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M-CASTL 2010 SYNTHESIS REPORT—VOLUME 1: OLDER ADULT SAFETY AND MOBILITY

David W. Eby & Lisa J. Molnar

Transportation Research Institute
&
Michigan Center for Advancing Safe Transportation throughout the Lifespan

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16. Abstract

The purpose of the annual M-CASTL synthesis report is to identify short and long-term research needs that support M-CASTL's theme and reflect the United States (US) Department of Transportation's (DOT's) and other National organization's transportation research agendas. The intent of the report is to synthesize current relevant knowledge 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 Conference. The report begins with a review of empirical findings indicating that older adults are at higher risk of a fatal crash and tend to suffer many negative consequences when driving privileges are taken away. Issues of aging and mobility are conceptualized as having three complementary and interdependent goals: (1) to understand and better manage the effects of medical conditions and medications on skills needed for safe driving; (2) to help those who are able to drive safely continue to do so; and (3) to identify and provide community mobility support to those who are no longer able or choose not to drive.

The report reviews background and recent research in several areas related to the three goals: medical conditions; screening and assessment; law enforcement; rehabilitation; technology; roadway design; caregiver economics; and community mobility. The research reviewed was gathered from a search of articles published in 2009 through February, 2010 in several peer-reviewed journals and conference proceedings. The report builds upon three recent reviews of the aging and mobility literature (Eby, Molnar, & St. Louis, 2008; Eby, Molnar, & Kartje, 2009; Eby, Molnar, & Vivoda, 2009) and serves as a companion to those reports.

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INTRODUCTION

A number of recent reports have documented the importance of safe mobility in older adulthood (Dickerson, et al., 2007; Eby & Molnar, 2009; Eby, Molnar, & Vivoda, 2009; Eby, Molnar, & Kartje, 2009; Molnar & Eby, 2008). The theme of the Michigan Center for Advancing Safe Transportation throughout the Lifespan (M-CASTL) is **Safety and Mobility throughout the Lifespan**. M-CASTL is dedicated to advancing expertise and technology in the many disciplines comprising the safety and mobility of both young people and older adults. Through its various programs and partnerships, M-CASTL works to increase understanding of and address—across the different dimensions of the roadway, vehicle, and driver—the risks and mobility issues 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. This volume (Volume 1) concentrates on the older end of the age spectrum, highlighting recent research findings for older adult safety and mobility. Volume 2 highlights recent research findings relative to young drivers.

The purpose of the annual M-CASTL synthesis report is to identify short and long-term research needs that support M-CASTL's theme and reflect the United States (US) Department of Transportation's (DOT's) and other National organization's transportation research agendas. The intent of the report is to synthesize current relevant knowledge to help focus the Center's research program and to maintain continuity in our research program. The synthesis report also serves as the background for the annual M-CASTL Transportation Research and Education Conference. The 2008 M-CASTL synthesis report (Eby, Molnar, & St. Louis, 2008), the first of the series, extensively covered the state of knowledge and research needs with regard to older adult mobility prior to 2008. The 2009 report reviewed findings from research published and presented from 2008 and early 2009 (Eby, Molnar, & Vivoda, 2009). These previous reports can be found at: http://m-castl.org/node/4. The present report synthesizes research findings from 2009 to February 2010. The report also includes earlier articles that were not contained previous synthesis reports.

Previous synthesis reports described the challenges for older adult safety and mobility that will be facing society in the coming decades. Many countries are experiencing an increase in the population of people 65 years of age or older (older adults). The strongest factor influencing this increase is that baby-boomers will begin reaching older adulthood in 2011. Not only will there be a larger proportion of the population comprised of older adults, but estimates suggest that older adult baby boomers are likely to take more trips and drive more miles in a motor vehicle than previous generations of older adults.

Self-Regulation of Driving

Eby, Molnar, and St. Louis (2008) also discussed how driving patterns change as people age, often referred to as "self-regulation" of driving. When compared to younger drivers, older drivers are more likely to avoid difficult driving situations (e.g., nighttime, inclement weather, and high traffic times) and often make other changes in driving (e.g., driving less overall, driving slower, driving more often with a passenger, and reducing in-vehicle distractions). The authors discussed how there is considerable variability in the extent

and types of self-regulation reported in studies. In addition, the evidence linking self-regulation to reduced crash risk is inconclusive, due in part to the limited number of studies that have been undertaken and the reliance on retrospective data on crash involvement.

In an M-CASTL-sponsored project, Molnar, Eby, Roberts, St. Louis, and Langford (2009) presented results of a project designed to develop a new approach to assessing self-regulation by older drivers. The project had several aims: 1) develop a comprehensive self-report measure of self-regulatory practices by older drivers that conceptualizes self-regulation as both reducing the extent of driving exposure and modifying the nature of driving exposure; 2) base development of the instrument on a conceptual framework derived from a number of data sources, including a literature review; expert opinion from the US and abroad; and analysis of data from an existing naturalistic driving data of older adults; 3) pilot test the instrument with a sample of older drivers recruited from the general older adult population and from populations with known losses in vision, cognition, or psychomotor abilities; and 4) produce a final instrument that can be used by English-speaking jurisdictions for studying self-regulation. The research team pilot tested the instrument with 137 drivers age 70 and above—105 were from the general population and 32 had clinically-determined visual, cognitive, or psychomotor losses. Feedback on the computer-based questionnaire was very positive, including the use of a computer for administration. Overall, the preliminary results suggest that study participants did engage in self-regulatory behavior, based on self-report, particularly at the strategic level. A majority of participants reported that they try to avoid a variety of specific driving circumstances including driving at night or in rush hour traffic, in bad weather, and at night in bad weather. Other driving circumstances avoided by one third or more including making unprotected left turns, driving on high traffic roads, and driving in unfamiliar areas. Many planned out their trips ahead of time or reduced overall travel by combining trips. However, very few reported having made modifications to their vehicles during the past year to make driving easier. At the tactical level, a majority tried to avoid in-vehicle distractions with the exception of changing radio stations, and most tried to leave more room between their cars and the cars ahead of them. Participants reported few life-goals changes with the exception of buying a different vehicle in the past year. Few differences in these self-regulatory practices were found between men and women, or between younger (age 70-79) and older participants (age 80-88). However, participants recruited from the clinic population were more likely than those recruited from the general population to report trying to avoid driving at night, driving in unfamiliar areas, driving on the expressway, and talking conversationally with passengers while driving.

M-CASTL has recently sponsored these principal investigators to extend this work to validate responses on the questionnaire to GPS-derived driving behaviors measured during 2 months of real-world driving in a sample of 12 older adults. A brief overview of this project can be found here: http://m-castl.org/node/66.

A prospective cohort study in Maryland, US investigated changes in driving behavior in relation to crash risk among 645 drivers age 55 and older (Ross, Clay, et al., 2009). Crash risk was defined by performance on the useful field of view (UFOV) test and driving behaviors were self-reported. The study found that over the 5-year study period, participants at risk for crashes restricted their driving more than those not at risk, both at baseline and in the subsequent follow ups. Restricted driving included driving fewer days per week, driving in a more limited geographic region, and avoiding difficult driving

situations. At-risk drivers, however, were also twice as likely to be involved in at-fault crashes. The authors concluded that self-regulation among older drivers who are at increased risk for crashes was not an effective way to reduce the crash risk among this group of older adults.

Driving space restrictions among older drivers were recently investigated in relation to sense of direction and gender (Turano, et al., 2009). The study included 1,425 participants from the Salisbury Eye Evaluation Driving Study (SEEDS). Sense of direction was measured using the Santa Barbara Sense of Direction (SBSOD) scale (Hegarty, Richardson, Montello, Lovelace, & Subbiaha, 2002). Driving restrictions were measured by the Driving Habits Questionnaire (Owsley, Stalvey, Wells, & Sloane, 1999) and global positioning system (GPS) data collected from a device installed in each participant's vehicle during 5 days of driving. The study found that SBSOD scores were lower in women overall and were significantly correlated with both self-reported and actual geographic driving space restrictions, but only among women.

Crash Risk

Eby, Molnar, and St. Louis (2008) discussed the various ways in which crash risk for older adult drivers has been conceptualized. The authors discussed how older adults as a group have the fewest number of fatal crashes. When these crashes are expressed as a function of population, miles driven, or number of licensed drivers, older adults have higher fatal crash rates than all other drivers except for the youngest drivers.

NHTSA recently published findings from a study on behaviors and situations associated with increased older driver crash risk (Stutts, Martell, & Staplin, 2009). The study analyzed a national census of fatal crashes (Fatality Analysis Reporting System, FARS) and a national sample of police reported nonfatal crashes (National Automotive Sampling System, NASS) from 2002 to 2006. Data were analyzed for single- and two-vehicle crashes for three older adult age groups and various approaches were used to control for crash exposure. The study found that among older drivers, only those age 70 and older were overrepresented in a variety of crashes. Drivers age 60-69 did not differ in most cases from middle-age drivers. Older drivers were found to be at higher crash risk for all left turn situations. The researchers found that in two-vehicle crashes, older drivers were more likely to have been driving alone, driving the vehicle that was struck, and cited for "failure to yield." In single-vehicle crashes, older drivers were more likely to have been driving alone, hit a parked vehicle, and failed to make a maneuver to avoid a collision. Older driver crashes were also more likely to have occurred at driveways, alleys, and controlled intersections. The study also used a method to determine the at-fault crash involvement ratio. The study found that drivers age 60-69 had a lower than average at-fault crash risk, while drivers in crashes age 70-79 were almost twice as likely to be at fault and drivers age 80 and older were four times more likely to be at fault.

A study in Egypt evaluated all 258 traffic crashes involving older road users admitted to the University of Alexandria Emergency Department during a 6-month period (Abou-Raya & El Meguid, 2009). Hospital and police-reported data were analyzed to develop a characterization of older road user crashes. The study found that 57% were pedestrians, 26% were car drivers, and 14% were car passengers. About 70% were currently taking at least one medication, while 42% were taking four or more medications. Nearly 80% had a medical condition, with cardiovascular disease, sleep apnea, diabetes, osteoarthritis, and stroke being reported most frequently. Most pedestrian crashes were

due to the older person falling while crossing the roadway. Most older driver crashes occurred at intersections and were judged to have resulted from a number of factors including: failure to notice or respond appropriately to traffic control; misjudging stopping distance; inappropriate stopping (e.g., stopping at a green light); and misjudging traffic gaps during turns.

A statewide analysis of crashes in South Carolina, US compared the crashes of middle age drivers (age 35-50 years) to older drivers (age 65 year and older) between 2006 and 2007 (Hirth, Boland, Borrks, & Beeco, 2010). The study found that the most common contributing factors for middle-age driver crashes were: driving too fast for conditions; driving under the influence; driving on the wrong side of the road; running off the road; and exceeding the speed limit. The primary contributing factors for older drivers were: failure to yield the right of way; disregarding the traffic control device; driving too fast for conditions; running off the road; and driving under the influence.

Unintended acceleration (UA) errors among older adults were recently studied extensively using a driving simulator (Freund, Colgrove, Petrakos, & McLeod, 2008). In this study, UA was broadly defined as an "…inappropriate acceleration or failure to decelerate when deceleration or transition from accelerating to braking is required…" (pg. 406). Thus, running a stop sign, for example, was coded as a UA error. The study found that about one-third of the 176 older drivers committed a UA error. These errors were common with increasing age and declining cognitive function as measured by a number of standardized tests. Unfortunately, the authors did not present data on the types of UA errors separately.

A study in Baltimore, MD, US investigated the rate of red light running among older drivers as well as factors that may underlie this driving error (West et al., 2009). The study recruited 1,425 drivers age 67-87. Participants underwent a comprehensive clinical evaluation of perceptual, cognitive, and psychomotor abilities. Each participant also had his or her personal vehicle installed with a device to record driving for 5 days. This device included a color camera and global positioning system (GPS) that allowed an analyst to code red light running. The study found a low incidence of red light running among participants (3.8%). The only demographic or clinical variable associated with red light running was a narrowing of the attentional visual field, particularly in the vertical dimension.

The same set of authors in a different paper analyzed failures to stop at stop signs among older drivers (Keay, Jasti, Munoz, et al., 2009). Using the same 1,425 participants as previously described, the study found that among drivers who encountered a stop sign during their 5 days of driving, 15.8% failed to stop at least once and 7.1% failed to stop more than once. Failure to stop was related to missing bilateral visual field, but only in participants who drove in rural areas, where failure to stop at stop signs was more common. Participants from urban areas with visual field loss were more cautious at stop signs.

Researchers from the Netherlands investigated the ability of older drivers to merge onto a heavy-traffic motorway using a driving simulator (de Waard, Dijksteruis, & Brookhuis, 2009). The study compared the performance of 17 younger drivers (age 25-40) to 16 older drivers (age 65 and older), all of who were experienced, current drivers. The study measured driver workload and behaviors while manipulating traffic density, heavy truck density, and the presence of an experimental driver support system that

encouraged proper merging speed. The study found little difference between the age groups on driver behavior or workload resulting from an increase number of heavy trucks. In all conditions, however, older drivers merged at lower speeds. The study also found that longer acceleration lanes and the driver support system facilitated merging for both age groups.

A study in Ireland recently examined older pedestrian injuries and fatalities (Martin, Hand, Trace, & O'Neill, 2009). The authors examined a national database of pedestrian-involved crashes from 1998-2002 for two age groups of pedestrians: younger adults (age 18-64) and older adults (age 65 and older). The researchers found that older pedestrians were twice as likely to be killed, equally likely to receive a serious injury, and less likely to receive a minor injury in a crash than younger pedestrians. Older pedestrian crashes were also more likely to occur during daytime, under conditions with good visibility, and during good weather. These results, unfortunately, do not take into account exposure to crashes.

Mobility Needs

Despite the increased crash risk for the population for older drivers, there is still a need to ensure safe mobility for older citizens, either through efforts to extend safe driving or to provide other community mobility options. Like people of all ages, older adults have mobility needs that need to be satisfied if driving is no longer possible or desired.

A number of recent reviews (e.g., Dickerson, et al., 2007; Eby, Molnar, & Kartje, 2009; Eby, Molnar, & Vivoda, 2009) have concluded that: older adults are reluctant to give up driving and consider driving to be essential to a high quality of life; driving provides an opportunity for older adults to stay engaged in their community; and driving cessation is associated with a variety of negative physical and mental outcomes. For example, a recent study of 660 community-dwelling older adults investigated the consequences of driving cessation (Edwards, Perkins, Ross, & Reynolds, 2009). The prospective cohort study included adults ranging in age from 63 to 97, with participants being followed from 2000 to 2004. The study found that being a non driver was a risk factor for increased mortality. Non drivers were four to six times more likely to die than drivers over the 3-year study period.

These findings highlight the importance of helping older drivers maintain community mobility even when threats to traffic safety lead to decisions to to revoke or restrict an individual's license. At the same time, it is important to recognize that alternatives to driving are generally poor and often unacceptable. With this in mind, many in the field of transportation and aging conceptualize the issues as three complementary and interdependent goals: (1) to understand and better manage the effects of medical conditions and medications on skills needed for safe driving; (2) to help those who are able to drive safely continue to do so; and (3) to identify and provide community mobility support to those who are no longer able or choose not to drive (Dickerson, et al., 2007; Eby, Molnar, & Kartje, 2009; Eby, Molnar, & St. Louis, 2008; Eby, Molnar, & Vivoda, 2009; Molnar, Eby, & Dobbs, 2005). The remainder of this report reviews recent research in several areas related to the three goals: medical conditions; screening and assessment; law enforcement; rehabilitation; technology; roadway design; caregiver economics; and community mobility.

MEDICAL CONDITIONS

Previous work described the current thinking about how medical conditions associated with increasing age in older adulthood can increase the risk of a crash (Dickerson, et al., 2007; Eby, Molnar, & Kartje, 2009; Eby, Molnar, & St. Louis, 2008). These reviews discussed how it is not the medical condition itself that raises the risk of a crash, but rather how the condition influences functional abilities—those abilities needed to perform critical driving skills. Determining how these declines in skills translate into fitness to drive is an ongoing research focus.

The National Highway Traffic Safety Administration (NHTSA), working in conjunction with the American Association of Motor Vehicle Administrators, developed a guide called *Drive Fitness Medical Guidelines* to help licensing agencies and health personnel make decisions about an individual's fitness to drive (NHTSA, 2009a). Development involved an extensive literature review and expert advice to develop consensus-based guidelines for a range of medical conditions including: visual declines; physical limitations; dementia; diabetes; seizures; and sleep disorders. The review also covered a larger number of other medical conditions, but found that the research linking the medical conditions to poor driving performance or crash risk was either nonexistent, inconclusive, or did not suggest a specific recommendation. A different article, focusing only on dementia and driving, suggested guidelines for patients, families, and physicians (Kennedy, 2009).

The topic of how medical conditions affect driving behaviors and crash risk continues to receive much needed research attention. A study of 3,158 older drivers from three American states investigated the relationship between visual/medical factors and motor vehicle crashes (Cross, et al., 2009). The study pooled data from four cohort studies, three with a different age ranges (55-up, 48-94, and 65-84) and one with an unspecified age range. The study controlled for exposure using a self-reported driving measure. The study found that only two factors were significantly related to increased involvement in a motor vehicle crash involving an injury: arthritis and neurological conditions (stroke, multiple sclerosis, or Parkinson's). Analysis also showed an increased risk for an at-fault crash for falls and large decrements in the useful field of view. Finally, the study found that cancer decreased the relative risk for an at-fault crash and hypertension decreased the risk for an injury crash.

Vision and Visual Processing

Several studies have focused specifically on visual and visual processing problems. A study conducted in Alabama, US investigated the effects of visual field loss on on-road driving (Wood, et al., 2009). Although the study recruited people age 19 and older, the average age of participants in the study was over 50. Specifically the study investigated two types of visual field loss, hemianopia (one-half visual field loss in each eye) and quadrantanopia (one-quarter visual field loss in each eye). Participants drove an on-road course and were evaluated by an examiner who rode in the backseat. When compared to age-matched drivers without field loss (who were all judged to be safe drivers), 28% of drivers with hemianopia and 12% of drivers with quadrantanopia were judged to be unsafe drivers. These unsafe drivers exhibited errors in several critical driving skills including lane keeping, steering, and gap judgment.

Researchers from SEEDS investigated the effects of both visual and cognitive conditions on driving restriction and cessation among older adults (Keay, Munoz, et al., 2009). The study categorized 1,237 licensed drivers age 67 to 87, 1 year after enrollment in SEEDS into three categories: those who had stopped driving (cessation); those who only drove in their neighborhood (reduction); and those who drove beyond their neighborhood. All participants had completed a comprehensive baseline evaluation. The study found that driving reduction and cessation 1 year after baseline was predicted by the following baseline conditions and outcomes: depressive symptoms; slow visual scanning; poor visual-spatial ability; and reduced contrast sensitivity. Visual field loss was not associated with driving reduction or cessation. Similar results were reported in an Australian study that analyzed 5,206 older adult participants in the DYNOPTA project (Ross, Anstey, et al., 2009).

Janz, Musch, Gillespie, Wren, and Niziol (2009) investigated visual function concerns in drivers and non drivers with glaucoma. The study included 607 newly diagnosed glaucoma patients from 14 clinics around the US who participated in the Collaborative Initial Glaucoma Treatment Study (CIGTS). Approximately three-fourths were age 50 to 74. The researchers compared drivers to non drivers in cross-sectional analyses after a 6 month follow-up. All data were self-reported. The study found that among this population of glaucoma patients, drivers were more likely to be male, White, married, employed, and have fewer comorbid medical conditions. Among those who were still driving, the extent of visual field loss was related to more frequent reports of difficulty driving at night and performing driving skills that required visual search and visual processing. The authors noted that these results can be helpful for physicians when counseling patients regarding safe driving.

M-CASTL recently awarded a project to researchers at the University of Michigan designed to better understand the concerns, attitudes, and needs of vision care providers, particularly with regard to assessing driving among their older patients (Janz, Musch, Gillespie, & Crew, 2010). This project will survey vision care providers in Michigan to: (1) gather information on current Michigan attitudes and practices regarding assessment of older patient's driving status; (2) use preliminary findings to design a more comprehensive survey of the broader health care provider community who deals with older drivers; and (3) ultimately develop assessment tools and intervention aids that will enable health care providers to more effectively address the needs of older drivers. A description of this project can be found at: http://m-castl.org/node/64.

Dementia

A number of newly completed studies investigated the effects of early stage dementia or Alzheimer's disease on driving abilities using instrumented vehicles (i.e., vehicles installed with technology that can gather objective measures of driving performance). For example, a project in Iowa, US studied the association between functional abilities (cognitive, visual, and motor) and safe driving performance among those with a diagnosis of early stage dementia (Dawson, Anderson, Uc, Dastrup, & Rizzo, 2009). The study compared 40 drivers with probable early stage Alzheimer's disease with 115 older drivers without neurological disease. All participants completed a battery of functional ability tests and drove a 35-mile route in a University of Iowa instrumented vehicle. Among other findings, the study found that when compared to non cognitively

impaired drivers, those with early stage dementia committed significantly more safety errors during the drive, even when adjusted for age and sex.

The topic of driving behavior and early stage dementia using instrumented vehicles was explored in a symposium at the 2009 Annual Conference of the Gerontological Society of America (Eby, 2009; Eby & Porter, 2009; LeBlanc, 2009; Molnar, 2009; Silverstein & Gottlieb, 2009). Researchers from three US universities collaborated on a project sponsored by the Alzheimer's Association to instrument the personal vehicles of people diagnosed with memory-loss to collect objective driving performance data for 1 month of driving (Eby, Silverstein, et al., 2009). The specific aims of the study were to: 1) demonstrate the feasibility of using in-vehicle data collection to monitor driving actions of individuals with early stage dementia; 2) compare the validity of multiple forms of assessment of driving skills with naturalistic driving in individuals with early stage dementia; 3); bring greater visibility to deficits in driving performance unique to people with early stage dementia; 4) increase understanding of behaviors and issues of drivers with dementia and their families; and 5) inform decision-makers about appropriate intervals for checking driving competency. Driving data from 10 participants were compared to data from 26 non impaired older adults. Survey data were also collected from each older driver, his or her family member, and his or her occupational therapist. The study found that the dementia group: drove as safely as the general older adult population sample; had a smaller driving activity space; and got lost more frequently. The study also found a lack of insight on the part of both drivers and family members when reported driving behaviors were compared to actual driving, as well as lack of agreement between drivers and their family members on many survey items. Participants who had restrictions placed on their driving by the occupational therapist (e.g., driving only in the local area) were found to adhere to these restrictions when their objective behaviors were examined. The authors suggested that these findings should be further explored in a larger scale study.

Parkinson's Disease

A number of studies have also addressed the issue of Parkinson's disease (PD) and driving. Two reviews of PD and driving have been published recently (Klimeit, Bradshaw, Charlton, Stolwyk, & Georgiou-Karistianis, 2009; Uitti, 2009). Both reviews noted that most people with PD can drive safely, but a minority may be unsafe depending upon the type and severity of symptoms. The reviews discussed the four main effects of PD that can affect driving: cognitive decline; visual impairments; motor deficits; and daytime sleepiness due to PD medications. The reviews concluded that the research on PD and driving safety is limited and that there needs to be consistent procedures and guidelines for assessing fitness-to-drive in PD patients.

A study in Florida, US investigated the utility of a visual attention measure (the useful field of view, UFOV®) as a screening tool for predicting on-road driving performance in people with PD (Classen et al., 2009). The study involved comparison of 19 people with PD to an age-matched comparison group of 104 people without PD. Both groups completed a clinical evaluation, the UFOV test, and an on-road assessment. The study found that the UFOV test had a higher correlation with on-road driving performance for people with PD than other cognitive or visual tests. The authors note, however, that the small number of subjects in their study makes it difficult to generalize these results.

Researchers at the University of Iowa investigated the driving behaviors of people with PD using an instrumented vehicle (Uc, Rizzo, Johnson, Dastrup, Anderson, & Dawson, 2009). The study involved 84 people with PD and 182 age-matched comparison drivers without PD. All participants completed a comprehensive clinical evaluation and drove a standardized route in a vehicle equipped with technology to collect video and driving data. Errors on the driving test were determined by a professional driving instructor viewing video and driving data. The study found that drivers with PD scored lower on tests of cognition, vision, and motor function. The study also found that there was great variability among drivers with PD. When driving safety errors were adjusted for age, education, sex, and familiarity with the standardized driving route, drivers with PD made significantly more errors only for maneuvers related to lane keeping and stopping at stop signs, and for total safety-related errors overall. A number of clinical tests, including scores on the UFOV test, were predictive of the total driving errors.

Executive Cognitive Function

A simulator-based project studied the executive functioning of older drivers at left-turn intersections (Etienne, Marin-Lamellet, & Paire-Ficout, 2010). The study included 30 younger drivers (age 18-35) and 29 older drivers (age 62-78), all of whom were current drivers. Older drivers with significant neurological impairment were excluded. All participants completed an evaluation of three cognitive executive functions: inhibition (capacity to ignore irrelevant information), updating (ability to update and monitor the content of working memory), and flexibility (ability to intentionally disengage attention processes from a situation or strategy and engage these processes toward a new situation or strategy). Left-turn driving performance was measured by errors on tasks performed at 15 intersection encountered during the simulated drive (e.g., failure to use turn signals resulted in a penalty point). The study found that the older driver group scored lower on inhibition and updating when compared to younger drivers. Regression analysis showed that performance decrements at intersections, regardless of age, were related to the lower levels of flexibility and updating.

Medical Conditions Conclusions

The literature on the effects of age-related medical conditions and driving continues to grow. For a number of reasons, determining the effect of a specific condition on crash risk is difficult. There are few clear-cut cases in which older adults with medical conditions can be ruled either safe or unsafe to drive simply on the basis of the medical condition. For older adults with a medical condition, the decision to drive should be made based on the advice of a physician, a driving professional, and possibly a family member. Each driver is unique, and these personal variables should be taken into account when examining transportation safety and mobility issues on an individual level. Further, much of the research investigates each condition separately, although many people have co-morbid conditions. Future work should consider the combined effects of co-morbid conditions or how various treatment options affect traffic safety and mobility.

EXTENDING SAFE DRIVING

Given the preference of most people for driving a personal automobile to satisfy their transportation needs, and the lack of effective alternatives, there is a strong incentive for keeping older adults driving for as long as they can safely do so. In this section, we review the latest research and thinking on the many issues and countermeasures designed to extend safe driving for older adults.

Screening and Assessment

How to properly evaluate driving fitness has been the topic of much debate and research in the past decade. As discussed in a number of recent reviews (Dickerson, et al 2007; Eby, Molnar, & Kartje, 2009; Eby, Molnar, & Vivoda, 2009) decisions about driving fitness require accurate and meaningful information about the changes in driving-related abilities people may experience and how these changes affect safe driving. Many researchers (e.g., Eby, Molnar, & Vivoda, 2009; Molnar & Eby, 2008; Staplin, 2008) distinguish between screening and assessment procedures. Screening represents the first step in identifying potentially at-risk drivers and is intended to identify gross and nonspecific functional impairments. The screening process may prompt self-regulation of driving or non driving actions to extend safe driving, or it may lead to in-depth assessment. Screening results, by themselves, should not be the basis for licensing actions. In-depth assessment should be used to determine the level and cause for an observed impairment and 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.

Self-Screening

In the context of older adult driving, self-screening refers to screening for functional ability declines or potential problems with driving that a person performs on themselves. A number of recent reports (Eby, Molnar, & St. Louis, 2008; Eby, Molnar, & Vivoda, 2009) describe several self-screening tools that range from simple paper-and-pencil to sophisticated computerized formats, including the AAA's Roadwise Review. There are a number of advantages of self-screening (Eby, Molnar, Shope, Vivoda, & Fordyce, 2003): (1) it is non-intrusive and less threatening than other types of screening or assessment; (2) older adult drivers may be more likely to engage in this type of screening earlier in disease onset; and (3) self-screening tools can be widely and cheaply distributed resulting in global availability. On the other hand, self-screening may not be useful to people with cognitive impairment and might even be dangerous to them if they misinterpret the feedback.

Bédard, Riendeau, Weaver, and Porter (2009) compared scores on the Roadwise Review to scores from an on-road driving evaluation in 30 older drivers. Participants also completed the UFOV and the trail making test. The study found that scores on the Roadwise Review (number of mild or serious problems identified) did not correlate significantly with scores on the on-road test, UFOV, or trail making test. The authors concluded that the study indicates a lack of congruence between the findings of the Roadwise Review and actual performance using standardized approaches.

Licensing Agencies

Licensing agencies play an important role in the driver evaluation process—they 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, and it is the licensing agency that has sole authority to deny or restrict a person's driver license. Recent studies have investigated several aspects of the licensing agencies' role in maintaining safe mobility among older people.

In October 2009, the California Department of Motor Vehicles (DMV) published a report on the development of the California Three-Tier Driving-Centered Assessment System (Hennessy & Janke, 2009). The authors reported that the three-tier system takes a "driving-centered" approach to assessment (taking into account when, where, why, and how an individual drives), as opposed to the current "driver-centered" approach (identification of high-risk drivers) used by most licensing agencies. The proposed system includes three tiers. The first tier is a brief completion of four screening tools: Snellen test of visual acuity; test of contrast sensitivity; recalling social security number (cognitive screen); and DMV counter-person observations of physical limitations. Those who pass these screens are deemed "driving well" and can renew their license after successful completion of a rules-of-the-road test. Those who fail proceed to the second tier where they take a computer-administered assessment of perceptual-response time (processing speed). Those who fail this assessment proceed to the third tier, which is an on-road evaluation. This evaluation not only considers a driver's abilities, but also the level of risk for making a driving error in that driver's normal driving. For example, a driver with poor contrast sensitivity may be deemed "driving well" if he or she appropriately avoids low contrast driving conditions. The report concludes with several recommendations for implementing the three-tier system.

A study in British Columbia, Canada investigated the effects of restricted driver's licenses on crash risk among older drivers (Nasvadi & Wister, 2009). The researchers analyzed license records and insurance claims crash records for drivers age 66 andolder in British Columbia over a 7-year period. Drivers with restrictions on their licenses were compared to drivers without restrictions on estimated at-fault crash risk. The study only considered three types of license restriction: restricted speed (no driving on highways and/or no driving over a certain speed); restricted geographical radius; and restricted time of day travel (no nighttime and/or rush hour driving). The study found that at-fault crash risk was significantly lower for older drivers who held restricted licenses after controlling for age and sex. The study also found that restricted drivers retained their licenses longer and were crash-free for a longer period of time than those with unrestricted licenses. The study did not include a measure of driving exposure, both in terms of amount of driving and compliance with restrictions.

Meuser, Carr, and Ulfarsson (2009) examined the crash history and licensing outcomes for older drivers who were reported to the Missouri, US state licensing agency as medically impaired. The study focused on 4,100 drivers age 50 and older reported in the years 2001-2005. In Missouri, reported drivers in most cases must submit a physician's evaluation within 30 days of being reported (or 60 days if an extension is requested). Depending upon what this evaluation indicates, the reported driver may be given a licensing action (full/restricted/revoked license) or required to be evaluated further. The authors found that of reported drivers, most reports came from police officers (30%), followed by license office staff (27%), physicians (20%), family members (16%), and others (7%). The average age of reported drivers was 80 years. When compared to

control drivers, the crash involvement of reported drivers was four times higher. About one-half of reported drivers did not submit a physician evaluation after being reported and subsequently had their license revoked. Most of the remaining reported drivers either failed to schedule further testing or failed the testing. Of the reported drivers in this study, 96.5% retired from driving at some point during the process.

Health Professionals

Physicians and other health professionals are uniquely positioned to assess driving-related problems as part general medical treatment and care. Eby, Molnar, and St. Louis (2008) discussed how older drivers are likely to listen to a health professional regarding driving reduction and cessation, but physicians are often reluctant or uncomfortable with making fitness-to-drive decisions or lack the necessary information to do so. Many of these issues are discussed by Marottoli (2008). The legal and ethical requirements of physicians regarding older adults and driving have been summarized in the *Physician's Guide to Assessing and Counseling Older Drivers* (Wang, Kosinski, Schwartzberg, & Shanklin, 2003). Each state's legal requirements are different. Some states require physicians to report "unsafe drivers," some require reporting for specific medical conditions, and some states encourage reporting but do not mandate it. Further, protection for physicians who report patients vary by state, with only a handful of states providing immunity from prosecution for reporting a driver. Finally, some state licensing agencies utilize a medical advisory board comprised of physicians and other experts to review reported cases and make recommendations. However, not all states have such boards

A study in South Carolina, US surveyed primary care physicians at a large hospital about their interactions with aging patients and their understanding of reporting requirements related to driving (Witte, Brooks, Logan, & Beeco, 2009). The study found that most respondents thought that physicians should be responsible for reporting unfit drivers to the licensing agency. Most reported, however, that they did not feel qualified to make judgments about driving fitness, were unaware of reporting requirements, and thought they could benefit from educational programs on determining driving fitness.

Silverstein and Barton (2010; see also Silverstein, Barton, Chan, Lloyd, Belony, & Gromack, 2009) investigated stakeholder opinion on current and future directions for Massachusetts, US regarding how the medical advisory board and licensing agency treat medically at risk drivers. Massachusetts is a state where physicians are not mandated to report drivers (although they are encouraged), physician reporting is not confidential, and reporting physicians do not have immunity from prosecution. The study involved structured interviews with a wide range of 23 stakeholders in the state. The study found that nearly all stakeholders thought the state should provide immunity for physician's who report medially at-risk drivers to the licensing agency. Opinions were mixed on whether the state should continue with voluntary reporting or mandate it. About two-thirds disagreed with the current practice of not granting confidentiality to physician's who report drivers. Finally, a large majority of stakeholders were not satisfied with the state's medical advisory board practices and composition.

Oregon's 2002 law mandating health care practitioners to report cognitively impaired drivers to the department of motor vehicles was evaluated by Snyder and Ganzini (2009). The study examined the 1,664 eligible cases reported between 2003 and the first quarter of 2006 regardless of age (30% were age 60-79; 58% were age 80 or older). Cases were analyzed for characteristics of the impairment and likelihood of failing to

retain driving privileges. The study found that 89% of cases involved cognitive impairment and the other cases involved, surprisingly, visual or functional impairment. The percentages of drivers losing their license after physician reporting varied by age group and sex: for drivers who were aged 60-79, 84% or men and 91% of women lost their license; for drivers age 80 and older, 94% of men and 96% of women lost their driving privileges. The odds of losing a license were also significantly higher if the cognitive impairment was progressive or the impairment involved insight or judgment.

Law Enforcement

Law enforcement officers also have contact with older drivers, often after crashes or driving violations, and are in a unique position to serve as an important screen for potentially unsafe driving. As previously discussed, police officers refer more older adults for reassessment than any other stakeholder group (Meuser, Carr, & Ulfarsson, 2009). Law enforcement officers seem to recognize the need for information about processing older drivers during crashes and traffic stops, but there is little information that they can use to assist them. NHTSA has recognized the lack of educational materials for law enforcement and has developed a law enforcement educational module that has been launched publicly (NHTSA, 2004). The older driver law enforcement course has four key messages:

- Be sensitive to the special needs of older adults and declines that occur from age-related medical conditions;
- Write the citation—citations help the licensing agencies identify potentially problem drivers;
- Make a referral to the licensing agency or to aging services so that the drivers can receive appropriate intervention (this does not necessarily mean loss of driving privileges);
- Make a difference in community relations by getting engaged with seniors before there's a traffic stop through volunteering, traffic safety courses, SALT programs, etc.

Indeed, the websites of most national law enforcement groups address older drivers. However, most of these sites simply repeat information that can be found on the NHTSA website. National organizations that represent age-related diseases (e.g., the Alzheimer's Association) are developing tools to help law enforcement officers understand and manage older adults who may have those diseases. There has been, however, surprisingly little discussion or research on best practices for law enforcement's role in helping to maintain safe mobility in an aging society.

NHTSA (2005) collaborated with a number of organizations involved with aging drivers, including the National Sheriff's Association Traffic Safety Committee, to develop and publish a review of law enforcement programs focused on older driver safety. This publication, called *Turning the Corner…and Still Driving*, addressed several topics: older adult driving issues; promising approaches and keys to successful programs; and resources and contacts.

More recently, the Older Driver Education & Research Team (2007) at the Washington University School of Medicine, developed *Health, Functional Status, & Older Driver Safety: A Curriculum for State Highway Patrol Driver Examiners & Troopers*. This

publication presents a complete curriculum for training police officers about the special issues related to older drivers including: red flags of concern; the process of reporting drivers to the licensing agency; how to fill out the required forms; crash statistics; problem maneuvers for older drivers; medical conditions and driving; and a wealth of other information. An evaluation of the curriculum is planned.

Rehabilitation

Rehabilitation refers to the restoration of skills that have been lost due to injury, illness, or inactivity to a normal or near normal level. Some declines in critical driving skills experienced by older adults may be reversible through fitness or cognitive training programs. A recent review discussed the potential mechanisms underlying the relationship among physical activity, driving ability, and road safety (Marmeleira, Godinho, & Vogelaere, 2009).

M-CASTL sponsored a project to assess the effects of a cognitive training program on several factors including driving performance (Seidler, Bernard, Buschkuehl, Jaeggi, Jonides, & Humfleet, 2010). This project had two aims: 1) determine whether a 5-week working memory training program improved working memory performance for young and older adults; and 2) determine whether benefits associated with the program transferred to other tasks including driving. The study involved recruiting both young (mean age = 21 years) and older adults (mean age = 68 years) and randomly assigning them to the training program or to a knowledge training control condition. The cognitive training program used a dual *n*-back task, which involved remembering simultaneously presented visual and auditory sets of information. The participant's task was to remember *n* stimuli back in the set and respond if the current stimulus matched. A different response was given if the match was auditory or visual. The *n* was changed depending on how well the participant was performing this very difficult memory task. A session lasted about 20-25 minutes and participants participated in 17 to 25 sessions. Performance was measured by the final *n* for each session. Participants in the control group trained on trivia and vocabulary for 23-minute sessions. The study found that both age groups improved on the *n*-back task over the course of the training program, although older adults performed less well overall. This training transferred to other measures of working memory. The training also seemed to show transfer to complex motor tasks including driving performance as measured on a driving simulator. The authors caution that these results are preliminary, with more older adults currently completing the experiment.

Korner-Bitensky, Kua, von Zweck, and van Benthem (2009) conducted a systematic review of articles on older driver retraining published between 2004 and 2008 to determine the effects on improving driving performance and reducing crash risk. The study concluded that there was: strong evidence that education programs that include on-road training improve driving performance and moderate evidence that these programs also improve knowledge; moderate evidence that physical fitness programs improve driving performance; and moderate evidence that educational programs in isolation do not reduce crash risk.

A Canadian study investigated whether maintaining a drivers' license could motivate older adults to regularly participate in a physical fitness program (Caragata, Tukko, & Damini, 2009). This small-scale study included 19 people who participated in a "Fit to Drive" physical fitness programs (1 hour, twice a week, for 6 weeks). Five additional

older drivers served as a comparison group who did not participate in the fitness program. Both groups completed pre and post surveys and physical examinations. The study found that when compared to the control group, participants in the physical fitness group scored better on several measures of fitness, including strength, endurance, and flexibility. Those in the fitness group also reported that they thought their driving skills had improved and they were more confident while driving. People in the comparison group reported no improvements in driving.

Two studies examined the effects of cognitive speed of processing training on driving outcomes. One of these combined data from two longitudinal studies of older drivers. Participants in the project who showed reduced speed of processing ability based on a cutoff were randomly assigned to speed of processing training or a control condition (Edwards, Delahunt, & Mahncke, 2009). The study found that when compared to the control group, those who completed 80% or more of the training program were 40% less likely to stop driving over the subsequent 3 years. The other study examined the impact of cognitive speed of processing training on driving exposure and difficulty (Edwards, Myers, Ross, Roenker, Cissel, McLaughlin, & Ball, 2009). As with the previous research, the 134 drivers who showed poor cognitive processing speed were randomly assigned to either receive cognitive processing speed training or to a control group. The study found that control group participants reported greater declines in driving exposure, geographic space, and driving difficulty over the subsequent 3 years when compared to those who received cognitive processing training.

Technology

One way to extend safe driving among older adults is to use technology to help with various parts of the driving task. Technologies that can help older adults maintain safe mobility vary widely, from vehicle adaptive equipment (e.g., special mirrors, hand operated throttle), to advanced technologies (e.g., navigation system, night vision enhancement), to vehicles designed specifically for older adults. As discussed in previous reviews (Eby, Molnar, & Kartje, 2009; Eby, Molnar, & St. Louis, 2008), technologies that have the potential to increase the safety and mobility of older drivers must be affordable, relatively easy to use, and work to enhance safe driving. These technologies must be designed for use by older drivers, who may use technologies differently than young people (Caird, 2004; Dingus et al., 1997; Eby & Kostyniuk, 1998; Kostyniuk, Streff, & Eby, 1997; Stamatiadis, 1998; Wochinger & Boehm-Davis, 1995). Understanding patterns of use for the various technologies that are being developed is crucial for optimizing the benefits of technology for all users (Vrkljan & Polgar, 2007).

Simões and Pereira (2009) published a book chapter on older drivers and the introduction of new in-vehicle advanced technologies. The chapter distinguishes different types of intelligent transportation systems (ITSs): advanced driver assistance systems (designed to cooperate with driver to achieve driving goals); and in-vehicle information systems (designed to provide drivers with information and communication). The authors argued that ITS can be beneficial for older drivers but that systems need to be designed for them and that training on their use will be necessary. In addition, they pointed out that behavioral adaptations over time to new technologies will occur and should be understood when designing the technology. The authors also cautioned that the introduction of new technologies into cars will not necessarily represent an improvement for older drivers.

The issue of increase in driver workload resulting from the use of adaptive equipment was recently investigated (Benoit, Gélinas, Mazer, Porter, & Duquette, 2009). The study examined the use of a hand controlled throttle/brake among a group of 27 younger (age 25-45) and 27 older (age 60 and older) participants. None of the participants had physical impairments that required the use of a hand controlled throttle/brake. All participants completed a clinical examination of cognitive and perceptual status and a questionnaire on driving habits. Following the examination, participants drove an 18-mile route in an automatic-transmission car with an evaluator who measured the participant's workload at four points. Workload was measured using the NASA Task Load Index (TLX), which required the participant to self-rate a number of dimensions related to the current driving task that can be combined to estimate workload. Vehicle speed was automatically collected using an in-vehicle device. After the drive, the hand-control device was installed and participants practiced using it. Once they were familiar with its operation, they drove the same 18-mile route and completed the same NASA TLX ratings. The study found that modifying the throttle and brake to be hand controlled significantly increased the demands of the driving task for both young and older participants. Older adults who exhibited declines in attentional abilities had a greater increase in the driving task demand when using the hand controls. Also, women in both age groups showed a higher increase in workload when using the hand controls.

Researchers from the Massachusetts Institute of Technology AgeLab presented a concept for a car designed to optimize older adult driving safety (Coughlin, Reimer, & Mehler, 2009; Reimer, Coughlin, & Mehler, 2009). This concept, called the AwareCar, is based on the idea that crashes can be mitigated by exploiting the interactive and overlapping roles of the vehicle, environment, and driver. The researchers used the public health perspective of "wellness" (the pursuit of optimal personal goals) as a framework for AwareCar. To that end, they viewed driver performance as dynamic and improvable and the vehicle as a wellness platform that supports optimal driving performance. According to the authors, the framework in based on three wellness inspired components: detection and monitoring of the driver's state (e.g., fatigue, impairment); providing information to the vehicle, environment, and driver; and producing alerts as needed to meet the needs of the driving situation. The research findings and challenges on these three components were further explored by the authors.

Roadway Design

One clear way to keep older adults safely driving as long as possible is to make improvement to the roadway and infrastructure that better accommodate the common functional declines associated with aging. Many organizations have recognized this. Indeed, the FHWA began an initiative over a decade 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 (Staplin, Lococo, & Byington, 1998). The FHWA website states that a revised version of this document will available sometime this year. Two new studies on roadway infrastructure related to older drivers have been published in the past year.

Inman (2010) conducted a study to assess the feasibility of an infrastructure-based warning at signalized intersections to warn drivers of red-light violators. The author conducted a study of driver behavior at yellow-lights to determine the point in a yellow-

light cycle where the driver was equally likely to stop or proceed into the intersection, called the decision point. Using a simulator, the author studied the yellow-light behaviors of young drivers (men age = 35 years) and older drivers (mean age = 72 years), under a number of traffic conditions and yellow-signal onset times. The study found great variability in decision points among drivers (the range was 1.7 to 5.3 sec). When decision points by age group were analyzed, older drivers' decision points were slightly closer to the intersection. The mean decision point for both groups was well within the time required to stop at the intersection, taking into account travel speed. The author concluded that the current recommended yellow/red light intervals are reasonable.

The effect of advanced street name signs on crashes, particularly older driver crashes, was investigated in a study conducted in Arizona, Massachusetts, and Wisconsin, US (Gross, Lefler, Lyon, & Eccles, 2010). Advanced street name signs use fonts, colors, and placement that enhance conspicuity, legibility, and comprehension. Signs were installed at 82 sites in Arizona, 65 sites in Massachusetts, and 46 sites in Wisconsin. All sites were controlled intersections with high traffic volumes. Crash rates were calculated before and after installation. The study found no significant differences in crash rate after sign installation in any of the three states or overall. Analyses of older driver involved crashes also showed no significant change in crashes after sign installation. The authors concluded that although there was no improvement in crash rates, advanced signs may still be beneficial for wayfinding.

Extending Safe Driving: Conclusions

Significant research effort has recently been concentrated on helping older adults remain driving for as long as they can safely do so. The work on self-screening shows promise in helping people learn about themselves so that they can make better decisions about driving. Yet, as such tools are developed, it is important to evaluate them to be sure that they are leading to the intended outcomes. In addition, longer-term evaluations are needed to determine the effects of self-screening on choosing appropriate self-regulatory behaviors and on improving traffic safety. Research on screening and assessment at licensing agencies is progressing. The three-tier system pilot tested in California shows particular promise, in part because it recognizes the workload burden that screening and assessment place on licensing agency staff. The issues related to health professionals and assessment of older adults for driving fitness continue to be debated. While progress is being made in developing educational tools, more research is needed to develop understand best practices and policy for physician reporting and medical advisory boards.

Law enforcement's role in maintaining safe driving for older adults has in large part been unrecognized. This seems to be changing with the work in Missouri on developing a curriculum for law enforcement. There are other issues that still need to be addressed including: understanding and improving the dynamics between young patrol officers and the older adults they encounter in traffic stops and crash scenes; developing quick and easy to use driver fitness tools for law enforcement; and developing and evaluating educational and training tools for law enforcement.

Fitness and cognitive retraining programs are showing promise for helping people regain some abilities needed for safe driving. Further work is needed, particularly in evaluating the effects of these programs on traffic safety. Technologies for maintaining safe driving

continue to be developed and research is needed to ensure that these technologies can be easily used by older drivers and that they do not compromise driving safety. Jurisdictions are slowly changing the roadway infrastructure following the FHWA guidelines for accommodating older drivers. Research should continue to assess whether these recommendations do indeed help older drivers (and all drivers) be safer on the roadway. Much more work is needed to better understand how to keep older adult pedestrians safe.

TRANSITIONING TO NON-DRIVING

Despite large individual differences in the functional abilities, most older adults will eventually be faced with decisions about reducing or stopping driving and how to maintain mobility. Transitioning to non-driving is a multifaceted issue with significant societal outcomes. There has been limited research 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 has also been little research on how driving cessation affects the family member/caregiver who takes on the responsibility of coordinating transportation for the older adult. 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).

During the past year there have been a number of research efforts directed at helping smooth the transition from being a driver to non-driving mobility. Indeed, M-CASTL had as its 2009 research theme: *Supporting the transition from driving to non-driving to ensure the safe mobility of older adults*. M-CASTL sponsored four projects related to transitioning to non-driving. The titles of these projects are: Assessing driving in older adults: Perspectives of vision care providers; Development of a protocol to assess the effects of workload on older drivers: A first step; Driving cessation and caregiving continuum: Adult child/parent dynamic; and Using vehicle instrumentation to better understand the transitioning process: An exploratory study. Details on these studies can be found here: http://www.m-castl.org/node/2.

M-CASTL also published the results of an M-CASTL-sponsored project (Kostyniuk, Connell, & Robling, 2009). This study examined the process of driving reduction and cessation from the perspective of older adults and adult children. The objective of the study was to better understand the family dynamics that influence reduction and cessation and to identify common themes. The study analyzed transcribed focus groups conducted with older adult drivers/former drivers and adult children of older drivers. The study found several themes among current and former older drivers, including a reluctance to stop driving; avoidance of specific difficult driving conditions; perceived importance of driving for independence and quality of life; unwillingness to acknowledge declining driving abilities; lack of perceived risk to other motorists; and lack of planning for driving cessation. The study also found that the main barriers to driving cessation were a reluctance of older adults to increase the burden on their children and reluctance by children to initiate taking over the responsibility for transporting the older adult parent. These results begin to highlight the complex family dynamics involved in driving reduction and cessation.

The National Highway Traffic Safety Administration (NHTSA, 2009b), in collaboration with the American Society on Aging, published an education module to help educate older adult mobility professionals on how to help older drivers, families, and communities deal with issues related to transitioning to non-driving mobility. This comprehensive document includes 15 modules on a variety of topics including statistics about older drivers; understanding driving skills; warning signs and dangerous coping mechanisms;

having the conversation about driving; types of assistance; and retirement from driving. The document also includes lists of associated resources, handouts, and references.

Several other studies have been published on this topic in the past year, including two special issues of *Topics in Geriatric Rehabilitation* (McCarthy, 2009). A discussion of the seven articles in the first issues was included in a previous synthesis report (Eby, Molnar, & Vivoda, 2009). The seven articles in the second issue discussed a wide range of topics. Kerschner (2009) discussed the transition from being a driver to a non-driver in terms of losses and new beginnings. She suggests a policy agenda for helping people to plan for this transportation transition. Crabtree, Troyer, and Justiss (2009) examined the intersection of driving with a disability and being a public transportation passenger with a disability. Eberhard and Mitchell (2009) compared the US and Great Britain in terms of licensing rates, motor-vehicle fatality rates, and mobility options among older adults. The authors found that licensure rates for men are decreasing while rates for women are increasing. Fatality rates for both age groups are decreasing, while driving is increasing. They also found that older women in the US but not Great Britain tend to drive less than men and stop driving sooner. The authors suggested that if women drove longer, safer mobility could result through these women providing transport to spouses who should not be driving.

Morgan, Winter, Classen, and McCarthy (2009) conducted a systematic literature review on gender differences in driving self-regulation and cessation among older adults. The study had several findings and corresponding recommendations:

- Findings:
    - o Older women lack confidence in driving skills;
    - o Older women cease driving earlier than older men and have a greater need for alternative transportation and mobility support;
    - o Older men report increased driving exposure and less avoidance of difficult driving situations, when compared to older women;
    - o Older men experience greater depression following driving cessation when compared to women.
- Conclusions:
    - o Driving avoidance by women has implications for reduced mobility and safety. Older women may benefit from skills training.
    - o Because older women have varied reasons for driving cessation in addition to health reasons, there are more opportunities to intervene and prevent premature driving cessation.
    - o Health status was the most important factor predicting driving avoidance and cessation.
    - o Older men drive more than older women and tend to have a stronger connection to the driving role that may make driving cessation a more difficult transition.

A retrospective study in Southeast Virginia, US considered the driving behaviors of older adults during the 3 months prior to being referred for a formal driving evaluation (Petrakos & Freund, 2009). The authors sought to better understand the behavioral differences of drivers who fail and pass the evaluation. Study participants completed a questionnaire on driving behaviors over the past 3 months, a number of clinical tests, and a driving performance test on a driving simulator. The study included 57 drivers with a mean age of 79 years—28 failed the evaluation, 13 passed with restrictions; and 16

were deemed safe drivers. The study found that self-reported driving habits, including crashes and near crashes, did not predict the driving evaluation outcomes.

Pellerito (2009) examined the effects of driving cessation on older adults living in metropolitan Detroit, Michigan, US. The author conducted structured interviews with 30 participants ranging in age from 51-95 years exploring the positive, negative, and mixed effects of driving cessation. The author reported that participants cited the following negative consequences of cessation: decreased community mobility; decreased community participation; weakened social ties; decreased control; depression; and increased frustration. Participants also cited positive effects related to driving cessation including increased time with family members and significant others; increased community participation; strengthened social ties; increased sense of personal safety; and feelings of relief. The author also reported consequences of driving cessation that had both negative and positive aspects. These effects were increased introspection (primarily of death and dying) and decreased consumer spending.

Kafka and Bédard (2009) investigated the psychological factors associated with driving cessation among a sample of 233 older adults in Ontario, Canada. Participants, age 55 to 91 completed a questionnaire on demographics, functional abilities, heath status, personality traits, and psychological resources. The study found that demographic, functional abilities, and health status variables accounted for most of the variance in driving status, with participant age being the most important variable. Lower scores, however, on life purpose and higher external locus of control were also associated with driving cessation.

A study from Missouri, US examined driving cessation in older adults with dementia (Croston, Meuser, Berg-Weger, Grant, & Carr, 2009). The authors developed a questionnaire that explored issues related to mobility, driving, and driving cessation. Participants were drawn from referrals to a memory impairment clinic. All participants had to have a diagnosis of dementia, a history of past or current driving, and an informant (caregiver, usually a spouse) who could be contacted. Of those meeting the criteria (527 dyads), 119 (23%) returned the survey. The questionnaire was completed by both the participant and his or her informant. The study found that 28% of participants were actively driving. Slightly more than one-half of informants rated the participants as unsafe to drive. The barriers to driving cessation found in the study included: a lack of insight by the driver; the participant's personality; the informant's belief that the participants was still safe to drive; the risk of social isolation; and the lack of alternative transportation options. Only 12% of informants, however, reported that there was reluctance among families to address driving with the participant. Few informants sought professional or educational assistance for dealing with the issues of driving with dementia.

Choi, Adams, and Kahana (2009) sought to determine the impact of formal and informal transportation support on driving cessation. The study utilized data for 604 older adult participants from a longitudinal study in Florida (mean age of 78 years). Informal transportation support was defined as support from spouse, family, or friends, while formal transportation support came from organizations or hired assistants. The study found that after controlling for a number of health and sociodemographic factors, both types of support were related to driving cessation. The three most important factors influencing driving cessation in order were: support from friends; support from a hired

assistant; and support from a spouse. Support from family or organizations was not found to be related to cessation.

Caregiver Economics

A symposium at the 2008 Annual Conference of the Gerontological Society of America conference brought together a number of stakeholder groups to talk about the issues surrounding older adult safety and mobility (Classen, Molnar, Dobbs, Bédard, Dickerson, Eby, & McCarthy, 2008). Several symposium stakeholders commented on the economic issues related to older adult driving reduction and cessation. Stakeholders commented that few organizations are considering the full economic impact of mobility loss for older adults with declining health, both from the perspective of the individual, and his or her caregiver, and to society. Thus, in the absence of adequate community mobility options, the loss of mobility resulting from driving reduction/cessation increases caregiver costs, caregivers' employee costs, and reduces discretionary expenditures by people experiencing mobility loss.

Society is ill-equipped to provide good community mobility options for those who need them (see e.g., Dickerson, et al., 2007). As such, providing transportation to older adults often becomes the responsibility of a caregiver (most often a family member). According to the National Alliance for Caregiving (NAC) and AARP (2009), there were more than 45 million people providing unpaid care to someone age 50 or older (36 million providing care for those age 65 or older), with about 90% being a relative. More than 90% reported providing care for 1 or more hours per week, with about one-half reporting 9 or more hours of weekly support. The most frequently reported support-activity was providing transportation services (84%). Providing these services came at a cost to the caregiver. Although the majority of caregivers reported low financial hardship resulting from caregiving, 43% report at least some hardship and 10% report high levels of hardship (NAC and AARP, 2009).

Caregiving has two other financial impacts that need to be considered. The first is lost productivity at work. According to NAC and AARP (2009), more than two-thirds of caregivers reported needing to make some adjustment to their work to accommodate caregiving, such as taking time off, taking a leave of absence, retiring early, or adjusting a work schedule. A study by the MetLife Mature Market Institute (2006) estimated that the costs of lost productivity in the US due to caregiver accommodations were $17.1 billion annually. Another economic impact is increased health care costs for caregivers. The emotional, physical, and financial stresses of caregiving can lead to health problems. Indeed, a study in four US communities found that caregiving was a risk factor for mortality (Schultz & Beach, 1999). A recent case study of a large corporate US employer (Albert & Schultz, 2010) found that caregiving employees reported poorer physical and mental health than employees not providing care. The study estimated that health care costs for those employees providing care was about 8% higher than for those not providing care. The researchers extrapolated these data to the general US business sector and estimated that unpaid caregiving costs employers about $13 billion annually.

Transitioning to Non-Driving: Conclusions

There has been a much needed focus in recent research on understanding and smoothing the process of transitioning from being a driver to a non-driver. There is a need, however, to continue and expand this research. Based on the work reviewed

here, there is a clear need to better understand how the "conversation" about transitioning takes place in families and to identify successful strategies for having this conversation. Work is needed to better understand and facilitate the roles of the various people involved in the transitioning process. Research is showing clear differences in how older men and women transition to non-driving and the outcomes of this process. Researchers have also begun to address how various psychological traits are related to the process of transitioning, but more work in this area is needed. Smoothing the transitioning process for older adults with dementia continues to be a difficult issue.

The discussion of caregiver economics is new to the synthesis report series. There are significant economic costs associated with transitioning from being a driver to being a non-driver and these costs are not just for the driver himself or herself. Gaining a clearer understanding of the economics of driving cessation is needed in order to develop more effective policy. There is need to develop a model of these costs so that stakeholders can better understand the potential effects of their decisions.

COMMUNITY MOBILITY

As discussed in several places in this report, although many older drivers are able to compensate for declines in functional abilities by self-regulating their driving, most older people will at some point be faced with stopping driving. Estimates show that 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.

Among the community mobility 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 and there is considerable variation among the services in terms of how aware people are of the services, how difficult the services are to use, and how much they cost. Community mobility can also be enhanced through the development of communities that support aging in place, so called livable communities (Oberlink, 2008). A number of new studies on community mobility have recently been published.

A study by the Centers for Disease Control and Prevention addressed the factors that affect the choice to walk or drive among older adults (Naumann, Dellinger, Anderson, Bonomi, Rivara, & Thompson, 2009). The study recruited 406 drivers (age 65 or older) who were enrolled in a large US health plan. Participants completed a telephone interview that asked about demographics, health status, functional abilities, and preferred mode of travel for short trip in good weather. The study found that having confidence in one's walking ability increased the likelihood of choosing to walk on a short trip by about 20%, while a preference for walking for exercise increased this choice by 50%. Reporting poor health or a physical problem decreased the likelihood of choosing to walk.

Chen (2010) presented data on the travel characteristics of a stratified sample of 1,273 people who were representative of the older adult population in Taiwan. The study found that walking was the travel mode used most often by older adults for the three most popular activities for this age group: participating in outdoor exercise; chatting with neighbors; and shopping. The author concluded that older adults in Taiwan like to have activities local to their neighborhoods. The study also found that there were many barriers to safe walking in Taiwan including: obstructions in walkways (parked motorcycles, store displays); narrow sidewalks; and a lack of sidewalks.

A study in San Luis Obispo County, California, US investigated transportation option issues among a representative sample of 375 older adults (Nuworsoo, 2010). Participants completed a mail-back questionnaire. The three most commonly chosen modes of travel were driving alone (68%), riding as a passenger (16%), and fixed route transit (8%). These choices varied little by trip purpose. The study also addressed preferred modes of travel distinct from modes that were chosen. Data showed that 24%

of respondents preferred to use public transportation but only 11% were current users of these modes. Only one-half of older adults preferred to drive (as opposed to the 68% who were still driving) and there was little preference for walking or biking which agreed with the mode choice results. The study addressed reasons for not using public transit and found that the most commonly cited reasons were: lack of convenient routes, lack of knowledge about the systems; no stop nearby; and infrequent busses.

A study in Columbia, Missouri, US investigated the effect of a social marketing campaign to promote walking and cycling among 48 older (age 50 and older) and young (age 49 or younger) people (Fitzgerald, Kinser, Schubert, & LeMaster, 2009). The study further divided respondents into those who participated in the community-based program and those who did not. Structured interview data showed: older and younger people shared many of the same concerns about walking and cycling in their own neighborhood; older adults were more concerned about personal safety and physical challenges; young adults were more concerned about a lack of time; younger adults were more willing to cycle or walk despite the perceived barriers; older adults participated in the program for health reasons; and younger adults participated in the program for social reasons.

Fortinski, Vine, Hennig, and Freund (2009) presented research on the development of a metric for community mobility self-efficacy; that is, a community's self-confidence in providing transportation for those who need it. The researchers completed the self-reported questionnaire through telephone interviews with 75 volunteers (mean age 76 years). The authors reported that the metric showed good internal consistency and other promising psychometric properties.

Finally, M-CASTL recently published a report on transportation accessibility in an M-CASTL sponsored project (Levine, Grengs, Chen, Enos, Kostyniuk, & Wargelin, 2010). The paper reconceptualized the field of transportation by arguing that the purpose of transportation is not movement per se, but access to activities at one's destination. The implication of this is that transportation outcomes are most appropriately evaluated in terms of accessibility, rather than mobility. This project developed and compared accessibility metrics among seven large metropolitan areas in the US by age group. The metrics include not only mobility but also the proximity of destinations. The researchers analyzed the place-based accessibility indicators developed in previous work and household- and person-level characteristics gleaned from metropolitan household travel surveys. Researchers compared accessibility characteristics of older and younger travelers in different land-use and transportation environments: between metropolitan regions, in different locations within a single metropolitan region, and with varying levels of access to transportation alternatives.

Community Mobility: Conclusions

Work is continuing to help us understand older adults' preferences for various modes of non-driving transportation and this work should continue. Research interest has started to focus more on developing livable communities, where goods, services, social contacts, and recreation are close to where the older adults live. Such communities also would allow for a more effective community mobility infrastructure. Finding ways to facilitate walking and cycling has been a topic of recent research and this work should continue.

CONCLUSIONS

This report updates that literature reviewed in the M-CASTL 2009 Synthesis Report (Eby, Molnar, & Vivoda, 2009) and defines additional areas where further research is needed. Judging by the volume of research reviewed in the present report, the issues of older adult safety and mobility are receiving much needed attention and funding. When considered in the context of pressing societal issues--generation of motor-vehicle produced greenhouse gases and dependence on foreign oil--research into maintaining safe mobility for our aging society will positively impact these issues. As discussed in this report, one cannot think about older adult transportation safety without also considering how mobility will be maintained once an older person can no longer, or chooses not to drive. The development of community mobility options to help maintain older adult mobility options that are available, accessible, acceptable, adaptable, and affordable will have the added benefits of reduced fuel use and greenhouse gas emissions. Such synergies make sponsorship of aging and mobility research a fiscally responsible choice for society.

Finally, as echoed in the previous report, there are several themes that thread through the current 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 or desired is an important component in safe mobility. Fourth, research to help older adults stay mobile will also help younger drivers. Fifth, developing alternatives to automobile use for personal travel will have a wide range of positive societal impact beyond helping older adults stay safely mobile. Sixth, policy and research needs to start recognizing the wide range of significant economic impacts the will come with the aging of the baby boomers. Finally, meeting the mobility needs of an aging population is complex and will require the expertise and collaboration of several academic and applied disciplines. M-CASTL will continue to provide these collaborative opportunities.

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