

The Mature Driver: Safety and Mobility Issues

FINAL REPORT
May 2002

Submitted by

Naomi G Rotter
Professor of Management
New Jersey Institute of Technology
School of Management

And

Claire McKnight
Associate Professor Civil Engineering
City College of New York
Institute for Transportation Systems



NJDOT Project Manager: Ken Stevenson



The contents of this report reflects 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 New Jersey Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

1. Report No. 995922	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Mature Drivers: Safety and Mobility Issues		5. Report Date May, 2002	
		6. Performing Organization Code	
7. Author(s) Naomi G. Rotter & Claire McKnight		8. Performing Organization Report No.	
		10. Work Unit No. (TRAIS)	
12. Authorizing Office and Address USDOT/NJDOT, CN600 Trenton, NJ 08625		11. Contract or Grant No. Final Report. 1/1/00 - 12/31/01	
		14. Sponsoring Agency Code	
13. Supplementary Notes			
16. To answer the question of whether New Jersey's mature drivers present an increased risk of injury and fatalities to themselves and others, analyses of accident and violation records were performed. A survey was also conducted of a sample of State Departments of Motor Vehicles regarding licensing of mature drivers. The data analyses showed that New Jersey's older drivers, similar to those in other states, are involved in fewer crashes when compared to other age groups. Their rate of crash involvement per population also decreases. For crash involvements per licensed driver, we found a similar pattern of decrease with age until the drivers reached their mid-nineties. Then the trend showed an increase. Mature drivers have accidents in different places and times than do younger drivers and may be less safe than middle-aged drivers. If there is a risk posed, the risk is to older drivers themselves since a greater percentage of their crashes result in fatalities than do other age groups. But as a group, mature drivers are involved in few accidents and fewer fatal accidents than younger drivers. Of states responding to the survey, six reported some type of age-related provision in the licensing law. The variety of provisions included: reducing the renewal cycle period, no mail renewal after a certain age, eligibility to be selected for a sample of drivers requiring medical examination, and the need to be re-tested on knowledge and road skills. Most interestingly, states frequently reported use of medical review as a basis for restricting or suspending the license of elderly drivers.			
17. Key Words Mature, older, drivers, safety, accidents, violations, suspensions, crash risk, licensing, policy, medical review, driving ability, visual, cognitive, medical, psychomotor, fitness to drive		18. Distribution Statement	
19. Security Classification (of this report) Unclassified	20. Security Classification (of this page) Unclassified	21. No. of Pages 118	22. Price

ACKNOWLEDGEMENTS:

This work was sponsored by the New Jersey Department of Transportation and the National Center for Transportation and Industrial Productivity at New Jersey Institute of Technology.

We are grateful to Ken Stevenson of the New Jersey Department of Transportation who was our project manager and provided valuable assistance, connections, and feedback. He was extremely accessible in answering our many questions. We are also grateful to our colleague, Dr. Raghavan Srinivasan of Dowling College for his assistance with the statistical analyses. Finally, we appreciate the efforts of our research assistants, Ruth Mateo and Sheikh Jamilur Rahman for their work in researching the literature and general assistance on whatever task was at hand.

TABLE OF CONTENTS

SUMMARY	1
Demographic Trends In New Jersey	1
Analysis of Accident and Violation Data	1
Survey of State Motor Vehicle Associations	2
Conclusions	3
INTRODUCTION	4
THE MATURE POPULATION OF NEW JERSEY	5
Older Population of New Jersey	5
Licensed Drivers	6
REVIEW OF THE LITERATURE	9
The Problem And Overview Of The Literature Review	9
Crash Risk Defined	10
Some Dimensions Of The Issue Of Older Drivers	10
Crash Risk of Older Drivers	10
Types Of Accidents	12
National Statistics Regarding Fatalities In Automobile Crashes	13
Factors Associated with Driving Abilities	14
Visual Factors	14
Cognitive Factors	18
Psychomotor Factors	20
Medical Conditions	21
Predicting Accident Frequency	36
Assessing Driving Abilities	36
Self-assessments Tests	36
Clinical Instruments	37
Behavioral Sampling	37
Compensating For Ability Losses	37
Self-Restrictions On Driving	37
Accommodating To Ability Decline	38
The Decision to Stop Driving	38
Skill Enhancement	38
Policy Factors	39
Licensing Issues:	39
Physicians' Role in Assessing Older Drivers	47
Identifying "Fitness to Drive"	49
Summary of the Literature Review	50
ANALYSIS OF DATA	54
Description of The Data	54
Analysis of Data	54
Crash Data	54
Suspension and Violation Data	55
Results of Analysis of Crash Data	56
Number Of Crashes By Age	56
Situations of crashes	60

Severity of Accidents	63
Characteristics of the Crash.....	65
Results of the Analysis of Suspensions and Violations Data.....	69
Conclusions from Data Analysis.....	72
THE SURVEY OF STATE MOTOR VEHICLE AUTHORITIES.....	74
Description and Distribution of the Survey	74
Survey Findings.....	75
Age Related Provisions	75
Non-Age Related Provisions That Are Aimed Primarily At Older Drivers.....	76
On-going Studies on Older Drivers Supported by State DMVs	80
Summary of Survey Findings	81
CONCLUSIONS AND RECOMMENDATIONS.....	82
Conclusions.....	82
Recommendations	83
REFERENCES	85
BIBLIOGRAPHY	96
Web Sites Concerning Older Drivers.....	107
APPENDIX.....	109

LIST OF FIGURES

Figure 1	Driver Fatality Rates by Age and Sex, 1996	11
Figure 2	Crash Involvements by Age (1993-1995 and 1998-2000)	57
Figure 3	Trends in Driver Involvements	58
Figure 4	Crash Involvements by Gender and Age (1998 to 2000)	59
Figure 5	Involvement Rate by Age (per 10,000 population)	59
Figure 6	Involvements per 10,000 Licensed Drivers – 2000	61
Figure 7	Driver Involvement Rates per 10,000 People	61
Figure 8	Percent of Involvements by Light Conditions	62
Figure 9	Percent Involvements during Bad Weather or Wet Roads	62
Figure 10	Percent of Involvements by Road System	63
Figure 11	Percent Involvements by Time of Day	64
Figure 12	Percent of Involvements in Fatal Crashes	64
Figure 13	Number of Involvements in Fatal Crashes	65
Figure 14	Percent of Involvements in Injury and Fatal Crashes	66
Figure 15	Percent of Involvements by Vehicle Action	66
Figure 16	Percent of Involvements by Physical Condition of Driver	67
Figure 17	Percent of Involvements by Contributing Circumstances	67
Figure 18	Percent of “At-Fault” Involvements	69
Figure 19	Violation Rates for over 40 Drivers (per 10,000 People)	70
Figure 20	Percent of Violations by Violation Type (40 to 100 Year Old Drivers)	70
Figure 21	Suspension Rates for Drivers Over 40 Years (per 10,000 People)	71
Figure 22	Percent by Type of Suspension Order (40 to 100 Year Old Drivers)	72

LIST OF TABLES

Table 1	Population - 55 Years and Over (Year 2000)	5
Table 2	Growth of Population 1980 to 2000	5
Table 3	Population of New Jersey Counties (2000)	6
Table 4	Population Growth in New Jersey Counties 1980 to 2000	7
Table 5	New Jersey License Rates by Age – 2000	7
Table 6	New York State License Rates	8
Table 7	Medications That May Impair Driving Skills	34
Table 8	Renewal Cycle Length for States with No Special Provisions for Older Driver License Renewal	41
Table 9	States Which Do Not Allow Mail Renewal for Older Drivers' Licenses	42
Table 10	States Which Have an Accelerated Renewal Cycle for Older Drivers' Licenses	43
Table 11	States Which Require a Vision Test for Older Drivers' License Renewal	44
Table 12	States Which Require a Road Test for Older Drivers' License Renewal	44
Table 13	States Which Prohibit Age Related Provisions for License Renewal	44
Table 14	States Which Ease Provisions for License Renewal for Older Drivers	45
Table 15	Vision-related Driver License Renewal Policies as of 1991	46
Table 16	Number of Crashes by Year in Data Sets	54
Table 17	Survey Respondents' Position or Office	75
Table 18	A Summary of Medical Review Policies in Participating States	78
Table 19	State Supported Research on Older Driver	80

The Mature Driver: Safety and Mobility Issues

SUMMARY

This project surveyed both the literature and the practice to examine the variables that relate to aging drivers and safety. In addition, analysis was done of accident and violation data in New Jersey from 1993-2000.

Demographic Trends In New Jersey

New Jersey's older population (age 65 and older) is growing at a somewhat faster rate than that of the United States as a whole and this trend of accelerated aging is expected to continue for at least the next 10 years. Two counties in particular, Cape May and Ocean, have a noticeably larger percentage of older residents (both over 20%) than the other counties of the state which hover in the 9-15% range.

The percentage of older citizens of New Jersey who were licensed drivers in 2000 was highest for the 55-64 age group and then dropped slowly for the 65-74 and the 75-84 cohorts. At 85, a marked drop was noted. If older cohorts show an increase in the percentage of licensed drivers, as is the national trend, then we can expect more senior drivers on the roads. If the current numbers do not move much, it suggests that older drivers in New Jersey may be self-screening themselves in terms of driving capability or they may have their licenses suspended or revoked due to medical review. These data need to be tracked to give some indication of the trends in New Jersey.

Analysis of Accident and Violation Data

The results of the analyses of accident and violation data reveal that New Jersey's older drivers show a propensity to accidents and a pattern of accidents that are similar to outcomes reviewed in Chapter 3

Our data show that number of crashes that the mature driver is involved with decline with age. Further, the rate of crash involvements per population also declines with age. The rate of crash involvements per licensed drivers declines with age until the mid-nineties.

Like older drivers in other states, New Jersey older drivers are involved in more accidents during daylight hours and good weather, probably because they avoid driving in the dark and bad weather. They have more accidents on local and private roads than younger drivers, again probably due to their choice to avoid driving on high-speed roads.

A greater percent of the crashes that a mature driver is involved in are fatal, but they are involved in fewer fatal accidents than younger drivers.

A greater percent of the accidents that a mature driver is involved in were while making a left turn than is true for younger drivers. The crashes that the mature driver is in are more likely to involve inattention, failure to yield right of way, or failure to obey traffic signals. The mature driver is more likely to be at fault than a middle age driver.

The mature driver has a lower rate of traffic violations per population than younger drivers, and the mature driver's violation is more frequently due to careless driving and less frequently due to speeding. The mature driver has a lower rate of suspensions than the middle aged driver, and the likelihood of the suspension being due to physical or medical conditions increases rapidly as the driver ages, reaching 100 percent for drivers over 90 year old.

In summary, the average mature driver has different types of accidents in different places and times than the younger driver. Many mature drivers appear to be less safe drivers than middle-aged drivers in many ways, but mature drivers as a group are involved in fewer accidents and fewer fatal accidents than younger drivers.

Survey of State Motor Vehicle Associations

The survey of State Motor Vehicle Associations, a combination of email and phone interview, yielded responses from 23 states. The survey was designed to elicit information about age related provisions in licensing and studies in the state regarding older drivers. Of the 23 states responding to the survey, six reported some type of age-related provision in the licensing law. The simplest provision was solely reducing the renewal cycle period. Other renewal provisions included no mail renewal after a certain age, eligibility to be selected for a sample of drivers requiring medical examination, and the need to be re-tested on knowledge and road skills.

Most interestingly, states frequently reported use of medical review as a basis for restricting or suspending the license of elderly drivers. Health care providers, law enforcement officers, agents of the licensing agency, and concerned relatives and friends, can typically initiate medical review. The request for medical review is examined by the licensing agency and a determination is made regarding the need for further information. Very few states had mandatory reporting of medical conditions, with Pennsylvania being the most stringent. Where a determination is made to do something about the driving privilege, several states reported use of restricted licenses rather than suspension or revocation. Typical restrictions include daylight driving, restricted driving range, speed, and type of highway. Some states are providing or recommending remediation courses to improve driving skills.

Several states have concluded, are currently conducting, or are planning to conduct studies regarding older drivers. The thrust of research seems to focus on developing tests that will effectively assess functional ability to drive, including

cognitive and physical abilities. Maryland, California, and Florida are the lead states in this effort. Along with test development is concern that there be appropriate remediation facilities that can assist older drivers in improving their driving abilities.

Conclusions

Analyses of the data support other studies that show older drivers do not present an increased crash risk to other drivers. Older drivers appear to be primarily a risk to themselves in that there is a slight increase in fatalities as they get past the age of 65. This is attributed to increased frailty of older drivers.

The pattern of accidents of older drivers in New Jersey suggests that older drivers are already avoiding hazardous driving conditions. Similar to national trends, they have more accidents during the daytime; are less likely than younger drivers to be in accidents when weather and road conditions are poor; and are somewhat more likely to have accidents on local roads than state or interstate highways.

Older drivers in New Jersey, like elsewhere, show a greater propensity to be involved in left-turn accidents than younger groups. This fact combined with the data showing that inattention is the most frequently cited contributing circumstance for older drivers suggests three remedies: training older drivers for intersection maneuvers, redesigning high accident rate intersections, and employing a device that could warn drivers of on-coming cars and whether they can get through the intersections safely.

The analyses of violations data reveal that careless driving is the most frequent citation. Speeding is not an issue. Careless driving is difficult to remedy. A proposed solution is one of training and giving older drivers techniques for focusing their attention while behind the wheel.

Our survey of practices in other state licensing agencies suggest that medical review is used as a way of ending the driving privilege for older drivers who show impaired driving skills. Several states offer restricted licenses. New Jersey might explore the experiences of other states that offer restrictions on driving licenses. Based on those experiences, a policy change might be warranted

An area for further study that emerged from our analyses is the medical review policy in each of the states. There is variability as to how it is initiated, whether there is mandatory physician reporting, whether there is confidentiality of reporting, how the medical review process works, and finally if there are alternatives to suspending or restricting licenses. Examination of the medical review policy in all states would provide a knowledge base for good practice.

Based on the results of the literature review, data analysis and survey of practices in other states, several recommendations are offered.

INTRODUCTION

New Jersey is gaining an aging population like the rest of the United States but more so. In 1990, people 65 and older comprised 12.5 percent of the population in United States while in New Jersey this group represented 13.2 percent. By 1998, this group had increased to 12.7 percent in the U.S. and 13.6 percent in New Jersey. Not only is this age category witnessing increase, within it the oldest old (people 85 and older) is also increasing. With the increase in older population comes an increase in the number of older drivers. From National Highway Traffic Safety Administration's (NHTSA) data archives, there were 18.5 million older licensed drivers in 1999.⁽¹⁾ This represents an increase of 39 percent from 1989 which contrasts to a 13 percent growth in total licensed drivers during this ten-year period. The rapidly expanding segment of the older driver continues growth that Waller⁽²⁾ noted ten years ago.

A problem clearly emerges for concerns regarding public policy and the quality of life for older drivers when these demographic data are coupled with well established data documenting the association of increased age with risk of injury or death in an automobile crash (e.g., Pike⁽³⁾) and the higher accident rate (per million miles driven) of the older driver.⁽⁴⁾

Given the potential problem of increased accidents occurring on the densely traveled roads of New Jersey, the New Jersey Department of Transportation in conjunction with the National Center for Transportation and Industrial Productivity requested a study to capture the dimensions of the issues regarding older drivers in the state. New Jersey's demographics coupled with the fact that it is the most densely populated state with congested roadways necessitates looking at both accident and violation data to understand the extent and nature of the problems regarding senior drivers.

The project's objective was to survey both the literature and the practice to build a knowledge base of the variables that relate to aging drivers and safety. Included in this knowledge base are the current activities and policies pertaining to older drivers in selected Departments of Motor Vehicles (DMVs) of other states. In addition, the study would provide an understanding of the problems of older drivers in New Jersey by examining existing accident and violation data

The anticipated result of this project is to assist the Department of Transportation and the Division of Motor Vehicles in its efforts to respond to safety and policy issues regarding older drivers. This final report summarizes findings from the literature review, presents the methodology used in its survey of Departments of Motor Vehicles as well as the results of the survey and the results of accident and violation data analysis.

THE MATURE POPULATION OF NEW JERSEY

Older Population of New Jersey

New Jersey, like the United States as a whole, has an aging population. By the year 2000, the number of New Jersey residents who were 65 or older was over 1.1 million or 13.2 percent of the total population, higher than the 12.4 percent for the United States as a whole, while the old old or the 85 and older group had reached 136,000 or 1.6 percent, slightly greater than the 1.5 percent of the United States population in that age group.⁽⁵⁾ See Table 1.

Table 1. Population 55 Years and Over (Year 2000)

	Total		55 - 64		65 years +		85 +	
	no.	percent	no.	percent	no.	percent	no.	percent
United States	281,421,906	100	24,274,684	8.6	34,991,753	12.4	4,239,587	1.5
New Jersey	8,414,350	100	753,984	9.0	1,113,136	13.2	135,999	1.6

Table 2 indicates that for the United States, the 65 plus and the 85 plus groups have been growing at about the same rate of 37 percent. In New Jersey, growth of the 65 and older group has increased at not quite 30 percent; when the fact that New Jersey is a slow growth state (only a 14 percent increase since 1980, compared to 24 percent for the whole country), this is a major increase. New Jersey's 85 and older category has increased over 94 percent in the 20 year period, a remarkable increase. Referring to Table 1 above indicates that the 55 to 64 age group is proportionally greater in New Jersey than the United States as a whole, suggesting that the trend for New Jersey to age faster than the country as a whole will continue.

Table 2. Growth of Population 1980 to 2000

	Growth in total population		Growth in 65+ population		Growth in 85+ population	
	Number	percent	Number	percent	Number	percent
United States	54,876,101	24.2%	9,493,367	37.2%	1,159,422	37.6%
New Jersey	1,049,527	14.3%	256,028	29.9%	66,002	94.3%

The counties with the largest 65 and older population are Bergen, Ocean, Essex, and Middlesex (Table 3). However, if we look at the proportion of the county's population that is older, the larger counties (Bergen, Middlesex, and Essex) are less prominent and Ocean and Cape May are the dominant counties. For the 85 and older category, the same pattern is seen.

Table 3. Population of New Jersey Counties (2000)

County	Total population	65 years +		85 +	
		no.	percent	no.	percent
Atlantic	252,552	34,437	13.6	4,118	1.6
Bergen	884,118	134,820	15.2	17,055	1.9
Burlington	423,394	53,218	12.6	5,491	1.3
Camden	508,932	63,769	12.5	7,543	1.5
Cape May	102,326	20,681	20.2	2,625	2.6
Cumberland	146,438	19,087	13.0	2,316	1.6
Essex	793,633	94,380	11.9	12,311	1.6
Gloucester	254,673	29,678	11.7	3,062	1.2
Hudson	608,975	69,271	11.4	8,245	1.4
Hunterdon	121,989	12,228	10.0	1,399	1.1
Mercer	350,761	44,140	12.6	5,426	1.5
Middlesex	750,162	92,590	12.3	9,424	1.3
Monmouth	615,301	76,923	12.5	9,814	1.6
Morris	470,212	54,530	11.6	6,652	1.4
Ocean	510,916	113,260	22.2	14,914	2.9
Passaic	489,049	59,033	12.1	7,697	1.6
Salem	64,285	9,311	14.5	1,092	1.7
Somerset	297,490	33,381	11.2	4,129	1.4
Sussex	144,166	13,152	9.1	1,626	1.1
Union	522,541	72,041	13.8	9,369	1.8
Warren	102,437	13,206	12.9	1,691	1.7

The rate of growth of the older age categories (Table 4) differ widely between the counties, ranging from a negative 4.3 percent over 20 years for Essex (the overall population of Essex has been shrinking) to 86.5 percent for Burlington County. The counties with the largest absolute increase in the 65 and over population are Ocean, Middlesex, Bergen, and Burlington. The counties with the highest rate of growth tend to be those with smaller population (Burlington, Somerset, and Gloucester) with one exception, Middlesex. For the 85 years and older population, the fastest growing counties are Ocean, Middlesex, Burlington, and Cape May.

Licensed Drivers

Table 5 shows the number and percent of the New Jersey population who have drivers licenses in the older age categories.⁽⁶⁾ While close to 95 percent of the population in the 55 to 64 age category has a drivers license, this drops off as the age increases, reaching less than 50 percent for the 85 plus age category. Actual driving (and therefore exposure to accidents) probably drops off even steeper, as many people keep their license even after ceasing to drive plus the amount that the older person drives is less than people in the prime years of life.

Table 4. Population Growth in New Jersey Counties
1980 to 2000

	Growth in total population		Growth in 65+ population		Growth in 85+ population	
	Number	percent	Number	percent	Number	percent
New Jersey	1,049,527	14.3%	256,028	29.9%	66,002	94.3%
Counties						
Atlantic	58,433	30.1%	3,733	12.2%	1,261	44.1%
Bergen	38,733	4.6%	29,954	28.6%	8,017	88.7%
Burlington	60,852	16.8%	24,679	86.5%	3,096	129.3%
Camden	37,282	7.9%	14,845	30.3%	3,931	108.8%
Cape May	20,060	24.4%	3,987	23.9%	1,436	120.8%
Cumberland	13,572	10.2%	3,567	23.0%	1,131	95.4%
Essex	-57,483	-6.8%	-4,260	-4.3%	4,057	49.2%
Gloucester	54,756	27.4%	11,990	67.8%	1,529	99.7%
Hudson	52,003	9.3%	-409	-0.6%	3,067	59.2%
Hunterdon	34,628	39.6%	4,123	50.9%	651	87.0%
Mercer	42,898	13.9%	9,008	25.6%	2,563	89.5%
Middlesex	154,269	25.9%	40,017	76.1%	5,569	144.5%
Monmouth	112,128	22.3%	17,533	29.5%	4,262	76.8%
Morris	62,582	15.4%	18,886	53.0%	2,954	79.9%
Ocean	164,878	47.6%	41,498	57.8%	11,103	291.3%
Passaic	41,464	9.3%	6,294	11.9%	3,022	64.6%
Salem	-391	-0.6%	1,817	24.2%	450	70.1%
Somerset	94,361	46.5%	15,179	83.4%	2,164	110.1%
Sussex	28,047	24.2%	3,031	29.9%	627	62.8%
Union	18,447	3.7%	7,550	11.7%	4,303	84.9%
Warren	18,008	21.3%	2,754	26.3%	561	49.6%

Table 5. New Jersey License Rates by Age - 2000

Age	Licenses	Population	Ratio of licenses to Population
55-64	713,350	753,984	0.946
65-74	496,908	574,669	0.865
75-84	319,262	402,468	0.793
85 +	67,128	135,999	0.494

However, the number of old old drivers is likely to increase in the future as more people live longer. Further the rate of being licensed among the older age categories, as well as the number of people, will increase in the future, because people born more recently obtained licenses at a higher rate than in their parents

generation. The data that might show the increasing rate of licenses among the older population is not available for New Jersey, but Table 6 provides comparable information for New York State. (Note that the rate at which people have licenses in any age group is lower in New York than in New Jersey; this is probably due to the influence on New York City (where many people do not own cars or drive) and to the lower incomes on average in New York State.) In the six year period shown, the increase in the rate of being licensed grew substantially (excepting the idiosyncratic low growth for the 65 to 69 group) from 3.5 percent for the 50 to 59 year olds to 28.6 percent for the 80 and over age group. It is likely that the high growth license rates for the older age groups will occur in New Jersey in the next decade.

Table 6. New York State License Rates

Ages	Ratio of licenses to population		Rate of growth
	1993	1999	'93 to '99
50-59	0.798	0.825	3.50%
60-64	0.738	0.774	4.90%
65-69	0.717	0.722	0.70%
70-74	0.675	0.707	4.80%
75-79	0.590	0.656	11.20%
80+	0.353	0.454	28.60%

REVIEW OF THE LITERATURE

The Problem And Overview Of The Literature Review

The issues of safety and mobility of older drivers stem from demographic increases in the older segment of the population and their increased risk for injury or death in an automobile crash when compared with younger segments. During the decade of the 80's, the proportion of drivers in the older category grew at a greater rate than all other licensed drivers.^(7,8) Barr⁽⁷⁾ observed that between 1989 and 1999, the number of older licensed drivers increased 39% to 18.5 million. In the same time period, the total number of all licensed drivers increased 13%. Hu et al⁽⁸⁾ found that from 1985-1995, the number of drivers' licenses issued to over-60 drivers increased 22% with the greatest increase in the over-70 driver age group. Moreover, these older drivers were driving more miles. When crash rates are based on mileage, drivers over the age of 85 have the highest fatality rates of all age groups.⁽⁴⁾ The actual rate for males over the age of 85 was 10 fatalities per 100 million vehicle miles traveled. In comparison, the rate for males age 40-44 was less than 1 per 100 million vehicle miles traveled.

Interest in older drivers is not a new phenomenon. Hakamies-Blomqvist⁽⁹⁾ noted a history dating to the 1930's. Then, drivers were often considered older after reaching 40. Whatever the dividing point, research on older drivers from the perspective of "crash risk" almost always uses chronological age. Hakamies-Blomqvist points out that chronological age is convenient but aggregates drivers with varying abilities. Use of chronological age presents problems when it comes to developing policies regarding older drivers. Thus the first area reviewed in the literature is the various ways crash risk is defined.

Regardless of the measure used to generate crash risk, the risk is an average for the entire age group. Yet, there is variance in how abilities related to driving are distributed within age groups. To safely operate an automobile, drivers need to perceive information about road conditions, other drivers, weather conditions and their own vehicles. This information needs to be effectively processed and appropriate responses need to be made quickly and accurately. The factors primarily involved in the perceptual and reaction processes are visual, cognitive, and psychomotor abilities. Health factors clearly have impact on the previously mentioned abilities and those most closely associated with driving are also reviewed

This literature review begins with definitions of crash risk, then provides descriptive information regarding older drivers and the types of accidents in which they are involved. Also considered are factors associated with driving ability, techniques for assessing driving abilities, and ways to compensate for ability decline. Finally, this review looks at policy issues regarding licensing of older drivers.

Crash Risk Defined

The numbers present varying pictures of risk that older drivers exhibit. Risk is typically defined as the number of accidents/exposure. Typically, measures of exposure become the problematic factor in the measure.⁽⁹⁾ Databases for accident statistics are kept by several government agencies. The denominator or exposure however, has varying approaches to its measurement. While it would be useful to have the population of licensed drivers by age category, these data are often not available. A surrogate measure is often the population in the age categories. If fewer drivers were actually driving in older age categories compared to the totals in the age group, then data regarding crash risks would be biased and underestimated for older categories. (The decision to stop driving is reviewed later.) When exposure is measured using accidents per capita or per licensed driver, the data reveal that older drivers have fewer accidents than other age categories. As Hakamies-Blomqvist points out, if the concern is general cost to the society, then using this type of risk is acceptable.

However, when risk is defined in terms of miles driven, a dramatically different picture regarding risk and older drivers is revealed. The driver fatality rates per miles traveled, as seen in Figure 1, reveal that older drivers and particularly, very older male drivers (*over 85*), have the highest crash risk of all demographic groups. This measure is more descriptive of costs to the specific age group. Janke⁽¹⁰⁾ however, reports that a crash per vehicle mile traveled (VMT) tends to exaggerate the crash risk of low-mileage drivers. She explains that high mileage drivers typically gather their VMT on freeways and these are generally safer roads with less exposure to situations that present crash risk (e.g. intersections). Low mileage drivers (into which older drivers group) more frequently travel on local roads and therefore face more potentially pernicious driving situations.

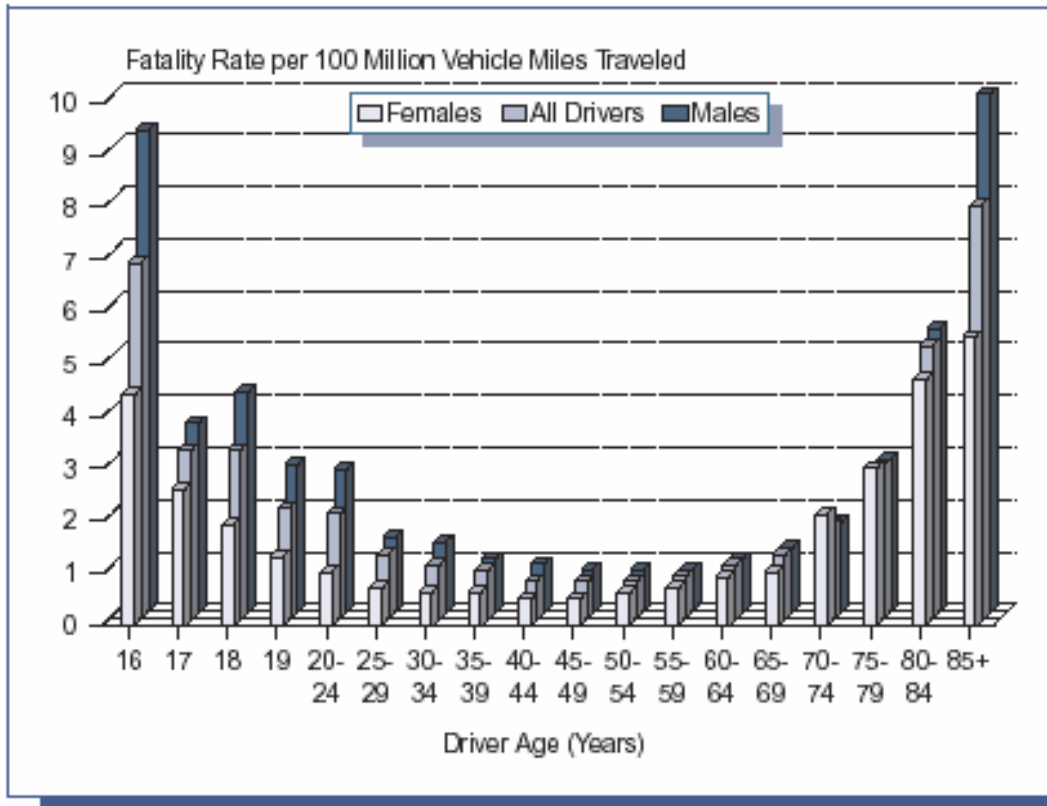
Yet a third measure of exposure is “time” in traffic. Chipman^(11,12) using time and mileage data in a Canadian study, demonstrates lower crash risk for older drivers when time is used than when mileage is used. Since each of the measures presents its own problems, it is important to be aware of the potential biases that are introduced.

Some Dimensions Of The Issue Of Older Drivers

Crash Risk of Older Drivers

The accident propensity of older drivers has received much interest in recent years. Studies of their risk, while primarily focused on older US drivers have also looked at drivers in the U.K., Sweden, Finland, and Australia. A review of the studies shows similar findings. Stamatiadis and Deacon⁽¹³⁾ examined Michigan accident records from 1978-1988. Their measure of accident propensity was based on a ratio of a particular type of at-fault drivers in a specific condition (e.g. females at fault at intersections) compared to the same type and condition not

Figure 1: Driver Fatality Rates by Age and Sex, 1996



(From *Traffic Safety Facts 2000: Older Population.*⁽¹⁾)

at-fault. The authors note that this measure is useful when direct exposure estimates are not available. Their data revealed that middle-aged and female drivers were, overall, the safest. Older drivers were found to be the least safe, however, there were cohort and gender effects. That is, younger cohorts of older drivers were less likely to be at fault in an accident than older or more distant cohorts. Gender interacted with age in accident propensity; females were safer drivers than males for the younger age groups but were less safe than males for the older age groups. A cohort effect was also obtained in a 1999 study of Finnish drivers.⁽¹⁴⁾ The researchers metric for accidents was the number for the age/gender group as a proportion of the total accidents in that category. For the 60-79 age group, male drivers showed a decrease in intersection accidents in successive cohorts. More specifically, drivers who fell into the age category of 60-69 in 1995 had a lower rate of intersection accidents than those who fell into the same age category in 1987. This did not hold for the 80+ male drivers who showed an increase with successive cohorts. Female drivers showed a decrease for successive cohorts aged 60-69, and no change for the 75+ cohorts. However for both male and female drivers, accidents at intersections increased with age.

Using a 1991 Wisconsin accident database and linking data from two-car accidents to hospital discharge information, Dulisse⁽¹⁵⁾ found that drivers age 65-74 did not impose “excess risk of either death or injuries” to others. (Dulisse looked at both deaths and hospitalizations for varying age groups per 100 million driver miles.) However, drivers 75 and over were associated with increased risk but it was small (1%) in terms of the total number of serious injuries. In another study using data from 1989-1992 for property damage and injuries (fatal and non-fatal) in accidents reported to police in Western Australia, Ryan, Legge and Rosman⁽¹⁶⁾ examined age and gender differences in crash involvement rates. Population data were used to determine the rates for crash involvement. The highest rates of involvement were for drivers 25 and younger (35%) while drivers 70 and older accounted for 3%. However, when distance traveled was factored in, the involvement rates looked similar for the youngest and oldest groups. Drivers over 75 had more direct and indirect right angle crashes and crashes associated with turning movements. Drivers over 75 were more likely to have crashes that resulted in fatalities and hospital admissions. Increased fragility of the older drivers is a frequent explanation.

Types Of Accidents

Looking at the problem of older drivers from the perspective of accident type, Richardson, Kim, Li, and Nitz⁽¹⁷⁾ examined accident data in Hawaii for 1991 and 1992. More specifically they looked at head-on, rear-end, broadside, sideswipe, and rollover crashes. For each type, they classified each vehicle in two-car crashes as being either the car that initiated the strike or the car that received the strike. They report that head-on and rear-end initiations, and rollover crashes decrease with age. But older drivers are more likely to be involved in crashes where they broadside or sideswipe other vehicles. They are also more likely to be broadsided or sideswiped. From the types of crashes they are involved in, Richardson et al infer that older drivers are more likely to be in crashes that involve driver error rather than poor judgment. Errors might be observation failures regarding traffic signals and other vehicles. An interaction was obtained between age and gender. Older females are more likely to be involved in headoners and sideswipers than older males and less likely to be rearended.

McGwin and Brown⁽¹⁸⁾ looked at crash types and age using 1996 data from Alabama. Their findings reveal that older drivers were more likely to be involved in crashes at intersections, in failing to yield right of way, to obey stop signs and signals, and with objects they did not see. They were less likely to be involved in accidents that were associated with driver fatigue, during early morning and evening, during bad weather, traveling at high speeds, on curved roads, and involving a single vehicle. McGwin and Brown infer that older drivers' accidents reflect problems in perception, judgment, and responding to traffic conditions. This is similar to the driver error inferred in the Richardson, et al study.⁽¹⁷⁾ McGwin and Brown⁽¹⁸⁾ also obtain interaction effects between age and gender for fault. While males were more likely to be the responsible party in accidents

involving younger drivers, females were more likely to be responsible among older drivers. A similar result for female drivers was obtained by Stamatiadis⁽¹⁹⁾. When the number of drivers determines crash rates, males have higher crash rates but when the criterion is personal miles traveled, females display higher rates except for the youngest drivers. If only fatalities are considered then males display higher rates.

Hu et al⁽⁸⁾ summarized findings which used crash data from North Carolina. In general, older drivers were increasingly at fault when two cars were involved. That was particularly the case for left-turns, right-turns and straight ahead angle crashes. Older drivers had problems at non-signalized intersections when compared to younger age groups.

Using an experimental approach, Dobbs, Heller and Schopflocher⁽²⁰⁾ compared driving skills in a controlled situation for three groups of drivers: older drivers with clinically significant declines, normal older drivers and normal younger drivers. Expert driving evaluators also evaluated them. Their results indicate that the category of hazardous errors distinguishes best among the groups. Hazardous errors were those that were obviously dangerous regardless of the type of maneuver and either required the driving evaluator to take control of the car or forced traffic to adjust to accommodate the error. Other errors that discriminated between safe and unsafe drivers were minor positioning errors (too close to lane markings), turning positioning errors (wide or cut turns), and scanning errors (no shoulder checks). Such information could be useful in screening procedures for licensing of older drivers, particularly those with cognitive impairment.

National Statistics Regarding Fatalities In Automobile Crashes

In 1999, older drivers (70+) accounted for 5% of all injuries in traffic crashes.⁽⁴⁾ however, older drivers accounted for 13% of all traffic fatalities. While in absolute numbers driver fatalities have increased markedly from 1989 to 1990 (46%), driver involvement rate per 100,000 drivers, shows a decrease and a leveling for older drivers. Rather consistently, older drivers fatalities occur during daylight, on weekdays, and involve another vehicle. When the accident involves both a younger and an older driver, the older driver is far more likely (59%) to be struck than the young driver (19%). In these two car crashes, both cars are likely to be proceeding straight ahead at the time of the collision, but in 27% of the cases, the older driver was making a left turn. The propensity for left turn intersection crashes was seven times higher for older drivers than younger drivers in 1999 and eight times higher in 1998. Older drivers in fatal crashes have the lowest proportion of intoxication of any adult driver age group.

Factors Associated with Driving Abilities

Operating an automobile requires an array of perceptual, cognitive and motor abilities. Information about other cars, road conditions and the automobile being driven must be discerned, processed and responded to quickly and accurately. This involves visual and perceptual factors, cognitive factors and psychomotor factors. All of these are sensitive to age-related declines. Beyond age related declines is the impact of medication that frequently increases among older citizens. Eby, Trombley, Molnar and Shope⁽²¹⁾ presented a comprehensive review of these factors in their 1998 report. The following section summarizes and updates their review.

Visual Factors

In a review of visual requirements for driving safety, Shinar and Scheiber⁽²²⁾ propose that vision is responsible for 95% of driving-related information inputs. Charman⁽²³⁾ notes that hearing is a second contributor but far below vision in importance. It would seem to reason that if good vision is necessary for safe driving, then poor vision is at least a pre-cursor to unsafe driving. Both Shinar and Schieber⁽²²⁾ and Charman⁽²³⁾ have noted however, that there is a *weak* positive correlation between increase in deteriorated vision and increases in unsafe driving. Shinar and Schieber reason that this weakness is due to several factors. In summary, accidents have multiple causes; typically, causes of accidents are cognitive such as distraction and misjudgments; vision-screening tests may be unreliable; more reliable tests of vision are not in widespread use; and drivers may compensate for deteriorated vision by restricting their own driving. Nonetheless, several aspects of vision have been studied in relation to driving. These include: static visual acuity, dynamic visual acuity, motion perception, contrast sensitivity, color vision, night vision and glare accommodation, visual field and useful field of view.

Static Visual Acuity

Static visual acuity deals with the ability to perceive details at a given distance, such as being able to read road signs. Static visual acuity is usually measured by the Snellen (letter) chart. In the United Kingdom the visual requirement for a driver's license is the ability to read a license plate in daylight (with corrected vision) at a distance of 67 feet.⁽²³⁾

Clearly static vision deteriorates noticeably after age 40 or 50.⁽²¹⁾ However, the relationship between visual acuity and safe driving is unclear. Charman⁽²³⁾ citing a Hills and Burg study in 1977 points to the very low correlation between visual acuity and accidents (<0.10) and only for drivers over 54. Since the tests have high contrast between the image of the letter and the background, these tests may not be sensitive to situations found in the field where contrast is not strong. Wood⁽²⁴⁾ used binocular visual acuity for a sample of young drivers, older drivers (age 60+) with normal vision and older drivers (60+) with early impairment. All

were legally eligible to drive in Australia. Driving ability was tested on a closed circuit course and measurements were made of errors in sign detection, central and peripheral reaction time, driving time and errors in speed estimation. Results indicated that all older drivers had poorer sign recognition ability and peripheral reaction time. Driving time was also slower for older drivers. Those drivers with early vision impairment performed even more poorly than those with normal vision. Since all drivers were legally eligible to drive and were frequent drivers, this research demonstrates the negligible prediction value of standard tests of high contrast visual acuity. Dunne⁽²⁵⁾ is exploring low contrast visual acuity as an indicator of accidents.

Dynamic Visual Acuity

Dynamic visual acuity (DVA) deals with the ability to perceive details of a moving target. It is measured moving a Snellen letter across the horizontal plane of the observer. Shinar and Schieber⁽²²⁾ refer to Burg's 1964 finding that dynamic visual acuity has stronger association with accident involvement than static acuity.

Motion perception

Motion perception is the ability to detect an object's movement from one location to another. This is another process that deteriorates with age and older adults require more movement for detection than younger ones.⁽²¹⁾ Shinar and Schieber⁽²²⁾ cite studies that link decrements in motion perception to accidents. Moreover, Eby et al.⁽²¹⁾ conclude from their review that older drivers may be slower in perceiving critical movement in traffic situations. This would provide less time for older drivers to react.

Contrast sensitivity

Contrast sensitivity is the ability to detect detail in gradually diminishing contrast to the background. Charman⁽²³⁾ reports that contrast sensitivity does correlate with driving performance. Eby et al.⁽²¹⁾ refer to work by Schieber in which he found that declines in age-related contrast sensitivity are associated with increased frequency of self-reported vision problems in driving. However, there is no strong link yet established between contrast sensitivity and accident propensity.

Color Vision

Color vision defects are not thought to hinder safe driving.⁽²³⁾ However, inability to recognize traffic signals does slow reaction to them. Whillans and Allen⁽²⁶⁾ advise that drivers with color vision defects maintain greater distances between vehicles. Charman also notes in his review that drivers with red color vision defect need four times the normal intensity to detect a red light. Some age related changes in color vision also occur due to changes in the lens. Lighthouse International reports on its website that blues and greens may become more

difficult to distinguish. Macular degeneration which is age related also affects color vision.

Night Vision And Glare

Night driving requires an additional set of visual abilities beyond day driving. It requires acuity in low light, as well as resistance and recovery from glare caused by on-coming cars. Eby et al⁽²¹⁾ synthesize research on illumination and aging and document that anatomical changes to the eye over time result in decreased sensitivity to light. This translates into older drivers needing significantly more light than younger drivers to see well. In daylight, the light is sufficient but at night, older drivers require brighter lights than younger drivers. Shinar and Schieber⁽²²⁾ discuss the effect of glare on vision in relation to aging. In general, glare interferes with vision. The effects of glare get worse with age. Despite the difficulties glare produces, the relationship between glare and crash risk is not well established.

Visual Field

Visual field is the area in which vision is possible with eyes held in a fixed position. Charman⁽²³⁾ notes in his review, that monocular field loss was not associated with accident involvement but that the accident rates for drivers with binocular field loss were twice the rate of drivers with normal fields. Moreover these drivers were unaware of their peripheral vision problems. Wood and Troubeck^(27,28) have studied the impact, experimentally, of reduced visual field. They use goggles to restrict the field and found that driving performance using a simulator was significantly worse with restricted fields. The effect was heightened when the subjects were older drivers. Similar to what Charman reported, Wood and Troubeck did not find decrements in driving performance with only monocular field restriction.

Eye Movements

The eye's ability to resolve detail is not uniform. In the center of the retina is a region with densely packed receptors that allows for fine resolution so that when we look directly at an object, we get the best image of it. However, objects move and so does the observer. Our ability to keep an object clearly in view depends on eye motion known as saccadic eye movements. These are quick eye movements that function to keep the image in the center of the retina for continued good resolution. Eby et al⁽²¹⁾ review literature on eye movements which indicates that in comparison to younger individuals, older adults take longer to begin saccadic movements and take more saccadic movements to keep an object in focus. This suggests that older adults may require more time to locate objects in their visual field. Maltz and Shinar⁽²⁹⁾ examined eye movements of older and younger drivers using computerized simulation of the view from the driver's seat. Their findings show that older participants had longer search times than younger participants and that they had shorter saccades (eye

movements) with more fixations (stopping to look). They also found that older adults scanned a smaller portion of the scene and would review it or go back to relook in comparison to younger adults who tended to scan scenes more evenly. Thus, it appears that with age, the scanning strategy loses efficiency.

Eby et al⁽²¹⁾ also reviewed research on tracking moving objects and the extent of upward and downward gaze. Findings on pursuit (tracking) eye movements shows that older adults track more slowly than younger adults and have a smaller range of upward and downward gaze. Combined, these results indicate that older adults would have to initiate more head movements to see the entire contents of a relevant visual field than would younger adults. This adds time to the task of driving.

Useful Visual Field

Ball, Owsley and their associates^(30,31,32) have pursued the relationship between useful field of view and driving accident propensity over a number of years. This process examines the driver's ability to simultaneously process information from central and peripheral visual fields similar to what occurs behind the wheel. The task involves looking at a visual display screen and identifying a central objects such as a car or truck and locating a peripherally displayed object which can be located in any of 24 various locations. Introducing visual distractions in the form of triangles can complicate the task. Ball, Owsley and their associates claim that if drivers cannot identify both central and peripheral targets, then they cannot adequately divide their attention between both fields as is needed for driving safely.

Using a sample of 294 subjects ranging in age from 60-85, Owsley et al⁽³²⁾ measured visual acuity, contrast sensitivity, visual field sensitivity, useful field of view, and mental status. All subjects underwent a comprehensive eye examination and medical conditions and medications were noted through a self-report questionnaire. Motor vehicle crash records for these subjects were tracked for three years following vision measurements. Fifty-six of the subjects had a least one crash during the 3-year period and 11 had at least 2 crashes. Of the various visual measurements used only useful field of view discriminated between those who experienced a crash and those who did not. Their finding reveal that older drivers with a 40% or greater reduction in the useful field of view were 2.1 times more likely to have had a crash. On the other hand driving less than 7 days a week was associated with a lower risk for crash involvement.

Visual Impairment And Driving.

Several studies which examine the effects of age and driving also considered visual impairment. Szlyk, Seiple, & Viana⁽³³⁾ examined a sample which varied in terms of age (younger and older) and vision (normal and impaired). Vision was measured using a test of visual field and driving through an interactive simulator. Self-reports were taken regarding accidents. Simulator driving speed decreased

for all older subjects and for younger subjects who had visual impairment. Older subjects also took longer for braking response time and had more lane boundary crossings. Finally age was also related to having accidents on the simulator course. For the major measures, age had an impact but visual status did not. Yet for the self-reports, younger subjects reported more accident involvement than older subjects. Szlyk believes compensatory factors account for the discrepancy. Older subjects drive more slowly, take fewer risks, and have more eye movements than younger subjects. The increased eye movements alone may not be a compensatory strategy but could be reflective of cognitive hesitancy and the need to confirm detected objects.

McGwin, Chapman, and Owsley⁽³⁴⁾ examined self-reported driving difficulties and visual functions among drivers aged 55 to 85. This sample was selected from ophthalmology practices and optometry clinics. Seventy-five percent of the sample had cataracts and the rest were cataract free. Subjects were measured for visual acuity, contrast sensitivity, glare disability, and useful field of view. In addition cognitive functioning was evaluated. Driving habits were measured by self-reports. The questionnaire was administered by interviewers and probed areas such as difficulty in driving in bad weather, congested traffic, alone, left turns, etc. Decreased visual acuity was associated with reported difficulty in night driving and on high traffic roads. Decreased contrast sensitivity was associated with more difficulty in making left turns, and those with decreased useful field of view reported more problems with driving in the rain.

Cognitive Factors

Cognition includes acquiring, processing, storing and retrieving information. Two particularly relevant processes are those of attention and memory. Attention, the process of focusing momentary awareness on a particular situation, is critical to safe driving. Driver distraction, a state when attention is diverted from driving tasks to irrelevant ones, is receiving a great deal of attention in the public media and in various local legislatures as they consider banning hand held cell phone use while driving. Cell phone activity is only one of many factors that detract from drivers' focusing attention on the road. Lack of attention results in actually not perceiving or misperceiving important road situations or vehicle situations. As a consequence, the driver either fails to make a maneuver, makes the maneuver too late, or makes an inappropriate maneuver.

Attention:

For the purpose of dealing with attention and driving, three processes are pertinent: vigilance or sustained attention, divided attention which is the ability to deal with two sources of information and two tasks simultaneously, and selective attention, which involves picking out relevant information and suppressing attention to irrelevant information.

Eby et al⁽²¹⁾ conclude from their summary of research that the relationship between vigilance and crash risk is not reliably established and that age differences in the ability to sustain attention have not consistently been found. Mounting evidence from studies on distraction will contribute to greater understanding of the role vigilance plays in crash risk.

Driving involves dividing attention between numerous sources of information, some relevant to the task and some unrelated but nonetheless attention grabbing. Drivers need to monitor the flow of traffic and attend to their own speed and driving maneuvers. Drivers also engage in “off-task” activities while driving such as conversing with passengers, talking on cell-phones, adjusting the radio, tape, and CD controls, and day-dreaming. Eby et al⁽²¹⁾ review research on age and divided attention which points toward a negative relationship between the ability to divide attention and age. It should be noted that dividing attention increases the mental load and thus decreases performance for all ages. In fact, Sekuler, Bennett, and Mamelak⁽³⁵⁾ examined changes with age in useful field of view (UFOV) which requires dividing visual attention between central and peripheral tasks, as a function of age and found that decline in UFOV begins as early as age 20. Brouwer, Waternink, Van Wolffelaar and Rothengatter⁽³⁶⁾ found that older drivers performed more poorly than younger ones during a driving simulation task which required divided attention between lane tracking and counting dots. When older drivers encountered the dot counting task, their lane tracking became significantly poorer. Similarly, their dot counting also showed more inaccuracies. Interestingly, older drivers made fewer errors in dot counting when they could respond vocally than when they had to respond manually. This suggests that in designing controls, no mode for control (e.g. voice, hands, feet) should be overloaded.

Finally, as stress increases, for instance, from increased traffic congestion or complicated maneuvers such as left turns, attentional focus narrows which should narrow the useful field of view. As UFOV constricts, there is more propensity for accidents. Janelle, Singer, and Williams⁽³⁷⁾ found among a sample of college students that performance declines were experienced in both central and peripheral visual tasks at higher levels of anxiety. They also noted eccentric search patterns with an increase in distraction.

Selective attention requires that relevant stimuli receive focus, while irrelevant ones be ignored. Applied to driving, drivers need to screen out irrelevant information and stimuli and focus on the task of driving. Eby et al⁽²¹⁾ found that there is a negative relationship between selective attention ability and crash risk. Moreover, selective attention ability appears to decline with age.

Memory:

Human memory is composed of working or short term memory (STM) which is limited in capacity and which engages in active processing, and long term memory (LTM), which theoretically has unlimited capacity and is the storage

reservoir. Eby et al's review⁽²¹⁾ of age and STM indicates that not only does STM show decrement with age, processing time for accessing information also increases with age. They cite research by French et al⁽³⁸⁾ which links hesitancy in decision making with crash risk. Radeborg and Briem⁽³⁹⁾ investigated the impact of driving on working memory. Using a simulated driving situation, they found that driving interfered with both recall and judgment of verbal material. That is, as driving added to mental load of working memory, attentional resources were siphoned off from a verbal task. Long term memory also has age related decrements. Studies⁽²¹⁾ indicate that with age, there is greater difficulty retrieving information. Combining slower processing speed with slower retrieval time, older drivers are at a disadvantage particularly as driving conditions add to information overload.

Psychomotor Factors

Driving is a task, which requires the ability to coordinate and move various parts of the body in relation to sensory inputs from the environment. One critical component of psychomotor abilities is that of reaction time. This involves the lapse of time from onset of a stimulus to completion of a physical response, such as the time it takes to brake a car in response to a traffic signal. Eby et al's literature review⁽²¹⁾ clearly presents evidence of the decline of reaction time with age. Further, they present findings that indicate that the slowing of reaction time with age is due more to central processing and decision making than to actual time it takes to make a movement. Hesitancy about what to do increases the reaction time not slowness of movement once the decision has been made about what to do.

Intersection navigation presents a driving situation that calls for an increase in coordination of response to a complicated visual scene. Keskinen, Ota, and Katilu⁽⁴⁰⁾ looked at the driving behavior of older drivers moving through intersections. While their results showed no difference in attentional behavior as measured by head movements, they did find variations in acceleration and the time to move through intersections which were related to age. From previous studies on reaction time, it seems that the slowing down comes in the central control process as sensory information is dealt with and a decision needs to be made about the best way to proceed.

Health Factors

According to the Center for Disease Control and Prevention (CDC) and National Center for Health Statistics (NCHS) life expectancy in the United States has increased since 1990 and 80% of all Americans are expected to reach the age 65 years and live longer in this millennium.⁽⁴¹⁾ Many of these older people live healthy active lives but Jeffrey Koplan, CDC Director, said that a significant number of people 85 years and over are affected by chronic diseases and disabilities that interfere with their daily activities. Disability increases with age and the percent of disabled people is higher in the 85 years of age and over

group than in the 70 to 74 year group. Heart disease, cancer and stroke are the leading causes of death in the United States. Other important causes of death are obstructive pulmonary disease, diabetes, pneumonia and influenza.⁽⁴¹⁾

Driving a car safely is one of the activities that can be affected by these health problems. Diabetes, for example, can damage some nerves in hands, legs or eyes and changes in blood sugar level also occur. Loss of consciousness and dizziness as result of some devices such as automatic defibrillator used to treat some heart disease can interfere with safe driving; stroke is also mentioned among the health problems that affect driving.⁽⁴²⁾

Health problems are more likely to affect older drivers than they affect young drivers.⁽²¹⁾ Additionally, some of the medications that older people use to treat their diseases, frequently more than one at the same time, and the side effects of these drugs can put them at risk while driving.⁽⁴³⁾

This section reviews the findings about the most common medical conditions and medications that affect mature drivers and their impacts on their driving abilities.

Medical Conditions

The likelihood of having diseases such as diabetes, heart disease, arthritis, dementia, psychiatric disorders and others increases with age. More than 80% of people 65 years and older have at least one chronic disease and the majority of them have two or more at the same time.^(44,45) Diabetes mellitus and coronary heart disease, for instance, have been found to be strongly associated especially in older people. Vokonas and Kannel,⁽⁴⁶⁾ in a review of medical literature, described this association as impressive and noted that diabetes can accelerate the process of arteriosclerosis causing a stroke.

Similarly there is a connection between depression and coronary heart disease. Ahto et al⁽⁴⁷⁾ conducted a study in Lieto, Finland, to analyze this relationship using 89 men and 73 women with coronary heart disease matched by age and sex with a control group of 178 men and 146 women free of heart disease; all participants were over 64 years old. The results showed that depression is more frequent in men with coronary heart disease than it is in men free of this disease. For women depression was associated with previous clinical depression, physical disability and the use of angiotensin-converting enzyme (ACE) inhibitors. Ahto et al noted "Possible limitations caused by a severe coronary heart disease on functional abilities may easily trigger a current depression among women who have had previous episodes of depression"

Waller, Naughton, Gibson, and Eberhard (as cited in Janke⁽⁴⁸⁾) found that among 119 patients admitted to hospitals for ischemic heart disease, 43% had hypertension problems, 20% had chronic lung disease, 14% were diabetics, 11% had peripheral vascular disease, 8% cerebrovascular episodes and 8% reduced vision, deafness, and renal disease.

These diseases affect the normal lives of older people including their ability to drive. Schwager⁽⁴⁵⁾ describes crashes among the elderly as a geriatric syndrome derived from chronic diseases along with changes in physiology and patterns of behavior. Odenheimer⁽⁴⁹⁾ lists Alzheimer's disease, vision problems, stroke, Parkinson's disease, arthritis, and diabetes as factors for unsafe driving. The National Institute on Aging⁽⁴²⁾ cited arthritis, Parkinson's disease, stroke, sleep problems and fainting, as examples of illnesses that can interfere with safe driving. In addition, they recommended that people who are at risk of losing consciousness should stop driving. Carr⁽⁴⁴⁾ pointed out that some older people can be safe drivers but others, with physiologic or cognitive impairments such as musculoskeletal disorders, sensory disorders, dementia, psychiatric disorders, stroke, sleep apnea, and alcohol and illicit drug use, put themselves and others at risk while driving.

Zhang et al⁽⁵⁰⁾ analyzed and quantified the relationship between possible risk factors and the severity of crashes involving elderly drivers in Ontario between 1988 and 1993. The database included accidents in which at least one driver was 65 years or older. Diabetes mellitus, chronic heart disease, epilepsy, amputations, vision disorders, and hearing loss were mentioned in the written police reports. The study also found that risk from these conditions increases as the age increases; drivers aged 80 and over are more likely to have these conditions than drivers 65 to 69.

McGwin et al⁽⁵¹⁾ conducted a population-based case-control study to analyze the connection between chronic medical conditions and at-fault crashes involving older drivers. Of 901 drivers 65 years and older from Mobile, Alabama who participated in the study, 244 were involved in at-fault crashes, 182 were involved in crashes for which they were not at-fault, and 475 were not involved in crashes. Information on driving habits, driving situations and types of vehicles was collected by telephone interviews and previous crash histories from 1991 to 1995 was obtained from the Alabama Department of Public Safety. The results of this study show that "several medical conditions and medications were associated with the risk of crash involvement among older drivers" (p. 430). Heart disease and stroke showed significant connection with the crashes; drivers with these diseases were more likely to be involved both in at-fault and not-at-fault car accidents than drivers free of these diseases. The researchers⁽⁵¹⁾ also noted that several previous studies have established a relationship between heart disease and car accidents. The researchers further noted that arthritis and diabetes increase the risk of being involved in a car crash especially for female drivers.

Heart Disease

Coronary Heart Disease is the leading cause of death in the adult population in the United States.^(52,41) The risk of coronary heart disease increases with age; approximately four out of five people who die of this disease are 65 years and older. Coronary Heart Disease is responsible for 50% of all deaths in people 65

years and over.^(53,54) For people 75 years and over, coronary heart disease causes 70% of all deaths. For people 85 years and over, coronary heart disease are responsible for 58% of the mortalities.⁽⁵⁴⁾ In a study to analyze different predictors of heart disease, Chen and colleagues⁽⁵⁵⁾ evaluated 1,749 people 65 years and over who had not had heart problems before the study. Participants were followed from 1982 to 1992 and 10% of them developed heart failure. The researchers concluded that older age increases the risk of heart failure.

Since sudden, unexpected death can occur as a result of heart disease the effects of heart disease on driving raises some concern about the risk that people who have any heart disease and drive may pose to society and themselves. Patients with arrhythmia (irregular heart beat), for example, risk personal and public safety while driving.⁽⁵⁶⁾ Sudden death and loss of consciousness are the most common complication among drivers and one of the most frequent causes of driver incapacity.⁽⁵⁷⁾ In a conference held in Washington, DC., in 1995 to discuss the growing issue of arrhythmias, driving and other activities, attendees found limited amount of data available about this issue.⁽⁵⁶⁾ One of the reasons for the limitation of data could be that for medical information to be released the authorization of the patient is required and in some cases of motor vehicle accidents there is uncertainty if a medical condition was the cause of the accident. However, at this conference it was pointed out that for interstate commerce "It is the intent of the Federal Motor Carrier Safety Regulation to disqualify a driver who has a current cardiovascular disease which is accompanied by and/or likely to cause symptoms of syncope, dyspnea [abnormal or uncomfortable breathing], collapses, or congestive heart failure." But the final decision will be made by the medical examiner and the motor carrier.

Patients who have an implantable cardioverter-defibrillator (ICD), a device used to treat ventricular tachyarrhythmias, constitute a critical group since this device is implanted into patients who have high risk of having an arrhythmia. Finch et al⁽⁵⁸⁾ conducted a study to evaluate the driving habits of patients with ICDs to see how their driving abilities were affected. They surveyed 105 patients with a mean age of 61 years old. All patients had received the ICD implant at the Medical University of South Carolina. Even though these patients were advised not to drive, 77% of them had resumed driving within 0-24 months; 67% had resumed driving three months after the implant. Forty-nine percent of the patients said that they had at least one shock, three of the patients had the shock while driving. During the shock episode, patients experienced dizziness and loss of consciousness, which are considered risk factors for safe driving. In a conference in 1991 of the American Cardiovascular Society to discuss the issue of heart disease and driving, the participants concluded that patients with ICDs may resume driving one year after the implant if there has not been a shock episode during that time.⁽⁵⁸⁾ In other countries, Great Britain, for example, patients have to stop driving and relinquish their drivers' licenses once they have an ICD implant. The conclusions of Finch and her colleagues is that patients who do not experience any symptoms after the ICD implant could be allowed to drive but patients who experience persistent symptoms should not be allowed to

drive. Curtis and colleagues⁽⁵⁹⁾ evaluated the driving safety of patients with implantable cardioverter-defibrillator. They surveyed 742 physicians about their patients' fatal and nonfatal accidents. Also, physicians were questioned about recommendations they give to their patients about driving and their knowledge of state driving laws. The response rate was 61. Twenty-five physicians reported 30 motor vehicle accidents related to shocks from 1980 to 1992. Nine of these accidents were fatal, and 21 were nonfatal involving 15 patients, 3 passengers and 3 bystanders. The conclusion of these researchers was that a driving restriction for a short period of time should be recommended to the patients but excessive or total restriction might not be necessary. Jung and colleagues⁽⁶⁰⁾ conducted a study of the European experience of driving after ICD implantation to estimate the risk of death and injury and to make recommendations about patients and fitness to drive. The frequency of the arrhythmia, the probability of recurrence and the probability of accidents as a result of these factors were analyzed. These researchers also had the problem of the limited data availability. They concluded that patients who had prophylactic ICD implantations should be allowed to drive for private purposes but commercial driving should be restricted. All other patients should be restricted initially; those without recurrences of ventricular tachyarrhythmias for six months after the implant could resume driving but patients with high risk and recurrences of unstable ventricular tachyarrhythmia should have total restriction.

In the opinion of Petch,⁽⁵⁷⁾ Chairman of the U.K. Medical Advisory Panel on Cardiovascular Disease and Driving, "Any disease capable of exposing an applicant for a first license or a driver applying for a renewal to a sudden failure of the cardiovascular system such that there is a sudden impairment of the cerebral functions constitutes a danger to road safety"(p.1175).

Researchers in Ontario, Canada⁽⁶¹⁾ conducted a study to determine the impact of the legislation of mandatory physician reporting for cardiac patients on motor vehicle accidents related to morbidity and mortality. Data were obtained from the Ontario Ministry of Transportation and all drivers with license suspension in 1996 due to cardiac disease participated in the analysis. Researchers found that only 994 licenses were suspended for cardiac reasons when approximately 72,407 licenses should have been suspended according to the legislation. As a consequence, only one death or serious injured was avoided when 29.2 events could have been avoided if the legislation had been followed. The study shows that physicians were not complying with the legislation and researchers concluded that "Mandatory Physician Reporting of patients with cardiac illness has a negligible impact on MVA related to morbidity and mortality"⁽⁶¹⁾ (p. 1257).

Syncope

A syncope is a temporary loss of consciousness due to a temporary reduction of blood circulation to the brain.⁽⁶²⁾ Emotional stress, changes in body position, low blood pressure and heavy sweating are factors that may cause syncope. Syncope is considered "one of the most common, and at the same time, one of

the most perplexing of problems that the medical practitioner is called upon to evaluate.”⁽⁶³⁾ Kou et al (as cited in Bänsch et al⁽⁶⁴⁾) consider that age, gender, or previous syncope do not predict syncope. Eby et al⁽²¹⁾ cited other researchers (Bonema and Maddens, 1992; Kapoor, 1994) who stated that syncope is very common in older adults; and Savage (1985) who said that at least 3% of the adult population has had at least one syncopal episodes.

According to Olshansky and Grubb,⁽⁶⁵⁾ data establishing the relationship between syncope and driving are difficult to obtain because patients who suffer a syncopal event while driving may report a different factor as the cause of the accident. This occurs due to the confusion that follows an accident or sometimes because of fear that their driver licenses may be revoked. The researchers point out that it is hard to determine when an individual passes out or goes to sleep behind the wheel. At the same time, the risk posed for patients with syncope seems to be small and other factors such as the frequency and length of driving may also influence this risk. However, they state that “syncope appears to be a significant cause of serious driving accidents in the elderly” (p.375) and that “individuals who experience recurrent unpredictable period of loss of consciousness, but who continue to drive, risk not only their own lives but the lives of others as well” (p.372). They⁽⁶⁵⁾ cited an earlier study, Rehns et al. (1995), which evaluated drivers involved in road crashes over a one year period. There were 84 elderly drivers and 67 of them were in at-fault accidents. Twelve of these accidents were believed to be due to syncope.

Bänsch, et al⁽⁶⁴⁾ conducted a study to evaluate the occurrence, risk prediction and prevention of syncope in patients who had received an implantable cardioverter-defibrillator (ICD), a device used to treat ventricular tachycardia (VT) and fibrillation (VF). The researchers analyzed information such as clinical history, outpatient chart reviews and episode events of 421 patients; 229 (more than 54%) had recurrent VT/VF and 62 (almost 15%) had syncope. The analysis showed that after the implantation, the survival rate free of VT/VF was 58% during the first year, 45% during the first two years and 37% during the first three years. For syncope the survival rate was 90% during the first year; 85% in the second year and 81% in the third year. The researchers found that syncope as a result of ICD implantation is very common, most often occurring soon after the implantation. The highest risk (10%) is found during the first year going down to five percent during the second year; it is still significant in the third year. Researchers concluded “that once patients had a VT recurrence, syncope during the first VT and a high VT rate were the strongest risk predictors of future syncope” (p.608). One patient in this study had syncope while driving a car and died shortly after the syncope, but a passenger in the front seat prevented an accident.

Personal injury, property damage and even death can be consequences of having a vasovagal syncope while driving according to a study conducted by Huagui et al.⁽⁶⁶⁾ From March 1990 to May 1996, Huagui and his colleagues from University of Nebraska Medical Center studied 245 patients who had had

syncope while driving. The researchers found that once a person has had syncope, the recurrence of another one is very high during the following three to six months; they therefore recommend that driving be restricted for at least three months.

Stroke

A stroke is the interruption of the blood supply to the brain that occurs when a blood vessel or artery is blocked or broken and that causes damage to the brain tissue. The kinds of stroke are thrombotic, embolic, hemorrhagic, and aneurysm.^(67,68) When a stroke occurs some brain cells die and people lose some abilities partially or totally depending on the seriousness of the stroke, the extent of the brain damage and the part of the brain where the stroke happens (right hemisphere, left hemisphere, cerebellum or the brain stem).⁽⁶⁹⁾ According to the National Stroke Association⁽⁶⁹⁾ intellect, sensation, perception and movement are the abilities most affected by stroke. Stroke is the third leading cause of death in the United States. Approximately 750,000 Americans have a new or recurrent stroke every year, and close to 160,000 of them die.⁽⁷⁰⁾ The same source affirms that almost four million Americans are living with the effects of strokes and approximately one-third of them are mildly impaired, another third are moderately impaired and the rest have severe impairments. Approximately 3% to 10% of stroke survivors will have another stroke during the following 30 days, 5% to 14% within a year and 25% to 40% within five years.

Age increases the risk of having a stroke; for people 55 years and over, each decade doubles this risk. People 65 years and over have a seven times higher risk of dying from stroke than the rest of the population, and two thirds of all strokes happen to this segment of the population. More than 23 percent of the over 65 years old stroke victims die within a year of the stroke.^(70,71) For men between the ages of 65 and 69, the prevalence of having a transient ischemic attack (TIA), which is defined as a mini-stroke that lasts less than 24 hours, is 2.7 percent, rising to 3.6 percent at ages 75 to 79. For women the prevalence is 1.6 percent for ages 65 to 69 and 4.1 percent for ages 75 to 79. Some conditions that are very common in older people, such as high blood pressure, diabetes and heart disease, also increase the risk of having a stroke.^(See references 68, 71, 72, and 73.) In the case of hypertension, the risk is four to six times higher than that of the general population.

The National Institute on Aging⁽⁴²⁾ considers stroke one of the illnesses that may interfere with the ability of older people to drive safely. Results of a recent study by researchers at the University of Alabama at Birmingham support this statement. McGwin et al⁽⁵¹⁾ conducted a population-based, case-control study to identify medical conditions and medications that may be related to at-fault crashes involving elderly drivers. McGwin and colleagues studied the 1996 driving records of 901 drivers 65 years and older. Of this sample, 244 drivers were involved in at-fault crashes; 182 were involved in crashes but were not-at-fault; and 475 were not involved in crashes. The results show that stroke

patients are twice as likely to be involved in at-fault crashes than the control group leading the researchers to conclude that the combination of age-related problems and neurological damage resulting from the stroke may affect the ability of safe driving in older people. Findings also show that arthritis and heart disease affect safe driving abilities.

The American Academy of Family Physicians⁽⁷³⁾ advise that some of the abilities required to drive safely, such as mobility, vision, thinking and reaction time, can be affected by stroke, and that people who have had a stroke are at high risk of having another during the year after the stroke. However, many drivers resume driving after a stroke. Stroke victims who are thinking about resuming driving should be warned that they may compromise their own safety and the safety of others.

Fisk et al⁽⁷⁴⁾ conducted a survey on patients who had been treated after a stroke in the psychology service of a university rehabilitation center from 1990 to 1995. Two hundred ninety (290) people who were drivers before the stroke participated in the study; the mean age was 66 years old. The researchers found that 30% of the patients resumed driving. While some of the drivers limited their driving to three or fewer days per week, others resumed their previous driving habits and were driving six to seven days a week. Approximately 35% were given advice about driving from their doctors, 27% from their families and almost 50% did not receive any advice. In addition, 90% of the participants did not have an evaluation of driving skills after the stroke. The researchers point out that even though their study does not directly address the crash-risk concern in this group of drivers “evidence suggests that stroke survivors have characteristics that elevate their risk” (p.1344). Fisk et al⁽⁷⁴⁾ cite a comparable 1986 study by Legh-Smith et al, which found that 42% of stroke victims who had driven before resumed driving after their stroke.

Janke⁽⁴⁸⁾ cited Jones, Giddens, and Croft (1983) who assessed 300 brain-damaged patients, some who had had a stroke, for driving capability. The researchers found that “while most of the patients performed well in the off-road tests, they were generally unreliable, emotionally unstable, and erratic on the road” (p.86). Wilson and Smith (1983), also cited by Janke,⁽⁴⁸⁾ evaluated patients who had had a stroke but were considered ready to drive by their doctors. When given a road test these patients had problems entering and leaving the highway and reacting adequately in emergency situations. They also had problems trying to align their vehicles with the side of the road. The researchers “call into question the adequacy of driving decisions presumably made on a medical basis alone.” (p.81)

Morgan and King⁽⁴³⁾ said that in the UK all stroke and transient ischemic attack (TIA) patients are immediately suspended from driving for at least one month due to the high risk of the occurrence of another attack, according to the guide of current medical standards for fitness to drive. They cited Noury and Lincoln (1993), who conducted a study of stroke victims who had been active drivers

before the stroke. The subjects took a road test, which they passed or failed. Then, they were randomly assigned to one of two groups for evaluation. The first group was evaluated using the stroke drivers screening assessment, and the second group was evaluated by their general practitioner. The evaluation results for the two groups were compared to the results of the previous road test. The researchers found that the results of the stroke screening test corresponded with the performance of the road test for 81% of the subjects, while the general practitioners' evaluation corresponded with the performance of only 56% of the clients. The researchers concluded that "it would appear that the present system allows a substantial proportion of unsafe drivers to resume driving and use of the stroke driving screening assessment would be a cheap and simple improvement on the present system." (p.527)

Diabetes

Diabetes is a disease that does not let the body convert the food into the energy the body needs to function; it is characterized by changes of levels of blood glucose. This disease is the fourth leading cause of death in the United States. There are two types of diabetes: type I and type II.⁽⁷⁵⁾ The National Institute of Diabetes and Digestive and Kidney Disease⁽⁷⁶⁾ states that 15.7 million people, which constitute 5.9% of the total population, have Diabetes, of which 6.3 million are 65 years and older (or 18.4 percent of this age group). The same source shows that adults with type I diabetes die from heart disease or stroke at 2 to 4 times the rate of people without diabetes. They also state that 90 to 95% of all Diabetes patients suffer from type II Diabetes. Older age is considered a risk factor for this type of Diabetes. Other common conditions in older people, such as heart disease, stroke, high blood pressure, have been found to worsen the condition of diabetic patients. In addition, Davidson, cited in Eby et al,⁽²¹⁾ found that changes in blood glucose concentration as a result of diabetes may result in cerebral vascular accidents, myocardial infarctions, diabetic retinopathy, kidney disease, and peripheral vascular disease.

Since Diabetes affects cognitive functions, there is a concern that it may put diabetic patients who drive at a higher risk of being involved in a crash than the rest of the population. Also, medications needed to treat diabetes, including insulin, may increase the risk of car accidents (DCCT Research Group, 1987, also cited in Eby et al.)⁽²¹⁾ However, Veneman⁽⁷⁷⁾ conducted a review of the literature about this issue and concluded that the majority of the studies reveal that this risk is not so much different than that of non-diabetic people. Nevertheless, he states that crashes as a result of hypoglycemia happen and there has been an estimated 5.2 % the numbers of accidents for insulin-dependent patients. The literature review by Janke⁽⁴⁸⁾ cites research by Ward and Stewart (1990) that evaluated the relationship between hypoglycemia in Insulin-dependent patients and driving. They found that the majority of the subjects had experienced hypoglycemic episodes, and at least 30% considered these episodes to be a major concern. Coma or convulsions were present in 43% of the hypoglycemia episodes; 7% reported frequent episodes.

Approximately 40% of the subjects suffered episodes while driving, and 13% of those involved in car crashes thought that it was a consequence of their hypoglycemia. Some other researchers^(44,78,42) mention diabetes disease among the illnesses that affect the abilities needed for safe driving. Carr⁽⁴⁴⁾ cited a 1994 study by Koepsell et al where diabetes was found to be the disease most predictive of motor vehicle crashes in older drivers. National Institute on Aging⁽⁴²⁾ recommends that diabetic patients who have problems controlling their blood glucose level should think about stopping driving.

Cox et al⁽⁷⁹⁾ conducted a study to analyze at which levels of blood glucose driving become impaired. Thirty-seven (37) adults (16 men and 21 women) with a mean age of 35.3 ± 7.1 years that had type I diabetes for at least two years, were taking insulin, were current drivers and were not taking another kind of medication that might affect driving performance or hypoglycemia, participated in the evaluation. A driving simulator (Atari Research Driving Simulator), which is a fixed platform and is considered to produce precise driving performance data in a realistic manner was used to assess driving. The results of this study show that driving performance was drastically affected by mild hypoglycemia in all different ranges (4.0-3.4, 3.3-2.8, < 2.8 mmol/l) and researchers indicated that when the blood glucose (BG) is in the range of 5.0-4.0, people should not drive without prophylactic treatment. Another finding of this study was that patients are not likely to take care of their level of blood glucose while driving even though they may be able to know when their driving was becoming impaired. In a previous study, Cox et al⁽⁸⁰⁾ evaluated driving decrement during and after hypoglycemia and how aware patients were of their driving decrements. They tested patients at euglycemia (mean blood glucose level 6.3 ± 0.89 mM), mild hypoglycemia (mean blood glucose level 3.6 ± 0.33 mM), and moderate hypoglycemia (mean blood glucose level 2.6 ± 0.28 mM) and at euglycemia again. Similar results were found and researches noted that "between 3.6 and 2.6 mM driving performance was disrupted and not reliably recognized by our patients."(p.239)

Clarke et al⁽⁸¹⁾ studied how people with Type I diabetes made their decision to drive as part of their daily activities based on their perceived level of blood glucose and the real measured level. The participants were selected from four different academic medical centers; two different groups were selected two years apart. The 158 participants tested their blood glucose (BG) at least twice a day. Each of them had a handheld computer to keep a record of symptoms, cognitive function as well of the insulin dosage, food, activity, estimated and actual blood glucose levels and if they drove or not. Participants said they would drive 43% to 44% of the time when they thought that their blood glucose was 3.3 to 3.9 mmol/l, and 38% to 47% of the time when their real blood glucose was less than 2.2mmol/l. Around 50% of the participants said that they would drive at least 50% of the time knowing that their blood glucose was less than 3.9 mmol/l. Based on these results, the researchers suggest that physicians and caregivers should advise their patients about the consequences of driving with hypoglycemia and how necessary is to check their BG level before driving

because persons with type I diabetes may not evaluate accurately when their BG level is too low to drive safely.

Dementia and Alzheimer's Disease

Dementia is a syndrome characterized by loss of cognitive functioning to a level that significantly affects the performance of normal activities. Mental abilities, especially memory, decline as a consequence of dementia^(82,83) According to Daly⁽⁸²⁾ dementia is the most common neurological disorder affecting the elderly. Daily activities like planning meals, using a telephone, keeping a checkbook, driving a car and other self-care tasks are adversely affected by this disease. There are more than 100 conditions that can cause dementia, including strokes, drug interactions and malnutrition. The most common form of dementia is Alzheimer's disease (AD).

Alzheimer's disease is a progressive neurological disorder characterized by changes in behavior, personality, and the ability to perform normal activities.⁽⁸²⁾ The Mini-Mental State Examination (MMSE) is used to identify possible demented patients; it consists of a physical examination and various sensory and motor tests.^(84,85)

According to the Clinical Dementia Rating Scale (CDR), dementia can be divided into three stages: early, middle, and late.⁽²¹⁾ In the early stage, it is difficult to identify the disease and some patients are reluctant to accept the diagnosis. Symptoms of the middle stage include apathy, agitation, paranoia, sleep disorders, incontinence, aggressiveness, and severe depression according to Katzman (1987) and McKhan et al (1984) as cited in Eby et al.⁽²¹⁾ For patients in the late stage there is an almost total loss of functioning (Adler, Rotunda, Dunken, 1996, as cited in Eby⁽²¹⁾). The risk of getting Alzheimer's disease increases with age and one out of 15 people 65 years and over has this disease while one out of three people 85 years and over has this disease.⁽⁸³⁾ But according to Rayl,⁽⁸⁶⁾ one out of 10 people who are over 65 suffer from this disease. It is also estimated that half of the people whose relatives have AD will suffer from the disease by the age of 90 years old.⁽⁸²⁾ The Alzheimer's Association reports that there are 4 million Americans with Alzheimer's disease and 14 million people are expected to have this disease by 2050.⁽⁸⁷⁾ According to the Western and Central Washington State Chapter of the Alzheimer's Association the symptoms of Alzheimer's Disease (e.g. memory loss, disorientation, and changes in vision and perception) can affect the ability to drive.⁽⁸⁸⁾ On the other hand, the Alzheimer's Association, Northern Virginia Chapter⁽⁸⁹⁾ points out that since "driving is a well-learned skill, a person with dementia still may appear to be driving well, even though the driving is really not safe." The patients themselves do not know the danger to which they expose themselves and others. The increased risk per mile of having an accident is 19 times higher for a driver with AD than for other older adults without the disease according to a study reported in 1998 by the Annals of Neurology.⁽⁹⁰⁾ The same source also cited a 1996 study that compared driving records of 143 drivers with

AD to 214 elderly drivers free of this disease and found no significant difference in traffic violation between these two groups. At the same time they noted that drivers with AD drove fewer total miles.

Carr et al⁽⁴⁴⁾ conducted a study for the Alzheimer's Disease Research Center at Washington University in St. Louis, Missouri to determine the difference in crash rates and characteristics between drivers with dementia of the Alzheimer type (ADT) and drivers without dementia. The subjects consisted of 63 drivers with very mild and mild dementia of the Alzheimer type plus a control group of 58. The mean age of the subjects was 77 years. Traffic data were obtained from the state-recorded traffic crashes, and information from the participants was used to estimate the number of miles traveled per year. According to the researchers, it is possible that significant differences may exist, but none were found in this study. However, other researchers have found very significant differences between drivers with AD and other older drivers not suffering from AD.

Cox et al⁽⁹¹⁾ found that Alzheimer's disease as well as dementia affect the characteristics of safe driving, for example, memory, visual attention, perception, and judgment. The Cox study evaluated the driving performance of 29 patients over 55 years old who met the criteria for probable Alzheimer's disease (based on the Diagnostic and Statistical Manual of Mental Disorders, 3rd edition). The six month study used a control group of 55 years and older current drivers. Three instruments were used in this study, (1) a background and driving-history questionnaire, (2) the MMSE, and (3) the Atari Research Driving Simulator. The researchers noted that in comparison to the control group, patients with Alzheimer's disease were less likely to comprehend how to operate the simulator, drove off the road more often, spent more time driving considerably slower than the speed limit, spent less time driving faster than the speed limit, applied less brake pressure in stop zones, spent more time negotiating left turns and drove more poorly overall. These researchers cited a 1997 study conducted by Johansson et al that noted that 50% of autopsies of elderly drivers involved in fatal crashes show evidence of Alzheimer's disease.

Duheck et al⁽⁹²⁾ examined the relationship between visual attention measures and driving performance in healthy older adults and individuals with very mild dementia of the Alzheimer's type (DAT). The participants were classified in three groups; healthy control, subjects with very mild DAT and subjects with mild DAT. All individuals had at least 10 years of driving experience and were actively driving at the time of the study. They used a series of tests, including a visual monitoring task, useful field of vision task, a two hour battery of psychometric tests, and a driving test. Researchers said that it was clear that demented drivers had lower driving scores and that the greater the severity, the lower the score. Additionally, their ability to pay attention "is affected by dementia severity and is predictive of on road driving performance" (p.P138).⁽⁹²⁾

Hunt et al⁽⁹³⁾ conducted a study to establish the effect of mild senile dementia of the Alzheimer type (SDAT) on driving. Twelve (12) patients with very mild

dementia, 13 with mild dementia and 13 persons without dementia (control group) participated. The presence of dementia and its severity was evaluated by experienced clinicians. The ability to follow the driving instructor's directions, appropriate decision making in traffic, and correct interpretation of traffic signs were taken into account along with overall driving performance. People with very mild SDAT and the control group were evaluated as safe drivers but 40% of the mild SDAT group had driving impairment and were not able to pass the road test. The researchers concluded that some SDAT patients have safe driving skills but the likelihood of poor driving increases as the severity of the disease increases.

These findings were similar to those found by Ott et al⁽⁹⁴⁾ who used patients of the Roger Williams Medical Center's AD and Memory Disorders Unit, excluding those who had never driven. All the subjects used in this study had had Single-Photon Emission Computed Tomography (SPECT) imaging done as part of the evaluation for suspected AD or any type of degenerative dementia. The researchers were able to find a correlation between the severity of driving impairment and the severity of dementia as measured by Clinical Dementia Rating (CDR) and Instrumental Activities of Daily Living (IADL), but not necessarily by global cognitive function as it was measured by The Mini-Mental State Examination (MMSE). Through this study, researchers were able to demonstrate the existence of a relationship between driving impairment and visual perceptual dysfunction. The study states that the severity of driving impairment in patients with AD has a relation to changes in regional cortical functions. Researchers concluded that "the contribution of such regional changes to driving impairment should be considered in future investigations of driving and dementia and in the development of screening examinations for driving impairment among this population" (p.159).

Dubinsky et al⁽⁹⁵⁾ addressed the issue of driving and Alzheimer's Disease to see how extensive the traffic safety problem was. Based on previous studies related to this problem, they concluded that "The relative risk of crashes for drivers with mild AD is greater than our society tolerates for any group of drivers" (p. 2209). They considered that the risk imposed to society and themselves by drivers suffering from AD is very similar to that of youngsters aged 16 to 19, but in the case of youngsters, they are expected to perform better as the approach adulthood contrary to the AD drivers, who are expected to get worse over time. They reported that in all the studies which evaluated AD drivers, they functioned worse than the control groups. They concluded that there is no doubt that AD patients have a higher accident rate than those not afflicted with AD. Researchers suggest that patients with very mild and mild AD disease should be told not to drive. They said that the first performance test of drivers with mild dementia was reported by Fitten and others in 1995; drivers with mild dementia were compared to drivers with diabetic retinopathy, multi-infarct dementia and healthy older adults. The researchers administered an on-the-road test on a 2.7 fixed mile road at a Veteran's Administration Medical Center. The results show that the performance of drivers with mild dementia was much lower than that of the control group and the retinopathy group.

Logsdon et al⁽⁸⁴⁾ examined the driving status of AD patients to identify those who were no longer safe drivers. Patients were divided into three (3) groups; group one consisted of 22 subjects still driving without difficulty, the second group had 23 subjects still driving but having difficulty, and the third group had 55 subjects who had already stopped driving because of cognitive impairment. Researchers pointed out that many patients with AD keep driving regardless of their cognitive impairment. The difference between the first two groups was minimal, but those who had stopped were more impaired than the first two groups. “This investigation points to the need for an assessment of driving safety as part of a thorough clinical evaluation of dementia” (p. 587).

Fox et al⁽⁹⁶⁾ evaluated 19 drivers in Australia with mild dementia, using a standardized open road evaluation and expert judgment. All patients participated in an on-the-road assessment conducted in a vehicle with automatic transmission, power steering, dual brakes and an engine cut off switch. A standardized route in traffic was used to analyze driving performance in daylight and in light to moderate traffic. Based on the driving assessment, 12 subjects were considered unsafe drivers and seven (7) of the patients passed; however, six months later, four out of the seven patients failed the same on-road evaluation test. Based on this finding, researchers suggest that drivers with AD should be periodically evaluated for driving performance.

The American Academy of Neurology has issued guidelines on driving and patients with Alzheimer’s disease. Dr. Richard Dubinsky, lead author of these guidelines states that Alzheimer’s patients with a mild severity level have a considerably high accident risk and should not drive while patients with a very mild severity level may still drive but should be monitored and evaluated every six months. Dr. John C. Morris holds a similar opinion; he finds the guidelines reasonable even though not all of the AD patients may be unsafe at the time. He states that all patients with Alzheimer’s disease will eventually become unsafe drivers.⁽⁸⁷⁾

Medications:

Elderly people (65 years old and over) constitute 12.8% (35 million) of the total population of the United States, but account for 25% of all prescriptions written. It is very common for elderly people to have more than one disease at the same time; therefore, they often take more than one medication at the same time.^(97,98,99) Multiple medications may interact in unexpected ways. Further, as a person gets older some physiological changes occur in their bodies that interfere with the way they absorb, metabolize, distribute and remove drugs from their bodies. As a consequence, a 75 year old person reacts to many medications differently than a person at age 25.⁽¹⁰⁰⁾ For example, there is an increase in the percentage of body fat (the total weight may not change), while body fluid (especially water), and the actions of gastrointestinal tract, albumin, liver and kidney function decrease. These changes are part of the reason why older

people have greater drug sensitivity and exaggerated effects "the action of a drug may be less predictable than it is in a younger person and the intended action altered."⁽¹⁰⁰⁾ Some of these effects may not be important, while others can be dramatic. Driving abilities, for instance, can be affected; "the use of prescription medications including those suspected of adversely affecting driving increases with age."⁽⁴⁵⁾

David B. Carr, M.D. director of the clinical program in the Older Adult Health Center at Washington University, finds that many medications affect driving performance; see Table 7.⁽⁴⁴⁾

Table 7. Medications That May Impair Driving Skills

<p>Opioids Benzoiazepines* Antidepressants ** Hypnotics Antipsychotics Antihistamines Glaucoma agents Nonsteroidal anti-inflammatory drugs Muscle relaxants</p>
<p>* Benzodiazepines with long half-lives appear to have a higher risk than those with short half-lives. ** Agents such as tricyclic antidepressants or other classes with sedating properties.</p>

McGwin et al⁽⁵¹⁾ conducted a population-based, case-control study to identify medical conditions and medications that may be related to at-fault crashes involving elderly drivers. Researchers found the use of nonsteroidal anti-inflammatory drugs (NSAID), angiotensin-converting enzyme (ACE) inhibitors and anti-coagulants, and benzodiazepines to be associated with car accidents among elderly. The at-fault crash rate was 70% higher in drivers taking NSAIDs.

Barbone et al⁽¹⁰¹⁾ studied the relationship between the use of psychoactive drugs and road traffic accidents in UK at all ages. Of 410,306 subjects who participated in the study, 19,386 had their first road traffic accident between 1992 and 1995, the period of the study. This included 1,731 drivers 18 years and over who had used a psychoactive drug (tricyclic antidepressant, benzodiazepine, selective serotonin-reuptake inhibitor). The day of their accident, 189 were taking tricyclic antidepressant, 84 selective serotonin-reuptake inhibitor, 235 benzodiazepine, and 47 other psychoactive drugs. The risk related to benzodiazepine use was higher among drivers younger than 30 years old, and

decreased as age increased. However, researchers state that “users of anxiolytic benzodiazepines and zopiclone were at increased risk of experiencing a road traffic accident. Users of anxiolytic benzodiazepines and zopiclone should be advised not to drive” (p.1331).

Benzodiazepines used to relieve insomnia and anxiety are widely prescribed among the elderly in the United States; 11 to 15 % of the adult population has taken benzodiazepines. Widely prescribed benzodiazepines include alprazolam (Xanax), clonazepam (Klonopin), diazepam (Valium) and lorazepam (Ativan), which are among the top 100 most commonly prescribed medications.⁽¹⁰²⁾

Quebec researchers⁽¹⁰³⁾ conducted a study to determine if the use of benzodiazepines, either long-life (those that take more than 24 hours to be eliminated from the body) and short-life (those that take less than 24 hours to be eliminated from the body), were associated with crash injury in the elderly. A group of 5,579 licensed Quebec drivers between the ages 67 and 84 and who had been injured in motor vehicle crashes during 1990-1993 participated in the study. These drivers were compared with a control group of 18,490 licensed control drivers in the same age range. The researchers concluded that exposure, either brief or extended, to long-life benzodiazepines increased the risk of the elderly in motor vehicle crashes. During the first seven days of exposure this risk can increase to 50% and it remains significant up to one year. Ray et al. (1992) and Leveille et al. (1994), both cited in Eberhard⁽¹⁰⁴⁾ also found that benzodiazepines increased the risk of motor vehicle crashes.

Opioids, used to treat patients who suffer chronic pain, were studied by Galsky et al.⁽¹⁰⁵⁾ to establish their effect on driving. Sixteen patients taking opioids regularly to relieve nonmalignant pain (Chronic Opioid Analgesic Therapy; COAT) were compared to 327 cerebrally compromised patients (CComp). The COAT patients were administered an off-road evaluation to predict on-road driving performance. The evaluation consisted of a pre-driver evaluation (PDE), a simulator evaluation (SDE), and a behavioral observation during simulator performance. The CComp group had the same evaluation and also an on-road test. The results were not conclusive. The researchers found that COAT patients had the same or better pre-driver evaluation and simulator scores than had the CComp patients. On some specific neuropsychometric tests in the PDE, the COAT patients had poorer performance than the control group but researchers found these differences to not be statistically significant. However, COAT patients had more difficulty following instructions and tended to react impulsively. Researchers stated that opioids seem not to adversely affect the factors required for safe driving such as cognition, coordination and perception in the off-road tests. Nonetheless, they said that “methodological problems may limit the generalization of results and recommendations are made for research beyond a pilot study” (p. 200).

Predicting Accident Frequency

Ball and Owsley⁽³¹⁾ have discussed several issues pertaining to research on the “older driver problem.” The first that they raise is the problem of defining “older”. They note that performance of older drivers often shows more within-group variability than does that of younger drivers. They argue that as a result, a few very debilitated older drivers can change the group mean so that conclusions of general impairment are erroneously drawn. Rather than using chronological age, they argue for tests of functional ability. Ball and Owsley further point out that much research on older drivers studies predictor variables in isolation. They argue that it is usually not a case of just visual or just cognitive or just motor impairments but some interactive effect of these factors.

Given this, they studied the effects of eye health, mental status, visual functions, self-reported driving habits and the useful field of vision among 53 participants with an average age of 70. Using various tests to measure the above variables, they built a model to account for accident frequency. The single most useful predictor was that of useful field of view. This visual dimension involves the size of the visual field over which information can be gathered during a brief glance. It thus involves both central and peripheral vision as well as attentional capabilities. Useful field of view was also a better predictor of intersection accidents than of accidents in general. The second single best predictor is that of mental status. This was measured with tests of cognitive ability (i.e. intelligence). Pursuing the association between cognitive ability and crash risk among older drivers, Stutts, Stewart, and Martell⁽¹⁰⁶⁾ examined cognitive test performance and propensity for crash involvement using 3,238 drivers from North Carolina who were 65 and older. While none of the five tests of cognitive ability were effective in screening out those drivers who had a high risk for accidents, there was an association between cognitive test performance and crash risk. Those drivers who scored in the lowest 10 percent were 1.5 times as likely to be involved in a crash than drivers who scored in the top 10 percent.

Assessing Driving Abilities

Existing tests for assessing the ability of drivers consist of self-assessment tests, clinical instruments, and behavioral sampling.

Self-assessments Tests

The American Automobile Association (AAA)⁽¹⁰⁷⁾ and the American Association for Retired Persons (AARP)⁽¹⁰⁸⁾ have devised paper and pencil tests for drivers to self-assess their driving habits and abilities. AAA’s assessment tool consists of a 16 page booklet which inquires about driving habits, awareness of problems while driving, and vision health issues. The booklet provides a scoring section which instructs users how to calculate and interpret the scores obtained on the questionnaire. Finally, it provides a section on ways to improve driving. AARP’s guide involves assessment of reaction time, vision, near crash experiences and

driving behavior. Assessment information on effectiveness is not available for either tool.

Clinical Instruments

A second group of tools that attempts to assess driving abilities deals with correlates of driving such as useful field of view and reaction time tests. Evaluation by physicians includes screening for attentional and memory problems, drug history, and cognitive impairment.

Behavioral Sampling

The final technique for assessing driving ability is behavioral sampling or on-road and simulator tests. These tests add the benefit of reality and a glimpse of how the driver actually behaves behind the wheel. These tests are thought to be the most valid and reliable for predicating driving ability. Simulators, though expensive, permit observation of driving behavior in a wider variety of situations than is available on a driving course.

Compensating For Ability Losses

Older drivers are often aware of a decline in their abilities and compensate for this sense of diminished ability by restricting their own driving. The compensation often takes the form of curtailing or ceasing to drive entirely. In their review of the literature of driving reduction and cessation of older drivers in the U.S., Kostyniuk, Trombley, and Shope⁽¹⁰⁹⁾ describe driving patterns of older drivers. They report for example that drivers age 65-74, drive about half the annual mileage of younger drivers (age 35-44). However, they also report that older drivers make about as many trips as younger cohorts.

Self-Restrictions On Driving

Older drivers also avoid driving at night, in poor weather conditions, and in congested traffic conditions. Kostyniuk, Trombley, and Shope⁽¹⁰⁹⁾ also find evidence that older drivers tend to drive more slowly and to leave greater distances between vehicles than do younger drivers. However, contrary to prevalent beliefs, older drivers do not drive less frequently on freeways but do tend to avoid freeways at heavy traffic hours, similar to avoiding heavy traffic on local roads.

The types of self-restrictions older drivers impose on themselves get reflected in the types of crashes to which they are exposed. Therefore, older drivers are more likely to be involved in crashes in the daytime, in good weather, and in off-peak traffic hours.⁽¹⁰⁴⁾

Accommodating To Ability Decline

In their review, Kostyniuk, Trombley, and Shope⁽¹⁰⁹⁾ report that older drivers compensate for various declines in ability by simplifying the task of driving. To assist in focusing attention, they listen less to the radio, avoid busy intersections, and drive more slowly. They would select less complex routes and limit driving to familiar territory. Another adaptation reported by older drivers is the preference for driving in the center lane of multi-lane highways.⁽¹¹⁰⁾ This gives them access to exits and also allows other vehicles to easily pass them. Use of a co-pilot has also been reported.⁽¹¹¹⁾ The co-pilot functions as a navigator and a source of information about traffic conditions. In these functions, Kostyniuk et al⁽¹¹¹⁾ note that a co-pilot reduces the need for the driver to divide attention between tasks.

The Decision to Stop Driving

The decision to stop driving is driven primarily by health reasons. Kostyniuk, Trombley, and Shope's literature review⁽¹⁰⁹⁾ specify research which lists deterioration of the eye such as macular degeneration, neural disorders such as Parkinson's disease and syncope, and muscular weakness such as post-stroke symptoms as being among the prime causes of driving cessation. The decision to stop driving altogether followed increased self-restriction in driving.

Besides health factors, psychological factors such as decreased confidence also contribute to driving cessation. Moreover, driving cessation is more frequent among women than among men. Eberhard⁽¹⁰⁴⁾ reported that men and women cease driving for different reasons. Men stop because of vision problems, slowed responses, loss of confidence and licensing problems. The main reasons women stop is loss of confidence and cost.

External factors also influence the decision to give up driving. Pressure from family, friends, and physicians affect the decision. Persson's (1993) survey regarding driving cessation found that older drivers believed the decision should be their own and that family members should not discuss the topic. However, if the topic is raised, older drivers were more comfortable with the topic being raised by a doctor than by a family member.

Kostyniuk, Trombley, and Shope⁽¹⁰⁹⁾ note the need for research on driving cessation. As more information is developed regarding demographic differences in the decision to stop driving, support systems could be designed to help foster an appropriate decision. Closely related to the decision to stop is the issue of transportation alternatives. Without a realistic alternative to driving, the appropriate decision to stop could be dangerously delayed.

Skill Enhancement

Eby, Trombley, Molnar and Shope⁽²¹⁾ list three major programs for improving driving skills of older drivers: 55Alive/Mature Driving which is sponsored by

AARP, Safe Driving for Mature Operators sponsored by AAA, and Coaching Mature Drivers sponsored by the National Safety Council.

55 Alive/Mature Driving: (<http://www.aarp.org/55alive/>): This program is taught in four two-hour sessions in many localities. Upon completion participants may qualify for a reduction in their auto insurance premium. It covers topics such as vision and hearing changes, effects of medication, reaction time changes, left turns and other right-of-way situations, new laws and their effect, and hazardous driving situations.⁽¹⁰⁸⁾

Coaching Mature Drivers, by the National Safety Council,⁽¹¹²⁾ is given as either a 4 or 8-hour course and qualifies drivers for insurance reductions.

Safe Driving for Mature Operators gives general driving instructions information and tests for night vision, glare and reaction time. It offers advice for improving driving performance. Most recently AAA has developed a website targeted at older drivers. (<http://www.ouraaa.com/aaainfo/community/toaaafits.html>) The mission of this site is to present refresher tips on safe driving and offer exercises to enhance flexibility.⁽¹⁰⁷⁾

In addition, some states such as California also offer programs for older driver skill improvement. However, only the Safe Driving for Mature Operators has assessment data which indicated that it results in a small improvement in driver performance. The evaluation of 55 Alive Program resulted in participants improving knowledge but no differences were obtained in self-reported crash involvement.

In 2001, Roenker et al⁽¹¹³⁾ has reported that training older drivers can improve their speed of processing and this transfers to improved driving. Drivers that were trained to improve detection of targets in the periphery improve their useful field of view (UFOV). As UFOV improves hazardous driving maneuvers decrease. UFOV thus is used both as a screening and a training device for drivers who might be at risk for crash involvement.

Policy Factors

Licensing Issues

While there has not yet been established a causal connection between advanced age and increased crash risk and there is not yet a well accepted protocol for identifying older drivers with driving impairments, states are concerned that they will be financially responsible for drivers whom they license. As Williams and Graham⁽¹¹⁴⁾ state, "The question before a court may focus not just on motorists' competence to drive, but also on the competence of the authorities who license them."

As a result of concerns by states for being held liable, some have introduced changes in their policy regarding licensing of older drivers. The following tables represent only special provisions for older drivers. With regard to vision testing, for example, Levy⁽¹¹⁵⁾ reported that in 1991 thirty-eight states required vision testing. The information on special provisions for licensing of older drivers reported on the Insurance Institute website (<http://www.hwysafety.org/>), lists three states (See Table 11 below) with vision testing based on age. Presumably other states such as Florida, California, and Arkansas include vision testing in the renewal procedure but do not use age as a basis for administering the vision test. Levy⁽¹¹⁵⁾ reports that states which mandate vision tests for re-licensing, whether to all or only older drivers, had fewer fatal crashes for older drivers. Interestingly when examining those states which retested vision exclusively for older drivers, the association between testing vision and reduced fatalities was not obtained. Methodological issues may account for this.

The existing mélange of license provisions reveal that the most frequent state response to the issue of age-related crash risk is no specific provisions in licensure based on age (see Table 8). One state, Indiana, has become more lenient in licensure since removing the requirement for a road test for those 75 and older in 1998. Thirteen states have age related accelerated renewal cycles (Table 10). Six states have provisions restricting mail renewal but not all of these provisions are age related (Table 9). Three states require vision testing after a certain age and two currently have aged related road test requirements. Arizona, Colorado, Connecticut (with some options), Illinois, and Maine have multiple age related provisions. There is accelerated renewal along with either no mail renewal, a required vision test or a required road test (Tables 11 and 12). Four states prohibit age-related provisions for license renewal and finally four states have some provision for license renewal which eases the process on an age related basis (Tables 13 and 14).

Since Illinois is among the most restrictive in issuing license renewals for older drivers, it would be instructive to see if these policies result in reduced accidents or accident rates among older drivers. Rock⁽¹¹⁷⁾ examined the effect of changing the renewal requirements for older drivers. In 1989, Illinois shortened the license term from 4 years to 2 years for drivers 81-86 and to 1 year for drivers aged 87 and up. At that time, Illinois also eliminated the mandatory road test for drivers 69-74 but maintained it for drivers 75 and up. Rock compared accidents in Illinois from 87-89 to 1995 for three age groups, 70-74, 75-80, and 81 and up.

Table 8. Renewal Cycle Length for States with No Special Provisions for Older Driver License Renewal (Information from the Insurance Institute for Highway Safety⁽¹¹⁶⁾)

State	Length of Renewal Cycle	Special Age Provisions
Alabama	4 years	None
Arkansas	4 years	None
Delaware	5 years	None
District of Columbia	5 years	None
Florida	6 years with clean record, 4 years without	Only 2 sequential mail renewals are permitted, regardless of age
Georgia	4 years	None
Kentucky	4 years	None
Michigan	4 years	None
Mississippi	4 years	None
Nebraska	5 years	None
New Jersey	4 years	None
New York	5 years	None
North Dakota	4 years	None
Ohio	4 years	None
Pennsylvania	4 years	None
South Carolina	6 years	None
South Dakota	5 years	None
Texas	6 years	None
Vermont	4 years	None
Virginia	5 years	None
Washington	5 years	None
West Virginia	5 years	None
Wisconsin	8 years	None
Wyoming	4 years	None

Table 9. States Which Do Not Allow Mail Renewal for Older Drivers' Licenses
 Information from the Insurance Institute for Highway Safety⁽¹¹⁶⁾

State	Length of Renewal Cycle	Accelerated Renewal	Mail Renewal
Alaska	5 years	None	No mail renewal for those 69 and older No mail renewal if prior renewal was by mail
Arizona	License valid until age 65	5 years for 65 and older	No mail renewal for those 70 and older
California	5 years	None	No mail renewal for those 70 and older Only 2 sequential mail renewals are permitted, regardless of age
Colorado	10 years	5 years for 61 and older	No mail renewal for those 66 and older No mail renewal if prior renewal was by mail
Connecticut	4 years	Optional 2 years for 65 and older	Generally no mail renewal, 65 and older can renew by mail if hardship is established
Florida	6 years with clean record, 4 years without	None	Only 2 sequential mail renewals are permitted, regardless of age

Table 10. States Which Have an Accelerated Renewal Cycle for Licenses for Older Drivers. Information from the Insurance Institute for Highway Safety⁽¹¹⁶⁾

State	Length of Renewal Cycle	Accelerated Renewal	Special Provisions
Arizona	5 years	5 years for 65 and older (Extended license provision for 18-64, see Table 9)	No mail renewal for those 70 and older
Colorado	10 years	5 years for 61 and older	No mail renewal for those 66 and older No mail renewal if prior renewal was by mail
Connecticut	4 years	Optional 2 years for 65 and older	Generally no mail renewal, 65 and older can renew by mail if hardship is established
Hawaii	6 years	2 years for 72 and older	None
Idaho	4 years	4 years for 63 and older, Drivers' choice of 4 or 8 years for 21-62	None
Illinois	4 years	2 years for 81-86 1 year for 87 and older	Road test for 75 and older
Indiana	4 years	3 years for 75 and older	None
Iowa	2 or 4 years Drivers' choice	2 years for 70 and older	None
Kansas	6 years	5 years for 65 and older	None
Maine	6 years	4 years for 65 and older	Vision Test at 1 st renewal after 40 and every 2 nd renewal until age 62. After 62, vision test with each renewal
Missouri	6 years	3 years for 69 and older 3 years for 21 and younger	None
Montana	8 years 4 years by mail	4 years for 75 and older	None
New Mexico	4 or 8 years Drivers' choice	4 years for 75 and older and for drivers who turn 75 in last half of 8 year cycle	None
Rhode Island	5 years	2 years for 70 and older	None

Table 11. States Which Require a Vision Test for Older Drivers' License Renewal Information from the Insurance Institute for Highway Safety⁽¹¹⁶⁾

State	Length of Renewal Cycle	Accelerated Renewal	Vision Test Required
Maine	6 years	4 years for 65 and older	Vision Test at 1 st renewal after 40 and every 2 nd renewal until age 62. After 62, vision test with each renewal
Oregon	4 years	None	Vision test every 8 years for 50 and older
Utah	5 years	None	Vision test for 65 and older

Table 12. States Which Require a Road Test for License Renewal Older Drivers Information from the Insurance Institute for Highway Safety⁽¹¹⁶⁾

State	Length of Renewal Cycle	Accelerated Renewal	Road Test Required
Illinois	4 years	2 years for 81-86 1 year for 87 and older	Road test for 75 and older
New Hampshire	4 years	None	Road test for 75 and older

Table 13. States Which Prohibit Age Related Provisions for License Renewal Information from the Insurance Institute for Highway Safety⁽¹¹⁶⁾

State	Length of Renewal Cycle	Accelerated Renewal	No Age Related Provisions By Law
Maryland	5 years	None	Age alone is not grounds for re-examination of drivers. Initial license at age 70 or older must provide physician's certification of fitness or proof of previous safe vehicle operation
Massachusetts	5 years	None	Cannot discriminate by age alone for licensing
Minnesota	4 years	None	Age alone not justification for re-examination
Nevada	4 years	None	Age alone not justification for re-examination, for 70 and older, mail renewals must have medical report

Table 14. States Which Ease Provisions for License Renewal for Older Drivers
Information from the Insurance Institute for Highway Safety⁽¹¹⁶⁾

State	Length of Renewal Cycle	Accelerated Renewal	Eased Provisions By Age
Connecticut	4 years	Optional 2 years for 65 and older	Generally no mail renewal, 65 and older can renew by mail if hardship is established
North Carolina	5 years	None	60 or older do not have to parallel park in road test
Oklahoma	4 years	None	Reduced fee for 62-64, fee waived for 65 and older
Tennessee	5 years	None	Licenses issued to 65 and older do not expire, reduced fee for 60 and older

The data reveal that from 1989 to 1995 crashes per 1000 drivers age 81 and up actually fell. However without looking at the rest of the age groups, it is difficult to tell if crashes dropped among all drivers or this is specific to drivers over age 81. Similar patterns of data were obtained for drivers in the 70-74 age groups and in the 75-80 group. However when fatal crashes alone are examined, the change in crash rate increased for the 81+ cohort and the 75-80 group. Fatal crashes decreased among the 70-74 group. Rock⁽¹¹⁷⁾ concludes that eliminating the road test for the 69-74 group had no negative impact on crash rates. Moreover, the more frequent renewal period for the 81+ group does not appear to have improved fatal crash rates. Rock⁽¹¹⁷⁾ cites Levy's 1995 research which indicates that use of a vision screening test for drivers age 70 and up reduced fatal crash risk 7%. Addition of a road test reduced risk by an additional 1%. He suggests that road tests do not add much beyond vision tests. Older drivers who fail vision test are not likely to make it to a road test. Given the results of Rock's study, he believes a four-year renewal policy with vision and road tests may be more cost effective than shorter cycle renewal periods.

One of the most comprehensive studies⁽¹¹⁸⁾ concerning the impact of licensing policies and other "non-policy" issues on traffic fatalities identified vision testing as a way to reduce fatalities among older drivers. Vision testing policy in the 48 contiguous states and Washington DC was categorized as representing: 1. no testing, 2. visual acuity, 3. visual acuity and depth, 4. visual acuity and peripheral vision; and 5. visual acuity, depth, and peripheral vision. Table 15 presents state driver license renewal policy with respect to vision testing.

Table 15. Vision-related Driver License Renewal Policies as of 1991⁽¹¹⁸⁾

No Vision Testing	Visual Acuity	Visual Acuity & Depth	Visual Acuity & Peripheral	Visual Acuity, Depth & Peripheral
Alabama	Alaska	Delaware	Arizona	Colorado
Connecticut	California	District of Columbia	Arkansas	Hawaii
Kentucky	Florida		Georgia	Illinois
Mississippi	Idaho		Iowa	Louisiana
New Jersey	Indiana		Maine	Maryland
Oklahoma	Kansas		Michigan	Massachusetts
Pennsylvania	Montana		Nebraska	Minnesota
Tennessee	Nevada		Oregon	Missouri
Vermont	New Hampshire		Rhode Island	North Carolina
West Virginia	New Mexico		South Carolina	North Dakota
	New York		Utah	Ohio
	South Dakota		Virginia	Wisconsin
	Texas			
	Washington			
	Wyoming			
10 Jurisdictions	15 Jurisdictions	2 Jurisdictions	12 Jurisdictions	12 Jurisdictions

Other policy issues that were considered include license renewal period, in-person vs. mail renewal, use of additional tests, and physician reporting policies.

Non-policy issues that were factored in for control purposes included: age, gender, socioeconomic status, population density, and environmental factors. Measures for age were state median age, the percentage of licensed drivers 60 and older and the percentage of the population 65 and over. The proportions of male and female drivers in each state measured gender. Socioeconomic status was included as a proxy measure for quality of vehicles and the amount of travel in each state. It was measured by per capita income and the percentage of high school and college degrees in the population. Population density was measured by population over square mile and the percentage of population in urban areas. Environmental measures were included to capture weather conditions and roadway preference. These were measured by state freeway and non-freeway mileage, state mean temperatures, and mean precipitation. FARS data from 1989-1991 for drivers age 60 and over in the 48 contiguous states and Washington DC were the source for the independent variable. Standardized driver fatality rates were calculated for each state using the total fatalities for drivers 60 and over for the 3-year period as the numerator and the driver age population cohort as the denominator per 100,000 licensed drivers.

Initial analyses compared states with no-vision testing to states with increasingly stringent testing policies. While the results did not attain significance, the outcome strongly suggested that no-testing resulted in higher fatality rates. The multiple regression analyses entered other factors into the equation and five factors accounted for a 51.4 percent of the variance. These included vision policy (none vs. vision test), age (the percent of older drivers), Socioeconomic status (per capita income), Population density (population per square mile) and the percent of non-interstate miles of road. No policy issue other than vision testing reached significance. Associated with decreased vehicle fatality rates of older drivers is that of vision testing, a higher percentage of older drivers, higher income, and population density. Increased fatalities were associated with higher proportions of non-interstate roadways. Finally, multiple regression was used to estimate how many lives might have been saved if states without vision testing policy had employed it. Connecticut and New Jersey were excluded from the estimate since the confidence interval for the number included a value of 0. However, with those two states excluded, the estimated lives saved in the period from 1989-1991 was 222. The aggregated savings estimate is 31 million dollars.

Physicians' Role in Assessing Older Drivers

Both Carr⁽⁴⁴⁾ and Hogan⁽⁷⁸⁾ argue that physicians should play a larger role in assessing the older person's ability to drive. To assist physicians in their assessment of driving ability, Ott and Mernoff⁽¹¹⁹⁾ suggest clear public policies and guidelines. In his discussion of the physician's role in assessing the older person's driving abilities, Carr⁽⁴⁴⁾ notes that many physicians are reluctant to get involved due to many concerns. Among some of them are lack of training in injury prevention, fear of losing a patient, and legal concerns.

Another reason for reluctance may be lack of awareness of medical conditions that should be reported. Research conducted by Kelly, Warke, and Steele⁽¹²⁰⁾ in Northern Ireland, assessed both doctors' and elderly patients' awareness of medical restrictions for driving for five particular conditions (epilepsy, myocardial infarction, stroke, 5-cm abdominal aortic aneurysm, and diabetes). One hundred fifty patients (age 60 - 95) and 50 doctors were interviewed face to face. Of 103 patients who considered themselves capable of driving, 48 would have been ineligible to be behind the wheel due to medical restrictions that might impair their ability to drive safely. Only 21 of the patients were currently driving and after the evaluation six of them were found not eligible to drive and were advised to stop.

Kelly, Warke and Steele⁽¹²⁰⁾ further found that only 24 of the 50 doctors knew the exact age that a driver is required to have a license review for fitness-to-drive (70 years old); only nine doctors knew that a license review should be done every three years. Regarding the medical conditions that have to be reported, 46 cited epilepsy, 30 myocardial infarction, 30 visual disorders, 24 stroke, 21 diabetes, six blackouts and two mentioned dementia. Concerning the type of restrictions for

the condition, nine doctors were correct for epilepsy, five for myocardial infarction, four for stroke, 22 for abdominal aortic, and eight for diabetes.

The researchers concluded that “patients have difficulty knowing if, as a result of their medical condition, they are eligible to drive or not. If patients are not able to decide this, then doctors need to be able to advise patients appropriately” (p.539). Interestingly, the researchers described the doctors’ awareness of medical restrictions and driving as poor and suggested more emphasis be given to this issue in undergraduate and postgraduate training. Kelly et al⁽¹²⁰⁾ also cited a 1998 study by Gillespie, Lien, and McMurdo that showed that “even among geriatricians, knowledge and attitudes to driving in older people varies considerably” (p.538).

In Utah, the Driver License Division manages a specialized licensing program for drivers who have medical conditions.⁽¹²¹⁾ These conditions include: diabetes mellitus and other metabolic conditions, cardiovascular, pulmonary, neurological, epilepsy and other episodic conditions, learning/memory/communications, psychiatric or emotional conditions, alcohol and other drugs, visual acuity, musculoskeletal abnormalities, chronic medical debilities, functional motor ability and hearing. Drivers with medical conditions may have total restriction or non-restriction depending on their functional ability. Utah Crash Outcome Data Evaluation System (CODES) evaluated this program to contrast the crash and citation rates of drivers with medical conditions to the rates for drivers without medical conditions. They made separate comparisons for each medical condition in the program. Independent analyses were performed for drivers with a single medical condition and drivers with multiple medical conditions. Control groups were selected from licensed drivers who had no functional disability. The driving records of the different groups from 1992 to 1996 were compared. For the majority of the functional ability categories, unrestricted drivers with medical conditions had higher crash rates than their matching control group. For at-fault crashes, the risk for drivers with a medical condition was 3.63 times higher than the relevant control group. The restricted drivers in the musculoskeletal abnormality or chronic medical disability group had a 11.29 times higher rates of at-fault crashes than their corresponding control group. Clearly, medical evaluation has utility.

One route around physicians’ concerns regarding medical evaluation of older drivers is to mandate reporting from anyone who has knowledge of driving inadequacies.⁽¹²²⁾ Mandating circumvents the issues of patient-physician relationship and fears of being sued. Pennsylvania enacted mandatory reporting of certain conditions that interfere with safe operation of a vehicle in 1994. With mandatory reporting, reports from physician reached 40,000 the first year and continues to increase at about 4,000 a year. California requires physicians to report patients with lapses in consciousness sufficiently severe to impair safe operation of a vehicle.⁽¹²³⁾ Missouri’s 1998 law requires health care workers (physicians, nurses, physical therapists, etc) to report patients with disorders that

can interfere with safe operation of a vehicle. As states fear litigation, we can expect mandatory reporting to increase.

Identifying “Fitness to Drive”

When age is used as the criterion for determining fitness to drive, it runs into an array of complicated legal, political, social, economic, and psychological issues. Using age alone could be considered discriminatory and the majority of older drivers drive competently. In fact four states have laws prohibiting the use of age as a basis for curtailing driving.

Road testing everyone would be prohibitive in expense and as the experience in Illinois indicates not that effective in reducing crash risk among older drivers. The need to develop a reliable and fast screening procedure has spurred the National Highway Traffic Safety Administration to partner with California Department of Motor Vehicles to developing a screening process. The California program involves a battery of tests administered in tiers.⁽¹²⁴⁾ The first tier was brief and inexpensive and intended to identify applicants whose physical conditions could impair their driving. The second tier would be longer and attempt to identify drivers who would actually perform poorly on road tests, and the third tier would be an actual road test. In a pilot test of these assessment tools, California DMV compared a group of individuals referred to departmental examiners as part of the normal re-examination process to a group of volunteers. The battery of test included tests for visual acuity, reaction time, perceptual speed, driving knowledge, low contrast acuity, and the number of observed problems on the part of the test administrator. Examples of problems are stiffness, difficulty understanding, balance problems, etc. Later tests were introduced to capture potential intersection problems. These added tests of neck flexibility, motion sensitivity, and useful field of view. Those tests which seem most promising in detecting who might be an unsafe driver are test of low contrast visual acuity and tests of reaction time. The number of observed problems by the administrator also proved to be a useful predictor. In predicting performance on the road test, tests of reaction time, and perceptual recognition speed proved useful.

NHTSA has also partnered with the Maryland Motor Vehicles Administration. The tests under development would take about 15 minutes and include tests of visual acuity and other visual abilities as well as tests of memory and physical mobility. The intent is to develop a technique of identifying “fitness to drive” that is affordable to licensing agencies and not unacceptably inconvenient to drivers. Results from this study are still in preparation and to date have focused on left turn intersection problems which are demonstrably higher among older drivers.

Summary of the Literature Review

Accident Propensity

The literature shows varied results regarding the accident propensity of older drivers depending on the metric used for crash risk. When risk is defined as the number of accidents in the age category compared to the number in the population in that age category, older drivers do not present an increased crash risk to others. However, when the metric becomes the number of accidents in the age category compared to vehicle miles traveled, older drivers present a similar profile to younger drivers and are a high risk for accidents and injury particularly to themselves. There is some evidence that younger cohorts of older drivers are safer drivers than older cohorts.

Types of Accidents

Research over several studies confirm that older drivers show a tendency to get involved in accidents that involve intersections, particularly left turn intersection maneuvers. They also were more likely to be involved in broadside and sideswipe types of accidents. Non-signalized intersections also present problems for older drivers. When older drivers are involved in accidents they are more likely to occur during the daytime, on a weekday, in good weather, on straight roads, and involve another vehicle.

Visual Factors

While vision accounts for 95% of driving related information, the standard static acuity vision test used in licensing shows little relationship to impaired driving ability. While several aspects of vision show decrements that are associated with driving problems, the area receiving most attention is useful field of view. This requires simultaneous processing of information for central and peripheral fields. Decline in this visual ability has been shown to discriminate between those older drivers who experience a crash and those who did not. Decreased visual acuity is also associated with self-reports of difficulty in driving in various conditions.

Cognitive Factors

Attention and memory are the two cognitive factors that figure prominently in operating a vehicle. Of the three attention processes, vigilance, divided attention and selective attention, more driving related research focuses on divided attention. Overall, the relationship between age and the ability to divide attention is negative. Thus, the ability to divide attention between a central task such as tracking the traffic ahead and a peripheral task such as monitoring surrounding traffic or signs or speed, decreases with age. While both short term and long term memory show decrements with age, the link to crash risk is inferred. That is, increased time needed for memory retrieval may lead to hesitancy in driving and this could contribute to situations which create a crash risk for older drivers.

Psychomotor Factors

Reaction time increase with age that presents heightened problems for older drivers particularly at intersections. The tendency of older drivers to be involved in intersection accidents may stem from difficulty in coordinating a response to complex visual input.

Health Factors

The diseases, which have been studied most frequently in relation to vehicle accidents among older drivers, are heart disease, syncope, stroke, diabetes, and dementia. The major issue involving driving and heart disease is the risk of loss of consciousness and/or sudden death. Various medical reporting systems may require, depending on the severity of the illness, that physicians report cardiac disease to licensing authorities. However, as evidenced by a study in Canada, under reporting seems to prevail. The relationship of syncope (loss of consciousness) to accidents seems obvious but it is somewhat difficult to specify since patients who suffer syncope episodes may report a different factor as the cause of the accident. Although the risk seems to be small, recurrence of an attack following the first one is frequent and driving should be restricted. Research examining the relationship of stroke to accidents among older drivers revealed that stroke patients were more likely to be the at-fault driver in a crash than drivers who had not suffered stroke. Again reporting systems show under reporting of the problem and drivers who are potentially not safe are permitted back on the road. Problems stemming from diabetes related to hypoglycemia. Even mild hypoglycemia affected driving abilities as gauged in a simulator. Physicians need to advise patients of this risk and the need to monitor blood glucose levels before driving.

The aging disorders that have received significant attention in relation to decreased driving ability are those of dementia and Alzheimer's disease since both affect cognitive functioning. In the early stages of these disorders, driving may not be noticeably affected. However, as the disorders progress into middle and late stages, driving is clearly affected and accidents rates increase. Guidelines on driving and Alzheimer's Disease have been issued by the American Academy of Neurology.

Medications

The medications used by older individuals to treat the various ailments can pose a risk to safe driving. Drugs that are used to treat insomnia and anxiety affect central nervous processing and have been associated with crash injury among the elderly. Opioid drugs used to treat chronic pain have also been identified as affecting driving performance. Other drugs that may have an impact include antihistamines, anti-inflammatory drugs, and muscle relaxants.

Predicting Accident Frequency

Most studies relating age and other factors to accident frequency are retrospective. However, one study attempted to predict accident frequency from visual functions, mental status and self-reported driving habits. In the model of prediction, the single best predictor was useful field of view, with mental status as the second single best predictor. Useful field of view was especially helpful in predicting intersection accidents.

Assessing Driving Abilities

Several tools are available for assessing driving ability. Both the American Automobile Association and AARP have created paper and pencil tests for drivers to self-assess driving habits and abilities. Other tools deal with clinical assessment of specific abilities that relate to driving such as useful field of view and reaction time tests. Tests of cognitive impairment also provide a surrogate measure of driving ability. Finally on-road tests and simulator tests are presumed the most valid and reliable measures of driving ability.

Compensating for Ability Loss, the Decision to Stop Driving, and Skill Enhancement

The most frequent compensation for ability loss is self-restriction of driving. Older drivers avoid driving in heavy traffic, at night, in bad weather and tend to drive more slowly and leave greater distances between vehicles. To assist in focusing attention, they listen less to the radio and report use of a co-pilot to navigate and report on traffic conditions. The decision to stop driving is primarily due to health conditions. However men and women stop driving for different reasons. For men vision problems is a primary reason and for women loss of confidence. Older drivers report that they prefer the topic of driving cessation being raised by the family physician rather than a family member. Both AAA and AARP offer programs to help older driver improve their skills. California also provides a driver skill enhancement course.

Policy Factors

The licensing of older drivers is an area of concern for states due to liability considerations. Most frequently states use vision testing as a prerequisite for license renewal. In 1991, only 10 licensing jurisdictions did not have any vision testing for renewal. Those that did, did not relate the vision testing to age.

Overall, 24 licensing authorities had no special provisions related to age. Thirteen states used age-related accelerated renewal cycles, six restricted renewal by mail, and two states have age related road test requirements. In a comprehensive study linking vision testing to traffic fatalities, Shipp (1998) concluded that vision testing is associated with lower traffic fatality rates.

Physicians Role in Assessing Older Drivers

Closely related to licensing policies is the role of physicians in assessing the older person's ability to drive. Physicians are reluctant to get involved and may not be aware of medical conditions that the states require be reported. To circumvent the reluctance of physicians to report condition, some states now require medical reporting.

Identifying Fitness to Drive

As states consider some limitation in licensing for older drivers, they will need to find tools to assess fitness to drive to fairly implement any program. Road testing for everyone would be prohibitive in expense and may not be that effective in reducing crash risk. Currently the National Highway Traffic Safety Administration is partnering with California and Maryland to develop screening processes. Results from these studies are just becoming available and have yet to ramp up to large-scale application.

ANALYSIS OF DATA

Description of The Data

To determine the history and characteristics of driving behavior of mature drivers in New Jersey, two types of data were analyzed: crash records and records of traffic violations and suspensions. Crash records for 1991 to 2000, with the exception of 1996, were provided by the New Jersey Department of Transportation. The data sets included variables extracted from the police reports for each accident. The data sets for 1991 and 1992 were incomplete and were therefore excluded from the analysis. The research team was told that the 1997 data had duplicate records for some accidents, so it also was excluded.

The data format for the crashes from the years before 1996 was different than the format for the post-1996 crashes, making it difficult and somewhat questionable to combine the remaining six years of data. Therefore most on the analysis of crashes was done using the 1998 through 2000 data. The 1993 through 1995 data were used to establish overall trends. The sizes of the crash records data sets are shown in Table 16.

Table 16. Number of Crashes by Year in Data Sets

1993	1994	1995	1998	1999	2000
220,134	228,820	224,995	268,902	275,755	302,424

The records of New Jersey violations and suspension orders for drivers 16 to 21 and 40 and older were obtained from the New Jersey Department of Motor Vehicle (NJDMV) for 1996 through 1999. (Note: the analysis of this data was done jointly for two projects, this one and one dealing with teenaged drivers; the discussion in this report will concentrate on the mature driver.) The research team had selected a subset of 228 events to be extracted from the database of 1600 different events. These events consisted of driving-related violations and suspensions such as: speeding, reckless driving, failure to yield, disobeying a traffic control devise (TCD), careless driving, driving under the influence, and others.

Analysis of Data

Crash Data

The numbers and characteristics of the crashes for drivers involved in the crashes were analyzed by the driver's age or age categories. Ideally, when comparing different groups of drivers, exposure to possible accidents is controlled for by dividing the number of crashes or driver involvements by a measure of exposure. The preferred measure of exposure is the vehicle miles traveled (VMT) by the drivers in the relevant category. However, VMT within a

state is not available broken down by age. The next most common measure of exposure is the number of driver licenses. In New Jersey, this information was only available for the year 2000; therefore, some of the analysis will be done for driver involvements per licensed driver using only 2000 data. The third measure of exposure typically used when neither vehicle miles nor licensed drivers is available is population. Much of the analysis of numbers and trends of crashes will be done using driver involvements per population.

Note that the lack of better exposure data is a particular difficulty for analyzing the crash records of the mature driver. For middle aged drivers, for example, over 90 percent have licenses and are actively driving; thus, population is highly correlated with both licensed drivers and the distance they drive. But as people age, they are more likely to stop driving, either voluntarily or because their license has been suspended. Those drivers who remain licensed often cut back on the amount they drive; they are less likely to work, which is a major cause of travel, and they may find driving so stressful that they minimize the amount that they drive. Further, many older drivers who have ceased driving, do not surrender their license. They may simply wait until it expires, or in a few cases, they may actually renew it for emergency purposes even though they are not currently driving. For all of these reasons, population or even driver licenses will over state exposure and make the crash rate appear lower than it would be with a more accurate measure of exposure. Note that the characteristics of the crashes will be studied using percentages; for example, the percentage of total crashes by an age category that involve left turns. Including a measure of exposure would not affect the percentages.

The age of the driver for the 1998 to 2000 data had to be calculated. This was done by comparing the date of the accident to the birth date of the driver. Many dates (although a small percentage) were incorrectly recorded, resulting in absurd ages, for example, negative ages, drivers who appeared to be very young (e.g., one or two years old), or extremely old (120 to 300 years). Only drivers between the ages of 14 and 100 were included in the analysis. In fact, the upper age limit was further restricted to those born in 1900 or later, because there appeared to be no convention for recording a year of birth in the 19th century (years were recorded as the last two digits of the year). As will be seen later, the characteristics of the crashes for drivers over 90 are anomalous, raising questions about years of birth recorded as 01 through 09 also; see Figure 8 for an example. Because the total number of crashes for drivers 90 and older is small, this does not affect the analysis of numbers of crashes very much; it does have a major impact on the percentages by age or age category for drivers over 90. This will be discussed further in section 4.3.2.

Suspension and Violation Data

Fifty eight of the 228 variables in the suspension and violation data set were types of suspension orders. There were grouped into the following ten categories:

- Speeding or exceeding speed limitations
- Fatality related
- Unqualified due to physical or medical conditions
- Probationary program - Failure to complete or points
- Persistent violator
- Operating under the influence
- Left scene of accident - injury
- Left scene of accident - failure
- Left scene of accident - Property damage only or other
- Unlicensed
- Probationary driver and improvement program

The remaining 154 variables were related to violations; they were grouped into the following 20 categories:

- Operating under the influence
- Unlicensed
- Equipment or vehicle related defects
- Struck animal
- Failure to yield
- Failure to obey traffic control device
- Reckless driving or racing
- Following too closely
- Careless driving
- Left scene of accident - fatality
- Left scene of accident - injury
- Left scene of accident - property damage only or other
- Improper crossing at railroad grade crossing
- Speeding or exceeding speed limitations
- Failure to notify - seizure
- Regular or special learners permit non-compliance
- Unsafe driver
- Operated at slow speed or blocked traffic
- Driving after underage drinking
- Failure to wear seat belt

The remainder of this chapter describes the results of the analysis, looking at how the number of driver involvements in crashes, characteristics of the crashes, and the numbers of suspensions and violations differ for the older driver compared to those of younger drivers. SPSS was used for the basic analysis and MS Excel was used for the graphs and tables.

Results of Analysis of Crash Data

Number Of Crashes By Age

Figure 2 shows the number of drivers involved in crashes by age for the 1993 to 1995 data and the 1998 to 2000 data. The most striking characteristic is the

peak in crash involvements for 17 year olds (the minimum legal driving age in New Jersey) and the rapid fall off to the early twenties. The number of crash involvements remains relatively flat until about 40 and then falls off until about 65. (Vehicle mile driven tends to peak in the 35 to 50 year old age range; NPTS, 1997.) From 65 to about 75, the number of drivers involved shows a slight downward trend, a slightly greater downward trend until about 85 and then a very low and flat trend until 100. It is clear that the mature driver is not involved in a large number of accidents compared to younger drivers.

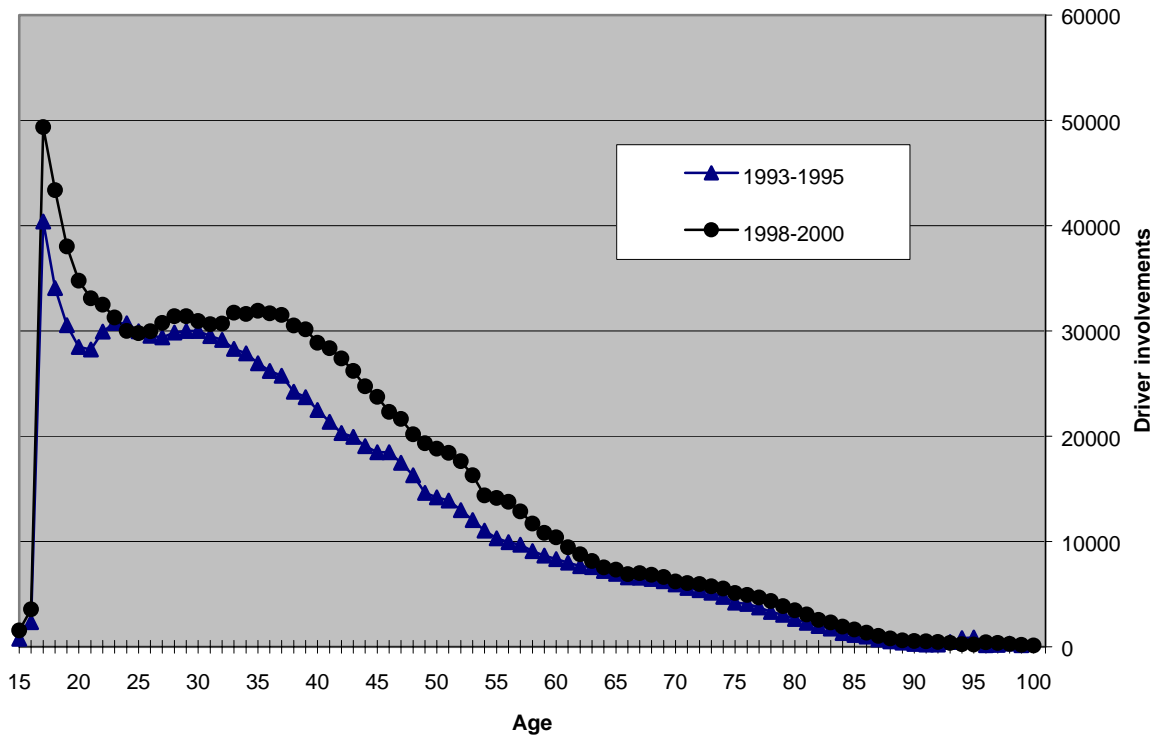


Figure 2. Crash Involvements by Age (1993-1995 and 1998-2000)

In comparing number of crash involvements in the period from 1993 to 1995 to that of 1998 to 2000, drivers in the youngest ages to early 20s and in the early thirties to early 60s had more accidents. This may be due partly to shifts in population but also probably reflects the change in the economy, which affects the amount people travel. In the years 1993 through 1995, New Jersey was recovering from a recession. The years 1998 to 2000 were a boom period.

Figure 3 shows driver involvements by age category for all six years (which span an eight year period). Note that the number of involvements shows a distinct increasing trend from 1993 to 2000 for the middle age categories, particularly 35 to 44 and 45 to 54 year olds. For the mature driver, there is a slightly

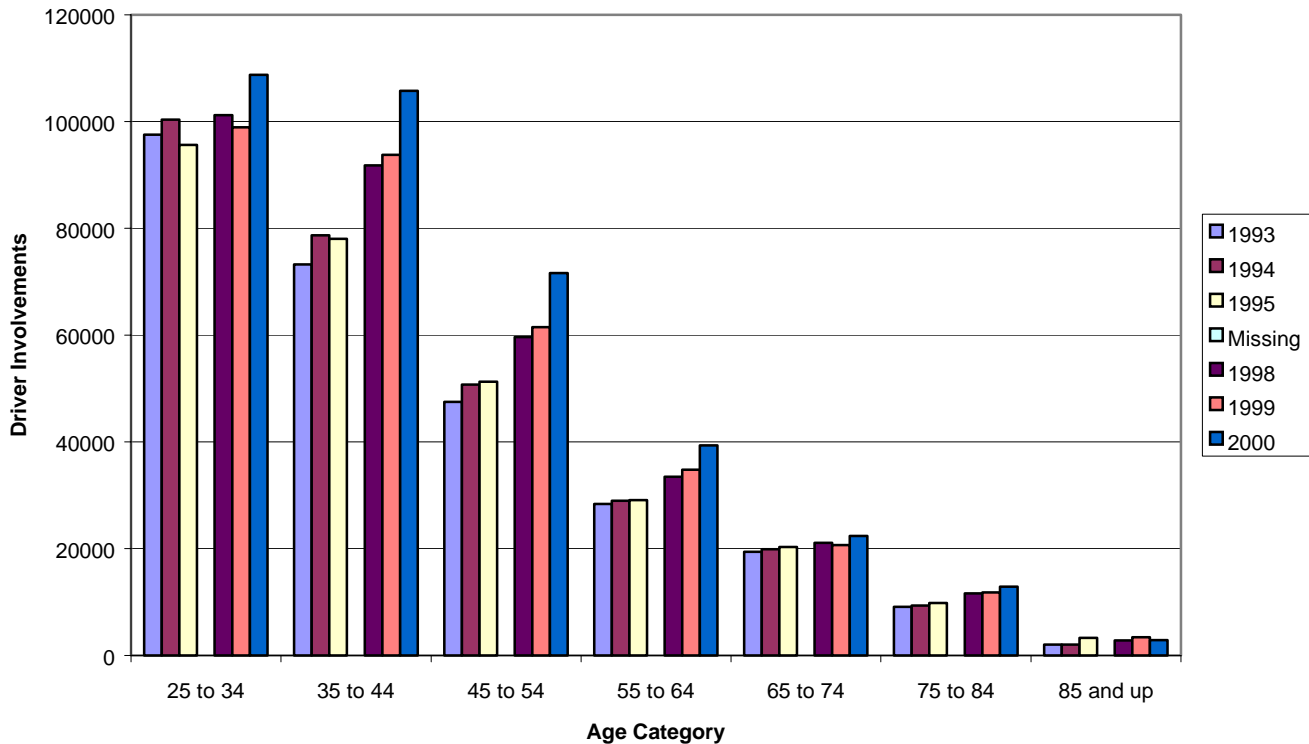


Figure 3. Trends in Driver Involvements

increasing trend, but for the oldest drivers (85 and up), there is almost no increase. This is surprising, since this is the age category that is increasing the fastest (see Chapter 2).

Figure 4 shows the crash involvements by gender. Women tend to have about two thirds as many crashes as men up to about 65. This is mostly due to the greater miles driven by men than women, although some researchers attribute part of this to women being more risk adverse than men. Starting at about 65 years, the crash involvements for the two genders become closer; this may reflect the greater longevity of women, particularly as the husbands die or become incapacitated and the wives take over the driving.

Figure 5 shows the crash involvement rates per 10,000 population. (Data for 2000 is not plotted because population figures by one year age increments are not yet available for all ages.) The curves for 1998 and 1999 are almost identical, suggesting any changes in crash involvements (as opposed to rates) is due to growth in the population.

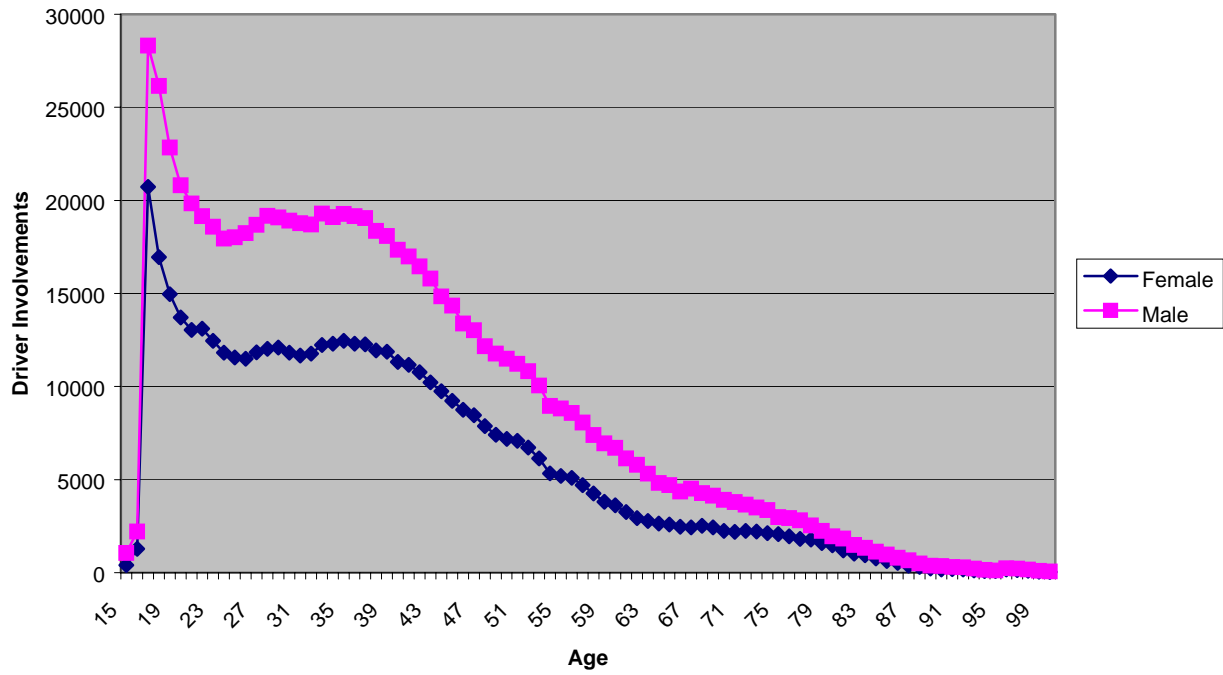


Figure 4. Crash Involvements by Gender and Age (1998 to 2000)

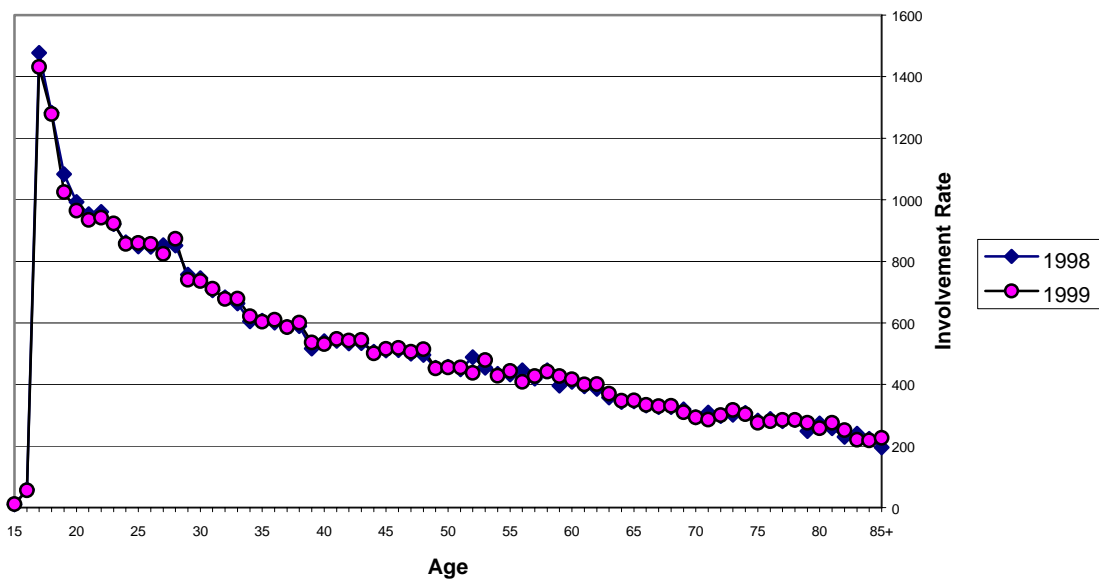


Figure 5. Involvement Rate by Age (per 10,000 population)

Figure 6 shows crash involvement rates per 10,000 driver licenses. (Only 2000 data is used because this is the only year that the number of licenses by age is available.) The pattern is very striking. The youngest drivers have many more crashes; by the early twenties, the rate per driver has dropped considerably and continues to decrease at a fairly constant rate until the early 90s. (The increase after that may be due to incorrectly recorded data; this will be discussed later.) Because drivers over 55 tend to drive less, the continuing decrease in accidents per driver at higher ages does not mean the older drivers are safer drivers, but the curve does show that older drivers are not involved in a large number of crashes.

Figure 7 shows the crash involvement rates per 10,000 population by age category for all six years. Again, we see a distinct upward trend with time, and again it is somewhat flatter for the older age categories. For the highest ages (85 and up), the trend is not consistent.

Situations of crashes

Figure 8 shows the percentages of crashes that occur during daylight and after dark (after dark with and without street lights were summed because their patterns with respect to age were similar and the numbers were small). The figure indicates that the percent of crashes occurring under daylight conditions increases with age, and from about 35 to 89, the increase is fairly constant. At the younger ages, this may be due to an increase in experience and better judgment about driving after dark, but probably at the upper ages, it reflects older drivers choosing to avoid driving after dark. The graph shows a sharp decline in the percentage of crashes during daylight for the age categories 90 and up; this anomalous trend appeared in many of the figures and caused the researchers to question the reliability of the data for these age categories. (One hypothesis as to the cause is that these relatively small cohorts (less than a thousand; the next smallest cohort is over 2500) may have a disproportionate number of mis-recorded years of birth. If only one digit of a two digit year were to be recorded, the result would make it appear that the driver had been born between 1900 and 1909 and therefore were in their nineties at the time of the accident. If these mis-recorded dates of birth were randomly drawn from the total population, the result would have crash characteristics close to the mean for the total population. As can be seen in Figure 8 and several subsequent figures, that is the case.)

Figure 9 shows the percent of driver involvements in crashes that occurred during inclement weather and when the pavement was not dry. (Categories have been summed because of low percentages and similar patterns.) The two curves show a similar pattern, decreasing crashes during bad weather and when the pavement is not dry. The likely explanation is again that younger drivers gain experience under bad conditions as they age and older drivers, who have more discretion about when they travel, avoid bad weather and road conditions. The over 90 cohorts show the same anomalous behavior as noted for Figure 8.

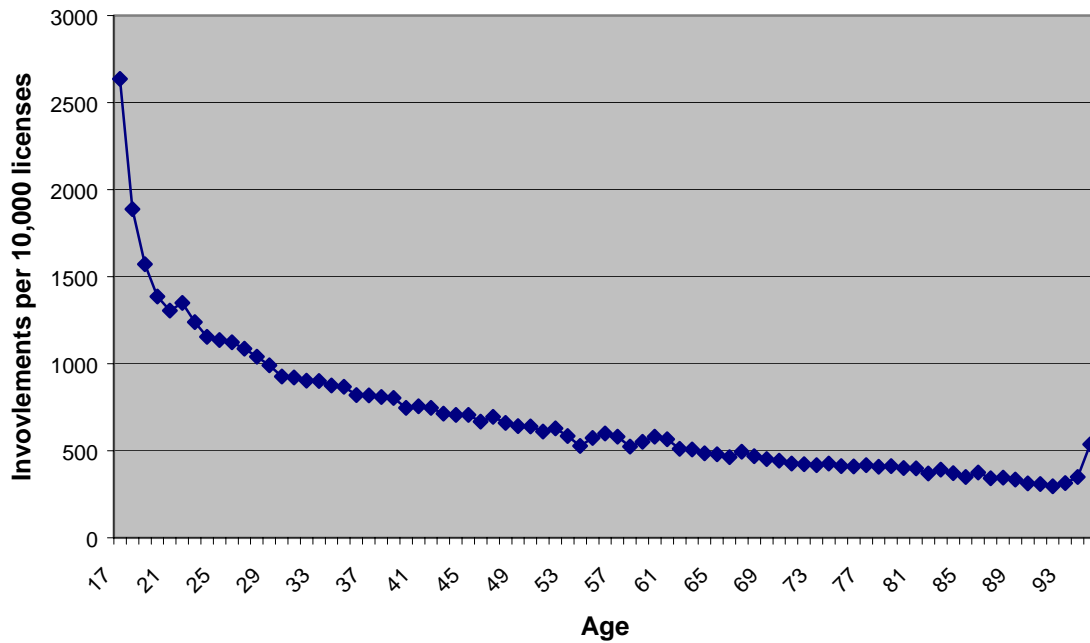


Figure 6. Involvements per 10,000 Licensed Drivers – 2000

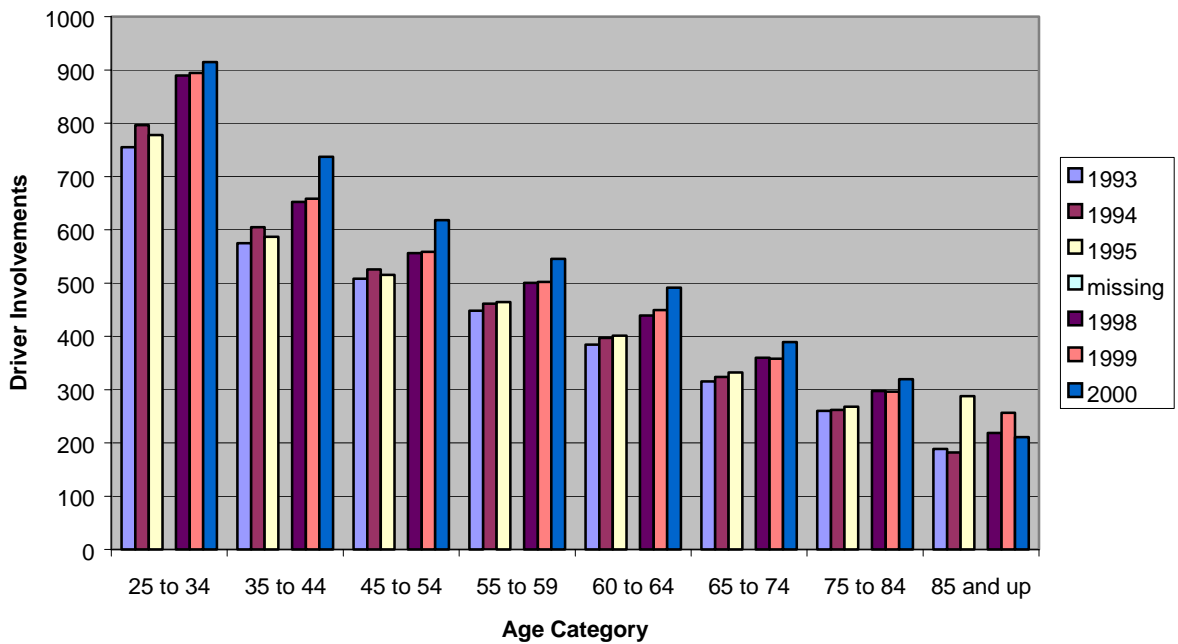


Figure 7. Driver Involvement Rates per 10,000 People

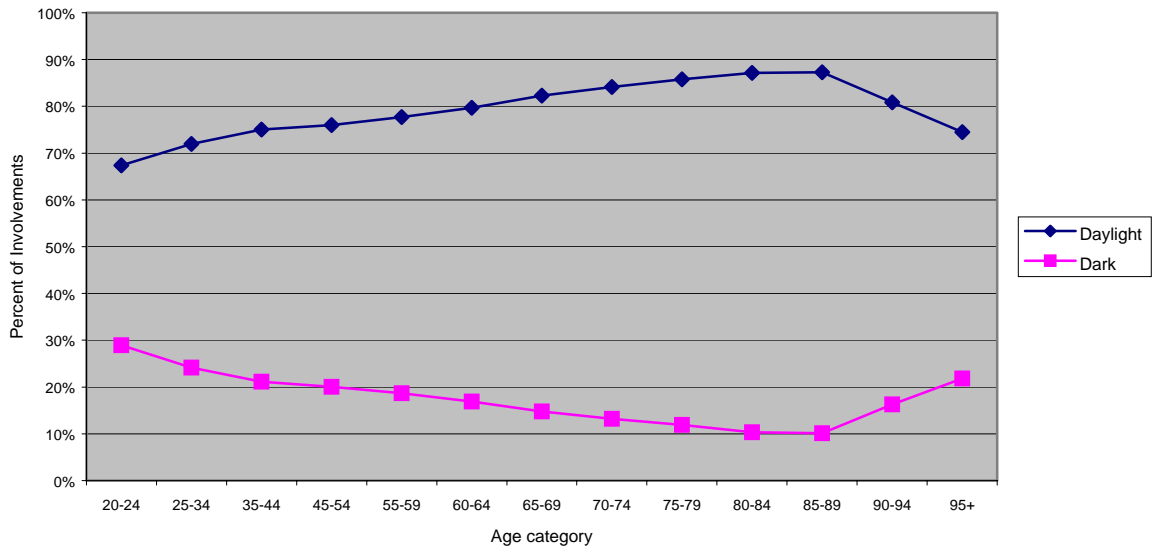


Figure 8. Percent of Involvements by Light Conditions

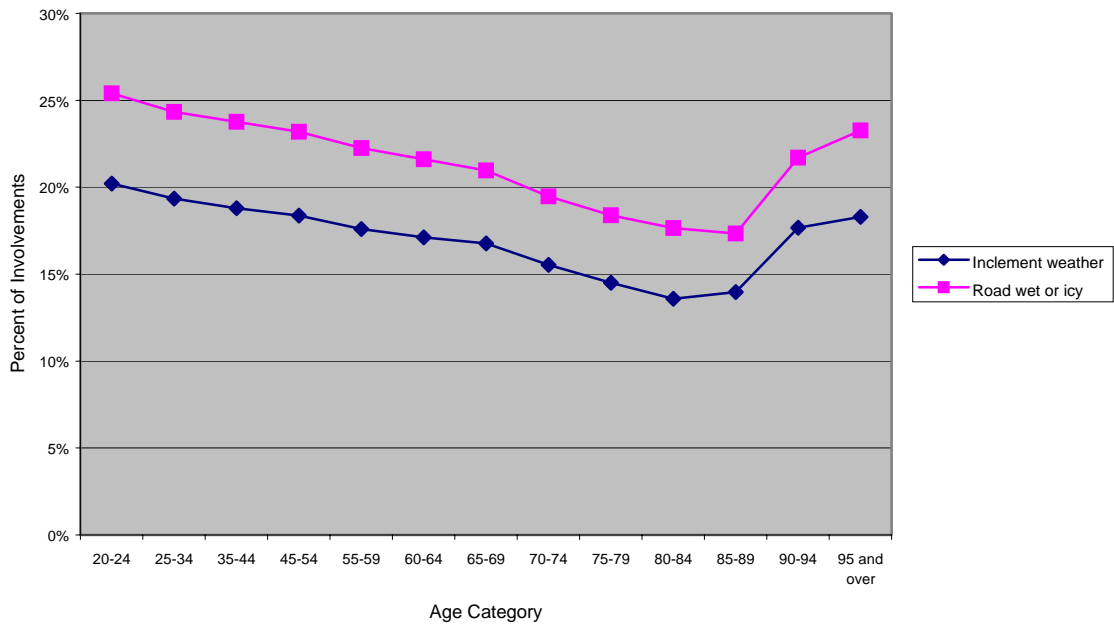


Figure 9. Percent Involvements during Bad Weather or Wet Roads

Figure 10 shows the driver involvements by the road system where the crash occurred. The majority of the crashes occurred on local (municipal and county) roads regardless of the age of the driver. However, starting with the 60 to 64 year cohort, the percent of involvements on local roads increases with age while the percent on state highways and interstates declines. This is consistent with shorter trips and also avoidance of high speed roads as the older driver feels less secure in their driving. Another phenomenon is the increase of drivers involved with crashes on private property; one possible reason for this is an increase in crashes in parking lots for the older drivers.

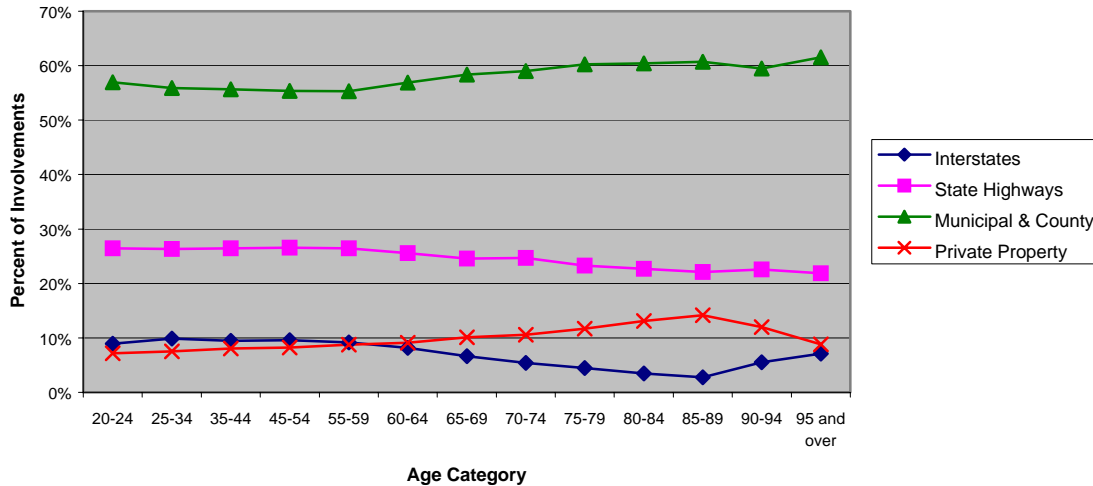


Figure 10. Percent of Involvements by Road System

Figure 11 shows driver involvements by time of day (only one age category under 65 was included, the 35 to 44 group, to reduce the confusion in the figure). As the driver becomes older, the number of crash involvements increases in the middle of the day (10 AM to 4 PM) and declines in all other time periods. This probably reflects the driving behavior as older drivers avoid driving after dark and during the congested peak commute periods. Also, the retired older driver no longer needs to commute which reduces the need to drive in the peak periods.

Severity of Accidents

Figure 12 shows the percent of fatal crash involvements by age of driver. The number of fatal crashes is small, making drawing conclusions from the data less certain; however, a strong pattern shows up. There is a slight upward trend for the below 65 cohorts, which shifts to a much stronger upward slope, in a curious step pattern, for the cohorts over 65. The tendency for fatal accidents to increase for older drivers is well established in the literature; see for example, Figure 1 in Chapter 3 of this report, which shows driver fatality rates per VMT by age. The rate increases significantly for driver categories over 65 years old. However it has also been shown that a significant number of the increased fatalities are due to the death of the older driver, which has been shown to be due to the

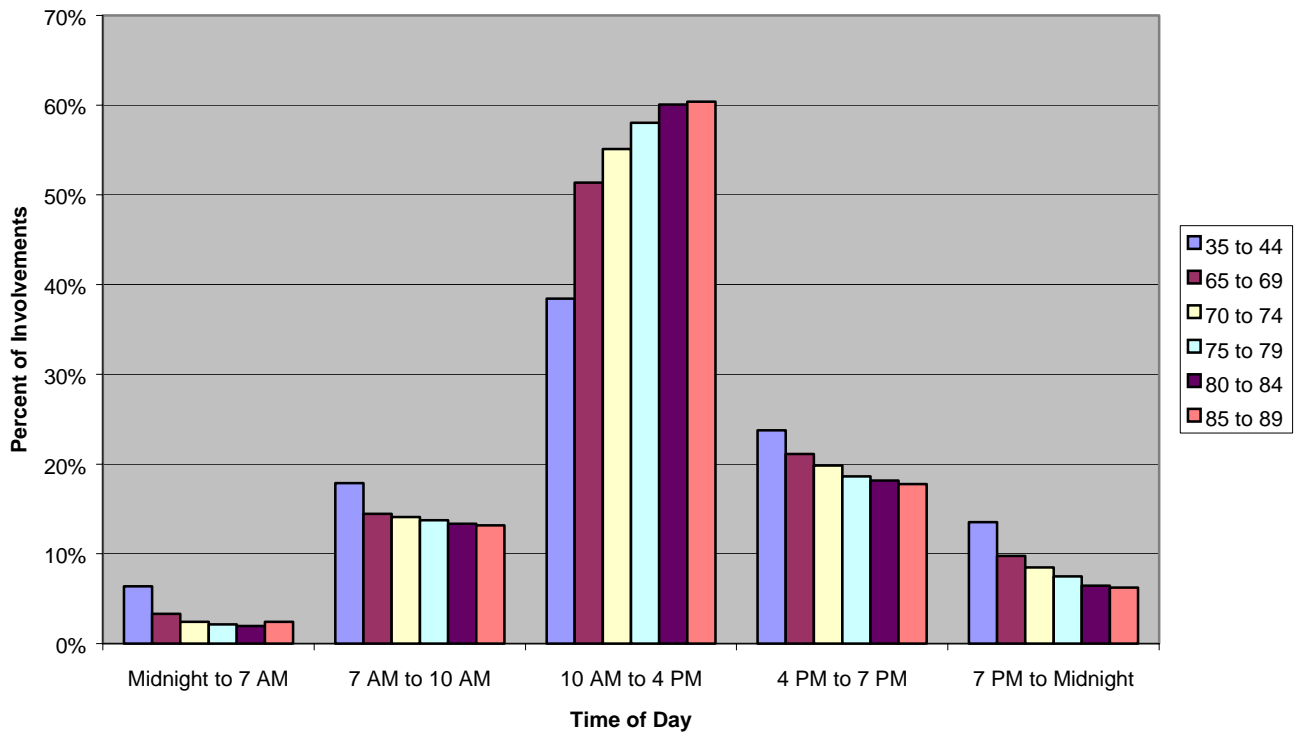


Figure 11. Percent Involvements by Time of Day

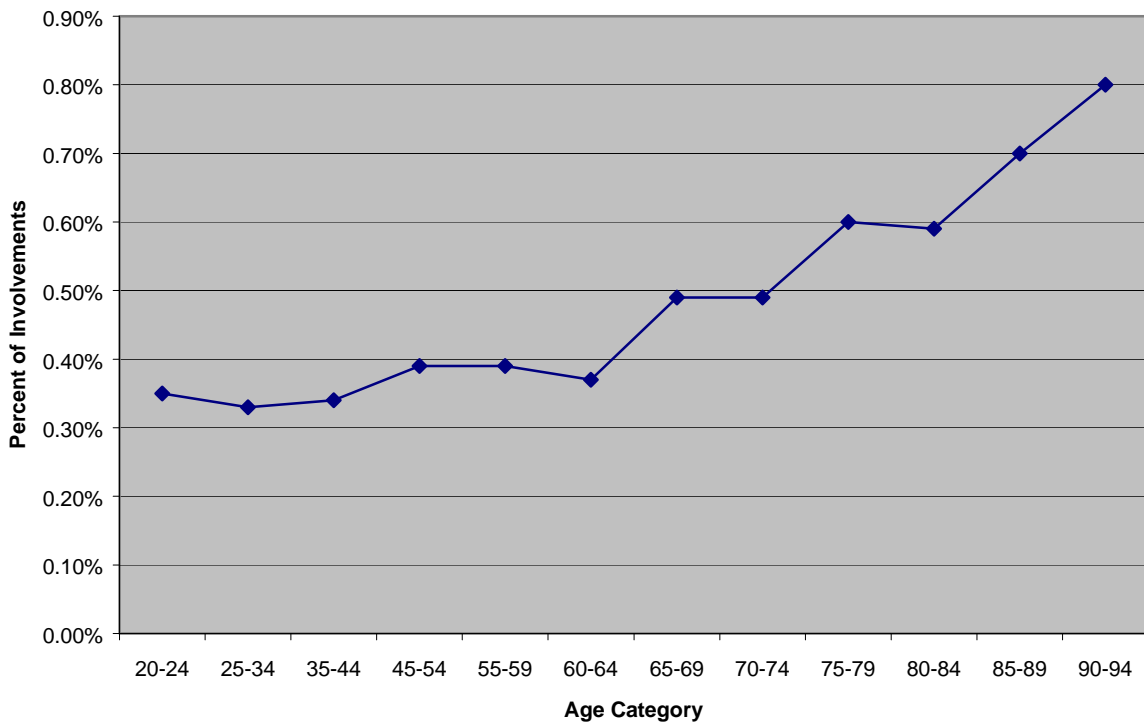


Figure 12. Percent of Involvements in Fatal Crashes

frailty of the older person more than to the nature of the crash (e.g., Mitchel, 2002). It also should be remembered that the number of crashes that the older driver had in New Jersey is small, so the number that are fatal is correspondingly small. Figure 13 shows the number of fatal crashes by age (be careful in interpreting the figure; the age categories up to 54 years old are ten year groupings and after 55, they are five year groupings). Drivers 65 and older were involved in only 12 percent of the total number of fatal crashes.

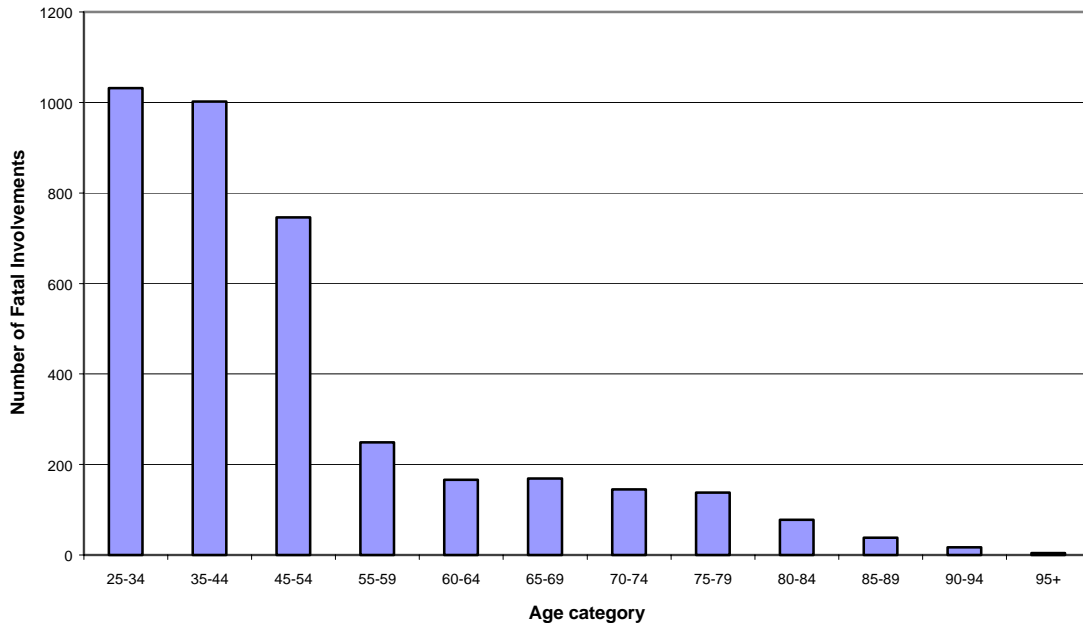


Figure 13. Number of Involvements in Fatal Crashes

Figure 14 shows the percent of involvements in injury and fatal crashes; starting with the 60 to 64 age category, the percent of crash involvements for each age category that resulted in an injury or fatality increases, but at a rather gentle rate.

Characteristics of the Crash

Figure 15 shows the action of vehicle immediately before the crash. As the driver is older, the percent of crashes while not going straight increases, but most prominently, crashes during left turns increases significantly up to the 80 to 84 age category. Deteriorating eyesight, slowing reaction times, and inattention have been suggested as the causes.

Figure 16 shows the physical condition of the driver at the time of the crash as judged by the police officer. The percentages are small, but there is an increasing tendency with age for the police officer to note a physical handicap. The perception of illness increases up to the 70 to 74 year old cohort and then is more or less flat.

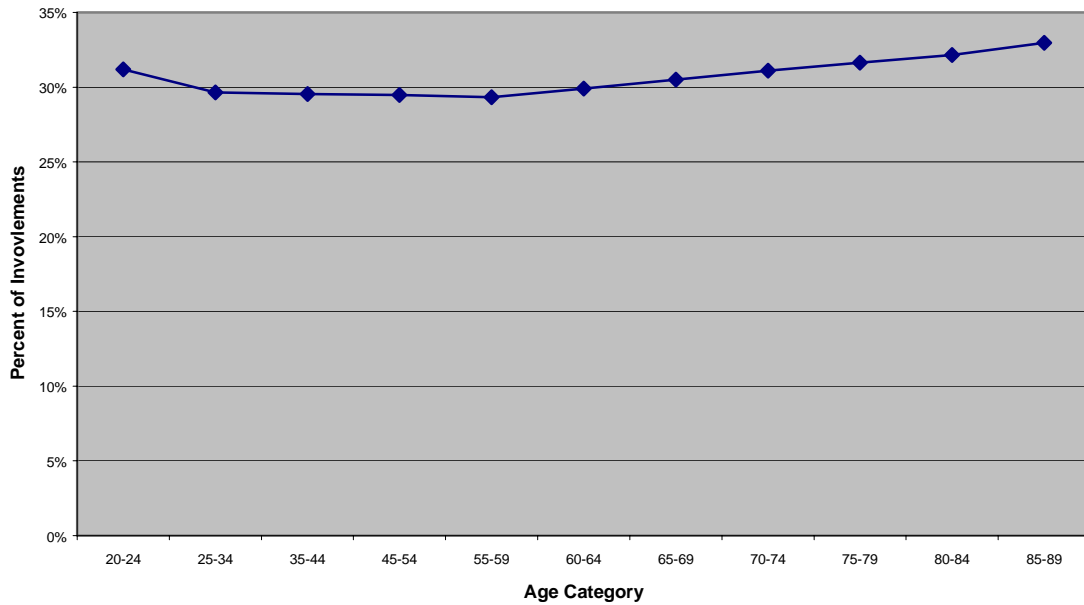


Figure 14. Percent of Involvements in Injury and Fatal Crashes

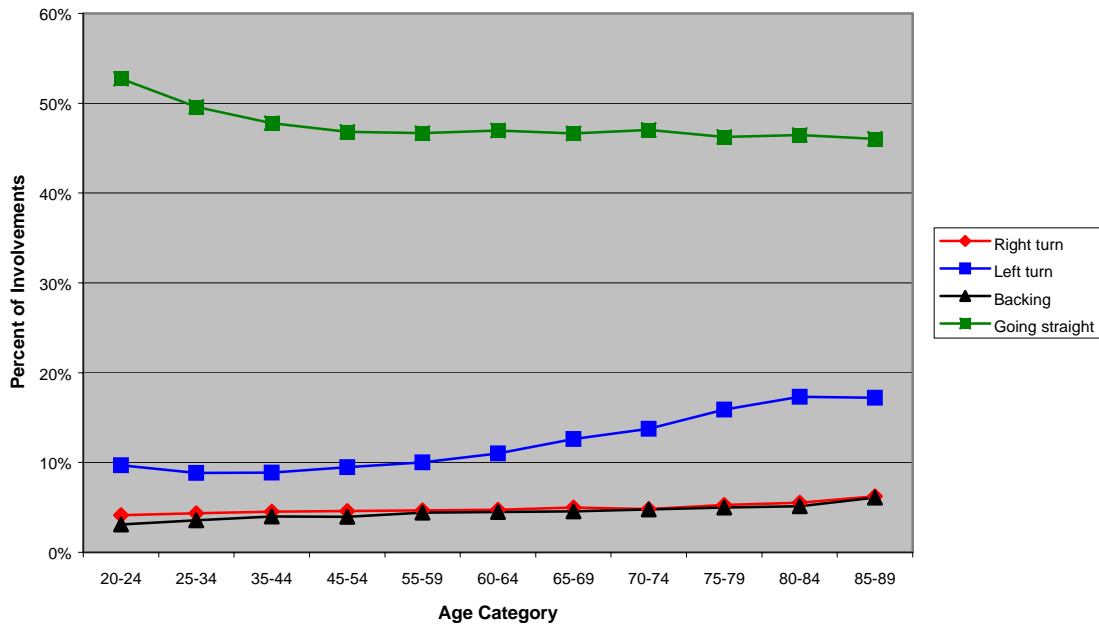


Figure 15. Percent of Involvements by Vehicle Action

Figure 17 shows circumstances (as identified by the police officer) that contributed to the crash; only those that show an increase with age are included in the figure. Inattention was identified more frequently than any of the other 25 circumstance for drivers of all ages (25 percent). Crashes for the 45 to 54 year

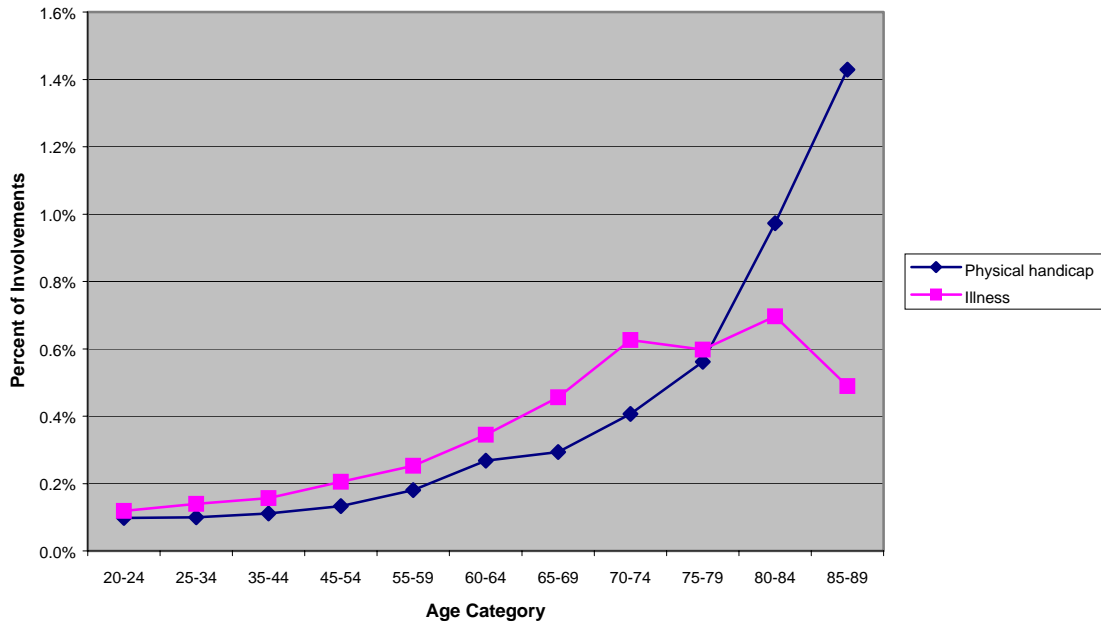


Figure 16. Percent of Involvements by Physical Condition of Driver

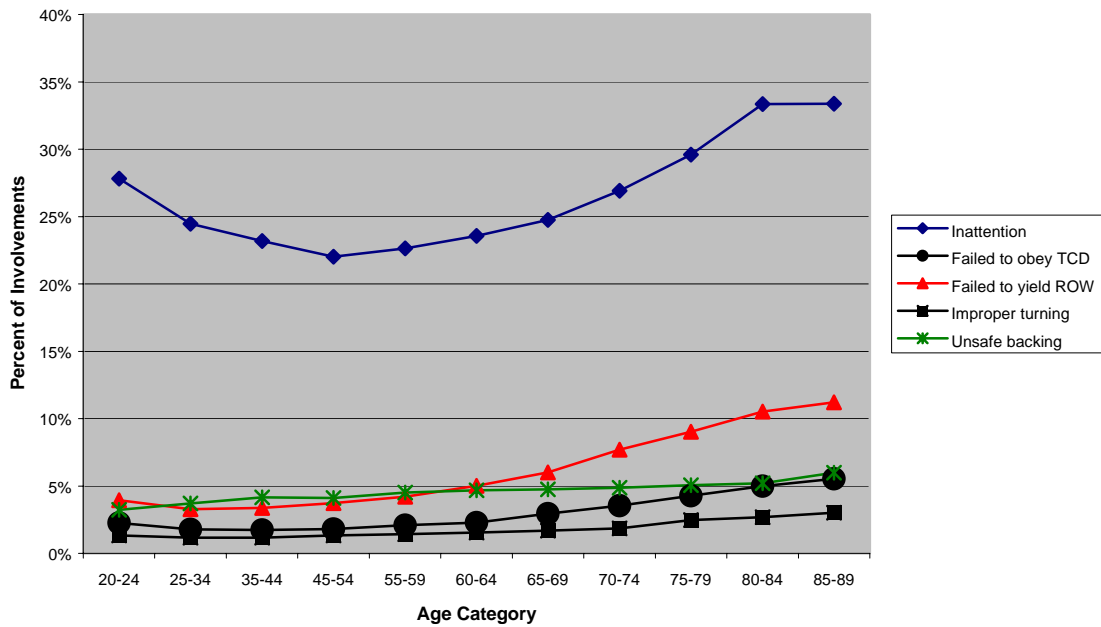


Figure 17. Percent of Involvements by Contributing Circumstances

old drivers are least likely to be attributed to inattention; the attribution increases significantly with driver age up to 80 years of age. Failure to yield, both to traffic control devices (TCDs) and to pedestrians and other vehicles, increases with age after about 60. Improper turning and unsafe backing both increase at a small rate for the older driver.

It would be useful to look at the responsibility for accidents by age; that is, is the older driver at-fault for the crash or a victim. The data sets include a charge for each driver, but the manner in which it was coded does not permit statistical analysis. As a proxy, the contributing circumstance was used. The 26 contributing circumstances included on the accident report form have been divided into those that imply fault and those that do not. (It should be noted that the at-fault circumstances indicate a contributing action on the part of the driver, but may not be the primary cause of the accident. It should also be noted that the contributing circumstances are in the judgment of the police officer.) The classification of the contributing circumstances are shown below:

Driver at fault

- Unsafe speed
- Driver inattention
- Failed to obey a traffic control device
- Failed to yield right of way to vehicle or pedestrian
- Improper lane change
- Improper use of turn signals or failure to signal
- Improper turning
- Following too closely
- Unsafe backing
- Dazzling, improper, or no lights
- Wrong way on one way road
- Improper parking
- Failure to keep right.

Other contributing circumstance (driver is victim):

- Pedestrian or bicycle action
- Vehicle defect
- Animal action
- Defective shoulder
- View obstructed or limited
- Water puddles
- Obstruction or debris on road
- Improper or inadequate lane marking
- Other roadway defects
- Traffic control device defective or missing
- None

Figure 18 shows the percent of drivers who are “at-fault” by age. The curve indicates that the lowest rate is for the 45 to 54 age group. The percent of

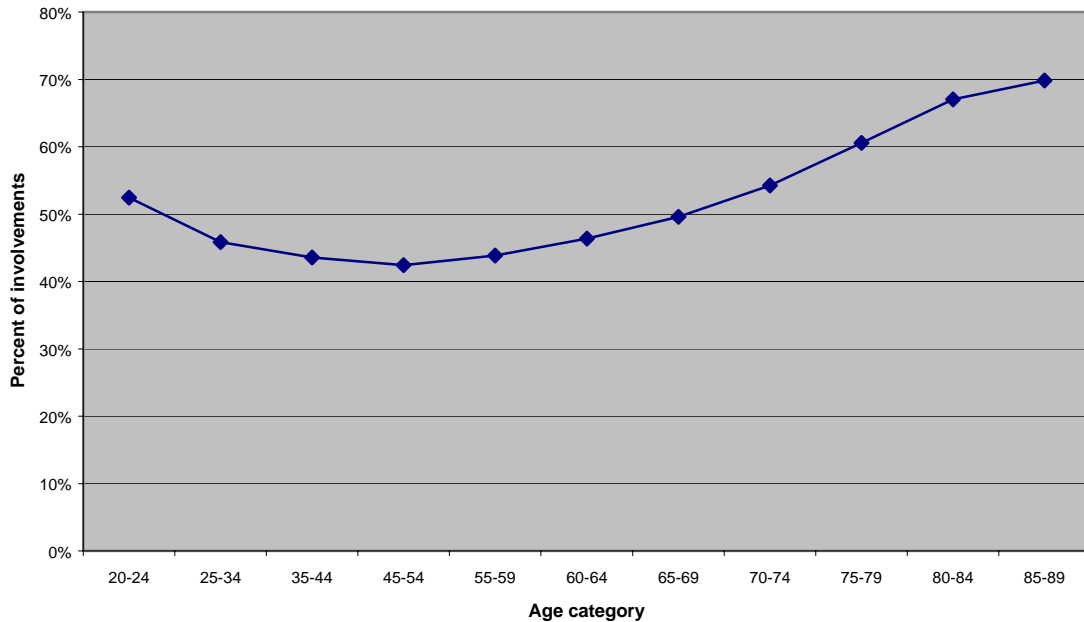


Figure 18. Percent of “At-Fault” Involvements

drivers who are “at-fault” increases as the driver’s age increases, and drivers in the 85 to 89 year range are “at-fault” 70 percent of the time.

Results of the Analysis of Suspensions and Violations Data

Figure 19 shows the trend in violation rates per 10,000 people. (The over 85 group was excluded due to incomplete data.) The violation rate drops steadily with age and increases steadily from 1996 to 1999 for each age group.

Figure 20 shows the percentages of violations by type of violation. (The types of violations shown were limited to those that were over one percent. In some cases types were combined.) The figure indicates that violations for speeding drop off rapidly with age, from close to 40 percent for middle aged drivers to less than 10 percent for drivers over 90. On the other hand, careless driving increases almost as much from six percent for middle aged drivers to 33 percent for the over 90 group. Failure to yield or to obey traffic control devices increases with age also but at a much lower rate. Unlicensed drivers decrease with age up to the 75 to 84 year olds, but increase by several percentage points for the oldest drivers.

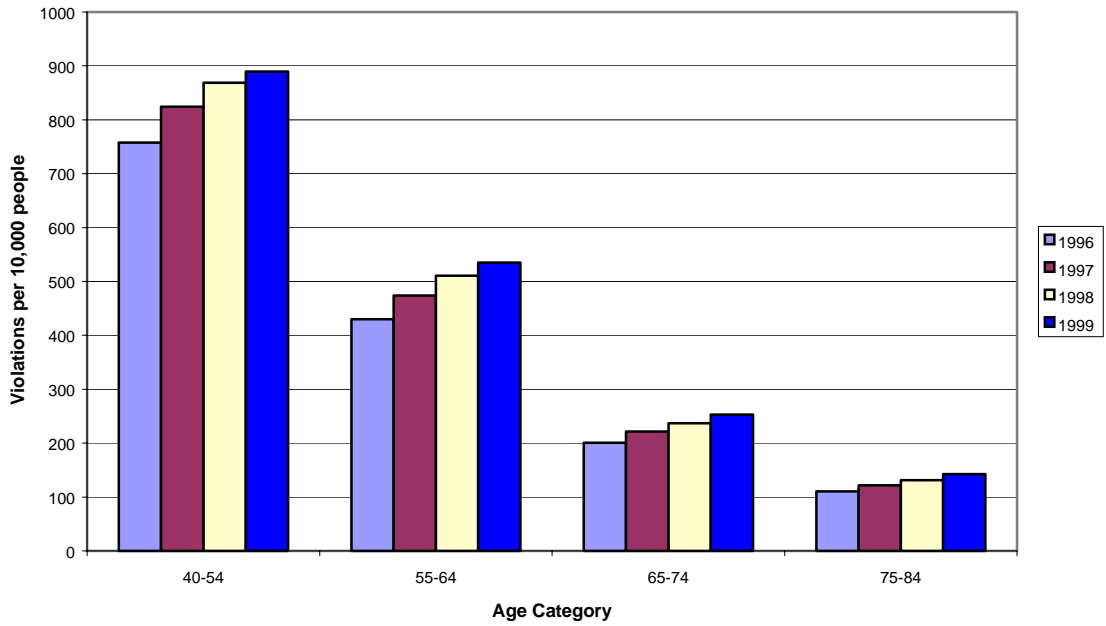


Figure 19. Violation Rates for over 40 Drivers (per 10,000 People)

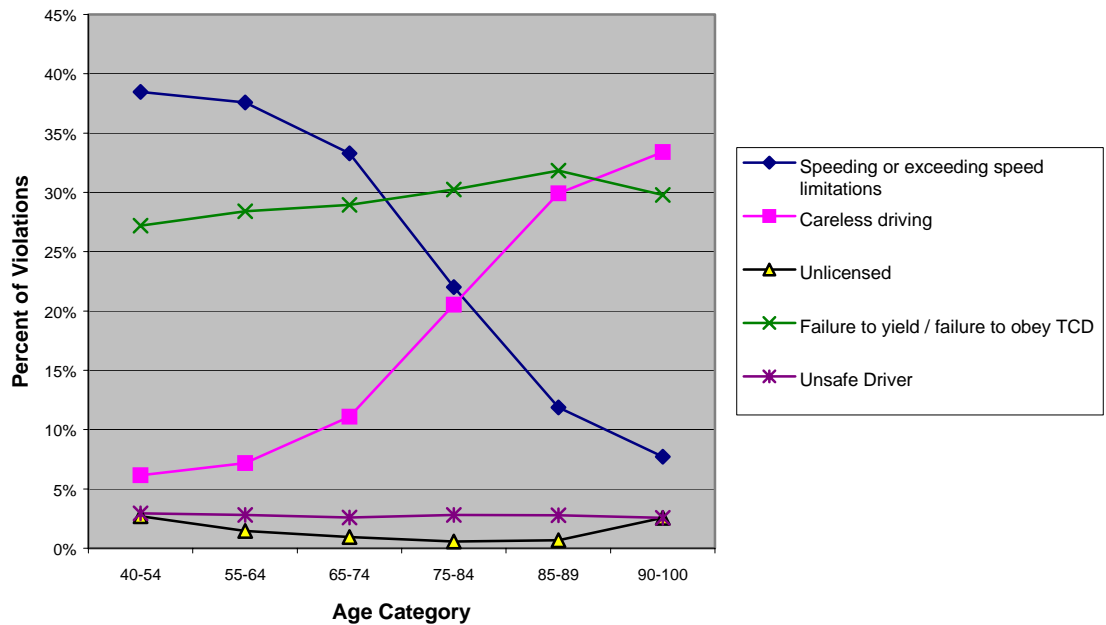


Figure 20. Percent of Violations by Violation Type (40 to 100 Year Old Drivers)

Figure 21 shows the trend in suspension rates per 10,000 people for drivers over forty. The suspension rates are much higher for the 40 to 54 age category, probably because a much higher percentage of people in these ages have licenses. The lowest rates are for the 65 to 74 year olds, but the differences among the over 55 year old groups are not great. No consistent trend can be identified from 1996 through 1999.

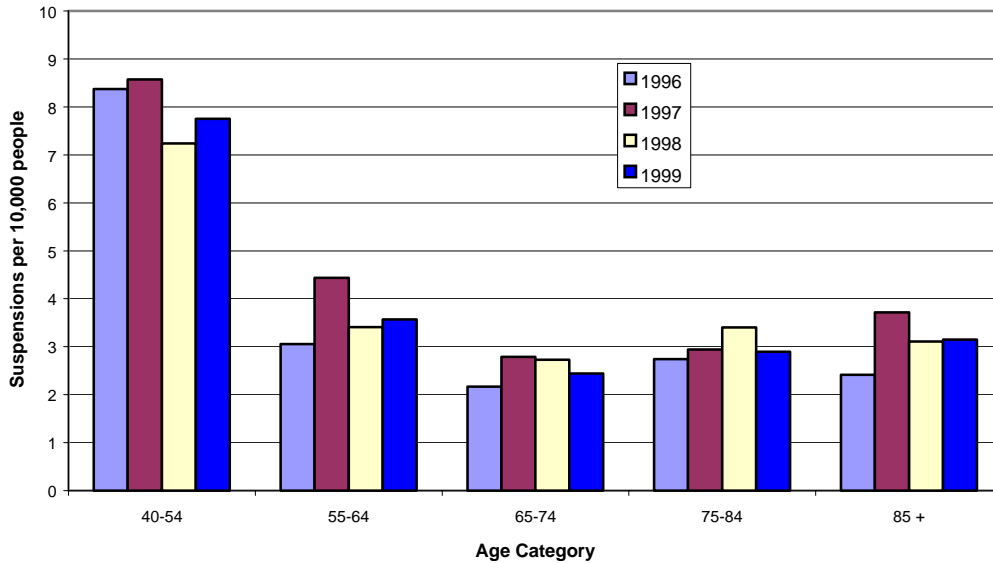


Figure 21. Suspension Rates for Drivers Over 40 Years (per 10,000 People)

Figure 22 shows the reasons for the suspension orders for different age categories. What is most noticeable is the rapid increase in suspensions because the driver is considered unqualified due to physical or medical conditions. This increases from about ten percent for middle aged drivers to 71 percent for the 65 to 74 year old cohort and to 100 percent for the over 90 drivers.

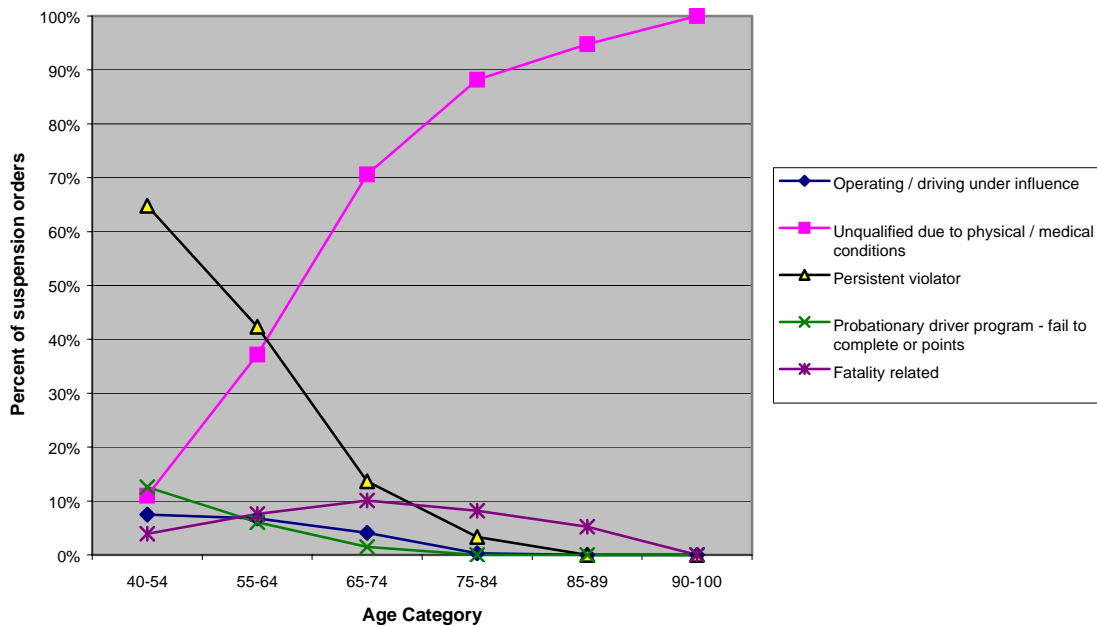


Figure 22. Percent by Type of Suspension Order (40 to 100 Year Old Drivers)

Conclusions from Data Analysis

The findings of the data analysis have not shown New Jersey mature drivers to differ from mature drivers elsewhere in the nation as described in Chapter 3. Some of the outstanding characteristics follow.

The number of crashes that the mature driver is involved with decline with age.

Further the rate of crash involvements per population also declines with age. The rate of crash involvements per licensed drivers declines with age until the mid-nineties.

Older drivers are involved in more accidents during daylight hours and good weather, probably because they avoid driving in the dark and bad weather.

They have more accidents on local and private roads than younger drivers, again probably due to their choice to avoid driving on high speed roads.

A greater percent of the crashes that a mature driver is involved in are fatal, but they are involved in fewer fatal accidents than younger drivers.

A greater percent of the accidents that a mature driver is involved in were while making a left turn than is true for younger drivers.

The crashes that the mature driver is in are more likely to involve inattention, failure to yield right of way, or failure to obey traffic signals.

The mature driver is more likely to be at fault than a middle age driver.

The mature driver has a lower rate of traffic violations per population than younger drivers, and the mature driver's violation is more frequently due to careless driving and less frequently due to speeding.

The mature driver has a lower rate of suspensions than the middle aged driver, and the likelihood of the suspension being due to physical or medical conditions increases rapidly as the driver ages, reaching 100 percent for drivers over 90 year old.

In summary, the average mature driver has different types of accidents in different places and times than the younger driver. Many mature drivers appear to be less safe drivers than middle aged drivers in many ways, but mature drivers as a group are involved in fewer accidents and fewer fatal accidents than younger drivers.

THE SURVEY OF STATE MOTOR VEHICLE AUTHORITIES

Description and Distribution of the Survey

A survey of State Motor Vehicle Authorities was devised to tap major issues of concerns regarding license policy for mature drivers. Issues were determined through conversations with individuals in the New Jersey Department of Transportation and identified in the literature review and surveys used in other studies (e.g. Center for Advancement of Public Health at George Mason University⁽¹²⁵⁾).

The survey went through several iterations of development and was shortened to make it adaptable to completion by e-mail. A copy of the survey can be found in the Appendix. The questions probe for special age related provisions in the license law as well as provisions that de facto have an impact on the older driver though not specifically age related. It also requests information on any studies that have been or are being done on older drivers. Finally, identification information is requested regarding the state and the respondent. There are six substantive questions.

The survey was initially disseminated by posting it on the Government Affairs listserv sponsored by the American Association of Motor Vehicle Administrators. It was posted in June, 2001. The survey was posted on a second listserv sponsored by the American Society of Public Administration. Surveys were returned from thirteen states. The states which responded to the posted survey were: California, Florida, Michigan, Minnesota, Missouri, Ohio, South Carolina, Montana, Nebraska, Vermont, Virginia, Washington, and Wisconsin. As a follow up to the listserv distribution, the researchers made phone calls to a group of ten states deemed important to contact either because of location, size, or known activities regarding older drivers. States included in the phone survey were Delaware, New York, Pennsylvania, Connecticut, and Massachusetts which either neighbor New Jersey or are in the Northeast; Texas and Illinois which have large populations; Arizona and North Carolina which attract retirement populations and Maryland, which is engaging in studies regarding senior drivers. Illinois was also selected because it has a stringent renewal policy regarding older drivers. The title of the person completing the questionnaire or the person's unit is found in Table 17.

Table 17. Survey Respondents' Position or Office

State Responding	Title or Responsibility of Respondent
Arizona	Community Relations
California	Research Program Specialist
Connecticut	Medical Review
Delaware	Director of Driver Services
Florida	Planner, Division of Driver Licenses
Illinois	Field Services Administrator
Maryland	Director of Driver Safety Research
Massachusetts	Director of Licensing
Michigan	Office of Services to the Aging
Minnesota	Southwest MN Agency of Aging
Missouri	Customer Assistance
Montana	Dep't of Justice, Motor Vehicle. Div.
Nebraska	Attorney, Dept. of Motor Vehicles
New York	Coordinator of Older Driver Programs
North Carolina	Manager of Medical Review
Ohio	Professor of Public Administration
Pennsylvania	Manager, Driver Safety Division
South Carolina	Associate General Counsel
Texas	Chief of Media Relations
Vermont	Assistant Attorney General
Virginia	Deputy Director, Driver Monitoring Div.
Washington	Director of Driver Services
Wisconsin	Nurse consultant, Medical Review

Survey Findings

Age Related Provisions

Of the 23 states responding to the survey, six reported some type of age-related provision in the licensing law. The simplest provision was solely reducing the renewal cycle period. Missouri shortens the cycle from six years to three years at age 70 and Montana shortens it from eight years to four starting at age 75. Arizona licenses drivers for an extended period from the age at which the license is obtained until age 65. After age 65, drivers need to have their vision tested every five years. Pennsylvania uses age 45 to introduce a required medical examination to get the license renewed. Starting at 45, Pennsylvania drivers become eligible to be selected, on a random basis, for a sample of 1,650 drivers who will be required to get medical examinations in order to complete renewal requirements. California uses age 70 as the demarcation for no mail renewal. Drivers age 70 and over who are up for renewal need to do so in person and to take a vision test and a knowledge test of traffic signs and traffic laws. Illinois has the most rigorous age-related provisions of the states responding. Up to age

75, the renewal cycle is every four years and a vision test is required. From 75-80, the cycle stays at four years but a mandatory road test is introduced. The renewal cycle shrinks to every two years from 81-86 and the licensing fee is reduced. However, the written test is waived if the driving record is good. The road test remains. At age 87, the renewal cycle reduces to every year but there is no licensing fee. Again, the written test is waived if the driving record is good but the road test remains.

Non-Age Related Provisions That Are Aimed Primarily At Older Drivers

The most prevalent non-age related provisions that are used to detect lack of fitness to drive are those dealing with medical review. Medical review can happen at any age when some event triggers a report of a driver to the medical review unit of the licensing agency. Events that most frequently trigger a medical review include reporting by physicians or other caregivers of some medical condition that affects driving ability, reports by police or other law enforcement officials who observe something amiss in driving ability, reports by licensing agency personnel who observe difficulties during in-person renewal, and reports by family members, friends or other caregivers. The most frequent source of referral is from the police who observe an instance of unsafe driving and upon questioning of the driver suspect some condition that warrants referral to the medical review unit.

In most of the surveyed states, the requirement for doctors to report medical conditions is voluntary. However, some states do have mandatory reporting systems. Pennsylvania's medical competency law appears to be the most extensive. Some other states with mandatory reporting of some conditions include California, Delaware, Nevada, New Jersey, New Mexico, Oregon, Utah, and West Virginia.⁽¹²⁶⁾

When a report is received by the medical review unit further investigation takes place to determine what will happen to the status of the driver's license privilege. The states where we conducted phone interviews all reported some form of medical review but the process had variations. In all states, the most drastic outcome is revocation of the driver's license. Some states, however, have a provision for a restricted license where the driver is limited by some specific provision. Some examples are:

- time of day when driving is permitted,
- type of vehicle,
- speed limit
- no passengers
- range of driving allowed (e.g. 5-mile radius from home, etc.)
- type of highway (e.g. no Interstates)

Some of the states that have a provision for a restricted license are California, Connecticut, Florida, Maryland, Missouri, Nebraska, and Washington. Table 18 lists these various restrictions. Typical restrictions such as corrective lenses,

additional mirrors or special vehicles are not included since they are more broadly based in application.

The most extensive review policy, found in Pennsylvania, is codified as the Medical Competency Law. Every caregiver is mandated to report conditions that affect the way a person drives. Pennsylvania reports getting about 40,000 reports a year. This law holds for everyone over fifteen years old. When the Pennsylvania DMV gets a report, they send out a notice to the individual regarding the condition. If more information is needed, then it is solicited. A retest might be called for if there are questions about ability. If the condition is severe, such as advanced Alzheimer's, Pennsylvania can recall the driver's license.

Some states have an anonymous reporting feature such as Texas so that family members or friends could make a referral in writing and request that they not be identified. When a referral is made in Texas, the driver is called in and interviewed by a state trooper. Texas Department of Safety is responsible for licensing in the Texas. Based on the conversation, a decision could be made to refer the case to a medical review board that is empowered to contact the individual's physician. Licenses can be revoked upon medical review.

Another provision that is offered by some states is the recommendation for some type of driving rehabilitation or remediation service to improve driving skills. For example, Illinois has a Super Senior Program. Since Illinois mandates road tests for drivers over the age of 75, they offer a review course that consists of reviewing the written portion on rules of the road and then simulated driving. Florida offers the TLC (Transportation Lifetime Choices Program), which deals with driving skills as self-regulation and alternatives to driving. New York provides a website dealing with issues of concern to older drivers and Maryland provides remediation and re-test for older drivers who do not pass a test on road driving skills. California also offers a "mature driver improvement course as well as a pamphlet (available at <http://www.dmv.ca.gov/pubs/matured/dl663toc.htm>) with tips for the mature driver. Massachusetts collaborates with AARP in an outreach program to make presentations at senior citizen centers.

New Jersey's medical review policy is similar to that found in most of the states surveyed. The unit responsible is the Driver Review Unit. Medical review of drivers is most commonly initiated by police officers who stop drivers and notice behavior that warrants medical review follow-up. Review can also be initiated by physicians, other health-care providers, and by relatives or concerned citizens. These instances require writing to the Department of Motor Vehicles and usually happen when the driving impairment becomes visible. Family members and friends can request confidentiality but it is not guaranteed. The driver can request a hearing and the name of the informant. While most reporting is voluntary, New Jersey does have mandatory reporting for loss of consciousness such as with seizures and epilepsy.

Once the Driver Review Unit receives information, it is reviewed and a determination is made if further information or testing is necessary. The driver can be required to submit further medical information, to have vision retested, to take a knowledge test or a road test. If the driver review unit is uncertain of the determination, the case is forwarded to a medical review board for evaluation. A license can be suspended or revoked upon determination by the medical review board. At present New Jersey does not offer any special restricted licenses beyond the typical corrective lenses or special vehicles. A summary of medical review policies of states that participated in the survey is presented in Table 18.

Table 18. A Summary of Medical Review Policies in Participating States

State	Medical Review Process	Outcomes when referral has merit	Types of Restrictions*
AZ	Upon referral and determination by DMV staff, can interview, re-examine, or refer to medical review board	Restrict License Suspend license Revoke license	Daylight driving Driving range
CA	Upon referral and determination by DMV staff, can interview, re-examine, or refer to medical review board	Restrict License Suspend license Revoke license	Daylight driving Driving range No freeways
CT	Upon referral and determination by DMV staff, can interview, re-examine, or refer to medical review board for hearing	Restrict License Suspend license Revoke license	GDL for medical reasons: time, location, vehicle
DE	Re-examination upon referral. For loss of consciousness, medical suspension without physician certification that disorder is under control.	Suspend license Revoke license	
FL	Upon referral and determination by Dept. of Highways & MV staff, can interview, re-examine, or refer to medical advisory	Restrict License Revoke License Driver Improvement Course	Daylight driving No passengers
IL	Upon referral and determination by Sec'y of State office can request MDs statement about driving ability. Can also refer to medical review board for determination of ability	Suspend license Revoke license	
MD	All referrals screened on functional ability to drive	Refer to OT Restrict License Revoke License	Driving range Daylight driving
MA	Upon referral and determination by RMV staff, can interview, re-examine, or refer to medical review board	Suspend license Revoke license	
MI	Upon referral to the department, can request medical history, re-examine, or refer to health consultants of Sec'y of State	Restrict license Suspend license Revoke license	Driving range Daylight driving Driving routes
MN	Upon referral, a Driver Evaluator, will interview and if needed re-examine, or refer to medical review board	Suspend license Revoke license	

MO	Upon referral and determination by director of Driver License Bureau, can interview, re-examine, or request physical examination	Restrict license Suspend license Revoke license	Daylight driving Driving range Driving speed
MT	Upon referral and determination by DMV, can request knowledge and driving test.	Restrict license Suspend license Revoke license	Driving range Daylight driving Driving routes
NE	Re-examine upon complaint	Restrict License Revoke License	Driving distance
NY	Upon referral and determination by DMV staff, can interview, re-examine, or refer to medical review board	Suspend license Revoke license	
NC	Upon referral and determination by DMV staff, can interview, re-examine, or refer to medical review board	Suspend license Revoke license	
OH	Upon referral and determination by DMV, can require vision, knowledge, maneuverability, or drive test. Each test can be repeated 4 times with six-month wait between testing.	Restrict license Suspend license Revoke license	Daylight driving
PA	Medical competency law: Caregivers required to report conditions which effect driving. DMV requests information from driver and can request a retest or do a medical recall.	Suspend license Revoke license	
SC	Upon referral from physician, law enforcement officer or field agent in DMV, can require medical statement, make an evaluation o refer to medical advisory board	Restrict license Suspend license Revoke license	Daylight driving Driving range Driving route
TX	Upon referral and determination by state trooper, can interview, re-examine, or refer to medical review board	Suspend license Revoke license	
VT	Upon referral and determination by DMV, can require knowledge, vision and driving test.	Suspend license Revoke license	
VA	Upon referral and determination by DMV, can require medical or vision statement from doctor, knowledge or road test.	Restrict license Suspend license Revoke license Periodic medical reports	Driving range Daylight driving Driving routes VA only With other licensed driver
WA	Re-examination upon referral and determination by Licensing Service Review	Restrict license Suspend license Revoke license	Daylight driving
WI	Upon referral from a physician will evaluate. If complex the case goes to a voluntary medical review board	Restrict license Suspend license Revoke license	Driving range Daylight driving Driving routes

* Restrictions beyond corrective lenses and vehicle adaptation

On-going Studies on Older Drivers Supported by State DMVs

Our final topic concerned studies regarding mature drivers that various states were supporting or implementing. Those states that reported engaging in or supporting studies were California, Florida, Maryland, Michigan, Nebraska, Virginia (conducted in 1998), and Wisconsin. Table 19 summarizes the focus of the studies.

Table 19. State Supported Research on Older Drivers

State	Focus of Study	Contact Person
California	Development of educational materials to compensate for age related deteriorations Also the Three Tier Assessment System http://www.dmv.ca.gov/about/profile/rd/resnotes/3_tier.html Dementia Frailty Study http://www.dmv.ca.gov/about/profile/rd/resnotes/dementia_study_tech.html Older Drivers License Restriction VS Revocation http://www.dmv.ca.gov/about/profile/rd/resnotes/older.htm Traffic Risk Accident Factors http://www.dmv.ca.gov/about/profile/rd/resnotes/traffic.htm	Shara Lynn Kelsey skelsey@DMV.ca.gov Mary Janke MJanke@DMV.CA.gov
Florida	Cooperative agreement with NHTSA to develop a program to identify drivers with cognitive impairment. Future phases will develop a driver skill assessment system with local referral, remediation network. Also have developed the Mature Driver Database.	Selma B. Sauls Sauls.Selma@hsmv.state.fl.us
Maryland	To identify tests for functional capacity that can be used to screen drivers for impaired driving. Currently looking at 11 different tests	Dr. Robert Raleigh 410-768-7375
Michigan	Older driver driving reduction	Dr. Lidia Kostyniuk lidakost@umich.edu
Nebraska	Routinely monitors statistics to see if older drivers are over-represented Working with medical association to create cognitive evaluation for doctors to use to assess driving ability	Fred Zwonecek Fredz@mail.state.ne.us
Virginia	Examine approaches for identifying and dealing with safety issues of senior drivers in Virginia http://www.caph.gmu.edu/matdriverfinalrept.pdf	David Anderson caph@gmu.edu
Wisconsin	Study of high risk drivers	Jennifer Enright-Ford jennifer.enrightford@dot.state.wi.us

In addition to the research, three states are planning policy initiatives. Arizona is planning a white paper; Pennsylvania and Washington have plans to develop a task force on mature drivers. While not part of the survey, Oregon has an Older Driver Advisory Committee and has presented a report of strategies to deal with safety and mobility issues regarding older drivers.⁽¹²⁷⁾

Summary of Survey Findings

The most interesting finding to emerge from the survey was the consistent use of the medical review board to identify unsafe driving among older drivers.

Typically, the police were the most frequent source of referrals, but other sources include agents at motor vehicle agencies who observe older drivers when they come in to renew licenses, a range of care-givers (including physicians), and family and friends. Some states are trying to work with police and with families to help them better identify and respond to issues of unsafe driving practices among older drivers. In some instances there is collaboration with local offices of aging.

The thrust of research seems to focus on developing tests that will effectively assess functional ability to drive, including cognitive and physical abilities. Maryland, California, and Florida are the lead states in this effort. Along with test development is concern that there be appropriate remediation facilities that can assist older drivers in improving their driving abilities. Finally a number of states provide restricted licenses for drivers rather than revoking their licenses. An assessment of this by California⁽¹²⁸⁾ indicated restriction was favorably viewed in comparison to revoking a license.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The results of the analyses of accident data support other studies that show older drivers do not present an increased crash risk to other drivers. To the extent that they are a risk, older drivers appear to be primarily a risk to themselves in that there is a slight increase in fatalities as they get past the age of 65. This is attributed to increased frailty of older drivers. Such a problem is better handled by redesign of the automobile than by changing policy regarding licensure.

Older drivers in New Jersey, similar to national trends, have more accidents during the daytime. They are less likely than younger drivers to be in accidents when weather and road conditions are poor, and somewhat more likely to have accidents on local roads than state or interstate highways. Such a pattern suggests that older drivers are already avoiding hazardous driving conditions.

While most of their accidents take place while driving straight ahead, older drivers in New Jersey, like elsewhere, show a greater propensity to be involved in left-turn accidents than younger groups. This fact combined with the data showing that inattention is the most frequently cited contributing circumstance for older drivers suggests three remedies. The first remedy is training older drivers for intersection maneuvers and giving them techniques for getting through the intersection safely. The second remedy is redesigning intersections that show high accident rates in general. The third remedy is a human engineering approach with some device that could warn drivers of on-coming cars and whether they can get through the intersections safely.

The results of the analyses of violations data reinforce findings from the accident data. That is, violations for older drivers were most frequently due to careless driving. This is similar to inattention as a cause of accidents. Speeding is not an issue. Careless driving is difficult to remedy. A proposed solution is one of training and giving older drivers techniques for focusing their attention while behind the wheel.

Finally, physical and medical conditions as a reason for suspensions for older drivers in New Jersey increase rapidly from the age of 65 on. Our survey of practices in other state licensing agencies suggest that medical review is used as a way of ending the driving privilege for older drivers who show impaired driving skills. However, several states offer restricted licenses. New Jersey might explore the experiences of other states which offer restrictions on driving licenses. If that reduces the extent of medical suspensions for older drivers without raising accident rates, a policy change might be warranted. The ability to drive remains key to the experienced quality of life. If restricted licenses allow older drivers to continue use of the automobile, albeit limited, then they could remain more independent without substantially adding accident risk to themselves or others.

One area that emerged from our analyses as appropriate for further study is the medical review policy in each of the states. It seemed clear that this policy allows states to evaluate the fitness to drive of older drivers without using age as a screening criterion. However, there is variability as to how it is initiated, whether or there is mandatory physician reporting, whether there is confidentiality of reporting, how the medical review process works, and finally if there are alternatives to suspending or restricting licenses. Examination of the medical review policy in all states would provide a knowledge base for good practice.

Recommendations

Based on the results of the literature review, data analysis and survey of practices in other states, the following recommendations are offered.

1. Identifying drivers at risk for crashes due to age.
 - a. Enforce vision test for renewal. Based on the study by Shipp (1998) and the fact that vision is the major source of information in driving, vision retesting should identify major problems that could increase crash risk.
 - b. Consider adding a test of peripheral vision since driving requires both foveal (central) and peripheral monitoring of road conditions.
 - c. Discontinue mail renewal after a certain age. Several states have discontinued mail renewal after a certain age such as age 70. The requirement to come in for renewal allows agents of licensing authorities to observe any conditions that might warrant medical review. To fully implement this, agents would need training to identify impairments that have impact on driving ability.
 - d. Continue to closely monitor states that are studying fitness to drive. Currently no tests have been identified which reliably and efficiently screen drivers for impaired driving skills.
 - e. Consider reviewing the reporting aspect of the medical review policy to make sure that the process easily provides the information needed to make judgments about driver ability. Publicize the process to those who are in a position to readily observe impairments that can impinge on driving. Work with medical and other associations of health care providers to insure that New Jersey's legislation is understood.
 - f. Examine the impact of restricted driving licenses in states which offer them to determine if it reduces the percentage of suspensions due to medical reasons for older drivers.
2. Improve the availability of skill enhancement training and skill assessment.

- a. Coordinate with various agencies on aging to inform older drivers about availability of skill enhancement training and about ways to assess their own driving skills.
 - b. Coordinate with various county offices on aging to publicize existing alternatives to driving and consider exploring
3. Continue to track trends regarding the number of licensed drivers by age as well as accident and violation data to monitor any changes that might occur which warrant attention.
4. Consider technical driver safety interventions
 - a. Consider study of engineering changes that could improve safety for all drivers but especially older drivers. While this topic was outside the scope of this study, any recommendations for changes to improve the safety of older drivers needs to explore collision warning systems and other devices that could enhance attention capabilities of older drivers.⁽¹²⁹⁾
 - b. Consider a review of the literature on traffic control devices, roadway design, and signage which was outside the scope of the study but needs consideration as a safety intervention for older drivers.
5. Review alternative modes of transportation for people who can no longer drive. NJ Department of Transportation in collaboration with NJ Department of Health and Senior Services should considering providing an inventory of alternative modes of transportation that are available for senior citizens and then publicize those services.
6. Consider providing a website such a New York State's Senior Drivers. This site could publicize various programs as well as driving alternatives. <http://www.nysgtsc.state.ny.us/senr-ndx.htm>⁽¹³⁰⁾

REFERENCES

1. NCSA (National Center for Statistics and Analysis) Traffic Safety Facts 2000: Older Population. [Online] Available from: <http://www.nhtsa.dot.gov/people/ncsa/>
2. Waller, P. F. (1991). The older driver. *Human Factors*, **33**, 499-505.
3. Pike, J. A. (1988) *The elderly and vehicle-related injury. In Effects of aging on driver performance* (pp. 61-71). Warrendale, PA Society of Automotive Engineers.
4. *Traffic Safety Facts. Older Population.* (1999). U. S. Department of Transportation, National Highway Safety Administration, DOT HS 809 091.
5. U.S. Census Bureau, U.S. Department of Commerce (2001) [Online] Available from: <http://www.census.gov>. [Accessed 8 December 2001.]
6. Data on drivers licenses by age were provided by the Division of Motor Vehicles of New Jersey and New York respectively.
7. Barr, R. A. (1991). Recent changes in driving among older adults. *Human Factors*, **33**, 596-600.
8. Hu, P. S., Jones, D. W., Reuscher, T., Schmoyer, R. S., & Truett, L. F. (2000). Projecting Fatalities in Crashes Involving Older Drivers, 2000-2025. (Report No. ORNL-6963) Oak Ridge, TN: Oak Ridge National Laboratories. http://www-cta.ornl.gov/Publications/Older_Drivers/
9. Hakamies-Blomqvist, L. (1998). Older drivers 'accident risk: Conceptual and methodological issues. *Accident Analysis and Prevention*, **30**, 293-297.
10. Janke, M. K. (1991). Accidents, mileage, and exposure to risk. *Accident Analysis and Prevention*, **23**, 183-188.
11. Chipman, M. L., Mac Gregor, C. G. Smiley, A. M. & Lee-Goslin, M. (1992) Time vs. distance as measures of exposure on driving surveys. *Accident Analysis and Prevention*, **24**, 679-684.
12. Chipman, M. L., Mac Gregor, C. G. Smiley, A. M. & Lee-Goslin, M. (1993) The role of exposure in comparisons of crash risk among different drivers and driving environments. *Accident Analysis and Prevention*, **25**, 207-211.
13. Stamatiadis, N. & Deacon, J. A. (1995). Trends in highway safety: Effects of an aging population on accident propensity. *Accident Analysis and Prevention*, **27**, 443-459.

14. Hakamies-Blomqvist, L. & Henriksson P. (1999). Cohort effects in older drivers' accident type distribution: are older drivers as old as they used to be? *Transportation Research Part F 2*, 131-138.
15. Dulisse, B.(1997). Older drivers and the risk to other road drivers *Accident Analysis and Prevention*, **29**, 573-582.
16. Ryan, G. A., Legge, M., & Rosman, D. (1998). Age related changes in drivers' crash risk and crash type. *Accident Analysis and Prevention*, **30**, 379-387.
17. Richardson, J., Kim, K., Li, L., Nitz, L. (1996). Patterns of motor vehicle crash involvement by driver age and sex in Hawaii. *Accident Analysis and Prevention*, **27**, 117-125.
18. McGwin, Jr. , G. & Brown, D. B. (1999) Characteristics of traffic crashes among young, middle-aged, and older drivers. *Accident Analysis and Prevention*, **31**, 181-198.
19. Stamatiadis, N. (1996). Gender effects on the accidents patterns of elderly drivers. *Journal of Applied Gerontology*, **15**, 8-22.
20. Dobbs, A. R., Heller, R. B., & Schopflocher. (1998). A comparative approach to identify unsafe older drivers. . *Accident Analysis and Prevention*, **30**, 363-370.
21. Eby, D. W. , Trombley, D. A., Molnar, L. J., & Shope, J. T. (1998). *The assessment of older drivers' capabilities: A review of the literature*. (Report No. UMTRI 98-24) Ann Arbor, MI: The University of Michigan Transportation Research Institute.
22. Shinar, D. & Scheiber, F. (1991). Visual requirements for safety and mobility of older drivers. *Human Factors*, **33**, 507-519.
23. Charman, W. N. (1997). Vision and driving – a literature review and commentary. *Ophthalmic Physiology and Optics*, **17**, 371-391.
24. Wood, J. M. (1999). How do visual status and age impact on driving performance as measured on a closed circuit driving track. *Ophthalmic Physiology and Optics*, **19**, 34-40.
25. Dunne, M.C.M. (1995). Defective vision and road accidents: Pilot study. Aston University, Birmingham, May, 1995. unpublished.
26. Whillans, M. G. & Allen, M. J. (1992). Color defective drivers and safety. *Optometry and Visual Science*, **69**, 263-466.

27. Wood, J. M. & Troubeck, R. (1992). Effects of restrictions on binocular visual field on driving performance. *Ophthalmic Physiology and Optics*, **12**, 291-298.
28. Wood, J. M. & Troubeck, R. (1995). Elderly drivers and simulated visual impairment. *Optometry and Visual Science*, **72**, 115-125.
29. Maltz, M. & Shinar, D. (1999). Eye movements of younger and older drivers. *Human Factors*, **41**, 15-25.
30. Ball, K. & Owsley, C. (1991). Identifying correlates of accident involvement for the older driver. *Human Factors*, **33**, 583-595.
31. Ball, K. , Owsley, C., Sloane, M.E., Roenker, D. L., & Bruni, J. R. (1993). Visual attention problems as a predictor of vehicle crashes in older drivers. *Investigative Ophthalmology and Visual Science*, **34**, 3110-3123.
32. Owsley, C. , Ball, K., Mc Gwin, G., Sloane, M. E., Roenker, D. L., White, M. F., & Overley, E. T. (1998). Visual processing impairment and risk of motor vehicle crash among older adults. *Journal of the American Medical Association*. **279**, (April 8). 1083-1033.
33. Szylk, J. , Seiple, w., & Viana, M. (1995). Relative effects of age and compromised vision on driving performance. *Human Factors*, **37**, 430-436.
34. McGwin, Chapman, and Owsley (2000). Visual risk factors for driving difficulty among older drivers. *Accident Analysis and Prevention*, **32**, 734-744.
35. Sekuler, A. B., Bennett, P. J. & Mamelak, M. (2000). Effects of aging on useful field of view. *Experimental Aging Research*, **26**, 103-120.
36. Brouwer,W. H., Waternink, W., Van Wolffelaar. P.C., & Rothengatter, T. (1991). Divided attention in experienced young and old drivers: Lane tracking and visual analysis in a dynamic driving simulator. *Human Factors*, **33**, 573-582.
37. Janelle,C. M., Singer, R. N. & Williams, A. M. (1999). External distraction and attentional narrowing: Visual search evidence. *Journal of Sport and Exercise Psychology*, **2**, 70-91.
38. French, D. J., West, R. J., Elander, J., & Wilding, J.M. (1993). Decision-making style, driving style, and self-reported involvement in road traffic accidents. *Ergonomics*, **36**, 627-644.
39. Radeborg, K., & Briem, V. (1999). The effect of concurrent task difficulty on working memory during simulated driving. *Ergonomics*, **42**, 767-777.

40. Keskinen, E. Ota, H., Katila, A. (1998). Older drivers fail in intersections: Speed discrepancies between older and younger male drivers. *Accident Analysis and Prevention*, **30**, 323-330.
41. National Center for Health Statistics (2001). Death among the elderly. [Online]NCHS Available from: <http://www.cdc.gov/nchs/releases/01facts/olderame> [Accessed July 10 2001].
42. National Institute on Aging (1999). Older Drivers. [Online] NIA Available from: <http://www.nia.gov/nia/health/agepages/drivers> [Accessed 4 April 2001].
43. Morgan, R., King, D. (1995). The older driver-a review. *Postgraduate medical journal*. **71** 525-528.
44. Carr, D. B. (2000). The older adult driver. *American Family Physician*, **61** 141-6.
45. Schwager, M. L. (2000). The elderly driver. [Online]. Rhode Island, Brown University. Available from: http://www.brown.edu/Departments/clinical_Neurosciences/articles/ms43299.html. [Accessed 2 October 2000].
46. Vokonas, P.S., Kannel, W.B., (1996). Diabetes mellitus and coronary heart disease in the elderly. *Clinics in Geriatric Medicine*, **12** (1) 69-78.
47. Ahto, M., Isoaho R., Puolijoki, H., Laippala, P., Romo, M., and Kivela S-L., (1997). Coronary heart disease and depression in the elderly---a population-based study. *Family Practice International*. **14** (6) 436-445.
48. Janke, M.K. (1994). Age-related disabilities that may impair driving and their assessment (Literature review) *California Department of Motor Vehicles*. RSS-94-156.
49. Odenheimer, G. (2001). Safe driving for seniors. [Online] *American Geriatrics Society*. Available from: <http://www.Americangeriatrics.org/education/forum/driving.s> [Accessed 10 August 2001].
50. Zhang, J., Lindsay J., Clarke, K., Robbins, G., Mao, J. (1999). Factors affecting the severity of motor vehicle traffic crashes involving elderly drivers in Ontario. *Accident Analysis and Prevention*. **32** 117-125.
51. McGwin, G., Sims, R.V., Pulley, L., Roseman J.M. (2000). Relations among chronic medical conditions, medications, and automobile crashes in the elderly: a population-based case-control study. *American Journal of Epidemiology*, **152** (5), 424-431.

52. Kannel, W.B. (1996) Prevalence, incidence and mortality of coronary heart disease, in *Atherosclerosis and Coronary Artery Disease*, eds.V. Fuster, R. Ross, and E.J. Topol, Lippincott-Raven Publishers, Philadelphia.
53. American Heart Association (1999). Risk factors and coronary heart disease. [Online] *AHA*. Available from: http://www.americanheart.org/Heart_and_Stroke_A_Z_Guide/riskfact.html [Accessed March 02 2001].
54. Kannel, W.B. (1997). Cardiovascular risk factors in the elderly. *Coronary Artery Disease*. **8** 565-575.
55. Chen Y-T., Vaccarino, V., Williams, C.S., Butler, J., Berkman, L.F., Krumholz, H.M. (1999). Risk factors for heart failure in the elderly: A prospective community-based study. *American Journal of Medicine*. **106** 605-612.
56. Epstein, A.E. et al., (1996). Personal and public safety issues related to arrhythmias that may affect consciousness: Implications for regulation and recommendation. [Online] Available from: <http://www.americanheart.org/Scientifics/statements/1996/0901.html> [Accessed October 04 2000].
57. Petch, M.C. (1998). Driving and Heart Disease. *European Heart Journal*. **19** 1165-1177.
58. Finch, N.J., Sneed, N.V., Leman, R.B., Watson, J. (1997). Driving with an internal defibrillator: Legal, ethical, and quality of life issues. *Journal of Cardiovascular Nurse*. **11** 2 58-67.
59. Curtis, A.B., Conti, J.B., Tucker, K.J., Kubilis, P.S., Reilly, R.E., Woodard, D.A. (1995). Motor Vehicle Accidents in patients with an implantable cardioverter-defibrillator. *Journal American College of Cardiology*. **26** 180-184.
60. Jung, W., Anderson, M., Camm, A.J., Jordaens, L., Petch, M.C., Santini, M., Rosenqvist, M., Luderitz, B. (1997). Recommendations for driving of patients with implantable cardiovascular defibrillators. *European Heart Journal*. **18** 1210-1219.
61. Simpson, C.S., Klein, G.J., Brenman, F.J., Krahn, A.D., Yee, R., Skanes A.C., (2000). Impact of a mandatory physician reporting system for cardiac patients potentially unfit to drive. *Canadian Journal Cardiology*, **16** 10 1257-1263.
62. American Heart Association (2000). *Syncope*. [Online] Available from: http://www.americanheart.org/Heart_and_Stroke_A_Z_Guide/syncope.html [Accessed 20 March 2001].

63. Grubb, B.P., Kosinsky, D. (1997). Tilt table testing: Concepts and limitations. *Pace* **20** (II) 781-787.
64. Bänsch, D., Brunn, Jürgen, B., Castrucci, M., Weber, M., Gietzen F., Borggreffe, M., Breithardt, G., Block, M. (1998). Syncope in patients with an implantable cardioverter-defibrillator: Incidence, prediction and implications for driving restrictions. *American College of Cardiology*, **31** (1) 608-615.
65. Olshanky, B., Grubb, B.P. (1998). 'Driving and syncope', in *Syncope: Mechanism and Management*, eds. Armonk, NY: Futura Publishing Co., Inc.
66. Huagui, L., Weitzel, M., Easley, A., Barrington, W., Windle, J., (2000). Potential risk of vasovagal syncope for motor vehicle driving. *The American journal of Cardiology*. **85** (15) 184-186.
67. National Stroke Association (NSA) (1999). What is Stroke/Brain Attack? [Online] NSA Available from: http://www.stroke.org/NS802.0_WhatIsStroke.html [Accessed 04 April 2001].
68. Tallman, T. (1999). Stroke. [Online] *Ohio State University Extension*. Available from: <http://www.ohioline.ag.ohio-state.edu/ss-fact/0168.html> [Accessed 13 October 2000].
69. National Stroke Association (2000a). Effects of Stroke. [Online] NSA. Available from: <http://www.stroke.org/effectsstroke.cfm> [Accessed 10 October 2001]
70. National Stroke Association (2000b). Brain attack statistics. [Online] NSA. Available from: <http://www.stroke.org/brainstat.cfm> [Accessed 23 November 2000]
71. American Heart Association (2001). 2001 heart and stroke statistical update. [Online] *AHA*. Available from: <http://www.americanheart.org/statistics/stroke.htm> [Accessed 2 March 2001].
72. National Stroke Association (2000c). Stroke risk. [Online] NSA. Available from: <http://www.stroke.org/strokerisk.cfm> [Accessed 10 October 2001]
73. American Academy of Family Physicians (1997). Recovering from a stroke. *American Academy of Family Physicians*, **55** (5).
74. Fisk, G., Owsley, C., Pulley, L.V. (1997). Driving after stroke: Driving exposure, advise, and evaluations. *Archives Physical Medical Rehabilitation*, **78** 1338-1345.
75. Gibson, L.M., Short, D. (1999). Diabetes and the older adult. [Online] Ohio, *Ohio State University Extension*. Available from:

<http://www.ohioline.ag.ohio-state.edu/ss-fact/0166.html> [Accessed 13 October 2000].

76. National Institute of Diabetes & Digestive & Kidney Disease. (1999). *Diabetes statistics in the United States*. [Online] NIDDK. Available from: <http://www.niddk.nih.gov/health/diabetes/pubs/dmstats/dmstats.htm> [Accessed 7 March 2001].
77. Veneman, T.F. (1996). Diabetes Mellitus and traffic incidents. *The Netherlands Journal of Medicine*, **48** 24-28.
78. Hogan, D.B. (1999). The older driver. [Online] *University of Calgary*. Available from: <http://www.med.ucalgary.ca/oemweb/elderdrivers/dementia.htm> [Accessed 4 October 2001].
79. Cox, D.J., Gonder-Frederick, L.A., Kovatchev, B.P., Julian, D. M., Clarke, W. L. (2000). Progressive hypoglycemia's impact on driving simulation performance. *Diabetes Care*. **30** (2) 163-170.
80. Cox, D.J. et al., (1993). Driving decrements in type I diabetes during moderate hypoglycemia. *Diabetes* **42** 239-243.
81. Clarke, W.L., Cox D.J., Gonder-Frederick, L.A., Kovatchev, B. (1999). Hypoglycemia and the decision to drive a motor vehicle by persons with diabetes. *Journal of American Medical Association*. **282** (8) 750-754.
82. Daly, M. P. (1999). Diagnosis and management of Alzheimer's disease. *Journal of American Board of Family Practice*. **12** (5), 375-385.
83. Odenheimer, G. L., Wieland, D., (2001). Dementia. *American Geriatrics Society* [Online] American Geriatrics Society. Available from: <http://www.americangeriatrics.org/education/forum/dementia.s> [Accessed 14 October 2001].
84. Logsdon, R.G., Teri, L., Larson, E.B. (1992). Driving and Alzheimer's Disease. *Journal General Internal Medicine*, **7** 583-588.
85. Huffman, G.B. (1998). Driving performance, mental status and Alzheimer's disease. (Tips from other journals) [Online] *American Family Physician*. Available from: http://www.findarticles.com/cf_dls/m3225/n6_v57/20482469/p1/article.j [Accessed 5 July 2001].
86. Rayl, AJ (2000) Clinical trials driving Alzheimer's research *USA TODAY Health* [Online] Available from: <http://www.usatoday.com/life/health/doctor/lhdoc088.htm> [Accessed 20 April 2001]

87. Apples For Health (2000). Driving Guidelines Issued for Alzheimer's patients [online] (*AFH*) Available from: <http://www.applesforhealth.com/drivealz2>. [Accessed 15 January 2001].
88. Western and Central Washington State Chapter of the Alzheimer's Association (2000). Driving safety [Online] Available from: http://www.alzwa.org/ArticlesOnLine/Driving_Safety_Article/PrinterFriendlyVersion.htm [Accessed 20 April 2000].
89. Alzheimer's Association, Northern Virginia Chapter (1999). Driving [Online] Available from: <http://www.alz-nova.org/caretips/driving.asp> [Accessed 20 April 2001].
90. Mayo Foundation for Medical Education and Research (2000). Caring for someone with Alzheimer's [Online] *MFMER* Available from: <http://www.mayohealth.org/home?id=HO00046&crit> [Accessed 05 July 2001].
91. Cox, D.J., Quillian, W.C., Thorndike, F.P., Kovatchev, B.P. (1998). Evaluating driving performance of outpatients with Alzheimer's disease. *Journal of the American Board of Family Practice*. **11** (4), 264-271.
92. Duchek, J.M., Hunt, L., Ball, K., Buckles, V., Morris, J.C. (1998). Attention and driving performance in Alzheimer's disease. *Journal of Gerontology*, **53B** (2) P130-P141.
93. Hunt, L., Morris, J.C., Edwards, D., Wilson, B. S. (1993). Driving performance in persons with mild senile dementia of the Alzheimer type. *Journal American Geriatrics Society*. **41** (7), 747-753.
94. Ott, B.R., Heindel, W.C., Whelihan, W.M., Caron, M.D., Piatt, A.L., Noto, R.B (2000). A single-photon emission computed tomography imaging study of driving impairment in patients with Alzheimer's disease. *Dementia Geriatric Cognitive Disorder*, **11** 153-160.
95. Dubinsky, R.M., Stein, A.C., Lyons, K. (2000) Practice Parameter: Risk of Driving and Alzheimer's Disease (an Evidence-Based Review), *Neurology*, **54** 2205-2211.
96. Fox, G.K., Bowden, S.C., Bashford, G.U., Smith, D.S. (1997). Alzheimer's disease and driving: prediction and assessment of driving performance. *Journal American Geriatric Society*, **45** 949-953.
97. Administration On Aging (AOA) (2000). Medicines: Use them safely. [Online] *Administration on Aging*. Available from: <http://www.aoa.dhhs.gov/aoa/pages/agepages/medicine.html> [Accessed 6 October 2000].

98. Calgary Regional Health Authority (CRHA) (2000). Drugs and the Older Adult. [Online] Calgary. *Calgary Regional Health Authority*. Available from: <http://www.crha-health.ab.ca/hlthconn/items/drugsoa.htm> [Accessed 6 September 2000].
99. Hobbs, F.B., Damon, B.L. (1996). 65+ in the United States: Numerical Growth. *U.S. Census Bureau*. [Online] Available from: <http://www.census.gov/prod/1/pop/p23-190/p23-190.html> [Accessed May 30 2000].
100. Ohio State University Extension (2000). Why Older People Are At Risk for Medications Problems [Online] Ohio, *Ohio State University Extension*. Available from: <http://www.ohioline.ag.ohio-state.edu/ss-fact/0127.html> [Accessed October 6 2000].
101. Barbone, F., McMahan, A.D., Davey, P.G., Morris, A.D., Reid I.C., McDevitt, D.G., McDonald, T.M. (1998). Association of road-traffic accidents with benzodiazepine use. *The Lancet*, **352** 1331-1336.
102. Longo, M.D., Johnson, B. (2000). Addiction: Part I. Benzodiazepines – side effects, abuse risk and alternatives. *American Family Physician*, **61** 2121-2128.
103. Hemmelgarn, B., Suissa, S., Huang, A., Boivin, J-F., Pinard, G. (1997). Benzodiazepine use and the risk of motor vehicle crash in the elderly. *Journal American Medical Association*. **278** (1) 27-31.
104. Eberhard, J. W. (1996). Safe mobility for senior citizens. *IATSS Research*, **20**, 29-37.
105. Galsky, T., Williams, J.B., Ehle, H. (2000). Effects of opioids on driving ability. *Journal Pain Symptom Management*, **19** (3) 200-208.
106. Stutts, J. C., Stewart, J. R. & Martell, C. (1998). Cognitive test performance and crash risk in an older driver population. *Accident Analysis and Prevention*, **30**, 337-346.
107. AAA Foundation for Traffic Safety, (2002). Drivers 55 Plus: Self-Rating Form. [Online] Available from: <http://www.aaafoundation.org/quizzes/index.cfm?button=driver55> {Accessed January 13, 2002}.
108. American Association of Retired Persons (2002). AARP 55 Alive Driver Safety Program: Test Your Driving I.Q. [Online] Available from: <http://www.aarp.org/55alive/ig.html> [Accessed May 9, 2002].

109. Kostyniuk, L. P., Trombley, D. A., & Shope, J. T. (1998). *The process of reduction and cessation of driving among older drivers: A review of the literature*. (Report No. UMTRI 98-23), Ann Arbor, MI: The University of Michigan Transportation Research Institute.
110. Knoblauch, R. L., Mitzburg, M. & Seifert, R. F. (1995). Older driver freeway needs and capabilities. *Compendium of Technical Papers, Institute of Transportation Engineers 65th Annual Meeting*, Washington, DC: ITE 629-633.
111. Kostyniuk, L. P., Streff, F. M., & Eby, D. W. 1997. *The Older Driver and Navigation Assistance Systems*, (Report No. UMTRI-97-47). Ann Arbor, MI: The University of Michigan Transportation Research Institute.
112. National Safety Council (2002) Public Safety Group Defensive Driving [Online] Available from: <http://www.nsc.org/training> [Accessed 10 May 2002].
113. Roenker, D., Ball, K., Wadley, V., Edwards, J., Clay, O., & Roth, D. (2001). Enhancing safety and mobility of older drivers: A meta-analysis. Paper presented at the 109th *Accident Analysis and Prevention*, **30**, 323-330. Annual Meeting of the American Psychological Association, San Francisco, CA, August, 2001.
114. Williams, C. & Graham, J. D. (1995). Licensing standards for elderly drivers. *Consumers' Research Magazine*, **78**, 18-23.
115. Levy, D. T. (1995). The relationship of age and state license renewal policies to driving licensure rates. *Accident Analysis and Prevention*, **27**, 461-467.
116. Insurance Institute website. U.S. Driver Licensing Renewal Procedures For Older Drivers as of October 2001. (http://www.hwysafety.org/safety_facts/state_laws/older_drivers.htm)
117. Rock, S. M. (1998). Impact from changes in Illinois drivers license renewal requirements for older drivers. *Accident Analysis and Prevention*, **30**, 69-74.
118. Shipp, M. (1998). Potential human and economic cost-savings attributable to vision testing policies for driver license renewal, 1989-1991. *Optometry and Vision Sciences*, **75**, 103-118.
119. Ott, B.R. & Mernoff, S.T. (1999). Driving Policy Issues and the Physician. [Online] *Brown University*. Available from: http://www.brown.edu/Departments/Clinical_Neurosciences/articles/bo42899.html [Accessed 20 March 2001].
120. Kelly, R., Warke, T., Steele, I., (1999). Medical restrictions to driving: the awareness of patients and doctors. *Postgraduate Medical Journal*. **75** 537-539.

121. Diller, E., Cook, L., Leonard, D., Reading, J., Dean, J.M. Vernon, D. (1999). Evaluating drivers licensed with medical conditions in Utah, 1992-1996. *Utah CODES*. NHTSA Technical Report, 1992-1996.
122. McKnight, J. A. (2000/2001). Too old to drive? *Issues in Science and Technology*, **17**, 63-69.
123. Messinger-Rapport, B. J. (2000). High risk on the highway. *Geriatrics*, **55**, 32-39.
124. Janke, M. K. & Eberhardt, J. W. (1998). Assessing medically impaired older drivers in a licensing agency setting. *Accident Analysis and Prevention*, **30**, 347-361.
125. Center for Advancement of Public Health at George Mason University. (1998). Study of Driver's License Options for Applicant's Age 70 or Older in Virginia, <http://www.safety.gmu.edu/survey.htm>
126. Information Insurance Institute [Online] Available from: <http://www.iii.org/individuals/auto/a/stateautolaws/>.
127. Oregon Department of Transportation, Driver and Motor Vehicle Services. Report of the Older Driver Advisory Committee, September 2000. [Online] Available from: http://www.odot.state.or.us/pdf/ODAC_Final_Recommendations.pdf
128. Hersch, Sandra Winter (1997) Older Drivers: License Restriction vs. Revocation. California Department of Motor Vehicles Research Notes, Summer. [Online] Available from: <http://www.dmv.ca.gov/about/profile/rd/resnotes/older.htm>
129. Hanowski, R., Bittner, A .C., Jr., Kipling, R.R., Byrne, E.A., and Parasuraman, R. (1995). "Analysis of Older Driver Safety Interventions: A human Factors Taxonomic Approach." Proceedings of the ITS America Conference." March, Washington, D.C.
130. NYS Governor's Traffic Safety Committee, Senior Drivers. (2002) [Online] Available from: <http://www.nysgtsc.state.ny.us/senr-ndx.htm>

BIBLIOGRAPHY

Ahto, M., Isoaho R., Puolijoki, H., Laippala, P., Romo, M., and Kivela S-L., (1997). Coronary heart disease and depression in the elderly---a population-based study. *Family Practice International*. **14** (6) 436-445.

Administration On Aging (AOA) (2000). Medicines: Use them safely. [Online] *Administration on Aging*. Available from: <http://www.aoa.dhhs.gov/aoa/pages/agepages/medicine.html> [Accessed 6 October 2000].

Alzheimer's Association, Northern Virginia Chapter (1999). Driving [Online] Available from: <http://www.alz-nova.org/caretips/driving.asp> [Accessed 20 April 2001].

American Academy of Family Physicians (1997). Recovering from a stroke. *American Academy of Family Physicians*, **55** (5).

American Heart Association (1999). Risk factors and coronary heart disease. [Online] *AHA*. Available from: http://www.americanheart.org/Heart_and_Stroke_A_Z_Guide/riskfact.html [Accessed March 02 2001].

American Heart Association (2000). *Syncope*. [Online] Available from: http://www.americanheart.org/Heart_and_Stroke_A_Z_Guide/syncope.html. [Accessed 20 March 2001].

American Heart Association (2001). 2001 heart and stroke statistical update. [Online] *AHA*. Available from: <http://www.americanheart.org/statistics/stroke.htm> [Accessed 2 March 2001].

Apples For Health (AFH) (2000). Driving Guidelines Issued for Alzheimer's patients [online] (*AFH*) Available from: <http://www.applesforhealth.com/drivealz2>. [Accessed 15 January 2001].

Ball, K. & Owsley, C. (1991). Identifying correlates of accident involvement for the older driver. *Human Factors*, **33**, 583-595.

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

Bänsch, D., Brunn, Jürgen, B., Castrucci, M., Weber, M., Gietzen F., Borggreffe, M., Breithardt, G., Block, M. (1998). Syncope in patients with an implantable cardioverter-defibrillator: Incidence, prediction and implications for driving restrictions. *American College of Cardiology*, **31** (1) 608-615.

Barbone, F., McMahon, A.D., Davey, P.G., Morris, A.D., Reid I.C., McDevitt, D.G., McDonald, T.M. (1998). Association of road-traffic accidents with benzodiazepine use. *The Lancet*, **352** 1331-1336.

Barr, R. A. (1991). Recent changes in driving among older adults. *Human Factors*, **33**, 596-600.

Brouwer, W. H., Waternink, W., Van Wolffelaar, P.C., & Rothengatter, T. (1991). Divided attention in experienced young and old drivers: Lane tracking and visual analysis in a dynamic driving simulator. *Human Factors*, **33**, 573-582.

Calgary Regional Health Authority (CRHA) (2000). Drugs and the Older Adult. [Online] Calgary. *Calgary Regional Health Authority*. Available from: <http://www.crha-health.ab.ca/hlthconn/items/drugsoa.htm> [Accessed 6 September 2000].

Carr, D. B. (2000). The older adult driver. *American Family Physician*, **61** 141-6.

Carr, D.B., Duchek, J., Morris, J.C. (2000). Characteristics of motor vehicle crashes of drivers with dementia of the Alzheimer type. *Journal of the American Geriatrics Society*, **48** (1), 18.

Center for Advancement of Public Health at George Mason University. (1998). Study of Driver's License Options for Applicant's Age 70 or Older in Virginia, <http://www.safety.gmu.edu/survey.htm>

Charman, W. N. (1997). Vision and driving – a literature review and commentary. *Ophthalmic Physiology and Optics*, **17**, 371-391.

Chen Y-T., Vaccarino, V., Williams, C.S., Butler, J., Berkman, L.F., Krumholz, H.M. (1999). Risk factors for heart failure in the elderly: A prospective community-based study. *American Journal of Medicine*. **106** 605-612.

Chipman, M. L., Mac Gregor, C. G. Smiley, A. M. & Lee-Goslin, M. (1992) Time vs. distance as measures of exposure on driving surveys. *Accident Analysis and Prevention*, **24**, 679-684.

Chipman, M. L., Mac Gregor, C. G. Smiley, A. M. & Lee-Goslin, M. (1993) The role of exposure in comparisons of crash risk among different drivers and driving environments. *Accident Analysis and Prevention*, **25**, 207-211.

Clarke, W.L., Cox D.J., Gonder-Frederick, L.A., Kovatchev, B. (1999). Hypoglycemia and the decision to drive a motor vehicle by persons with diabetes. *Journal of American Medical Association*. **282** (8) 750-754.

Cox, D.J. et al., (1993). Driving decrements in type I diabetes during moderate hypoglycemia. *Diabetes* **42** 239-243.

- Cox, D.J., Quillian, W.C., Thorndike, F.P., Kovatchev, B.P. (1998). Evaluating driving performance of outpatients with Alzheimer's disease. *Journal of the American Board of Family Practice*. **11** (4), 264-271.
- Cox, D.J., Gonder-Frederick, L.A., Kovatchev, B.P., Julian, D. M., Clarke, W. L. (2000). Progressive hypoglycemia's impact on driving simulation performance. *Diabetes Care*. **30** (2) 163-170.
- Curtis, A.B., Conti, J.B., Tucker, K.J., Kubilis, P.S., Reilly, R.E., Woodard, D.A. (1995). Motor Vehicle Accidents in patients with an implantable cardioverter-defibrillator. *Journal American College of Cardiology*. **26** 180-184.
- Daly, M. P. (1999). Diagnosis and management of Alzheimer's disease. *Journal of American Board of Family Practice*. **12** (5), 375-385.
- Diller, E., Cook, L., Leonard, D., Reading, J., Dean, J.M. Vernon, D. (1999). Evaluating drivers licensed with medical conditions in Utah, 1992-1996. *Utah CODES*. NHTSA Technical Report, 1992-1996.
- Dobbs, A. R., Heller, R. B., & Schopflocher. (1998). A comparative approach to identify unsafe older drivers. . *Accident Analysis and Prevention*, **30**, 363-370.
- Dubinsky, R.M., Stein, A.C., Lyons, K. (2000) Practice Parameter: Risk of Driving and Alzheimer's Disease (an Evidence-Based Review), *Neurology*, **54** 2205-2211.
- Duchek, J.M., Hunt, L., Ball, K., Buckles, V., Morris, J.C. (1998). Attention and driving performance in Alzheimer's disease. *Journal of Gerontology*, **53B** (2) P130-P141.
- Dulisse, B. (1997). Older drivers and the risk to other road drivers *Accident Analysis and Prevention*, **29**, 573-582.
- Dunne, M.C.M. (1995). Defective vision and road accidents: Pilot study. Aston University, Birmingham, May, 1995. unpublished.
- Eberhard, J. W. (1996). Safe mobility for senior citizens. *IATSS Research*, **20**, 29-37.
- Eby, D. W. , Trombley, D. A., Molnar, L. J., & Shope, J. T. (1998). *The assessment of older drivers' capabilities: A review of the literature*. (Report No. UMTRI 98-24) Ann Arbor, MI: The University of Michigan Transportation Research Institute.

Epstein, A.E. et. al., (1996). Personal and public safety issues related to arrhythmias that may affect consciousness: Implications for regulation and recommendation. [Online]

Available from:

<http://www.americanheart.org/Scientifics/statements/1996/0901.html>

[Accessed October 04 2000].

Finch, N.J., Sneed, N.V., Leman, R.B., Watson, J. (1997). Driving with an internal defibrillator: Legal, ethical, and quality of life issues. *Journal of Cardiovascular Nurse*. **11** 2 58-67.

Fisk, G., Owsley, C., Pulley, L.V. (1997). Driving after stroke: Driving exposure, advise, and evaluations. *Archives Physical Medical Rehabilitation*, **78** 1338-1345.

Fox, G.K., Bowden, S.C., Bashford, G.U., Smith, D.S. (1997). Alzheimer's disease and driving: prediction and assessment of driving performance. *Journal American Geriatric Society*, **45** 949-953.

French, D. J., West, R. J., Elander, J., & Wilding, J.M. (1993). Decision-making style, driving style, and self-reported involvement in road traffic accidents. *Ergonomics*, **36**, 627-644.

Galsky, T., Williams, J.B., Ehle, H. (2000). Effects of opioids on driving ability. *Journal Pain Symptom Management*, **19** (3) 200-208.

Gibson, L.M., Short, D. (1999). Diabetes and the older adult. [Online] Ohio, *Ohio State University Extension*. Available from: <http://www.ohioline.ag.ohio-state.edu/ss-fact/0166.html> [Accessed 13 October 2000].

Grubb, B.P., Kosinsky, D. (1997). Tilt table testing: Concepts and limitations. *Pace* **20** (II) 781-787.

Hakamies-Blomqvist, L. (1998). Older drivers 'accident risk: Conceptual and methodological issues. *Accident Analysis and Prevention*, **30**, 293-297.

Hakamies-Blomqvist, L. & Henriksson P. (1999). Cohort effects in older drivers' accident type distribution: are older drivers as old as they used to be? *Transportation Research Part F* **2**, 131-138.

Hanowski, R., Bittner, A .C., Jr., Kipling, R.R., Byrne, E.A., and Parasuraman, R. (1995). "Analysis of Older Driver Safety Interventions: A human Factors Taxonomic Approach." Proceedings of the ITS America Conference." March, Washington, D.C.

Heart Center Online (2000). Cardiovascular disease. Glossary. [Online] *HCO*. Available from: <http://www.heartcenteronline.com/myheartdr/glossary/description.cfm?id=777&curpage=glossary> [Accessed April 2 2001].

Hemmelgarn, B., Suissa, S., Huang, A., Boivin, J-F., Pinard, G. (1997). Benzodiazepine use and the risk of motor vehicle crash in the elderly. *Journal American Medical Association*. **278** (1) 27-31.

Hersch, Sandra Winter (1997) Older Drivers: License Restriction vs. Revocation. California Department of Motor Vehicles Research Notes, Summer. [Online] Available from:
<http://www.dmv.ca.gov/about/profile/rd/resnotes/older.htm>

Hills, B. L. & Burg, A. (1977). A reanalysis of Californian driver vision data: General finding. *TRRL Laboratory Report 768*, Crowthorne, Berks.

Hobbs, F.B., Damon, B.L. (1996). 65+ in the United States: Numerical Growth. *U.S. Census Bureau*. [Online] Available from: <http://www.census.gov/prod/1/pop/p23-190/p23-190.html> [Accessed May 30 2000].

Hogan, D.B. (1999). The older driver. [Online] *University of Calgary*. Available from: <http://www.med.ucalgary.ca/oemweb/elderdrivers/dementia.htm> [Accessed 4 October 2001].

Hu, P. S., Jones, D. W., Reuscher, T., Schmoyer, R. S., & Truett, L. F. (2000). Projecting Fatalities in Crashes Involving Older Drivers, 2000-2025. (Report No. ORNL-6963) Oak Ridge, TN: Oak Ridge National Laboratories.
http://www-cta.ornl.gov/Publications/Older_Drivers/

Huagui, L., Weitzel, M., Easley, A., Barrington, W., Windle, J., (2000). Potential risk of vasovagal syncope for motor vehicle driving. *The American journal of Cardiology*. **85** (15) 184-186.

Huffman, G.B. (1998). Driving performance, mental status and Alzheimer's disease. (Tips from other journals) [Online] *American Family Physician*. Available from:
http://www.findarticles.com/cf_dls/m3225/n6_v57/20482469/p1/article.j [Accessed 5 July 2001].

Hunt, L., Morris, J.C., Edwards, D., Wilson, B. S. (1993). Driving performance in persons with mild senile dementia of the Alzheimer type. *Journal American Geriatrics Society*. **41** (7), 747-753.

Information Insurance Institute <http://www.iii.org/individuals/auto/a/stateautolaws/>

Insurance Institute website. U.S. Driver Licensing Renewal Procedures For Older Drivers as of October 2001.
(http://www.hwysafety.org/safety_facts/state_laws/older_drivers.htm)

- Janelle, C. M., Singer, R. N. & Williams, A. M. (1999). External distraction and attentional narrowing: Visual search evidence. *Journal of Sport and Exercise Psychology*, **2**, 70-91.
- Janke, M. K. (1991). Accidents, mileage, and exposure to risk. *Accident Analysis and Prevention*, **23**, 183-188.
- Janke, M.K. (1994). Age-related disabilities that may impair driving and their assessment (Literature review) *California Department of Motor Vehicles*. RSS-94-156.
- Janke, M. K. & Eberhardt, J. W. (1998). Assessing medically impaired older drivers in a licensing agency setting. *Accident Analysis and Prevention*, **30**, 347-361.
- Jung, W., Anderson, M., Camm, A.J., Jordaens, L., Petch, M.C., Santini, M., Rosenqvist, M., Luderitz, B. (1997). Recommendations for driving of patients with implantable cardiovascular defibrillators. *European Heart Journal*. **18** 1210-1219.
- Kannel, W.B. (1996) Prevalence, incidence and mortality of coronary heart disease, in *Atherosclerosis and Coronary Artery Disease*, eds. V. Fuster, R. Ross, and E.J. Topol, Lippincott-Raven Publishers, Philadelphia.
- Kannel, W.B. (1997). Cardiovascular risk factors in the elderly. *Coronary Artery Disease*. **8** 565-575.
- Kelly, R., Warke, T., Steele, I., (1999). Medical restrictions to driving: the awareness of patients and doctors. *Postgraduate Medical Journal*. **75** 537-539.
- Keskinen, E. Ota, H., Katila, A. (1998). Older drivers fail in intersections: Speed discrepancies between older and younger male drivers. *Accident Analysis and Prevention*, **30**, 323-330.
- Knoblauch, R. L. , Mitzburg, M. & Seifert, R. F. (1995). Older driver freeway needs and capabilities. *Compendium of Technical Papers, Institute of Transportation Engineers 65th Annual Meeting*, Washington, DC: ITE 629-633.
- Kostyniuk, L. P., Streff, F. M., & Eby, D. W. 1997. *The Older Driver and Navigation Assistance Systems*, (Report No. UMTRI-97-47). Ann Arbor , MI: The University of Michigan Transportation Research Institute.
- Kostyniuk, , L. P., Trombley, D. A., & Shope, J. T. (1998). *The process of reduction and cessation of driving among older drivers: A review of the literature*. (Report No. UMTRI 98-23), Ann Arbor, MI: The University of Michigan Transportation Research Institute,.

Levy, D. T. (1995). The relationship of age and state license renewal policies to driving licensure rates. *Accident Analysis and Prevention*, **27**, 461-467.

Li H., Weizelt M., Easley A., Barrington W., Windle J. (2000). Potential risk of vasovagal syncope for motor vehicle driving. *The American Journal of Cardiology*. **85** 184-186.

Lighthouse International. Changes in the aging eye.
http://www.lighthouse.org/aging_eye_normal.htm

Logsdon, R.G., Teri, L., Larson, E.B. (1992). Driving and Alzheimer's Disease. *Journal General Internal Medicine*, **7** 583-588.

Longo, M.D., Johnson, B. (2000). Addiction: Part I. Benzodiazepines –side effects, abuse risk and alternatives. *American Family Physician*, **61** 2121-2128.

Maltz, M. & Shinar, D. (1999). Eye movements of younger and older drivers. *Human Factors*, **41**, 15-25.

Mayo Foundation for Medical Education and Research (2000). Caring for someone with Alzheimer's [Online] *MFMER* Available from:
<http://www.mayohealth.org/home?id=HO00046&crit> [Accessed 05 July 2001].

McGwin, Chapman, and Owsley (2000). Visual risk factors for driving difficulty among older drivers. *Accident Analysis and Prevention*, **32**, 734-744.

McGwin, Jr. , G. & Brown, D. B. (1999) Characteristics of traffic crashes among young, middle-aged, and older drivers. *Accident Analysis and Prevention*, **31**, 181-198.

McGwin, G., Sims, R.V., Pulley, L., Roseman J.M. (2000). Relations among chronic medical conditions, medications, and automobile crashes in the elderly: a population-based case-control study. *American Journal of Epidemiology*, **152** (5), 424-431.

McKnight, J. A. (2000/2001). Too old to drive? *Issues in Science and Technology*, **17**, 63-69.

Messinger-Rapport, B. J. (2000). High risk on the highway. *Geriatrics*, **55**, 32-39.

Morgan, R., King, D. (1995). The older driver-a review. *Postgraduate medical journal*. **71** 525-528.

National Center for Health Statistics (1999a) New Series of Reports to Monitor Health of Older Americans [Online] (*NCHS*) Available from:
<http://www.cdc.gov/nchs/releases/01facts/olderame> [Accessed 10 October 2001]

National Center for Health Statistics (1999b) Annual Report on Nation's Health Spotlights Elderly Americans. [Online] (*NCHS*) Available from:
<http://www.cdc.gov/nchs/releases/99news/hus99>
[Accessed 10 October 2001]

National Center for Health Statistics (2001). Death among the elderly. [Online] *NCHS* Available from:
<http://www.cdc.gov/nchs/releases/01facts/olderame> [Accessed July 10 2001].

National Institute on Aging (1999). Older Drivers. [Online] *NIA* Available from:
<http://www.nia.gov/nia/health/agepages/drivers> [Accessed 4 April 2001].

National Institute of Diabetes & Digestive & Kidney Disease. (1999). *Diabetes statistics in the United States*. [Online] *NIDDK*. Available from:
<http://www.niddk.nih.gov/health/diabetes/pubs/dmstats/dmstats.htm>
[Accessed 7 March 2001].

National Safety Council (2002) Public Safety Group Defensive Driving [Online] Available from: <http://www.nsc.org/training> [Accessed 10 May 2002].

National Stroke Association (NSA) (1999). What is Stroke/Brain Attack? [Online] *NSA* Available from: http://www.stroke.org/NS802.0_WhatIsStroke.html
[Accessed 04 April 2001].

National Stroke Association (2000a). Effects of Stroke. [Online] *NSA*. Available from:
<http://www.stroke.org/effectsstroke.cfm> [Accessed 10 October 2001]

National Stroke Association (2000b). Brain attack statistics. [Online] *NSA*. Available from: <http://www.stroke.org/brainstat.cfm> [Accessed 23 November 2000]

National Stroke Association (2000c). Stroke risk. [Online] *NSA*. Available from:
<http://www.stroke.org/strokerisk.cfm> [Accessed 10 October 2001]

NYS Governor's Traffic Safety Committee, Senior Drivers. (2002) [Online] Available from: <http://www.nysgtsc.state.ny.us/senr-ndx.htm>

Odenheimer, G. (2001). Safe driving for seniors. [Online] *American Geriatrics Society*. Available from: <http://www.Americangeriatrics.org/education/forum/driving.s>
[Accessed 10 August 2001].

Odenheimer, G. L., Wieland, D., (2001). Dementia. *American Geriatrics Society* [Online] American Geriatrics Society. Available from: <http://www.americangeriatrics.org/education/forum/dementia.s> [Accessed 14 October 2001].

Ohio State University Extension (2000). Why Older People Are At Risk for Medications Problems [Online] Ohio, *Ohio State University Extension*. Available from: <http://www.ohioline.ag.ohio-state.edu/ss-fact/0127.html> [Accessed October 6 2000].

Olshanky, B., Grubb, B.P. (1998). 'Driving and syncope', in *Syncope: Mechanism and Management*, eds. Armonk, NY: Futura Publishing Co., Inc.

Oregon Department of Transportation, Driver and Motor Vehicle Services. Report of the Older Driver Advisory Committee, September 2000. [Online] Available from: http://www.odot.state.or.us/pdf/ODAC_Final_Recommendations.pdf

Ott, B.R. & Mernoff, S.T. (1999). Driving Policy Issues and the Physician. [Online] *Brown University*. Available from: http://www.brown.edu/Departments/Clinical_Neurosciences/articles/bo42899.html [Accessed 20 March 2001].

Ott, B.R., Heindel, W.C., Whelihan, W.M., Caron, M.D., Piatt, A.L., Noto, R.B (2000). A single-photon emission computed tomography imaging study of driving impairment in patients with Alzheimer's disease. *Dementia Geriatric Cognitive Disorder*, **11** 153-160.

Owsley, C. , Stalvey, B., Wells, J. , Sloane, M. F. (1999). Older drivers and cataract: Driving habits and crash risk. *Journal of Gerontology, A (Biological Science, Medical Science)*. **54**, 203-211.

Owsley, C. , Ball, K., Mc Gwin, G., Sloane, M. E., Roenker, D. L., White, M. F., & Overley, E. T. (1998). Visual processing impairment and risk of motor vehicle crash among older adults. *Journal of the American Medical Association*. **279**, (April 8). 1083-1033.

Petch, M.C. (1998). Driving and Heart Disease. *European Heart Journal*. **19** 1165-1177.

Persson, D. (1993). The elderly driver: deciding when to stop. *Gerontologist*, **33**, 88-91.

Pike, J. A. (1988) *The elderly and vehicle-related injury. In Effects of aging on driver performance* (pp. 61-71). Warrendadale, PA Society of Automotive Engineers.

- Radeborg, K., & Briem, V. (1999). The effect of concurrent task difficulty on working memory during simulated driving. *Ergonomics*, **42**, 767-777.
- Rayl, AJ (2000) Clinical trials driving Alzheimer's research *USA TODAY Health* [Online] Available from: <http://www.usatoday.com/life/health/doctor/lhdoc088.htm> [Accessed 20 April 2001]
- Richardson, J., Kim, K., Li, L., Nitz, L. (1996). Patterns of motor vehicle crash involvement by driver age and sex in Hawaii. *Accident Analysis and Prevention*, **27**, 117-125.
- Rock, S. M. (1998). Impact from changes in Illinois drivers license renewal requirements for older drivers. *Accident Analysis and Prevention*, **30**, 69-74.
- Roenker, D., Ball, K., Wadley, V., Edwards, J., Clay, O., & Roth, D. (2001). Enhancing safety and mobility of older drivers: A meta-analysis. Paper presented at the 109th *Accident Analysis and Prevention*, **30**, 323-330. Annual Meeting of the American Psychological Association, San Francisco, CA, August, 2001.
- Ryan, G. A., Legge, M., & Rosman, D. (1998). Age related changes in drivers' crash risk and crash type. *Accident Analysis and Prevention*, **30**, 379-387.
- Schwager, M. L. (2000). The elderly driver. [Online]. Rhode Island, Brown University. Available from: http://www.brown.edu/Departments/clinical_Neurosciences/articles/ms43299.html. [Accessed 2 October 2000].
- Sekuler, A. B., Bennett, P. J. & Mamelak, M. (2000). Effects of aging on useful field of view. *Experimental Aging Research*, **26**, 103-120.
- Shinar, D. & Scheiber, F. (1991). Visual requirements for safety and mobility of older drivers. *Human Factors*, **33**, 507-519.
- Shipp, M. (1998). Potential human and economic cost-savings attributable to vision testing policies for driver license renewal, 1989-1991. *Optometry and Vision Sciences*, **75**, 103-118.
- Simpson, C.S., Klein, G.J., Brenman, F.J., Krahn, A.D., Yee, R., Skanes A.C., (2000). Impact of a mandatory physician reporting system for cardiac patients potentially unfit to drive. *Canadian Journal Cardiology*, **16** 10 1257-1263.
- Stamatiadis, N. & Deacon, J. A. (1995). Trends in highway safety: Effects of an aging population on accident propensity. *Accident Analysis and Prevention*, **27**, 443-459.

- Stamatiadis, N. (1996). Gender effects on the accidents patterns of elderly drivers. *Journal of Applied Gerontology*, **15**, 8-22.
- Stutts, J. C., Stewart, J. R. & Martell, C. (1998). Cognitive test performance and crash risk in an older driver population. *Accident Analysis and Prevention*, **30**, 337-346.
- Szylk, J. , Seiple, w., & Viana, M. (1995). Relative effects of age and compromised vision on driving performance. *Human Factors*, **37**, 430-436.
- Tallman, T. (1999). Stroke. [Online] *Ohio State University Extension*. Available from: <http://www.ohioline.ag.ohio-state.edu/ss-fact/0168.html> [Accessed 13 October 2000].
- Traffic Safety Facts. Older Population.* (1999). U. S. Department of Transportation, National Highway Safety Administration, DOT HS 809 091.
- Veneman, T.F. (1996). Diabetes Mellitus and traffic incidents. *The Netherlands Journal of Medicine*, **48** 24-28.
- Vokonas, P.S., Kannel, W.B., (1996). Diabetes mellitus and coronary heart disease in the elderly. *Clinics in Geriatric Medicine*, **12** (1) 69-78.
- Waller, P. F. (1991). The older driver. *Human Factors*, **33**, 499-505.
- Western and Central Washington State Chapter of the Alzheimer's Association (2000). Driving safety [Online] Available from: http://www.alzwa.org/ArticlesOnLine/Driving_Safety_Article/PrinterFriendlyVersion.htm [Accessed 20 April 2000].
- Whillans, M. G. & Allen, M. J. (1992). Color defective drivers and safety. *Optometry and Visual Science*, **69**, 263-466.
- Williams, C. & Graham, J. D. (1995). Licensing standards for elderly drivers. *Consumers' Research Magazine*, **78**, 18-23.
- Wood, J. M. (1999). How do visual status and age impact on driving performance as measured on a closed circuit driving track. *Ophthalmic Physiology and Optics*, **19**, 34-40.
- Wood, J. M. & Troubeck, R. (1992). Effects of restrictions on binocular visual field ond driving performance. *Ophthalmic Physiology and Optics*, **12**, 291-298.
- Wood, J. M. & Troubeck, R. (1995). Elderly drivers and simulated visual impairment. *Optometry and Visual Science*, **72**, 115-125.

Zhang, J., Lindsay J., Clarke, K., Robbins, G., Mao, J. (1999). Factors affecting the severity of motor vehicle traffic crashes involving elderly drivers in Ontario. *Accident Analysis and Prevention*. **32** 117-125.

Web Sites Concerning Older Drivers

NHTSA Older Road Users: This NHTSA Sites provides links to studies, data, references and policies.

<http://www.nhtsa.dot.gov/people/injury/olddrive/reseachstudies.html>

National Highway Safety Traffic Administration website: This is site provides access to crash statistics, driver performance and many other links to safety issues in general.

<http://www.nhtsa.dot.gov/>

Federal Motor Carrier Safety Administration:

<http://www.mcs.dot.gov/>

US Dept. of Transportation, Bureau of Transportation Statistics,

<http://www.tris.amti.com/>

The Insurance Institute of Highway Safety: An independent, nonprofit, research and communications organization dedicated to reducing highway crash. Includes state by state renewal procedures for older drivers

<http://www.highwaysafety.org/>

Penn State University: Researchers at Penn State and the University of Minnesota have joined forces to design new measures to prolong the safe driving time of older driver.

[http:// www.psu.edu](http://www.psu.edu)

University of Michigan, Transportation Research Institute

<http://www.umtri.com>

Coalition for Safer Highways

[http:// www.coalition4saferhwy.com](http://www.coalition4saferhwy.com)

The Highway Loss Data Institute: A nonprofit, public service organization that gathers, processes and publishes data on highway safety.

<http://www.carsafety.org/>

This site provides access to FARS (the Fatality Analysis Reporting System) and GES (General Estimates System). A query engine permits the user to generate tables using an interactive user interface.

<http://www-fars.nhtsa.dot.gov/>

NCSA (National Center for Statistics and Analysis) provides analytical and statistical support to NHTSA and the traffic safety community, through data collection, analysis, and crash investigation activities.

<http://www.nhtsa.dot.gov/people/nca/>

First and largest classroom driver improvement course specially designed for motorists age 50 and older. It is intended to help older drivers improve their skills while teaching them to avoid accidents and traffic violations.

<http://www.aarp.org/55alive/>

Nine step approach of George Mason University to conduct study on mature driver Client: Virginia Department of Motor Vehicles (DMV)

<http://www.safety.gmu.edu>

Bureau of Transportation Statistics

<http://www.bts.gov/>

AASHTO Strategic Highway Safety Plan: The American Traffic Safety Service Association Policy on Aging Drivers

http://safetyplan.tamu.edu/pubs_progs/browse.asp?ele=drv&goa=03

Driving Rehabilitation Services for Older Drivers: Resource site for older drivers

<http://www.rstc.com/drivingstudy/>

APPENDIX

Survey of DMVs concerning mature drivers

E-mail survey

The higher accident rates of older drivers are a concern to many people in the traffic safety organizations. The New Jersey Department of Transportation and its Division of Motor Vehicle Services have hired a team of researchers from New Jersey Institute of Technology and City College of New York to study what they can or should do to protect drivers from these accidents. As part of this study we wish to gain from the experiences and explorations of Divisions of Motor Vehicles from other states.

Please take five minutes to answer the survey and return it by either e-mail or regular mail. (The addresses are at the end).

GENERAL

1. What state and agency are you with?
2. Are you familiar with your agency's policy concerning mature drivers?

If not, please forward this questionnaire to a person in your agency that is familiar with it.

Provisions for older drivers

3. Do you have any provisions that use age as a criterion?
If so, what age is used?
4. Do you have any provisions that are aimed at the older driver although they do not specifically use age as a criterion?

If so, please describe them?

5. Has your state (or is your state currently) engaged in any studies regarding mature drivers?

- a. If yes, what was (is) the goal of this study?
- b. Who is conducting it?
- c. Who is the contact person?
- d. Please provide a telephone number or e-mail address where we can reach them.

6. We may have some follow up questions. In order for us to contact you again, please provide the following information:

- a. Your Name:
- b. Telephone number:
- c. E-mail address:

7. Would you like a copy of our findings?

Thank you very much for your time and effort!

Please return this survey by either

e-mail to:
kenstevenson@dot.state.nj.us

or
mail to:

Naomi Rotter
Professor of Management
New Jersey Institute of Technology
University Heights
Newark, New Jersey 07102