HIGHWAY FACILITIES FOR AN AGING ARIZONA POPULATION

Final Report 486

Prepared by:
Sharon A. Baggett, PhD
Quantec, LLC
6229 SE Milwaukie Ave.
Portland, OR 97202

June 2003

Prepared for:
Arizona Department of Transportation
206 South 17th Avenue
Phoenix, Arizona 85007
in cooperation with
U.S. Department of Transportation
Federal Highway Administration

The contents of the report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Arizona Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation. Trade or manufacturers' names which may appear herein are cited only because they are considered essential to the objectives of the report. The U.S. Government and The State of Arizona do not endorse products or manufacturers.

Technical Report Documentation Page

1. Report No. FHWA-AZ-03-486	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle **Highway Facilities for An Aging Arizona Population**		5. Report Date June 2003
		6. Performing Organization Code
7. Authors Sharon A. Baggett, PhD		8. Performing Organization Report No.
9. Performing Organization Name and Address **Quantec,** **LLC6229 SE Milwaukie Ave.** **Portland, OR 97211**		10. Work Unit No.
		11. Contract or Grant No. SPR-PL-1-(55) 486
12. Sponsoring Agency Name and Address **ARIZONA DEPARTMENT OF TRANSPORTATION** **206 S. 17TH AVENUE** **PHOENIX, ARIZONA 85007** Project Manager: John Semmens		13.Type of Report & Period Covered FINAL
		14. Sponsoring Agency Code

15. Supplementary Notes
Prepared in cooperation with the U.S. Department of Transportation, Federal Highway Administration

16. Abstract

The purpose of this research project is threefold: to examine the current knowledge of state-of-the-art highway design practices aimed at increasing the safety of older drivers; assess the crash and fatality data for older drivers in Arizona; and survey older adults regarding their perceptions of Arizona's roadways and possible needs for enhancement. Older adults increasingly make up a larger part of the driving population. Age related declines and complications from medical conditions put older drivers at higher risk of collision, and when in collision, of a fatal injury. Changes in visual acuity, cognition, use of certain medications, and functional impairment may contribute to reduced driving ability. In Arizona we found that, like older adults nationwide, older drivers were more likely have angle and left-turn collisions, to be in collisions involving intersections and junctions, at signaled and unsignaled left-turn intersections, and in daylight hours. Older adults surveyed rated driving at night as very difficult, followed by driving on a freeway and identifying street names, feel improvement could be made to lettering for roadway signs, intersection markings and signals, and support increasing the availability of sidewalks. Survey respondents most frequently rated larger and better-illuminated traffic signs as the most helpful design improvement that could be implemented and most frequently rated special senior driver testing programs as most the most effective screening and assessment option. It is recommended that Arizona use locations identified in this study as having high rates of collisions involving older adults to develop test sites for roadway improvements. We also recommend that the state begin to review its screening, assessment and education for older drivers with the intent of developing a more stringent screening and assessment process and develop and implement self-testing for older adults to support improved driving safety.

17. Key Words elderly drivers		18. Distribution Statement Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia, 22161		23. Registrant's Seal
19. Security Classification Unclassified	20. Security Classification Unclassified	21. No. of Pages 92	22. Price	

SI (MODERN METRIC) CONVERSION FACTORS*

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
	AREA			
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
	VOLUME			
fl oz	fluid ounces	29.57	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
	NOTE: Volumes greater than 1000L shall be shown in m^3.			
	MASS			
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000lb)	0.907	megagrams (or "metric ton")	mg (or "t")
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C
	ILLUMINATION			
fc	foot candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
	FORCE AND PRESSURE OR STRESS			
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
	AREA			
mm^2	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	2.47	acres	ac
km^2	Square kilometers	0.386	square miles	mi^2
	VOLUME			
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	Cubic meters	35.315	cubic feet	ft^3
m^3	Cubic meters	1.308	cubic yards	yd^3
	MASS			
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (or "metric ton")	1.102	short tons (2000lb)	T
	TEMPERATURE (exact)			
°C	Celsius temperature	1.8C + 32	Fahrenheit temperature	°F
	ILLUMINATION			
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
	FORCE AND PRESSURE OR STRESS			
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

TABLE OF CONTENTS

TABLES

FIGURES

GLOSSARY OF ACRONYMS

AAA	Region One Area Agency on Aging
ADOT	The Arizona Department of Transportation
DMV	Department of Motor Vehicles
FARS	U.S. Fatality Analysis Reporting System
UFOV	Useful Field of View
USDOT	U.S. Department of Transportation

EXECUTIVE SUMMARY

The state of Arizona, like the nation as a whole, has an increasing number of residents over the age of 65. Nationwide, the largest increase in licensed drivers is occurring in the over 85 population, and, by 2030, older drivers are expected to account for 18.9% of all vehicle miles driven, compared to 6.7% in 1990. The Arizona Department of Transportation (ADOT) recognized that with this growth comes a host of issues related to older drivers and that, while there was a vast literature related to these issues, there was need to assess current research and, based on findings from this assessment, recommend actions that should be taken to improve driving safety for older adults. This report summarizes the information gathered for use by ADOT in planning and decision-making regarding roadway improvements and other policy practices to meet the needs of older adults.

This report is divided into four main sections. In the first, we examine the current knowledge of factors affecting older drivers and review state-of-the art highway design practices aimed at increasing their safety. Older drivers are more likely than younger drivers to be involved in accidents involving left-turns at intersections, at intersections and junctions generally, when merging or passing, and in daylight hours. Older adults report additional difficulties in reading signs and street names, route finding, following pavement markings, and responding to signals.

Many of these accidents involving older adults may result from age-related physical and mental changes. The literature consistently cites (Staplin *et al.* 2001a) age-related decline in vision, such as reduced visual acuity, decline in contrast sensitivity, and shrinking visual field. Changes in cognition, such as declines in divided and selective attention, create risk as older drivers attend to multiple stimuli while driving. Studies have also clearly shown some memory loss with age, most significantly with short-term or working memory. These memory changes have all been correlated with increased crash risk, poor driving performance, and other adverse events, such as violations or being stopped by police. General "cognitive impairment" has also been shown to result in poorer driving performance by older adults, as measured by a drive test and on-road navigation tasks.

Other age-related physical and health factors have also been associated with increased risk for older drivers. These include conditions such as cataracts, glaucoma, and near vision impairment, as well as dementia, and the use of certain medications. Functional impairments, such as reduced ability for self-care and falls, have also been correlated with increased crash risk.

While there is evidence that older adults may compensate for age- and medical-related declines (limiting driving to safer times and places, driving more slowly and fewer miles, and driving with friends or "copilots") a host of national organizations and individual researchers have recommended increased screening, assessment, and education of older drivers. Recommendations include involving community and private sector organizations/professionals who have a major role in identification of at risk drivers and should, within the limits of privacy and confidentiality, report the status of referred

drivers back to external sources. Licensing agencies themselves should also identify at-risk drivers, using pre-screening devices (such as objective and standard criteria on forms, observation by counter personnel), history of crash or violations, age, or selective sampling of drivers for special screening. Consistent recommendations include using a protocol, such as Trail Making, to discern memory and cognitive impairments, using on-road driving tests tailored to those areas that most discriminate problems of older drivers (e.g., intersection navigation, merging, backing from driveways and in parking lots, freeway entry) and expanding education and self-testing to allow older adults to better monitor their driving performance.

The second section of this report presents a summary of our analysis of accident data for persons 65 years and older, provided by ADOT's Traffic Records Section for the three-year period from 1999 to 2001 and compares that summary to data from Washington and Oregon where possible. While the overall population 65 and over in Arizona did not grow as a percentage of the total population, the older population is "aging," with an increasing percentage of older adults in the over 75 and over 85 age categories. In about 85% of accidents involving older adults, the driver was a resident of the state. Overall, our data show that older Arizona drivers are significantly more likely than are younger drivers to:

- Have angle and left-turn collisions (and less apt to have rear-end collisions).
- Be involved in accidents in daylight driving conditions and in rural areas.
- Be in accidents involving intersections and junctions, stop signs or signals, and raised medians.
- Suffer fatal injuries in an accident.

These findings are consistent with national data and with the state data we compared.

In the third section, we present data from a survey conducted with older adults regarding their perceptions of Arizona's roadways and possible needs for enhancement. The survey was administered to a sample of senior center participants in Maricopa County. While senior center participants represent only one sector of the aging population of Arizona, given the consistency of their responses with the issues and preferences identified in the literature and in the pattern of collisions discerned from the accident data, we believe the responses are generally representative of older Arizona drivers.

The survey data indicate that older Arizona drivers:

- Are very concerned about older drivers on the road.
- Most often rate driving at night as "very difficult," followed by driving on a freeway and identifying street names.
- Feel improvement could be made on many aspects of Arizona roadways, with lettering for signs most frequently rated as "not very good," followed by intersection markings and signals and availability of sidewalks.

- Most frequently rate larger and better-illuminated traffic signs as the most helpful design improvement.
- Most frequently rate special senior driver testing programs as most the most effective screening and assessment option.
- Most frequently rate changing the timing of traffic signals to allow more time for the walk cycle as most helpful action for pedestrians.

Based on the findings from the literature review, the analysis of collision data, and the survey of older adults, we present recommended actions that ADOT should take to enhance driving safety for older adults. Given budget constraints and other factors, only some roadway, pedestrian, screening, assessment and education activities can be undertaken. We recommend that roadway improvements receive priority, including a pilot program to implement design enhancements identified in the Federal Highway Administration's Handbook (Staplin *et al.* 2001a) on selected test sites chosen from those we identified as having high rates of collisions involving older drivers. Recommended roadway improvements include:

- Modification of left-turn phase indicators.
- Larger and better-illuminated signs and devices for lane assignment on intersection approach.
- Improved signage, both in size, lighting, and contrast, and advance distance notification of required tasks (e.g., merge, on-ramp, exits, four-way stops) on all roadways.
- Pedestrian crossing design improvements, including increased timing at crosswalks, median refuge islands, more frequent pedestrian opportunities, and placards explaining pedestrian control signals.

The literature confirms and older adults concur that some screening of older drivers is important. Most states use some combination of no renewal by mail, reduction in intervals between licensing, vision testing, on-road driving and knowledge re-testing to address license renewal requirements for older adults, with the number of assessment components increasing with age. Based on our review, we recommend the following enhancements to ADOT:

- Explore the costs and benefits of implementation of measures, such as the Trail Making protocol to discern memory and cognitive impairments.
- At time of re-licensure, use on-road driving tests tailored to those areas that most discriminate problems of older drivers, such as intersection navigation, merging, backing from driveways and in parking lots, freeway entry. These tests could be instituted as part of re-licensure requirements for drivers beyond a given age and for those identified as at-risk (see next).
- Work with the state legislature, organizations, and professionals to develop a system of reporting required of medical and other care professions; reporting would require these entities to refer older adults to ADOT if specific concerns are identified.

As a low-cost initiative, at a minimum the state should adopt some form of education and self-testing to support older adults in monitoring their own driving performance.

1. INTRODUCTION

PURPOSE

The purpose of this research project is threefold: to examine the current knowledge of factors affecting older drivers and state-of-the art highway design practices aimed at increasing the safety of older drivers; to assess the crash and fatality data for older drivers in Arizona; and to survey older adults regarding their perceptions of Arizona's roadways and possible needs for enhancement. This information was gathered through an extensive review of the literature, analysis of Arizona Department of Transportation's (ADOT) accident data on older drivers from 1999-2001, and a survey of older adults in the Phoenix and outlying areas. This report summarizes the information gathered and will be used to assist ADOT's planning and decision-making regarding roadway improvements and other policy practices to meet the needs of older adults.

BACKGROUND

Demographic trends indicate a dramatic shift in the age of the population, with the current population of adults 65 and over estimated to more than double by the year 2040. The largest increases are expected in the "over 75" and "over 85" categories. Per mile driven, adults over age 65 have higher crash-rate deaths than any other group except teen drivers (NHTSA 2001) and are more likely than younger drivers to die from their injuries (IIHS 2000).

A variety of aging-related declines contribute to the difficulties faced by older drivers. Risk factors include declines in vision, hearing, cognitive functions such as reduced reaction time, and physical impairments that may affect driving ability. In spite of these declines, older adults adapt in many ways, including driving fewer miles at night and on the highway, driving with others, and limiting trips to increase their safety. Older adults are also less likely to drink or to drive in bad weather and more likely to wear seat belts than are younger drivers.

Given the risks associated with aging and the growing older population, attention has turned to increasing safety for these older drivers. Interventions recommended include, among others, screening during the licensing and renewal process and roadway enhancements such as increased illumination or size of signage or re-design of intersections. Research also continues into computerized accessories in automobiles that may assist older adults with aging-related declines in reaction time and vision.

Decisions made regarding licensing and roadway enhancements should be based on accurate, up-to-date information. This report summarizes the current literature on older drivers and interventions to facilitate ADOT's decision-making process.

PROJECT OVERVIEW

This report is comprised of three components - a literature review, an analysis of Arizona's older drivers crash data, and a survey of older adults. The first section contains information gathered through a review of books, journals, and Internet Web sites. Several recent literature reviews related to this topic have been published. The review here was thus limited to more recent publications and to areas not covered in these previous reviews. A bibliography of relevant journal articles, books, reports and Web sites dealing with older drivers and roadway design is included as Appendix B.

The second section presents the analysis of accident data for persons 65 years and older, provided by the Arizona Department of Transportation, Traffic Records Section, for the three-year period from 1999 to 2001. For comparison purposes, drivers were grouped into three age categories: under 25, 25 to 64, and 65 and over. Accident factors, such as time of day, location, and other variables were compared across age groups. The demographics of older adults and older drivers in Arizona and the types of accidents in which they were involved are presented first. These results are followed by a comparative analysis of the type and severity of accidents in which they were involved and by data on older pedestrian accidents.

The third section contains the results of the survey of older adults. The survey asked older adults to rate Arizona roadways and to indicate their perceptions of additional needs to enhance the driving safety of older adults. This non-random survey was administered through the Maricopa County Area Agency on Aging and its senior center network. Center sites were chosen to represent both the English- and Spanish-speaking communities of older adults and urban, suburban, and adjacent rural areas. Results were entered into a database and summarized into tables for display in this report. The surveys are included as Appendix D.

2. REVIEW OF LITERATURE

INTRODUCTION

Our society is aging, but whether or not older drivers pose a safety problem depends on how the issue is viewed. At least one author suggests that researchers often dissect the attributes of elderly drivers in order to diagnose deficiencies in aspects of their lives affecting driving. As a result of this approach, much of the time, components such as concentration, hand-eye coordination, head and neck mobility, are each isolated and treated accordingly. By so doing, one considers these "synecdoches," parts standing for the whole. (Rothe, Cooper, and De Vries 1990) Such an approach does not fully allow for the older adult's experience, compensation, self-regulation of driving, or other variables that might mitigate the safety-hazards implied by analyzing single components or looking merely at crash rates and population statistics.

Physical declines with age are not contested, nor are the increasing rates of growth of the elderly, especially the very elderly, or the increase in the numbers of older drivers in the coming decades. The degree to which older adults pose a safety risk in the future, however, may be mitigated by other factors, such as more driving experience, the advent of driving assistance devices, safer vehicles, roadway improvements, improved screening or restricted licensing, or technologies yet to be created.

Whether or not one agrees that the growing numbers of older adults indicate heightened risk on our roadways, much of the research reviewed recommends undertaking actions to reduce the risk posed to older drivers and to communities as the population ages. The recommendations also recognize the value placed on transportation to older people, providing access to what is needed for social and emotional well-being. (Carp 1988; Simoes 2002)

This chapter provides a limited synthesis of the vast literature on the topic of older drivers and pedestrians. Several detailed syntheses of this literature (Eby *et al.* 1998; Staplin *et al.* 1999) have previously been completed. Rather than repeat these works, Quantec has summarized their key findings and augmented them with the results reported in more recent literature.

OLDER ADULT DRIVERS

Overall Population

Demographic data clearly document the dramatic shift in the age of the population, with estimates that, by the year 2040, adults aged 65 and older are expected to increase from 33.6 million in 1995 to 70 million (Census 1996). The largest increases are expected in the "over 75" and "over 85" categories. By 2030, it is estimated that:

- The 14.7 million people 75 and older in 1995 could increase to 32.1 million.

- The 3.6 million older adults 85 and over in 1995 could increase to 8.8 million.

The proportion of these age groups within the total population will also increase, with those over 65 increasing from about 13% in 1995 to over 20% in 2030. Between 1995 and 2050, the proportions of those over 75 and over 85 are expected to triple. (Burkhardt and McGavock 1999)

Population of Drivers and Miles Driven

While it is not difficult to identify the numbers of persons of specific ages holding a driver's license, determining the numbers of those still driving is more difficult. This is especially true among older drivers, with the proportion of actual drivers decreasing with each age group. As shown in Table 1, the largest increase in licensed drivers between 1990 and 1996 occurred in the over 85 population. (Burkhardt and McGavock 1999)

Table 1 Estimated Increases in Licensed Drivers

Population	Nationwide Personal Transportation Survey		Federal Highway Administration 1996
	1990	1995	
All 16 and over	89.2%	88.8%	86.4%
65 and over	75.2%	77.5%	75.5%
85 and over	34.4%	40.2%	40.8%

On average, older adults drive more miles annually now than in the past but still average fewer annual miles than other age groups. (Burkhardt *et al.* 1998) This is due in part to retirement and the fact that older adults report driving less to meet their needs. (Glasgow and Brown 1997) Although older adults as a whole reduce their miles driven as they age, the increased numbers of older adults and the increased years they are driving, contribute to the estimate that the total number of miles driven by older adults is expected to increase significantly in the future. A conservative estimate projects the total annual mileage driven by older male drivers to increase from slightly less than 100 billion miles to more than 400 billion miles between 1990 and 2020. During this same time frame, the mileage driven by older women will increase from fewer than 50 billion miles to 240 billion miles, an increase of almost 500%. Overall, by 2030, older drivers are expected to account for 18.9% of all vehicle miles driven, compared to 6.7% in 1990. (Burkhardt and McGavock 1999)

Viewed in a slightly different way, a recent analysis of older drivers in California found that, between 1983 and 1995, daily auto travel increased by 77%, time spent driving by 40%, and the miles driven by 98%. (Wachs 2001) These increases are expected to continue, reaching peak levels between 2030 and 2050.

COLLISION RATES & FATALITIES

Whether older adults compare favorably or unfavorably to other age groups in collision rates and fatalities depends on the choice of statistics. Older adults have very low crash rates per 100,000 licensed drivers, especially compared with drivers under 25. (Glasgow 2000; IIHS 2001) The number of deaths of elderly people related to motor vehicles is few, one percent or less. Per mile driven, however, older adults have higher rates of fatal crashes than any age group except the youngest drivers. Their deaths are due primarily to their fragility, increasing the chance of complications from injuries.

While the number of adults 70 and over involved in fatal crashes increased 33%, from 3,719 in 1989 to 4,934 in 1999, overall traffic fatalities fell from 45,582 to 41,345 during this same period. (TRIP 2002) In 2000, 6,643 people 65 years of age and older died in motor vehicle crashes; this is a 7% drop since 1999, but a 25% increase since 1975. (IIHS 2000)

Projections for fatality rates for older adults in the future vary widely. One study, using the U.S. Fatality Analysis Reporting System (FARS) data from 1975 to 1998, projected that older adults would represent 27% of all traffic fatalities by 2015. (Bedard *et al*. 2001) Another study estimated that by 2030, older adults will represent 25% of the driving age population and 25% of fatal crash involvements. (Lyman *et al.* 2001)

Per mile driven, those 85 years and older have the highest driver fatalities of any age group, and their numbers are the fastest growing among older adults.

Gender Differences

Males of all ages have much higher motor vehicle fatality rates per 100,000 people than females. By age 85 and beyond, the vehicle fatality rate for men is three times as high as that of women. (IIHS 2000) However, given that more women are driving now than in the past, the number of vehicle fatalities involving women 65 and over is expected to rise by 373% between 1975 and 2015, compared to a 271% increase for men of this age group. (Bedard *et al.* 2001)

The number of miles driven is also related to vehicle crashes among older drivers. Reviewing panel data, the influence of mileage driven, the single most important risk factor in crash involvement for both male and females on the likelihood of being involved in crashes was a significantly smaller factor for female than for male drivers. For females, both the amount of annual driving and limitations in "gross mobility" (the inability to raise arms above shoulder height) were the most significant risk factors in predicting crashes. For males, use of antidepressants was the second most important risk, doubling the risk compared to older drivers not using antidepressant drugs. The amount of annual driving was the primary risk factor. (Hu *et al.* 1998)

Urban/Rural Differences

While all Americans are dependent on automobiles for transportation, older adults rely on them to accomplish more than 98% of all surface travel. (TRIP 2002) The older rural population is especially reliant on automobiles, and the number of licensed drivers varies with urban and rural residence and the presence of transportation alternatives. Older women are more likely to limit their driving than are men, and to stop driving altogether; rural older women, however, are more likely to continue driving, probably due to the lack of available alternatives. (Glasgow 2000)

Collision Types: Drivers

Studies in both Europe and the U.S. have shown that driving accident patterns of older adults differ significantly from those of younger drivers. Older drivers, for example, are rarely involved in speed violations or driving under the influence of alcohol. Their main areas of accidents are at intersections or in more complex traffic conditions. (Simoes 2002) The level, per five-year increment, of older driver involvement in multiple-vehicle intersection crashes increases moderately from age 55, more sharply for those 70 and over, and even more significantly for those 80 and older. (IIHS 1991)

Studies of older adults indicate they are more likely to commit certain types of driving violations that lead to collision, including failure-to-yield, disregarding a signal control, driver inattention, and disregarding a stop or yield sign. (Khattak *et al.* 2002) In a review of previous research, the following factors were related to collisions involving older adults:

- Accidents involving turning movement, head-on accidents while turning left, accidents in rural areas at night, and snowy weather. (Stamatiadis, Taylor, and McKelvey 1991)
- Horizontal curves, where driver is going too fast or surprised by curve alignment. (Lyles *et al.* 1997)
- Merging or changing lanes (regardless of ramp versus mainline location), passing/overtaking, running off the road (both to left and to the right), failing to yield. (Knoblauch, Nitzburg, and Seifert 1997; Harkey, Huang, and Zeeger 1996)
- Right angle collisions and head-on/left-turn collisions, collisions at two-phase (no turning phase) signalized intersections. (Staplin *et al.* 1998)
- Multiple vehicles at an intersection, with particularly high risk at uncontrolled and stop sign-controlled intersections. (Preusser *et al.* 1998)
- Left-turning maneuvers at signalized intersections and turning or entering maneuvers at stop-controlled intersections. (HSIS 2002)

Some factors identified, such as higher accident rates on rural roads or in snowy weather, are clearly related to geographic location of the research. Other findings, such as over-involvement of older adults in daylight accidents, or in accidents on dry roads, can probably be accounted for by exposure, since a larger percentage of older drivers conduct more of their driving under these "good conditions" (a result of self-imposed restrictions).

Collision Types: Pedestrians

Older adults are less involved in pedestrian-vehicle collisions than other age groups, but when involved, are more likely to be killed, with rates of fatal accidents increasing after age 75. (Zegeer *et al.* 1993) Adults age 65 and older made up 21% of pedestrian deaths in 2000; their pedestrian-vehicle collision mortality rate is 2.85 per 100,000 person years, higher than that for any other age group. (Harruff, Avery, and Alter-Pandya 1998; NHTSA 2001). The percentage of pedestrian-vehicle collisions resulting in death is 20% for those 70 and over compared to less than 8% for those 14 and under. (Zegeer, Seiderman *et al.* 2002). These pedestrian-vehicle collisions involving older adults are more likely to occur during daylight hours and at intersections. (NHTSA 1998; Tobey, Shunamen, and Knoblauch 1983)

Studies have found several factors associated with pedestrian-vehicle conflicts involving older adults, including:

- Pedestrian not respecting crossing rules, crossing out-of-time with traffic lights, violation of pedestrian right of way by drivers, maneuvers of vehicles (u-turns), violation of red light by drivers, and other reasons such as speed and alcohol use (Simoes 2002).
- Turning and reversing vehicles. (Zegeer *et al.* 1993).

An analysis by Council and Zeeger (1992) of pedestrian accidents showed older pedestrians to be over represented in both right- and left-turn accidents, with those aged 65-74 more often struck by a vehicle turning right and those 75 and over more likely to be struck by a left-turning vehicle.

What Older Adults Say: Issues with Traffic Safety

Older adults are clearly aware of the challenges that age-related changes pose for safe driving. In a follow-up survey administered to a sample of drivers in a crash involvement analysis, older drivers most often mentioned intersection negotiation and changing lanes as driving problems. These same drivers reported not stopping properly at red lights, and especially at stop signs (20%), running amber lights (41%), difficulty caused by sign placement (44%), and size and/or clarity of sign lettering (46%) as issues. The size or clarity of signs posed more difficulty for those 75 and over than did sign placement (Cooper 1990).

In a statewide survey of 664 senior drivers in Illinois (Benekohal *et al.* 1992), respondents identified the following as difficult as they grow older (proportion responding in parentheses):

- Reading street signs in town (27%).
- Driving across an intersection (21%).
- Finding the beginning of a left-turn lane at an intersection (20%).
- Making a left turn at an intersection (19%).
- Following pavement markings (17%).
- Responding to traffic signals (12%).

These same drivers identified highway features that become more important as they age:

- Lighting at intersections (62%).
- Pavement markings at intersections (57%).
- Number of left-turn lanes at an intersection (55%).
- Width of travel lanes (51%).
- Concrete lane guides (raised channelization) for turns at intersections (47%).
- Size of traffic signals at intersections (42%).

In focus groups (Benekohal *et al.* 1992), older drivers reported confusion at intersections with too many islands and difficulty seeing unpainted raised curbs. They also felt there was value to textured pavements (rumble strips) as a warning of upcoming raised medians, approaching signals, and roadway edge or shoulder lane boundaries. These drivers expressed a preference for turning left on a protected arrow phase versus making a permitted-phase turn.

Twenty-five percent of another 692 older drivers surveyed reported that merging onto the highway was difficult, as was finding a gap large enough to merge onto the mainline (Knoblauch, Nitzburg, and Seifert 1997). Of those surveyed, 34% of those ages 50 to 72 and 26% of those 73 to 97, reported that they wished the entrance lanes were longer. Older drivers in other focus groups echoed these responses (Lerner and Ratte 1991), saying that merging onto the freeway was the most difficult maneuver they faced while driving, with many noting that they had trouble maintaining speed to enter the mainline.

In other focus groups (Staplin *et al.* 1997), older drivers reported their most common problems as:

- Difficulty in turning their heads at skewed (non-90 degree) angles to view intersecting traffic.
- Difficulty in smoothly performing turning movements at tight corners.
- Hitting raised concrete barriers such as channelizing islands in the rain and at night.
- Finding oneself positioned in the wrong lane, especially a turn only lane, during an intersection approach, due to poor visibility of pavement markings or the

obstruction of roadside signs meant to inform drivers of intersection traffic patterns.
- Difficulty at the end of an auxiliary (right) turn lane in seeing potential conflicts well and quickly enough to smoothly merge with adjacent-lane traffic.
- Merging with adjacent lane traffic at a pavement width reduction, when the lane drop occurs near (i.e., within 150 m [500 ft]) an intersection) (Staplin *et al.* 2001).

A survey of 1,329 American Association of Retired Persons members 50 and over found that 21% noted difficulty with accurately judging distances in construction zones, as well as negotiating complex work zones, narrow lanes, lanes closures and lane shifts (Knoblauch, Nitzburg, and Seifert 1997).

In focus groups conducted by the Beverly Foundation for the National Highway Traffic Safety Administration (Kerschner and Aizenberg 1999), older drivers in California, Michigan, and Florida were asked to identity, from a list of possible highway actions, three that would most benefit them. Their responses included (proportion of those choosing in parentheses):

- Larger and better-illuminated traffic signs (75%).
- Consistent naming for streets and routes (68%).
- Reflective signs and road edge markings (61%).
- Dedicated lanes and signal cycles for left turns (51%).
- Special driving routes and travel corridors for seniors (11%).

Results from the 2000 Florida Department of Transportation, Satisfaction Survey for Florida Residents, show that of the older drivers (including those 45 and over, with 80% of sample 65 and over) surveyed: (Zhong 2003)

- 38% disagreed with the statement that, in Florida, "At night, the visibility of roadway striping and markings is good."
- 17% disagreed with the statement that "roadway signs are clearly readable."

Some of the comments mentioned by those surveyed included:

- Problems with visibility of street signs/roadways (7%).
- Traffic light problems/timing of lights/not enough lights (7%).
- More public transportation needed (6%).
- Wider roads are needed (5.5%).

AGE-RELATED CHANGES: RISK FACTORS FOR OLDER DRIVERS

As noted earlier, literature reviews on age-related physical and health changes have been undertaken by others (Eby *et al.* 1998; Staplin *et al.* 1999), with the purposes of developing a self-assessment tool for older drivers and identifying older adults most at risk of crashes. Age-related impairments in vison, cognition, and mobility can interfere with the ability to recognize and react quickly - skills required for safe driving. Some age-related areas of change, such as those occurring in reaction time, have received a great deal of research effort, and there is a high level of consistency in the findings; e.g., declines in attention and its influence on driving. Other areas of research, such as the effects of certain medical conditions and medications, are still in their infancy, and the implications for driving much less certain.

In general, the research has seldom included the extent to which older adults adapt to the myriad age-related changes as a variable determining the driving outcomes (crash rates, violations), although there is evidence that they limit driving to safer times and places, drive more slowly and fewer miles, and drive with friends or "copilots." (Kostyniuk, Streff, and Eby 1997; Ball *et al.* 1998; Forrest *et al.* 1997; Marottoli *et al.* 1996; Stutts 1998) No clear evidence, however, exists on whether such self-regulation is, in fact, associated with safer driving or reduced violations or collisions. As more attention is given to assessing older drivers and adapting roadways to their needs, further research is needed on age-related changes, effects of medical factors, adaptation mediating loss, and other factors that affect their driving.

Visual Perception Factors

Increasing age leads to anatomical changes that adversely affect the visual system, both perception and function. These include changes in the amount of light reaching the retina and reduced photoreceptors, making nighttime driving more difficult (Owsley and Ball 1993; Weale 1982; Eby *et al.* 1998; Schieber *et al.* 1992; Schieber 1994); reduced contrast sensitivity and increased sensitivity to glare, making the reading of signs more difficult (Schieber *et al.* 1992); and reduced ability to accommodate, leading to difficulty in near-distance reading, such as dashboard displays. (Owsley and Ball 1993) Older adults also show decline in abrupt or "saccadic" eye movement, resulting in a reduced ability to keep an image on the fovea (a small rodless area of the retina that affords acute vision) when either they or the object of observation is in motion. This suggests that older adults might take longer to locate objects, and further changes in "pursuit" eye movements make it more difficult to resolve the details of moving objects. (Warabe, Kase, and Kato 1984; Sharpe and Sylvester 1978) Restriction in the maximum extent of the gaze without head movement also occurs with age, resulting in the need for older drivers to move their head rather than merely their eyes in order to change focus. (Huaman and Sharpe 1993)

Visual Acuity

Reductions in sensitivity to light and dark adaptation suggest that older drivers would have greater difficulty seeing and recovering sight after having headlights flashed in their eyes. (Eby *et al.* 1998) Age-related reductions in visual acuity - both static and dynamic - make it more difficult to see objects from a distance and to resolve fine detail when there is motion between the stimulus and the observer. (Owsley and Sloane 1990) Decreased visual acuity has also been associated with difficulty driving at night and on high traffic roads (McGwin, Chapman, and Owsley 2000), with adverse driving events, e.g., crashes, moving violations, being stopped by the police during previous 5.75 years (Marottoli *et al.* 1998), and, for low contrast acuity, with correlations between on-the-road performance and time to respond to the acuity stimuli (McKnight and McKnight 1998).

These changes, along with age-related decline in contrast sensitivity, suggest that signage have larger letters, increased illumination, and greater contrast between the letters and the background. (Eby *et al.* 1998; Schieber *et al.* 1992) Decreased contrast sensitivity has also been associated with difficulty in making left turns (McGwin, Chapman, and Owsley 2000). It should be noted, however, that some of these same researchers and others have conducted studies where no association of visual acuity, contrast sensitivity, or ocular disease with motor vehicle crashes was found. (Owsley *et al.* 1998; Margolis *et al.* 2002; Sims *et al.* 2000)

Visual Field

Increasing age also results in shrinkage of the size of the visual field, leading to an increase in crash risk (Schieber 1994). It is estimated that 24% of older driver crashes are due to useful field of view (UFOV) reduction of (40% (Owsley *et al.* 1998). The shrinkage of the visual field is more critical in traffic safety - and in predicting crash risk- when the driver is presented with a distracting task and the UFOV is reduced. (Ball *et al.* 1988; Ball *et al.* 1993; Ball and Owsley 1991; Ball and Rebok 1994; McGwin, Chapman, and Owsley 2000) Glaucoma and decreased UFOV were also found to be independently associated with risk of crash resulting in injury among older drivers. (Owsley, McGwin, and Ball 1998) McGwin *et al.* (2002) found that difficulty driving in the rain, on the interstate, during rush hour, making left-hand turns, and parallel parking were all associated with impaired UFOV.

Other vision changes, such as declines in space, motion, and color perception, have not been consistently identified with age, nor has their influence on driving safety been clearly shown (Eby *et al.* 1998).

Cognitive Factors

Declines in cognitive processes, those involved with receipt, storage, and use of information, are evident with age. Declines in attention, memory, problem solving, and spatial cognition impact the ability to safely and effectively operate a vehicle. Research has indicated a clear association between the first two and increased risk for older

drivers. For problem solving, at least one study showed no evidence that reduced cognitive efficiency in older drivers reduced decision-making quality when compared to younger drivers (Walker *et al.* 1997).

Attention

Two attentional processes have been linked to problems for older drivers: divided and selective attention.

Divided attention, monitoring two or more stimuli simultaneously and performing two tasks simultaneously, is required in numerous driving situations, such as driving while manipulating the radio or talking to passengers, or monitoring driving speed and traffic flow. Under observation, simulation, and actual driving tests, older drivers have been found to experience particular difficulty with situations requiring divided attention, e.g., turning left at intersections or using in-vehicle displays (Staplin *et al.* 1999; Mourant *et al.* 2001; Fox 1998).

Older adults show reduced capability of selective attention, the ability to ignore irrelevant while attending to relevant stimuli or tasks, and of attention switching, the ability to quickly shift one's attention to important stimuli, when compared to younger adults. Numerous studies have identified an inverse relationship between selective attention and vehicle crashes (although at least one researcher suggests that it is the attention switching required rather than sustained attention that is the causal factor) (Parasuraman 1991; Staplin *et al.* 1999). In the Owsley *et al.* (1998) study, selective attention was not, however, associated with crash occurrence.

There are several tests available to measure selective and/or divided attention, including the Embedded Figures Test, the Stroop Test, and the Trail Making Test, Parts A and B (modified). Of these, poorer performance on the Trail-Making Test has been correlated significantly with crash involvements among older drivers in on-road driving exams (Cushman 1992; Janke 1994; Janke and Eberhard 1998) and has been recommended for inclusion in driver screening for relicensing. (Staplin *et al.* 1999)

Memory

Memory, allowing the storage of information, provides drivers with the ability to recall traffic laws, remember driving skills, locations and driving conditions, and safety rules. Although reasons for it are not well understood, studies have clearly shown some memory loss with age, most significantly with short-term or working memory. (*Handbook of Psychology of Aging* 2001; Light 1996) Studies have measured impaired memory by the following:

- Lower scores on immediate word recall (Hu *et al.* 1998).
- Memory task performance (Johansson *et al.* 1996).
- Scores on the Brief Test of Attention, Trails A, and Serials Seven from the Mini Mental State Examination (Keyl *et al.* in press).

- Borderline cognitive impairment, an MMSE score of 23-25 (Marottoli *et al.* 1996).

These have all been correlated with increased crash risk, poor driving performance, and other adverse events, such as violations or being stopped by police. General "cognitive impairment" has also been shown to result in poorer driving performance by older adults, as measured by a drive test and on-road navigation tasks (Janke and Eberhard 1998; McKnight and McKnight 1998).

Other associated declines with age, including problem-solving, have yet to show a relationship with driving ability or risk of crash. Two remaining abilities, cognitive mapping and way finding, decrease with age (Kostyniuk, Streff, and Eby 1997) and these deficiencies may result in driving difficulties for older adults.

Psychomotor Skill Factors

Psychomotor skills involve the ability to move and orient the body. These skills, especially those of the upper body, are essential to safe and efficient driving. Changes with age, such as reduced ability to turn the neck and head, stiff knees, ankles or hips, or reduced muscle strength, may all present challenges for older drivers. Research into these changes accompanying aging has focused principally on reaction time, flexibility, and coordination.

Data clearly linking simple reaction time - one response to one stimulus - and choice reaction time - distinguishing between more than one stimulus and possibly choosing one - have not yet definitively shown a relationship with older driver performance. At issue is the difficulty of measuring reaction time in non-laboratory or simulation environments, i.e., in on-the-road tests. Flexibility, particularly limited neck range of motion in older adults, has been associated (self-reported) with adverse driving events (Marottoli *et al.* 1998; Staplin *et al.* 1999) and with impeded ability to scan to the rear, back up, and turn the head to observe blind spots (Janke 1994). Coordination, or precision of movement, is also involved in efficient driving. While coordination has been shown to decline with age, evidence that these deficits affect driving has not been established (Staplin *et al.* 1999).

HEALTH FACTORS

Older adults are more likely to suffer from health problems than are younger persons. The association between certain medications, physical limitations, and medical conditions and motor vehicle crashes and other driving difficulties, however, are controversial, with studies limited by small sample sizes, cross-sectional or retrospective study designs, and/or self-reported data (Margolis *et al.* 2002). Ascertaining the effects of these factors on driving safety and the need for testing of these potential risk factors among older adults continues to challenge researchers as the population ages and the prevalence of these factors increases.

Medications

Table 2 summarizes some of the limited data on medications that may impair the safety of the older driver and characterizes the drug classes by strength of the research evidence raising concern about their use among older drivers. It should be noted that this review is dated by almost a decade and its authors noted at the time the limitations of the studies they examined, including the use of young subjects rather than elders to test effects on driving, the number of studies completed in Europe rather than the U.S., and the lack of knowledge of the studies' design choices.(Eby *et al.* 1998) We identified only limited recent research to follow-up these earlier, controversial studies.

Table 2 Summary Showing the Strength of Evidence that Specific Medications Impair the Safety of Older Drivers[1]

Medication	Psychomotor Impairment	Increased Crash Risk
Benzodiazepenes	**Compelling**	Strong
Cyclic antidepressants	Strong	Weak
Opiods	Weak	Little data
Antihistamines	Weak	Little data
Insulin	Strong	Weak
Sulfonylureas	Weak	Little data

Medical or Age-related Conditions

Vision

The presence of cataracts has been associated with reduced traffic safety among older drivers. The presence of cataracts contributes to deficits in acuity and increased sensitivity to glare. While some research has found cataracts associated with crash risk, recent research has identified a reduction in risk due to surgical intervention.

- In a study following drivers 55 and over with cataracts after cataract surgery and a control group having no corrective surgery, the authors found that those who had cataract surgery had almost half the subsequent crash rate over the 4-6 year period following surgery compared with those who did not choose surgery. During this same follow-up period, the crash rate for those having the surgery increased 27%, compared to a 75% increase for those who decided against surgery. Even considering possible explanatory variables, such as higher rates of night driving among the control group, the authors conclude that surgical intervention to improve vision could have widespread benefit to driver safety. (Owsley *et al.* 2002)

[1] (Eby et al. 1998)

- Similar findings were noted in a pilot study investigating the relationship between levels of cataract development and legibility of roadway signs at night. The authors reported that subjects with early cataracts and significant cataracts identified fewer signs correctly for all sign luminance levels, with and without glare present, than did subjects with no cataracts and subjects who had cataracts surgically removed. There was little difference in visual performance when comparing subjects with no cataracts to post-surgery subjects. The study found that all subjects, at any stage of cataract development, have a functional disability when reading highway signs at night. This visual disability is more severe for low sign luminance levels.(Carroll *et al.* 2002)
- Those with cataracts were two times more likely than those without cataracts to reduce the number of driving days per week and number of destinations, and were four times more likely to report driving difficulty in the rain, high traffic, rush hour, and at night, driving alone, making left turns across traffic, and driving on interstate highways. Adjusted for driving exposure the association between cataract and at-fault crash involvement was defined as a "relative risk" of 2.48, with 95% precision and confidence interval of 1.0-6.14. (Owsley *et al.* 1999)
- In a program to identify drivers with cataracts and administer a special exam (which most often resulted in the imposition of driving restrictions), older drivers with cataracts had a pre-exam crash risk rate 1.33 times that of the control group of drivers without medical conditions and 1.46 times higher than that of all licensed drivers in Washington state. After the exam, these rates dropped substantially - below that of the general population of drivers, with the authors attributing this result to lower exposure with increasing age and the reductions imposed after the exam (Salzberg and Moffat 1998).

Other vision impairments associated with driving difficulty among older adults include:

- Near vision impairment was associated with reported driving difficulty and reduced driving frequency - three or fewer days per week (Lyman, McGwin, and Sims 2001)
- Glaucoma was significantly associated with crash risk (independent of visual functional problems), with a stronger relationship for males than for females (Owsley *et al.* 1998). In another study glaucoma was independently associated with crash risk, with crash cases 3.6 times more likely to report glaucoma than those in the control group (Owsley, McGwin, and Ball 1998). Glaucoma was the only medical condition shown to increase crash risk in a rural health panel study, and was evident only among older male drivers (Hu *et al.* 1998).

Dementia

Alzheimer's Disease (AD) is the most common cause of dementia, but behaviors identified as dementia can also be due to long-term alcohol use, multiple strokes, cardiac insufficiency, and nutritional imbalance, among other factors. The literature is ambiguous regarding the risk of drivers with dementia. While drivers have been shown to be at increased risk for crashes (Johansson *et al.* 1996), especially in more advanced stages of

the disease, many self-regulate their driving, driving fewer miles or only on familiar routes, or stop driving altogether (Staplin *et al.* 1998). Other studies have shown that even those with mild dementia were more likely to be classified as "unsafe" using a standardized road test than were drivers with no dementia (Hunt *et al.* 1997a, 1997b). Salzberg and Moffat (1998) evaluated the driving records of older drivers with various psychiatric conditions (such as Alzheimer's, bipolar disorders, other dementia, confusion/memory loss). For the 30% of the drivers who passed a special exam, usually resulting in restrictions on their driving, the restrictions resulted in reduced collision and violation rates, but the group rates still exceeded by four times the rates of the control group of drivers without psychiatric conditions.

Heart Disease and Cardiopulmonary Disorders

The impact of cardiac and related pulmonary disease on driving safety and risk of crash among older drivers has not been conclusively determined. As with research on the effects of medications and other medical conditions, the studies showing significant effects have suffered from small sample sizes, self-reported data collection techniques, and retrospective designs. (Eby *et al.* 1998) One recent prospective study did identify increased systolic blood pressure drop as one of several motor vehicle crash risk factors for the women studied. (Margolis *et al.* 2002)

Other reviews have identified no increased societal risk associated with drivers with cardiovascular disease (Janke 1994) or conflicting assessment of risk for drivers with unique cardiac conditions, such as syncope, a sudden and transient loss of consciousness. For the latter, there is a lack of agreement on whether adults who have experienced syncope should drive. But for this, and for other conditions, such as heart attack, there is some indication that a 3 to 7-month waiting period before driving is necessary to reduce crash risk (Janke 1994; Sheldon and Koshman 1995). While at least one study showed increased risk among drivers with cardiovascular disease and unrestricted licenses versus those with driving restrictions, the study did not account for exposure, particularly the self-regulated reduction in driving by those with restricted licenses (Diller *et al.* 1999).

Parkinson's Disease

One early study found that the presence of Parkinson's disease does affect reaction time. The relationship varies, however, with the onset of medication, leading the authors to recommend that the timing of screening or assessment of reaction time and other psychomotor function is especially critical, since medication can improve the slowness of movement associated with the disease (Poser 1993).

Stroke

Stroke has been associated with cessation of driving (Campbell, Bush, and Hale 1993; Marottoli *et al.* 1993; Stewart *et al.* 1993), with reported difficulty with driving (Lyman, McGwin, and Sims 2001), and with crashes (Sims *et al.* 2000). Assessing the risk of stroke for driving safety, however, is dependent upon assessing the outcome of the stroke

on cognitive and functional capabilities. These outcomes vary widely, as does the research on the effects of various cognitive processes (see above). Thus definitive testing for stroke-related activities remains complex.

Functional impairments/functional status

Functional status and the associated activities of daily living have been related to driving behavior and risk of crash in older adults. Specifically, the research indicates:

- The ability for self-care is associated with reduced driving frequency. (Gallo, Rebok, and Lesikar 1999; Lyman, McGwin, and Sims 2001).
- Older adults reporting difficulty with opening a jar and performing light housework had elevated crash risks. (Sims *et al.* 2000).
- Several activities, including difficulty using stairs, walking at least a quarter mile, carrying a heavy object, and feeding one's self, were associated with driving three or fewer days per week - reduced driving frequency. (Lyman, McGwin, and Sims 2001).
- Falls are associated with decreased mileage driven (Forrest *et al.* 1997), reported difficulty driving (Lyman, McGwin, and Sims 2001), and crash risk (Margolis *et al.* 2002).

Arthritis, Bursitis, and Back Pain

Arthritis is the most common cause of reduced flexibility and joint pain in older adults (Roberts and Roberts 1993) and maybe involved in the reduced flexibility of the neck noted earlier. Bursitis, most common in the shoulder, has also been associated with traffic crashes (Stewart *et al.* 1993), but occurs in a very small number of older adults. Other research found a significant association between crash risk and persistent back pain. (Hu *et al.* 1998; Foley, Wallace, and Eberhard 1995)

Diabetes and Related Disorders

Much of the earlier research (1960s through early 1980s) could not take into account advances in pharmacology and technology for controlling the effects of the disease and more recent research has noted that the small population may not warrant increased assessment for driving risk. More recent research, however, shows some risk, but also effective interventions to reduce this level among older adults.

The research on diabetes, like that on dementia, and its impact on driving risk is made more complex by the varying course the disease takes in individuals. For example, Owsley *et al.* (1998) found a significant association between crash risk and a diagnosis of diabetic retinopathy from the time of subject enrollment to a three-year follow-up. Others found injury risk in crashes involving elders to be 2.6 times higher for diabetic drivers, and higher for those treated with insulin, having diabetes more than five years, of having both diabetes and coronary heart disease (Koepsell *et al.* 1994). Salzburg and Moffat (1998) found, in their study using a very small sample size of drivers tested and referred

to, and passing a special exam, that the drivers with diabetic retinopathy and diabetes mellitus had a pre-exam crash risk rate 3.2 times that of the control group of older drivers without medical conditions. Their pre-exam risk rate was 3.5 times higher than for all licensed drivers in Washington state. After the exam, and the restrictions imposed on these older drivers with diabetic complications, their risk dropped below that of the control group, a change attributed by the authors to reduced exposure.

In another model for assessment, the AMA recommends dividing patients into three levels, based on the probability of loss of consciousness, based on a one to three year history and number of episodes. These levels may vary over the life span and with medical intervention. Driving assessment and restriction could, however, be tied to the drivers identified level. (Eby *et al.* 1998)

RECOMMENDATIONS

The following discussion of recommendations is taken from the literature, but should not be viewed as definitively representing the findings of our own research. [See Conclusions, p. 46 for a summary of recommendations based on the literature review, data analysis, and survey results undertaken in this project.]

Assessing Drivers

The assessment and possible restriction of drivers is an issue fraught with complexity. Many older drivers, as shown in the research reviewed above, recognize limitations occurring as they age and self-restrict driving. For many older adults, especially those residing in rural or large suburban areas without effective transportation alternatives, automobile travel is essential to meet daily needs, including socialization. Concern has been voiced about wholesale restrictions based on age. Bedard *et al.* (1997) note that imposing restrictions on all older adults would not maximize the independence of older adults and also ensure public safety. While the abilities of some older adults will decline below acceptable thresholds, those of others will remain above these thresholds for their entire lives. Others have cautioned that when making decisions to assess and/or to restrict driving, the increased risks associated with age or certain conditions should be compared to other driving risks generally accepted by society (Epstein *et al.* 1996).

Still, with the growing number of older drivers and research indicating clear risk associated with a variety of age and medically-related conditions, states, along with local community and private sector organizations, have developed approaches to screening and education/counseling efforts. Many of these were described in the Safe Mobility for Older Drivers Handbook (Staplin *et al.* 1999) and are not described individually in this literature review. Based on the Staplin *et al.* (1999) review, a "model" program outline was put forth. Key components included:

- Community and private sector organizations/professionals have a major role in identification of at risk drivers and will, within the limits of privacy and confidentiality, report the status of referred drivers back to external sources.
- A licensing agency itself may also identify at-risk drivers, using pre-screening devices (such as objective and standard criteria on forms, observation by counter personnel), history of crash or violations, age, or selective sampling of drivers for special screening using criteria such as age and crash rates.
- Once pre-screening occurs, all, including special populations, would enter a "first-tier" functional screening process. In this process, measures of gross impairment, vision, and knowledge of road tests would be used to screen the most obvious incidences of drivers with serious physical or mental limitations. Testing should take less than five minutes, be easily administered by existing staff and in existing facilities, and require no special equipment. Those not passing this level of screening would typically receive restrictions on or loss of driving privileges. Others passing this first level, but by a marginal rate, could be identified for further screening.
- The "second tier' testing would screen for more detail regarding medical conditions, cognitive function, and more subtle functional impairments. This level of screening might be conducted by an agency external to the licensing organization, and by physicians and other providers, who would all use uniform reporting procedures. Results for drivers will vary and individuals may be "tagged' for retesting given chronic or deteriorating conditions, advanced age, or other indicators of risk.
- The model calls for education and counseling for all test recipients, including referrals to available transportation alternatives, materials outlining strategies for compensating aging or disease-related losses, and self-testing materials to monitor their own driving performance.

In addition, the Staplin *et al.* (1999) review highlighted specific areas of testing and possible approaches, based on given age-related or medically related changes in older adult drivers. These, along with other recommendations identified, are shown in Table 3.

Other assessment recommendations identified include:

- Testing for the right to drive more frequently and more stringently, including the possibility of "tiered" testing to screen people for impairments significantly related to driving (reaction time, visual and cognitive performance); multiple testing given to those with low scores. (Wachs 2001)

- Studying results of efforts in Maryland and other states to train health care professionals about age-related driving issues. (Wachs 2001)

Table 3 Assessment of Older Drivers: Review of Recommendations

Assessment- Condition	Recommendation/Potential for Research	Source
Alzheimer's Disease and Associated Disorders	MMSE Score 10, plus diagnoses of dementia: immediate cessation of driving Diagnoses of Alzheimer's Disease 2 years or more: monitoring and rescreening	(Lundberg *et al.* 1997) (Staplin *et al.* 1999)
Cataracts	Special exam coupled with driving restrictions (at night/dusk; fog/rain) Physician counseling regarding restricting night/rain/fog driving	(Salzberg and Moffat 1998) (Staplin *et al.*1999)
Diabetes & Associated Conditions	Physician counseling regarding importance of compliance with treatment and recommendation of individually tailored driving restrictions	(Staplin *et al.*1999)
Falls	Physician assessments should include falls in patient history Licensing agencies should include question about falling on license renewal applications	(Staplin *et al.*1999) (Staplin *et al.*1999)
Cardiac and Cardiopulmonary Conditions	Physician recommendation of 3-7 month period of driving cessation following incidence of arrhythmia, syncope	(Janke 1994; Sheldon and Koshman 1995)
Arthritis, Bursitis, Back Pain	Physicians should include question about bursitis in patient history Licensing agencies should include question about bursitis on license renewal applications and questions about symptoms associated with arthritis/back pain (stiffness, immobility, pain level)	(Staplin *et al.*1999) (Staplin *et al.*1999)
Assessment: Age-Related Changes		
Contrast Sensitivity	Test slides available for DMV-model vision screener devices/wall charts/computer displays of test stimuli UVOV protocols in test of cognitive status for licensing renewal applications	(Staplin *et al.*1999) (Staplin *et al.*1999; Kline 2002)
Attention/Speed of Processing	Licensing agencies should implement Trail-Making protocol or other paper/pencil or computer-based protocols for testing gross deficits in attention and information-processing abilities for licensing renewal applications	(Staplin *et al.*1999)
Perceptual Skills/Visual Search	Licensing agencies should implement Trail-Making protocol for licensing renewal applications	(Staplin *et al.*1999)
Cognitive ability	Licensing agencies should use simulators to test those recovering from strokes, cerebral vascular disorders, and those with progressive cognitive disorders	(Staplin *et al.*1999)
Navigation errors	Licensing agencies should implement on-road driving tests for older drivers referred for reexamination	(Staplin *et al.*1999)
Maneuver Errors	Licensing agencies should include, in road tests for older driver reexamination, conditions and maneuvers problematic for drivers with cognitive decline; scoring errors should not penalize drivers for errors that do not discriminate between impaired and unimpaired.	(Staplin *et al.*1999)

In a recent approach to assessment, the state of Oregon, after studying the effects of aging on driving ability, approved HB 3071 in 2001. The bill states that determinations regarding a person's ability to safely operate a motor vehicle may NOT be based solely on diagnosis of a medical condition, but must be based on the actual effect of a cognitive or functional impairment on the person's ability to safely operate a motor vehicle. A

Medical Work Group, comprised of both physicians and health care providers, worked in consultation with the Department of Motor Vehicles (DMV) to identify cognitive and functional impairments likely to affect a person's ability to safely operate a motor vehicle, and to require physicians and health care providers to report a person demonstrating these impairments to DMV. Providers will be required to report functional and cognitive impairments:

- Severe and/or uncontrollable to a degree that precludes (or may preclude) the safe operation of a motor vehicle.
- Those that cannot be corrected by medication, therapy or surgery; or by driving device or technique.

DMV will phase-in the new mandatory medical reporting process beginning May, 2003 in six Oregon counties. Additional counties will be subsequently phased-in over the course of one year, until the new Administrative Rules (Transportation 2003) are operational throughout the state.

In an education project related to assessment, staff at the University Transportation Center for Alabama (Owsley 2001) examined the current system for dealing with drivers with diminished capabilities to identify ways of enhancing the system in order to reduce the state's high injury and fatality rates. The state currently has no re-screening process for persons holding an Alabama license. Two resource guides resulted from the project. The first targeted Medical Unit staff that review cases referred to them by law enforcement officers, private citizens or physicians. The resource guide provides information on common functional impairments that impact driving, a list of state resources available to assist persons with these impairments, and articles from the research literature to guide the Medical Unit staff in making decisions about driver abilities. The second resource guide is a pamphlet and accompanying pocket guide for educating law enforcement officers about the types of impairments that can impact driving and how these manifest themselves on the road as unsafe driving practices. The impact of this educational intervention has not yet been evaluated.

Self-Assessment

Given that many older adults are aware of challenges to their driving ability with age, and many self-restrict their driving based on age-related changes, self-evaluation of older drivers appears to be one of the least costly, most easily implemented interventions for reducing risk among older drivers. A recent project focused on the development of a comprehensive self-evaluation tool for older drivers, based on research from a review of the literature, focus groups with older adults, and input from a panel of experts (Eby *et al.*

2000). The researchers began with a model including five components of self-evaluation[2]:

- Health factors/drug use (general health and medical conditions, medications, drug and/or alcohol use).
- Driving abilities (perceptual, cognitive, psychomotor abilities).
- Driving skills.
- Driving experiences (incidents or lack thereof, including near-crashes, crashes, tickets, speeding with no consequences).
- Appraisal of driving (cognitive appraisal, including perception of self as a good driver, fear, concern over driving ability).
- Outcome of driving decisions, such as when or where to drive, what speed to drive, and other strategic and tactical decisions.

In reviewing these components and applying them to the older driver, the researchers specified this model as shown in Figure 1.

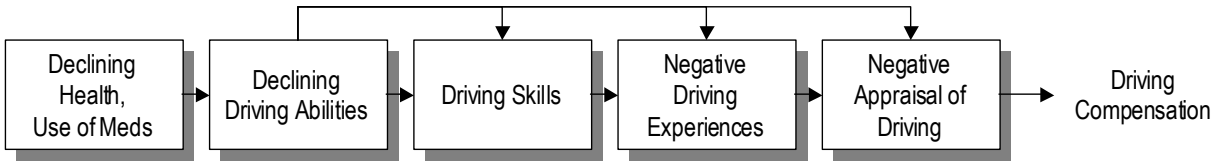

Figure 1 General Model of Influences on Driving Applied to the Older Driver[3]

The researchers compared the responses on the self- evaluation instrument - the Driving Decisions Workbook - against scores on a short survey; the MMSE; the Gross Impairment Screening Battery (Staplin *et al.* 1999),which includes several tests of cognitive, perceptual and psychomotor abilities, such as the Trail Making A and B, head/neck rotation, and others; and results from a short on-road course testing thirteen maneuvers, such as turns, lane change, and backing up.

Results from this research suggest that the workbook is useful to older drivers, increasing general knowledge and self-awareness, self-reported indications of plans to change driving behavior, increased likelihood of seeing a doctor about some declining ability, and consideration of taking a driving refresher course. Testing of the workbook continues, but the research does indicate that a relatively simple tool can have impact on behaviors older adults can take to reduce their risk of driving incidents.

[2] See Eby et al 2000, page 11 for further detail on assessment domains

[3] Eby et al. 2000.

Enhancing the Driving and Walking Contexts

Based on the volume of research concerning the needs of older drivers, at least two recent handbooks delineate detailed recommendations for roadway and pedestrian improvements to accommodate older drivers. (Staplin *et al.* 2001a, 2001b) As the authors note, these documents are meant to supplement existing standards and guidelines in the areas of highway geometry, operations, and traffic control devices. As noted by the authors, the recommendations included in these volumes are "directed toward new construction, reconstruction, scheduled maintenance, and spot treatments to ameliorate demonstrated safety problems, emphasizing countermeasures with model additional cost during installation and the potential for cost savings over the life cycle" (Staplin *et al.* 2001b). The two handbooks should be included in the library of ADOT, available to highway designers, traffic engineers, and highway safety specialists. Both are available on-line and in hard-copy; see Appendix A for information on accessing/ordering documents.

The recommendations contained in these books are not re-stated here; nor are detailed drawings or photographs included (these are available in both guidebooks cited). Rather a summary of the areas of improvement recommended in these books, as well as by international researchers (Simoes 2002), is provided.

In general at intersections, older adults require:

- Protected turns.
- Increased visibility at intersections [all-way stops can be installed where there is a high rate of crashes; roundabouts cut collisions by 40%]. (IIHS 2002)
- Adequate roadside information at an intersection approach (a separate signal to control movements in each lane of traffic is recommended).
- Roadway design for easing the task, such as avoidance of skewed intersections (right-angles are better) and a minimum brightness ratio of 2 between painted edge of roadway and the road surface if lighted (contrast of 3 if no lighting).

When driving onto or off of highways/freeways, older drivers need:

- Advance information with adequate size, lighting and glare protection.
- Road design that allows an increased distance to merge with traffic.
- Separated slip roads to drive into or out of highway traffic.

In construction zones, older drivers need advance and clear roadside information, including increased distance to change or merge lanes with lane closures. At railway crossings, clear and advance warning is needed. In general, older drivers need good visibility, clear information, and advanced warning.

Based on the literature reviewed in this section, three priority areas of modification were identified. That is, if only some changes can be made to roadways and pedestrian

walkways due to budget constraints, the need to incorporate design changes gradually into re-designs or new projects, or other factors, the following should receive priority:

- "Modification of left-turn phase indicators for better understanding, consistency in signal indication and sequence for protected/unprotected left-turn-phasing, or elimination of sight-distance restrictions." (HSIS 2002)
- Other intersection enhancements, including larger and better-illuminated signs and devices for lane assignment on intersection approach.
- Improved signage, both in size, lighting, and contrast, and advance notification of required tasks (e.g., merge, on-ramp, exits, four-way stops) on all roadways.
- Pedestrian crossing design improvements, including increased time at crosswalks, median refuge islands, more frequent pedestrian opportunities, and placards explaining pedestrian control signals.[4,5]

It should be noted, however, that new research continues to test the technical means of implementing some of these changes. A recent Florida report presented the results of a study whose goal was the evaluation of various traffic control devices to determine their effectiveness for older drivers. This project field tested existing improvements or those currently being implemented throughout the state, evaluated the effectiveness of two types of enhanced traffic control devices (a new font and new pavement marking materials), and assessed the feasibility of evaluating traffic control devices using simulation. Study results showed very definite advantages in the use of larger lettering on signage, as well as the use of wider pavement markings (stripes) and raised pavement markers. No definite advantage was shown for offset left turn lanes over conventional left turn lanes under the conditions tested. Other findings included:

- Clear View font was found to yield significantly greater legibility distances than the other fonts for advance street name signs but not for ground-mounted street name signs.
- No significant differences were found in the absolute or comparative visibility of the new lane markers evaluated. The authors attributed this result to the newness of materials whose luminance contrast exceeds by far the minimum requirements for reflectivity of these materials and recommend that a more stringent evaluation would test these stripes at regular intervals to determine if and when older drivers distinguish a difference among them before the end of their service life. (Guerrier and Fu 2002)

In another look at pedestrian crosswalks, research focused not only on placement but additional variables in an analysis of 5 years of pedestrian crashes at 1,000 marked

---

[4] For further consideration in prioritizing recommendations, see Florida's Elder Road User Program, in which the DOT delineates short and long-term implementation plans for design improvements; http://www11.myflorida.com/trafficoperations/temanual/Chap6/6.1pdf.

[5] Other suggestions for making pedestrian travel safe and accessible include adopting legislation for upgrading the urban pedestrian infrastructure and developing more walking alternatives in all communities.

crosswalks and 1,000 matched unmarked comparison sites. None of the sites had a traffic signal or stop sign on the approaches. The study found that:

- On two-lane roads, the presence of a marked crosswalk "alone" at an uncontrolled location was associated with no difference in pedestrian crash rate, compared to an unmarked crosswalk.
- On multi-lane roads with traffic volumes above about 12,000 vehicles per day, having a marked crosswalk alone (without other substantial improvements) was associated with a higher pedestrian crash rate (after controlling for other site factors) compared to an unmarked crosswalk.
- Raised medians provided significantly lower pedestrian crash rates on multi-lane roads, compared to roads with no raised median.

The authors recommend more-substantial improvements to provide for safer pedestrian crossings on certain roads, such as adding traffic signals with pedestrian signals when warranted, providing raised medians, speed-reducing measures, and other approaches (Zegeer, Stewart *et al.* 2002). These findings are supported by recent research noting that crosswalks alone do little to protect older pedestrians at urban intersections (Koepsell *et al.* 2002).

These studies, like other recent work investigating several issues concerning the relationship of fixed lighting parameters to the safety and comfort of older drivers (Mace and Porter 2002), highlight the evolution that continues in addressing the needs of older drivers through modification in design and operations. These more recent studies also highlight the importance of looking not only at single interventions, but rather examining sometimes complex, multi-dimensional design modifications that may be necessary to significantly improve the safety of older drivers.

Education for Older Adults

Support for educating older drivers regarding age-related changes, recommended accommodations, need for assessment, and other factors that can help them remain safe and effective drivers (or to limit driving if necessary) is growing. Among the specific recommendations are:

- Consider elderly driver training concerning specific gap-judgment problems should be considered. (HSIS 2002)
- Implement the Motor Vehicle Useful Field of View Program training might be an effective means of assessing and enhancing many of the functional psychomotor tasks required by senior drivers. (Klavora and Heslegrave 2002)
- Evaluate current drivers' training classes for older adults and develop various forms of training and education to address the diverse needs of older drivers. (Wachs 2001)

Driver Education and Assessment: Summary

The literature confirms that most states use some combination of "no renewal by mail", reduction in intervals between licensing, vision testing, on-road driving and knowledge re-testing to address age-related impairment in their license renewal requirements for older adults. The number of assessment components often increases with age. (Staplin *et al.* 2001b) As previously described, suggestions for enhancements to current assessment efforts focus primarily on measurement of cognitive impairment, using on-road driving tests tailored to those areas that most discriminate the problems of older drivers, and use of the Trail Making protocol to discern memory and cognitive impairments related to crash risk at the time of screening for relicensure (Staplin *et al.* 1999).

FUTURE POSSIBILITIES

While not specifically related to roadway and pedestrian modifications, there is a growing literature on the potential of technology to assist older drivers. A particular area of focus is the difficulties older drivers face in carrying out navigational tasks while simultaneously maintaining safe control of the motor vehicle. Advanced technologies such as in-vehicle route guidance and navigational displays are seen as having the potential to improve safety and mobility if designed in accordance with the abilities of older drivers.

Some research has focused on the use of vision enhancement systems to help drivers see critical hazards and the roadway during low-visibility conditions. These systems are typically implemented in head-up displays that present information on the dashboard or windshield (Caird 2001). A European study conducted an evaluation of a route guidance system, in which the driver enters a destination and is then guided along the determined route by vocal and visual indications on a color screen. Results determined that the timing of the information supplied, updated road network information, and symbol size and character are important components for a system designed to assist older adults. Overall, older drivers showed a high level of willingness to use such systems. (Marin-Lamellet and Dejeammes 1995) Another study of the use of an advanced traveler information system in the U.S., however, found that older drivers, compared to younger subjects, were less accurate in obtaining information from the in-vehicle display, made lane-position errors, and spent more time driving outside their lanes. (Mourant *et al.* 2001) Other vehicle design changes, such as radar warning of oncoming vehicles (HSIS 2002), have also been mentioned.

Whatever the technology, there are implications for licensure testing and renewal (methods would have to assess the driver's ability with and without the technical assistance systems) and for the systems of the departments of transportation (roadway network information systems would need to be kept current and in formats allowing for communication with companies supporting in-vehicle technology).

3. ANALYSIS OF COLLISION DATA

INTRODUCTION

As part of the overall examination of the needs of older drivers in Arizona, Quantec staff analyzed accident data for persons 65 years and older, provided by ADOT, Traffic Records Section, for the three-year period from 1999 to 2001. The original research plan called for an examination of data for five years prior to the project. While ADOT provided Quantec with accident data for 1997 and 1998, they were extracted from a database that was replaced in 1999 and included age data that was unreliable.[6] Thus, the analysis reported here includes only data from the three years in which driver age was reliable.

Throughout this chapter, "drivers" refers to those drivers that were involved in an accident. Using this term implies no assumption of causality, merely involvement.

METHODOLOGY

Data were extracted from an Access database and linked at the person and accident level. Analysis was primarily conducted at the driver level, with linked accident-level data used where appropriate. Drivers with reported ages younger than 16 or older than 101 were dropped from the analysis. For comparison purposes, drivers were grouped into three age categories:

- Under 25.
- 25 to 64.
- 65 and over.

For the bulk of age comparisons (and unless stated otherwise), the youngest group was not included, as a wealth of literature indicates that the accident patterns of younger drivers differ substantially from their older counterparts.

For many variables in the database, meaningful analysis was not possible, primarily due to missing data (for example, 99.4% of the observations for the variable "Familiar" are missing for older drivers). A discussion of the variables not used, and the reasons for their elimination from the analysis, appears in Appendix B.

To address whether older drivers in Arizona differ significantly from comparable drivers in other western states, Quantec collected accident data for older adults in both Washington and Oregon for the same time period. Where possible, and appropriate, we

---

[6] The database prior to 1999 defaulted to a birth year of 1912 (corresponding to Arizona's statehood). This resulted in 16,333 drivers involved in accidents appearing to have been born in 1912 for 1997 and 1998 combined. For 1999 – 2001, no single birth year for drivers over the age of 85 has more than 300 members.

compared the Arizona data to that of these other western states. As expected, there were few database variables across the three states with exactly the same names and variable codes, thereby limiting the comparisons. We also sought to draw comparisons to national data, such as that in the FARS Database. FARS data, however, includes only fatal accidents; fatal accidents represented only 0.8% of all accidents involving older drivers in our study. We did not attempt to provide comparisons with FARS given this small sample in the Arizona database.

Given the goal of describing the accident behavior of the older drivers, we calculated frequencies and chi-square statistics for all variables. For every variable where age of driver was included, the differences between younger and older drivers was significant at a level greater than 0.0001.[7]

RESULTS

The demographics of older adults and older drivers in Arizona and the types of accidents in which they were involved are presented first. These results are followed by a comparative analysis of the type and severity of accidents in which they were involved and by data on older pedestrian accidents.

Demographics

As indicated in the literature review, concern exists over the growth of older adults as a larger share of the total population, a result of increasing life expectancies and declining birthrates. The trend, however, is not apparent in the past decade in Arizona. As Figure 2 shows, persons over the age of 65 comprised roughly 13% of Arizona's population in both 1990(Census 1990) and 2000(Census 2000). The state's "snowbird" population[8] is not accounted for in this data.

As Table 4 indicates, while the overall population 65 and over did not grow as a percentage of the total population, the older population is "aging," with an increasing percentage of older adults in the over 75 and over 85 age categories.

---

[7] When comparing datasets the size of the ones used in the current study, they would need to have nearly identical distributions to not have significance. If two relatively small samples have significantly different distributions, their chi-square statistics will be large. Similarly, as the sample sizes increase, the difference in distributions can decrease while maintaining the large chi-square statistic. However the level of significance apparent in this analysis indicates both large sample size and significantly different distributions.

[8] Snowbirds are older adults establishing temporary residency in Arizona during the winter months, numbering roughly 300,000 in 2001(http://www.cob.asu.edu/seid/cbr/AZBpdfs/AZB_0108.pdf)

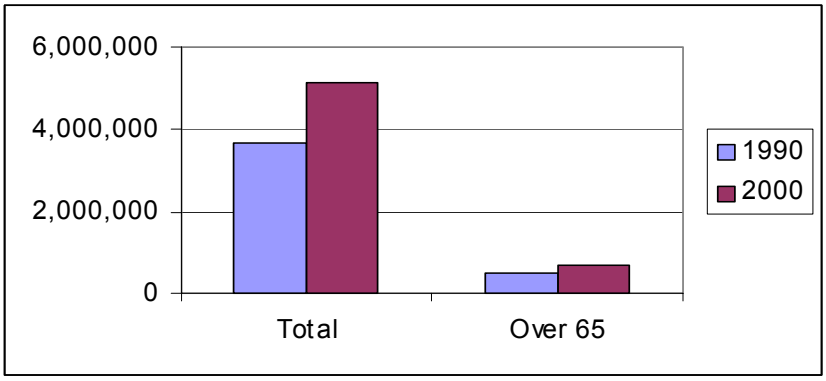

Figure 2 Older Adult Population of Arizona – 1990 and 2000

Table 4 Population Change by Age: Arizona 1990 and 2000

	Total Population	65 +	% of Total Population	75 and Over	% of Total 65+	85 and Over	% of Total 65 +
1990	3,665,228	478,774	13%	188,730	39%	37,717	20%
2000	5,130,632	667,839	13%	303,998	46%	68,525	23%

As shown in Figure 3, 8% of the 1.1 million drivers involved in accidents in Arizona between January 1999 and December 2001 were aged 65 and over.

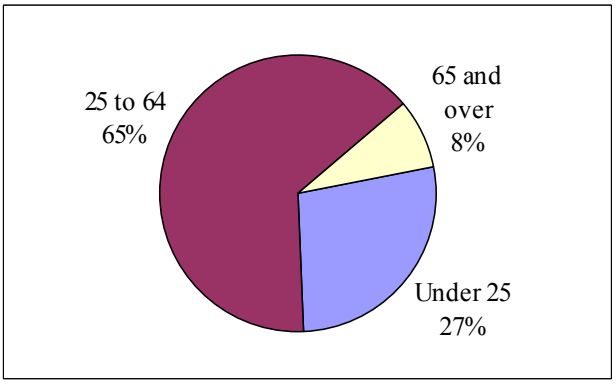

Figure 3 Age Breakdown of Drivers Involved in Accidents 1999 – 2001

As shown, Table 5, the number of older drivers involved in accidents showed a slight decline between 1999 and 2001.

Table 5 Number of Drivers Involved in Accidents by Age and Year

	1999	2000	2001
65 and over	18,221	18,253	17,636
Under 65	208,962	217,511	211,228
65 and over, % of Total	8.0%	7.7%	7.7%

Males make up 63% of the older drivers involved in Arizona roadway accidents, a larger share than that found among younger drivers (Figure 4). This difference may be related to the finding noted in the literature review indicating that older males relinquish their licenses later in life and at a lower rate than do older females. The gender breakdown of older drivers in Arizona is similar to that found in Oregon (62% of drivers over 65 in Oregon were males).

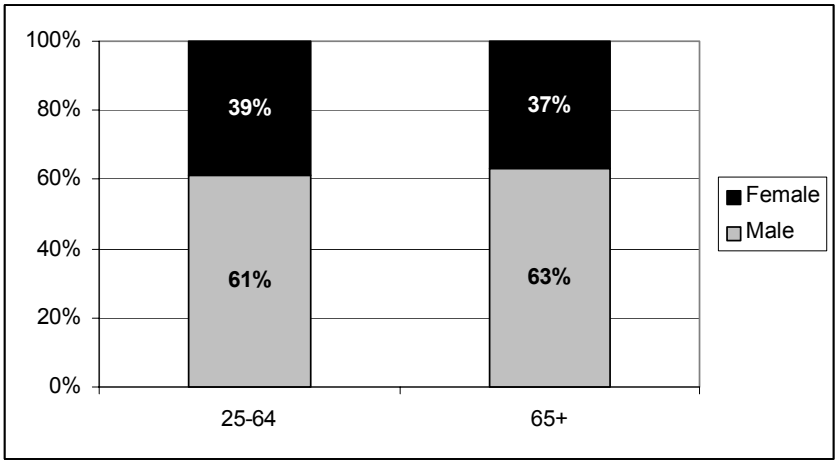

Figure 4 Gender of Driver by Age Cohort

Slightly more than 84% of older drivers involved in accidents in Arizona during the three-years examined were residents of the state. The remaining drivers represent all 49 other U.S. states (as well as the District of Columbia, American Samoa, Guam, and Puerto Rico), every Mexican state and Canadian province, and 11 other foreign countries.

Collision Variables

Older drivers in Arizona were more apt to have angle and left-turn collisions and less apt to have rear-end collisions than are younger drivers (Table 6). We were unable to conduct comparisons with Washington and Oregon due to differences in the names and types of categories used to define type of collision.

Table 6 Collision Type by Age Cohort[9]

	25-64	65+
Angle	20.4%	27.8%
Left Turn	11.6%	15.0%
Rear-End	47.8%	35.7%
Other	20.2%	21.5%

As shown in Table 7, accidents were more likely to occur in daylight driving conditions for older drivers than their younger counterparts. This reflects the pattern that older drivers conduct a larger share of their driving during daylight hours than do younger drivers. The pattern was similar for older drivers in Washington and Oregon.

Table 7 Accident Time of Day by Age Cohort

	AZ 25-64	AZ 65+	WA 65+	OR 65+
Daylight	76%	86%	83%	88%
Dawn or Dusk	5%	3%	4%	3%
Darkness	19%	11%	13%	9%

Accidents in inclement weather do not appear to involve older adults more often than their younger counterparts. Figure 5 illustrates the predominant weather conditions for older drivers, which does not significantly differ from the patterns of younger drivers. Climate differences between Arizona and both Washington and Oregon do not allow for comparisons of weather conditions at time of accident.

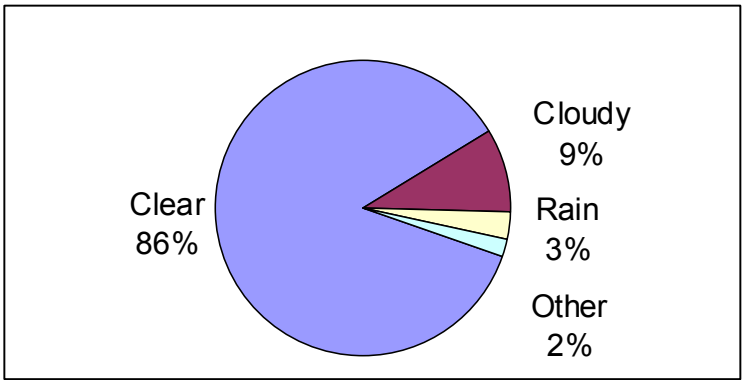

Figure 5 Accident Weather Conditions: Drivers 65+

In comparison to younger drivers, a higher percentage of accidents involving older divers in Arizona occurred in rural locales. (Table 8). Similarly, older drivers had a higher percentage of accidents at intersections and junctions than did younger drivers (Tables 9 and 11). This difference becomes more pronounced as age increases (Tables 10 and 12).

[9] Single vehicle accidents were excluded from this analysis.

Table 8 Accident Locale by Age Cohort

	25 to 64	65+
Not Reported	33.2%	32.9%
Urban	55.6%	50.6%
Rural	11.2%	16.5%

Table 9 Intersection Related Accidents by Age Cohort

	AZ 25 - 64	AZ 65+	Wa 65+	OR 65+
Intersection Related	44%	51%	45%	54%
Driveway Access	10%	13%	11%	N/A
No Relationship	46%	36%	44%	N/A

Table 10 Intersection Related Accidents by Age Cohort (65+)

	65-69	70-74	75-79	80-84	85+
Intersection Related	47.8%	50.3%	52.0%	53.5%	53.9%
Driveway Access	12.4%	12.7%	13.8%	15.6%	15.3%
No Relationship	39.8%	36.9%	34.2%	30.8%	30.6%
Alley	>0.1%	>0.1%	>0.1%	>0.1%	>0.1%

Table 11 Junction Related Accidents by Age Cohort

	25 to 64	65+
Intersection	27%	36%
Junction Area	20%	16%
Non-Junction Area	43%	34%
Driveway Access	10%	14%

Table 12 Junction Impacts by Age Cohort (65+)

	65-69	70-74	75-79	80-84	85+
Intersection	32.9%	35.4%	37.3%	41.3%	41.8%
Junction Area	16.5%	16.8%	16.6%	14.1%	13.7%
Non-Junction Area	38.0%	35.0%	32.2%	28.8%	28.9%
Driveway Access	12.5%	12.8%	13.8%	15.7%	15.4%
Alley	>0.1%	>0.1%	>0.1%	>0.1%	>0.1%

Accidents involving a stop sign or signal were more likely with older drivers than younger drivers (Table 13). As shown in Table 14, these effects increase with advanced age.

Table 13 Control Type By Age Category

	25-64	65+
Striping	43%	40%
Stop Sign	10%	15%
Illumination	16%	9%
Signal	29%	33%
Other	3%*	3%

* Total not equal to 100% due to rounding.

Table 14 Control Type By Age Category (65+)

	65-69	70-74	75-79	80-84	85+
Striping	43%	41%	39%	37%	34%
Stop Sign	13%	14%	15%	17%	19%
Illumination	11%	10%	8%	8%	8%
Signal	30%	32%	35%	36%	36%
Other	3%	3%	3%	2%	3%

The data also indicate that raised medians were involved in more accidents for older drivers than younger drivers (19% versus 16%), although medians as a whole (of all types) were involved in more accidents for younger drivers than for older drivers (47% versus 45%).

Fatalities

Older drivers are more than twice as likely as their younger counterparts to be in a fatal accident (0.23% versus 0.48% as shown in Figure 6). From another perspective, an accident involving an older driver is almost 50% more likely to result in a fatality (0.57% versus 0.83%, Figure 8). This is in line with the 0.6% fatality rate in accidents involving older drivers for Oregon State between 1999 and 2001 and lower than the 0.97% reported for Washington State for the same period. As age increases, this trend becomes more pronounced (Figures 7 and 9). Aside from fatalities, injuries are fairly consistent across the two age groups.

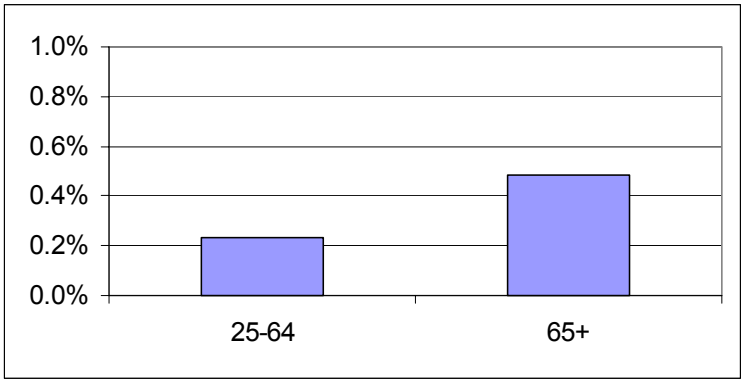

Figure 6 Percent of Fatalities by Age Group

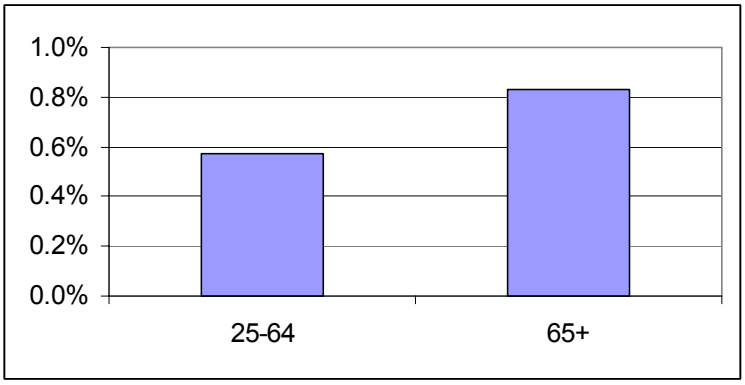

Figure 7 Percent of Accidents Resulting in a Fatality by Age Group

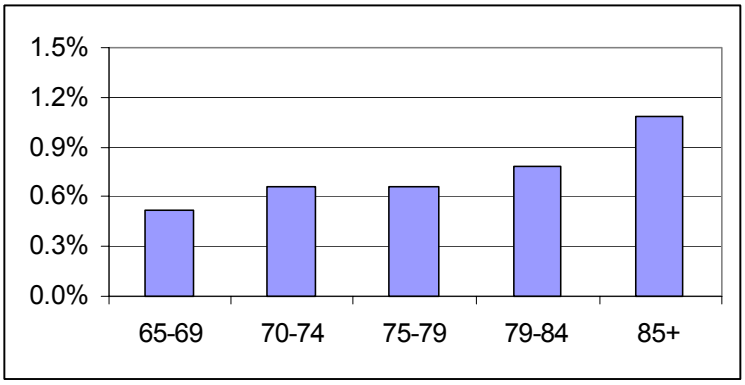

Figure 8 Driver Fatalities in an Accident by Age Group (65+)

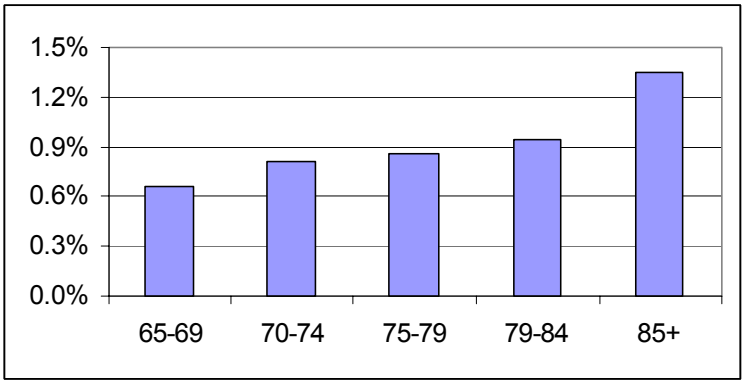

Figure 9 Accidents Resulting in a Fatality by Age Group (65+)

PEDESTRIAN ACCIDENTS

There were 370 pedestrians over the age of 65 involved in auto vehicle accidents between 1999 and 2001 (12% of the total number of pedestrian accidents). Though the overall annual number of pedestrian accidents increased over this period, the number involving older pedestrians remained stable (Table 15).

Table 15 Pedestrian Accidents per Year by Age Group

	Under 65	Over 65	Total
1999	845	129	974
2000	917	117	1,034
2001	1,050	124	1,174

Males represented 65% of older pedestrians involved in accidents, a share comparable to younger pedestrians. A larger share of these accidents proved fatal to the older pedestrians than their younger counterparts (19% versus 12%).[10]

SUMMARY

The data on older drivers analyzed here, and the differences found between the older adults and younger drivers, are consistent with the literature reviewed in Chapter 2, and with the characteristics of the drivers and collisions found in both the Washington and Oregon data for the same time period. Our data show that older drivers are significantly more likely than are younger drivers to:

- Have angle and left-turn collisions and less apt to have rear-end collisions.
- Be involved in accidents in daylight driving conditions and in rural areas.
- Be in accidents involving intersections and junctions, stop signs or signals, and raised medians.
- Suffer fatal injuries in an accident.

We found no difference in collision patterns by age group for accidents involving inclement weather conditions.[11]

---

[10] Significance at 0.02.

[11] In addition to the analysis reported in this chapter, we reviewed the database to determine the locations of the most frequent collisions involving older drivers. The top 100 of these sites are reported in Appendix C.

4. SURVEY OF OLDER DRIVERS

BACKGROUND

The views of older drivers are vital to a thorough assessment of their needs. To assist ADOT in reviewing the options for possible roadway improvements, we conducted a survey with a sample of older adults to explore perceptions of highway facilities in the state and ideas for improvements to accommodate the needs of older adults.

METHODOLOGY

Given the available budget, a random sample of older citizens was not feasible. Quantec worked with the Region One Area Agency on Aging (AAA) in Maricopa County to distribute the survey in key senior centers. The center directors were to administer to those who volunteered to complete the survey and return them as a batch to the AAA, identifying their center with their returns. A total of 126 surveys were returned; however, 12 of these were mailed and we could not discern the center from which they came. Of the total returned, 121 were complete and used in the analysis.[12] We acknowledge the limitations of this sample. Senior centers reach a unique sector of the older adult population. In distributing to a variety of senior centers, however, we were able to include English- and Spanish-speaking, urban, suburban, and semi-rural respondents. Table 16 summarizes the characteristics of the centers where we distributed the surveys.

Table 16 Profile of Surveyed Senior Centers

Center Name	City	Location	Profile of Elders Served by Center				Surveys Returned*
			Anglo	Hispanic	Asian	Other	
Mesa Senior Center	Mesa	Suburban	99%	1%	0%	0%	13
Tempe Senior Center	Tempe	Suburban	15%	65%	20%	0%	19
El Mirage Senior Center	El Mirage	Semi-rural	25%	75%	0%	0%	22
Glendale Senior Center	Glendale	Suburban	60%	25%	15%	0%	55
Squaw Peak Senior Center	Phoenix	Urban	80%	10%	0%	10%	7
Unknown**	NA	NA	NA	NA	NA	NA	12

* Five surveys returned were incomplete and could not be included in the final analysis.

** Twelve surveys were mailed in rather than delivered to Area Agency on Aging staff; no identifying codes were used since assumption was that each would be identified when turned into agency. All of these "unknowns" were English versions.

General areas addressed in the survey included:

- Demographics.

[12] Not all respondents completed each survey question. The totals in all tables in this section reflect only the number of responses completed and vary by survey question.

- Assessment of driving difficulties.
- Suggested improvements for older drivers. [See Appendix D for copies of the survey.]

Descriptive statistics, primarily frequencies and cross-tabulations, were calculated for closed-ended items. Qualitative responses were reviewed for common themes and unique or different responses. Chi-square analyses of cross-tabulations were hindered by the level of missing data, so no significant and meaningful differences between respondents on variables of sex, race, and location were identifiable.

Tables 17 - 21 profile the survey respondents. As shown in Table 17, 79% of surveys were completed in English and 21% in Spanish. The percentage of female respondents completing English surveys was much higher than males, but the sample was much more balanced for the respondents completing the survey in Spanish. The majority of respondents were full-time Arizona residents, and, of those providing their age, the largest percentage fell between the ages of 65 and 74. Slightly more than half of respondents reported living in an urban area.

Table 17 Survey Respondents
Gender and Language of Survey

Survey Language	Female		Male	
	Freq.	%	Freq.	%
English	72	90%	27	79%
Spanish	8	10%	7	21%
Total	***80***	***100%***	***34***	***100%***

Table 18 Arizona Residency Status

Arizona Resident	Freq.	%
No	9	8%
Yes	109	92%
Total	***118***	***100%***

Table 19 Age of Survey Respondents

Age Category	Freq.	%
55-64	20	18%
65-74	46	42%
75-84	37	34%
Greater than 85	7	6%
Total	***110***	***100%***

Table 20 Ethnicity of Survey Respondents

Ethnicity	Freq.	%
American Indian or Alaska Native	3	3%
Black, African American, or Negro	6	5%
Latino	21	19%
White	81	73%
Total	***111***	***100%***

Table 21 Location of Residence

Place of Residence	Freq.	%
Rural	11	11%
Suburban	38	36%
Urban	55	53%
Total	***104***	***100%***

RESULTS

We initially asked survey respondents to assess their overall concern with older adults, including themselves, driving in their community. Table 22 shows their responses, with more than half responding that they are "very concerned" about older drivers.

Table 22 Level of Concern About Older Drivers in Community

Level of Concern	Freq.	%
Not Concerned	10	8%
Somewhat Concerned	41	35%
Very Concerned	67	57%
Total	***118***	***100%***

We asked respondents to rate their difficulty with certain types of driving tasks. Table 23 summarizes their responses. As shown, driving at night was rated as "very difficult" by almost one-third of respondents, with driving on a freeway and identifying street names following in percent rating "very difficult."

Table 23 Rating of Difficulty of Driving Tasks

Task	Very Difficult		Somewhat Difficult		Not at all Difficult		Total
	Freq.	%	Freq.	%	Freq.	%	
Driving in the Rain	16	14%	51	44%	49	42%	116
Driving in High-Density Traffic	19	17%	52	47%	40	36%	111
Driving at Night	34	30%	45	40%	34	30%	113
Parallel Parking	21	19%	32	29%	59	53%	112
Changing Lanes	6	5%	30	27%	76	68%	112
Passing Other Cars	7	6%	23	21%	82	73%	112
Merging into Freeway when no Separate Entrance Lane is Provided	16	13%	63	53%	40	34%	119
Driving on a Freeway	25	22%	30	26%	60	52%	115
Negotiating Curves	7	6%	15	14%	88	80%	110
Backing out of a Parking Space or Driveway	11	9%	24	21%	81	70%	116
Making Left-Hand Turns at Intersections without Left-Turn Signal	18	16%	41	36%	55	48%	114
Driving in Parking Lots	9	8%	20	17%	87	75%	116
Identifying Street Names	23	20%	35	30%	57	50%	115

Respondents also provided an overall rating of Arizona's roadway and pedestrian facilities. As shown in Table 24, respondents clearly feel that improvement could be made, with lettering for signs most frequently rated as "not very good," followed in frequency by intersection markings and signals and availability of sidewalks.

Table 24 Rating of Arizona Roadways

Item	Very Good		Use Improvement		Not Very Good		Total
	Freq.	%	Freq.	%	Freq.	%	
Lighting for Signs	23	19%	20	17%	76	64%	119
Size of Lettering for Signs	34	29%	32	27%	52	44%	118
Intersection Markings and Signals	35	30%	12	10%	71	60%	118
Distance of Freeway On-Ramps	46	40%	12	11%	56	49%	114
Road Edge Markings	38	32%	32	27%	47	40%	117
Pedestrian Crosswalks and Signals	39	33%	32	27%	48	40%	119
Sidewalks Available	29	25%	24	21%	62	54%	115

In the survey, we presented a list of highway design improvements that could be helpful to drivers, and we asked respondents to rate how helpful each would be to them as they

drive in Arizona. Table 25 shows that respondents felt all would be helpful, with signage, street naming, and left-turn intersection improvements receiving the highest frequency of "very helpful" responses. We then asked those surveyed to identify which of these would be "most helpful." As shown in Table 26, larger and better-illuminated traffic signs were the improvement most frequently rated as "most helpful."

Table 25 Rating of Helpfulness of Roadway Design Options

	Very Helpful		Somewhat Helpful		Not at all Helpful		Total
	Freq.	%	Freq.	%	Freq.	%	
Larger and Better Illuminated Traffic Signs	87	73%	30	25%	2	2%	119
Consistent Naming for Streets and Routes	90	77%	21	18%	6	5%	117
Reflective Signs and Road-Edge Markings	96	83%	16	14%	4	3%	116
Dedicated Lanes and Turn Signals for Left Turns	91	79%	19	17%	5	4%	115
Special Driving Routes and Travel Corridors for Older Adults	47	42%	39	35%	27	24%	113
Traffic Circles or Round-Abouts	41	39%	31	29%	34	32%	106

Table 26 Most Helpful of Highway Design Options

Design Option	Freq.	%
Consistent Naming for Streets and Routes	12	14%
Dedicated Lanes and Turn Signals for Left Turns	18	20%
Larger and Better Illuminated Traffic Signs	30	34%
Reflective Signs and Road Edge Markings	15	17%
Special Driving Routes and Travel Corridors for Older Drivers	10	11%
Traffic Circles or Round-Abouts	3	3%
Total	***88***	***100%***

Next, we asked respondents to review a list of driver screening and assessment options and rate how effective each would be in enhancing driver safety. Table 27 shows that more than half of respondents rated driving testing; periodic examinations of driving ability and visual and cognitive ability; and requiring doctors to report potential problem

drivers as very effective options for improving driver safety. And as Table 28 indicates, "Special Senior Driver Testing Programs" was rated as most effective option by 30% of respondents.

Table 27 Effectiveness of Screening and Assessment Options

	Very Helpful		Somewhat Helpful		Not at all Helpful		Total
	Freq.	%	Freq.	%	Freq.	%	
Special Senior Driver Testing Programs	60	52%	45	39%	10	9%	115
Periodic Examinations of Driving by the Driver Licensing Agency	56	50%	34	30%	22	20%	112
Periodic Reassessment of Visual and Cognitive Ability	66	58%	40	35%	8	7%	114
Remedial Courses to Enhance Driver Skills	39	34%	55	48%	21	18%	115
Requiring Doctors to Report Patients with Potential Driving Problems to State	63	53%	31	26%	24	20%	118

Table 28. Most Effective Action Related to Screening & Assessment

Most Effective Action	Freq.	%
Periodic Examinations of Driving by the Driver Licensing Agency	11	13%
Periodic Reassessment for Visual and Cognitive Ability	18	21%
Remedial Courses to Enhance Driver Skills	8	10%
Requiring Doctors to Report Patients with Potential Driving Problems to State	22	26%
Special Senior Driver Testing Programs	25	30%
	84	*100%*

In the third in this series of questions, we asked respondents to review a list of actions that could be taken to improve pedestrian safety and rate how helpful each would be to them as they travel about Arizona. Then we asked them to identify which one action of the list would be "most helpful." Their responses are shown in Tables 29 and 30. As shown, allowing more time for walk cycle received the most frequent rating of "very helpful," followed by more median strips/islands and more sidewalks.

Table 29 Helpfulness of Actions to Improve Pedestrian Safety

Action	Very Helpful		Somewhat Helpful		Not at all Helpful		Total
	Freq.	%	Freq.	%	Freq.	%	
More Visible Crosswalks	25	22%	5	4%	1	0.9%	116
Allow More Time for Walk Cycle	65	56%	41	35%	11	9%	117
Crosswalks at Mid-Block	36	33%	39	35%	35	32%	110
More Sidewalks	49	44%	48	43%	14	13%	111
More Median Strips - Islands - to Separate Traffic Lanes	52	45%	9	8%	1	0.9%	115

Table 30 Most Helpful Pedestrian/Roadway Design Action

Most Helpful Action	Freq.	%
Change Timing of Traffic Signals to Allow More Time for "Walk Cycle"	38	38%
Crosswalks at Mid-Block	10	10%
More Median Strips [Islands] to Separate Traffic Lanes	21	21%
More Sidewalks	12	12%
More Visible Crosswalks	18	18%
Total	***99***	***100%***

SUMMARY

The findings from the older drivers surveyed are consistent with the literature reviewed in Chapter 2. Our data indicate that older Arizona drivers:

- Are very concerned about older drivers on the road.
- Most often rate driving at night as "very difficult," as well as driving on a freeway and identifying street names.
- Feel improvement could be made on many aspects of Arizona roadways, with lettering for signs most frequently rated as "not very good," followed by intersection markings and signals and availability of sidewalks.
- Most frequently rate larger and better-illuminated traffic signs as the most helpful design improvement.
- Most frequently rate special senior driver testing programs" as the most effective screening and assessment option.
- Most frequently rate changing the timing of traffic signals to allow more time for the walk cycle as most helpful action for pedestrians.

This page intentionally left blank

5. CONCLUSIONS

The literature reviewed for this report identified a wide array of age-related declines that may influence safe driving among older adults, coping mechanisms used by older adults to compensate for these changes, and screening, assessment and education approaches to maximize safe driving for older drivers. The collision data analyzed revealed that older drivers in Arizona were more likely than younger drivers to be in collisions with the following circumstances:

- Angle and left-turn collisions.
- Rural locales in daylight hours.
- Intersections and junctions and accidents involving a stop sign or signal and raised medians. The difference between younger and older drivers also becomes greater with increasing age.

Older drivers in Arizona were less apt to have rear-end collisions than younger drivers. All of these findings are consistent with the trends identified in the literature for older drivers nationwide.

Finally, the surveys of older drivers in Arizona indicate their priorities for roadway and pedestrian improvements, including:

- Improvement could be made on many aspects of Arizona roadways, with lettering for signs most frequently rated as "not very good", followed in frequency by intersection markings and signals and availability of sidewalks.
- Larger and better-illuminated traffic signs would be he most helpful design improvement.
- Special senior driver testing programs were rated most often as the "most effective" screening and assessment option for older drivers.
- Changing the timing of traffic signals to allow more time for the walk cycle was most frequently rated most frequently to be the "most helpful" action for pedestrians.

RECOMMENDATION: ROADWAY MODIFICATIONS

Based on the literature reviewed, data analyzed, and surveys completed for this report, three priority areas for roadway modification are recommended. Given budget constraints, the need to gradually phase in changes as new projects are undertaken or older roadway attributes retrofitted, the following should receive priority:

- Modification of left-turn phase indicators.
- Larger and better-illuminated signs and devices for lane assignment on intersection approach.

- Improved signage, both in size, lighting, and contrast, and advance distance notification of required tasks (e.g., merge, on-ramp, exits, four-way stops) on all roadways.
- Pedestrian crossing-design improvements, including increased timing at crosswalks, median refuge islands, more frequent pedestrian opportunities, and placards explaining pedestrian control signals.

RECOMMENDATION: DESIGN IMPROVEMENT DEMONSTRATION

- AZ DOT should ensure that the most recent handbooks delineating detailed recommendations for roadway and pedestrian improvements to accommodate older drivers (for example, Staplin *et al.* 2001a, 2001b) are included in their library, available to highway designers, traffic engineers, and highway safety specialists. Both are available on-line and in hard-copy; see Appendix A for information on accessing/ordering documents.
- We recommend, that given the consistency of findings in this report, particularly in regard to the location and types of accidents most common among older drivers, ADOT should:
  i. Review the top sites that we identified for accidents involving older adults and analyze these to determine their characteristics (intersections, signaled/non-signaled, stop sign, illumination, etc.).
  ii. Following this review, select a sample of sites and implement some or all of the recommended improvements from the FHWA handbooks for sites of this type.
  iii. Evaluate the outcomes of implementing the recommended design changes and determine the costs associated with these outcomes.

RECOMMENDATION: SCREENING, ASSESSMENT, AND EDUCATION

The literature confirms and older adults concur that some screening of older drivers is important. Most states use some combination of no renewal by mail, reduction in intervals between licensing, vision testing, on-road driving and knowledge re-testing to address license renewal requirements for older adults, with the number of assessment components increasing with age. Based on our review, we recommend that Arizona take the following steps:

- Explore the costs and benefits of implementation of measures, such as the Trail Making protocol, to discern memory and cognitive impairments.
- At time of re-licensure, use on-road driving tests tailored to those areas that most discriminate problems of older drivers, such as intersection navigation, merging, backing from driveways and in parking lots, freeway entry. These tests could be instituted as part of re-licensure requirements for drivers beyond a given age and for those identified as at-risk (see next).
- Work with the state legislature, organizations, and professionals to develop a system of required reporting by medical and other care professions; reporting

would require these entities to refer older adults to ADOT if specific concerns are identified.

- As a low cost initiative, at a minimum the state should adopt some form of education and self-testing to support older adults in monitoring their own driving performance.

This page intentionally left blank

APPENDIX A

To order:

Highway Design Handbook for Older Drivers
U.S. Department of Transportation
Federal Highway Administration
Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296
Report # FHWA-RD-103

Or read on-line:
http://www.tfhrc.gov/humanfac/01103/coverfront.htm.

Guidelines and Recommendations to Accommodate Older Drivers and Pedestrians
U.S. Department of Transportation
Federal Highway Administration
Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296
Report # FHWA-RD-01-051

Or read on-line:
http://www.tfhrc.gov////////humanfac/01105/01-051.pdf

This page intentionally left blank

APPENDIX B

Several of the variables included in the database provided by ADOT were unable to be included in the current analysis. Others were outside of the range of the current study. Beyond the variables discussed in the report, the following variables were analyzed and not included because either:

1. They were found to be irrelevant to the analysis; or
2. They did not have enough data for analysis.

Not Relevant

- Road Surface: 94% asphalt 5% concrete.
- Violation_1 and Violation_2: No discernable influence on results.
- Control: 91% "Non-controlled access" 8% "Mainline."
- Lane: No discernable influence on results.
- Grade: No discernable influence on results.
- Physical_1: 97% of observations were either "Not Reported" (16%) "No apparent influence" (79%) or "Unknown" (2%).
- Vision: 94% of observations were either "Not Obscured" (78%) or "Unknown" (16%).
- Defect_1: 99% of observations were either "No apparent defect" (83%) or "Unknown" (16%).

Missing Data

- Defect_2: 99% of observations were either "Not Reported" (16%) or "Unknown" (83%).
- Familiar: 99% unreported.
- Alignment: 99% unreported.
- Special_Location: 97% unreported.
- Road_Condition: 96% unreported.
- Physical_2_2: 99% unreported.

This page intentionally left blank

APPENDIX C

Table 31 below illustrates the 100 roads and intersections that represent the greatest problems for drivers aged 65 and above. Included in each ranked citation are the road and cross street/feature where the accident occurred, the frequency of accidents involving older adults for the period 1999-2001, and the rank of that road/cross feature for those drivers under 65 years of age for the same period.

Table 31 High Frequency Accident Areas for Older Drivers 1999-2001

Rank (Older)	Onroad	Crossing Feature	Frequency	Rank (Younger)
1	07 SKY HARBOR BLVD	07 24TH ST	58	6
2	S 095	M244	56	62
3	10 BROADWAY BLVD	10 WILMOT RD	53	38
4	07 SOUTHERN AV	07 POWER RD	52	425
5	S 069	M295	50	45
6	10 ORACLE RD	10 RIVER RD	50	68
7	S 077	M075	48	111
8	07 MAIN ST	07 GREENFIELD RD	46	643
9	I 010 0	M145	45	1
10	07 BELL RD	07 BOSWELL BLVD	45	1,360
11	I 010	M144	44	2
12	S 077	M073	44	105
13	S 202	M008	40	11
14	U 060	M147	40	340
15	07 POWER RD	07 SOUTHERN AV	40	383
16	S 077	M074	39	89
17	07 POWER RD	07 BAYWOOD AV	39	555
18	10 BROADWAY BLVD	10 KOLB RD	39	125
19	I 010	M146	38	3
20	07 BELL RD	07 DEL WEBB BLVD	38	1,107
21	07 DUNLAP AV	07 19TH AV	38	50
22	07 MAIN ST	07 POWER RD	37	655
23	07 MAIN ST	07 RECKER RD	37	933
24	10 BROADWAY BLVD	10 CRAYCROFT RD	37	53
25	10 GRANT RD	10 WILMOT RD	37	410
26	10 SPEEDWAY BLVD	10 KOLB RD	36	219
27	U 060	M179	35	10
28	07 BROADWAY RD	07 POWER RD	34	938
29	10 GRANT RD	10 BEVERLY AV	34	543
30	07 BELL RD	07 EL MIRAGE RD	33	1,278
31	07 BELL RD	07 R H JOHNSON BLVD	33	988
32	07 MAIN ST	07 48TH ST	33	2,070

Rank (Older)	Onroad	Crossing Feature	Frequency	Rank (Younger)
33	07 UNIVERSITY DR	07 GILBERT RD	33	100
34	07 UNIVERSITY DR	07 LINDSAY RD	33	290
35	07 POWER RD	07 MAIN ST	32	476
36	S 202 0	M001	31	4
37	07 MCKELLIPS RD	07 GILBERT RD	31	92
38	10 SPEEDWAY BLVD	10 PANTANO RD	31	454
39	I 010 0	M146	30	5
40	07 ALMA SCHOOL RD	07 WARNER RD	30	94
41	07 HAMPTON AV	07 POWER RD	30	696
42	07 SHEA BLVD	07 90TH ST	30	83
43	10 THORNYDALE RD	10 INA RD	30	288
44	07 7TH ST	07 BELL RD	29	216
45	07 BELL RD	07 99TH AV	29	1,049
46	07 GREENFIELD RD	07 MAIN ST	29	645
47	07 POWER RD	07 BROADWAY RD	29	536
48	10 INA RD	10 THORNYDALE RD	29	97
49	10 SPEEDWAY BLVD	10 SWAN RD	29	120
50	10 TANQUE VERDE RD	10 SABINO CANYON RD	29	142
51	U 060 0	M182	28	26
52	07 BELL RD	07 83RD AV	28	461
53	07 DUNLAP AV	07 35TH AV	28	36
54	07 UNIVERSITY DR	07 STAPLEY DR	28	266
55	10 INA RD	10 ORACLE RD	28	289
56	10 KOLB RD	10 22ND ST	28	124
57	10 WILMOT RD	10 5TH ST	28	435
58	SA089	M372	27	450
59	07 BASELINE RD	07 GILBERT RD	27	136
60	07 MAIN ST	07 LINDSAY RD	27	713
61	07 MCKELLIPS RD	07 COUNTRY CLUB DR	27	51
62	10 KOLB RD	10 BROADWAY BLVD	27	232
63	10 SPEEDWAY BLVD	10 WILMOT RD	27	304
64	10 WILMOT RD	10 BROADWAY BLVD	27	436
65	U 060	M142	26	991
66	07 19TH AV	07 DUNLAP AV	26	73
67	07 ARIZONA AV	07 WARNER RD	26	77
68	07 BELL RD	07 40TH ST	26	44
69	07 BELL RD	07 87TH AV	26	716
70	07 MAIN ST	07 74TH ST	26	2,233
71	07 MAIN ST	07 HIGLEY RD	26	1,272
72	07 SOSSAMAN RD	07 SOUTHERN AV	26	1,420
73	07 SOUTHERN AV	07 RURAL RD	26	126
74	07 UNIVERSITY DR	07 VAL VISTA DR	26	521
75	10 GRANT RD	10 SWAN RD	26	366

Rank (Older)	Onroad	Crossing Feature	Frequency	Rank (Younger)
76	10 PANTANO RD	10 BROADWAY BLVD	26	553
77	10 PIMA ST	10 WILMOT RD	26	563
78	I 010 0	M144	25	7
79	S 087	M252	25	434
80	07 19TH AV	07 NORTHERN AV	25	104
81	07 COUNTRY CLUB DR	07 SOUTHERN AV	25	32
82	07 MCKELLIPS RD	07 RECKER RD	25	1,426
83	07 UNION HILLS DR	07 91ST AV	25	1,561
84	10 22ND ST	10 KOLB RD	25	131
85	10 TANQUE VERDE RD	10 KOLB RD	25	277
86	S 095	M245	24	451
87	U 060	M178	24	8
88	07 44TH ST	07 THOMAS RD	24	133
89	07 51ST AV	07 INDIAN SCHOOL RD	24	56
90	07 BELL RD	07 98TH AV	24	2,160
91	07 BROWN RD	07 MESA DR	24	322
92	07 DOBSON RD	07 SOUTHERN AV	24	37
93	07 INDIAN SCHOOL RD	07 32ND ST	24	144
94	07 THOMAS RD	07 44TH ST	24	148
95	07 UNIVERSITY DR	07 GREENFIELD RD	24	876
96	10 BROADWAY BLVD	10 PANTANO RD	24	444
97	10 GOLF LINKS RD	10 CRAYCROFT RD	24	185
98	10 INA RD	10 LA CHOLLA BLVD	24	244
99	10 KOLB RD	10 SPEEDWAY BLVD	24	511
100	10 RIVER RD	10 1ST AV	24	382

This page intentionally left blank

APPENDIX D

Copies of the Older Driver Survey (both the English and Spanish versions), as discussed in Chapter 4, are included in this appendix.

This page intentionally left blank

Arizona Department of Transportation

Transportation Planning Division

206 South Seventeenth Avenue Phoenix, Arizona 85007-3213

Janet Napolitano
Governor

Victor M. Mendez
Director

Dale Buskirk
Acting Division
Director

February 27, 2003

This survey, being conducted by Quantec, LLC, for the Arizona Department of Transportation (ADOT), is designed to gather information concerning the needs and characteristics of older drivers in the state. Your responses will assist ADOT as they plan roadway and pedestrian improvements to meet the needs of Arizona residents and visitors. Your views are very important. All responses will remain confidential; no identifying information will be connected to your responses.

1. Are you concerned about older adults – yourself or others – driving in your community?

   ❑ Very concerned

   ❑ Somewhat concerned

   ❑ Not concerned

2. When in Arizona, to what extent are the following driving tasks difficult for you? ***Check the box that applies for each.***

Driving Tasks	Very Difficult	Somewhat Difficult	Not at all Difficult
Driving in the rain			
Driving in high density traffic			
Driving at night			
Parallel parking			
Changing lanes			
Passing other cars			
Merging into freeway when no separate entrance lane is provided			
Driving on a freeway			
Negotiating curves			
Backing out of a parking space or drive			
Making left hand turns at intersections without left-turn signal			
Driving in parking lots			
Identifying street names			

3. Overall, how would you rate the following aspects of roadway and pedestrian facilities in Arizona? ***Check the box that applies for each***.

Aspect of AZ Facilities	Very Good	Good, but Could Use Improvement	Not Very Good
Lighting for signs			
Size of lettering for signs			
Intersection markings & signals			
Distance of freeway on-ramps			
Road edge markings			
Pedestrian crosswalks and signals			
Sidewalks available			

4. Of the following actions that relate to the automobile and the highway, how helpful would each be to you as you drive in Arizona? ***Check the box that applies for each.***

	Very Helpful	Somewhat Helpful	Not at all Helpful
Larger & better illuminated traffic signs			
Consistent naming for streets and routes			
Reflective signs and road edge markings			
Dedicated lanes and turn signals for left turns			
Special driving routes and travel corridors for older adults			
Traffic circles or round-abouts			

4a. Of the actions listed above, which ***one*** would be the most helpful?

_____

5. Of the actions related to screening and assessment of older drivers, how effective do you think each would be in enhancing driver safety? ***Check the box that applies for each.***

	Very Effective	**Somewhat Effective**	**Not Very Effective**
Special senior driver testing programs			
Periodic examinations of driving by the driver licensing agency			
Periodic reassessment for visual and cognitive ability			
Remedial courses to enhance driver skills			
Requiring doctors to report patients with potential driving problems to state			

5a. Of the actions listed above, which one do you feel would be most effective?

_____

6. Of the following actions that relate to pedestrians and the roadways, how helpful would each be to you as you travel about Arizona? Check the box applies for each.

	Very Helpful	**Somewhat Helpful**	**Not Very Helpful**
More visible crosswalks			
Change timing of traffic signals to allow more time for “walk cycle”			
Crosswalks at mid-block			
More sidewalks			
More median strips [islands] to separate traffic lanes			

6a. Of the actions listed above, which ***one*** do you feel would be most helpful?

_____

7. What one improvement to the roadways do you think would most contribute to improving your driving safety?

_____

7a. What one improvement would best improve pedestrian safety?

_____

Finally, we would now like to know a little about you. This information allows us to compare older drivers in Arizona with those from other states.

8. Is Arizona your usual place of residence? By usual residence I mean your primary residence or the place where you live and sleep most of the time?

❑ Yes

❑ No

ANSWER QUESTIONS 9-12 ONLY IF ARIZONA IS *NOT* YOUR USUAL RESIDENCE

9. What is your primary state or country of residence during the months you are not living in Arizona? _____

10. How many months do you intend to spend in Arizona during your current visit?

- ❑ Less than one month
- ❑ 1-2 months
- ❑ 3-4 months
- ❑ 5-6 months
- ❑ More than 6 months

11. How often to would you say that you come to Arizona?

- ❑ Every year
- ❑ Every two to three years
- ❑ No regular schedule to visits

12. If you have been coming to AZ before this year, what is your average length of stay?

- ❑ Less than one month
- ❑ 1 to 2 months
- ❑ 3-4 months
- ❑ 5-6 months
- ❑ More than six months

13. Do you consider yourself to be currently living in an urban, suburban, or rural area?

- ❑ Urban
- ❑ Suburban
- ❑ Rural

14. Are you:
    - ❑ Male
    - ❑ Female

15. What is your race:
    - ❑ American Indian or Alaska Native
    - ❑ Asian
    - ❑ Native Hawaiian or other Pacific Islander
    - ❑ Black, African American, or Negro
    - ❑ White

16. Are you:
    - ❑ Hispanic or Latino
    - ❑ Not Hispanic or Latino

17. What is your age? _____ years

Thank you for your responses!

Arizona Department of Transportation

Transportation Planning Division

206 South Seventeenth Avenue Phoenix, Arizona 85007-3213

Janet Napolitano
Governor

Victor M. Mendez
Director

Dale Buskirk
Acting Division
Director

February 27, 2003

Esta encuesta es parte de un proyecto dirigido por Quantec, LLC, para El Departamento de Transporte de Arizona (ADOT) y ha sido diseñada para obtener información sobre las necesidades y características de los conductores mayores de edad en el estado. Sus respuestas ayudarán al ADOT en la planificación tanto de mejoras en carreteras como mejoras para los peatones residentes y visitantes en el estado. Sus opinones son muy importantes y se mantendrán en estricta confidencialidad**;** ninguna información personal se asociará con sus respuestas.

1. ¿Le preocupa que la gente mayor – o usted mismo/a u otros – maneje en su comunidad?

   ❑ Me preocupa mucho

   ❑ Me preocupa un poco

   ❑ No me preocupa

2. Cuando usted está en Arizona, ¿hasta qué punto son difíciles para usted las siguientes habilidades de manejo? ***Seleccione la casilla que aplique.***

Habilidad	Muy Difícil	Un Poco Difícil	No Difícil
Manejar bajo la lluvia			
Manejar con mucho tráfico			
Manejar de noche			
Estacionarse en paralelo			
Cambiar de carril			
Rebasar otros carros.			
Entrar a la autotpista cuando no hay carril de acceso			
Manejar en las autopistas			
Controlar bien el auto en las curvas			
Salir de reversa de un lugar de estacionamiento			
Dar vuelta a la izquierda en intersecciones sin señalamiento para vuelta a la izquierda			
Manejar en los estacionamientos			
Identificar los nombres de las calles			

3. Por lo general, ¿cómo calificaría usted los siguientes aspectos de las facilidades viales y peatonales en Arizona? ***Seleccione la casilla que aplique***.

Facilidad Vial o Peatonal	**Muy Buena**	**Buena, Pero Podría Mejorarse**	**No Buena**
Iluminación de las señales de tránsito			
El tamaño de las letras en las señales			
Señalización de los semáforos			
Longitud del carril de acceso a las autopistas.			
Las líneas blancas que marcan las orillas de las rutas viales			
Cruces peatonales y señales			
Otras opciones para peatones, por ejemplo divisores (o islas) en la avenidas principales.			
La disponibilidad de aceras			

4. En cuanto a los siguientes aspectos con relación a las autopistas, ¿qué tan útiles serían cada uno de ellos para manejar en el Estado de Arizona? ***Seleccione la casilla que aplique.***

Aspecto de Las Autopistas	**Muy Útil**	**Algo Útil**	**Sin Utilidad Alguna**
Señalización más grande y con mejor iluminación			
Un sistema consistente de nombrar las calles y rutas			
Señalización luminosa y líneas luminoas en las calles y avenidas			
Carriles y señales para dar vuelta a la izquierda			
Rutas y carriles especiales para mayores de edad			
Rotundas			

4a. De las opciones arriba, ¿cuál sería de mayor utilidad?

_____

5. En cuánto a los siguientes aspectos de evaluación para conductores mayores de edad, ¿qué tan efectivos considera que sean para mejorar la seguridad del conductor? ***Seleccione la casilla que aplique.***

Aspecto de Evaluación	**Muy Efectivo**	**Algo Efectivo**	**Sin Efectividad Alguna**
Programas especiales para evaluar las habilidades de manejo en la gente de mayor edad			
Exámenes frecuentes del manejo			
Frecuentes exámenes de visión y aptitud mental			
Cursos correctivos para mejorar las destrezas de manejo			
Requerir que los doctores reporten al estado aquellos pacientes con posibles problemas para manejar			

5a. De las opciones arriba, ¿cuál sería la más efectiva?

_____

6. De los siguientes aspectos relacionados con peatones y carreteras, ¿cuánto le ayudaría a usted cada uno de ellos en sus viajes alrededor del estado? ***Seleccione la casilla que aplique***.

Aspecto de Carretera	Ayudaría Mucho	Ayudaría Un Poco	No Ayudaría
Cruces peatonales más visibles			
Aumentar el lapso de tiempo en los semáforos para permitirle a los peatones más tiempo para cruzar			
Cruces peatonales a la mitad de la avenida o calle			
Más aceras			
Más divisores para separar los carriles de tránsito			

6a. De las opciones arriba, ¿cuál le ayudaría más?

_____

7. ¿Cuál mejora a las vías públicas haría la mejor contribución a su seguridad al manejar un vehículo?

_____

7a. ¿Cual sería la mejora ideal para aumentar la seguridad de peatones?

_____

Finalmente, quisiéramos saber un poco sobre usted. Esta información nos permite comparar los conductores mayores de edad en Arizona con los de otros estados.

8. ¿Es Arizona su estado de residencia fija? Residencia fija quiere decir su residencia principal o el lugar donde vive y duerme la mayoría del tiempo?

   ❑ Sí

   ❑ No

CONTESTE LAS PREGUNTAS 9 – 12 SOLO SI ARIZONA *NO ES* SU ESTADO DE RESIDENCIA FIJA

9. ¿Cuál es el Estado o País principal donde reside durante los meses que no esta en Arizona? Escriba el nombre del Estado o País_____

10. ¿Cuántos meses piensa usted quedarse en Arizona durante esta visita?

    ❑ Menos de un mes

    ❑ 1-2 meses

    ❑ 3-4 meses

    ❑ 5-6 meses

    ❑ Más de seis meses

11. ¿Cada cuanto visita Arizona?

    ❑ Cada año

    ❑ Cada dos o tres años

    ❑ No tengo rutina fija

12. Si usted ha visitado a Arizona antes de este año, ¿cuál es la duración promedio de su estadía?
    - ❑ Menos de un mes
    - ❑ 1 - 2 meses
    - ❑ 3-4 meses
    - ❑ 5-6 meses
    - ❑ Más de seis meses

13. ¿Considera usted que vive en una área URBANA, SUBURBANA, o RURAL?
    - ❑ Urbana
    - ❑ Suburbana
    - ❑ Rural

14. Es usted:
    - ❑ Hombre
    - ❑ Mujer

15. ¿Cuál es su raza?
    - ❑ India americana o nativa de Alaska
    - ❑ Asiática
    - ❑ Nativa de Hawaii o de otra isla del pacífico
    - ❑ Negra, africana americana
    - ❑ Blanca

16. Es usted:
    - ❑ Hispano o Latino
    - ❑ No Hispano o Latino

17. ¿Cuál es su edad? _____ Años

Gracias por sus respuestas!

REFERENCES

Ball, K., B.L. Beard, D.L. Roenker, D.L. Miller and D.S. Griggs. 1988. "Age and visual search: expanding the useful field of view." *Journal of the Optical Society of America* A (5):2210-2219.

Ball, K. and C. Owsley. 1991. "Identifying correlates of accident involvement for the older driver." *Human Factors* 33:583-595.

Ball, K., C. Owsley, M.E. Sloane, D.L. Roenker and J.R. Bruni. 1993. "Visual attention problems as a predictor of vehicle crashes in older drivers." *Investigative Ophthalmology and Visual Science* 34:3110-3123.

Ball, K., C. Owsley, B. Stalvey, D.L. Roenker, M.E. Sloane and M. Graves. 1998. "Driving avoidance and functional impairment in older drivers." *Accident Analysis & Prevention* 30:313-322.

Ball, K. and G.W. Rebok. 1994. "Evaluating the driving ability of older adults." *Journal of Applied Gerontology* 13:20-38.

Bedard, M., D.W. Molloy, G.H. Guyatt, M.J. Stones and D.S. Strang. 1997. "Competency to drive in cognitively impaired older adults." *Annals of the Royal College of Physicians and Surgeons of Canada* 30:346-352.

Bedard, M., M.J. Stones, G.H. Guyatt and J.P. Hirdes. 2001. "Traffic-related fatalities among older drivers and passengers: past and future trends." *The Gerontologist* 41 (6):751-756.

Benekohal, R.F., P. Resende, E. Shim, R.M. Michaels and B. Weeks. 1992. *Highway Operations Problems of Elderly Drivers in Illinois*. Springfield, Il.: Illinois Department of Transportation.

Burkhardt, J.E. and A.T. McGavock. 1999. "Tomorrow's older drivers: Who? How many? What impacts?" *Transportation Research Record* no.1693:62-70.

Burkhardt, J.E., A.M. Berger, M.A. Creedon and A.T. McGavock. 1998. *Mobility and Independence: Changes and Challenges for Older Drivers*. Washington, D.C.: U.S. Department of Health and Human Services and the National Highway Traffic Safety Administration.

Caird, J.K., Horrey, W.J., Edwards, C.J. 2001. "Effects of conformal and nonconformal vision enhancement systems on older-driver performance." *Transportation Research Record* no.1759:38-45.

Campbell, M.K., T.L. Bush and W.E. Hale. 1993. "Self-report and medical record report agreement of selected medical conditions in the elderly." *American Journal of Public Health* 79:1554-1556.

Carp, F.M. 1988. "Significance of mobility for the well-being of the elderly." in *Transportation in an Aging Society: Improving Mobility and Safety of Older Persons.* Vol 2, Technical Papers. Special report 218. Washington, D.C.: Transportation Research Board.

Carroll, J.T., J.R. Graham, L.E. King, G.L. Mancil and R.M. Mancil. 2002. "The Effect of driver cataract development on roadway sign nighttime legibility." Paper read at 16th Biennial Symposium on Visibility and Simulation, at Iowa City, Ia.

Census, U.S. Bureau of the. 1990. *Basic Facts.* U.S. Bureau of the Census 1990 [Cited. Available from http://factfinder.census.gov/servlet/basicfactstable?_lang=en&_vt_name=.

___. 1996. *65+ In the United States.* Washington, D.C.: U.S. Government Printing Office.

___. 2000. *State and County Quick Facts.* U.S. Bureau of the Census, May 2003 [Cited. Available from http://quickfacts.census.gov/qfd/states/04000.html.

Cooper, P. J. 1990. "Elderly drivers' views of self and driving in relation to the evidence of accident data." *Journal of Safety Research* 24:9-17.

Cushman, L. 1992. *The Impact of Cognitive Decline and Dementia on Driving in Older Adults.* Washington, DC: AAA Foundation for Traffic Safety.

Diller, E., L. Cook, D. Leonard, J. Reading, J.M. Dean and D. Vernon. 1999. *Evaluating Drivers with Medical Conditions in Utah, 1992-1996.* Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration.

Eby, D.W., J.T. Shope, L.J. Molnar, J.M. Vivoda and T.A. Fordyce. 2000. *Improvement of Older Driver Safety through Self-Evaluation: The Development of a Self-Evaluation Instrument.* Ann Arbor, Mich.: University of Michigan Transportation Research Institute.

Eby, D.W., D.A. Trombley, L.J. Molnar and J.T. Shope. 1998. *The Assessment of Older Drivers' Capabilities: A Review of the Literature.* Ann Arbor, Mich.: University of Michigan Transportation Research Institute.

Epstein, A.E., W.M. Miles, D.G. Benditt, A.J. Camm, E.J. Darling, P.L. Friendman, A. Garson, J.C. Harvey, G.A. Kidwell, G.J. Klein, P.A. Levine, F.E. Marchlinski, E.N. Prystowsky and B.L. Wilkoff. 1996. "Personal and public safety issues related to arrhythmias that may affect consciousness: implications for regulation and physician recommendations." *Circulation* 94:1147-1166.

Foley, D.J., R.B. Wallace and J.W. Eberhard. 1995. "Risk factors for motor vehicle crashes among older drivers in a rural community." *Journal of the American Geriatrics Society* 43 (7):776-781.

Forrest, K.Y.Z., C.H. Bunker, T.J. Songer, J.H. Cohen and J.A. Cauley. 1997. "Driving patterns and medical conditions in older women." *Journal of the American Geriatrics Society* 45:1214-1218.

Fox, J.E. 1998. "The Effects of age and ATIS use on driving performance: a simulator study." Paper read at 42nd Annual Meeting of the Human Factors and Ergonomics Society.

Gallo, J.J., G.W. Rebok and S.E. Lesikar. 1999. "The Driving habits of adults aged 60 and older." *Journal of the American Geriatrics Society* 47:334-335.

Glasgow, N. 2000. "Older Americans' patterns of driving and using other transportation." *Rural America* 15 (3):26-31.

Glasgow, N. and D.L. Brown. 1997. "Gender differences in driving behavior among nonmetropolitan older residents: problems and prospects." Paper read at Gerontological Society of America, Annual Meeting, at Cincinnati, OH.

Guerrier, J.H. and S-H Fu. 2002. *Elder Roadway User Program Test Sections and Effectiveness Study.* Tallahassee, Fla: Florida Department of Transportation.

Handbook of Psychology of Aging. 2001. Edited By J. E. Birren and K. W. Schaie. 5th Ed. San Diego, CA: Academic Press.

Harkey, D., H. Huang and C.V. Zeeger. 1996. "Examination of older driver problems on freeways using the Highway Safety Information System." Submitted to the Transportation Research Board for presentation and publication.

Harruff, R.C., A. Avery and A.S. Alter-Pandya. 1998. "Analysis of circumstances and injuries in 217 pedestrian traffic fatalities." *Accident Analysis & Prevention* 30:11-20.

HSIS. 2002. *Accident Analysis of Older Drivers at Intersections.* Highway Safety Information System Summary Report. McLean, Va.: Turner-Fairbank Highway Research Center. Cited December 23 2002. Available from http://ntl.bts.gov/docs/hsis/94-021.htm.

Hu, P.S., D.A. Trumble, D.J. Foley, J.W. Eberhard and R.B. Wallace. 1998. "Crash risks of older drivers: a panel data analysis." *Accident Analysis & Prevention* 30:569-582.

Huaman, A.G. and J.A. Sharpe. 1993. "Vertical saccades in senescence." *Investigative Ophthalmology and Visual Science* 34:2588-2595.

Hunt, L.A., C.F. Murphy, D. Carr, J.M. Duchek, V. Buckles and J.C. Morris. 1997a. "Reliability of the Washington University Road Test: a performance-based assessment for drivers with dementia of the Alzheimer type." *Archives of Neurology* 54:707-712.

___. 1997b. "Environmental cueing may affect performance on a road test for drivers with dementia of the Alzheimer type." *Alzheimer Disease and Associated Disorders* 11 (Suppl. 1):13-16.

IIHS. 1991. *IIHS Facts: Elderly.* Washington, D.C.: Insurance Institute for Highway Safety.

___. 2000. *IIHS Fatality Facts: "Elderly".* Washington, D.C.: Insurance Institute for Highway Safety.

___. 2001. "Older drivers up close." *Insurance Institute for Highway Safety Status Report* 36 (8):1-7.

___. 2002. "Biggest problem at stop signs isn't running through; it's stopping but then failing to yield." *IIHS Status Report* 37 (9):6-7.

Janke, M.K. 1994. *Age-Related Disabilities that May Impair Driving and Their Assessment: A Literature Review.* Sacramento, CA: California Department of Motor Vehicles.

Janke, M.K. and J.W. Eberhard. 1998. "Assessing medically impaired older drivers in a licensing-agency setting." *Accident Analysis & Prevention* 30:347-361.

Johansson, K., L. Bronge, C. Lundberg, A. Persson, M. Seideman and M. Viitanen. 1996. "Can a physician recognize an older driver with increased crash potential." *Journal of the American Geriatrics Society* 44:1198-1204.

Kerschner, H. and R. Aizenberg. 2002. *Transportation in an Aging Society* [Web Report]. Washington, D.C.: AAA Foundation 1999. Cited October 31 2002. Available from http://www.seniordrivers.org/research/index.cfm?selection=1.

Keyl, P.M., G.W. Rebok, F.W. Bylsma, L. Turn, J. Brandt, S. Teret, G.A. Chase and H.L. Sterns. in press. *Cognitive Function, Driving Simulator Performance, and Crash History in Alzheimer's Disease Patients and Elderly Controls.*

Khattak, A.J., M.D. Pawlovich, R.R. Souleyrette and S.L. Hallmark. 2002. "Factors related to more severe older driver traffic crash injuries." *Journal of Transportation Engineering* 128(3):243-249.

Klavora, P. and R.J. Heslegrave. 2002. "Senior drivers: an overview of problems and intervention strategies." *Journal of Aging & Physical Activity* 10 (3):322-335.

Kline, T.L. 2002. "UFOV test targets crash risk for elderly." *The Chronicle* 50 (1):5.

Knoblauch, R.L., M. Nitzburg and R.F. Seifert. 1997. *Investigation of Older Driver Freeway Needs and Capabilities: Final Report.* Washington, D.C.: Federal Highway Administration.

Koepsell, T., L. McCloskey, M. Wolf, A.V. Moudon, J. Kraus and M. Patterson. 2002. "Crosswalk markings and the risk of pedestrian-motor vehicle collisions in older pedestrians." *Journal of the American Medical Association* 288 (17):2136-2143.

Koepsell, T.D., M.E. Wolf, L. McCloskey, D.M. Buchner and D. Louie. 1994. "Medical conditions and motor vehicle collision injuries in older adults." *Journal of the American Geriatrics Society* 42 (7):695-700.

Kostyniuk, L.P., F.M. Streff and D.W. Eby. 1997. *The Older Driver and Navigation Assistance Systems*. Ann Arbor, Mich.: University of Michigan Transportation Research Institute.

Lerner, N.D. and D.J. Ratte. 1991. "Problems in freeway use as seen by older drivers." *Transportation Research Record* no. 1325:3-7.

Light, L.L. 1996. *Memory and Aging*. Edited By E. L. Bjork and R. A. Bjork. New York, NY: Academic Press.

Lundberg, C., K. Johansson, B. Bjerre, C. Blomqvist, A. Braekhus, W.H. Brouwer, F.W. Bylsma, D.M. Carr, L. Englund, R.P. Friedland, L. Hakamies-Blomqvist, G. Klemetz, D. O'Neill, G.L. Odenheimer, M. Rizzo, M. Schelin, M. Seideman, K. Tallman, M. Viitanen, P. Waller and B. Winblad. 1997. "Dementia and driving: an attempt at consensus." *Alzheimer Disease and Associated Disorders* 11 (1):28-37.

Lyles, R.W., M.R. Kane, F. Vanosdall and F.X. McKelvey. 1997. *Improved Traffic Control Device Design and Placement to Aid the Older Driver.* Washington, D.C.: Transportation Research Board.

Lyman, J.M., G. McGwin, Jr. and R.V. Sims. 2001. "Factors related to driving difficulty and habits in older drivers." *Accident Analysis & Prevention* 33:413-421.

Lyman, S., S.A. Ferguson, A.F. Williams and E.R. Braver. 2001. *Older Driver Involvements in Police-Reported Crashes and Fatal Crashes.* Arlington, VA: Insurance Institute for Highway Safety.

Mace, D.J. and R.J. Porter. 2002. "Fixed roadway lighting to benefit older drivers." Paper read at 16th Biennial Symposium on Visibility and Simulation, at Iowa City, Ia.

Margolis, K.L., R.P. Kerani, P. McGovern, T.J. Songer, J.A. Cauley and K.E. Ensrud. 2002. "Risk factors for motor vehicle crashes in older women." *Journal of Gerontology: Medical Sciences* 57a (3):M186-M191.

Marin-Lamellet, C. and M. Dejeammes. 1995. "The Processing of complex guidance symbols by elderly drivers: a simulator-based study and an evaluation of the Carminat Guidance System by the European Community Drive-Eddit Project." Paper read at 1995 Vehicle Navigation & Information Systems Conference. 6th International VNIS: A Ride Into the Future, at Seattle, WA.

Marottoli, R.A., L.M. Cooney, D.R. Wagner, J. Doucette and M.E. Tinetti. 1996. "Predictors of automobile crashes and moving violations among elderly drivers." *Annals of Internal Medicine* 121:842-846.

Marottoli, R.A., A.M. Ostfeld, S.S. Merrill, G.D. Perlman, D.J. Foley and L.M. Cooney. 1993. "Driving cessation and changes in mileage driven among elderly individuals." *Journal of Gerontology: Social Sciences* 48:S255-S260.

Marottoli, R.A., E.D. Richardson, M.H. Stowe, E.G. Miller, L.M. Brass, L.M. Cooney and M.E. Tinetti. 1998. "Development of a test battery to identify older drivers at risk for self-reported adverse driving events." *Journal of the American Geriatrics Society* 46 (5):560-568.

McGwin, G. Jr., V. Chapman and C. Owsley. 2000. "Visual risk factors for driving difficulty among older drivers." *Accident Analysis & Prevention* 32:735-744.

McKnight, A.J. and A.S. McKnight. 1999. "Multivariate analysis of age-related driver ability deficits." *Accident Analysis & Prevention* 31:445-454

Mourant, R.R., Feng-Ji Tsai, Talal Al-Shihabi and B.K. Jaeger. 2001. "Measuring divided-attention capability of young and older drivers." *Transportation Research Record* no. 1779:40-45.

NHTSA. 1998. *Traffic Safety Facts 1998: A Compilation of Motor Vehicle Crash Data from the Fatality Analysis Reporting System and the General Estimates System.* Washington, D.C.: U.S. Department of Transportation.

___. 2001. *Traffic Safety Facts 2000: Older Population.* Washington: National Highway Traffic Safety Administration.

___. 2001. *Traffic Safety Facts 2000: Pedestrians*. Washington, D.C.: U. S. Department of Transportation.

Owsley, C. and K. Ball. 1993. "Assessing visual function in the older driver." *Clinics in Geriatric Medicine* 9:389-401.

Owsley, C., K. Ball, G. McGwin Jr., M.E. Sloane, D.L. Roenker, M.F. White and E.T. Overley. 1998. "Visual processing impairment and risk of motor vehicle crash among older adults." *Journal of the American Medical Association* 279:1083-1088.

Owsley, C., G. McGwin Jr. and K. Ball. 1998. "Vision impairment, eye disease, and injurious motor vehicle crashes in the elderly." *Ophthalmic Epidemiology* 5 (2):101-113.

Owsley, C., G. McGwin Jr., M.E. Sloane, J. Wells, B. T. Stalvey and S. Gauthreaux. 2002. "Impact of cataract surgery on motor vehicle crash involvement by older adults." *Journal of the American Medical Association* 288 (7):841-849.

Owsley, C. and M.E. Sloane. 1990. "Vision and aging." in *Handbook of Neuropsychology*. Edited By F. Bolter and J. Grafman. Amsterdam, the Netherlands: Elsevier.

Owsley, C., B. Stalvey, J. Wells and M.E. Sloane. 1999. "Older drivers and cataract: driving habits and crash risk." *Journal of Gerontology: Medical Sciences* 54a:M203-M211.

Owsley, C., B.T. Stalvey, J.M. Wells. 2001. *A Crash Reduction Strategy: Training Transportation Professionals in Alabama about How to Manage Drivers with Diminished Capabilities.* Birmingham, Ala.: University Transportation Center for Alabama.

Parasuraman, R. 1991. “Attention and driving performance in Alzheimer's dementia.” Paper read at Strategic Highway Research Program and Traffic Safety on Two Continents, at Gothenberg, Sweden.

Poser, C.M. 1993. “Automobile driving fitness and neurological impairment.” *Journal of Neuropsychiatry* 5:342-348.

Preusser, D., F. Williams, S. Ferguson, R. Ulmer and H. Weinstein. 1998. “Fatal crash risk for older drivers at intersections.” *Accident Analysis & Prevention* 30 (2):151-165.

Roberts, W.M. and P.C. Roberts. 1993. “Evaluation of the elderly driver with arthritis.” *Clinics in Geriatric Medicine: Medical Considerations in the Older Driver* 9:311-322.

Rothe, John Peter, P. J. Cooper and B. De Vries. 1990. *The Safety of Elderly Drivers: Yesterday's Young in Today's Traffic.* New Brunswick, N.J.: Transaction Publishers.

Salzberg, P. and J. Moffat. 1998. *The Washington State Department of Licensing Special Exam Program: An Evaluation.* Olympia, Wash.: Washington Traffic Safety Commission.

Schieber, F. 1994. *Recent Developments in Vision, Aging, and Driving: 1988-1994.* Ann Arbor, Mich.: The University of Michigan Transportation Research Institute.

Schieber, F., D.W. Kline, T.J.B. Kline and J.L. Fozard. 1992. *The Relationship between Contrast Sensitivity and the Visual Problems of Older Drivers.* Warrendale, Pa: Society of Automotive Engineers, Inc.

Sharpe, J.A. and T.O. Sylvester. 1978. “Effects of age on horizontal smooth pursuit.” *Investigative Ophthalmology and Visual Science* 17:465-468.

Sheldon, R. and M.L. Koshman. 1995. “Can Patients with neuromediated syncope safely drive motor vehicles?” *American Journal of Cardiology* 75:955-956.

Simoes, A. and C. Marin-Lamellet. 2002. “Ch. 17: Road users who are elderly: drivers and pedestrians.” in *Human Factors for Highway Engineers*. Edited By R. S. Fuller and J.A.Santos. New York: Pergamon.

Sims, R.V., G. McGwin Jr., R.M. Allman, K. Ball and C. Owsley. 2000. “Exploratory study of incident vehicle crashes among older drivers.” *Journal of Gerontology: Medical Sciences* 55a (1):M22-M27.

Stamatiadis, N., W.C. Taylor and F.X. McKelvey. 1991. “Older drivers and intersection traffic control devices.” *Journal of Transportation Engineering* 117 (3):311-319.

Staplin, L, K.H. Lococo, A.J. McKnight, A.S. McKnight and G.L. Odenheimer. 1998. *Intersection Negotiation Problems of Older Drivers, Volume II: Background Syntheses on Aging and Intersection Driving Difficulties.* Washington, D.C.: National Highway Traffic Safety Administration.

Staplin, L., D. Harkey, K. Lococo and M. Tarawneh. 1997. *Intersection Geometric Design and Operational Guidelines for Older Drivers and Pedestrians, Volume I: Final Report.* Washington, D.C.: Federal Highway Administration.

Staplin, L., K. Lococo, S. Byington and D. Harkey. 2001. *Guidelines and Recommendations to Accomodate Older Drivers and Pedestrians*. McLean, Va: U.S. Department of Transportation, Federal Highway Administration, Research Development and Technology, Turner-Fairbank Highway Research Center.

___. 2001a. *Highway Design Handbook for Older Drivers and Pedestrians.* FHWA-RD-01-103. McLean, Va.: U.S. Dept. of Transportation, Federal Highway Administration. Available from http://www.tfhrc.gov/humanfac/01103/coverfront.htm.

___. 2001b. *Guidelines and Recommendations to Accomodate Older Drivers and Pedestrians.* McLean, Va: U.S. Department of Transportation, Federal Highway Administration, Research Development and Technology, Turner-Fairbank Highway Research Center.

Staplin, L., K.H. Lococo, J. Stewart and L.E. Decina. 1999. *Safe Mobility for Older People Notebook.* Washington, DC: U.S. Department of Transportation.

Stewart, R.B., M.T. Moore, R.G. Marks, F.E. May and W.E. Hale. 1993. *Driving Cessation and Accidents in the Elderly: An Analysis of Symptoms, Diseases, Cognitive Dysfunction and Medications.* Washington, D.C.: AAA Foundation for Traffic Safety.

Stutts, J.C. 1998. "Do older drivers with visual and cognitive impairments drive less?" *Journal of the American Geriatrics Society* 46:854-861.

Tobey, H.N., E.M. Shunamen and R.L. Knoblauch. 1983. *Pedestrian Trip Making Characteristics and Exposure Measures.* Washington, D.C.: Federal Highway Administration, Office of Safety and Traffic Operations.

Transportation, Oregon Department of. 2003. *Medically At-Risk Driver Program.* Salem, Ore.: Oregon Dept. of Transportation, January 23, 2003. Cited. Available from http://www.odot.state.or.us/comm/news/medicalrulesfaq.htm.

TRIP. 2002. *Traffic Safety and Older Americans: Making Roads Safer for Motorists.* Washington, D.C.: The Road Information Program.

Wachs, M. 2001. *Mobility for California's Aging Population.* CPRC Brief: Strategic Planning on Aging no. 6. Berkeley, Ca.: California Policy Research Center.

Walker, N., W.F. Bradley, A.D. Fisk and C.L. McGuire. 1997. "Aging and decision-making: driving related problem solving." *Human Factors* 39 (3):438-444.

Warabe, T., M. Kase and T. Kato. 1984. "Effect of aging on the accuracy of visually guided saccadic eye movement." *Annals of Neurology* 16:449-454.

Weale, R.A. 1982. *A Biography of the Eye.* London, U.K.: H.K. Leis.

Zegeer, C.V., C. Seiderman, P. Lagerway, M. Cynecki, M. Ronkin and R. Schneider. 2002. *Pedestrian Facilities Users Guide: Providing Safety and Mobility.* Washington, D.C.: U. S. Department of Transportation, Federal Highway Administration, Research and Development, Turner-Fairbank Highway Research Center.

Zegeer, C.V., J.R. Stewart, H.H. Huang and P.A. Lagerwey. 2002. *Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations: Executive Summary and Recommended Guidelines.* McLean, Va: University of North Carolina, Chapel Hill, Highway Safety Research Center and Federal Highway Administration, Turner-Fairbank Highway Research Center.

Zegeer, C.V., J.C. Stutts, H. Huang, M. Zhou and E. Rodgman. 1993. "Analysis of elderly pedestrian accidents and recommended countermeasures." *Transportation Research Record* no. 1405:56-63.

Zhong, M. 2003. *Florida Department of Transportation Satisfaction Survey for Florida Residents* [Electronic report as attachment to correspondence]. Florida Department of Transportation.