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M-CASTL 2008 SYNTHESIS REPORT: VOLUME 1, OLDER ADULT MOBILITY

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16. Abstract

The theme of the Michigan Center for Advancing Safe Transportation throughout the Lifespan (M-CASTL) is **Safety and Mobility throughout the Lifespan**. The purpose of the annual synthesis report is to identify short and long-term research needs that support the M-CASTL theme and reflect the US DOT's national transportation research agenda. The intent of the reports is to help focus the Center's research program and to maintain continuity over each year of the grant. The synthesis report also serves as the background for the annual M-CASTL Transportation Research and Education (TR&E) meeting. This report addresses the research needs for older adult mobility. The areas reviewed are: populations trends; driving trends; traffic safety; mobility needs; medical conditions and medications; screening and assessment; education and rehabilitation; vehicles and advanced technology; roadway design; Transitioning to non-driving; and alternative transportation options. This synthesis reviews some of what is known about maintaining older adult mobility and defines several areas where further research is needed. There are several themes that thread through this synthesis report. First, mobility is needed by all people. If mobility needs are not met by driving, then they must be met by other means. Second, older adults are not a homogeneous group. Older adults vary greatly in: the functional declines they may be experiencing; their ability to compensate for declines; their financial and social resources; and their personalities. All of these characteristics interact with the factors influencing safe mobility. Third, older adults, as well as all drivers, need lifelong education to maintain safe mobility. For the older adult, learning about roadway design changes, how to use advanced technology, and the transportation options available when driving is no longer possible is an important component in safe mobility. Fourth, research to help older adults stay mobile will also help younger drivers. Finally, meeting the mobility needs of an aging population is complex and will require the expertise and collaboration of several academic and applied disciplines. The M-CASTL will continue to provide these collaborative opportunities.

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INTRODUCTION

Safe mobility is a basic human need. The theme of the Michigan Center for Advancing Safe Transportation throughout the Lifespan (M-CASTL) is **Safety and Mobility throughout the Lifespan**. The M-CASTL strives to advance expertise and technology in the many disciplines comprising the safety and mobility of both young people and older adults. Both young people and older adults present unique safety and mobility challenges. The M-CASTL also works to increase understanding of and address—across the different dimensions of the roadway, vehicle, and driver—the risks related to the two ends of the age spectrum. The specific thrusts of the Center focus on understanding and addressing: the changing perceptual, cognitive, and psychomotor abilities of older drivers; the transportation needs of young people and older adults when they are unable or choose not to drive themselves; and the elevated crash risk of young drivers.

The purpose of the annual synthesis report is to identify short and long-term research needs that support the M-CASTL theme and reflect the US DOT's national transportation research agenda. The intent of the report is to help focus the Center's research program and to maintain continuity over each year of the grant. The synthesis report also serves as the background for the annual M-CASTL Transportation Research and Education (TR&E) meeting. The first volume (this report) addresses the research needs for older adult mobility and the second volume addresses the research needs for young driver safety.

POPULATION TRENDS

Most industrialized countries are experiencing a dramatic increase in the population of people 65 years of age or older. In the US, the number of people in this age group is projected to grow from about 35 million in 2000 to more than 86 million in 2050 (US Census Bureau, 2004). In terms of the percent of the total population, those 65 years of age and older will account for about 20.7 percent of the population in 2050, up from about 12.4 percent in 2000. Even larger increases are expected from the oldest-old; that is, those 85 years of age or older. This age group is expected to grow from about 4.3 million in 2000 (1.5 percent of the US population) to 20.9 million in 2050, when then they will account for 5 percent of the population (US Census Bureau, 2004).

What is causing this increase in the elderly population? One factor is that people are living longer. According to the US Census Bureau (2008), life expectancy is projected to increase from 76.0 years in 1993 to 82.6 years in 2050. The unknown effects of increasing obesity in US society, however, may lower this projection. In addition to increased lifespan, much of the growth in the elderly population can be attributed to the baby boomers. The baby boomers are the cohort born in America during the period of increased birth rates following World War II, between 1946 and 1964 (US Census Bureau, 2006). Thus, the first baby boomer will turn age 65 in 2011. By 2028, all living baby boomers will be between the ages of 65-82 years.

DRIVING TRENDS

Dependence on the Personal Automobile

Most baby boomers consider driving to be indispensable to their well-being and independence. This partly results from the lack of transportation alternatives (Kostyniuk, Shope, & Molnar, 2000) and partly from the culture under which the baby boomers grew up. Furthermore, during the years in which baby boomers were first being licensed to drive (approximately 1961-1981), changes in family composition, the tendency to move out of urban areas (suburbanization), and the increased availability and affordability of automobiles made the personal automobile the preferred choice for personal mobility (McGuckin & Srinivasan, 2003).

Driver License Holding

Driver license holding is high among the current older adult population and is increasing. The percentage of older adult males holding licenses is over 90 percent. The percentage of older adult women holding licenses in the US is lower but increasing. Between 1993 and 2006, there was an 8 percentage point increase in licensure for women aged 65-69 and a 22 percentage point increase for women aged 70 and over. Thus, the licensure rates for women are approaching those of men, and this trend is expected to continue as the baby boomers age (Burkhardt & McGavock, 1999).

Changes in Annual Driving Distances

Not only will there be a larger proportion of older adult drivers holding licenses, they will also be driving more miles. When compared to 1990, the average number of trips per person for people 65 years of age or older increased from 2.4 to 3.4 in 2001 (Hu & Reuscher, 2004). This increase was greater than for any other age group. Since 1969, the average annual number of vehicle miles traveled for older adults has also increased dramatically.

Behavioral Adaptations

It is well-established that driving patterns change as people age. These changes result from changes in lifestyle, economic status, and from drivers regulating their driving to compensate for declining abilities (Hakamies-Blomqvist, 2004). Collectively, these changes have been labeled behavioral adaptation (Hakamies-Blomqvist, 2004; Smiley, 2004). A large body of literature has shown that when compared to younger drivers, older adult drivers are more likely to avoid difficult driving situations such as nighttime, inclement weather, high traffic times, urban areas, and highways (Gallo, Rebok, & Lesikar, 1999; Kostyniuk, Shope, & Molnar, 2000; Stamatiadis, Taylor, & McElvey, 1991; Chipman, MacGregor, Smiley, & Lee-Gosselin, 1993; Hakamies-Blomqvist & Wahlström, 1998; Ball et al., 1998). Some older drivers also make adaptations to strategic driving behaviors such as driving slower, driving more often with a passenger, avoiding unprotected left turns across traffic, needing larger traffic gaps for merging, and more frequent use of a safety belt (Ball, et al., 1998; Eby, Molnar, & Olk, 2000; Hakamies-Blomqvist & Wahlström, 1998; Keskin, Ota, & Katila, 1989; Van Wolffelaar, Rothengatter, & Brouwer, 1991). However, more recent work shows there is considerable variation across studies, making it difficult to determine the extent of self-regulation by older drivers. For example, rates of self-reported avoidance of night driving vary from 8 percent (Baldock, et al., 2006), 25 percent (Charlton, et al., 2001), 60 percent (Ruechel & Mann, 2005), and 80 percent (Ball at al., 1998). There are also mixed results with regard to the association between self-regulation by older drivers and the functional declines they may be experiencing (Baldock et a., 2006; Ball et al., 1998; Charlton, et al., 2001, 2006; Stalvey & Owsley, 2000). While it appears that gender (Charlton, et al., 2001; Kostyniuk & Molnar, 2005, 2007; Hakamies-Blomqvist & Wahlström, 1998), awareness and insight into functional impairments (Ball et al., 1998; Freund et al., 2005; Owsley et al., 2004; Owsley, Stalvey & Phillips, 2003; Stalvey & Owsley, 2003), and self-perceptions of driving confidence (Baldock et al., 2006; Charlton, et al., 2001) are also closely tied to behavioral adaptations, these factors are not consistently examined in studies. More research is needed to help understand the relationship between adaptations and traffic safety.

TRAFFIC SAFETY

Crash Risk

The traffic safety impact of the aging population has received considerable research attention in the past decade (e.g., Transportation Research Board, TRB, 2004). Despite the infrequent, yet highly publicized, fatal crashes involving older adult drivers, there is still debate as to whether or not older adults as a group pose a risk on the roadway to themselves or others. In terms of the number of driver deaths, there are far *fewer* fatalities for older adults than for younger people. This fact, however, can be misleading since we know that there are fewer people in the older age groups, driver licensure rates drop in the older adult population, and older people drive less than younger people. Each of these factors could lead to fewer total fatal crashes after age 50, independent of declining driving abilities.

In order to account for these possible effects, it is better to consider motor vehicle fatality data by calculating rates. Figure 1 shows driver motor vehicle fatality rates by 100,000 people in each age group; that is, population-based rates. These data show that when corrected for the decreasing number of people in the older age groups, the rate of crashes begins to increase after age 74 and then decrease after age 84. However, not all people hold licenses, particularly in the youngest and the oldest age groups. As such, population-based rates do not adequately address the risks of fatal crashes by age group. Also plotted in Figure 1 are driver motor vehicle fatal crash rates by 100,000 licensed drivers in each age group. Note that in the middle age groups, the rates of licensure are very similar to the population-based rates, as nearly all US citizens in the middle age groups hold a license. At the two ends of the age spectrum, however, we see significantly increased fatal crash rates, suggesting that these age groups are at a higher risk of a fatal crash than drivers in the middle age groups.

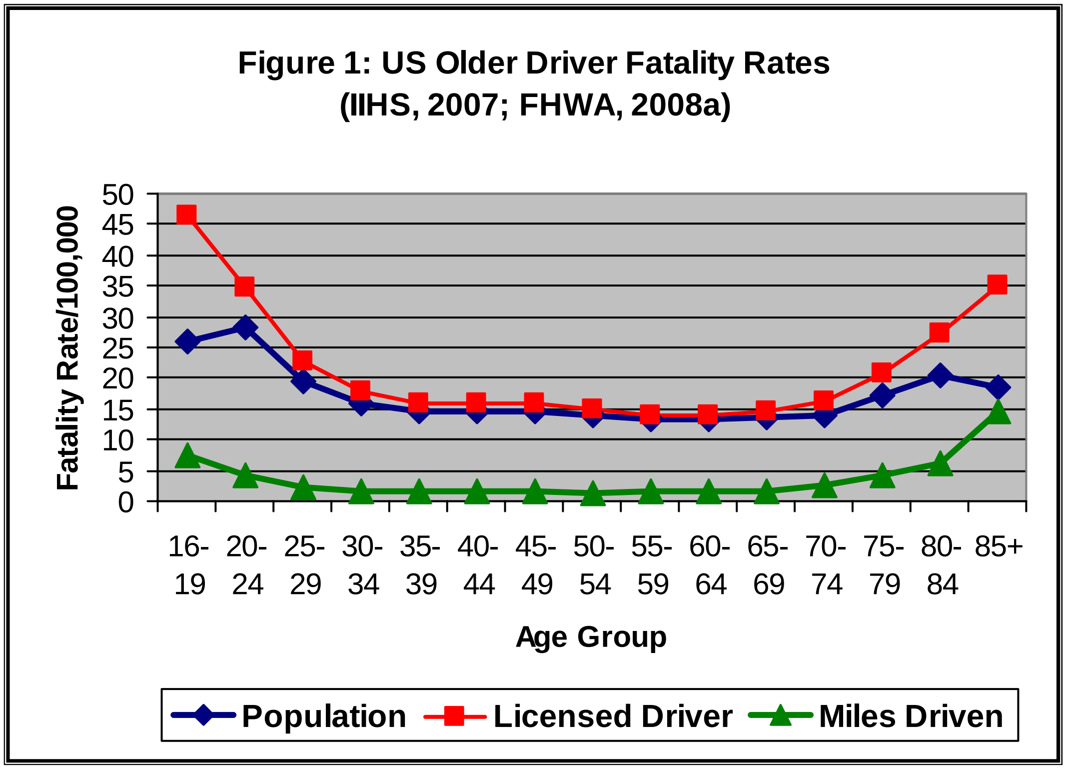

Figure 1: US Older Driver Fatality Rates (IIHS, 2007; FHWA, 2008a)

Older adult drivers, however, reduce their exposure to a crash by driving fewer miles. In order to partially account for the reduction in driving for older adults, we have calculated fatal motor vehicle crash rates per 100 million miles traveled by age group (2001-2002 data). These data are also plotted in Figure 1. When fatal crash rates are considered by miles driven, the rate is higher for drivers 85+ years of age than for any other age group.

The data in Figure 1 seem to clearly support the conclusion that drivers aged 70+ years are at increased risk for a fatal crash when compared to all but the youngest drivers. It is widely recognized, however, that older people are more susceptible than young people to injury and death from a motor vehicle crash, due to frailty (Vivano, et al., 1990; Evans, 1991; Dejeammes & Ramet, 1996). The effect of frailty upwardly biases fatal crash rates for older adults. Work by Li, Braver, and Chen (2003) have shown that even when rates are corrected for frailty, older adults are still at a higher risk of crashing than all but the youngest age group.

Recent research from Europe and Australia, however, has questioned this conclusion. This research presented evidence that the crash rate per mile driven may be biased upward for older drivers because of their tendency to self-restrict total miles driven (Hakamies-Blomqvist et al., 2002; Hakamies-Blomqvist, 2004; Langford, Fitzharris, Newstead, & Koppel, 2004; Langford, Methorst, & Hakamies-Blomqvist, 2006). This so-called "low mileage bias" was demonstrated using both Finnish and Dutch data. This research compared self-reported crash involvement by age group and self-reported annual travel distances. This work found that only those older adult drivers who traveled less than about 3000 km per year have an elevated crash rate (about 10 percent of the population in the Langford, Methorst, and Hakamies-Blomqvist, 2006, study).

Staplin, Gish, and Joyce (in press) recommend caution in interpreting these findings noting that both the crash and mileage data are self-reported in the studies and participants were self-selected. Staplin et al. present data showing poor reliability of annual mileage estimation within subjects as well as data showing large errors in estimation of annual mileage when compared to an objective measure (odometer reading). Large underestimation of annual mileage was found for objectively determined low mileage drivers whereas overestimation was found for objectively determined high mileage drivers. These results inversely mirror the results presented by Hakamies-Blomqvist, Langford, and colleagues. Thus, these results cast doubt on the low mileage bias. Further research is needed on the low mileage bias using objective crash and travel data.

MOBILITY NEEDS

Given the increase in older driver crash risk and increasing tendency for older adults to be responsible for crashes, what should society do? The issue of older driver safety is surrounded by a fair amount of confusion, emotions, and naïve solutions. One solution we often hear voiced is to simply "get old folks off of the road" (see e.g., Carr, 2000). This solution ignores the fact that only a portion of older drivers are dangerous, some older adult drivers can improve their skills through training, and older people, like all people, have mobility needs that still need to be satisfied if driving is no longer possible.

Like all drivers, older adult drivers are reluctant to give up driving and consider it to be essential to independence and quality of life (Carp, 1988; Kaplan, 1995). Driving provides an opportunity for older adults to stay engaged in their community and to participate in activities that enhance their well being, particularly in areas where alternative transportation options are limited. A number of recent studies suggest that driving cessation is associated with increased depressive symptoms over time and declines in general psychological well-being (e.g., Fonda, Wallace, & Herzog, 2001; Marottoli, Leon, Glass, Williams, Cooney, Berkman,& Tinetti, 1997; Ragland, Satariano, & MacLeod, 2005). Given the reliance on and preference for personal automobile travel, one's license should only be taken away after a comprehensive assessment shows that a person can no longer drive safely and that he or she cannot benefit from rehabilitation. At the same time, society must recognize that alternatives to the personal automobile for transportation are generally poor in most areas and considered unacceptable to many older adults (see, e.g., Kostyniuk, Shope, & Molnar, 2000). The mobility needs for older adults who can no longer drive still need to be met. As such, two complementary but interdependent goals have emerged with respect to older drivers: to help those who are able to drive safely continue to do so; and to identify and provide community mobility support to those who are no longer able to drive (Molnar, Eby, & Dobbs, 2005).

MEDICAL CONDITIONS AND MEDICATIONS

There are a number of medical conditions that are more likely in the older population that increase risk and are, therefore, associated with aging. In fact, it is not the condition itself that raises the risk of a crash, but rather how the condition influences functional abilities—those abilities needed to execute critical driving skills. A fully-managed medical condition, such as high blood pressure, may not affect driving at all.

Medical Conditions

Diabetic Retinopathy

According to the National Eye Institute (2008), diabetic retinopathy is the leading cause of blindness in Americans. This diabetic eye disease causes changes in the blood vessels of the retina, the light-sensitive layer of cells in the back of the eye needed for vision. People with diabetic retinopathy may have blood vessels that bleed or leak or have abnormal blood vessels grow that easily rupture obscuring vision (NEI, 2008b). Despite the clear effects on visual functioning, few studies have addressed the impact of diabetic retinopathy on driving and crashes. More research is needed in this area.

Congestive Heart Failure

Congestive heart failure (CHF) is when the heart does not provide enough blood flow to suit the body's needs. The causes of CHF include disease of the coronary artery, heart attack, damaged heart valves and/or muscle, arrhythmia, and congenital birth defects (Mayo Clinic, 2008). The condition causes blood to congest in various organs of the body, leading to organ dysfunction or failure. People with CHF are often fatigued, have shortness of breath, swelling of arms, legs and/or body, lack appetite, and have difficulty remaining alert (Mayo Clinic, 2008). CHF is more common in older individuals. According to the National Institutes of Health (1996), about 1.7 percent of the US population (4.8 million people) have CHF, while the incidence for those aged 70 or more is 10 percent. Unfortunately, there has been no work relating CHF to driving performance or crash risk.

Abnormal Blood Pressure

Abnormal blood pressure conditions include hypertension (high blood pressure) and hypotension (low blood pressure). Hypertension is quite common, affecting about 30 percent of Americans (Hajjar, Kotchen, & Kotchen, 2006).

An estimated 19 percent of people with hypertension over 59 years of age are unaware of the problem or are untreated (Ong et al., 2007). There has been little research on the effect of hypertension on crash risk. It is known, however, that hypertension can lead to other chronic conditions such as a stroke, coronary heart disease, a heart attack, and dementia (Dobbs, 2005). These conditions can have a serious effect on traffic safety. Hypotension is less common than hypertension, affecting an estimated 10-20 percent of older adults (WebMD, 2008). Chronic hypotension is generally not considered a problem, except for when blood pressure abruptly drops causing lightheadedness or syncope (WebMD, 2008). Again, this chronic condition has not been studied in relation to traffic safety.

Sleep Apnea

Sleep apnea is characterized by snoring, breath cessations, sleep disturbances, and daytime drowsiness (Haraldsson, Carenfelt, & Tingvall, 1992). The condition has been shown to affect various abilities related to safe driving such as forced choice and delayed reaction times, decreased vigilance and attentive abilities, impaired cognitive functioning, and psychomotor difficulties (Bédard et al., 1991; Findley et al., 1986; Greenberg, Watson, & Depula, 1987; Kales et al., 1985). One obvious concern of apnea is drowsiness while driving. Research addressing how to reducing the crash risk associated with apnea is needed.

Parkinson's Disease

Parkinson's disease (PD) is a brain disorder that affects nerve cells that produce the vital neurotransmitter known as dopamine (National Parkinson's Foundation, 2008). Dopamine is necessary for the brain to smoothly control movement. When about 80 percent of the dopamine-producing cells have died, the symptoms of PD appear. These symptoms include tremors, slowed movement, stiffness, and poor balance (National Parkinson's Foundation, 2008). PD also causes cognitive impairment including memory deficits, slowed information processing, decreased sustained and divided attention abilities, and decreased visuospatial awareness (Radford, Lincoln, & Lennox, 2004). The National Institute of Neurological Disorders and Stroke (2004) estimates that there are about 500,000 cases of PD in the US, with 50,000 new cases reported each year. The average age of onset is 60 and both the prevalence and incidence of PD increases with age. Because of the progressive nature of PD, drivers with this disorder will need to give up driving at some point in time, but may have difficulty knowing when that time has arrived (Campbell, Bush, & Hale, 1993). Indeed, a number of studies have shown that the driving abilities of people with PD are compromised (Devos, et al., 2007; Heikkilä, Turkka, Kallanranta, & Summala, 1998; Singh, Pentland, Hunter, Provan, 2006; Wood, Worringham, Mallon, & Silburn, 2004; Zesiewicz, et al., 2002). Despite the demonstrated effect of PD on driving ability, there is a paucity of studies that have examined crash risk. More research is needed to understand PD and crash risk as well as studies that address easing the transition to non-driving for those with PD.

Dementia

Dementia/Alzheimer's (DA) is characterized by intellectual deterioration, particularly memory loss, in an adult that is severe enough to interfere with occupational or social performance (McKhann, et al., 1984). This condition occurs almost exclusively in the older adult population. Because of variation in how DA is diagnosed, prevalence estimates range from 4 to 16 percent of the older adult population (Terry & Katzman, 1983; Adler, Rottunda, & Dusken, 1996; Cushman, 1992; Evans et al., 1989). Progression usually spans an average of 8 years from the time symptoms first appear, although DA has been known to last as long as 25 years. People with early-stage dementia do drive and studies show that up to 45 percent of all DA patients still drive (Carr, Jackson, & Alguire, 1990; Logsdon, Teri, & Larson, 1992; Lucas-Blaustein et al., 1988). The vast majority of these people drive alone (Lucas-Blaustein et al., 1988). Perhaps because of impaired insight, research shows that people with DA do not change their behaviors after a crash (Lucas-Blaustein et al., 1988). Research has shown that drivers with dementia drive more poorly than drivers without dementia (see e.g., Adler, Rottunda, & Dusken,, 1996; Lucas-Blaustein et al., 1988; Silverstein, Flaherty, & Tobin, 2002; Underwood, 1992). More research is needed to understand how poor driving performance in DA patients might or might not translate into an elevated crash risk.

Diabetes Mellitus

According to the American Diabetes Association (2008), a person is diabetic when their body does not produce or properly use insulin, a hormone that helps to convert food into energy for cells. Diabetes is thought to be genetic, with obesity and an inactive lifestyle contributing to its likelihood. It is estimated that about 7 percent of the US population has diabetes and it is more common in the older population (20.9 percent for those aged 60 or older) (American Diabetes Association, 2008). Diabetes causes a variety of vascular problems that can lead to various health conditions including heart attacks, visual deficits, and loss of feeling in the extremities. Insulin and other medications used to control diabetes can also adversely affect driving abilities. All of these symptoms can affect the ability to drive safely. Studies relating crash risk and diabetes have yielded inconsistent results (Charlton et al., 2004; Dobbs, 2005; Janke, 1994). More research is needed in this area.

Chronic Obstructive Pulmonary Disease

Chronic obstructive pulmonary disease (COPD) is a class of conditions that disrupt the functioning of the respiratory system. The two most common COPDs are emphysema and chronic bronchitis (COPD International, 2004). There are an estimated 16 million cases of COPD in the US and prevalence increases with age. COPD is the 4th leading cause of death for people aged 65-84 in the US (COPD International, 2004). The symptoms of COPD are similar to asthma, but much more severe and long-lasting. The symptom of greatest concern is chronic hypoxemia, or lack of oxygen in the blood. There are few studies examining COPD and driving performance or crash risk.

Depression

Clinical depression is characterized by chronic feelings of worthlessness and sadness, loss of interest in things that used to be pleasurable, loss of energy, disturbed sleep, loss of appetite, thoughts of suicide, and difficulty concentrating (WebMD, 2006). As discussed in a report by the US Department of Health and Human Services (USDHHS, 1999), the prevalence of depression in the older adult population is difficult to estimate. This report cites estimates ranging from 5 to 35 percent for adults aged 65 years or more. Although the research is sparse, some studies show that depressed people are at higher risk of crash (Sims et al., 2000). An important aspect of maintaining safe mobility in an aging society is to facilitate the transition from driving to non-driving so that that mobility can be maintained even when driving is no longer possible. There is clear evidence that the loss of driving privileges result in depression (Azad, Byszewski, Amos, & Molnar, 2002; Fonda, Wallace, & Herzog, 2001; Marottoli, de Leon, Glass, Willimas, Coonery, Berkman, & Tinetti, 1997; Ragland, Satariano, MacLeod, 2005; Siren, Hakamies-Blomqvist, & Lindeman, 2004; Windsor et al., 2007). These results show that the process of transitioning from driving to finding alternative modes of transportation needs significant improvement.

Medications

Benzodiazepines

Benzodiazepines are the class of medications that are central nervous system depressants. They are used to treat anxiety, muscle spasms, insomnia, and seizures, and are also used as a sedative (Jones, Shinar, & Walsh, 2003; Ray, Thapa, & Shorr, 1993). These drugs are more commonly known as tranquilizers and hypnotics. There are two kinds of benzodiazepines: “long half-life” and “short half-life.” An evening dose of a long half-life hypnotic can markedly impair psychomotor function the next day, but a similar dose of a short half-life drug results in less impairment (Ray, Thapa, & Shorr, 1993). While long half-life drugs generally are eliminated from the body in 24 hours for older adults, this elimination may take more than 72 hours because of an age-related decrease in metabolic efficiency (Regestein, 1992; Salzman, 1992). The literature investigating the associations between benzodiazepines and crash risk is rather limited. More research investigating the association between benzodiazepines and crash risk are needed.

Antihistamines

Antihistamines are drugs used to alleviate the symptoms of mild allergic reactions. This class of drugs is widely available over-the-counter in the form of tablets, ointments, drops, and sprays. Research shows that the sleep inducing and sedative properties of this class of drugs may impair driving ability (Verster & Volkerts, 2004). The relationship between drowsiness/sedation-producing antihistamines and crash risk has not been firmly established and more research is needed.

Antidepressants

Antidepressants are prescribed for severe and clinical depression. Some antidepressants can produce sedation as a side effect. Susceptibility to sedation as a side effect may increase with age

(Sanders, 1986). Use of sedating antidepressants is consistently associated with deterioration in a wide variety of vehicle-handling skills (Clayton, Harvey, & Betts, 1977; Hindmarch, 1988; Ramaekers, 2003; Seppala et al., 1975; Smiley, 1987). Some studies have found that sedating antidepressants increase crash risk among older adults (Hu et al., 1998; Leveille et al., 1994; Ray et al., 1992). More research is needed to educate older adults drivers to use nonsedating antidepressants if they are effective; to avoid driving if they are drowsy, even if they are taking non-sedating antidepressants; and to work with their health care provider to determine their fitness to drive.

Screening and Assessment

Making informed decisions about driving fitness requires meaningful information about the changes in driving-related abilities drivers may experience and how these changes affect driving. Although many of these changes result from medical conditions that become more prevalent as we age, the effects of these conditions vary by individual, and are complicated by the medications used to treat them. Thus, screening and assessment has increasingly focused on the functional declines that can affect driving rather than on the medical conditions that lead to these declines.

Screening and assessment can occur in a variety of settings and at various levels of complexity. Screening signifies the first step in identifying at-risk drivers and is intended to identify more obvious functional impairments. Screening may prompt and/or inform more in-depth assessment but it should not be used by itself to determine driving fitness. In-depth assessment to determine the level and cause for an observed impairment is needed to support decisions about whether someone should continue driving and under what conditions. Collectively, screening and assessment contribute to a comprehensive, multi-faceted approach for identifying older drivers who may be at risk.

Licensing Agencies

Licensing agencies have a unique opportunity to screen for fitness to drive because older drivers, like everyone else in the driving population, must go through a license renewal process. Drivers' license renewal policies in the US vary from state to state in terms of the length of the renewal cycle, requirements for accelerated renewal for older drivers, other renewal provisions. A recent expert panel on driver licensing policy developed the following research needs (Molnar & Eby, 2008):

- Design and test screening and assessment tools and/or programs using large-scale epidemiological studies across multiple jurisdictions based on objective measures;
- Translate research findings into specific recommendations for licensing agencies, clinicians, and other relevant organizations;
- Extend current focus on statistical significance to consider clinical usefulness (e.g., by identifying appropriate cutoffs and addressing sensitivity and specificity tradeoffs);
- Evaluate research outcomes within the context of how applicable and defensible they would be at the individual driver level;
- Expand the focus beyond individual measures of driving fitness to batteries of instruments;
- To determine effectiveness, expand evaluation of programs/practices to promote older driver safety and mobility.

Health Professionals

Physicians and other health professionals are uniquely positioned to assess driving-related problems as part of more general medical treatment and care. To the extent that declines in abilities are identified early, opportunities for rehabilitation or remediation can be recommended and facilitated. In the event that driving ability is too compromised, evidence suggests that many older drivers will stop driving voluntarily, if advised to do so by their personal physician (Coughlin, et al., 2004; D'Ambrosio et al., 2007). At the same time, many physicians report that they are uncomfortable with making fitness-to-drive decisions or lack the necessary information to do so (Drickamer & Marottoli, 1993; Miller & Morley, 1993; Jang et al., 2007). In such cases, patients can be referred to other clinicians, especially occupational therapists or certified driving rehabilitation specialists, for more comprehensive evaluation, including both clinical and on-road driving assessment. There are a number of research-related needs to enhance the health professional's ability to help maintain older adult mobility (Molnar & Eby, 2008):

- Develop standardized education and training for clinicians, police officers, and licensing personnel on fitness-to-drive issues;
- Develop guidelines for licensing agencies and clinicians to refer drivers for specialized driving evaluations;
- Develop education programs for clinicians on the requirements/policies for reporting;
- Develop methods for providing incentives for physician participation in medical advisory boards;
- Develop and provide education and training to members of medical advisory boards on issues such as driving and medical conditions;
- Develop resources through community collaboration to support the transition from driving to alternative modes of mobility.

EDUCATION AND REHABILITATION

The aging process affects everyone in one way or another and many older adults will eventually be faced with questions about their ability to continue to drive safely. How they answer these questions, and whether they are even willing to consider them, depends to a great extent on the information available to them about functional declines in abilities that can affect driving, strategies for compensating for, or overcoming, these declines, and how to plan for a time when driving is no longer possible. In addition, the older adult's family members and the medical profession also play a role in helping to maintaining safe mobility for aging drivers. The effectiveness of these groups' ability to help older adult drivers is dependent on the quality of information and training they receive. Thus, the availability of sound education and rehabilitation is essential for maintaining mobility among older adults.

There are several educational programs available for the older adult driver. Educational resources vary widely in terms of purpose, format, and content. While many older drivers do recognize their declining abilities and take steps to adjust their driving, others are unaware of the changes they are experiencing and the implications of these changes for safe driving. Thus, one focus of many education programs is simply to increase older drivers' awareness and knowledge about these issues. Other programs combine education with some type of training to help older drivers compensate for, or when possible, overcome functional declines. Such education and training programs are often part of the rehabilitation process for older drivers identified as functionally impaired by occupational therapists, certified driving rehabilitation specialists, and other professionals.

Are formal educational programs for older adult drivers effective? This question can be addressed in a number of ways. Most educational programs gather feedback from participants about how much they liked the programs and ways to improve them. These data are useful for program developers, but do not address the core outcomes of programs: amount learned; changes in behaviors due to the program; and changes in motor vehicle crash/injury risk. These outcomes need to be addressed in a more formal evaluation. Of those that have been formally evaluated, the research shows that educational programs:

- Increase the driver's knowledge and awareness (Eby et al., 2003; Eby et al., in press; Owsley, Stalvey, & Phillips, 2003; Marottoli, 2007; Marottoli et al., 2007a; Stalvey & Owsley, 2003);
- Increase safe driving behaviors, by self report (McCoy et al., 1993; Owsley et al., 2004; Owsley, Stalvey, & Phillips, 2003);
- Improve on-road evaluation scores (Bédard, et al., 2004; Marottoli, 2007; Marottoli, et al., 2007a);
- Do *not* help to prevent roadway injuries or crashes (Berube, 1995; Ket et al., 2005; Kua et al., 2007; Nasvadi & Vavrik, 2007; Owsley et al., 2004);
- May *increase* the number of crashes for men aged 75 years or older (Nasvadi & Vavrik, 2007).

The latter two findings may be surprising to some readers. Educational programs are voluntary, so those who participate are self-selected and may be worse (or better) drivers than the general driving population. However, a study by Nasvadi and Vavrik (2007), controlled for self-selection bias and found increased crash rates for drivers 75 years of age and older. Without further research, we can only speculate why this occurred. One possibility is that educational programs may increase confidence in this age group, exposing them to greater risk of crash (Hunt & Arbesman, 2008). It seems premature to give up on these types of programs, so more research is needed in this area.

Driver Self-Awareness Tools

Another type of educational tool for older adult drivers is the class of instruments that allow older drivers, in their own home, to learn more about functional declines they may be experiencing and what they may do about them. Three tools appear promising: *Driving Decisions Workbook* (Eby et al., 2000, 2003); *SAFER Driving: Enhanced Driving Decisions Workbook* (Eby et al., in press), and the *AAA Roadwise Review* (Staplin & Dihn-Zarr, 2006). While early self-awareness results are encouraging, there is clearly a need for further research to evaluate the effects of self screening on driver behavior. In particular, objective data are needed about the actual changes in behavior made by drivers as a result of self-awareness education (e.g., seeking out further assessment and evaluation, participating in driver education/training activities, and modifying and/or reducing actual driving), and ultimately whether self-awareness education can help lead to reductions in crash involvement.

Rehabilitation

Rehabilitation refers to the restoration of proper functioning. Some declines experienced by older adults, particularly those related to physical abilities, may be reversible through rehabilitation. While the debilitating effects of medical conditions on driving can often be helped through medical intervention (medicine, surgery, etc.), exercise and cognitive rehabilitation programs may also be promising.

Fitness

Fitness training programs involve helping older people drive more safely by improving range of motion, strength, and stamina. These programs show great promise in helping older drivers extend their driving lifetime (Marottoli, et al., 2007b; Ostrow, Shaffron, & McPherson, 1992). Given these promising results, and the fact that exercise programs have many other benefits other than improving driving performance, much more research should be conducted in this area.

Cognitive

We often hear the phrase “use it or lose it” in reference to aging and cognition, and there is evidence to support this common knowledge (see e.g., Hultsch, Hertzog, Small, Dixon, 1999). Recent efforts, however, have investigated whether cognitive functioning can be restored through training. There is strong evidence that proper and intensive training can improve cognitive functioning (see e.g., Ball et al., 1988, 2002; Delahunt et al., 2008). The effect of cognitive training on driving performance has also been studied. Kua et al. (2007) concluded that there is only limited evidence that cognitive retraining can improve driving. More research into this innovate approach to improving driver safety is needed. Of particular interest are the products of several companies (e.g., CogniFit, Posit Science, and Nintendo) that show that cognitive functioning can be improved through cognitive training. What is not known is whether or not these programs can improve the cognitive abilities to the level where they can positively impact the performance of critical driving skills or impact older driver crash risk.

VEHICLES AND ADVANCED TECHNOLOGY

Vehicle design, features, and technology are constantly changing. One obvious way to maintain safe mobility in an aging society is to design vehicles and technology that accommodate the age-related changes in functional abilities that tend to be experienced by older adults.

Automobile Design

In order to sell cars, automotive manufacturers design vehicles that are safe, comfortable, and meet the needs to the automobile purchasing public. Vehicle designs are slowly being altered or adapted by automobile manufacturers to make driving easier, more comfortable, and safer for older adult drivers (Coughlin, 2005; Pike, 2004).

Without a doubt, the automotive industry will respond to the coming wave of aging baby boomers by designing vehicles that take into account the functional declines associated with aging. Current vehicle designs, however, are not meeting these needs. Several studies report on the problems older adults have using vehicles

(Herriotts, 2005; Murray-Leslie, 1991; Petzäll, 1995; Shaheen & Niemeier, 2001; Zhao, Popovic, & Ferreira, 2007; Zhao, Popovic, Ferreira, & Lu, 2006). One factor that may be preventing automotive manufacturers from developing more age-friendly vehicles is the lack of research that has specifically addressed optimizing the design of vehicles to account for age-related functional declines (Shaheen & Niemeier, 2001). Research is needed relating age-related functional declines to specific design features to accommodate these declines.

Vehicle Adaptations

Vehicle adaptations provide an opportunity for older drivers to compensate for some age-related functional declines that can lead to unsafe driving, such as reduced strength, flexibility, range of motion, and vision-related deficits (Mollenhauer, Dingus, & Hulse, 1995; Mitchell, 1997). Vehicle adaptations help drivers with disabilities and/or aging-related concerns to do things like get in and out of the car, fasten and unfasten their safety belt, and exert control in operating the car (Shaheen & Niemeier, 2001). No research has yet determined the benefits of these aftermarket modifications on traffic safety.

There are many types of adaptive equipment that can be added to a vehicle. Although adaptive equipment is readily available to the older adult who can afford them, research has shown that many individuals who could benefit from vehicle adaptation, and professionals who work with these individuals, are not aware of the options (Silverstein, Gottlieb, & Van Ranst, 2005). Research is needed to help educate professionals, family members, and older adults themselves on how aftermarket vehicle adaptations can help improve driving.

Advanced Technology

Advanced technology systems for vehicles have the potential to increase the safety and mobility of older drivers (Caird, 2004; Perel, 1998). Intelligent Transportation Systems (ITS) combine advances in wireless communication technologies, automotive electronics, computing, and global positioning systems. Successful ITS applications, particularly for older drivers, need to be affordable, relatively easy to use, and work to enhance safe driving. One way to promote affordability is to develop systems that are flexible enough to benefit drivers of all ages, yet are still able to help older drivers compensate for diminished abilities. Until recently few ITS applications were developed to take into account the unique requirements of older drivers. In an excellent review of older drivers and ITS, Caird (2004) points out that while older drivers are the group most likely to benefit from ITS, they are also the group most likely to suffer from the effects of ITS. Poorly designed ITS applications could increase distractions for older users, leading to a higher risk of crash. On the other hand, systems designed for optimal use by older drivers would also be beneficial to drivers of all ages. To achieve widespread use of ITS by older drivers, future ITS applications will need to be carefully designed to ensure that safety is enhanced rather than reduced (Henderson & Suen, 1999; Stamatiadis, 2001). Research is needed on how advanced technology affects older adult safety and mobility.

It is clear that older drivers use ITS applications differently then younger drivers (Caird, 2004; Dingus et al., 1997; Eby & Kostyniuk, 1998; Kostyniuk, Streff, & Eby, 1997; Stamatiadis, 1998; Wochinger & Boehm-Davis, 1997). For example, in an evaluation of navigation assistance applications, Kostyniuk, Streff, and Eby (1997) found that older drivers used the system more frequently than young people, entered a greater number of destinations into the system, and utilized the technology with a “co-pilot.” Understanding these patterns of use for the various ITS applications that are being developed is crucial for optimizing the benefits of ITS for all users (Vrkljan & Polgar, 2007). Such research is lagging.

Studies have also found that older drivers take much longer to learn how to use ITS technology (Caird, 2004; Kostyniuk, Streff, & Eby, 1997). Whether this is a cohort effect of people who did not grow up using computer technologies, or an effect of aging per se, is not known. Nevertheless, it is clear that acceptance of ITS applications by older drivers will be largely dependent upon the quality of training received.

The most promising ITSs for older drivers include route guidance, night vision enhancement systems, collision warning systems, and automatic crash notification (Caird, 2004). Each of these types of technology need additional research to optimize their use by older adult drivers.

ROADWAY DESIGN

The majority of roadways in the US and most other countries are more than 50 years old. The US interstate roadway system, for example, celebrated its 50th anniversary in 2006 (Federal Highway Administration, FHWA, 2008b). When these roadways were being built, life expectancy in the US was only 68 years of age (Centers for Disease Control and Prevention, CDC, 2003), an age that today is considered to be barely older adulthood. It is, therefore, not surprising that roadways were generally designed to accommodate the driving capabilities of yesterday's "85 percentile driver;" that is one who is relatively young and healthy by today's standard (Oxley, Fildes, Corben, & Langford, 2006). Given the types of problems older adult drivers have on the road, it seems clear that improved roadways can play a key role in enhancing safe driving among older adults.

Intersections are especially dangerous for older drivers (see e.g., Staplin et al., 1998). As described by Dewer (2007), it is possible to reduce the crash risk of older drivers at intersections through changes in roadway design such as protected left-turn signals and improved roadway channeling, stop signs, and signal timing. Similarly, well-maintained roadway markings (e.g., painted edge-lines, lane control marking) can enhance safety by providing visual cues to drivers to help them know which lane to use and to stay in their lane. Some aspects of freeway driving can be problematic for older drivers – for example, driving through construction zones – and may be made easier by changes in roadway design. Collectively, improvements in roadway design can serve to make the roadway more forgiving not only to older drivers, but also to the general population of drivers on the road. In addition, design improvements at intersections can benefit older pedestrians who are considerably more likely to be killed by automobiles than younger pedestrians (NHTSA, 2008).

People recognize that roadways should be enhanced for the older driver. A state-of-the-art review of current knowledge and practice to enhance older adult driving safety was undertaken by the Monash University Accident Research Centre in Australia (Fildes, 1997) to identify best practices and develop strategies. Among other tasks, this project brought together 22 international experts from government, community, and research in order to prioritize older driver research topics. Of the 15 topics considered, "highway design for older drivers" ranked 4th overall, and received a top priority ranking from 10 of the participants. Indeed, several US agencies have recognized the potential of roadway design changes for improving safety and mobility in an aging society (e.g., Potts, Stutts, Pfefer, Neuman, Slack, & Hardy, 2004; Staplin, Lococo, Byington, & Harkey, 2001; Stutts, 2005).

Signs

All of us are aware of roadway signage, particularly when we are traveling in an unfamiliar area. In order to enhance sign conspicuity, legibility, and comprehension, symbols are often used instead of words. Symbols can convey more information with fewer characters and are legible at further distances (Dewer et al., 1994; Jacobs, Johnson, & Cole, 1975; Kline, Ghali, Kline, & Brown, 1990). Symbols have the additional benefit of being language independent so that non-native drivers can utilize the signage. However, much of the driving public does not understand what certain symbols indicate, particularly older adult drivers (Al-Madani & Al-Janahi, 2002; Dewar, Kline, & Swanson, 1994; Shinar, Dewar, Summala, & Zakowska, 2003). Word signs are by far the most common sign found on roadways. Sign legibility can be adversely affected by nighttime, particularly for older drivers. Even with good legibility, drivers of all ages sometimes do not understand what the words mean. Educational efforts are needed to improve sign comprehension among older drivers.

Pavement Markings

Pavement markers include painted lines, painted curbs, raised/reflective markers, rumble strips, and word or symbol messages. Pavement markings are particularly important at night where they are illuminated by vehicle headlights and ambient lighting. Nighttime conspicuity can also be enhanced by the use of paint with retroreflective properties. Research has found that pavement markings at night are less visible to older drivers than younger drivers even with high-beam headlights (Benekohal et al., 1992; Graham, Harrold, & King, 1996; Zwahlen & Schnell, 1999). Even when pavement markings are conspicuous and legible, research has found that pavement markings are difficult for many people to understand. Public information and education programs need to be developed to improve pavement marking comprehension.

Signals

Signal are used to convey information to drivers at roadway areas in which vehicles come into conflict, such as crossing paths at an intersection. Because they are placed in the driver's field of view and are lighted, signals are generally conspicuous and legible. The common three-color traffic signal is well-understood by drivers. Comprehension of other signals, however, may be poor. Signal comprehension should be addressed in educational programs for older drivers.

Intersections

The intersections of roadways are dangerous places. According to the FHWA (2007), intersection crashes account for more than 45 percent of all crashes and 21 percent of fatalities. Numerous studies have found that older adult drivers are over-represented in intersection crashes (e.g., Abdel-Aty, Chen, & Schott, 1998; Baker et al., 2003; Chandraratna & Stamatiadis, 1993; Cook et al., 2000; Garber & Srinivasan, 1990; Hauer, 1988; Kostyniuk, Eby, & Miller, 2003; McGwin & Brown, 1999; McKelvey & Stamatiadis, 1988; Preusser et al., 1998; Rothe, 1990; Ryan, Legge, & Rosman, 1998). A study in the US, for example, examined the fatal crash risk of drivers aged 65 or more years relative to drivers aged 40-49 during 1994-1995 (Preusser et al., 1998). The study found that drivers aged 65-69 were 2.26 times more at risk for a multiple-vehicle fatal crash at an intersection when compared to the younger driver group. Risk of a fatal intersection crash increased with age. Drivers aged 85 years of more were 10.62 times likely to have a multiple-vehicle fatal crash at an intersection than younger drivers. The authors also found that stop sign controlled or uncontrolled intersections were especially dangerous for older drivers.

What makes intersections so dangerous for older drivers? Two recent studies have examined the differences in errors negotiating intersections between younger and older drivers (Bratiman, Kirley, Ferguson, & Chaudhary, 2007; Mayhew, Simpson, & Ferguson, 2006). Collectively these studies have found that in intersection crashes, older drivers are more likely to: fail to yield the right-of-way; disregard the traffic signal; be responsible for the crash; be at stop-controlled or uncontrolled intersections; and be turning left. This work also found that older drivers tend to be in crashes when roadway conditions are relatively safe, such as during the day and on dry roads. Both studies suggest research needs to be done to help reduce the risk of intersections crashes including advanced vehicle technology (such as collision avoidance systems); education and training programs; and intersection modifications, such as the more frequent use of roundabouts.

Roundabouts

A roundabout is a circular nonsignalized intersection design where all traffic moves in the same direction around the center of the intersection. Despite an undeserved negative reputation in America, roundabouts may help alleviate some of the difficulties older drivers have with negotiating intersections. Indeed, several studies have shown that roundabouts reduce the number and severity of crashes (Elvik, 2003; Flannery, 2001; Flannery & Datta, 1996; Oxley, Fildes, Corben, & Langford, 2006; Persaud, Retting, Garder, & Lord, 2000; 2001). Elvik (2003), for example, found that changing signalized intersections to roundabouts can reduce the total number of injury crashes by up to 50 percent and fatal crashes by up to 70 percent. These safety benefits were found for drivers of all ages.

Are roundabouts safer for older adult drivers? Studies show that older drivers are concerned about negotiating roundabouts (Benekohal et al., 1992; Lord, van Schalkwyk, Staplin, & Chrysler, 2005; Mesken, 2002), particularly ones that have multiple lanes. It is likely that much of this concern stems from a lack of familiarity with the roundabout design, rules, signage, and pavement markings. To date, no research has specifically evaluated the safety benefits of older versus younger drivers using roundabouts. Research should also address the lack of familiarity for US drivers with roundabout design and signage.

Pedestrians

The safety of older adult pedestrians is of concern. The pedestrian fatality rates for the oldest age groups are higher than for any other age group. In 2006, more than 900 pedestrians aged 60 or more died in the US (NHTSA, 2008). Given what is known about age-related declines and the fact that most older adults prefer to travel in an automobile, elderly pedestrians are likely to have perceptual, cognitive, or psychomotor declines that make it difficult for them to safely walk along roadways (Langlois et al., 1997). A detailed analysis of roadway design features and older adult pedestrian crashes provide some insights on pedestrian road-crossing behavior (Shankar, Sittikariya, & Shyu, 2006). The authors applied multivariate analysis techniques to a pedestrian crash database to control for vehicle volumes. The study found that older adult pedestrian crashes were more frequent when a center turn lane was present, when the spacing between controlled intersections was more than ½ mile, and when roadways were poorly lit. While the last finding is obvious, the authors suggested that the first two factors induced older adult pedestrians to cross roadways at mid-block, where there is no traffic control. More research is needed to improve the safety of older adult pedestrians.

Roadway Work Zones

Although work zones are not a roadway design element, they are common, necessary, and intermittent situations that drivers must deal with. As described by Dewar and Hanscom (2007), work zones can be hazardous "…because motorists are confronted with unexpected and often confusing conditions." (pg. 403). The most current data show that more than 1,000 people died in work-zone-related motor vehicle crashes in 2006 with another 40,000 being injured (Workzonesafety.org, 2008).

Work zones may be especially difficult for older drivers. Older people tend to process information more slowly, have more difficulty dividing attention, have vision problems (especially at night), and have slowed reaction times. Other work has shown that older adults respond more slowly to novel stimuli than younger people (Hoyer & Familant, 1987). Drivers with early stage dementia may be at particular risk because of memory problems. All of these declines can impact older driver safety in work zones. Some work has shown that older adult drivers may be less safe in work zones. In a survey of AARP members across the US (mean age 72.2 years), 20 percent of respondents reported that they have problems negotiating highway work zones (Knoblauch, Nitzburg, & Seifert, 1997). The specific problems identified by these drivers were: congestion, lack of adequate warning, narrow lanes, lane closures/shifts, and lane keeping. Given these results, we would expect that older adult drivers would be over-represented in work zone crashes. Research, however, has not investigated this.

Highway Design Handbook

The FHWA began an initiative several years ago that resulted in the 1998 publication of the *Older Driver Highway Design Handbook*, which included recommendations for geometrics, signing, and pavement markings in four major areas of roadway design – intersections, interchanges, roadway curvature and passing zones, and construction/work zones. Feedback from workshops conducted across the US with state and local design and traffic engineers responsible for day-to-day design decisions led to development and publication of an updated handbook, the *Highway Design Handbook for Older Drivers and Pedestrians* and a condensed companion document with just the recommendations and implementation guidelines (Staplin, Lococo, Byington, Harkey, 2001). Recommended design elements are organized around three main topics: intersections and interchanges; curves; and temporary traffic control zones. The handbook is built on the premise that wholesale changes to the entire roadway infrastructure would be cost-prohibitive and therefore tailors its recommendations to new construction, reconstruction of existing facilities, regularly-scheduled maintenance activities, and "spot treatments" where there are crashes or other demonstrated safety problems, or where a proactive approach to prevent further problems is desired. Nevertheless, individual recommendations still need to be evaluated to determine whether they are cost effective and are having the intended impacts on safety. Although some work has evaluated the older adult driver safety benefits of some of the recommendations (Classen et al., 2006; Shechtman et al., 2007), more research is needed in this area.

TRANSITIONING TO NON-DRIVING

Despite individual differences in the effects of aging on functional abilities, most older adults will eventually be faced with difficult decisions about whether they will need to reduce or stop driving, and if they do, how they can maintain community mobility and well being. One major study of older drivers in the US concluded that each year, more than 600,000 adults age 70 and older stop driving and become dependent on others to meet their transportation needs (Foley, Heimovitz, Guralnik, & Brock, 2002). Many of the reasons given by older adults for stopping driving related to health and medical problems, especially vision. However, the process of driving cessation is clearly a complex one and other factors such as the availability of personal and environmental resources also come into play. Driving cessation has been described as a spontaneous, gradual process, with many older drivers becoming increasingly more vulnerable to difficulties in traffic, limiting their driving under certain conditions, and driving progressively less than before. At the same time, there is considerable variation in how older drivers respond to driving-related problems, what steps they take to continue driving safely, and how well they adapt if they are forced to stop driving. For example, many drivers with functional declines restrict their driving to circumstances under which they feel safest, but others do not appear to practice appropriate driving self-regulation. Similarly, while there is evidence that stopping driving is associated with increased depressive symptoms over time (Fonda, Wallace, & Herzog, 2001; Marottoli, Mendes de Leon, Glass, Williams, Cooney, Berkman, et al., 1997; Ragland, Satariano, & MacLeod, 2005), many older drivers are able to successfully transition from driving, making the adaptations necessary to maintain their community mobility and well-being.

Unfortunately, there has been limited research relative to older adults in general on how the driving cessation process affects well being and what role driving restrictions play in the process, as well as what factors might lessen the adverse outcomes that can result from stopping driving. There is clearly a need to better understand the process of driving cessation among older adults and to identify factors that allow older drivers to successfully manage the transition from driving to other transportation options (Dickerson et al., 2007).

Livable Communities

One approach that holds promise for helping older adults transition from driving has to do with how we can make our communities more livable. The issue of how livable our communities will be for us as we grow older is an important one and yet people rarely think about it until it has become clear that their needs are no longer being met. Now that our society is aging, the role of the physical and social environments in promoting independence and strengthening civic and social ties has become increasingly recognized.

A livable community has been defined as one that has affordable and appropriate housing, supportive community features and services, and adequate mobility options, which together facilitate personal independence and the engagement of residents in civic and social life (Kochera, Straight, & Guterbock, 2005; Kochera & Bright, 2006). One of the most important aspects of a livable community is the high level of engagement of its residents, ranging from participation in social activities and relationships, to volunteering, to civic participation in community planning, and the political process. Such engagement is a vital part of successful aging and transportation is the means by which people not only connect to the goods and services, but also stay engaged. Research is needed on: how communities can facilitate driving by older adults by improving the travel environment, supporting driver education, and promoting safe driving throughout the lifespan; and how communities can take positive steps to enhance mobility options, including public transportation, walking and bicycling, and specialized transportation for individuals with varied functional capabilities and preferences.

ALTERNATIVE TRANSPORTATION OPTIONS

While many older drivers are able to compensate for declines in functional abilities and continue to drive safely for some time, others stop driving, often suddenly, because of health conditions, medical problems, involvement in a crash, or recognition that they are no longer safe drivers. Currently, about one in five adults age 65 and older do not drive, with those least likely to drive being the oldest old (age 85 and older), women, non-whites, the poor, and individuals with disabilities (Rosenbloom, 2004). Older adults who are no longer able or choose not to drive must still be able to meet their transportation needs to retain their mobility and hence quality of life. This can be especially challenging given the increasing trend for people to “age in place.” By staying in their own homes (particularly in rural and suburban areas), they may have fewer transportation resources available to them than if they sought out more transportation-friendly retirement areas.

Unfortunately, few people plan for the time when they will no longer be able to drive. Among the alternative transportation options for older adults are traditional public transit (e.g., buses, light rail, trains, and subways), paratransit (demand response services including ADA transit services), specialized transit services (e.g., those operated by health and human service providers), supplemental transportation programs (e.g., operated by private sector transit services, community groups, and volunteer groups), and other alternatives such as walking or bicycling (Suen & Sen, 2004).

The extent to which these options are available varies by community. There is also considerable variation among the various services in terms of how aware people are of the services, how difficult the services are to use, and how much they cost.

Public transportation, the most traditional form of alternative transportation, accounts for about 2-4 percent of trips by older persons, and for 30 percent of trips for older persons who no longer drive (Stowell-Ritter, 2008). Older residents living in highly urbanized areas, however, are much more likely to use public transportation. At the same time, public transportation is not available for much of the population. In one survey, 60 percent reported not having public transportation available within a 10 minute walk of their home (Kochera, Straight, & Guterbock, 2005). When public transportation is available, there are often barriers to its use.

For older adults who are relatively physically fit, walking or bicycling may be viable means of getting around. However, little has been done in the US to address the need for a safe infrastructure that includes sidewalks, road crossings, and traffic signals for pedestrians, and bicycle lanes and road crossings for bicyclists. Without attention to these infrastructure issues, walking and bicycling will continue to hold risk for the older adult population, given their growing numbers in the population and their susceptibility to injury.

The Beverly Foundation (2001) measures the effectiveness of transportation services by the extent to which they are available, accessible, acceptable, adaptable, and affordable. First, transportation must be available and in operation when people need it. Accessibility has to do with whether people can get to and physically use the service. Acceptability has to do with how well the service meets the personal standards of users relative to such things as cleanliness of the vehicle, safety of the waiting area if there is one, and politeness of the driver. Adaptability has to do with whether the service is flexible enough to be responsive to the special needs of individual users. Affordability is the cost of the service and if there are options for reducing out-of-pocket costs.

A recent paper by the Transportation and Aging Interest Group of the Gerontological Society of America (Dickerson et al., 2007) has noted several research needs related to alternative transportation:

- A definitive methodology is needed to predict the future number of people who will be limiting or giving up driving ;
- Research is needed to better understand how to map older adult functional declines to transportation services;
- There is a need to develop and evaluate community models that demonstrate the continuum of services that are friendly to older adults;
- There is a need to develop transportation alternatives that are responsive to the special needs of the person with dementia;
- Research is needed on the development and testing of a transportation transitions model that links the driver safety and transportations options sectors to help support older adults and their families as they make the transition from driving to transportation dependence.

CONCLUSIONS

This synthesis reviews some of what is known about maintaining older adult mobility and defines several areas where further research is needed. There are several themes that thread through this synthesis report. First, mobility is needed by all people. If mobility needs are not met by driving, then they must be met by other means. Second, older adults are not a homogeneous group. Older adults vary greatly in: the functional declines they may be experiencing; their ability to compensate for declines; their financial and social resources; and their personalities. All of these characteristics interact with the factors influencing safe mobility. Third, older adults, as well as all drivers, need lifelong education to maintain safe mobility. For the older adult, learning about roadway design changes, how to use advanced technology, and the transportation options available when driving is no longer possible is an important component in safe mobility. Fourth, research to help older adults stay mobile will also help younger drivers. Finally, meeting the mobility needs of an aging population is complex and will require the expertise and collaboration of several academic and applied disciplines. The M-CASTL will continue to provide these collaborative opportunities.

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