3. OVERVIEW OF THE LITERATURE

The population of the United States is growing, and the number of elderly persons (aged 65+) is growing more rapidly than any other age group. In this chapter, we briefly review the current literature on the aging population, elderly drivers, and driving. With an emphasis on the elderly, we will identify trends in population growth, review some of the studies addressing driving and health issues of the elderly, review impacts related to transportation and mobility, examine crash literature, and look at other factors that could affect projections of the number of crashes involving the elderly driver.

3.1 THE ELDERLY POPULATION IN THE UNITED STATES

According to the U.S. Census Bureau, half the population of the United States in 1860 was under age 20; ninety years later, the median age had increased to 30. The Census projects that, in 2035, the median age will reach its peak at 38.7 years. (Day, 1996, p. 7)

In the 20th century, our nation's population tripled, but the number of elderly (i.e., persons 65 and over) increased by a factor of eleven (Hobbs and Damon, 1996, p. 2-2). The number of elderly U.S. residents went from 3.08 million (4.1% of the total U.S. population) in 1900 to 12.3 million (8.1%) in 1950 to 31.08 million (12.5%) in 1990. The number of elderly persons is predicted to reach 53.35 million (16.4%) by 2020. Only ten years later, the percentage of the U.S. population that is over 65 years of age is predicted to be over 20%, and this percentage is not expected to decrease before mid-century (Hobbs and Damon, 1996, p. 2-3).

Several explanations for this aging of the population exist. Two of the more obvious reasons are the maturing of the "baby boom" generation and improvements in health care, resulting in longer life expectancies. Between 1946 and 1964, 75 million babies were born in the United States. In 2010, the first of these individuals will be nearing retirement. In the year 2020, the baby boom generation will be between the ages of 56 and 74 (Day, 1996, pp. 7-9). By 2030, all “boomers” will be over 65 years of age.

Improvements in health care have resulted in an increase in life expectancy. In the late 1700s, life expectancy at birth was only about 35 years! A hundred years later, it was approximately 47 years for whites, although it was much lower for non-whites. For baby boomers, average life expectancy is around 68 years (Hobbs and Damon, 1996, p. 3-1).

3.1.1 By Age Groups and Cohorts

“The older population itself is getting older” (Administration on Aging, 1999). Of the three age groups (65-74, 75-84, and 85+) considered in this study, the 85+ group is growing the fastest. In 1998, the 65-74 age group was eight times larger than the same age group in 1900; the 75-84 age group was 16 times larger; and the 85 and over age group was 33 times larger! (Administration on Aging, 1999).

The growth trend of this oldest-old group is projected to continue. Between 1995 and 2025, this age group is expected to almost double (Table 3.1).

It should be noted that the percent of the young-old population (i.e., age group 65-74) as a part of the entire U.S. population will actually decrease slightly around the years 2000-2005. This decrease is due to a decrease in the birth rate during the Depression years. Following 2010, however, the population of all elderly age groups will increase sharply.

Table 3.1. Population Projections for the Total United States, by Age Group, for the Years 2000-2025, with Comparison to the 1995 Population

Age group	Number in 1995	Number in 2000	Number in 2005	Number in 2010	Number in 2015	Number in 2020	Number in 2025
All ages[a]	262,820,000	274,634,000	285,981,000	297,716,000	310,134,000	322,742,000	335,050,000
% increase		4%	4%	4%	4%	4%	4%
All elderly (ages 65+)	33,532,395	34,709,734	36,166,552	39,408,398	45,566,613	53,219,272	61,951,824
% of all ages	13%	13%	13%	13%	15%	16%	18%
% increase		4%	4%	9%	16%	17%	16%
Ages 65-74	18,759,220	18,135,538	18,368,960	21,057,448	26,243,458	31,384,875	35,424,538
% of all ages	7%	7%	6%	7%	8%	10%	11%
% increase		-3%	1%	15%	25%	20%	13%
Ages 75-84	11,145,006	12,314,793	12,898,112	12,680,364	13,129,891	15,374,496	19,481,045
% of all ages	4%	4%	5%	4%	4%	5%	6%
% increase		10%	5%	-2%	4%	17%	27%
Ages 85+	3,628,169	4,259,403	4,899,480	5,670,586	6,193,264	6,459,901	7,046,241
% of all ages	1%	2%	2%	2%	2%	2%	2%
% increase		17%	15%	16%	9%	4%	9%

Sources: total population counts through 2025 from U.S. Census Bureau publication P25-1130, Table F, p. 9, middle series (http://www.census.gov/prod/1/pop/p25-1130/); elderly population counts through 2025 derived from http://www.census.gov/population/www/projections/stproj.html (Series A).

[a]Note that these numbers represent total (institutionalized and non-institutionalized) elderly population projections. The projections provided in Chapter 5 are for non-institutionalized populations.

3.1.2 By Gender

Mortality rates for men exceed those for women. For the older age groups, the gender imbalance is even greater. The male to female ratio is growing closer, however. In 1995, there were only 69 men for every 100 women for persons 65 years or older. In 2025, the ratio is expected to be closer to 83 men for every 100 women. Table 3.2 shows the projected ratios of men to women in different age groups.

Projecting population totals by gender is important because of historical driving trends. For example, in 1965, only about 28% of all drivers' licenses for ages 65 and over were issued to women. In 1995, however, over 50% of all drivers' licenses for ages 65+ were issued to women.

Table 3.2. Projected Ratios of Men to Women, Total United States, Compared with the 1995 Ratios

Age group	Gender ratio,[a] 1995	Gender ratio, 2000	Gender ratio, 2005	Gender ratio, 2010	Gender ratio, 2015	Gender ratio, 2020	Gender ratio, 2025
All ages	95.4	95.5	95.6	95.7	95.8	95.9	96
All elderly	69.0	70.4	72.4	75.0	78.1	80.8	82.9
Ages 65-74	80.1	82.2	84.4	86.3	87.8	89.1	90.5
Ages 75-84	63.5	66.9	69.9	73.3	77.0	80.2	83.0
Ages 85+	38.9	40.5	43.0	45.4	47.5	49.6	52.4

Source: U.S. Census Bureau, www.census.gov/population/www/projections/stproj.html and www.census.gov/population/www/projections/natproj.html .
[a]Gender ratio is defined as the number of males per 100 females.

3.1.3 By Economic Status

Personal income/economic status is an extremely important factor for the elderly. For example, medical expenses are generally greater for the elderly than they are for the average person under age 65. In addition, a fixed income may not keep up with the general rate of inflation. A major source of income for the elderly is Social Security, as reported by 91% of older persons (Administration on Aging, 1999). Many older persons continue employment, about half of which is part-time work. In the transportation equation, elderly persons find that the costs of owning an automobile may be too high or that they must limit the number of trips they take to save on the costs of transportation.

The U.S. Census Bureau provides historical data on average annual incomes, for different age groups. The median income for all households in the United States in 1995, for all ages, was $34,076, and for the same time period, the median income for the elderly (i.e., 65 and over) was $19,096. Table 3.3 presents historical data on income levels of the elderly in comparison with the income level of “all households.”

Table 3.3. Median Household Income by Type of Household for Selected Years (1996 Dollars)

	1969	1979	1983	1989	1993	1996
All households	$33,072	$34,666	$32,941	$36,598	$33,660	$35,172
Married-couple, no children, householder 65+						
Including wife's income	$18,553	$23,724	$27,642	$29,230	$28,263	$29,210
Excluding wife's income	$14,340	$15,675	$18,116	$18,982	$18,710	$19,174
One-person household, male 65+	$8,936	$11,227	$13,615	$14,288	$14,821	$14,586
One-person household, female 65+	$7,025	$9,382	$10,926	$11,388	$10,823	$11,454

Source: U.S. Census Bureau, "Changes in Median Household Income," from Table 4, at http://www.census.gov/hhes/income/mednhhld/t4.html .

The U.S. Census Bureau also provides historical *mean* incomes by age-gender groupings. Table 3.4 shows mean income for individuals in two elderly age categories for selected years.

Table 3.4. Mean Income for the Elderly, by Gender (1998 Dollars)[a]

Year	Mean income in 1969	Mean income in 1979	Mean income in 1983	Mean income in 1989	Mean income in 1993	Mean income in 1996	Mean income in 1998
All Males, 65+	$17,814	$19,719	NA	$24,779	$24,138	$25,247	$27,997
All Females, 65+	$8,977	$11,331	$13,012	$14,515	$13,413	$14,480	$15,419
Males, 65-74	NA	NA	NA	$27,305	$25,870	$27,891	$30,441
Females, 65-74	NA	NA	NA	$15,045	$14,090	$15,236	$16,043
Males, 75+	NA	NA	NA	$20,091	$21,262	$21,226	$24,547
Females, 75+	NA	NA	NA	$13,791	$12,545	$13,608	$14,729

Source: U.S. Census Bureau, Historical Income Tables, from Table P-9, at http://www.census.gov/hhes/income/histinc/p09.html .

[a]NA = not available.

The Bureau of Economic Analysis provides data on total personal income, by state, for all ages and makes projections for future income. However, these projections are for total personal income and are not provided by age-gender categories. The U.S. Census Bureau does not make income projections.

Full retirement age in the year 2000 is 65; however, beginning in 2003, full retirement age gradually increases to age 67 for those born in 1960 or later. It is possible that individuals will not retire at their full retirement age. For example, persons born in 1943 (or later) who work beyond their normal retirement age will receive an 8% benefit for each year that they delay their retirement (http://www.ssa.gov/pubs/10035.html).

3.1.4 By Race, Ethnicity, and Social Characteristics

The size of non-white racial/ethnic groups is projected to increase dramatically after the year 2010. This increase is due to higher fertility rates (especially among Hispanics and Blacks) as well as immigration and lower mortality rates (among Asian and Pacific Islanders and Hispanics). Although the racial and ethnic components of the elderly population will change, how this change will affect transportation and mobility among the elderly cannot be quantified at this time. Therefore, this factor will not be considered further in this study.

Social characteristics, including marital status, living/housing arrangements, and education, of the elderly population may be important characteristics to consider when describing transportation usage. Historically, older men are more likely to be married than older women; women are more likely to be widowed than men. In 1997, the numbers of single (never married) and divorced elderly were approximately equal for men and women.

In 1995, most elderly men (73%) lived with a spouse while only 41% of elderly women lived with a spouse. More elderly women (42%) lived alone or with non-relatives. About 7% of elderly men and 17% of elderly women lived with other relatives. In 1996, the percentage of elderly persons living in nursing homes increased dramatically with higher age groups, ranging from about 1% in the 65-74 age group to almost 20% in the 85+ age group. In 1997, most (79%) households headed by older persons owned their own homes; only 21% were renters (Administration on Aging, 1999). In addition, there is a trend for households comprised of older persons to move to rural or suburban communities. In these locations, transportation needs are greater than in urban settings where mass transportation is available (National Association of Development Organizations Research Foundation, 1999, p. 3).

The highest educational level achieved by the elderly is increasing. In 1970, only 28% of the elderly had completed high school; in 1998, 67% had high school degrees. Education level varies by race and ethnicity, with Blacks and Hispanics having lower educational levels than Whites. As the racial composition of the elderly changes, it is highly likely that the educational levels will also change. The relation of education level to health has been studied and is discussed more fully in Section 3.2.3.

In summary, race, ethnicity, and social characteristics are important factors to understanding the makeup of the elderly population and their transportation needs. It is difficult, however, to quantify the impact of these factors on transportation use by the elderly. Therefore, race, ethnicity, and the social characteristic of marital status will not be considered further in this analysis. Educational levels and health are very closely related and will be considered together in a later section. In addition, living/housing arrangements have an impact on the decision to drive. That is, in households in which there is another driver, the elderly, especially elderly women, do not drive as much. This fact has been incorporated within our projection model and is explained more fully in Chapter 5.

3.1.5 By Geographic Distribution

According to Census estimates, about half of the elderly population in the United States currently lives in nine states – California, Florida, New York, Texas, Pennsylvania, Ohio, Illinois, Michigan, and New Jersey. The states with the highest per capita elderly population are Florida, Pennsylvania, Rhode Island, West Virginia, and Iowa, all of which have an elderly population which is at least 15% of their total population (Administration on Aging, 1999). Although some elderly persons maintain homes in different areas of the country and alternate their residence location based on personal reasons (e.g., changes in the weather), this migration pattern is difficult to quantify and will not be considered in this analysis. Immigration has changed the racial profiles in some border states; however, because the impact of changes in racial composition on transportation issues – especially crash data – has not been quantified, this factor will not be included in the projection analysis. Distribution of the elderly population by gender and age group for each Census region for 1995-2020 is shown in Figures 3.1-3.4.

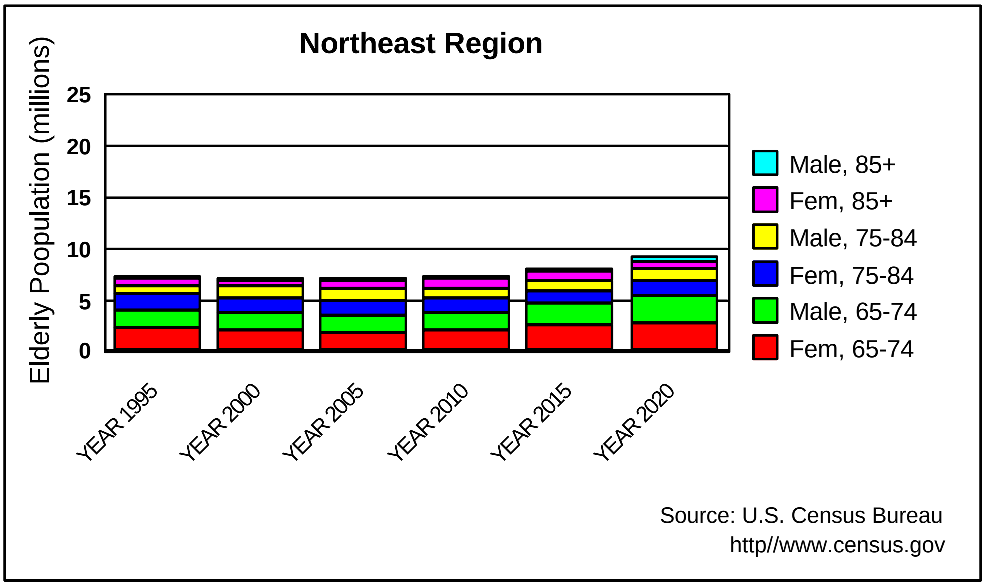

Figure 3.1. Distribution of the Elderly Population in the Northeast Region by Gender and Age Group between 1995 and 2020

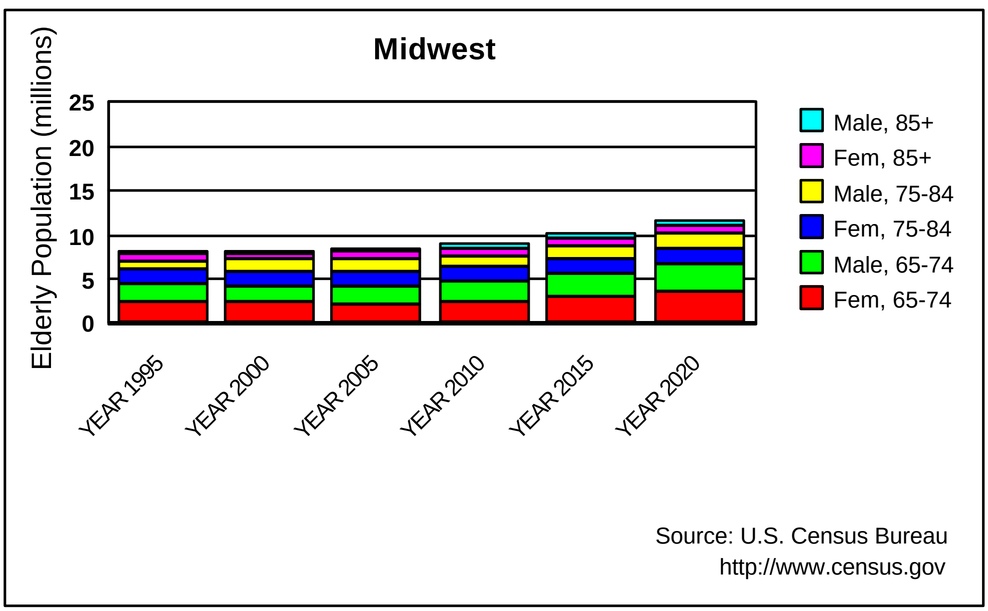

Figure 3.2. Distribution of the Elderly Population in the Midwest Region by Gender and Age Group between 1995 and 2020

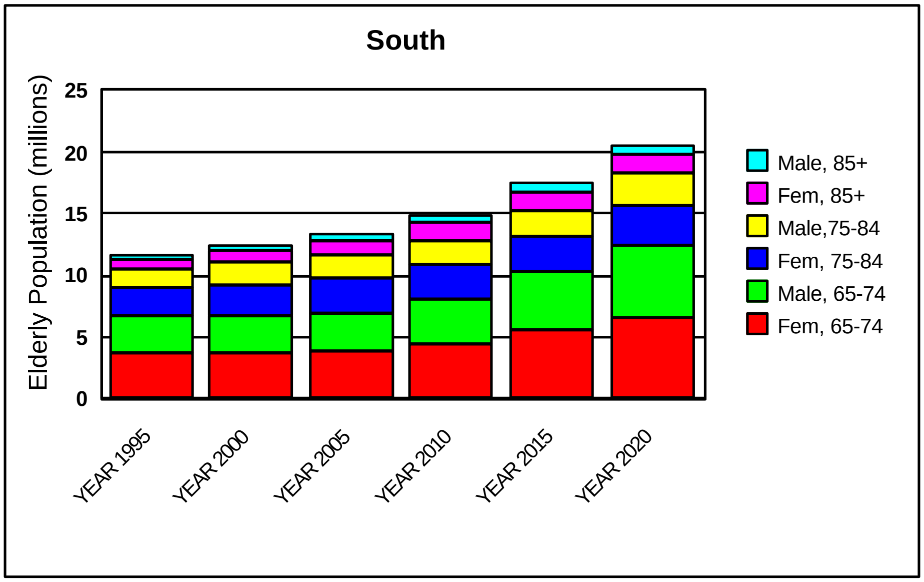

Figure 3.3. Distribution of the Elderly Population in the South Region by Gender and Age Group between 1995 and 2020

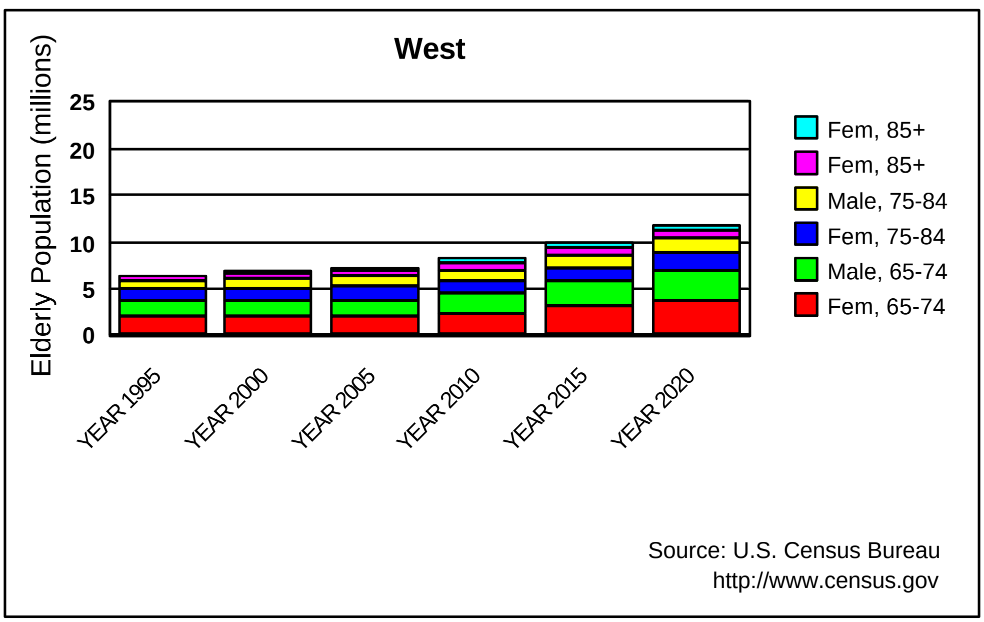

Figure 3.4. Distribution of the Elderly Population in the West Region by Gender and Age Group between 1995 and 2020

More elderly people live in rural areas than in metropolitan areas. The marked growth of the elderly in rural areas is a result of aging-in-place, out-migration of young people to more urban areas with better paying jobs, and in-migration of retirees from urban areas (Rogers, 1999).The number of older persons varies among the regions. The greatest concentration of the elderly (for both rural and urban areas) is in the South (see Figures 3.1-3.4). Because non-metropolitan America is less economically well off and has fewer public transportation options, the elderly, especially those who do not drive or own an automobile, find it difficult to reach health care facilities, to attend social events, or to meet basic shopping needs (National Association of Development Organizations Research Foundation, 1999).

3.2 HEALTH ISSUES

The U.S. Census Bureau has projected the future population of the elderly. These projections, however, do not forecast the health of this population. Physical and cognitive health is directly related to driving abilities as well as to survival in crashes. As seniors age, the occurrences of physical and cognitive impairments and overall frailty increase. Among all elderly, in 1996, 10.5% were unable to carry on a major activity; this percentage can be compared with 3.5% of those under 65 years of age. In addition, over 27% of seniors listed their health as fair or poor, with very little difference between the sexes (Administration on Aging, 1999).

With obvious implications for both safety and mobility, it is especially important to attempt to quantify (1) the numbers of elderly with disabilities that could limit their driving skills and (2) the correlation between health impairments and the decisions of whether to drive and how much to drive.

The elderly are experiencing better health than in the past. Manton, Corder, and Stallard (1997) studied chronic disease trends among the elderly in the United States using the National Long Term Care Surveys (NLTCS) and saw much lower chronic disability rates. Freedman and Martin (1998), using data from the Survey of Income and Program Participation (SIPP) also found large health improvements in the elderly. In addition, Freedman and Martin found that these improvements have been greatest among those 80 and older. Manton, Stallard, and Singer (1994, p. 61) explain this trend as due to decreased smoking, increased education, and better life styles (more exercise and better nutrition) among seniors. It should be noted, however, that Wallace and Franc do not concur with these studies and contend that the conclusions need further verification (Wallace and Franc, 1999, p. 18). If, indeed, disability rates are declining, the ability of the elderly to continue to drive to later ages would be extended.

Because of increases in the number of elderly and a decline in mortality, the number of nursing home residents is predicted to approximately double (from 1.67 million residents of nursing facilities in 1990) between 1990 and 2025 (American Health Care Association, 1997, p. 7). Nursing home residents average 3.67 activities of daily living (ADL) limitations each. The typical nursing home resident is an 82-year-old woman who needs assistance with some personal activities (American Health Care Association, 1998).

3.2.1 Impacts of Failing Health on Driving Abilities

Older persons are more likely to suffer from health problems (Eby et al., 1998, p. 39). Specific medication taken by older persons to alleviate poor health conditions may affect driving ability. In addition, certain medical conditions may affect driving ability. Although certain drugs (e.g., benzodiazepines) and certain severe health conditions (e.g., Alzheimer’s Disease) obviously affect driving ability, research is not clear cut on other drugs and health conditions associated with advancing age.

What is true, however, is that older persons experience increasing medical problems. The problem is how to tie health measures (e.g., “excellent,” “poor”) to driving measures (e.g., whether to drive, how much to drive). Wolinsky (1990) contends that metric coding of perceived health status (and, by implication, more objective categorical assessments of health status) does not optimally exploit the elicited information and is not legitimate. For example, assigning the numerical values of 1, 2, 3, and 4 to perceived individual health conditions of “poor, fair, good, and excellent” assumes that the difference between “2” and “3”is equal to the difference between “3” and “4.” There is no direct metric relationship between an individual’s ranking of his/her perceived health status and his/her decision to drive or not to drive. Nor is there a direct metric relationship between perceived health status and the decision of how much to drive. As the numbers of older drivers increase, we must consider how perceptual (visual), cognitive, and/or psychomotor impairments of the elderly affect their ability to navigate a vehicle.

In 1998, Eby et al. published an extensive review of the literature on older drivers’ capabilities. Age-related changes on visual perception (i.e., anatomical changes, eye movements, sensitivity to light, dark adaptation, visual acuity, spatial contrast sensitivity, visual field, space perception, motion perception, color perception), cognitive factors (i.e., attention, perceptual style – field dependence/independence, short-term and long-term memory, problem solving, spatial cognition), and psychomotor skills (i.e., reaction time, flexibility, and coordination) and their effects on driving abilities are well-documented.

Owsley, McGwin, and Ball (1998) studied visual risk factors among elderly drivers involved in crashes that resulted in injury. In this study, elderly drivers with a useful field of view reduction of more than 40% were at least 20 times more likely to be involved in a crash involving injury than were those with minor visual limitations. The study suggested “that visual processing impairment, a major cause of disability in older adults, and glaucoma, projected to affect almost 1.6 million older adults in the U.S. by the year 2000, increase older drivers’ risk for involvement in an injurious crash” (Owsley, McGwin, and Ball, 1998, p. 112).

In a study to compare predictors of driving fitness, Duchek et al. (1998) examined the results of several vision tests, psychometric tests, and diagnoses of mild Alzheimer’s Disease. This study indicated that a diagnosis of mild dementia alone may not be the best predictor of impaired driving and that results of the visual search task may be better predictors. It should be noted that the visual search task is not the same as visual acuity tests administered at drivers licensing sites. Driver licensing tests are not considered adequate to identify older drivers that might be involved in crashes (Ball, 1997, p. 46).

Several studies have shown that older drivers, in general, recognize their limitations and self-regulate their driving to times and places that they consider safest. Self-regulation may reduce crash risk for older drivers, in that it keeps them from being involved in situations in which they have difficulty maneuvering (Ball et al., 1998, p. 321).

In a literature review on the mobility needs of older women, Wallace and Franc (1999) examined the disability-mortality paradox between men and women and its implications for future gender differences among elderly drivers. According to Wallace and Franc's research, women over age 70 were about twice as likely as men to report health limitations. Although women have a longer life expectancy than men, women report more disabling chronic diseases, such as degenerative arthritis, than men. While studies have documented more chronic heart disease among men than among women, improvements are being made in treatments of heart disease, and it is possible that the health of elderly men will improve. Health conditions such as degenerative arthritis make driving difficult or impossible, but there is no evidence that the rate of degenerative arthritis is declining.

"Although the literature has converged on the finding that visual and cognitive impairments contribute to unsafe driving, there is little agreement across studies about which medical conditions and functional impairments elevate crash risk" (Sims et al., 1998, p. 556).

3.2.2 Impacts of Increasing Frailty on Casualty Rates

Due to increasing frailty, the likelihood of an elderly person being severely or fatally injured in an accident increases (Evans, Gerrish, and Taheri, 1998). That is, in a crash of a particular magnitude, younger victims are more likely to survive than elderly victims. An injury that would kill 10% of persons 65-79 years old would kill 50% of persons aged 80 and above. This higher mortality rate in crash victims over 80 is attributed to post-traumatic complications (U.S. Department of Transportation, 1997A, pp. 10-11). It has been estimated that about a third of health care costs from serious injury crashes are spent on the elderly although the elderly currently only represent about 12% of the U.S. population. These higher costs are attributable to complications and longer recovery times (U.S. Department of Transportation, 1997A, pp. 10-11).

Many studies have discussed the familiar "U"-shaped curve which compares number of fatalities per vehicle miles driven by age. According to this graph, older drivers and teen-age drivers are the most likely victims of crashes. The over-representation of older drivers in serious crashes is a combined product of frequency in which they are involved in a serious crash and the chance of injury or death resulting from the crash (Hakamies-Blomqvist, 1999).

3.2.3 Health and Education Levels

It has been noted that higher education levels are correlated with better health and longevity. This relationship may result from improved access to medical care, but it may also result from a better, more health-conscious lifestyle (Manton, Stallard, and Singer, 1994, pp. 70-71).

Wallace and Franc (1999) noted several striking correlations between higher education and better health. Citing results from the Longitudinal Study of Aging for 1984, they noted significant delays in the onset of disabilities in persons over 70 years of age in comparison with persons of the same age group with slightly less education. Unfortunately, it is difficult to disassociate the education component from income, net economic worth, or other socio-behavioral characteristics when attempting to predict health and functional capabilities. Functional capabilities are definitely related to the decision to cease or continue driving (Wallace and Franc, 1999, pp. 21-23).

3.2.4 Assessment Tools and Retraining

Older driver tools for assessing driving abilities (or lack thereof) and for retraining/rehoning driving skills exist in several variations. The most common include self-assessment tools, clinical (physician-completed) assessments, and road tests (Eby et al., 1998, pp. 77-84). If the use of assessment tools becomes more widespread and consistently applied, this may impact the number of older drivers.

Self-assessments largely are limited to an individual's own measures of abilities to carry out activities of daily living (ADLs). These measures are very subjective and are prone to environmental influences (e.g., family opinions, social implications). Thus, a less subjective test is desirable. The American Association of Retired People (AARP) has provided simple performance tests that older drivers can use for self-administration.

Fields and Valtinson (1998) reviewed the literature on the use of neuropsychological tests for predicting driving ability. They concluded that "neuropsychological tests have limited predictive validity."

In 1996, Ball and Owsley developed a test to predict the likelihood of an older driver being involved in a crash. The "Useful Field of View" (UFOV) is a computerized program which measures visual attention and cognitive processing speed. According to Ball's studies, drivers with lower UFOV scores were much more likely to be involved in crashes than those with a "normal" UFOV (Owsley and Ball, 1998). Ball also noted that current vision screening tests at drivers licensing sites are insufficient to screen for the useful field of vision (Ball, 1997, pp. 42-47).

In addition to the UFOV being an assessment tool, it may also be an effective training tool. Practice with the UFOV improved the reaction time, expanded the size of the attentional field, and seemed to improve driving ability in a test conducted in 1998 (Roenker, Cissell, and Ball, ND). However, there are no statistics on the long-term effect of UFOV training on driving fitness.

Older driver training programs are being developed to assist older drivers with age-related problems. Three such programs are the *55 Alive/Mature Driving* program, sponsored by the AARP, *Safe Driving for Mature Operators*, sponsored by the American Automobile Association (AAA), and *Coaching Mature Drivers,* sponsored by the National Safety Council (NSC). Evaluations of these retraining programs have indicated that they provide valuable educational information; however, evaluations have provided inconclusive evidence that these training courses actually decrease crashes. It is almost certain that assessment and, possibly, retraining of the burgeoning population of the elderly in the next two to three decades will be necessary.

Staplin and Hunt (1999) conducted research to identify driver assessment tools, remediation techniques and procedures, and licensing. They documented a wide range of remedial treatments, including adaptive equipment, retraining, physical therapies and exercise programs, instruction in driving skills, and other tests (p. 37).

3.2.5 Better Health, Extended Life Spans, Later Retirement, and Greater Mobility

Elderly drivers are taking more trips and driving more miles than they did in the past. They are adapting their travel patterns as needed to maintain an active, social lifestyle. One of the primary fears of the elderly, above personal security or health concerns, is losing mobility, expressed as loss of the ability to drive (Staplin and Hunt, 1999, p. 38).

Although advancing age brings encroaching frailty, older people are actually improving their functional capabilities. The age for full retirement has been extended, but seniors can still expect to spend many active years as retirees. As healthy, energetic participants in society, the elderly will experience expanded transportation needs as their demand for greater mobility grows.

3.3 TRANSPORTATION AND MOBILITY

The 21st century will see the American population aging. Will greater numbers of persons over 65 be driving, and will the elderly be driving further? What kind of changes will we see in driving habits, travel patterns, and the use of alternative transportation? How will the use of “smart” cars and “smart” highways impact the safety and mobility of the elderly?

3.3.1 Numbers of Drivers

According to Table DL-220 from *Highway Statistics Summary to 1995*, the number of drivers’ licenses issued to persons over age 60 increased from 27,838,000 in 1985 to 34,013,000 in 1995, a 22% increase (U.S. Department of Transportation, 1997B). The greatest increase in licenses issued was in the age group of 70 and over – an increase of almost 50%! Figure 3.5 shows the growth of the number of elderly persons holding drivers licenses between 1963 and 1995.

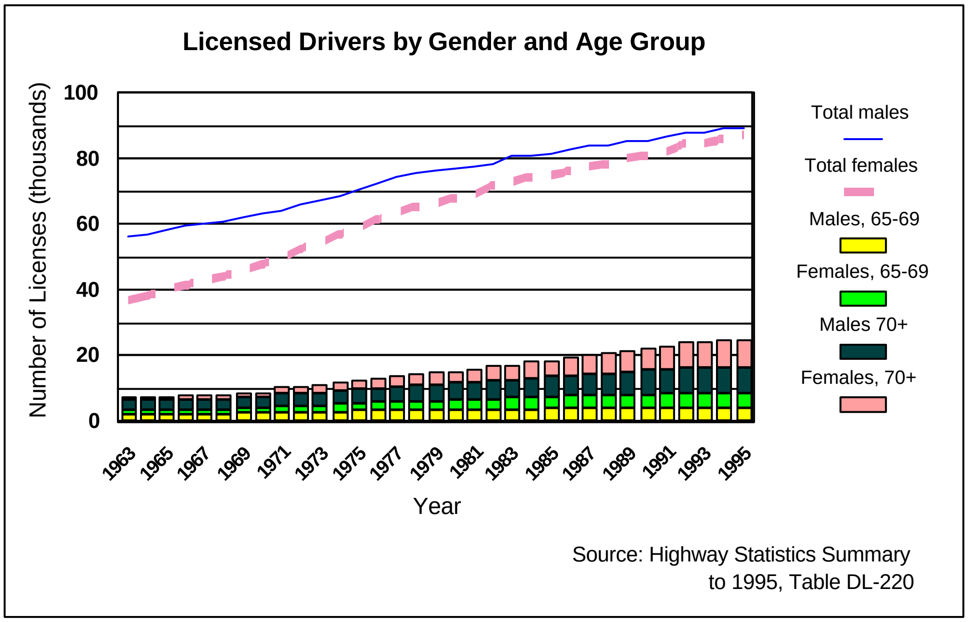

Figure 3.5. Licensed Drivers by Gender and Age Group, 1963-1995.

When Fields and Valtinson contacted the Departments of Motor Vehicles in all 50 states to ascertain state policies for licensing the elder driver, they found that there was no uniformity across the states. Some states require renewal in person after a certain age, as well as a vision test and a road test. Other states require no tests of ability and have lengthened the time intervals between renewals. In some states, doctors are required to report unsafe drivers to the state; other states require the physician to get the patient's written permission before reporting a physical impairment (Fields and Valtinson, 1998).

Some individuals, particularly among the elderly, obtain drivers licenses even though they may not intend to drive a vehicle. Reasons for obtaining a license include identification, "status," or just in case it might be needed. In addition, states may not purge their data sets to account for licensees moving out of state or dying. Therefore, the number of drivers licenses issued is not a valid measure of the actual number of drivers. Eberhard (1996) compared numbers of drivers licenses issued, according to Federal Highway Administration (FHWA) historical data for 1993, with survey data from the 1993

Asset and Health Dynamics of the Oldest Old (AHEAD) study. The AHEAD survey documented numbers of persons who actually drove, by age category. In each age group, more people held drivers licenses than actually drove. The likelihood of driving declined with age. Based on historical data, elderly men are more likely to drive than elderly women.

Because of the lack of uniformity of requirements for licensing the older driver and because the possession of a driver's license does not imply that a person actually drives, simply knowing the numbers of licenses issued is not sufficient for determining whether the holder of a drivers license actually drives.

Burkhardt et al. (1998) projected the elderly driver population by age and gender through the year 2030. These projections, which are based on drivers license ratios and licensing patterns, place the number of elderly male drivers in 2030 at 2.28 times the number in 1996. Burkhardt et al. projected the number of elderly females driving in 2030 to be between 2.03 and 2.72 times the number in 1996. The greatest projected increase in the number of elderly drivers was for the oldest old (85+) age category (Burkhardt et al., 1998, pp. 24-38).

Wiggers (1999) projected future drivers to 2030 using FHWA licensed driver counts in combination with the AHEAD driver rates. The AHEAD survey asked respondents to identify their driving status as "drive," "don't drive," and "never drove." Using this information, Wiggers (1999, pp. 39-60) calculated a rate at which former drivers cease to drive when they become elderly. He then calculated the percentages of elderly in each age group who will still be driving in the future (Wiggers, Table 7). (For more information, see Section 10.1, Table 10.3.)

Prior to our model, Burkhardt et al. (1998) and Wiggers (1999) provided two principal alternatives to projecting the number of drivers in the future. In each alternative, the authors stressed that the methodology used assumptions that could be incorrect.

3.3.2 Changes in Driving Habits

In the United States, driving an automobile is critical to achieving independence and mobility. Kostyniuk, Trombley, and Shope (1998) reviewed the literature on driving reduction or cessation among older drivers. They documented that driving habits change as drivers age. For example, after retiring, there is no daily commute to work; in addition, older persons avoid driving at night, in heavy traffic conditions, and during adverse weather conditions; finally, they may drive more slowly than younger drivers. When driving becomes more difficult because of age-related factors, the decision to curtail or stop driving implies dependence on friends and family or on public transportation. Age-related factors leading to a reduction in driving include declines in vision, cognitive ability, psychomotor ability, and health problems, among other reasons (Kostyniuk, Trombley, and Shope, 1998, p. 23).

> Studies have focused on driving reduction and cessation within specific populations of older drivers, and the findings may not be generalizable to other groups of elderly. ... There is a need to examine driving reduction and cessation decisions among representative populations of older people with differing education, income, and living situation characteristics. ... The driving cessation process may have distinct stages, and advice and other interventions from external sources may be perceived differently at each stage. The stages could be a function of an individual's health, age, and the amount of compensatory driving behavior they have implemented (Kostyniuk, Trombley, and Shope, 1998, pp. 32-34).

Marottoli et al. (1993) examined specific risk factors from a driving survey of former participants of the EPESE study group to see if there were specific causes for driving cessation among those who had stopped driving since the earlier study. Factors that were examined included "higher age, lower income, not working, neurologic disease, cataracts, lower physical activity level, and functional disability." Using a multiple logistic regression model, Marottoli found that the elderly continued to drive if no risk factors were present, 17% stopped driving if one or two factors were present, and 49% stopped driving if three or more factors were present (Marottoli et al., 1993).

According to Schatz, Stutts, and Wilkins (1999A), seniors do not **plan** to stop driving and, indeed, are reluctant to give up the freedom of mobility associated with a personal automobile. Men are especially reluctant to stop driving because they feel a responsibility to provide transportation and are generally more hesitant to ask for help from family or friends. When the elderly do stop driving, they generally depend on family members for transportation needs. Even when seniors have access to public transportation, they often feel that it is not adequate because it does not fit their schedules and they have concerns for personal safety. Seniors feel that they will know when it is time to stop driving; however, some continue driving even after loss of license or at-fault crashes. Other seniors, especially women, may stop driving prematurely. At least one study reported that women are twice as likely to stop driving as men and that men generally cease driving only because of poor health and disability. It is certain that, at least for the current elderly cohorts, a larger percentage of senior men drive than senior women (Schatz, Stutts, and Wilkins, 1999B, pp. 1-2). Women may stop driving because the "man of the family" prefers to drive. Once a senior stops driving, the chance that she will resume driving is 10% or less. Unfortunately, however, these women may outlive their driver-husbands and may need to reinitiate driving to maintain mobility.

Smiley (1999) discussed adaptive strategies employed by the elderly when they experience declining functional capabilities and changing mobility needs. She noted that the most frequent strategic adaptation of the elderly is to reduce exposure – to drive less and to avoid driving at night or in inclement weather. In addition, older males tend to increase their frequency of use of seat belts, which is a strategic decision. The most frequent tactical adaptation is in speed reduction, increased headway, and lengthened gaps at intersections.

3.3.3 Driving Distances

The elderly drive fewer miles annually than persons under age 65. However, their average annual mileage is increasing, especially for women. Based on Nationwide Personal

Transportation Survey (NPTS) data, Burkhardt et al. (1998) predicted that annual miles driven by the elderly would increase dramatically by 2030. In a separate article, Burkhardt (1998A) estimated that between 1990 and 2020, the total annual mileage driven by male older drivers will increase by 465% – and, Burkhardt asserted, this estimate is conservative. For senior women drivers, the total annual vehicle miles driven will increase almost 500%.

Although the total annual VMT per person of elderly drivers is predicted to increase (Section 7), it is expected that the elderly will almost certainly continue to drive fewer miles than drivers in the labor force. Persons who drive less generally do most of their driving on local roads, rather than expressways. The crash rate on local streets, which include problems such as congestion, difficult intersections, pedestrians, and other hazards, is higher than that of divided highways with controlled access (See also Section 3.4.1.). Because it is impossible to quantify what percentage of the VMT of older drivers is actually driven on the different types of roads, however, this phenomenon was not factored into the ORNL model.

3.3.4 Alternative Transportation Modes

Scott Bogren, editor of *Community Transportation,* has stated that "Today, senior transportation services are one of the fastest growing segments of the transit industry." (Bogren, 1998, p. 5).

To determine the most appropriate alternative transportation option for the elderly, several criteria must be addressed. First, the physical, functional, and budgetary constraints of the elderly person desiring alternative transportation must be considered. Second is the geographic location. Because most transportation providers need to make a profit, public transportation is more prevalent in urban or more densely populated areas. For areas with limited appeal for "typical" public transportation, alternative service options (e.g., public agencies, volunteer groups, etc.) and other innovative options may be available (Suen, 1999).

The typical city bus is not the transit service desired by seniors. Many seniors are concerned that they will fall while boarding or departing from the bus or during transit if they must stand while the vehicle is moving. In addition, because they don’t want to be considered old and slow, they feel rushed to pay their fares and find a seat. “Smart” fare cards, better on-board displays, auditory cues, and other devices will assist the elderly passenger and perhaps encourage more transit use (Suen, Mitchel, and Henderson, 1998).

An example of an alternative senior transportation service is the Independent Transportation Network (ITN) operating within a 15-mile radius of Portland, Maine. The ITN, which uses automobiles to transport elderly riders at the riders’ convenience, is one innovation which seems to have gained approval among its elderly riders.

Additional mobility options in some locations include pedestrian facilities. For seniors, walking is the second most important travel mode after the private vehicle. Pedestrian accommodations to aid elderly pedestrians at intersections include crosswalk lighting and better signs.

For any alternative transportation option, the elderly person must feel safe, secure, and free from harassment while occupying the transit vehicle, while waiting for the transportation vehicle to arrive, and while getting to and from the boarding location (U.S. Department of Transportation, 1997A, p. 50).

3.3.5 “Intelligent” Technologies and Other Adaptive Equipment

The Intelligent Transportation System (ITS) is developing highway and in-vehicle devices that may help seniors with the driving task. Current ITS applications include route guidance mechanisms, emergency vehicle location and response systems, adaptive cruise control, vision enhancement, and collision warning systems. Because of their fairly recent incorporation within the market and their relative expense, these systems are not currently widespread among the older driver population (Caird, 1999, p. 3). Hazard warnings, tourist services, and “smart” signs are typical highway devices that assist all travelers, including the elderly.

Caird (1999) reviewed several studies of the elderly and ITS applications. He found that the elderly do not want to relinquish their control of the vehicle (as with anti-collision devices) and do not want to be startled by loud noises (e.g., warning devices). Women are more reluctant than men to try new technologies. The elderly were, however, enthusiastic about receiving up-to-date information (e.g., road conditions and weather) and appreciative of devices such as breakdown detection and emergency alerts.

The use of head-up displays (HUDs), a technology long used in aviation, is being studied for automobiles. HUDs display certain information to the driver on the windshield; thus drivers can see information (e.g., speed) displayed on the windshield rather than needing to shift their visual focus to a location within the vehicle. The shorter refocusing distance may benefit the elderly driver especially. However, after a critical examination of HUD research literature, Tufano (1997) cautioned that human factors testing of HUDs has been inadequate to determine either the operational benefits or safety-related risks of HUDs in automobiles.

According to Schatz, Stutts, and Wilkins (1999A), seniors do not like “clutter” in their vehicles and prefer to drive a vehicle that is familiar to them. Therefore, some of the in-vehicle guidance mechanisms may be less appealing to seniors. Other in-vehicle systems, such as those to help drivers access emergency assistance, have gained wider popularity.

Seniors approve of improved roadway environment/markings such as protected left turns and more reflective road markings. These vision enhancement systems appear to be promising emerging technologies for assisting the elderly.

> A variety of ITS in-vehicle applications will affect older driver performance. Fear of using technology, difficulty seeing displayed information, ease of use, the need for quick responses to warnings, long auditory or visual messages, and a lack of effective training are significant barriers to large-scale acceptance of ITS applications by older drivers. ... In-vehicle displays must be seen across a wide range of lighting conditions and, more importantly, across age-related changes in the visual system. ... ITS systems offer the potential to increase the mobility and safety of future older drivers. However, these systems are not the only countermeasures available. ... [R]esearch is still needed to determine the degree to which in-vehicle ITS's can offset declines due to aging processes and whether this objective is realistic. ... [T]he relationships between driving performance with these systems and safety (i.e., accidents) has yet to be determined. ITS applications must, at the minimum, keep preexisting levels of safety constant (Caird, 1999, pp. 23-26).

According to Pike (1999), additional in-vehicle devices that may someday provide protection and/or assistance to seniors include changes in seat belt design, making the belts easier to put on and take off as well as more comfortable; seat belts and air bags that adapt to the condition of a particular crash or the size of the person; seat design to protect the rider from neck injuries; and mechanical devices that assist those with physical limitations when entering/exiting the vehicle. Simple in-vehicle accommodations – for example, making the legibility of the transmission selector positions more pronounced (e.g., ensuring that "P" is distinguishable from " R") might also help. It should be noted that no studies have quantified the impact of these technologies on crash involvement rates and they are not factored into ORNL's model.

According to Koppa (1999) visual acuity correction in the form of special eyeglasses may assist some elderly drivers. In addition, hearing losses can be accommodated through after-market addition of in-vehicle visual warning devices to augment auditory warnings. Other add-on devices can make levers and handles easier for arthritic hands to operate. Extensions of pedals and relocations of controls are also possible to help with drivers who have difficulty moving their legs or who have strength limitations. It should be noted that ORNL could find no other data on the crash involvement rates of drivers using these types of after-market devices and did not incorporate the usage of these technologie in the projection model.

Specific highway enhancements to reduce the crash involvement of the elderly have been recommended (Staplin, 1999). These highway design changes include larger and brighter signage and pavement/curb guides (to accommodate problems with nighttime driving); intersection designs and redesigns to improve visibility and ensure standard, consistent positioning of turn/merge lanes and signage (to alleviate the maneuverability problems of the elderly at intersections); improvements in freeway entrance/exit lanes and signage; and improved pedestrian controls and longer crossing times at crosswalks (Staplin, 1999).

ITS technologies and adaptive technologies will certainly impact driving strategies of the elderly and may have a significant impact on their crash involvement in the future. The actual extent of these impacts are impossible to quantify at this time, however, and were not factored into our model.

3.4 CRASH LITERATURE

To predict the number of older drivers involved in crashes in the future (e.g., 2020), it is necessary to look at crash data from the past. A discussion of available crash data sets is provided in Chapter 4. Sections 3.4.1-3.4.5, below, provide a brief overview of the current literature providing analyses of crash data.

With increasing age comes increasing frailty. The increasing risk associated with traffic crashes as drivers age was discussed in Section 3.2.2 and will not be addressed further in this chapter.

3.4.1 Crash Involvement

"Crash involvement" may be measured in several different ways. One way is simply to count the number of crashes (or the number of fatal crashes). However, simply counting crashes does not provide an idea of a crash rate. As noted in Hu, Young, and Lu (1993, p. 56), a crash rate can be calculated in several ways, including the following:

- Crashes per capita,
- Crashes per licensed driver,
- Crashes per vehicle miles driven, and
- Crashes based on the proportion of drivers at fault.

Each of these calculations results in a different viewpoint of the older driver's crash involvement. For example, based on numbers of licensed drivers, older drivers have fewer crashes than do younger drivers; however, based on miles driven, drivers over age 75 have the highest crash rate of any age group – even teenagers (Eby et al., 1998, p. 1). These crash rates are examined in greater detail in Section 3.4.2 below, which is a synthesis of research conducted as part of the GM settlement agreement.

A crash rate based on crashes per mile driven has been used frequently as a measure of risk. According to Janke (1991), however, the use of crashes/VMT exaggerates the accident risk of low-mileage groups – such as the elderly. That is, crashes are not a result of some factor times VMT; crashes occur from exposure to crash risk. VMT is only one component of this risk. Another component is type of roadway. Using1984 data compiled by the California Business, Transportation, and Housing Agency, Janke (1991, p. 184) noted that were 2.75 times more crashes/mile driven occurred on non-freeways than on freeways. Because high-mileage drivers generally amass most of their VMT on freeways, they face less risk of being involved in a crash than low-mileage drivers who drive primarily on local streets and roads (e.g., elderly drivers). Therefore, the high crash rate of elderly drivers (as measured by crashes/VMT) is not necessarily an indicator of their being dangerous drivers.

3.4.2 Other GM Project Results (Projects G.1 and G.8)

The settlement agreement between GM and DOT includes other projects that are related to the objectives of this research. The most closely related project is Project G.1, "Changes in Crash Involvement Rates as Drivers Age." The purpose of Project G.1 was to determine how a number of risks vary with driver age from two distinct perspectives. The first problem was to determine how risks change that older drivers themselves face – a matter mainly of concern to the older driver. The second problem was to determine how risks change that older drivers impose on other road users – a matter mainly of concern to the general public.

Evans, Gerrish, and Taheri (1998) used data from the Fatality Analysis Reporting System (FARS) for 1994-1996 and other data sources (same time frame) to compare crashes and crash rates of older drivers to those of other age groups. They arrived at the following preliminary findings:

- During the 1994-96 time frame, the average number of *driver* fatalities per year (all motorized vehicles) reached its maximum value at age 21.5 for males (593.5 fatalities) and age 18.5 for females (191.7 fatalities) and then generally decreased. Therefore, when looking at a simple *count* of fatalities, younger drivers are fatally injured in traffic crashes far more often than the older driver.
- When the number of fatalities (by age and gender) is divided by overall population, driver deaths per capita for males are highest among males under 22 and over 80. Females show a similar but much more muted pattern.
- Driver fatalities per licensed driver show a similar pattern to that of fatalities per population. That is, the fatality rate as measured by the greatest number of fatalities per licensed driver occurs in ages under 22 and over 80.
- Using data from FARS and also the NPTS, driver fatalities per unit distance traveled was computed. This measure shows a similar pattern although even more pronounced at the under 22 and over 80 ages because older and younger drivers drive fewer miles than drivers between the ages of 22 and 80.

Evans, Gerrish, and Taheri (1998) went on to examine influences that affect the crash risk – e.g., amount and type of driving, driving capabilities, vehicle type, time of day, alcohol consumption, seat belt use, and driving risks. Results indicated that rates of severe crash involvements per vehicle miles traveled (VMT) were smaller for the elderly than for drivers under 20 years of age.

Evans, Gerrish, and Taheri (1998) compared the risks that elderly drivers impose on others by examining involvements in single-vehicle crashes involving pedestrians. The authors noted that "licensing an older driver (data goes up to age 80) does not pose a greater threat to other road users than licensing younger drivers – indeed it poses substantially less risk than licensing a 20-year-old" (Evans, Gerrish, and Taheri, 1998, p. 12).

GM Project G.8, "Investigations of Crashes and Casualties Associated with Older Drivers," used detailed crash data from North Carolina data sets to compare fault and violation records of drivers over age 65 with fault and violation records for drivers age 45 to 64. Using North Carolina data sets as well as national data, the project investigated the harm rendered by the older driver to self as well as the harm to other drivers. This research resulted in the following highlights:

- The percent of at-fault drivers in two-vehicle crashes increase steadily from 40% for 45-54 year olds to approximately 80% for the oldest drivers in the North Carolina data; very similar trends appear in the FARS data.
- Corresponding odds ratios for chances of being at fault for age categories 55-64, 65-74, 75-84, and 85+ relative to those 45-54 are 1.22, 1.77, 3.27, and 4.57, respectively.
- Older drivers are increasingly at fault for (1) left-turn maneuver crashes, (2) right-turn crashes, and (3) straight-ahead angle crashes.
- In single-vehicle crashes involving drivers 65+, a very high 9.2% resulted in serious injury or fatality.
- The older driver has special problems at non-signalized intersections.

- As age increased, being struck as a pedestrian became more likely than striking a pedestrian as a motor vehicle driver.
- Poisson regression models developed to predict expected numbers of crashes per driver for specific types of crashes estimated the following: 21.0 crashes/year for every 1,000 male drivers aged 65-74 residing in "urban" counties with populations of 100,000-300,000, of which 1.2 of these would result in a moderate to fatal injury in the other vehicle.

3.4.3 Gender Effects

Studies have examined gender differences in fatal crashes. For example, in 1998, male drivers (all ages) were involved in almost three times as many fatal crashes as female drivers (National Highway Traffic Safety Administration, 1999A). Evans, Gerrish, and Taheri (1998) compared gender-based crash rates for elderly drivers and found that the curves of these gender-based crash rates, when plotted, were remarkably similar. In addition, when the rates of traffic deaths to all deaths was plotted, there was very little gender difference between the ages of 20 and 70.

In 1995, Massie, Campbell, and Williams studied crash data and travel data to produce crash involvement rates per VMT by age and gender. They observed that "men had a higher risk than women of experiencing a fatal crash, while women had higher rates of involvement in injury crashes and all police-reported crashes" (p. 73).

Continuing this line of study in 1997, Massie, Green, and Campbell studied the effects of driver age, driver gender, time of day, and average annual mileage on severe and fatal crashes. Men consistently have a higher risk of crash involvement per mile driven than women. It had been thought that this greater involvement was because they drove more (greater exposure). After adjusting for the greater number of average annual miles driven by men than women, this study suggested that, if women drove similar amounts, women's involvement rates would be lower than men's regardless of crash severity (Massie, Green, and Campbell, 1997). In addition, after adjustment to make average annual miles equal for both genders, men's crash-involvement rates for injury and property-damage-only were higher than women's rates. Although Massie, Green, and Campbell have no definitive explanation for why women's crash rates are so much lower than men's crash rates (after adjustment for equal average annual mileage), they offer some suggestions concerning why the injury and property damage rates (crashes/VMT) are higher for women than men. It is possible that women are involved in a greater number of injury and property-damage-only crashes *per VMT* because of driving inexperience, which is due to their lower average annual mileage; therefore, when the rates are adjusted for this lower mileage, the differences in fatal crash rates become even greater and the women's crash rates for non-fatal crashes drop below those of men. Another possible explanation involves the types of streets on which women drive. Persons with low average annual mileage (in this case, women) drive more on urban and local streets and roads than they drive on rural interstates. Urban and local streets have higher crash rates than do rural interstates.

One study identified gender-specific health factors related to crash risks. Factors that place elderly female drivers at risk include living alone and experiencing back pain. Risk factors for men include being employed, scoring low on word-recall tests, having a history of glaucoma, or using antidepressants. The number of miles driven and use of antidepressants were the most significant risk factors for men (Hu et al., 1998, p. 569).

Stamatiadis (1999) examined gender distinctions in crashes involving elderly drivers. He used two-vehicle crash records for Kentucky between 1994 and 1996, eliminating crashes for which he could not determine which one of the two drivers was at fault. He then calculated a crash rate for age-gender groups based on the percent of crashes for which the driver was at fault divided by the percent of crashes for which the driver (same age-gender group) was not at fault. Although there were no significant differences in the crash rates of males and females for ages up to 55, statistically significant (5% level) gender differences were noted for age groups 55-64, 65-74, and over 75. Females were more often at fault than males for these age groups. Stamatiadis concluded that, while elderly women have higher accident and at-fault rates than elderly men using mid-1990s data, this gender effect could be caused by a lack of driving experience when younger. He suggested that, because there are no significant gender differences in the at-fault rates for the younger age cohorts, this phenomenon may not continue in the future.

3.4.4 Crashes Involving Elderly Drivers

In 1972, traffic fatalities reached a peak when a total of 55,600 persons were killed in highway crashes, a rate of 4.41 fatalities per 100 million annual VMT. In 1998, total fatalities had decreased to 41,471 persons at a fatality rate of only 1.6 fatalities for each 100 million annual VMT (U.S. DOT, 1997B, Table FI-200; National Highway Traffic Safety Administration, 1999A, Table 1). The overall number of fatalities and fatality rates (fatalities per million VMT) have decreased regularly since 1972. This trend has not proved true for the elderly, however. Figure 3.6 shows the steady increase in the number of older driver fatalities annually since 1980.

As noted in Section 3.4.3, certain factors place older drivers at risk, and these factors differ by gender. As noted in Section 3.2, various health factors associated with aging, especially those involving vision degradation, have been correlated with traffic crashes. In 1988, Evans documented older driver involvement in severe and fatal crashes and noted that the risks faced by older drivers and the risks caused to other drivers are decreased by the reductions in miles driven by older drivers. Evans concluded that the problems of aging drivers are more related to a loss of mobility than to an increase in risks (Evans, 1988).

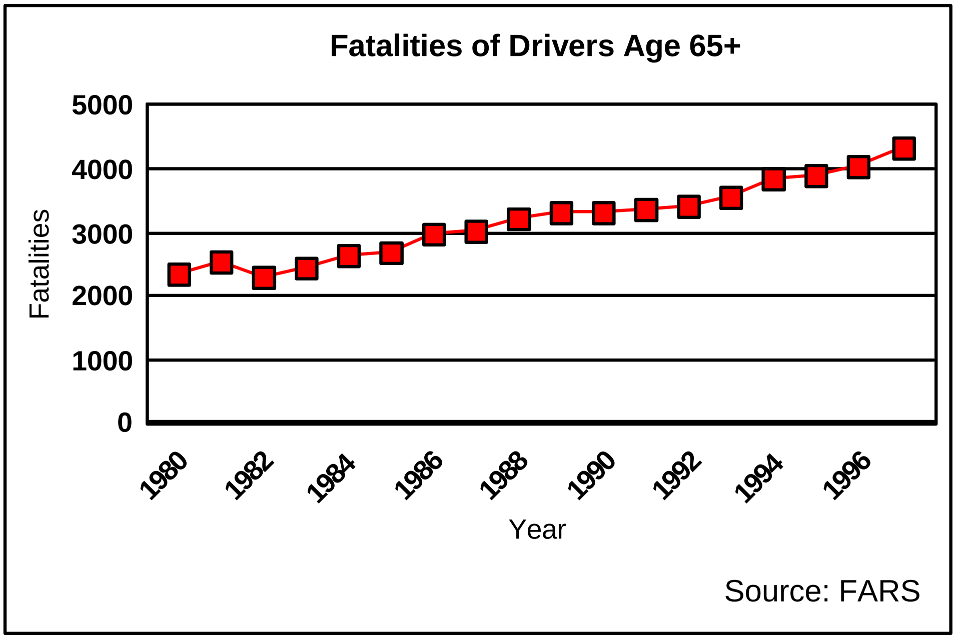

Figure 3.6. Fatalities of Drivers Age 65 or over from 1980-1997.

According to the *Older Driver Highway Design Handbook*, the "single greatest concern in accommodating older road users, both drivers and pedestrians, is the ability of these persons to safely maneuver through intersections" (U.S. DOT, 1998, p. 3). Intersections present problems for all drivers. About 50% of all crashes (fatal and non-fatal) of drivers under age 65 occur at intersections, and almost 60% of all older driver crashes occur at intersections (National Highway Traffic Safety Administration, 1993). However, when statistics for only fatal crashes are compared for elderly and non-elderly drivers, the percentages are not so close. For example, over 50% of all fatal crashes for drivers age 80 and over occur at intersections, which can be compared with only 24% of all fatal crashes for drivers under age 50 (U.S. DOT, 1998, p. 3).

Although freeways have lower fatality rates than any other type of U.S. highway, entrance and exit ramps present a distinct problem to older drivers. Older drivers were cited most frequently as being at fault for failure to yield and improper lane use (U.S. DOT, 1998, p. 15). Anecdotal evidence suggests that horizontal curves also present difficulty for older drivers (U.S. DOT, 1998, p. 19). In work zones, failure to yield was a major contributing factor as was driver inattention. Older drivers respond more slowly than younger drivers to unexpected stimuli and tend to be much slower to detect a warning sign, make a decision, and complete a vehicle maneuver (U.S. DOT, 1998, pp. 23-24). All of these traffic conditions contribute to crashes involving the older driver.

3.4.5 Projections of Crashes and Casualties

Because of the increasing population of elderly persons (i.e., persons 65 and older) in the next quarter century, historical trends of their increasing mobility (which implied greater exposure to traffic crashes), and historically high fatality "rates"(i.e., fatalities per vehicle miles driven), predictions of a crash problem involving the elderly are impossible to ignore.

Burkhardt (1998B, pp. 6-7) projects that the number of elderly-driver-involved fatalities will more than triple between 1995 and 2030, from 7,038 to 23,121 (Burkhardt, 1998B, Figure 2). It should be noted that Burkhardt's purpose in this document is not to document his methodology for arriving at this projection. Rather, the purpose of the report is to influence policy decisions for ensuring mobility and independence of older drivers into the future. This report is discussed more fully in Section 10.1.

Wiggers (1999) projects that elderly traffic fatalities will be about 2.5 times greater in 2030 than they were in the mid-1990s. (Wiggers averages the numbers of elderly traffic fatalities between 1993 and 1997 to use as the comparison number.) He estimates an increase in fatalities from 6,326 to 15,889 (Wiggers, 1999, Table 3). Wiggers also notes a dramatic increase in the number of elderly female drivers in the future. The percentage of female drivers killed will increase from 41% (1993-1997 average) to 59% (2030 projection) of all elderly female traffic fatalities (Wiggers, 1999, pp. vii-viii). This report is also discussed more fully in Section 10.1.

Both the Burkhardt and Wiggers projections indicate significant increases in elderly crash-involved traffic fatalities in the next three decades. Based on increasing elderly population numbers and on elderly drivers' increased VMT (crash exposure), these increases in the numbers of crash-related fatalities of the elderly seem inevitable. In addition, as shown in Table 3.5, between 1986 and 1996, the percentages of traffic fatalities that represent persons age 65 and over increased faster than the proportion of the elderly within the entire population (Hakamies-Blomqvist, 1999).

Table 3.5. Comparison of Changes in Percentages of the Elderly in the General Population and in a Count of Total Traffic Fatalities, 1986-1996

Year	Population Over Age 65 (%)	Traffic Fatalities of Persons Over Age 65 (%)
1986	12.1%	13%
1996	12.8%	16.9%

Even with the "increases" noted above, the cause of death for the elderly in 1996 was 19.8 times more likely to be caused by heart disease and 12.4 times more likely to be caused by cancer than by a traffic crash (U.S. Census Bureau, 1999). The primary causes of death at various ages are shown in Figure 3.7. As can be seen in this figure, traffic-related fatalities are a more common cause of death for age groups under 65 than for the elderly. For example, motor vehicle crashes account for 14.7% of all deaths in age group 15-34, but less than 1% of all deaths for age group 65 and above.

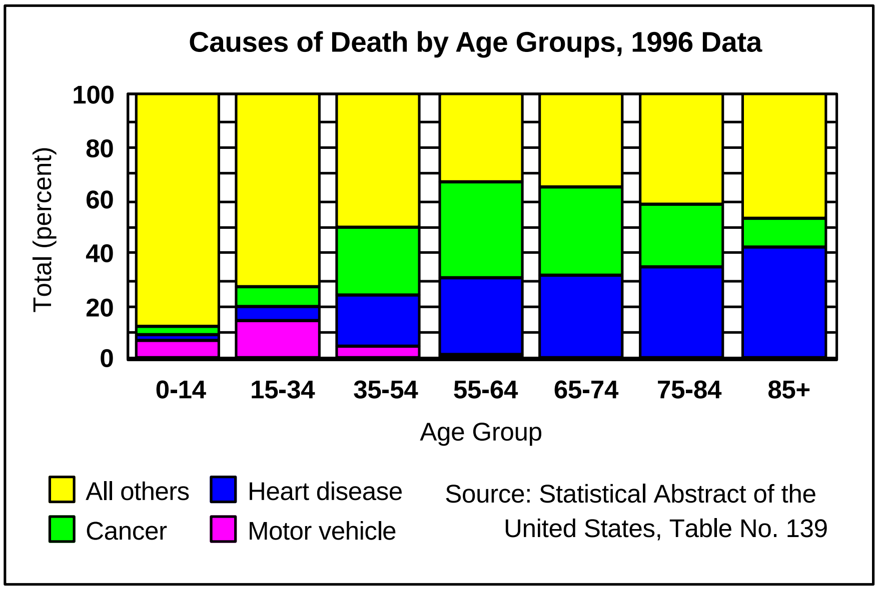

Figure 3.7. Comparison of Selected Causes of Death, by Age Group, 1996 Data.