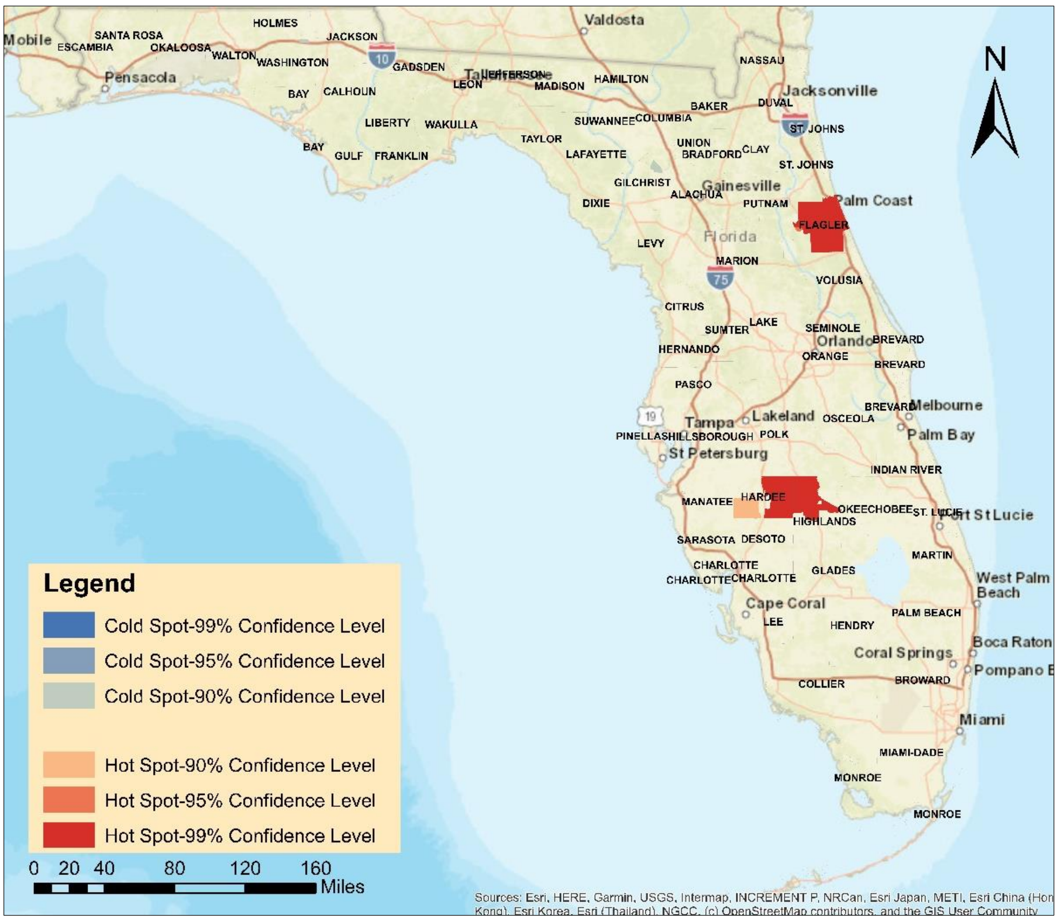


Figure 4-7: Rural Hot Spots and Cold Spots for Crashes Involving Aging Non-motorists

4.2.5 Rural Target Regions

Rural target regions are the areas that experience a higher number of crashes involving aging road users in rural counties. The hot spot analysis was used to identify these target regions. Since it is not possible to conduct outreach activities in the entire county, the identified hot spots that were statistically significant at a 99% confidence level for total crashes involving aging road users and those crashes involving aging non-motorists were identified as the rural target regions.

Rural Target Regions Based on Total Crashes Involving Aging Road Users

A total of 213 CBGs were identified as statistically significant hot spots at 90%, 95%, and 99% confidence levels. Of the 213 CBGs, 187 CBGs were statistically significant at a 99% confidence level. These 187 CBGs were identified as the rural target regions based on the total crashes involving aging road users. The rural target regions were in Flagler, Glades, Hardee, Highlands, Okeechobee, Putnam, and Walton counties.

It is worth mentioning that the SMFL Coalition has identified the following ten rural counties as priority counties in 2020: Baker, Bradford, Columbia, Desoto, Hamilton, Hardee, Jackson, Jefferson, Okeechobee, and Walton. Note that the SMFL Coalition updates its urban and rural priority counties every year. About 24% of the rural target regions were consistently found within the SMFL rural priority counties. Figure 4-8 shows the rural target regions based on total crashes involving aging road users. Table 4-5 summarizes the list of rural target regions for total crashes involving aging road users.

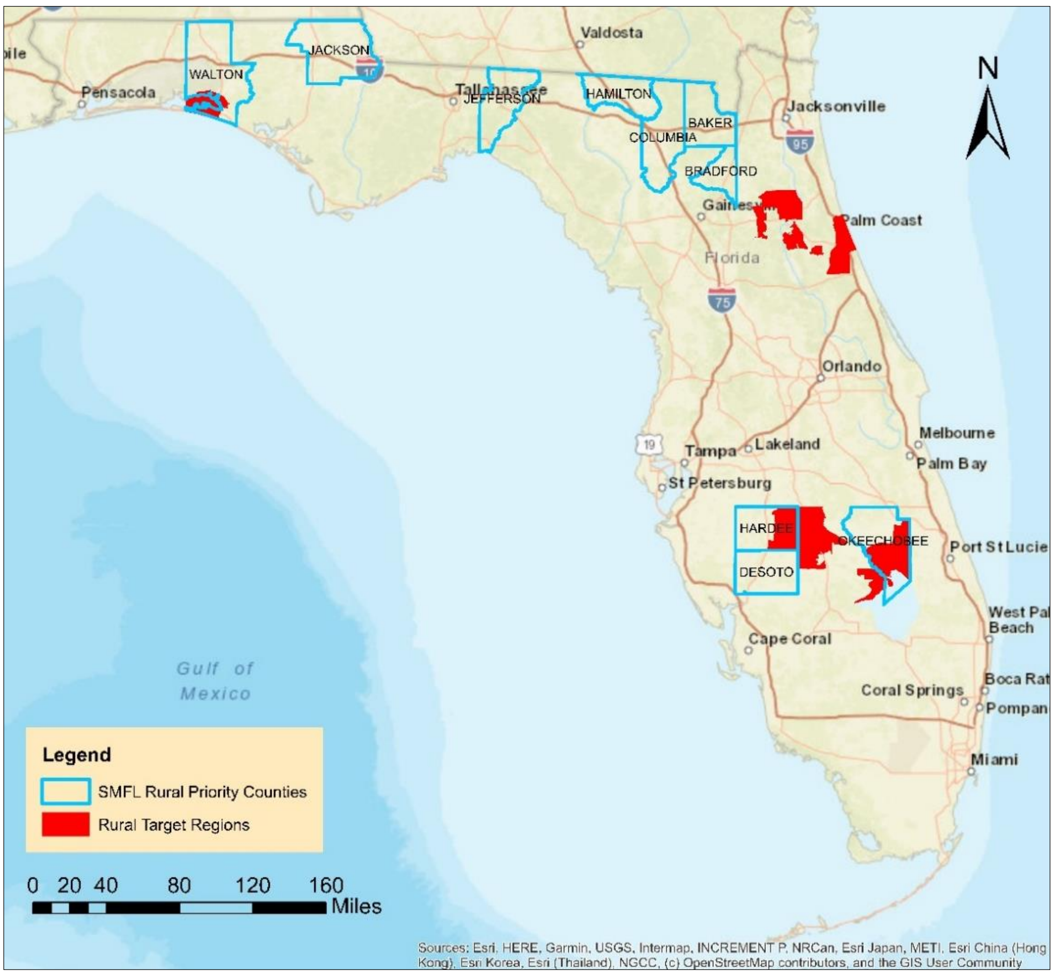


Figure 4-8: Rural Target Regions Based on Total Crashes Involving Aging Road Users

Table 4-5: Rural Target Regions for Total Crashes Involving Aging Road Users (65+)

FDOT District	County	CBG Total	CBG Target Regions	CBG Proportion[a]	Total Area (sq. mi.)	Target Regions (sq. mi.)	Area Proportion[b] (sq. mi)
1	Glades	11	2	18.2%	986.88	119.28	12.1%
1	Hardee*	20	3	15.0%	638.34	254.07	39.8%
1	Highlands	79	62	78.5%	1,106.02	433.8	39.2%
1	Okeechobee*	28	25	89.3%	891.90	378.57	42.4%
2	Putnam	61	32	52.5%	826.92	364.16	44.0%
3	Walton*	45	17	37.8%	1,239.59	188.73	15.2%
5	Flagler	52	49	94.2%	570.82	251.16	44.0%
Total	**7**	**296**	**190**	**64.2%**	**6,260.48**	**1,989.82**	**31.8%**

Note: *represents Safe Mobility for Life (SMFL) Program and Coalition rural priority counties; proportion[a] is the ratio of the number of CBGs in the target region to the total number of CBGs within the county; proportion[b] is the ratio of the area of the target region to the total area of the county; CBG = census block group; FDOT = Florida Department of Transportation; sq. mi. = square miles.

Rural Target Regions Based on Crashes Involving Aging Non-motorists

A total of 122 CBGs were detected as hot spots. Among these 122 CBGs, 120 hot spots were statistically significant at a 99% confidence level. These 120 CBGs were selected as the rural target regions based on the crashes involving aging non-motorists. The rural target regions were in Flagler, Hardee, Highlands, and Putnam counties. Figure 4-9 presents the identified rural target regions based on crashes involving aging non-motorists. About 7% of the rural target regions based on the crashes involving aging non-motorists were found within the 2020 SMFL rural priority counties. However, the identified rural priority counties were not based on the crashes involving aging non-motorists. Table 4-6 presents the list of the counties with identified rural target regions for crashes involving aging non-motorists.

Table 4-6: List of Rural Target Regions for Crashes Involving Aging Non-motorists (65+)

FDOT District	County	CBG Total	CBG Target Regions	CBG Proportion[a]	Total Area (sq. mi.)	Target Regions (sq. mi.)	Area Proportion[b] (sq. mi.)
1	Hardee*	20	8	40.0%	638.34	293.72	46.0%
1	Highlands	79	60	75.9%	1,106.02	308.44	27.9%
2	Putnam	61	1	1.6%	826.92	11.23	1.4%
4	Flagler	52	51	98.1%	570.82	511.57	89.6%
Total	**4**	**212**	**120**	**56.6%**	**3,142.11**	**1,124.96**	**35.8%**

Note: *represents Safe Mobility for Life Program and Coalition (SMFL) rural priority counties; proportion[a] is the ratio of the number of CBGs in the target region to the total number of CBGs within the county; proportion[b] is the ratio of the area of the target region to the total area of the county; CBG = census block group; FDOT = Florida Department of Transportation; sq. mi. = square miles.

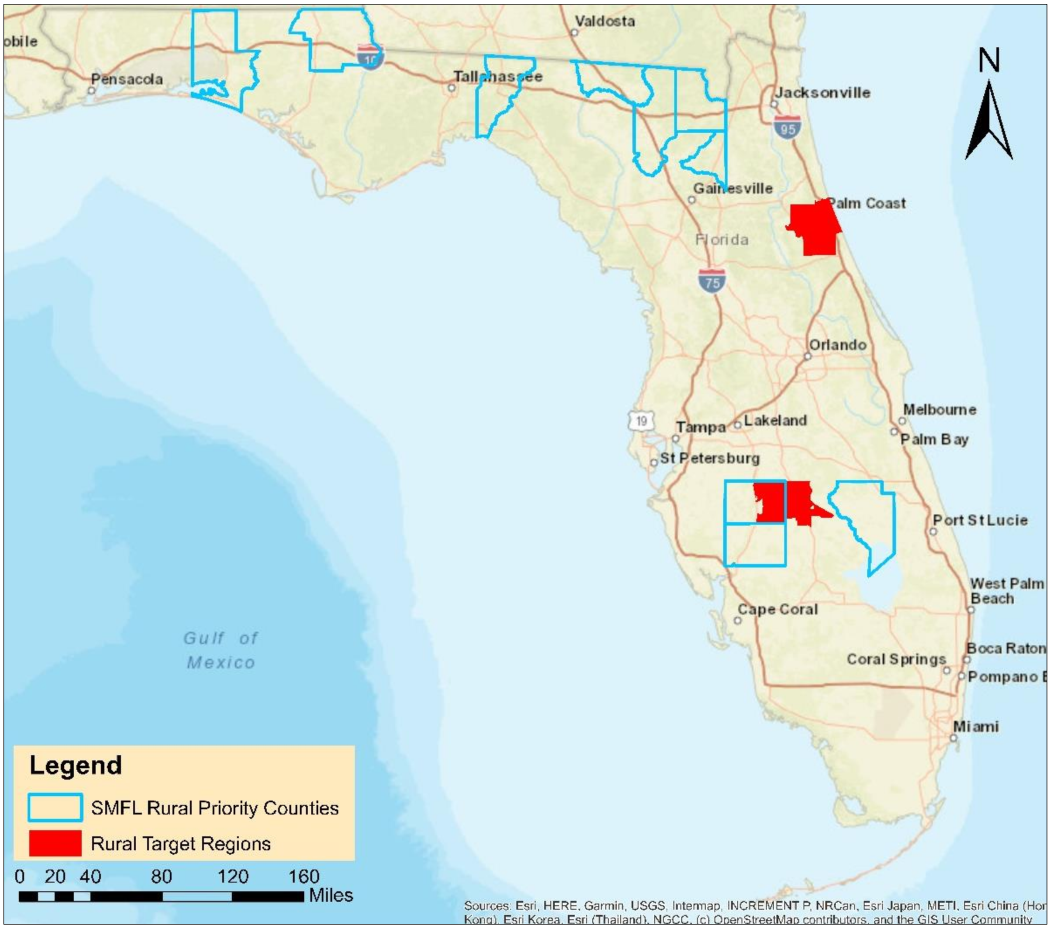


Figure 4-9: Rural Target Regions Based on Crashes Involving Aging Non-motorists

4.2.6 Relation between Work Zone Related Crashes and Target Regions

Table 4-7 presents the statistics of the crashes involving aging road users that were work zone related. Of the 748,952 crashes that involve aging road users, 10,125 (~1.4%) were work zone related crashes. Of the 10,125 work zone related crashes, 4,329 (~42.8%) occurred in the target regions. Of the 404,958 crashes that occurred in urban target regions, 3,909 (~1.0%) were work zone related crashes. Although rural target regions have fewer total crashes (14,286), about 2.9% (420) crashes were work zone related crashes. This proportion is higher compared to the proportion of work zone related crashes in urban target regions.

Table 4-7: Statistics of the Work Zone Crashes and Aging Road Users

Crash Category	Statewide Total	Statewide Proportion	Urban Target Regions Total	Urban Target Regions Proportion	Rural Target Regions Total	Rural Target Regions Proportion
Work Zone Crashes	10,125	1.4%	3,909	1.0%	420	2.9%
Non-work Zone Crashes	713,461	95.3%	401,049	99.0%	14,286	97.1%
Unknown	25,366	3.4%				
Total	**748,952**		**404,958**		**14,706**	

4.3 Crashes Involving Aging Road Users and the Built Environment

In addition to the hot spot analysis, which did determine the target regions, the current study examined the relationship between crashes involving road users and the built environment. Such a relationship was examined using spatial regression models. The models were developed in ArcGIS and were used to determine how locations with high crash clusters relate to causal factors.

4.3.1 Ordinary Least Square Regression

Ordinary Least Squares (OLS) is a commonly used regression technique. It acts as the starting point for all spatial regression analyses. However, this method assumes that data are completely independent, and the environment is homogeneous; and thus cannot be adapted by spatial autocorrelation and non-stationarity. As such, a geographically weighted regression (GWR) method was used in this project to account for spatial autocorrelation and the possible spatial non-stationarity of the relationship between the built environment and crashes involving aging road users.

As stated earlier, the OLS regression acts as the starting point of all spatial regression analyses because of its ability to create global model coefficient variables and assess the global multicollinearity among the explanatory variables (ESRI, 2020a). In this regard, the OLS regression model was created to assess the global multicollinearity among the explanatory variables. The global multicollinearity among the explanatory variables was checked through the variance inflation factor (VIF). Variables with large VIF values (greater than 7.5) are considered redundant and should be removed from the analysis. In this project, the VIF values for all explanatory variables were found to be less than 7.5, and therefore, all the explanatory variables were included in the analysis.

4.3.2 Geographically Weighted Regression (GWR)

The GWR is one of the several regression techniques for spatially varying relationships. The GWR technique captures spatial variability by calibrating a multiple regression model that allows different relationships over geographic space and provides local parameter estimates for variables in a spatial context (Brunsdon et al., 1996). In this method, the spatial dependency of observation is considered as the weight matrix due to environment homogeneity, and non-stationarity regression coefficients were derived locally and separately for each point. The GWR is presented in Equation 4-1 (Fotheringham et al., 2002).

$$y = \sum_{j=0}^{n} \beta_j(u_i, v_i) X_{ij} + \varepsilon_i \qquad (4\text{-}1)$$

where,

y = response variable,
X_{ij} = j^{th} explanatory variable (total population density, median household income, etc.),
n = number of explanatory variables,
ε_i = residual of the model, and
β_j = regression coefficient of the explanatory variables.

An adaptive kernel was used to conduct the GWR analysis, using the corrected Akaike Information Criterion (AICc), to determine the optimal bandwidth parameter. The adaptive kernel was used because of the uneven distribution of the crashes involving aging road users. Also, the adaptive kernel estimates the optimal bandwidth that minimizes the AICc. The spatial autocorrelation of the standardized residuals was checked using the Global Moran's I, as explained in Section 4.3.3.

4.3.3 Spatial Autocorrelation (Global Moran's I)

Global Moran's I is the tool used to measure spatial autocorrelation based on both feature locations and feature values simultaneously (ESRI, 2020c). For a given set of features and an associated attribute, this tool evaluates whether the pattern expressed is clustered, dispersed, or random. Mathematically, the Global Moran's *I* statistic is presented in Equation 4-2.

$$\mathrm{I} = \frac{n}{S_0} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} z_i z_j}{\sum_{i=1}^{n} z_i^2} \tag{4-2}$$

where,

z_i	=	deviation of an attribute for feature i from its mean $(x_i - \mu)$,
$w_{i,j}$	=	spatial weight between feature i and j,
n	=	the total number of features, and
S_0	=	the aggregate of all spatial weights presented in Equation 4-3.

$$S_0 = \sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} \tag{4-3}$$

The Z_I-score for the statistic is computed using Equation 4-4.

$$Z_I = \frac{\mathrm{I} - E[\mathrm{I}]}{\sqrt{V[\mathrm{I}]}} \tag{4-4}$$

where,

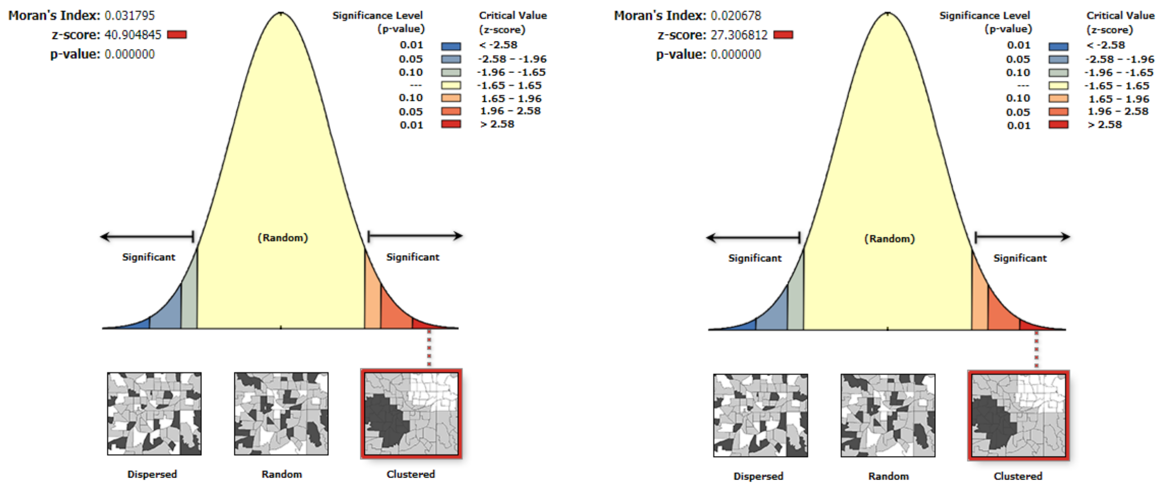
$$E[\mathrm{I}] = -1/(n-1) \tag{4-5}$$

$$V[\mathrm{I}] = E[\mathrm{I}^2] - E[\mathrm{I}]^2 \tag{4-6}$$

The result of the Global Moran's I analysis is always interpreted within the context of its null hypothesis. The null hypothesis states that the attribute being analyzed is randomly distributed among the features in the study area, i.e., the spatial processes promoting the observed pattern of values are a result of random chance.

When the *z*-score or *p*-value indicates statistical significance, a positive Moran's I index value indicates a tendency toward clustering (ESRI, 2020c). Thus the spatial distribution of high values and/or low values in the dataset is more spatially clustered than would be expected if underlying spatial processes were random. On the other hand, a negative Moran's I index value indicates a tendency toward dispersion. Indicating that the spatial distribution of high values and low values in the dataset are more spatially dispersed than would be expected if underlying spatial processes were random. A dispersed spatial pattern often reflects some type of competitive process that a feature with a high value repels other features with high values; similarly, a feature with a low value repels other features with low values. On the other hand, when the *z*-score or *p*-value is not statistically significant, the null hypothesis cannot be rejected, indicating the spatial distribution of feature values may be the result of random spatial processes.

Figures 4-10(a) and 4-10(b) present the results of the Global Moran's I statistic for total crashes involving aging road users and crashes involving aging non-motorists, respectively. As presented in Figure 4-10, the *z*-score value of 40.9048 and 27.307 was found for the total crashes involving aging road users and crashes involving aging non-motorists, respectively. These values indicate that there is a less than 1% likelihood that this clustered pattern could be the result of random chance. In this case, it is possible to reject the null hypothesis and examine what might be causing a statistically significant spatial structure in the data.



(a) Total Crashes Involving Aging Road Users

(b) Crashes Involving Aging Non-motorist

Figure 4-10: Spatial Autocorrelation Results (Global Moran's I)

4.3.4 Results of the GWR

As stated earlier, the GWR was used to examine the relationship between crashes involving aging road users and the built environment. The output features (i.e., CBGs) with a standard deviation of the residuals (SDR) values less than −2.5 have a lower density of crashes involving aging road users. On the other hand, the CBGs with SDR values greater than 2.5 have a significantly higher density of crashes involving aging road users. The CBGs with SDR values between −0.5 and +0.5 have relatively lower density of crashes involving aging road users.

Total Crashes Involving Aging Road Users

Table 4-8 provides the results of the GWR for the total crashes involving aging road users. Figure 4-11 presents the spatial relationship between total crashes involving aging road users and the built environment. The total crashes involving aging road users were found to be clustered in the areas with higher total population density and with a higher proportion of the aging population, especially in South Florida. Freeway roadway density, sidewalk proportion, and bus stop density were associated with more crashes involving aging road users. This indicates that the higher the freeway density, sidewalk proportion, and bus stop density, the higher the likelihood of crash occurrence. On the other hand, non-freeway SHS roadway density and median household income were associated with a decrease in the likelihood of crash occurrence. This indicates that the higher the median household income and the higher the non-freeway SHS roadway density, the lower the likelihood of the crash occurrence.

Table 4-8: Model Results for Total Crashes Involving Aging Road Users (65+)

Variable	Estimate	Standard Deviation
Intercept	6.071672	7.980086
Total population density	0.000325	0.000462
Aging proportion	8.471935	12.015237
Median household income	-0.000033	0.000039
Non-freeway SHS roadway density	-0.0086563	0.465346
Freeway roadway density	0.231633	1.197814
Sidewalk proportion	3.669386	4.908921
Bus stop density	0.734899	0.647615

Note: SHS = State Highway System.

Crashes Involving Aging Non-motorists

Table 4-9 presents the results of the GWR for the crashes involving aging non-motorists. Figure 4-12 portrays the spatial relationship between crashes involving aging non-motorists and the built environment. The results show that crashes involving aging non-motorists were clustered in the areas with higher total population density and with a higher proportion of the aging population, especially in South Florida. Sidewalk proportion and bus stop density were associated with higher crashes involving aging non-motorists. This indicates that the higher the sidewalk proportion and bus stop density the higher the likelihood of the crash occurrence. On the other hand, non-freeway SHS roadway density and median household income were associated with a decrease in the likelihood of crashes. This indicates that the higher the median household income and the higher the non-freeway SHS roadway density the lower the likelihood of the crash occurrence.

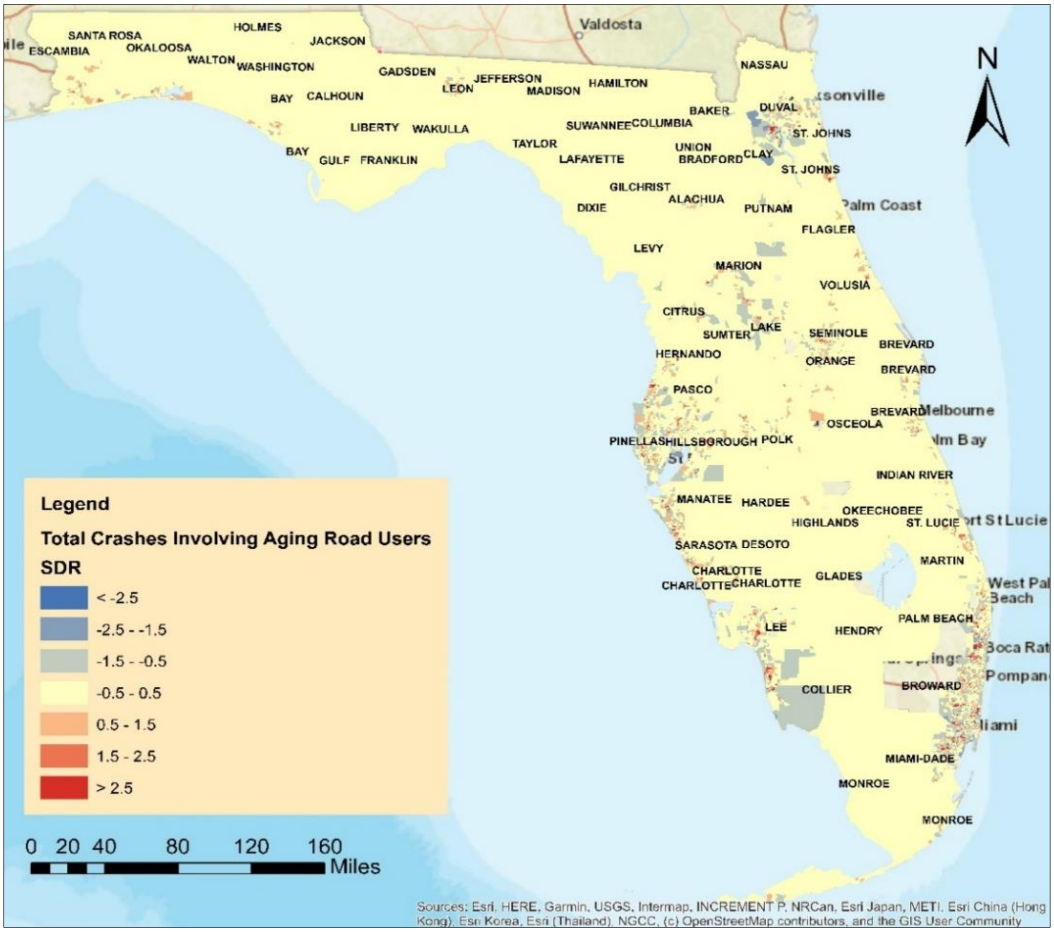


Figure 4-11: SDR of the Total Crashes Involving Aging Road Users

Table 4-9: Model Results for Crashes Involving Aging Non-motorists (65+)

Variable	Estimate	Standard Deviation
Intercept	0.044182	0.247401
Total population density	0.000012	0.000017
Aging proportion	0.204446	0.379159
Median household income	-0.000001	0.000001
Non-freeway SHS roadway density	-0.003427	0.012687
Sidewalk proportion	0.025459	0.183797
Bus stop density	0.013638	0.021167

Note: SHS = State Highway System.

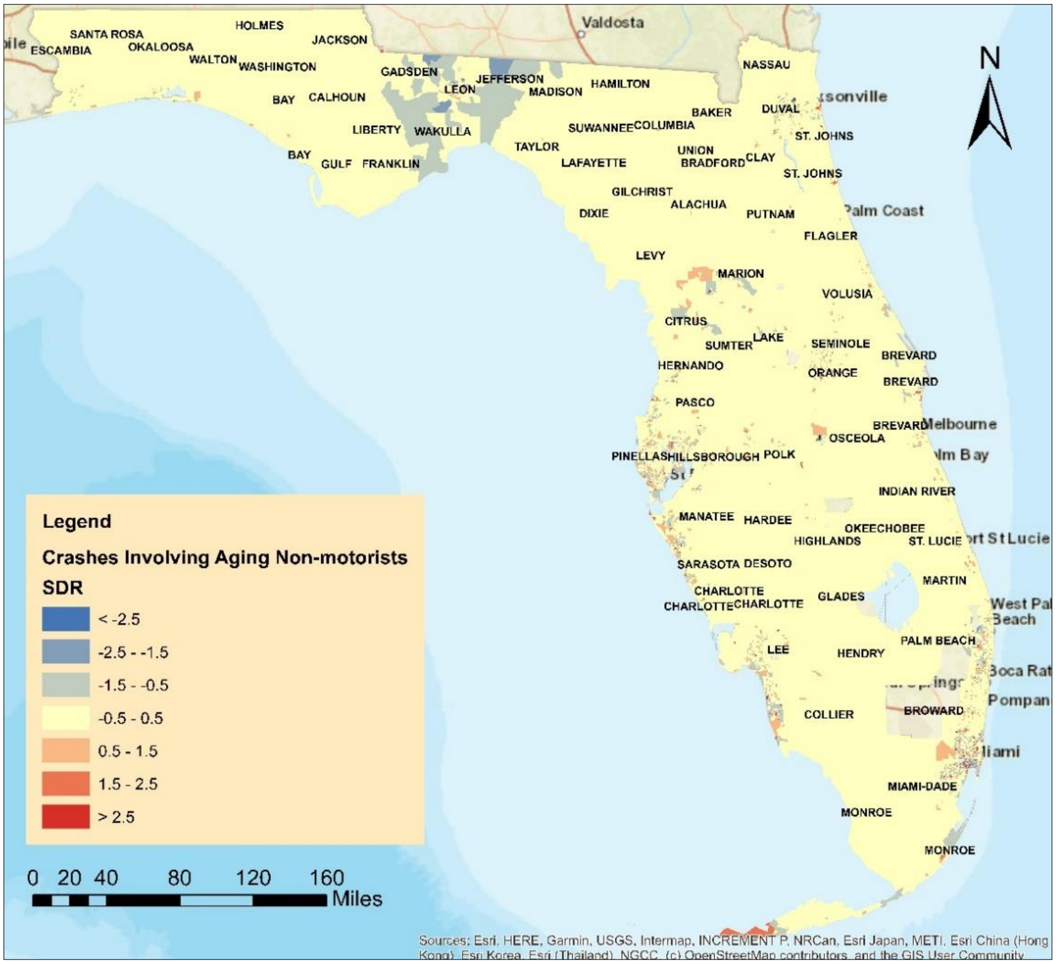


Figure 4-12: SDR of the Crashes Involving Aging Non-motorists

4.4 Summary

This chapter discussed the following:

- The approach used to identify and prioritize target regions for conducting public outreach activities for improving the safety and mobility of the aging population.
- The list of the target regions based on the total crashes involving aging road users.
- The list of the target regions based on the crashes involving aging non-motorists.
- The relationship between crashes involving aging road users and the built environment.

Figure 4-13 presents the target regions for urban and rural counties for total crashes involving aging road users. Also, Figure 4-14 presents the target regions for urban and rural counties for crashes involving aging non-motorists.

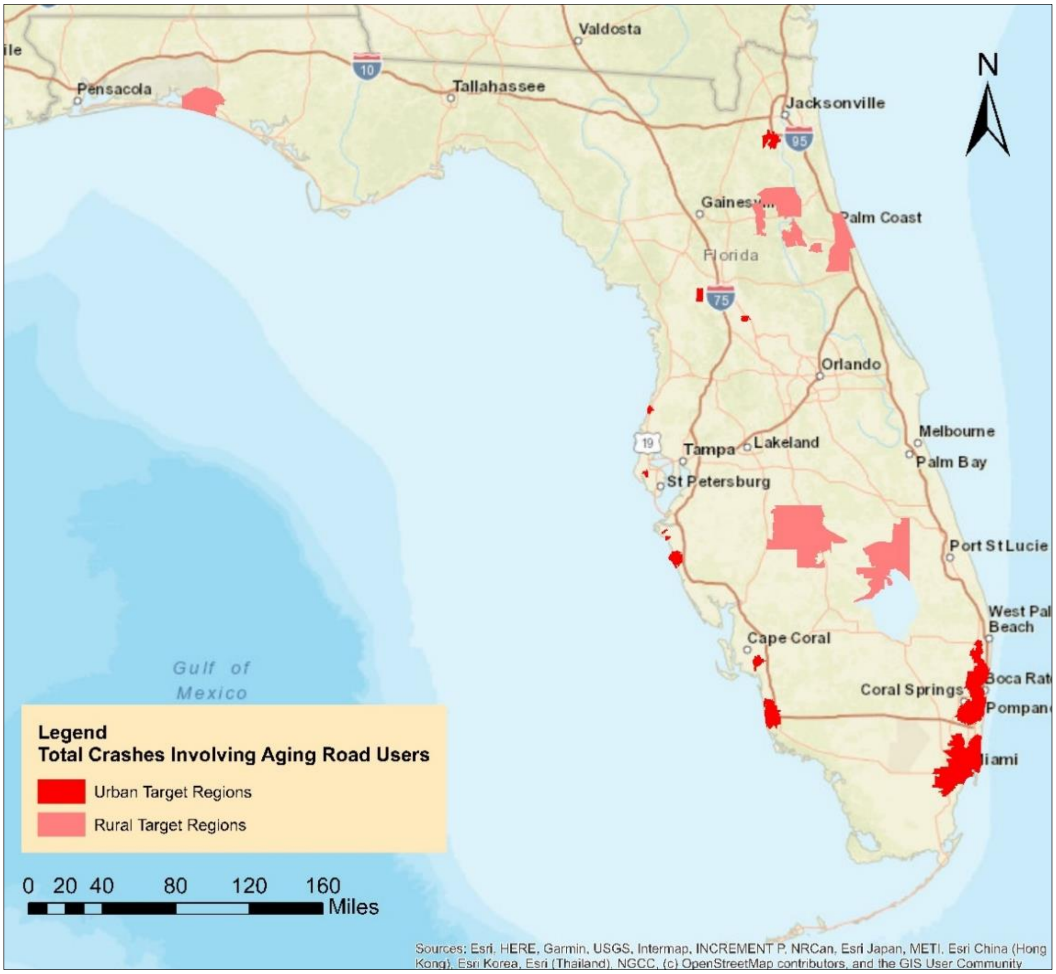


Figure 4-13: Urban and Rural Target Regions for Total Crashes Involving Aging Road Users

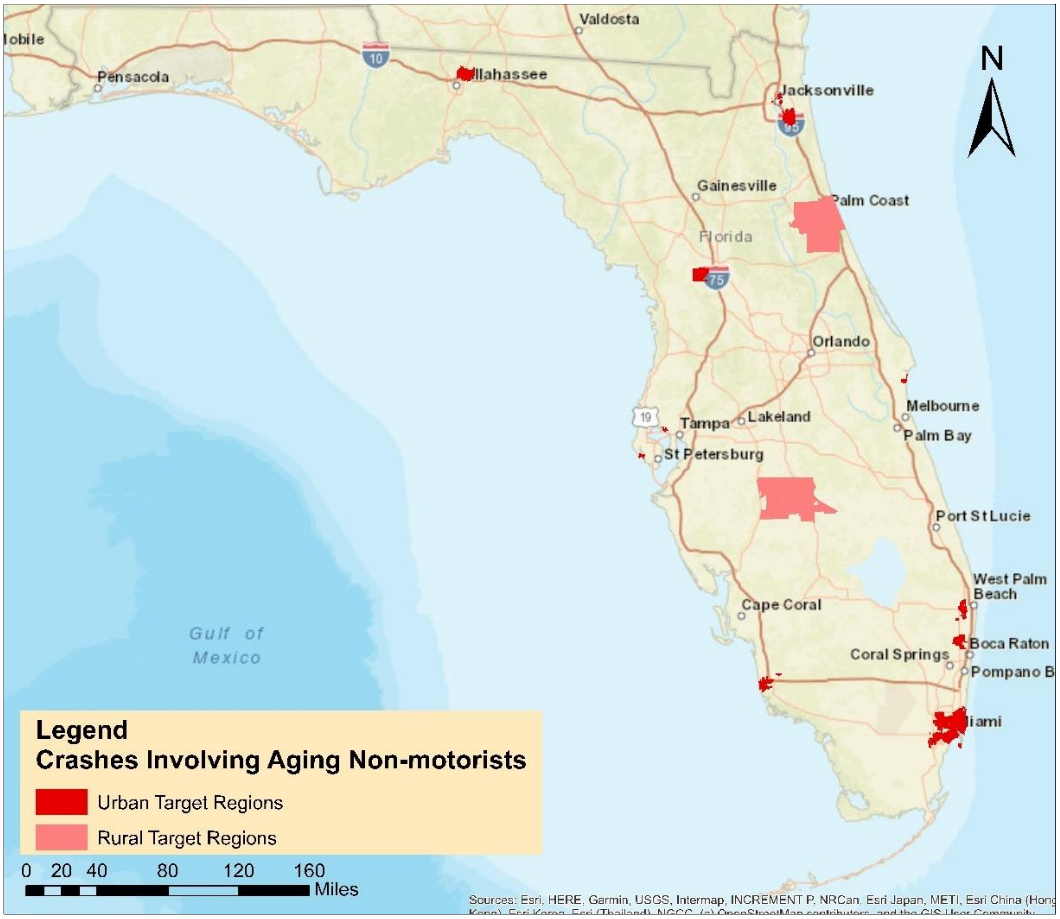


Figure 4-14: Urban and Rural Target Regions for Crashes Involving Aging Non-motorists

CHAPTER 5
SPECIFIC OUTREACH ACTIVITIES

This chapter focuses on a detailed review of all outreach activities being conducted by FDOT's SMFL program and recommends specific outreach activities at the target regions. Also presented the criteria used to recommend the specific outreach activities at the target regions.

5.1 Review of Outreach Activities

FDOT has been implementing several safety-focused countermeasures, including increased visibility, increased pedestrian features at intersections, countdown pedestrian signals, advanced street name signs, etc., since the early 1990s to compensate for the natural changes that occur as people age. FDOT continues implementing these countermeasures based on the FHWA Design Handbook for Aging Population (Brewer et al., 2014). In addition to engineering improvements, FDOT has been proactively addressing the specific needs of Florida's aging road users from several angles. The main focus is to educate aging road users, expand transportation choices and promote community design features to meet the mobility needs of the aging road users, and develop and distribute resources and tools to support safe skills and encourage early planning to safely transition from driving (FDOT, 2018, 2019, 2020).

In 2004, the FDOT State Traffic Engineering and Operations Office established the SMFL Program with a focus on improving the safety and mobility of Florida's aging road users. The program primarily focused on the engineering changes on the SHS roadway network to better accommodate aging road users. Implemented engineering countermeasures included increasing lane and edge line pavement marking widths to six inches, placing larger lettering on guide signs, installing refuge islands, incorporating longer walk times, considering slower walking speeds at signalized intersections, installing advanced warning signs, etc. The program has also developed and distributed tip cards to help educate road users on infrastructure improvements that may be confusing to some aging road users such as roundabouts and countdown pedestrian signals.

In 2009, FDOT partnered with the FSU Pepper Institute on Aging and Public Policy to establish the statewide SMFL Coalition (FDOT, 2017). The Coalition aims to improve the safety and mobility of aging road users in Florida by achieving a reduction in the number of aging road user fatalities, serious injuries, and crashes, while maintaining their safe mobility and connection to the community (FDOT, 2017). This goal was achieved through developing and distributing educational materials, resources, and information that are beneficial to the aging population. The Coalition developed and supported some of the programs that helped Florida achieve a reduction in traffic-related fatalities and serious injuries involving aging road users, as explained in the following section.

5.2 Existing Outreach Activities

The SMFL Coalition conducted several outreach activities at the state and local level to advocate and educate all stakeholders on the mission and resources available from the SMFL Coalition. These outreach activities include: distribution of educational materials, outreach events and workshops, and public service announcements (PSAs). These outreach activities are available on the SMFL Coalition website, http://safemobilityfl.com/ResourceCenter.htm. More details on these outreach activities are discussed in the following subsections.

5.2.1 Distribution of Educational Materials

Education provides road users with increased knowledge of safety actions, traffic rules, and guidelines. Education is critical, especially to aging road users, because they experience the decline of sensory, cognition, physical abilities, and sometimes memory. Educational materials distributed include:

Florida's Guide to Safe Mobility for Life

This guide helps Florida's road users achieve mobility independence. It provides information that helps aging road users learn how to maintain safe driving skills and build a transportation plan that explores life beyond the driver's seat. The guide includes interactive worksheets along with state and local resources to help aging road users build a transportation plan that works for them.

Driver Medical Referral Visor Card

This card developed by the FLHSMV helps to determine whether the observed driver behavior raises a red flag about a potential medical condition that affects safe driving.

Families & Caregivers Brochure

This brochure provides tips for talking with aging drivers about safe driving concerns and where to find additional resources.

You Hold the Keys Tip Card

This tip card helps road users understand the effects of aging on driving, be proactive, and have a personalized transportation plan in place before needed.

How to Choose Your Lifelong Community Checklist

This checklist helps to determine if a community has features and services that contribute to a rewarding, healthy, and active life, with a special focus on transportation, as people grow older.

How to Use Find a Ride Florida Tip Card

This tip card provides information that helps Floridians learn how to use the FindaRideFlorida.org website, an online listing of transportation service providers in Florida. This website helps Florida's road users find all of the transportation options available in their community.

Transit Ready Kit

This kit provides road users with tips for riding transit and information on the importance of transit and how to safely use transit services. It also provides tips on personal items that may be needed while using the transit system to ensure safety.

CarFit Tip Card

This tip card helps aging drivers improve the fit of their vehicle for their safety and comfort, promotes conversations among aging people and families about driving safety and links adults with relevant local resources that can help them drive safer longer.

Tips on How to Use Transportation Options in Florida Series

Bicycling Booklet: This booklet provides information that helps road users learn how to safely include bicycling in their transportation plans.

Public Transit Brochure: This brochure helps road users understand the benefits of riding transit and how to safely do so in Florida.

Walking Booklet: This booklet helps road users safely explore their community on foot.

Transportation Network Companies (TNCs): This brochure helps road users learn how to safely use TNCs, also known as ride-sourcing companies.

Golf Carts: This brochure contains information on how to operate golf carts safely and legally in Florida.

Roadway Safety Tip Cards Series

Flashing Yellow Arrow Tip Card: This tip card educates road users on what to do when they see flashing yellow arrows at the signalized intersections.

Turning Right on Red Tip Card: This tip card informs drivers how and when to legally and safely turn right on red.

How to Safely Navigate a Roundabout Tip Card: This tip card teaches road users how to navigate a roundabout safely and confidently.

Wrong-Way Driving on the Interstate Tip Card: This tip card identifies signs that indicate one-way ramps and what to do if you accidentally enter an off-ramp or see a wrong-way driver.

Roadway Safety Graphics

Flashing Yellow Arrow: These graphics educates road users on what to do when they see flashing yellow arrows at the signalized intersections.

Roundabouts: These graphics contains information that teaches road users how to navigate a roundabout safely and confidently.

Wrong-Way Driving: These graphics help road users identify signs that indicate one-way ramps and what to do if you accidentally enter an off-ramp or see a wrong-way driver.

Turning Right on Red: These graphics inform drivers how and when to legally and safely turn right on red.

Rectangular Rapid Flashing Beacons (RRFB): These graphics educates road users on what to do when seeing RRFB at the crosswalks.

5.2.2 Safe Mobility for Life Outreach Events

The SMFL Coalition conducts outreach events at the state and local levels to advocate and educate all stakeholders on the mission and resources available from the SMFL Coalition (FDOT, 2017). These outreach events include:

Keys to Achieve Safe Mobility for Life Workshop

These are the interactive events created and held by the Coalition to educate older adults on the key areas to stay mobile and to share the Coalition resources.

Safe Transit for Life Workshop

The Coalition conducts these events in priority counties to help educate and promote the use of public transportation among older adults by walking to a bus stop and using transit while traveling to and from a local destination.

Safe Bicycling for Life Workshop

These interactive events are developed and conducted by the Coalition to help road users learn how to safely bike in their communities.

Safe Walking for Life Workshop

Since walking is an essential part of people's lives, regardless of the mode of transportation, this workshop helps aging road users to safely explore their community on foot.

5.2.3 Public Service Announcements (PSAs)

As the Coalition believes that transportation resources are critical to a person's life, the Coalition tests and distributes a positive and empowering safety message, *"You Hold Keys to Your Transportation Future"*, in radio PSA that airs in over 60% of the urban and rural priority counties. Other safety messages include *"How to Build a Transportation Plan"* PSA and "*How to Use Find a Ride Florida"* PSA.

5.3 Criteria to Recommend Specific Outreach Activities

This section discusses the criteria used to recommend specific outreach activities at the target regions. Recommended outreach activities at the target regions are based on the existing outreach activities being conducted by the FDOT SMFL Coalition. General outreach activities were recommended at all target regions that meet the following criteria (termed as *base criteria*):

- Urban target regions with at least 6.2 total crashes involving aging road users per year per mile of the SHS roadway network.
- Rural target regions with at least 0.39 total crashes involving aging road users per year per mile of the SHS roadway network.

Note that these values were based on the 85th percentile of the total number of crashes involving aging road users per year per mile of the SHS roadway network and were used as the *base criteria*. Table 5-1 summarizes the specific outreach activities and the potential crash types (and categories) that could be reduced by each of the specific outreach activities.

Table 5-1: Crash Types That Could Potentially be Reduced by Specific Outreach Activities

Outreach Activity	Potential Crash Types That Could be Reduced
• Florida's Guide to Safe Mobility for Life • Families & Caregivers Brochure • How to Build a Transportation Plan PSA • Find a Ride Tip Card • You Hold the Keys Tip Card • You Hold the Keys PSA	• Total crashes involving aging road users
• Driver Medical Referral Visor Card • You Hold the Keys Tip Card • Keys to Achieve Safe Mobility for Life Workshop • You Hold the Keys PSA	• Crashes involving aging drivers
• CarFit Outreach Events • CarFit Tip Card	• Crashes involving aging drivers • Severe crashes
• Bicycling Booklet • Walking Booklet • Safe Walking for Life Workshop	• Crashes involving aging non-motorists
• Flashing Yellow Arrow Tip Card/Graphics	• Intersection-related crashes • Left-turn crashes
• Turning Right on Red Tip Card/Graphics	• Intersection-related crashes • Right-turn crashes
• Transit Ready Kit • Public Transit Brochure • Safe Transit for Life Workshop • Bicycling Booklet • Walking Booklet • Safe Walking for Life Workshop	• Crashes associated with bus stops

Note: All the outreach activities are expected to reduce the total crashes involving aging road users; PSA = public service announcement.

Table 5-1 (Cont'd): Crash Types That Could Potentially be Reduced by Specific Outreach Activities

Outreach Activity	Potential Crash Types That Could be Reduced
• How to Safely Navigate a Roundabout Tip Card/Graphics	• Roundabout-related crashes
• Wrong-Way Driving on the Interstate Tip Card/Graphics	• Wrong-Way Driving (WWD) crashes
• How to Use Find a Ride Florida PSA • Transportation Network Companies • Find a Ride Tip Card	• Crashes that are not associated with bus stops

Note: All the outreach activities are expected to reduce the total crashes involving aging road users; PSA = public service announcement.

In addition to the general outreach activities which were recommended at all urban and rural target regions that meet the base criteria of at least 6.2 and 0.39 total crashes per year per mile in urban and rural regions, respectively, specific outreach activities were recommended at the target regions with the following criteria:

- Higher proportion of crashes involving aging drivers
- Higher proportion of FS crashes
- At least one crash per year involving aging non-motorist
- Higher proportion of intersection-related crashes
- Higher proportion of roundabout-related crashes
- Higher bus stop density
- No or low bus stop density

The following subsections provide the details of the recommended outreach activities at the target regions.

5.3.1 All Target Regions

The following outreach activities are considered to have the potential for improving safety and mobility of aging road users at all target regions:

- Florida's Guide to Safe Mobility for Life
- Families & Caregivers Brochure
- How to Build a Transportation Plan PSA
- Find a Ride Tip Card
- You Hold the Keys Tip Card
- You Hold the Keys PSA

These six outreach activities have the information that applies to all aging road users, i.e., aging drivers and aging non-motorists and they may not affect a specific crash type. Therefore, these outreach activities were recommended at the target regions with a higher proportion of crashes involving aging road users. The distribution of these materials will help to improve the safety and mobility of all aging road users.

These outreach activities were recommended at 2,204 (out of 2,592) urban target regions and 162 (out of 190) rural target regions with the following criteria: (*Note: Total crash rate is based on only crashes involving aging road users*.)

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year

For rural areas:

- Total crash rate is at least 0.39 crashes per mile per year

5.3.2 Target Regions with Higher Proportion of Crashes Involving Aging Drivers

The following outreach activities are considered to have a greater potential for improving safety of aging drivers:

- Driver Medical Referral Visor Card
- You Hold the Keys Tip Card
- Keys to Achieve Safe Mobility for Life Workshop
- You Hold the Keys PSA

These four outreach activities have information that is more pertinent to aging drivers and are considered to affect crashes involving aging drivers. These outreach activities were therefore recommended at the target regions with a higher proportion of crashes involving aging drivers. The distribution of these materials is expected to improve the safety and mobility of aging drivers.

These outreach activities were recommended at 1,888 (out of 2,592) urban target regions and 141 (out of 190) rural target regions based on the following criteria: (*Note: Total crash rate is based on only crashes involving aging road users*.)

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year
- At least 79% of total crashes involve aging drivers

For rural areas:

- Total crash rate is at least 0.39 crashes per mile per year
- At least 77.4% of total crashes involve aging drivers

5.3.3 Target Regions with Higher Proportion of Crashes Involving Aging Drivers and FS Crashes

The following outreach activities are considered to have a potential for improving safety of aging drivers and reducing crash severity:

- CarFit Outreach Events
- CarFit Tip Card

These outreach activities have the information that helps aging drivers improve the fit of their vehicles for their safety and comfort. These are considered to reduce the frequency of crashes involving aging drivers and the severity of crashes involving aging road users. Therefore, these outreach activities were recommended at the target regions experiencing a higher number of crashes involving aging road users and at least one FS crash per year. The distribution of these materials is expected to improve the safety and mobility of aging drivers as well as reducing the severity of crashes involving aging road users.

These outreach activities were recommended at 217 (out of 2,592) urban target regions and 24 (out of 190) rural target regions based on the following criteria: (*Note: Total crash rate is based on only crashes involving aging road users*.)

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year
- At least 79% of total crashes involve aging drivers
- At least one FS crash per year

For rural areas:

- Total crash rate is at least 0.39 crashes per mile per year
- At least 77.4% of total crashes involve aging drivers
- At least one FS crash per year

5.3.4 Target Regions with Higher Proportion of Crashes Involving Aging Non-motorists

The following outreach activities are considered more beneficial for improving safety and mobility of aging non-motorists:

- Bicycling Booklet
- Walking Booklet
- Safe Walking for Life Workshop

Since these outreach activities have the information that helps aging non-motorist to explore their community on foot, they are considered to impact crashes involving aging non-motorists. Therefore, the distribution of these materials at the target regions experiencing a higher proportion of aging non-motorist crashes is expected to improve the safety and mobility of aging non-motorists.

These outreach activities were recommended at 385 (out of 2,592) urban target regions and 14 (out of 190) rural target regions based on the following criteria: (*Note: Total crash rate is based on only crashes involving aging road users*.)

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year
- At least one crash per year involving aging non-motorists

For rural areas:

- Total crash rate is at least 0.39 crashes per mile per year
- At least one crash per year involving aging non-motorists

5.3.5 Target Regions with Higher Proportion of Intersection-related Crashes

The following outreach activities are considered to have a potential for improving intersection safety:

- Flashing Yellow Arrow Tip Card/Graphics
- Turning Right on Red Tip Card/Graphics

These outreach activities have the information that will help aging road users understand how to safely navigate the signalized intersections, and are considered to have more impact on intersection-related crashes. Therefore, distributing these materials at target regions with a higher proportion of intersection-related crashes will improve the safety of the aging road users at signalized intersections.

Flashing Yellow Arrow Tip Card/Graphics was recommended at 1,110 (out of 2,592) urban target regions and 82 (out of 190) rural target regions with the following criteria: (*Note: Total crash rate is based on only crashes involving aging road users*.)

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year
- At least 23.7% of total crashes are intersection-related
- At least 5.1% of total crashes are left-turn crashes
- At least one signalized intersection

For rural areas:

- Total crash rate is at least 0.39 crashes per mile per year
- At least 31.3% of total crashes are intersection-related
- At least 4.4% of total crashes are left-turn crashes
- At least one signalized intersection

Turning Right on Red Tip Card/Graphics was recommended at 516 (out of 2,592) urban target regions and 64 (out of 190) rural target regions with the following criteria: (*Note: Total crash rate is based on only crashes involving aging road users*.)

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year
- At least 23.7% of total crashes are intersection-related
- At least one right-turn crash per year
- At least one signalized intersection

For rural areas:

- Total crash rate is at least 0.39 crashes per mile per year
- At least 31.3% of total crashes are intersection-related
- At least one right-turn crash per year
- At least one signalized intersection

5.3.6 Target Regions with Higher Bus Stop Density

The following outreach activities are considered to have a potential for improving safety and mobility of transit users:

- Transit Ready Kit
- Public Transit Brochure
- Safe Transit for Life Workshop
- Bicycling Booklet
- Walking Booklet
- Safe Walking for Life Workshop

The transit-related outreach activities (i.e., Transit Ready Kit, Public Transit Brochure, and Safe Transit for Life Workshop) provide road users with tips for riding transit and information that promotes the use of public transportation among aging road users. Since areas with higher bus stop density may also include non-motorists activities it is also important to provide outreach activities related to aging non-motorists such as Bicycling Booklet, Walking Booklet, and Safe Walking for Life Workshop. These outreach activities are expected to improve the safety of aging road users in areas with a higher density of bus stops.

These outreach activities were recommended at 1,971 (out of 2,592) urban target regions and 2 (out of 190) rural target regions with the following criteria: (*Note: Total crash rate is based on only crashes involving aging road users*.)

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year
- At least 1.16 bus stops per mile

For rural areas:

- Total crash rate is at least 0.39 crashes per mile per year
- At least one bus stop

5.3.7 Target Regions with Higher Proportion of Roundabout-related Crashes

How to Safely Navigate a Roundabout Tip Card/Graphics is considered to improve the safety and mobility of aging road users when using the roundabout. This tip card is expected to reduce roundabout-related crashes. This outreach activity was recommended at 34 (out of 2,592) urban target regions and 0 (out of 190) rural target regions with the following criteria: (*Note: Total crash rate is based on only crashes involving aging road users*.)

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year
- At least one roundabout-related crash per year

For rural areas:

- Total crash rate is at least 0.39 crashes per mile per year
- At least one roundabout-related crash per year

5.3.8 Target Regions with No or Low Bus Stop Density

The following outreach activities are considered to have a potential for improving safety and mobility of aging road users:

- How to Use Find a Ride Florida PSA
- Transportation Network Companies
- Find a Ride Tip Card

These outreach activities provide the information that helps road users to find all the transportation options available in the community and use TNCs, also known as ride-sourcing companies. These outreach activities may be beneficial to the areas with a lower density of bus stops.

These outreach activities were therefore recommended at 94 (out of 2,592) urban target regions and 160 (out of 190) rural target regions with the following criteria: (*Note: Total crash rate is based on only crashes involving aging road users*.)

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year
- Up to 1.16 bus stops per mile

For rural areas:

- Total crash rate is at least 0.39 crashes per mile per year
- No bus stop

5.4 Summary

This chapter focused on the detailed review of the outreach activities being conducted by the FDOT SMFL Coalition and recommends specific outreach activities at the target regions.

In summary, the existing outreach activities being conducted by the FDOT SMFL Coalition include:

- Distribution of Educational Materials:
  - Florida’s Guide to Safe Mobility for Life
  - Driver Medical Referral Visor Card
  - Families & Caregivers Brochure
  - You Hold the Keys Tip Card

- How to Choose Your Lifelong Community Checklist
  - How to Use Find a Ride Florida Tip Card
  - Transit Ready Kit
  - CarFit Tip Card
  - Tips on How to Use Transportation Options in Florida Series:
    - Bicycling Booklet
    - Public Transit Brochure
    - Walking Booklet
    - Transportation Network Companies
    - Golf Carts
  - Roadway Safety Tip Cards Series:
    - Flashing Yellow Arrow Tip Card:
    - How to Safely Navigate a Roundabout Tip Card
    - Turning Right on Red Tip Card
    - Wrong-Way Driving on the Interstate Tip Card
  - Roadway Safety Graphics:
    - Flashing Yellow Arrow
    - Roundabouts
    - Rectangular Rapid Flashing Beacons
    - Wrong-Way Driving
    - Turning Right on Red

- Safe Mobility for Life Outreach Event:
  - Keys to Achieve Safe Mobility for Life Workshop
  - Safe Transit for Life Workshop
  - Safe Bicycling for Life Workshop
  - Safe Walking for Life Workshop

- Public Service Announcements (PSAs)
  - How to Build a Transportation Plan PSA
  - You Hold the Keys PSA
  - How to Use Find a Ride Florida PSA

Table 5-2 provides a summary of the recommended specific outreach activities at the target regions.

Table 5-2: Recommended Specific Outreach Activities at the Target Regions

Criteria	Outreach Activities
All Target Regions	• Florida's Guide to Safe Mobility for Life • Families & Caregivers Brochure • How to Build a Transportation Plan PSA • Find a Ride Tip Card • You Hold the Keys Tip Card • You Hold the Keys PSA
Target Regions with Higher Proportion of Crashes Involving Aging Drivers	• Driver Medical Referral Visor Card • You Hold the Keys Tip Card • Keys to Achieve Safe Mobility for Life Workshop • You Hold the Keys PSA
Target Regions with Higher Proportion of Crashes Involving Aging Drivers and FS Crashes	• CarFit Outreach Events • CarFit Tip Card
Target Regions with Higher Proportion of Crashes Involving Aging Non-motorists	• Bicycling Booklet • Walking Booklet • Safe Walking for Life Workshop
Target Regions with Higher Proportion of Intersection-related Crashes and Left Turn Crashes	• Flashing Yellow Arrow Tip Card/Graphics
Target Regions with Higher Proportion of Intersection-related Crashes and Right Turn Crashes	• Turning Right on Red Tip Card/Graphics
Target Regions with Higher Bus Stop Density	• Transit Ready Kit • Public Transit Brochure • Bicycling Booklet • Walking Booklet • Safe Walking for Life Workshop
Target Regions with Higher Proportion of Roundabout-related Crashes	• How to Safely Navigate a Roundabout Tip Card/Graphics
Target Regions Associated with WWD Crashes	• Wrong-Way Driving on the Interstate Tip Card/Graphics
Target Regions with No or Lower Bus stop Density	• How to Use Find a Ride Florida PSA • Transportation Network Companies • Find a Ride Tip Card

Note: FS = fatal and serious injury; PSA = public service announcement; WWD = wrong-way driving.

Table 5-3 presents a summary of the recommended outreach activities along with the number of the target regions per specific outreach activities at both urban and rural target regions.

Table 5-3: Summary of Recommended Outreach Activities at the Target Regions

Outreach Activities	Urban Target Regions No. of CBGs	Urban Target Regions Area (sq. mi.)	Rural Target Regions No. of CBGs	Rural Target Regions Area (sq. mi.)
Florida's Guide to Safe Mobility for Life	2,204	757.74	162	752.52
Families & Caregivers Brochure	2,204	757.74	162	752.52
Find a Ride Tip Card	2,204	757.74	162	752.52
How to Build a Transportation Plan PSA	2,204	757.74	162	752.52
Driver Medical Referral Visor Card	1,888	683.44	141	711.98
You Hold the Keys Tip Card	1,888	683.44	141	711.98
Keys to Achieve Safe Mobility for Life Workshop	1,888	683.44	141	711.98
You Hold the Keys PSA	1,888	683.44	141	711.98
CarFit Outreach Events	217	130.33	24	151.99
CarFit Tip Card	217	130.33	24	151.99
Bicycling Booklet	385	170.08	14	38.71
Walking Booklet	385	170.08	14	38.71
Safe Walking for Life Workshop	385	170.08	14	38.71
Flashing Yellow Arrow Tip Card/Graphics	1,110	378.48	82	424.14
Turning Right on Red Tip Card/Graphics	516	224.57	64	352.53
Transit Ready Kit	1,971	630.74	2	4.8
Public Transit Brochure	1,971	630.74	2	4.8
How to Safely Navigate a Roundabout Tip Card/Graphics	34	10.97	0	0
How to Use Find a Ride Florida PSA	1,829	697.01	160	747.72
Transportation Network Companies	1,829	697.01	160	747.72
Total	**2,592**	**987.53**	**190**	**1,989.82**

Note: CBG = census block group; PSA = public service announcement; sq. mi. = square miles.

CHAPTER 6
IMPACT OF OUTREACH ACTIVITIES

This chapter focuses on the approaches to quantify the impact of outreach activities. It presents a detailed review of the existing approaches used to evaluate the impact of outreach activities. It also discusses the procedures to quantify the impact of outreach activities at the target regions.

6.1 Existing Approaches

Outreach activities are a well-recognized component of a safety program in the transportation system and other disciplines. The outreach program has been widely used to engage a large audience and to bring knowledge and expertise on a particular topic to the public. These outreach activities have been recognized as one of the strategies to reduce traffic crashes for all road users (Riaz et al., 2019). The outreach programs have proven to be crucial in educating road users, especially vulnerable population groups, including the aging population, about safe transportation practices. Understanding and quantifying the impact of these programs is essential to establishing whether interventions that have been implemented were effective at improving the safety of road users. Also, understanding their impact will help refine the activities and substantiate investing in such programs. The outcome of the program's evaluation is influenced by the techniques used to conduct such evaluations. Generally, the following two approaches were used in evaluating the outreach programs: process evaluation and outcome evaluation.

Process Evaluation

This type of evaluation determines whether the program activities have been implemented as intended and resulted in certain outputs. Also, it provides a better understanding of how valuable the content is and how effectively the program was delivered. It requires an understanding of what is supposed to happen during a program and a systematic approach to tracking what happens (Pulllen-Seufert & Hall, 2008). Data needed to conduct the *process evaluation* depends on the program's goals and objectives. Some of the data required may include:

- number and type of outreach activities/events conducted,
- number and type of educational materials distributed,
- the cost of running the outreach programs,
- number and demographic of individuals/groups attending the outreach program,
- number of resources developed and information provided, and
- number of visitors, page views, and resources accessed on the website.

For the *process evaluation* approach, the effectiveness of the outreach program can be assessed based on how the program works in practice through:

- assessing the management of the program in terms of delivery and cost-efficiency,
- assessing staffing requirements, and the training of program staff,
- examining how and to what extent the program was implemented,
- investigating to what extent the target group was reached,
- assessing the acceptability of the program to the target group, or

- assessing the efficiency of the method of program delivery.

Outcome Evaluation

The *outcome evaluation* measures the program's effects on the target population by assessing the progress in the outcomes that the program is to address. This type of evaluation determines whether the outreach program implemented has made a difference in a target group in terms of crash reduction or any other related measures. For example, how changes in behavior, attitudes, knowledge, or skills obtained from the outreach program helped road users to improve safety through the reduction in the number of crashes and crash causality. The data required to conduct the *outcome evaluation* depends on the program's goals and objectives. Some of the data needed may include:

- crash data,
- information on the program implementation date,
- areas where the program was implemented,
- type of program implemented, and
- information on the program's target group.

Note that the *outcome evaluation* should be specific and reflect the program's goals and objectives. For example, an evaluation of a "*Flashing Yellow Arrow"* tip card that educates road users on what to do when they see flashing yellow arrows at signalized intersections would measure road users' ability to safely turn left at the signalized intersection. Therefore, the outcome would be the reduction of intersection-related crashes, especially left-turn crashes.

The objective of this research was to evaluate how aging road users benefit from the outreach activities through a reduction in aging road users' fatalities and serious injuries. Several approaches have been used to quantify the impact of the outreach activities, including before-after evaluation, survey, and media exposure. These approaches are discussed in the following sections.

6.1.1 Before-after Evaluation

Before-after evaluation is the common approach normally used to quantify the impact of any safety improvement program. Before-after evaluation includes the following commonly used approaches:

- Simple before-after evaluation
- Before-after evaluation with a control group

Simple Before-after Evaluation

In this approach, the outcomes before the program implementation are determined and compared to the outcomes measured afterward. The difference in the results of the two groups is usually attributed to the impact of the program. However, events other than those being investigated may also affect the outcome of the program. For example, the results of an evaluation of a speed enforcement program could be confounded by the highway department making engineering changes in the same areas as the enforcement efforts. Therefore, the outcome cannot be reflected as the impact of the implemented program alone.

Before-after Evaluation with a Control Group

This approach assesses the program's impacts by comparing the group that receives outreach programs with an equivalent group that does not. The group that receives the outreach program is the "treatment" or "experimental" group and the other group is the "control" or "comparison" group. In this approach, both groups are tested before the program intervention and after it has been delivered. The before measure is used to obtain a baseline measure and to demonstrate the equivalence of the groups before the program implementation. The analysis of the after data should then show whether there has been any change in both groups and whether the change in the experimental group is significantly different from the change in the control group. This approach accounts for the effect of other changes that may occur between the two assessment periods.

Previous Studies on Before-after Evaluation

Several studies used before-after evaluation to quantify the impact of outreach activities (Dunckel et al., 2014; Gelinne et al., 2017; Natarajan et al., 2008; Ragland et al., 2003; Sandt et al., 2016; Van Houten et al., 2013; Van Houten & Malenfant, 2004). Dunckel et al. (2014) used the data-driven approach to quantify the impact of the deployed outreach activities in Montgomery County, Maryland. Ragland et al. (2003) used surrogate evaluation measures to assess the impact of the deployed countermeasures in San Francisco, California. The study used video-recorded observations of pedestrian and driver behavior (e.g., pedestrian/vehicle conflicts and pedestrian crossing time) and intercept surveys of pedestrians at study intersections. Van Houten et al. (2013) examined the effects of a one-year high-visibility pedestrian right-of-way enforcement program on yielding to pedestrians at uncontrolled crosswalks in the City of Gainesville, Florida. The evaluation involved some areas that received enforcement and those that did not receive enforcement.

Sandt et al. (2016) used a pre-post design with a comparison group to examine the effect of high-visibility enforcement activities and low-cost engineering treatment components of the *"Watch for Me NC"* intervention. *Watch for Me NC* is a multi-faceted, community-based pedestrian safety program that includes widespread media and public engagement in combination with enhanced law enforcement activities (Sandt et al., 2016). Van Houten & Malenfant (2004) used the multiple baseline design to determine the effectiveness of the enforcement component of the *Courtesy Promotes Safety* program in increasing drivers yielding to the pedestrians, and changes in yielding behavior produced by enforcement at uncontrolled crosswalks and untreated crosswalks controlled by traffic signals.

The SMFL Coalition has been conducting a simple before-after evaluation to assess the impact of outreach activities. The Coalition uses crash data involving aging road users to determine if the outreach activities have resulted in fewer fatalities and serious injuries involving aging road users.

6.1.2 Survey

Surveys are tools used to collect quantitative and qualitative data on participant knowledge, behavior, or impressions before, during, and after the program. These data are usually collected in the form of questionnaires. Questionnaires are also useful for collecting demographic information about participants such as age, gender, and ethnicity. Surveys are useful in a formative evaluation to collect baseline data on the knowledge, attitudes, and behavior of the target population group. They contain a fixed set of questions often with a fixed set of answers. A survey must be well planned to collect the desired information since data gathered from a survey is limited to the questions and answers. Different studies have used the survey approach to examine the impact of an outreach program. For example, Riaz et al. (2019) used the survey to evaluate the road safety education program *"Traffic Weeks"* among higher secondary school students in Belgium. The study explored whether the program affects socio-cognitive variables using a questionnaire based on the theory of planned behavior.

Moreover, the SMFL Coalition conducted several surveys to gain a better understanding of safety and mobility issues faced by the aging population including their attitude towards driving. One survey on transitioning from driving found that only 15% of respondents were preparing for the time when they could no longer drive. This information helped the Coalition to develop materials and resources to address the needs and bring awareness to these important issues (FDOT, 2017).

6.1.3 Media Exposure

This evaluation strategy involves designing an effective media outreach strategy and collecting useful media exposure data. The outcome of the media exposure depends on the amount and type of media coverage and audience awareness. Also, tracking the types of outreach activities, amount of exposure (i.e., audience size), costs, and interest generated can be correlated with behavioral changes to determine the impact of outreach activities. For example, the Coalition has been tracking the number of visitors, page views, and resources accessed on the Coalition’s website to determine the impact of outreach activities.

6.2 Performance Measures for Before-After Evaluation

Performance measures are normally used to determine the effectiveness of any deployed program or countermeasure. In this research project, crashes involving aging road users were used as the performance measure that can be used to quantify the impact of outreach activities. Specifically, crash frequency involving aging road users and the number of aging FS were used. Since specific outreach activities were recommended at the specific target regions based on certain criteria, the performance measures may differ depending on the goal and objective of the specific outreach activities. For example, the impact of "*How to Safely Navigate a Roundabout"* tip card would be determined through a reduction in roundabout-related crashes involving aging road users since the card intends to educate aging road users on how to safely navigate the roundabout.

Currently, the Coalition uses the number of fatalities and serious injuries involving aging road users as the performance measure to assess the effectiveness of the outreach activities. However, to capture the effectiveness of each specific outreach activity, it is important to use specific performance measures for each specific outreach activity at a specific target region. Table 6-1 presents the performance measures for each recommended specific outreach activity currently being conducted by the SMFL Coalition. Performance measures were grouped into several categories depending on the type of the recommended outreach activities at the target regions. These performance measures include:

- Crash frequency involving aging road users
- Number of FS crashes involving aging road users
- Crash frequency involving aging drivers
- Number of FS crashes involving aging drivers
- Crash frequency involving aging non-motorists
- Number of FS crashes involving aging non-motorists
- Number of intersection-related crashes involving aging road users
- Number of roundabout-related crashes involving aging road users
- Number of wrong-way driving (WWD) crashes involving aging road users

In this case, the outreach activities are considered effective if they meet the program's goals and objectives that include the reduction in the crash frequency involving aging road users and the number of FS crashes involving aging road users. The crash data involving aging road users before and after the implementation of the outreach activities can be collected, processed, analyzed, and compared. For the outreach activity to be effective, target crashes (as listed in Table 6-1) following the implementation of the outreach activities (i.e., during the after-period) should be less than the target crashes prior to the deployment of the outreach activities (i.e., during the before-period).

Table 6-1: Performance Measures for Recommended Specific Outreach Activities

Criteria	Outreach Activities	Performance Measures
All Target Regions	• Florida's Guide to Safe Mobility for Life • Families & Caregivers Brochure • How to Build a Transportation Plan PSA • Find a Ride Tip Card • You Hold the Keys Tip Card • You Hold the Keys PSA	• Crash Frequency Involving Aging Road Users • Number of FS Crashes Involving Aging Road Users
Target Regions with Higher Bus Stop Density	• Transit Ready Kit • Public Transit Brochure • Safe Transit for Life Workshop • Bicycling Booklet • Walking Booklet • Safe Walking for Life Workshop	• Crash Frequency Involving Aging Non-motorists • Number of FS Crashes Involving Aging Non-motorists
Target Regions with No or Lower Bus Stop Density	• How to Use Find a Ride Florida PSA • Transportation Network Companies • Find a Ride Tip Card	• Crash Frequency Involving Aging Road Users • Number of FS Crashes Involving Aging Road Users
Target Regions with Higher Proportion of Crashes Involving Aging Drivers	• Driver Medical Referral Visor Card • You Hold the Keys Tip Card • Keys to Achieve Safe Mobility for Life Workshop • You Hold the Keys PSA	• Crash Frequency Involving Aging Drivers • Number of FS Crashes Involving Aging Drivers

Note: FS = fatal and serious injury; PSA = public service announcement; WWD = wrong-way driving.

Table 6-1: Performance Measures for Recommended Specific Outreach Activities (continued)

Criteria	Outreach Activities	Performance Measures
Target Regions with Higher Proportion of Crashes Involving Aging Drivers and FS Crashes	• CarFit Outreach Events • CarFit Tip Card	• Crash Frequency Involving Aging Drivers • Number of FS Crashes Involving Aging Drivers
Target Regions with Higher Proportion of Crashes Involving Aging Non-motorists	• Bicycling Booklet • Walking Booklet • Safe Walking for Life Workshop	• Crash Frequency Involving Aging Non-motorists • Number of FS Crashes Involving Aging Non-motorists
Target Regions with Higher Proportion of Intersection-related Crashes and Left Turn Crashes	• Flashing Yellow Arrow Tip Card/Graphics	• Number of Intersection-related Crashes Involving Aging Road Users
Target Regions with Higher Proportion of Intersection-related Crashes and Right Turn Crashes	• Turning Right on Red Tip Card/Graphics	• Number of Intersection-related Crashes Involving Aging Road Users
Target Regions with Higher Proportion of Roundabout-related Crashes	• How to Safely Navigate a Roundabout Tip Card/Graphics	• Number of Roundabout-related Crashes Involving Aging Road Users
Target Regions Associated with WWD Crashes	• Wrong-Way Driving on the Interstate Tip Card/Graphics	• Number of WWD Crashes Involving Aging Road Users

Note: FS = fatal and serious injury; PSA = public service announcement; WWD = wrong-way driving.

6.3 Approach to Quantify the Impact of Outreach Activities

Program evaluations are crucial in safety analysis as they help agencies determine a program's impact and identify potential areas for improvement. The main focus of the program evaluations include:

- Measure performance of the program
- Understand and justify the program's effectiveness
- Understand the return on investment
- Improve the effectiveness of future decisions
- Improve the program delivery or outcome
- Provide a basis for policy or regulations
- Validate expansion and justify the need for funding
- Understand the strengths and weaknesses of the program

The design of a program evaluation is highly dependent on the program's characteristics, goals, and objectives. Even though evaluating the impact of outreach activities is very important, it is difficult compared to evaluating the traditional engineering-related safety countermeasures. This research provides the step-by-step procedures that can be used to quantify the impact of the outreach activities. Selecting the appropriate evaluation tools will help agencies estimate the program's impact and identify potential areas for improvement. Based on the selected performance measure, i.e., the number of crashes involving aging road users, the *simple before-after evaluation* method was recommended to quantify the impact of outreach activities at the target regions.

The step-by-step procedures for conducting a simple before-after evaluation for quantifying the impact of the outreach activities at the target regions are discussed in the following section. The recommended method can also be enhanced by using the before-after evaluation with a control group. The before-after evaluation with a control group accounts for the effect of other changes that may occur between the two assessment periods.

6.4 Procedures to Quantify the Impact of Outreach Activities

Figure 6-1 provides the step-by-step procedure used to quantify the impact of outreach activities at the target regions, as adapted from Sentinella (2004). These steps are further discussed in the following sections.

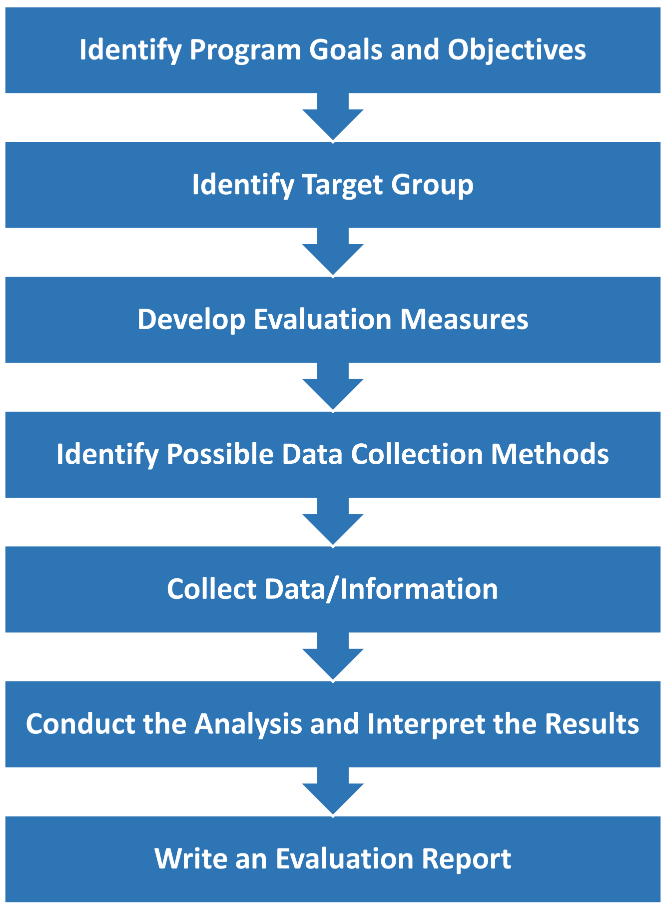


Figure 6-1: Evaluation Procedure

6.4.1 Identify Program Goals and Objectives

Since an evaluation of the program measures the extent to which the SMFL Coalition has met its goals and objectives, the first step is to identify the goals and objectives of the program. A goal is a general statement about the desired outcome of the program. For example, in this project, the goal is to improve the safety and mobility of the aging population. An objective serves as the measurable outcome of the program that relates to the goal of the project. For instance, in this project, the objective is to reduce the number of fatal and serious injuries involving aging road users. Therefore, the outreach activities can be effective if they meet the stated goals and objectives.

6.4.2 Identify Target Group

Based on the defined program goals and objectives, it is important to identify the target group intended to receive the program interventions. This will help determine whether the program has any effects on the targeted group in terms of achieving the program's goals and objectives. As stated earlier, in this project the aging road users are the target group. As defined in Florida's ARUSSP, aging road users include drivers, transit riders, motorcyclists, passengers, operators of non-motorized vehicles, bicyclists, and pedestrians over age 50, with a special focus on the 65 years and older age groups (FDOT, 2017).

6.4.3 Develop Evaluation Measures

The Safe Mobility for Life Program's evaluation can be enhanced by evaluating two different measures: process measures and outcome measures.

Process Measures: These include the suitability of the materials for the target group, the acceptability of the deliverers of the program to the target group, participants' opinions about the program, and participants' satisfaction with the program. It can also measure the way the program was used and received by the participants (FDOT, 2017; Sentinella, 2004).

Outcome Measures: These measures the overall impact of the program in improving the safety of road users. The improvement can be measured through the reduction in road casualty or crash rates. A reduction in casualty or crash rates may be anticipated from behavior change, i.e., road users will behave more safely as a result of the outreach program. Outcome measures are normally measured against a baseline, the existing level of safe behavior, attitudes, knowledge, or skills before the program is implemented. The amount of change after the implementation of the program was measured against this baseline. Baseline information can also include local context data to describe what the conditions are in the area where the intervention is being implemented, such as the demographics of the area, the type of environment, and the existing engineering and enforcement countermeasures. Outcome measures require a large sample over a long period to find a statistically significant reduction in crash or casualty rates (Sentinella, 2004).

The evaluation methods depend on the availability of the data and resources needed to carry out the evaluation and the program's goals and objectives. Since the objective of this project is to improve the safety and mobility of aging road users by reducing the number of crashes involving aging road users, the outcome evaluation method serves as the best method for this project.

6.4.4 Identify Possible Data Collection Methods

Data collection methods serve as the crucial step in quantifying the impact of outreach activities. These methods should balance what is the most desirable with what is feasible within the timescale and resources available. Both qualitative and quantitative data collection methods could be adopted, depending on the program's evaluation goals and objectives. In this project, because the focus is on the outcome measures (e.g., reduction in crashes involving aging road users), quantitative data collection methods serve as the best data collection approach.

Quantitative methods collect data expressed in terms of numbers and are normally used to examine whether the interventions have a detectable effect. For this research effort, to attain the stated objective, the quantitative data collection methodology before and after the implementation of the outreach activities serves as the suitable data collection method.

6.4.5 Collect Data

All necessary data before and after implementation of the outreach activities should be collected. Data that may be collected include crash data involving aging road users before and after the implementation of outreach activities. The following crash data variables need to be collected:

- Crash number
- Latitude and longitude of crash
- Crash date
- Crash severity
- Age of occupants, drivers, and non-motorists involved in crash
- Crash location (i.e., intersection-related, roundabout-related)
- Crash type
    - Left-turn crash
    - Right-turn crash
    - Pedestrian crash
    - Bicyclist crash
    - Wrong-way driving crash

6.4.6 Conduct the Analysis and Interpret the Results

Following data collection, processing, and analysis of the evaluation measures, the results need to be interpreted and placed into context. This means clarifying the original objectives of the evaluation and relating the findings to the theory behind the outreach activities. A statistical test should be conducted to test if there is a significant improvement in the safety of aging road users following the implementation of the outreach activities.

6.4.7 Write an Evaluation Report

The last step is to document the findings obtained from the evaluation. This step is very important as it provides a report on the performance of the program. It will also increase the understanding of the effectiveness of the program and help identify strategies to continually improve the program outcomes.

6.5 Summary

This chapter focused on the approaches to quantify the impact of outreach activities. It presented a detailed review of the existing approaches to evaluate the impact of outreach activities. It also provided the step-by-step procedures to quantify the impact of outreach activities at the target regions. In summary, the existing approaches used to quantify the impact of outreach activities include:

- Before-after Evaluation
    - Simple Before-after Evaluation
    - Before-after Evaluation with a Control Group
- Survey
- Media Exposure

Among the aforementioned approaches, before-after evaluation is the most commonly used approach and is often recommended to quantify the impact of outreach activities. The specific performance measures for before-after evaluation include:

- Crash frequency involving aging road users
- Number of FS crashes involving aging road users
- Crash frequency involving aging drivers
- Number of FS crashes involving aging drivers
- Crash frequency involving aging non-motorists
- Number of FS crashes involving aging non-motorists
- Number of intersection-related crashes involving aging road users
- Number of roundabout-related crashes involving aging road users
- Number of WWD crashes involving aging road users

Before-after evaluation is recommended to be used to quantify the impact of outreach activities at the target regions using the following step-by-step procedure:

- Step 1: Identify Program Goals and Objectives
- Step 2: Identify Target Group
- Step 3: Develop Evaluation Measures
- Step 4: Identify Possible Data Collection Methods
- Step 5: Collect Data/Information
- Step 6: Conduct the Analysis and Interpret the Results
- Step 7: Write an Evaluation Report

CHAPTER 7
PROCEDURE TO CONDUCT THE ANALYSIS ANNUALLY

The objective of this project is to develop a GIS-based approach to identify and prioritize target regions to conduct outreach activities to improve the safety and mobility of the aging population. Since the process of conducting outreach activities at the target regions to improve the safety and mobility of aging road users is not a one-time process, there is a need to develop procedures to repeat the analysis annually. As such, this chapter documents the step-by-step procedures to repeat the analysis annually. These procedures intend to provide support and guidance to transportation practitioners to repeat the analysis every year. The first section discusses the data required to identify and prioritize target regions. A step-by-step procedure for data processing is presented next. The third section documents the procedures to identify target regions and the last section provides the procedures to recommend outreach activities at the target regions.

7.1 Data

The following data are needed to identify and prioritize target regions that benefit the most from the outreach activities:

- Crash data
- Socioeconomic and demographic data
- Roadway geometric characteristics data
- Infrastructure-related data

Table 7-1 summarizes the data sources and variables along with their original and final data formats.

Table 7-1: Data Variables

Data	Variables	Source	Year	Original Format	Final Format
Crash data	• Crashes involving aging road users • Crashes involving aging non-motorists	• FLHSMV • Signal Four Analytics	2014-2018	Excel	Shapefile
Socioeconomic and demographic data	• Total population • Aging population • Median household income	• FGDL	2014-2018	Shapefile	Shapefile
Roadway geometric characteristics data	• Freeway roadway density • Non-freeway SHS roadway density	• FDOT's GIS shapefiles	2020	Shapefile	Shapefile
Infrastructure-related data	• Sidewalk proportion • Bus stop density	• FDOT's GIS shapefiles • FTDE	2020	Shapefile	Shapefile

Note: FDOT = Florida Department of Transportation; FGDL = Florida Geographic Data Library; FLHSMV = Florida Department of Highway Safety and Motor Vehicles; FTDE = Florida Transit Data Exchange; GIS = Geographic Information System; Note: SHS = State Highway System.

7.1.1 Crash Data

Crash data involving aging road users for the most recent five years are required. These data can be requested from the FLHSMV. Since crash data from FLHSMV does not include latitudes and longitudes of crashes, the specific crash coordinates need to be extracted from the Signal Four Analytics database. The analysis is spatially conducted at the macroscopic level with CBGs as the unit of analysis. Thus, crash frequency, crash severity, and other variables are aggregated at the CBGs level. Use the following steps to aggregate crashes involving aging road users at each CBGs.

- Generate Crash Shapefiles: generate crash shapefile by importing crashes involving aging road users in ArcGIS and exporting it in shapefile (.shp) format.

- Assign Crashes Involving Aging Road Users to Each CBG: use *Spatial Join* under *Overlay* in the *Analysis Tools* to assign crashes involving aging road users to each CBG. Specify the search radius of 150 ft, as shown in Figure 7-1:

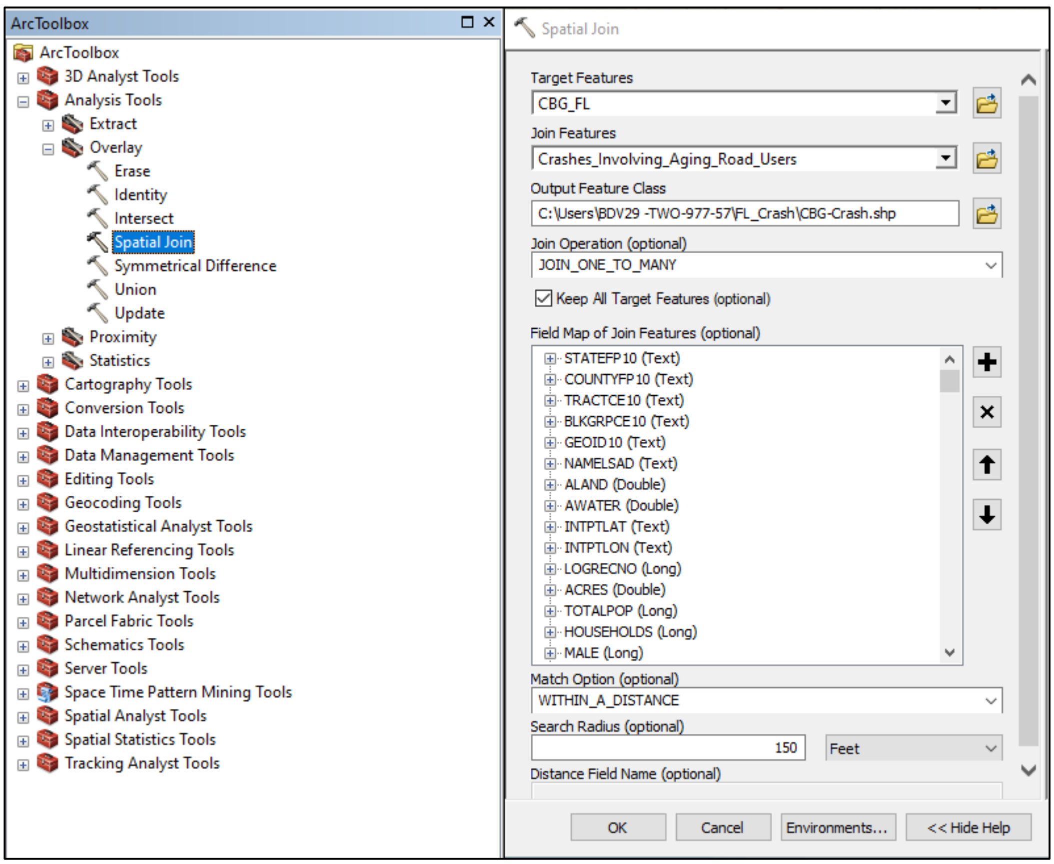


Figure 7-1: Assign Crashes to CBGs

7.1.2 Roadway Geometric Characteristics Data

Use the most recent FDOT GIS shapefiles to extract the following roadway geometric characteristics data.

- Freeway roadway miles
- Non-freeway SHS roadway miles

Use the following steps to extract the miles of SHS roadway network within CBG:

Step 1: Generate an Individual Shapefile for Each CBG

The file obtained from the FGDL includes the data on a total of 11,442 CBGs. Use the *Split* function under *Extract* in the *Analysis Tools* to generate an individual shapefile for each CBG. Use the following specifications, as shown in Figure 7-2:

- Input Features: CBG
- Split Features: CBG
- Split Field: GEOID10

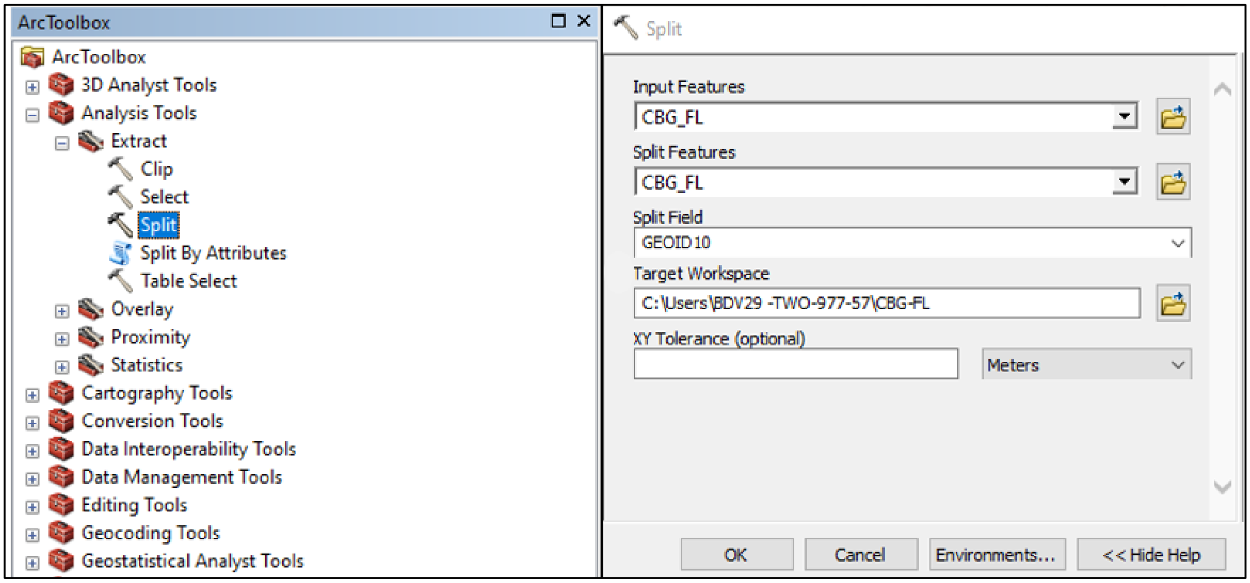


Figure 7-2: Generate an Individual Shapefile for each CBG

Step 2: Extract Roadway Miles within CBG

Use the *ModelBuilder* to build a model that will *create* a graphic buffer, *clip* roadway within the CBG, and *measure* the roadway miles within each of the 11,442 CBGs. Make sure to check the *Recursive* tab when specifying the input features to iterate the process for all 11,442 CBGs, as shown in Figure 7-3. Use the following specifications:

- Workspace or Feature Dataset: Specify the workspace which stores feature classes to iterate
- Check the *Recursive* tab

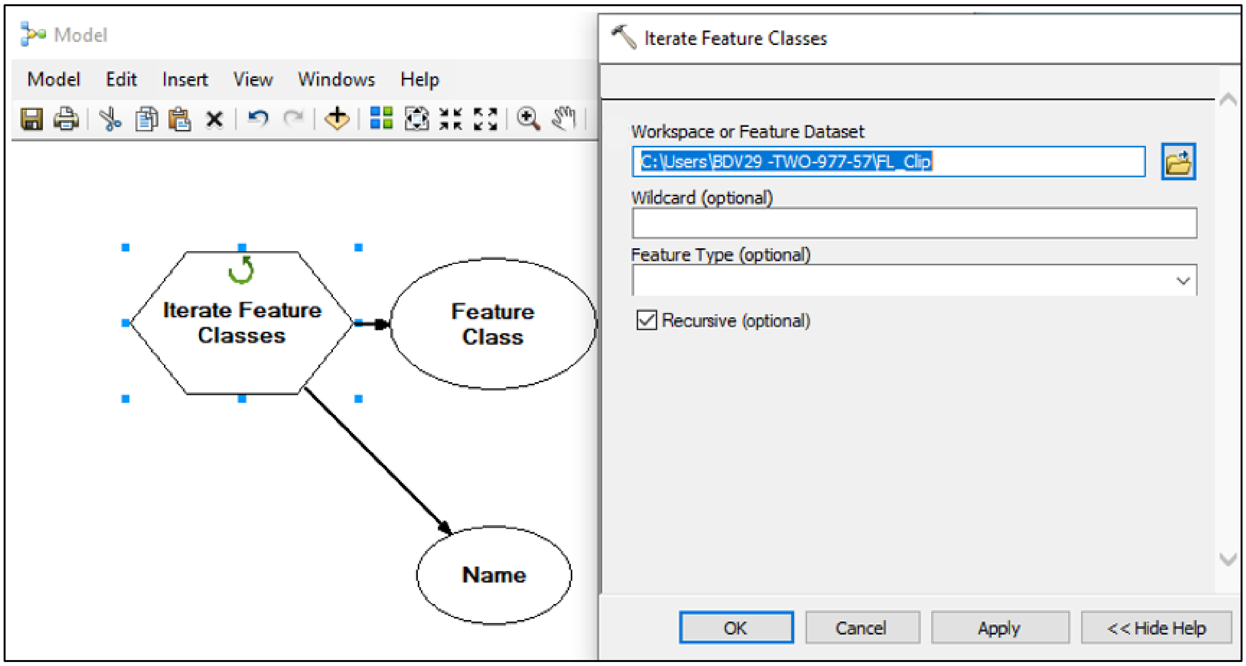


Figure 7-3: Specify Input Feature Classes for ModelBuilder

Note: Specify CBGs from ***Step 1*** as the input features for the *Graphic Buffer*, the graphic buffer output as the input features for *Clip*, and the clip output as the input features for the *Add Geometry Attributes*, as shown in Figure 7-4.

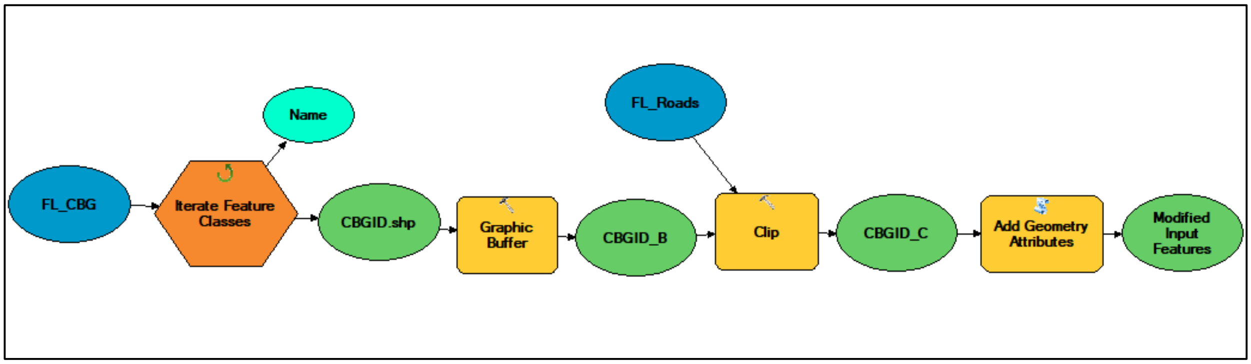


Figure 7-4: Model to Extract Roadway Miles within CBG

Use the following specifications when building the model:

- *Graphic Buffer* specifications, as shown in Figure 7-5:
  - Input Features: CBGID (obtained from ***Step 1***)
  - Output Feature Class: Workspace which stores feature classes to iterate and used in the next process, i.e., *Clip*
  - Check linear unit and specify 150 ft.

- *Clip* specifications, as shown in Figure 7-6:
  - Input Features: CBGID_B (graphic buffer output)
  - Clip Features: Roads

- Output Feature Class: Workspace which stores feature classes to iterate and used in the next process, i.e., *Add Geometry Attributes*

- *Add Geometry Attributes* specifications, as shown in Figure 7-7:
  - Input Features: CBGID_C (clip output)
  - Geometry Properties: Check LENGTH
  - Length unit: MILES_US

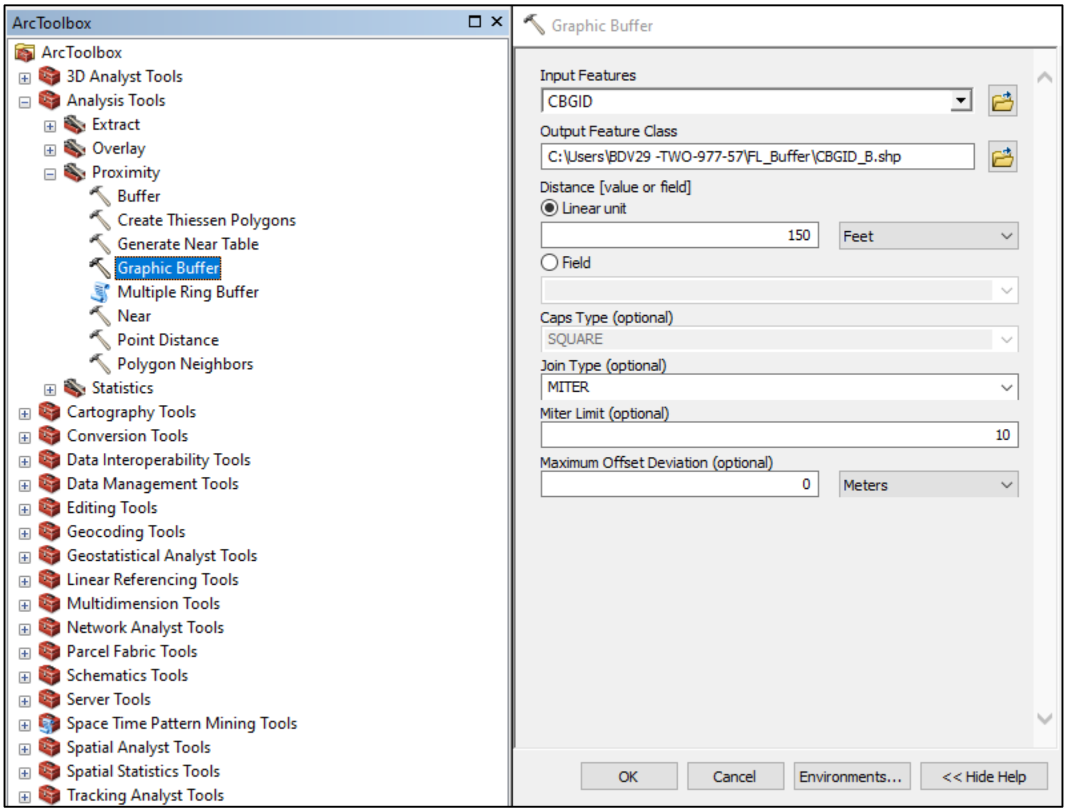


Figure 7-5: Graphic Buffer Specifications

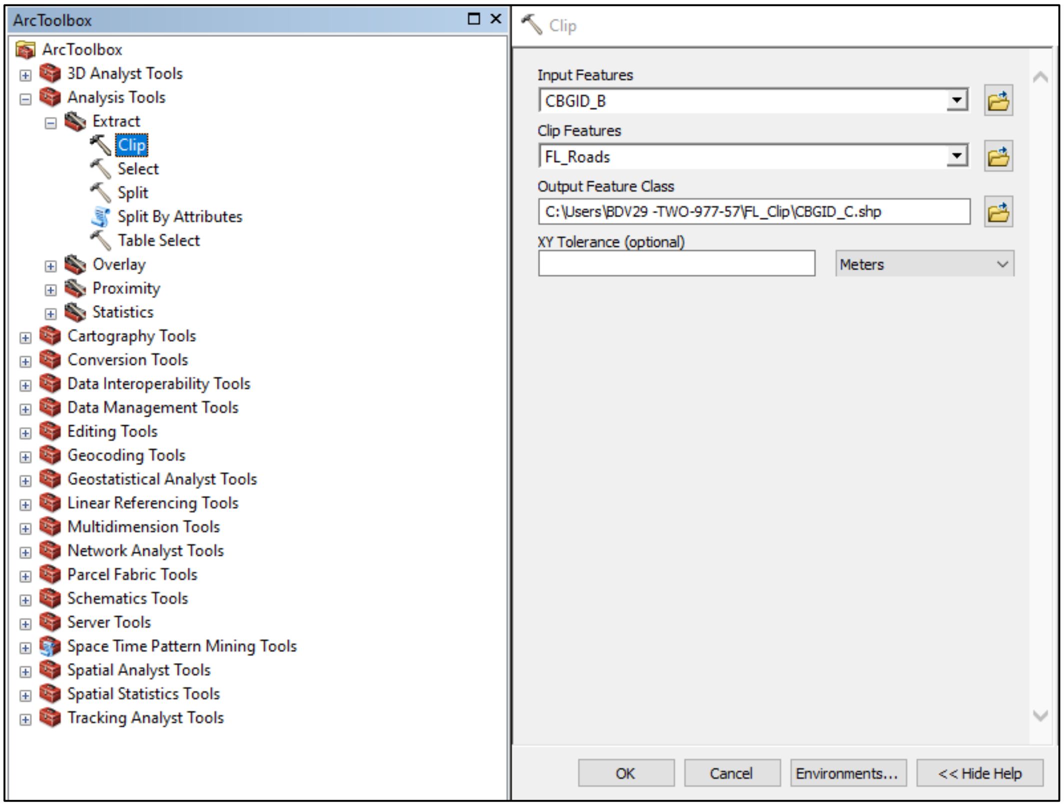


Figure 7-6: Clip Specifications

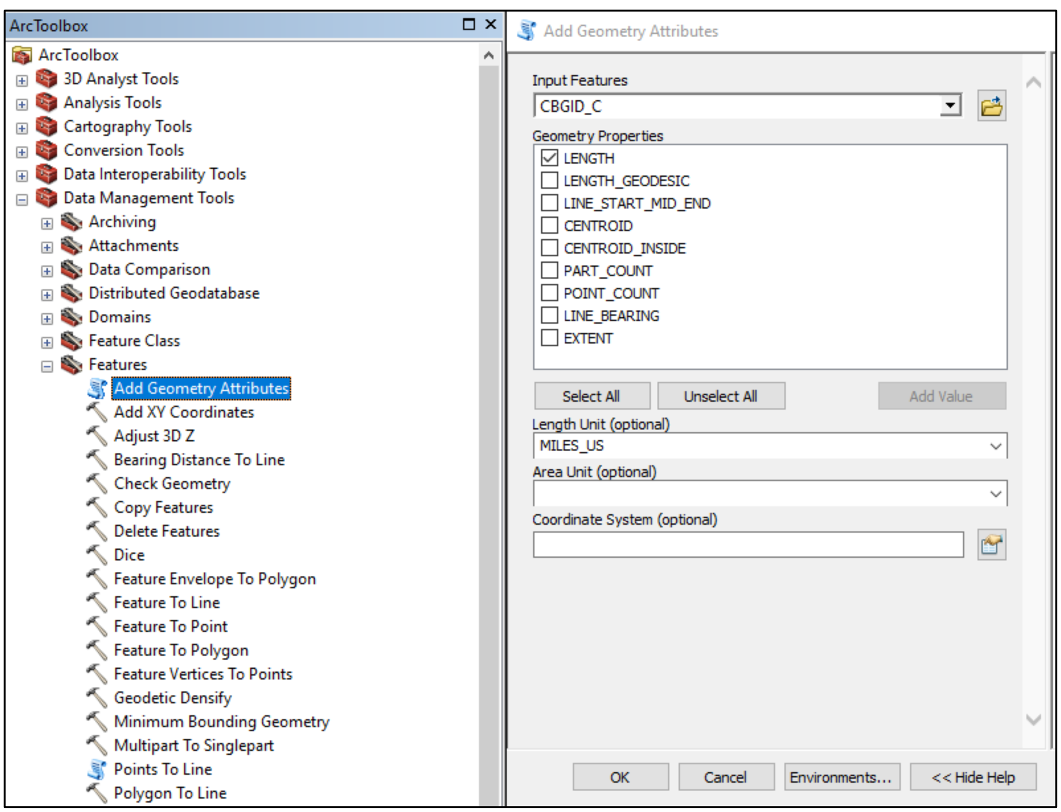


Figure 7-7: Add Geometry Attributes Specifications

Step 3: Determine the Freeway and Non-freeway SHS Miles within CBGs

Use *Functional Classification* codes 1, 2, 11 & 12 to extract miles of freeway roadways within CBGs. Similarly, use *Functional Classification* codes 4, 6, 7, 8, 9, 14, 16, 17, 18 & 19 to extract miles of non-freeway SHS roadways within CBGs. These codes are defined by FDOT, Transportation Data, and Analytics Office (FDOT, 2021a), and are provided in Figure 7-8.

Once the total miles of the freeway roadway network and the total miles of the non-freeway SHS roadway network are extracted, the total miles of the SHS roadway network within CBG is calculated by adding the total miles of the freeway roadway network and the non-freeway SHS roadway network within each CBG.

Attribute domain values

Value	***Definition***
01	Principal Arterial-Interstate - RURAL
	Definition Source: Florida Department of Transportation, Transportation Data & Analytics Office
02	Principal Arterial-Expressway - RURAL
	Definition Source: Florida Department of Transportation, Transportation Data & Analytics Office
04	Principal Arterial-Other - RURAL
	Definition Source: Florida Department of Transportation, Transportation Data & Analytics Office
06	Minor Arterial - RURAL
	Definition Source: Florida Department of Transportation, Transportation Data & Analytics Office
07	Major Collector - RURAL
	Definition Source: Florida Department of Transportation, Transportation Data & Analytics Office
08	Minor Collector - RURAL
	Definition Source: Florida Department of Transportation, Transportation Data & Analytics Office
09	Local - RURAL
	Definition Source: Florida Department of Transportation, Transportation Data & Analytics Office
11	Principal Arterial-Interstate - URBAN
	Definition Source: Florida Department of Transportation, Transportation Data & Analytics Office
12	Principal Arterial-Freeway and Expressway - URBAN
	Definition Source: Florida Department of Transportation, Transportation Data & Analytics Office
14	Principal Arterial-Other - URBAN
	Definition Source: Florida Department of Transportation, Transportation Data & Analytics Office
16	Minor Arterial - URBAN
	Definition Source: Florida Department of Transportation, Transportation Data & Analytics Office
17	Major Collector - URBAN
	Definition Source: Florida Department of Transportation, Transportation Data & Analytics Office
18	Minor Collector (Fed Aid) - URBAN
	Definition Source: Florida Department of Transportation, Transportation Data & Analytics Office
19	Local - URBAN
	Definition Source: Florida Department of Transportation, Transportation Data & Analytics Office

Attribute definition source: Florida Department of Transportation, Transportation Data & Analytics Office

Figure 7-8: Functional Classification Codes

7.1.3 Infrastructure-related Data

The infrastructure-related variables include bus stops and miles of sidewalk. Use the FTDE Portal of the FTIS to extract bus stop data. Use *Spatial Join* under *Overlay* in the *Analysis Tools* to assign bus stops to each CBG. Specify the search radius of 150 ft.

Use the most recent FDOT GIS shapefiles to extracted sidewalk data. This data needs to be pre-processed prior to importing into ArcGIS. The data preprocessing step should account for the sidewalk on one side while maintaining sidewalk continuity. Use similar steps as illustrated in ***Step 2*** to extract the sidewalk miles within each CBG.

7.1.4 Socioeconomic and Demographic Data

Use the 2015 FGDL with selected fields from the years 2014 through 2018 to extract the following variables:

- Total population
- Aging population
- Median household income

Note that these variables can be obtained directly for each CBG.

7.2 Data Processing

The data processing task includes the following steps:

- derive explanatory variables,
- derive response variables,
- identify urban and rural counties, and
- create polygon shapefiles for urban and rural CBGs.

7.2.1 Derive Explanatory Variables

Explanatory variables include:

- Total population density
- Median household income
- Aging proportion
- Freeway roadway density
- Non-freeway SHS roadway density
- Sidewalk proportion
- Bus stop density

Total population density refers to the total population within CBG per area of the CBG, as shown in Equation 7-1.

$$\frac{Total\ Population}{Area\ of\ CBG} \tag{7-1}$$

Median household income for each CBG can be used directly as reported in the CBGs data.

Aging proportion refers to the aging population within CBG per total population in the CBG, as shown in Equation 7-2.

$$\frac{Aging\ Population}{Total\ Population} \tag{7-2}$$

Freeway roadway density can be determined as the ratio of the total miles of the freeway roadway network within CBG to the area of the CBG, as shown in Equation 7-3.

$$\frac{Total\ Miles\ of\ Freeway\ Roadway\ Within\ CBG}{Area\ of\ CBG} \tag{7-3}$$

Non-freeway SHS *roadway density* can be determined as the ratio of the total miles of the non-freeway SHS roadway network within CBG to the area of the CBG, as shown in Equation 7-4.

$$\frac{Total\ Miles\ of\ Non-freeway\ SHS\ Roadway\ Within\ CBG}{Area\ of\ CBG} \tag{7-4}$$

Sidewalk proportion can be determined as the ratio of the total miles of the sidewalk within the CBG to the total miles of the non-freeway SHS roadway network within the CBG as shown in Equation 7-5.

$$\frac{Total\ Miles\ of\ Sidewalk\ Within\ CBG}{Total\ Miles\ of\ Non-freeway\ SHS\ Roadway\ Within\ CBG} \tag{7-5}$$

Bus stop density can be determined as the ratio of the total number of bus stops within the CBG to the total miles of the non-freeway roadway network within CBG, as shown in Equation 7-6.

$$\frac{Total\ Number\ of\ Bus\ Stops\ Within\ CBG}{Total\ Miles\ of\ Non-freeway\ SHS\ Roadway\ Within\ CBG} \tag{7-6}$$

7.2.2 Derive Response Variables

The response variables include:

- Total crashes involving aging road users per year per mile of the SHS roadway network
- Crashes involving aging non-motorists per year per mile of the non-freeway SHS roadway network

The *total crashes involving aging road users per year per mile* can be determined as the ratio of the total number of crashes involving aging road users within the CBG to the total miles of the SHS roadway network within the CBG, as shown in Equation 7-7.

$$\frac{Total\ Number\ of\ Crashes\ involving\ Aging\ Road\ Users\ per\ Year\ Within\ CBG}{Total\ Miles\ of\ SHS\ Roadway\ Network\ Within\ CBG} \tag{7-7}$$

The *crashes involving aging non-motorists per year per mile* can be determined as the ratio of the total number of crashes involving aging non-motorists within the CBG to the total miles of the non-freeway SHS roadway network within the CBG, as shown in Equation 7-8.

$$\frac{Total\ Number\ of\ Crashes\ involving\ Aging\ Non-motorists\ per\ Year\ Within\ CBG}{Total\ Miles\ of\ Non-freeway\ SHS\ Roadway\ Network\ Within\ CBG} \quad (7\text{-}8)$$

7.2.3 Identify Urban and Rural Counties

Use the definition of rural counties at Section 288.0656 of the Florida Statutes to identify rural counties. Section 288.0656 of the Florida Statutes define rural counties as:

- a county with a population of 75,000 or less, or
- a county with a population of 125,000 or less which is contiguous to a county with a population of 75,000 or less.

Based on these criteria, there are 36 urban counties and 31 rural counties. A total of 10,495 CBGs are in urban counties and 714 CBGs are in rural counties.

7.2.4 Create Polygon Shapefiles for Urban and Rural CBGs

Import the urban CBGs in ArcGIS and export it in shapefile (.shp) format and use the *Spatial Join* under *Overlay* in the *Analysis Tools* to create polygons for urban CBGs. Repeat this process to create the polygon shapefiles for rural CBGs.

7.3 Identify Target Regions

This part includes:

- hot spot analysis, and
- identification of urban and rural target regions.

7.3.1 Hot Spot Analysis for Urban Counties

Use the following procedures to conduct hot spot analysis for urban counties.

Hot Spot Analysis for Total Crashes Involving Aging Road Users

Use the *Optimized Hot Spot Analysis* tool under *Mapping Clusters* in the *Spatial Statistics Tools* to conduct the hot spot analysis for total crashes involving aging road users in urban counties. Use the following specifications, as shown in Figure 7-9:

- Input Features: urban CBGs
- Analysis Field: total crashes involving aging road users per year per mile (CRASHPYPMI)

The results are in tabular form as well as in graphical form showing the hot spots and cold spots at 90%, 95%, and 99% confidence levels. Note that generally, confidence level indicates how stable the estimate is. The stable estimate is the one that would be close to the calculated estimate if the analysis is repeated. Therefore, the results at a 95% confidence level mean that we are 95% sure that if this analysis is repeated several times, the results would match 95% of the time.

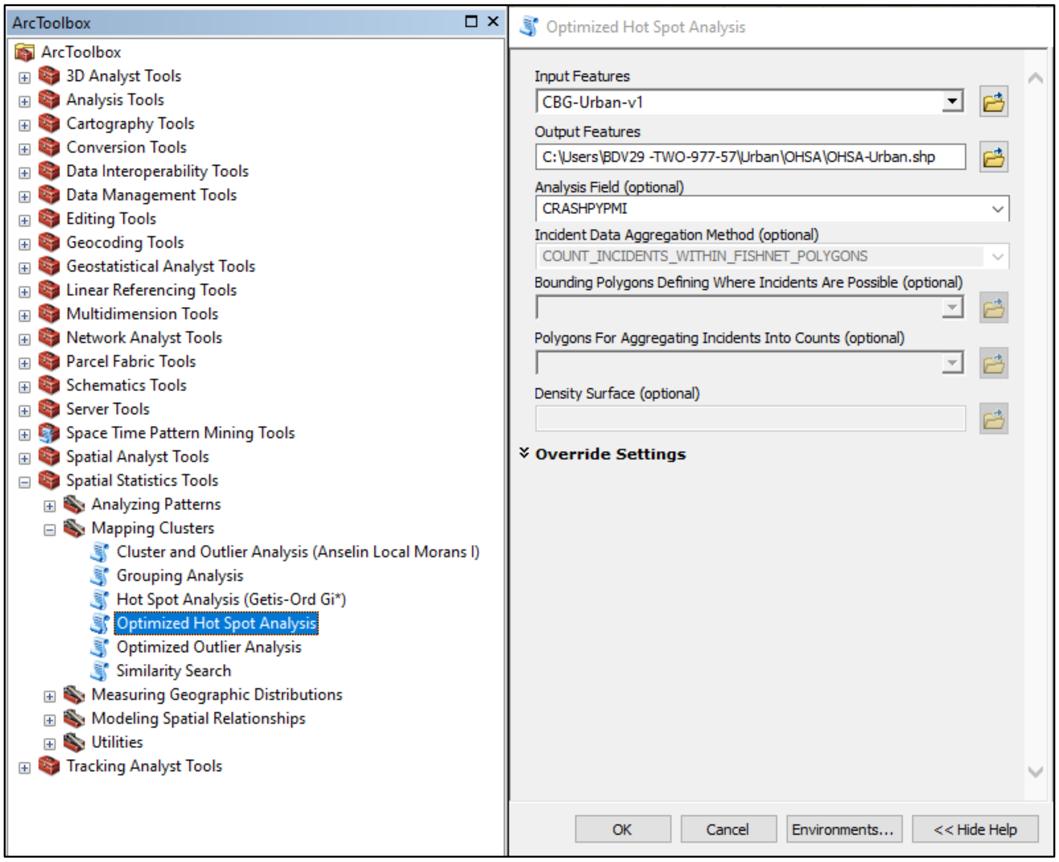


Figure 7-9: Hot Spot Analysis for Total Crashes Involving Aging Road Users

Hot Spot Analysis for Crashes Involving Aging Non-motorists

Use the *Optimized Hot Spot Analysis* tool under *Mapping Clusters* in the *Spatial Statistics Tools* to conduct the hot spot analysis for crashes involving aging non-motorists in urban counties. Use the following specifications, as shown in Figure 7-10:

- Input Features: urban CBGs
- Analysis Field: crashes involving aging non-motorists per year per mile (PEDPYPMILE)

The results are in tabular form as well as in graphical form showing the hot spots and cold spots at 90%, 95%, and 99% confidence levels. Note that generally, confidence level indicates how stable the estimate is. The stable estimate is the one that would be close to the calculated estimate if the analysis is repeated. Therefore, the results at a 95% confidence level mean that we are 95% sure that if this analysis is repeated several times, the results would match 95% of the time.

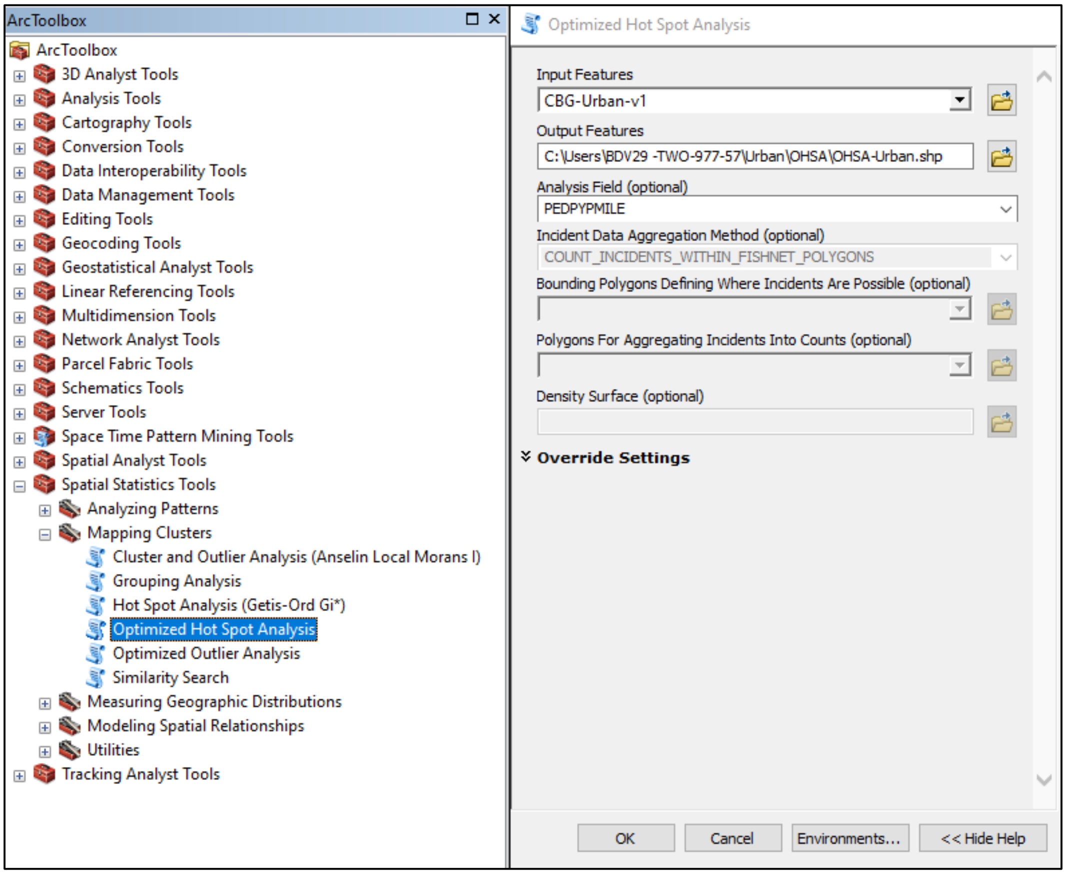


Figure 7-10: Hot Spot Analysis for Crashes Involving Aging Non-motorists

7.3.2 Hot Spot Analysis for Rural Counties

Repeat the procedures described in Section **7.3.1** to conduct hot spot analysis for rural counties.

7.3.3 Identify Urban Target Regions

Identify urban target regions based on:

- Total crashes involving aging road users.
- Crashes involving aging non-motorists.

Use the *Select by Attributes* tool and specify "***Gi-Bin=3***" as indicated in Figure 7-11 to select all the hot spots at 99% confidence level as the target regions based on the *total crashes involving aging road users*.

Repeat the same process to identify target regions based on *crashes involving aging non-motorists*.

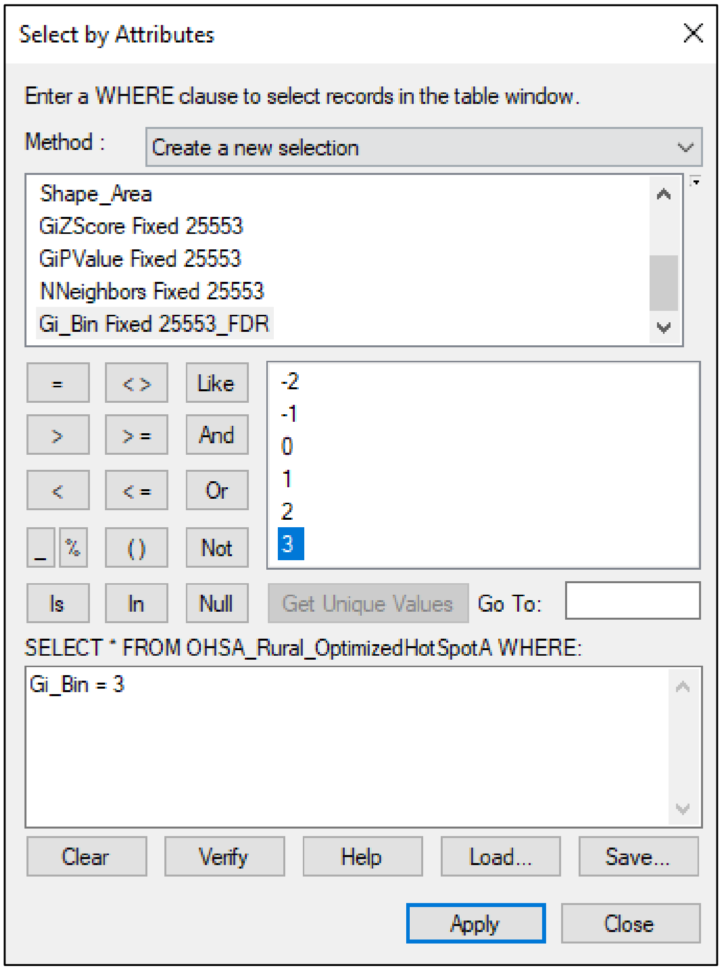


Figure 7-11: Select Urban Target Regions

7.3.4 Identify Rural Target Regions

Identify rural target regions based on:

- Total crashes involving aging road users.
- Crashes involving aging non-motorists.

Repeat the procedures described in Section ***7.3.3*** to identify rural target regions.

7.4 Recommend Specific Outreach Activities at the Target Regions

Use the following steps to recommend the specific outreach activities at the target regions:

- identify potential crash types that could be reduced by specific outreach activities,
- develop criteria to recommend specific outreach activities at the target regions, and
- develop procedures to evaluate the impact of outreach activities.

7.4.1 Identify Potential Crash Types That Could be Reduced by Specific Outreach Activities

Table 7-2 summarizes the specific outreach activities and the potential crash types (and categories) that could be reduced by each of the specific outreach activities.

Table 7-2: Potential Crash Types That Could be Reduced by Specific Outreach Activities

Outreach Activity	Potential Crash Types That Could be Reduced
• Florida's Guide to Safe Mobility for Life • Families & Caregivers Brochure • How to Build a Transportation Plan PSA • Find a Ride Tip Card • You Hold the Keys Tip Card • You Hold the Keys PSA	• Total crashes involving aging road users
• Driver Medical Referral Visor Card • You Hold the Keys Tip Card • Keys to Achieve Safe Mobility for Life Workshop • You Hold the Keys PSA	• Crashes involving aging drivers
• CarFit Outreach Events • CarFit Tip Card	• Crashes involving aging drivers • FS crashes involving aging drivers
• Bicycling Booklet • Walking Booklet • Safe Walking for Life Workshop	• Crashes involving aging non-motorists
• Flashing Yellow Arrow Tip Card/Graphics	• Intersection-related crashes • Left-turn crashes involving aging road users
• Turning Right on Red Tip Card/Graphics	• Intersection-related crashes • Right-turn crashes involving aging road users
• Transit Ready Kit • Public Transit Brochure • Safe Transit for Life Workshop • Bicycling Booklet • Walking Booklet • Safe Walking for Life Workshop	• Crashes involving aging non-motorists • Crashes involving aging road users and those that occurred in the vicinity of bus stops
• How to Safely Navigate a Roundabout Tip Card/Graphics	• Roundabout-related crashes involving aging road users
• Wrong-Way Driving on the Interstate Tip Card/Graphics	• WWD crashes involving aging road users
• How to Use Find a Ride Florida PSA • Transportation Network Companies • Find a Ride Tip Card	• Crashes that are not associated with bus stops

Note: All the outreach activities are expected to reduce the total crashes involving aging road users; PSA = public service announcement; WWD = wrong-way driving.

7.4.2 Criteria to Recommend Specific Outreach Activities at the Target Regions

Table 7-3 summarizes the criteria that can be used to recommend specific outreach activities at the target regions. Note that total crashes include only those that involve aging road users.

Table 7-3: Criteria to Recommend Specific Outreach Activities at the Target Regions

Target Regions	Performance Measures	Criteria	Outreach Activities
All target regions	• Total crashes involving aging road users	• At least 85th percentile of the total crashes per year per mile	• Florida's Guide to Safe Mobility for Life • Families & Caregivers Brochure • How to Build a Transportation Plan PSA • Find a Ride Tip Card • You Hold the Keys Tip Card • You Hold the Keys PSA
Target regions with a higher proportion of crashes involving aging drivers	• Total crashes involving aging road users • Crashes involving aging drivers	• At least 85th percentile of the total crashes per year per mile • At least 85th percentile of the total crashes involve aging drivers	• Driver Medical Referral Visor Card • You Hold the Keys Tip Card • Keys to Achieve Safe Mobility for Life Workshop • You Hold the Keys PSA
Target regions with a higher proportion of crashes involving aging drivers and FS crashes	• Total crashes involving aging road users • Crashes involving aging drivers • FS crashes involving aging road drivers	• At least 85th percentile of the total crashes per year per mile • At least 85th percentile of the total crashes involve aging drivers • At least one FS crash per year	• CarFit Outreach Events • CarFit Tip Card
Target regions with a higher proportion of crashes involving aging non-motorists	• Total crashes involving aging road users • Crashes involving aging non-motorists	• At least 85th percentile of the total crashes per year per mile • At least one crash per year involved aging non-motorists	• Bicycling Booklet • Walking Booklet • Safe Walking for Life Workshop
Target regions with a higher proportion of intersection-related crashes	• Total crashes involving aging road users • Intersection-related crashes • Left-turn crashes	• At least 85th percentile of the total crashes per year per mile • At least 85th percentile of the total crashes are intersection-related • At least 85th percentile of the total crashes are left-turn crashes • At least one signalized intersection	• Flashing Yellow Arrow Tip Card/Graphics

Note: The criteria are the same for both urban and rural target regions. However, the urban and rural target regions need to be analyzed separately; PSA = public service announcement; WWD = wrong-way driving.

Table 7-3: Criteria to Recommend Specific Outreach Activities at the Target Regions (continued)

Target Regions	Performance Measures	Criteria	Outreach Activities
Target regions with a higher proportion of intersection-related crashes	• Total crashes involving aging road users • Intersection-related crashes • Right-turn crashes	• At least 85th percentile the total crashes per year per mile • At least 85th percentile of the total crashes are intersection-related • At least one right right-turn crash per year • At least one signalized intersection	• Turning Right on Red Tip Card/Graphics
Target regions with higher bus stop density	• Total crashes involving aging road users • Crashes involving aging non-motorists • Crashes associated with bus stops	• At least 85th percentile of the total crashes per year per mile • At least 85th percentile of the bus stop per mile • At least one bus stop for rural target regions	• Transit Ready Kit • Public Transit Brochure • Safe Transit for Life Workshop • Bicycling Booklet • Walking Booklet • Safe Walking for Life Workshop
Target regions with a higher proportion of roundabout-related crashes	• Total crashes involving aging road users • Roundabout-related crashes	• At least 85th percentile of the total crashes per year per mile • At least one roundabout-related crash per year	• How to Safely Navigate a Roundabout Tip Card/Graphics
Target regions associated with WWD crashes	• WWD crashes	• At least one WWD crash per year	• Wrong-Way Driving on the Interstate Tip Card/Graphics
Target regions with no or low bus stop density	• Total crashes involving aging road users • Crashes that are not associated with bus stops	• At least 85th percentile of the total crashes per year per mile • At most 15th percentile of bus stops per mile	• How to Use Find a Ride Florida PSA • Transportation Network Companies • Find a Ride Tip Card

Note: The criteria are the same for both urban and rural target regions. However, the urban and rural target regions need to be analyzed separately; PSA = public service announcement; WWD = wrong-way driving.

7.4.3 Before-after Analysis to Evaluate the Impact of Outreach Activities

Before-after evaluation is recommended to be used to quantify the impact of outreach activities at the target regions using the following step-by-step procedure:

- Step 1: Identify Program Goals and Objectives
- Step 2: Identify Target Group
- Step 3: Develop Evaluation Measures
- Step 4: Identify Possible Data Collection Methods
- Step 5: Collect Data/Information
- Step 6: Conduct the Analysis and Interpret the Results
- Step 7: Write an Evaluation Report

The before-after analysis could be based on the following crash-related performance measures:

- Crash frequency involving aging road users
- Number of FS crashes involving aging road users
- Crash frequency involving aging drivers
- Number of FS crashes involving aging drivers
- Crash frequency involving aging non-motorists
- Number of FS crashes involving aging non-motorists
- Crash frequency involving aging road users in the vicinity of bus stops
- Number of left-turn and right-turn crashes at intersections involving aging road users
- Number of roundabout-related crashes involving aging road users
- Number of WWD crashes involving aging road users

7.5 Summary

This chapter documented the step-by-step procedures that can be adopted to conduct the analysis annually. In summary, the steps are divided into five parts:

- Collect data
    - Crash data
    - Roadway geometric characteristics data
    - Infrastructure-related data
    - Socioeconomic and demographic data

- Process data
    - Derive explanatory variables
    - Derive response variables
    - Identify urban and rural counties
    - Create polygon shapefiles for urban and rural CBGs

- Identify target regions
    - Conduct hot spot analysis for urban and rural counties
    - Identify urban and rural target regions

- Recommend specific outreach activities at the target regions
    - Identify potential crash types that specific outreach activities could potentially reduce
    - Develop criteria to recommend specific outreach activities at the target regions
    - Develop a process to evaluate the impact of outreach activities

- Quantify the impact of outreach activities
    - Conduct before-after evaluation

CHAPTER 8
SUMMARY AND CONCLUSIONS

Being a popular retirement destination in the country, Florida leads the nation with 20% of its population of age 65 years and older. This percentage is higher than the national average of 16%. Over 27% of Florida's population is expected to be over the age of 65 by the year 2030. With this significant increase in the older population, it is obvious that the number of aging road users will increase. As per Florida's 2017 ARUSSP, aging road users include drivers, transit riders, motorcyclists, passengers, operators of non-motorized vehicles, bicyclists, and pedestrians over age 50, with a special focus on the 65 years and older age groups. As such, the FDOT has been proactively addressing the specific needs of Florida's aging road users through its SMFL Program.

Reaching out to the target population in the entire state and conducting the outreach activities for the safety improvement of the aging road users is a challenge, especially with a large state and limited resources. Therefore, it is essential to identify and prioritize target regions that have above-average crash rates involving individuals age 65 years and older. In addition to targeting regions that experience a disproportionately high crash rate involving older road users, it is also important to proactively identify regions based on the built environment. Regions with certain land use, demographic, and socioeconomic characteristics may be perceived to be "less safe" and more prone to crashes involving aging road users, and hence, may need specific countermeasures.

The primary goal of this research was to develop a GIS-based approach to identify and prioritize target regions to conduct outreach activities to improve the safety and mobility of the aging population. The research goal was achieved through the following objectives:

1. Identify and prioritize target regions.
2. Recommend outreach activities at the target regions.
3. Develop approach to quantify the impact of outreach activities.
4. Develop procedures to conduct the analysis annually.

8.1 Identify and Prioritize Target Regions

Target regions are areas that experience a significant number of crashes involving aging road users. Identifying and prioritizing the target regions is crucial, especially in safety improvement plans, since it is impossible to conduct outreach activities in the entire state or county. A GIS-based approach was used to identify and prioritize target regions based on the total crashes involving aging road users. These target regions were identified separately for the urban and rural counties. In this research, all the hot spots that were statistically significant at a 99% confidence level for total crashes involving aging road users and for the crashes involving aging non-motorists were identified as the target regions for conducting outreach activities. The following key findings were obtained from the analysis results:

- There were 2,592 urban target regions based on total crashes involving aging road users. These target regions were in Broward, Clay, Collier, Duval, Lake, Lee, Manatee, Marion, Miami-Dade, Sarasota, Palm Beach, Pasco, Pinellas, and Sumter counties.

- A total of 1,285 urban target regions were identified based on the crashes involving aging non-motorists. These target regions were in Brevard, Collier, Duval, Hillsborough, Leon, Marion, Miami-Dade, Palm Beach, and Pinellas counties.

- There were 190 rural target regions based on total crashes involving aging road users. These rural target regions were in Flagler, Glades, Hardee, Highlands, Okeechobee, Putnam, and Walton counties.

- A total of 120 rural target regions were identified based on the crashes involving aging non-motorists. These rural target regions were in Flagler, Hardee, Highlands, and Putnam counties.

- Total crashes involving aging road users were clustered in the areas with higher total population density with a higher proportion of the aging population, especially in South Florida.

- Freeway roadway density, sidewalk proportion, and bus stop density were associated with more crashes involving aging road users. This indicates that the higher the freeway density, sidewalk proportion, and bus stop density, the higher the likelihood of crash occurrence.

- Non-freeway SHS roadway density and median household income were associated with a decrease in the likelihood of crash occurrence. This indicates that the higher the median household income and the higher the non-freeway SHS roadway density, the lower the likelihood of the crash occurrence.

8.2 Recommend Outreach Activities at the Target Regions

In this research project, outreach activities were recommended at the target regions based on the existing outreach activities being conducted by the SMFL Coalition. General outreach activities were recommended at all target regions that meet the following criteria (termed as *base criteria*):

- Urban target regions with at least 6.2 total crashes involving aging road users per year per mile of the SHS roadway network.
- Rural target regions with at least 0.39 total crashes involving aging road users per year per mile of the SHS roadway network.

Note that these values were based on the 85^{th} percentile of the total number of crashes involving aging road users per year per mile, and were used as the base criteria. Other specific outreach activities were recommended at the target regions with the following criteria: (*Note: Total crash rate is based on only crashes involving aging road users*.)

Higher Proportion of Crashes Involving Aging Drivers:

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year
- At least 79% of total crashes involve aging drivers

For rural areas:

- Total crash rate is at least 0.39 crashes per mile per year
- At least 77.4% of total crashes involve aging drivers

Higher Proportion of Aging Drivers and FS Crashes:

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year
- At least 79% of total crashes involve aging drivers
- At least one FS crash per year

For rural areas:

- Total crash rate is at least 0.39 crashes per mile per year
- At least 77.4% of total crashes involve aging drivers
- At least one FS crash per year

Higher Proportion of Crashes Involving Aging Non-motorists:

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year
- At least one crash per year involving aging non-motorists

For rural areas:

- Total crash rate is at least 0.39 crashes per mile per year
- At least one crash per year involving aging non-motorists

Higher Proportion of Intersection-related Crashes: Left-turn Crashes:

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year
- At least 23.7% of total crashes are intersection-related
- At least 5.1% of total crashes are left-turn crashes
- At least one signalized intersection

For rural areas:

- Total crash rate is at least 0.39 crashes per mile per year
- At least 31.3% of total crashes are intersection-related
- At least 4.4% of total crashes are left-turn crashes
- At least one signalized intersection

Higher Proportion of Intersection-related Crashes: Right-turn Crashes:

For urban areas:

- Total crash rate is at least 6.2 crashes per mile per year

- At least 23.7% of total crashes are intersection-related
- At least one right-turn crash per year
- At least one signalized intersection

For rural areas:
- Total crash rate is at least 0.39 crashes per mile per year
- At least 31.3% of total crashes are intersection-related
- At least one right-turn crash per year
- At least one signalized intersection

Higher Proportion of Roundabout-related Crashes:

For urban areas:
- Total crash rate is at least 6.2 crashes per mile per year
- At least one roundabout-related crash per year

For rural areas:
- Total crash rate is at least 0.39 crashes per mile per year
- At least one roundabout-related crash per year

Higher Bus Stop Density:

For urban areas:
- Total crash rate is at least 6.2 crashes per mile per year
- At least 1.16 bus stops per mile

For rural areas:
- Total crash rate is at least 0.39 crashes per mile per year
- At least one bus stop

No or Low Bus Stop Density:

For urban areas:
- Total crash rate is at least 6.2 crashes per mile per year
- Up to 1.16 bus stops per mile

For rural areas:
- Total crash rate is at least 0.39 crashes per mile per year
- No bus stop

Table 8-1 presents the recommended outreach activities along with the number of target regions for both urban and rural counties.

Table 8-1: Recommended Outreach Activities at the Target Regions

Outreach Activities	Urban Target Regions No. of CBGs	Urban Target Regions Area (sq. mi.)	Rural Target Regions No. of CBGs	Rural Target Regions Area (sq. mi.)
Florida’s Guide to Safe Mobility for Life	2,204	757.74	162	752.52
Families & Caregivers Brochure	2,204	757.74	162	752.52
Find a Ride Tip Card	2,204	757.74	162	752.52
How to Build a Transportation Plan PSA	2,204	757.74	162	752.52
Driver Medical Referral Visor Card	1,888	683.44	141	711.98
You Hold the Keys Tip Card	1,888	683.44	141	711.98
Keys to Achieve Safe Mobility for Life Workshop	1,888	683.44	141	711.98
You Hold the Keys PSA	1,888	683.44	141	711.98
CarFit Outreach Events	217	130.33	24	151.99
CarFit Tip Card	217	130.33	24	151.99
Bicycling Booklet	385	170.08	14	38.71
Walking Booklet	385	170.08	14	38.71
Safe Walking for Life Workshop	385	170.08	14	38.71
Flashing Yellow Arrow Tip Card/Graphics	1,110	378.48	82	424.14
Turning Right on Red Tip Card/Graphics	516	224.57	64	352.53
Transit Ready Kit	1,971	630.74	2	4.8
Public Transit Brochure	1,971	630.74	2	4.8
How to Safely Navigate a Roundabout Tip Card/Graphics	34	10.97	0	0
How to Use Find a Ride Florida PSA	1,829	697.01	160	747.72
Transportation Network Companies	1,829	697.01	160	747.72
Total	**2,592**	**987.53**	**190**	**1,989.82**

Note: PSA = public service announcement; sq. mi. = square miles.

8.3 Approach to Quantify the Impact of Outreach Activities

Program evaluations are crucial in safety analysis as they help agencies determine a program's impact and identify potential areas for improvement. The design of a program evaluation is highly dependent on the program's characteristics, goals, and objectives. Even though evaluating the impact of outreach activities is very important, it is difficult compared to evaluating the traditional engineering-related safety countermeasures. This research recommends the step-by-step procedures that can be used to quantify the impact of the outreach activities. Selecting the appropriate evaluation tools will help agencies estimate the program's impact and identify potential areas for improvement. Based on the selected performance measure, i.e., the number of crashes involving aging road users, the *simple before-after evaluation* method was recommended to quantify the impact of outreach activities at the target regions.

Before-after evaluation is recommended to be used to quantify the impact of outreach activities at the target regions using the following step-by-step procedure:

- Step 1: Identify Program Goals and Objectives
- Step 2: Identify Target Group
- Step 3: Develop Evaluation Measures
- Step 4: Identify Possible Data Collection Methods
- Step 5: Collect Data/Information
- Step 6: Conduct the Analysis and Interpret the Results
- Step 7: Write an Evaluation Report

8.4 Develop Procedures to Conduct the Analysis Annually

The objective of this project is to develop a GIS-based approach to identify and prioritize target regions that benefit the most from the outreach activities. Since the process of conducting outreach activities at the target regions to improve the safety and mobility of aging road users is not a one-time process, there is a need to develop procedures to repeat the analysis annually. As such, this chapter documents the step-by-step procedures to repeat the analysis annually. The procedures intend to provide support and guidance to transportation practitioners to repeat the analysis every year. The step-by-step procedures that can be adopted to conduct the analysis annually. In summary, the steps are divided into five parts:

- Collect data
    - Crash data
    - Roadway geometric characteristics data
    - Infrastructure-related data
    - Socioeconomic and demographic data

- Process data
    - Derive explanatory variables
    - Derive response variables
    - Identify urban and rural counties
    - Create polygon shapefiles for urban and rural CBGs

- Identify target regions
    - Conduct hot spot analysis for urban and rural counties
    - Identify urban and rural target regions

- Recommend specific outreach activities at the target regions
    - Identify potential crash types that specific outreach Activities could potentially reduce
    - Develop criteria to recommend specific outreach activities at the target regions
    - Develop a process to evaluate the impact of outreach activities

- Quantify the impact of outreach activities
    - Conduct before-after evaluation

8.5 Implementation Strategy

The process of identifying and prioritizing target regions can be repeated every year using the most recent five years of crash data and the most recent SHS roadway network. The identified target regions can easily be incorporated in FDOT's *eTraffic*, a GIS-based website that displays various layered information on the state-maintained system, including SMFL features, traffic signals, mid-block crosswalk (MBX) treatments, and intersection control evaluation (ICE) (FDOT, 2021b). However, variables such as bus stops and the proportion of sidewalk miles need to be updated every few years (e.g., five) to capture any changes associated with these variables.

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