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Safe Mobility for Older Americans

Report of the Committee for the Conference on Transportation in an Aging Society

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This report has been reviewed by a group other than the authors according to the procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

The conference was sponsored by the National Highway Traffic Safety Administration; the Federal Highway Administration; the Federal Transit Administration; the Office of the Secretary, U.S. Department of Transportation; the National Institute on Aging of the National Institutes of Health; the National Center for Injury Prevention and Control of the Centers for Disease Control and Prevention; the Eno Transportation Foundation; the AAA Foundation for Traffic Safety; the Beverly Foundation; and the Transportation Research Board.

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Preface

In the years following the 1988 publication of the Transportation Research Board's (TRB's) *Special Report 218: Transportation in an Aging Society: Improving Mobility and Safety for Older Persons* (TRB 1988), an unprecedented volume of research and development activity on aging occurred in North America, Australia, and Europe. A decade after the report was released, TRB planned and conducted an international conference on the safety and mobility of older persons.

The purpose of the conference was to review what had been accomplished in research and implementation since the publication of *Special Report 218* and to identify future research and implementation needs for achieving safer mobility for older persons. Funding for the conference was provided by the National Highway Traffic Safety Administration; the Federal Highway Administration; the Federal Transit Administration; the Office of the Secretary, U.S. Department of Transportation; the National Institute on Aging of the National Institutes of Health; the National Center for Injury Prevention and Control of the Centers for Disease Control and Prevention; the Eno Transportation Foundation; the AAA Foundation for Traffic Safety; the Beverly Foundation; and TRB. The National Research Council (NRC) appointed a committee under the chairmanship of Richard Marottoli to plan and conduct the conference, which was held November 7–9, 1999, at the National Institutes of Health in Bethesda, Maryland.

The conference committee commissioned research papers to be presented and discussed at the conference, planned all aspects of the conference program, and met after the conference to review the information generated and to deliberate on its findings and recommendations for future research and program initiatives designed to meet the challenges ahead.

The result of these activities is publication of two separate documents that together provide a comprehensive update to *Transportation in an Aging Society*. The first, *Conference Proceedings 27: Transportation in an Aging Society: A Decade of Experience* (TRB 2004), contains the technical papers commissioned by the committee and presented at the conference. This companion document, *Safe Mobility for Older Americans*, contains the committee's summary of research accomplishments during the past decade, committee recommendations, and a discussion of crosscutting issues.

This document briefly introduces the problem: America is an aging society. As the proportion of older persons grows and they experience the functional declines that often accompany the aging process, their safe mobility will become a significant national issue.* A discussion of the history of research in this area and suggestions

* Mobility, in this context, refers to more than simply moving from one place to another. It even goes beyond access to life's necessities, such as medical appointments and food. Mobility for older people encompasses quality-of-life issues, such as access to social and cultural experiences.

concerning the future magnitude of potential safety issues based on census projections and current crash rates are included. These introductory materials are followed by a series of committee recommendations that build on those offered by *Special Report 218*. The committee developed its recommendations on the basis of its deliberations, analyses, and judgment. It drew on the wealth of information generated by the conference as well as on other sources. The recommendations are organized by topic area: strategic considerations, drivers, vehicles, roadway environment, and alternative transportation. Each section also addresses research needs for the specific area of inquiry.

Chapter 4, “Crosscutting Issues,” is presented to frame this complex discussion properly. Identifying and characterizing the safe mobility needs associated with older persons lead to an understanding that the issues cannot be isolated by discipline, organization, population segment, transportation mode, or any other taxonomy. This document concludes with a brief summary of the research recommendations offered by the individual authors of the technical papers. Those recommendations appear in their entirety in *Conference Proceedings 27*.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by NRC’s Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. The committee thanks the following individuals for their review of this report: Germaine Odenheimer, M.D., Donald W. Reynolds Department of Geriatric Medicine, University of Oklahoma Health Sciences Center, Oklahoma City; Nina Silverstein, Gerontology Institute, University of Massachusetts, Boston; Donald R. Trilling, Alexandria, Virginia; Harold van Cott, Bethesda, Maryland; and Thomas M. Welch, Iowa Department of Transportation, Ames.

Although the reviewers have provided many constructive comments and suggestions, they were not asked to endorse the committee’s findings, conclusions, or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by C. Michael Walton, University of Texas at Austin. Appointed by NRC, he was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of the report rests solely with the authoring committee and the institution.

Suzanne Schneider, Associate Executive Director of TRB, managed the report review process. The report was edited and prepared for publication by Norman Solomon. The committee thanks Dr. Susan B. Herbel for her assistance in writing and editing major portions of this document.

The committee and TRB staff pay tribute to Patricia F. Waller, who passed away as this report was being prepared. The committee expresses its special appreciation to

Dr. Waller for her wisdom and insights as a member and for her help in the preparation of this report and *Conference Proceedings 27*. It was Dr. Waller who first pointed out, during one of the committee meetings, the need for a chapter on crosscutting issues, and many of the ideas in that chapter are hers. The members of the committee recognize Dr. Waller for her exemplary career contributions and superb professional example, and observe that it was an honor and distinct pleasure knowing and working with her.

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1

Introduction

American society is continuing to experience a demographic transformation that will have far-reaching consequences in areas such as health care, retirement, housing, and transportation. For the entire 20th century, the growth rate in the number of Americans over 65 greatly exceeded the growth rate of the population as a whole.

During the past 50 years, the U.S. population has grown older. From 1950 to 2000 the proportion under 18 years of age fell from 31 to 26 percent while the proportion over 65 rose from 8 to 12 percent. From 2000 to 2050 a small decline in the proportion of the population under 18 years of age is anticipated while a sizeable increase in the proportion of elderly is expected. As the “baby boom” generation turns 65, beginning in 2011, the size of the elderly population will grow substantially. By 2050 it is projected that one in five Americans will be elderly (Pastor et al. 2002).

The U.S. Census Bureau has predicted that the number of senior Americans will more than double between 1996 and 2050, from 34 million to 78 million (Rosenbloom 2004). By the end of the period, one in four Americans will be over 65 years of age. During the same period, the number of Americans aged 85 and older, the fastest-growing cohort, is expected to quadruple (U.S. Department of Transportation 2003). From an international perspective, two-thirds of all the elderly who have ever lived are alive today (Center for Strategic and International Studies and Watson Wyatt Worldwide 2000).

The “graying of America” (Blackman et al. 1999) is due to a number of factors:

- More people are staying alive into old age for a variety of reasons, including health care improvements.
- Research and prevention services have focused on the major causes of death and disability in older persons—arthritis, cancer, cardiovascular disease, dementia, and diabetes. This focus has resulted in breakthroughs in treatment and care and has prolonged lives.
- The baby boom generation (those born between 1945 and 1965) has matured. “Between 1946 and 1964, 75 million babies were born in the United States. In 2010, the first of the boomers who choose to retire at age 65 will be entering retirement, and by 2030, all ‘boomers’ will be over 65 years of age” (Hu et al. 2000).
- Those of childbearing age are having fewer children. In spite of predictions to the contrary, fertility rates have continued to fall for the past 40 years (Rosenbloom 2004).

Fertility in every developed nation has fallen beneath the replacement rate of 2.1 (Center for Strategic and International Studies and Watson Wyatt Worldwide 2000). While the number of older people is increasing, the population composing the work-force (aged 15 to 64) is diminishing in all developed nations (Center for Strategic and International Studies and Watson Wyatt Worldwide 2000). By the early 2020s, therefore, far fewer taxpayers and caregivers will be supporting each retired person.

Demographers refer to this phenomenon of increased longevity as the “squaring of the pyramid” (see [Figure 1](#)). Historically, population age groups were largest at the bottom (the youngest cohorts) and gradually grew smaller at the top (the oldest cohorts). Currently, the population graphic can more nearly be characterized as a square rather than a pyramid because of the rapid growth in the proportion of the population over 65, and such a characterization will be even more apt in the future. Thus, in addition to growth in the sheer number of older people, there is an evolving and significant shift in the age composition of the total population (Rosenbloom 2004).

Concerns related to the transportation of older individuals in the coming years are not new. The authors of *Special Report 218* recognized that mobility is essential to the quality of life and that most older adults equate mobility with the ability to drive. Not only is the number of older drivers increasing, but today they are driving more miles. Their exposure to vehicle crashes in general and to fatal crashes in particular is thus increased.

While older drivers are involved in fewer crashes per capita or per licensed driver, they are overrepresented in crashes and fatalities per mile driven and are more likely to be killed or injured as a result of collision than are drivers in most other age groups (Evans 1988; McCoy et al. 1989; Williams and Carsten 1989; Hu et al. 2000). For injured victims who are hospitalized and recover, the length of hospital stay is extended with increasing age (Sartorelli et al. 1999). The elderly who sustain traffic injuries represent a costly problem in terms of both acute health care costs and the need for continued care. As the elderly proportion of the United States population increases, the burden of motor vehicle collisions in the elderly is also likely to increase.

Several trends indicate that the older drivers of today may be different from the older drivers of yesterday. The following are among the important characteristics of the current generation of older Americans that differentiate them from previous generations:

- They are wealthier. Persons 65 or older currently represent approximately 20 percent of the population, but they control more than 40 percent of all disposable income. Older adults in the United States have about \$1.6 trillion in buying power, and their resources are expected to increase by 29 percent over the next 5 years (Coughlin 2002).
- They are leading healthier, longer lives. More than 80 percent of higher-income older adults report good to excellent health, and the nation has experienced a decrease

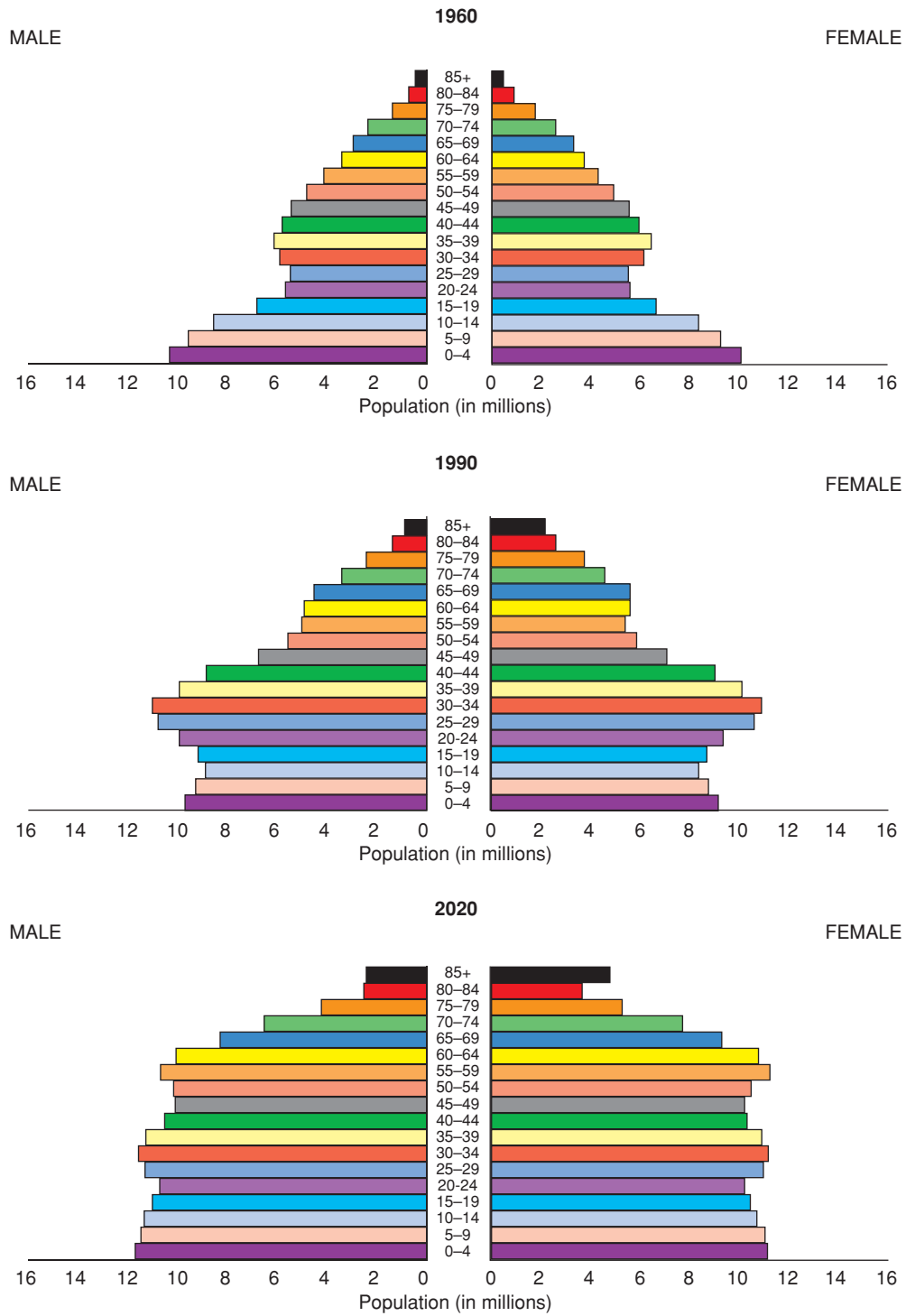


FIGURE 1 Squaring of the U.S. population pyramids, 1960–2020.
(Source: U.S. Census Bureau, International Data Base.)

in disability for all income groups (Coughlin 2002). Since people are expected to live much longer, it also might be expected that at some point many of them will suffer disabilities that affect their ability to drive safely. However, whether there will be an actual increase in disability prevalence is debatable.

- They are more highly educated and technologically savvy. The number of older adults with 4 or more years of college has doubled in the past 20 years. The fastest-growing segment of computer/web users is 50 years of age or older (Coughlin 2002).
- They prefer “aging in place” and are likely to remain in whatever housing arrangement they occupy prior to retirement for as long as possible (Rosenbloom 2004).

Compared with previous generations, today’s older adults enjoy better health care. They consider themselves to be relatively healthy, are actively engaged in the lives of their families and communities, and are currently meeting their own mobility needs. These trends are likely to continue among individuals over the age of 65. However, the impact of increased longevity on the eventual incidence of disability is not clear. As the elderly reach their 80s and beyond, the rates of disability that are being effectively lowered among the young-old may once again begin to rise, with the shift occurring at increasingly advanced ages because of health care improvements. If so, disabilities with a direct impact on mobility in general and driving in particular will present continuing challenges to all who have a stake in transportation safety.

Because mobility is such a critical component of independence and quality of life in later years, and because the cost of providing alternative transportation is so high in the United States, it will continue to be important for older persons to retain access to the private automobile for as long as possible. Trilling and Eberhard (2004) indicate in their vision for the future a desirable system for safe mobility for older persons. They describe it as follows:

The transportation system offers safe mobility to all people and allows older adults to remain independent and to age in place. Investments in highway and pedestrian infrastructure and public transportation services support independence. Medical and social service communities, transportation managers, motor vehicle administrators, and caregivers work together to enable safe driving as late in life as possible and to offer other convenient transportation options when driving and walking must be curtailed. Public and private organizations form new partnerships to enable all citizens to enjoy safe mobility for life.

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2

Research History

Historically, research on older drivers has followed three distinct periods and areas of inquiry. First, in the 1970s, research focused on whether older drivers represented a problem. Results showed that older drivers have fewer crashes per capita but more per mile driven (Sirén et al. 2001; see Hakamies-Blomqvist and Wahlstrom 1998 for a comprehensive review). The second period began in the 1980s and focused on identifying what in the aging process contributed to the increased risk for older drivers. The following findings were documented during this period (Hakamies-Blomqvist 2004):

- Older drivers have more crash fatalities and injuries per mile driven than middle-aged drivers, as is shown in [Figure 2](#).
- Older drivers are more likely than middle-aged drivers to be at least partly at fault in their crashes (McGwin and Brown 1999; Stewart et al. 1999).
- Intersection incidents are overrepresented in older-driver crashes.
- The increased crash risk in older drivers, which begins after age 75, is generally attributed to age-related functional deficits.
- Older-driver crashes are less likely to be reported as involving alcohol and speeding, and the occupants are more likely to wear safety belts than would be expected in other age cohorts.

Subsequent to the publication of *Special Report 218*, “the field of cognition and aging brought deeper understanding to the discourse” (Hakamies-Blomqvist and Wahlstrom 1998). It was also during this period that crash propensity was questioned, and it was shown that older drivers’ high injury and fatal crash rates could be explained at least in part by their greater physical frailty (Sirén et al. 2001; Li et al. 2001). Therefore, to understand more clearly the safety implications of the aging population, one needs to examine not only the fatality rate but also the crash rate.

[Figure 3](#) shows that, while older drivers and passengers may be more likely to die in a crash, their crash involvement rate compares favorably with that of middle-aged drivers at least until age 75. While the perceived problem is that older drivers constitute a highway hazard and a major cause of crashes, research suggests that there is no marked increase in crashes until drivers are 80 or older, and even then the increase is relatively small. Data also indicate that older adults are more likely to bring death and injury to themselves than to other vehicle occupants or pedestrians. Moreover, it is also important to bear in mind that the absolute number of deaths from crashes falls steadily with age.

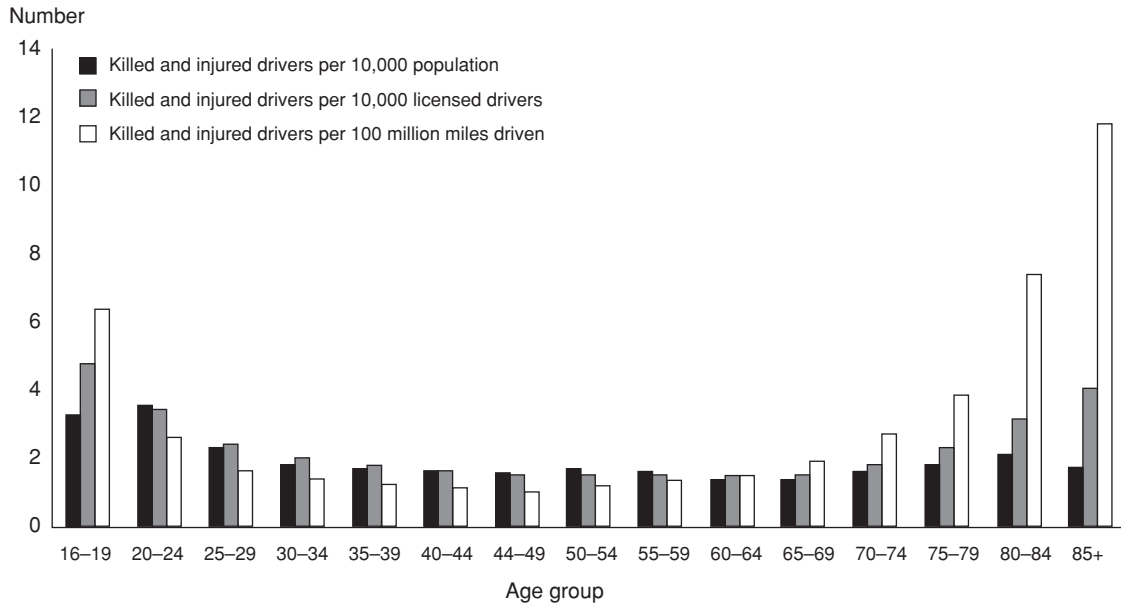


FIGURE 2 Driver fatalities and injuries by age, related to population, number of driver licenses, and mileage driven, 1997.

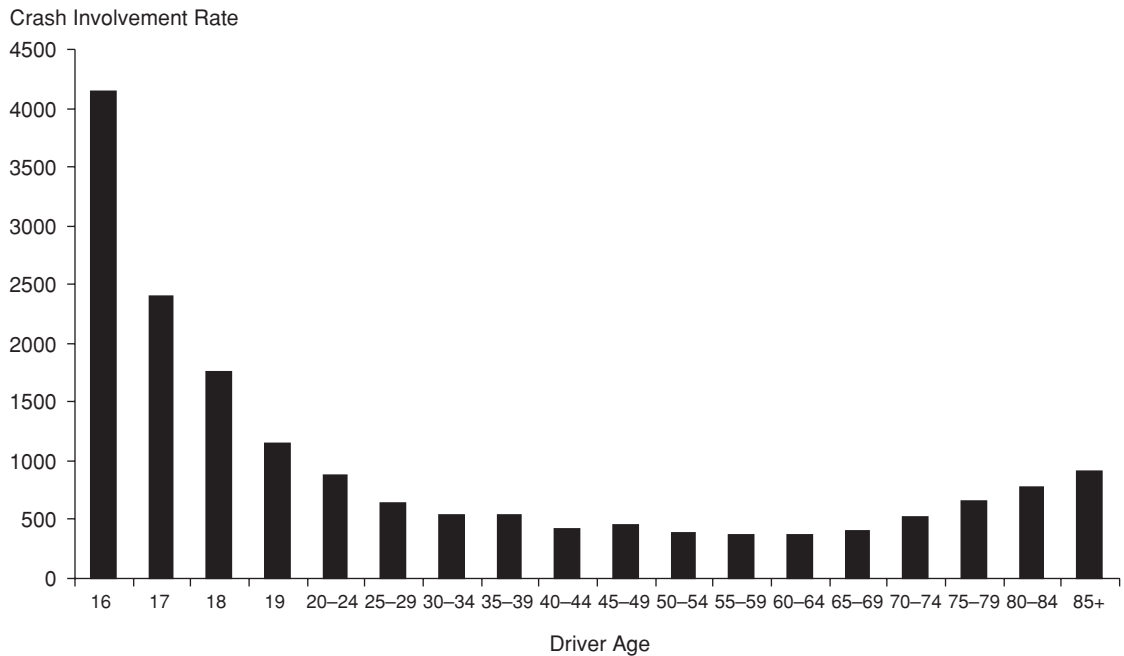


FIGURE 3 Crash involvement rate per 100 million vehicle miles traveled.

While safety is and will continue to be a concern, researchers coming of age in the 1990s have been more likely to balance the traditional focus on safety with a broader discussion of transportation and mobility needs.

In 1986, the Transportation Research Board (TRB) “initiated a study on the mobility and safety needs of older persons. It convened a panel of experts to review the design and operation of the surface transportation system and to recommend improvements that would better serve an aging population” (TRB 1988, 2). Subsequently, “Congress asked for ‘a comprehensive study and investigations of (1) problems which may inhibit the safety and mobility of older drivers using the Nation’s roads and (2) means of addressing these problems’” (TRB 1988, 2). The results were published in 1988, and the original committee’s findings are worth summarizing and reviewing for an understanding of the research activities implemented over the following decade and beyond:

- Mobility¹ is essential to the quality of life of older persons, and the automobile is the primary means of meeting that mobility need.
 - Most older drivers have good driving records.
 - Older persons are among the most vulnerable to injury in motor vehicle crashes.
 - In general, visual and cognitive performance on driving-related tasks diminishes with age. At the same time, there is a great deal of variability in performance among individuals.
 - Because, for any individual, age is a poor predictor of performance, age alone should not be the basis for restricting or withholding driver’s licenses.
 - Sign visibility and maintenance standards, assumptions about performance used in intersection design and traffic operations, and vehicle crashworthiness standards fail to account for the needs and capabilities of older persons using the roadway system.
 - The population of older persons who are able to live in their own homes but who are unable to drive is growing. Better and more efficient specialized transportation service will be needed for this group to allow them to maintain their mobility and independence.
 - Too little research is under way that could improve the mobility and safety of older persons, and research responsibilities are scattered across several different federal agencies.

TRB’s *Special Report 218* was a milestone in the history of transportation research and served as a blueprint for a decade of research. That report summarized knowledge

¹ Mobility, in this context, refers to more than simply moving from one place to another. It even goes beyond access to life’s necessities, such as medical appointments and food. Mobility for older people encompasses quality-of-life issues, such as access to social and cultural experiences.

about the special needs of older persons and speculated on how those emerging needs might affect future mobility and safety (Schieber 2004).

The interval between the issuance of *Special Report 218* and the present has seen a shift in emphasis from describing the “older-driver issue” to investigating the factors that underlie elevated crash risk for some older persons. To this end, research has focused on the physical, health, and cognitive changes known to accompany aging and their impact on mobility. There have been four recurring themes in the research since the issuance of *Special Report 218*: (a) understanding changes in mobility with age and factors affecting such behavior changes, (b) understanding the functional impairments that place some older drivers at risk for crashing as they age, (c) identifying methods for the early detection of these functional changes, and (d) discovering how the transportation system might be altered in response to these functional changes.

CHANGES IN MOBILITY WITH AGE

In 1988, “fundamental gaps exist[ed] in our understanding of how human performance changes across the life cycle and how those changes affect the driving task” (TRB 1988, 76). Since that time a great deal of research has been conducted on the driving habits of older adults and factors that affect such behaviors. Results indicate that older drivers limit their driving in specific contexts. For example, older drivers are less likely to drive alone, in fog, in rain, in high traffic, or at night (Chu 1994; Hennessy 1995). Overall, older adults tend to limit their driving to particular times and places in which they feel safe (Ball et al. 1998; Chu 1994; Hennessy 1995; Janke 1994). [Although some persons with dementia or a related disorder may not make prudent choices about driving, older drivers, in general, tend to limit driving on their own (Ball and Owsley 2000).]

AGING-RELATED IMPAIRMENT AND MOBILITY

“Vision” is obviously a prerequisite for driving, but the term encompasses a wide range of functional abilities. While many licensing agencies continue to test high contrast static visual acuity (ability to see detail), other functional aspects of vision have been found to be more strongly related to crashing, most notably contrast sensitivity (ability to detect objects against their background) (Owsley et al. 2001; Owsley et al. 2002). Reliable indices of contrast sensitivity are readily available and can be easily administered. Similarly, over the past 15 years the role of age-related diseases of the eye and their treatment (e.g., cataracts, glaucoma) in crash risk has been investigated. Glaucoma and cataracts, accompanied by visual function impairment, have both been associated with increased crash risk (Owsley et al. 2001; Owsley, McGwin et al. 1998), and cataract removal has been associated with decreased crash risk (Owsley et al. 2003). The association between visual function and driving safety is now much clearer than it was a decade ago and is well summarized in *Conference Proceedings 27* (see Owsley 2004).

Overall health conditions have also been explored in relation to their impact on the driving ability of older adults. For example, Campbell et al. (1993) compared drivers and nondrivers 70 years of age and older and found that 32 percent of the nondrivers cited health or medical reasons as influencing their decision to cease driving. Similarly, Forrest and Hunter (1997) compared female drivers and nondrivers and found that some specific medical conditions (e.g., diabetes, angina, self-reported vision) were associated with driving cessation. From a sample of 404 very old drivers (84 or over), Brayne et al. (2000) reported that the reason provided most frequently for driving cessation was general health problems. Furthermore, compared with older drivers, older individuals who have ceased driving have a higher number of medical conditions (e.g., Parkinson's disease, stroke, cataracts, macular degeneration), as well as poorer self-ratings of health (Campbell et al. 1993; Marottoli et al. 1993).

Research since 1988 has also elucidated the impact of medications on crash risk. Ray et al. (1992) found an increased injurious crash risk associated with benzodiazepine and cyclic antidepressant use in drivers 65 and older. Leveille et al. (1994) also found an increased risk of crashes associated with antidepressant use. Similarly, Foley et al. (1995) found that the use of nonsteroidal anti-inflammatory drugs (NSAIDs) was associated with a twofold increase in the likelihood of crashing. McGwin et al. (2000) found that after adjusting for age, gender, race, and annual mileage, use of NSAIDs, angiotensin converting enzyme (ACE) inhibitors, anticoagulants, and benzodiazepine was associated with involvement in at-fault crashes. Interactions between drugs were also explored, and results indicated that individuals taking both NSAIDs and ACE inhibitors were 3.4 times more likely to be involved in a crash than were individuals taking neither of the drugs.

Whether medication usage actually contributes to crash risk may depend on other factors. For instance, Hemmelgarn et al. (1997) determined that the probability of vehicle crashes for elders taking benzodiazepines varies on the basis of length of time and type (i.e., duration of action) of medication taken. Also, the increase in crashes correlated with the use of certain drugs may be related to the underlying disorder as much as to the treatment. For example, an untreated or undertreated depressed individual may be as likely to crash as or more likely to crash than one who is adequately treated. Overtreatment, or medication doses that are too high for an individual, can also increase the risk of crash involvement.

Declines in physical functioning can also affect driving behavior. For example, Sims et al. (2001) found that crash-involved drivers were more likely to have experienced at least one fall in the past year than were noncrash controls. In fact, many researchers have found similar risk factors for falls and vehicle crashes (Foley et al. 1995; Koepsell et al. 1994). Physical factors other than falls that have been shown to affect driving safety include head and neck rotation, lower limb strength, and upper limb strength. Marottoli et al. (1998) determined that limited neck rotation was linked significantly to self-reported crashes spanning a prior 5-year period. Investigating the effects of such physical limitations, Hunter-Zaworski (1990) found that when head

movements were restricted, older drivers failed to compensate as compared with younger drivers, who successfully offset the physical limitation. In a study of lower limb strength, Marottoli et al. (1994) found that individuals with three or more foot abnormalities or impaired knee flexion as well as poor performance on the rapid walk test had more self-reported crashes and citations. Hu et al. (1998) determined that reaching ability is associated with increased crash risk. Similarly, in a study of upper limb strength, Retchin et al. (1988) discovered that older adults who had quit driving had worse grip strength and reaction time than older adult drivers.

Declines in physical and cognitive skills have been linked to mobility restrictions such as increased driving avoidance, decreased driving exposure, and driving cessation. For example, Stutts (1998) found that poorer cognitive abilities—as measured by the Trail Making Test, a measure of visual attention and executive function, and the Short Blessed Test, a measure of mental status—were associated with decreased driving exposure (miles driven per year). Similarly, Ball et al. (1998) found that older drivers who were cognitively impaired, as indicated by the Mattis Mental Status Screening Examination, tended to report more avoidance of certain driving situations and fewer days of driving per week. Reduced speed of cognitive processing, as measured by useful field of view (UFOV) performance, was also associated with the avoidance of several types of driving situations (Ball et al. 1998).

While adequate vision and physical functioning are important, the past decade again highlighted the importance of impairments in certain critical cognitive domains to driving safety. Impaired memory has been implicated as a contributing factor in crash involvement (Foley et al. 1995; Johansson et al. 1996; Hu et al. 1998). Furthermore, visual attention and visuospatial ability have been found to be significantly associated with self-reported crashes (Marottoli et al. 1994; Marottoli et al. 1998). A consistently strong predictor of both retrospective and prospective crashes across a number of studies has been impairment in visual processing speed, particularly as measured by the UFOV test (U.S. Department of Transportation 2003a).

EARLY DETECTION

Since the discovery of the relationship between functional measures and driving competence, research has focused on determining the usefulness and feasibility of such measures as screening tools. The early identification of at-risk older drivers, and perhaps their remediation, has been a central theme since the publication of *Special Report 218* (see Staplin 2004). Short screening batteries of both physical and cognitive measures have been field tested at licensing bureaus. The Older Driver Program, initiated in Maryland in the late 1990s, is of particular interest with respect to an overall programmatic approach (see [Box 1](#)).

The Model Driver Screening and Evaluation Program (U.S. Department of Transportation 2003a) recommends validated screening practices that can assist in retaining mobility and enhancing safety.

Box 1**OLDER DRIVER PROGRAM**

The Maryland Motor Vehicle Administration (MVA) Older Driver Program encourages a commonsense approach to understanding the needs of citizens, regardless of age, and recognizes the benefits of safe mobility for life. The program recognizes that although functional abilities are jeopardized by conditions related to advancing age, the stereotype equating older age with loss of driving ability threatens the independence of older drivers, underestimates the financial costs to communities, and fails to acknowledge that public transportation and mobility alternatives for older adults are woefully inadequate for most. With National Highway Traffic Safety Administration (NHTSA) and National Institutes of Health support and many collaborators, Maryland developed a scientifically sound approach for proactively identifying, assessing, and remediating drivers for personal and public safety. The effort included a statewide multidisciplinary consortium concerned with (a) older-driver issues and safe mobility for life and (b) research on functional capacity testing to determine the level of training, counseling, and remediation needed for safe, independent mobility.

Of particular note, the research program focused on keeping older drivers on the road by using screening tests of vision, physical ability, and a variety of cognitive skills. The tests were designed to be administered quickly and efficiently in office settings to detect emerging threats to driving safety and to make determinations about driving remediation and training needs. Subsequent evaluation found them to yield scientifically valid predictions of driving risk (U.S. Department of Transportation 2003a). The results of these screening tests are not used to take away driver's licenses. Instead, they can be used at license renewal for early prevention and intervention to prolong independent, safe mobility. In addition, they are being used by MVA's Medical Advisory Board physicians to determine the appropriate course of action for a given individual for that individual to achieve safe mobility. The results of the Maryland pilot program are incorporated in the Model Driver Screening and Evaluation Program offered by NHTSA (U.S. Department of Transportation 2003a).

CHANGES IN THE TRANSPORTATION SYSTEM

The functional changes that accompany the aging process have become better understood over the past decade, and a movement is under way to adjust the traffic environment to these changes. The recent publication of two Federal Highway Administration (FHWA) handbooks (*Highway Design Handbook for Older Drivers and Pedestrians* and *Guidelines and Recommendations to Accommodate Older Drivers and Pedestrians*) is a first step in the process of implementing this knowledge. Some practices recommended in the *Design Handbook* include modification of pavement markings and curb edgings for nighttime driving, geometric enhancements to intersections, improved directional signing and enhanced use of portable changeable message signs at freeways, modifications of signal timing at pedestrian crossings, and signage and channelization enhancements designed to reduce information-processing demands placed on drivers approaching work zones (Staplin 2004). Many of these improvements have been called for by older drivers themselves (Iowa Safety Management System 2002).

As the recent publication *Safe Mobility for a Maturing Society: Challenges and Opportunities* (U.S. Department of Transportation 2003b) points out, the next step in this process is to inform highway engineers of these guidelines, develop training programs for traffic and highway engineers to ensure understanding of the issues, and encourage use of the guidelines in future highway design.

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3

Committee Findings and Recommendations

The committee members reviewed available data, deliberated among themselves, and used professional judgment to synthesize findings and recommendations from the technical papers, discussions, and information provided at the international conference, in numerous focus groups, in *Special Report 218*, and from other sources. The resulting recommendations are directed to policy makers, the research community, government agencies, older persons and their caregivers, the private sector, and other stakeholders.

The committee's findings and recommendations are presented under five headings: strategic considerations, drivers, vehicles, the roadway environment, and alternative transportation. Two types of recommendations are offered: (a) actions that should be considered now to improve older adult safety and mobility and (b) future research needs. In some cases action was thought essential, but the committee recognized the need for more research before effective initiatives can be designed and implemented with confidence.

STRATEGIC CONSIDERATIONS

Actions for Current Consideration

Meeting the transportation needs of older people will require a comprehensive strategy. At the national level it will be necessary to focus the nation's attention on issues such as the following: educating policy makers on aging and transportation concerns, considering the need to support remediation and training to keep older drivers safely on the road, and encouraging the design of better highways and more crashworthy vehicles. At the state level, the establishment of statewide consortia could be encouraged, including members from most state agencies, professionals (medicine, social services, safety groups, law enforcement, AARP, American Automobile Association, area agencies on aging, etc.), nonprofit agencies involved with seniors, transportation services, academic institutions, and others. Key goals of these consortia would include the following:

- Ongoing improvement of driver assessment practices, including identification and counseling of the at-risk driver (linking research to practice);
- Ongoing improvement of the remediation and training programs available to the at-risk driver (linking research to practice);

- Coordination of user-friendly mobility options for drivers who are restricted or must cease driving;
- Coordination of effective public and private systems for the delivery of services;
- Development of public information and education programs on the functional capacity changes that may occur with aging, how these changes may affect driving, and the importance of planning for driving limitations or driving cessation;
- Ongoing implementation of roadway design and rehabilitation improvements;
- Ongoing improvements of vehicle crashworthiness; and
- Encouragement of land use designs that will provide senior-friendly housing choices.

A comprehensive strategy is recommended in which national, state, and local government agencies work in partnership with private-sector institutions, organizations, and older persons themselves to develop and implement practical, affordable, and effective solutions that preserve safe and independent mobility for older Americans while serving the public health and safety needs and promoting the quality of life and economic vitality of society as a whole.

Research Needs

The quantity and quality of research addressing safe mobility for older persons that has been accomplished over the past decade are remarkable. However, even with the publication of the current update report, gaps continue to exist. An ongoing initiative to identify and catalogue research needs will ensure a reduction in overlap and a focus on projects with the greatest and most immediate benefit. Accordingly, the committee believes that a continuing effort is needed to review research accomplishments, identify gaps in the knowledge base, and develop research agendas to help guide the efforts of researchers and focus scarce resources where they will produce the greatest benefit.

Providing safe mobility for older persons presents a multifaceted and complex series of issues to be addressed. To succeed, a comprehensive policy supported by effective implementation strategies is required. Yet, the past decade has produced little in the way of a comprehensive policy to address the mobility needs of an aging nation. Without leadership and intervention, transportation policy making appears likely to continue its struggle for serious attention from the public and policy makers (Cobb and Coughlin 2004). To contribute to progress on this front, existing research and research applications should be reviewed and catalogued with the goal of identifying potentially effective policy initiatives.

DRIVERS

Actions for Current Consideration

Much older driver safety research over the past decade has focused on identifying factors that increase crash risk among older drivers. Such factors include some medical

conditions and the medications used to treat them, as well as visual, cognitive, and physical impairments that become more prevalent among older adults. In addition, research has evolved from simply identifying aging adults with functional deficiencies and removing them from the driving population to identifying those with specific conditions that place them at increased crash risk and intervening to promote safe mobility (Owsley 2004).

It is a myth that aging makes all older persons high-risk drivers. Owsley (2004) summarizes recent research concerning which functional impairments, medical conditions, and medications place some older drivers at increased risk and discusses efforts to develop interventions that reduce their impact on older-driver safety and mobility. Many older persons do not differ significantly in their driving skills from their middle-aged counterparts, who statistically are the safest group on the road per mile driven (Staplin and Hunt 2004).

Seniors suffer a profound loss of quality of life when their mobility becomes significantly restricted, with cascading costs to families and to society. Since the dominant form of transportation remains the personal automobile, retaining one's driving privilege is presently, and for the foreseeable future, the strongest determinant of mobility. Hence, the inherent conflict for practitioners is to balance quality-of-life issues for the individual with public safety considerations (Staplin and Hunt 2004).

Ultimately, responsibility for removing unfit drivers from the roadways lies with the motor vehicle licensing and regulation agencies in each state. However, many of these agencies are poorly equipped to meet this obligation in terms of enabling legislation, training personnel, and other resource issues. Accordingly, consideration should be given to the following approaches:

- Encouraging motor vehicle agencies or departments of public safety responsible for driver licensing, license renewal, and vehicle registration to adopt practices that reflect an understanding of the functional declines in key safe driving abilities that occur with normal aging and the diseases associated with aging and that place older persons at risk for crash involvement. This effort would require appropriate administrative and medical staff within these agencies or departments to allow for fair, competent, and timely review of all cases in which a fitness-to-drive determination is required.
- Cataloguing the laws and capturing the actual practices for reporting at-risk drivers in different states and comparing the consequences for public safety and personal mobility from one jurisdiction to another. An effective way to accomplish this might be to establish a national organization made up of administrative and medical staff from each jurisdiction to seek harmonization of reporting and review practices.
- Continuing the development of a model licensing process that emphasizes a cost-effective driver screening and assessment program to help ensure a minimal level of fitness for all licensed drivers referred to medical advisory boards. Through prevention and remediation activities, this process aims to extend the safe driving years for as long as possible.

Certified driving rehabilitation specialists drawn principally, though not exclusively, from the occupational therapist profession constitute perhaps the largest group of practitioners in the United States with the expertise necessary for identifying and counseling high-risk older drivers. There are, however, far too few such specialists nationwide to meet the need.

Occupational therapists are integral members of the health care system and combine in-depth understanding of the functional requirements for driving with insights about the extent to which clients rely on driving to meet their everyday needs. They may be in an ideal position not only to evaluate fitness to drive but also to identify and provide referrals for specialized treatment or appropriate rehabilitation/remediation programs (Staplin and Hunt 2004).

To provide enhanced expertise in this area, consideration should be given to expanding in-service medical education for professionals in driver assessment, rehabilitation, and referral options. The number of occupational therapists and others trained as certified driving rehabilitation specialists could be expanded, as could the role of driving schools that are interested in increasing their technical competence through special training programs to focus on the needs of older drivers.

Assistive technology refers to equipment that can be used to increase, maintain, or improve the functional capabilities of individuals with disabilities. One of the most active areas in this field is the development of automotive adaptive equipment and vehicle modifications. While age is not considered a disability, there are conditions associated with aging that can be effectively managed with the use of appropriate assistive technology (Koppa 2004). Much may be known by the disability community that could be extended to the older-driver population more generally. In this regard, it would be useful to catalogue and disseminate information about assistive devices that can help compensate for functional changes associated with the aging process.

Public opinion draws its primary perceptions from the occasional tragic crash involving an older driver. Research clearly demonstrates that these episodes are not representative, but it also serves to identify the physical and cognitive problems many older drivers eventually face. The pace of age-related debilitating change cannot be predicted for the individual, but for older drivers as a group, many characteristics can be anticipated and responses developed. A public information and education program could disseminate accurate knowledge, distribute specialized information and corrective strategies to help older people stay safely on the road longer, alert seniors to the possibility that one day they may have to move out of the driver's seat into an alternative means of transportation, and enlighten the interest groups with a particular stake in the safety and mobility of seniors (Milton 2004).

The committee believes that it would be useful for current research findings to be summarized and synthesized to provide a basis for developing and implementing public information and education campaigns targeted to increase awareness of the transportation challenges facing older adults. Such campaigns could focus on

- Providing information on strategies for maintaining mobility through driving or the use of alternative transportation options,
- Informing older persons about the importance of planning for driving limitations or cessation, and
- Encouraging individuals to plan and save for their future mobility needs.

Research Needs

It is well established that the range of performance for older age cohorts dramatically exceeds the range for younger ones, and as the distribution of abilities flattens and elongates with advancing age, characterizing an individual in terms of a group average is prone to error. Thus, the use of a person's chronological age alone as a surrogate for driving risk has been fairly and consistently criticized (Staplin and Hunt 2004).

Research should be continued to identify the precise characteristics that distinguish safe drivers from those who are at elevated crash risk or who are no longer capable of driving safely. These results can assist in developing more effective and efficient screening and intervention methods.

As treatments, countermeasures, interventions, policies, and programs affecting older-person driving and mobility are developed, evaluation of their effectiveness is crucial. It is important to understand the safety implications, as well as the potential societal and personal costs and benefits. An effort is needed to rigorously evaluate and document the effectiveness of interventions for reducing crash risk by overcoming functional impairments such as treatment of eye conditions, training in specific cognitive skills related to driving, physical training, exercise regimens, and driver education programs.

The evidence indicates that most older drivers have a general awareness of their diminishing capabilities and make appropriate strategic and tactical adaptations to compensate. The result is that their absolute crash involvement rates, calculated per million drivers, remain at the levels of middle-aged drivers until advanced age. Older drivers can be assisted in making appropriate adaptations through driver education efforts, but research is needed to develop specific advice on how best to reduce risk (Smiley 2004). This effort will entail

- Further identifying and defining the characteristics (physical, emotional, social, cognitive, etc.) of persons who appropriately modify their driving behavior in response to declining functional abilities, and the types of modifications they use;
- Developing materials and methods, such as self-assessment tools, to make drivers more aware of how functional declines can affect their driving performance and providing them with specific steps they can take to modify their driving behavior and reduce their crash risk; and
- Developing supporting materials (screening tools, evaluation guides, etc.) for the medical community, caregivers, licensing regulators, and others to assist older drivers in appropriate modifications of driving behavior.

Finally, there is little doubt that “volunteer bias” is present in at least some of the studies of older travelers. Given the assumption that better-educated and healthier people are more likely to volunteer as participants in research projects, logic dictates that the samples tend to be slightly biased toward the “cream of the crop” (Schieber 2004). To avoid this bias, promising findings should be replicated in larger field studies. Population-based evaluations of screening, assessment, and intervention methods (proved in smaller field or laboratory studies) should be conducted in real-world settings.

VEHICLES

Actions for Current Consideration

Vehicle-related safety improvements are designed to prevent crashes (crash avoidance), protect vehicle occupants and pedestrians in the event of a crash (crashworthiness), and assist vehicle occupants and other road users after a crash has occurred (postcrash assistance).

Crash avoidance technologies can be direct, such as speed controls that automatically reduce speed if the vehicle is too close to another in front, or indirect, such as comfort and convenience features designed to reduce fatigue, aid concentration, and generally improve driver attentiveness and performance (Pike 2004).

Crashworthiness refers to the safety performance of the vehicle in the event of a crash and relates to concepts such as safety belts, air bags, and head restraints. It may also include attention to a vehicle’s impact on striking a pedestrian (Pike 2004).

The greater physical frailty of older persons leads to a greater likelihood that they will be killed or injured in a crash. It is estimated that at least half of the increased fatality risk of drivers age 75 years or older compared with 30-year-old drivers might be due to frailty, which brings about a higher susceptibility to being killed in a given crash, rather than to a higher probability of crash involvement (Hakamies-Blomqvist 2004). Furthermore, the disproportionate fatality rate of older pedestrians who are struck by motor vehicles is mainly due to increasing fragility of people as they age. Characteristics of vehicle design can have a marked effect on the nature and severity of the injuries sustained by a pedestrian struck by a vehicle. One area currently being addressed for pedestrian protection internationally is the design of vehicles to effectively provide the pedestrian with “optimum” crash conditions (Oxley et al. 2004). Consideration should be given to older-person characteristics, capabilities, and limitations in designing the driver–vehicle interface in order to minimize the occurrence of crashes. In the development and testing of occupant restraint systems, the physical characteristics and, in particular, greater fragility of older persons’ bodies should be considered to maximize the level of protection provided while minimizing the risk of inducing injury.

Technology to improve the safety performance of motor vehicles holds promise for protecting older persons. Intelligent transportation systems (ITS) rest on various combinations of advances in wireless communication technologies, automotive electronics,

computing, and the Global Positioning System. A number of ITS applications may have importance for older drivers (e.g., route guidance, emergency vehicle location and response, vision enhancement systems, and collision warning systems) (Caird 2004). Accordingly, the committee believes that industry research into and development of ITS should be promoted and that automakers should be encouraged to provide education in new technologies. In addition, the insurance industry should give consideration to offering technology discounts for use of proven “safety technologies.”

Research Needs

Areas for future vehicle-related research include the following:

- The role of advanced technologies in the safe mobility of older persons could be defined and evaluated. Findings from these inquiries could be applied in vehicle and system design and operation.
- Vehicle technologies that address the unique safety and operational issues (slower reaction times, poorer nighttime vision, loss of joint flexibility, etc.) associated with older drivers, passengers, and pedestrians could be studied.

ROADWAY ENVIRONMENT

Actions for Current Consideration

By 2020, adults aged 65 and older will account for an estimated one-fifth of licensed U.S. drivers. “In effect, if design is controlled by even 85th percentile performance requirements, the ‘design driver’ of the early 21st century will be an individual over the age of 65” (Staplin et al. 2001). The good news is that roadway improvements intended to help the older driver generally benefit all road users.

The most widely used guidelines for highway design in the United States are those published in *A Policy on Geometric Design of Highways and Streets*, the “Green Book,” created by the American Association of State Highway and Transportation Officials (AASHTO). Many of the design formulas in the the Green Book are based on assumptions about the perception–reaction time of the “design driver.” *Special Report 218* presented evidence suggesting that the perception–reaction time assumptions of the models of driver behavior used in the AASHTO Green Book may not allow sufficient time to accommodate the general behavioral slowing seen in older road users (Schieber 2004).

Several major categories of research in the area of highway geometric design and operations received considerable attention during the decade following the issuance of *Special Report 218*. Perhaps the most critical work in this area dealt with research that evaluated whether commonly applied models of human driving performance accommodate the capabilities of representative older drivers. The accumulated wisdom of this research was published in the *Older Driver Highway Design Handbook* (FHWA 1998) and updated in *Highway Design Handbook for Older Drivers and*

Pedestrians (Staplin et al. 2001b) and its companion, *Guidelines and Recommendations to Accommodate Older Drivers and Pedestrians* (Staplin et al. 2001a). What is needed now is implementation of the *Highway Design Handbook* in roadway construction and rehabilitation initiatives and through modification of current design practices and standards. Similarly, the handbook guidelines for sidewalk and walkway construction in areas populated by older adults merit implementation, and walking should be promoted as a transport mode as well as for exercise and recreation.

Research Needs

Since publication of the *Highway Design Handbook*, many states and communities have implemented some of the recommended infrastructure improvements. However, evaluation results are nearly nonexistent. Evaluation efforts are needed to determine the effectiveness of specific provisions, such as improved delineation for night driving, as well as to provide support for expanded implementation. Such efforts could include

- Cataloguing and evaluating the impact of state and local efforts to apply FHWA's *Highway Design Handbook for Older Drivers and Pedestrians* (these results can help identify future research and development needs), and
- Identifying and publicizing state and local best practices in the area of roadway improvements to accommodate older drivers and pedestrians.

ALTERNATIVE TRANSPORTATION

Actions for Current Consideration

Significant research efforts have examined travel behavior, technological innovation, and service provision, but the true challenge may be to understand personal lifestyle and transportation decision making as people age. Where people choose to age and how they allocate their resources are personal decisions that will influence the range of mobility choices they will have when they are old (Cobb and Coughlin 2004).

Older persons have shown a strong preference for privately owned automobiles as their transportation mode of choice. However, mobility alternatives to the private automobile may first be sought for the trips that older drivers choose to avoid (e.g., nighttime, congested areas, and peak times), and they later may be sought for all travel by people who have stopped driving entirely. These options allow older persons to maintain their dignity, independence, and choice for as long as possible (Suen and Sen 2004).

The key characteristics of mobility options to the automobile have been described in terms of “the five A’s”: availability, accessibility, acceptability, affordability, and adaptability (Kerschner and Aizenberg 2004). Transportation alternatives must be available when they are needed, including evenings, weekends, holidays, and specific

days of the week. They must also be accessible: bus stairs must be negotiable; chair seats must be high enough, the bus stop must be within walking distance; pickups must come all the way up the driveway. To be acceptable to older adults, transportation alternatives need to be clean, safe, and user-friendly. To make them more affordable, they can incorporate a coupon or voucher system for those who cannot pay the normal user-based fees. Finally, alternative transportation systems for older adults need to be adaptable to meet the special needs of the older population. Examples are accommodating wheelchairs and making multiple stops in a single trip.

On the basis of these characteristics, consideration should be given to the following approaches to improving transportation alternatives for older adults:

- Identifying and publicizing model programs from across the United States and abroad that best serve the transportation needs of older adults and promoting more widespread implementation of successful programs;
- Providing access to “mobility managers” at the state and community levels who assist older persons in identifying accessible alternatives for their transportation needs;
- Taking steps to ensure that the lighting, visibility, and personal security needs of older persons are addressed in transit and paratransit² systems; and
- Reviewing and, if appropriate, amending state liability statutes to provide protection to volunteer driver networks, and educating volunteers about these protections.

Well-trained, sensitive, and helpful staff are at least as important as high-quality equipment and infrastructure and can make up for many deficiencies in equipment. Transport personnel often do not adequately understand the mobility needs of seniors or the mobility limitations and abilities of those with impairments. Sensitivity training and certification, with the aid of gerontologists who are familiar with age-related mobility declines, could be expanded for transportation personnel (including management, operations, and frontline staff) who are involved in the provision of services for the aging. Licensing bureaus or some other entity could be reinvented to serve as mobility resource centers.

² “Paratransit” does not have a standard definition, but it has come to mean public or group transportation, usually provided by automobiles, vans, or minibuses, organized to complement standard fixed-route transportation. Paratransit services often provide mobility to specific population groups, such as the elderly or people with disabilities, who have some difficulty relying entirely on fixed-route transit services. Because paratransit services are in many places offered to comply with requirements of the Americans with Disabilities Act (ADA), the term has come to have a close association in the minds of many with that important law. There are, however, many paratransit services that are independent of those required to comply with the ADA.

Many organizations deliver transportation-related services to older persons—the medical community and health care providers, consumer-oriented businesses, senior centers, churches, and so forth. However, these organizations rarely work collaboratively. Identifying an agency to coordinate these services would reduce overlap and improve transportation alternatives in general. Significant benefits would ensue from improved communication, coordination, and cooperation methods among the diverse agencies involved in serving the older population’s transportation needs.

Finally, although many agencies and organizations within a community, region, or state can and should contribute to an integrated alternative transportation system, it is critical that one agency or group assume ownership of the program to ensure its efficient operation and long-term viability.

In addition to documenting model programs, the policies and structure that are in place to support such programs need to be identified. Successful approaches for marketing and promoting such programs should be documented, as well.

Research Needs

Public and private investment in transportation innovation is vitally important. These investments should increase automobile safety for drivers and passengers but also stimulate new ways of providing alternative transportation or entirely new service concepts that may fall outside the current institutional capacity of providers. When these solutions are available, decision makers will more likely address the mobility needs of older adults. Policy making most generally links problems to solutions. It is less likely to focus on identifying problems where there are no known, acceptable, and affordable solutions (Freund 2004; Cobb and Coughlin 2004). Research is therefore needed to develop and test innovative solutions for meeting the transportation needs of older adults, including greater use of technology and the linking of available resources in new and creative ways.

To complete the picture, there is need for additional research on the economic costs to the individual, family, and community of driving cessation and the loss of mobility, as noted at the conference. In addition to the possible depressive symptoms from the loss of autonomy and social contact, more information is needed about the direct and indirect costs of new demands for time by family caretakers or others to provide mobility; possible earlier admissions to residential care facilities; the loss of participation in the economy; and the impact on local, regional, and national social services and health care sectors. These evaluations will be difficult analytically, but whatever estimates are established would be of substantial use in cost–benefit or policy analyses, to put into context higher levels of transportation expenditures for maintaining safe mobility (U.S. Department of Transportation 2004).

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4

Crosscutting Issues

The preceding chapter organized the committee’s findings and recommendations under five headings: strategic considerations, drivers, vehicles, the roadway environment, and alternative transportation. However, safe mobility for older persons as an issue cannot be so succinctly categorized; there are facets that cut across the boundaries of any taxonomy that might be created. Effective solutions to the transportation safety and mobility needs of an aging population will depend on more than research programs, demonstration projects, and professional discussions that point toward technically feasible solutions. Responsible discussions will entertain more than transportation-related solutions and, for that matter, will go beyond a focus on older persons.

This chapter presents the following crosscutting issues: policy, planning, cost–benefit considerations, and technology. These issues do not affect any single part of the transportation system, the population, or the political process; rather, they cut across all topics and boundaries.

POLICY

Assumptions about the future transportation desires and needs of older persons have been made on the basis of a combination of research studies, surveys, focus groups, and professional dialogue. One common theme emanates from researchers, practitioners, and policy makers: mobility *reduction* is not a solution to the safety problem that might be generated by more older adults taking more trips and driving more miles. Nor is it a solution to the larger issue of the social and political trade-offs implied by using the nation’s limited resources to create transport systems and options that keep America’s seniors moving.

The technical papers by Freund (2004) and Cobb and Coughlin (2004) both address policy as a separate issue, but many of the other papers commissioned for the conference also have policy implications. Without clearly articulated and widely supported policy decisions that promote and encourage the development, implementation, and evaluation of programs, and the dissemination of knowledge gained from these efforts, the objectives may be difficult if not impossible to achieve.

The allocation of limited resources across all ages and across all issues requires a delicate balancing act, and there are always winners and losers to some degree. The best options are often those that benefit more than one age group or those that affect more than one issue. Therefore, consideration might focus on how transportation

enhancements benefit not just older recipients but also the larger society. The following are examples:

- With earlier retirements and improving health and life expectancy, older citizens are enjoying increasing numbers of potentially productive years (Bass 1993, 6). The availability of transportation can enable many of them to access goods and services that enhance a community's economy. Furthermore, they may continue to participate in the workforce, which contributes to the overall economy, as well as Social Security and Medicare funding.
- Older persons contribute hundreds of thousands of volunteer hours. They give back to society in ways that amount to millions of dollars worth of labor and expertise. Loss of mobility would seriously affect the ability of seniors to access locations where these hours are donated.
- Senior-friendly land use policy may lead to sidewalks and crosswalks that allow older persons to walk more easily and safely. Policies that support the design of "livable communities" can ultimately improve quality of life for all citizens.

Regardless of the difficult decisions that lie ahead with respect to balancing competing interests and scarce resources, providing safe mobility for older persons at some level is vital to the future of the nation. To accomplish such a goal, one overriding issue outweighs all others: leadership or decision making in the political context. While considerable progress has been made since the publication of *Special Report 218* (TRB 1988), a highly visible agency or organization has not appeared to assume ownership of the issue and coordinate advocacy on its behalf. Furthermore, a comprehensive, coordinated, and communicated transportation policy has not been forthcoming (Cobb and Coughlin 2004).

The issue of older-person safety and mobility is owned by a group of unwilling participants, including physicians and other health care practitioners, families, and law enforcement. A small group of passionate researchers and advocates continue to study and speak out, but they lack the visibility and coordination to be heard convincingly. Sustained, articulate, and highly visible leadership is necessary to the development and implementation of effective solutions. One encouraging sign is the recently published *Physician's Guide to Assessing and Counseling Older Drivers* (www.ama-assn.org/ama/pub/category/10791.html), which was developed by the American Medical Association in cooperation with the National Highway Traffic Safety Administration. It was developed to assist physicians in evaluating the ability of their older patients to operate a motor vehicle safely as part of their everyday personal activities.

The previous discussion leaves unanswered the question of "formal" regulation through licensing agencies. However, a primary trade-off in using licensing regulations to ensure safety may be a reduction in mobility. As has been discussed elsewhere in this document, loss of mobility certainly leads to degradation in the quality

of life, more illness brought on by isolation and depression, and losses to the economy in terms of opportunities to work and volunteer for programs that enhance the community.

Beyond their implications for driver licensing, policy initiatives will determine the broader distribution of resources, which affects the decision to build roadways and vehicles that are safer and easier to use, to develop new technologies, to create transportation alternatives, and to provide the training and technical assistance required by older populations and their caregivers.

PLANNING

Safe mobility for older persons requires planning at all levels: federal, state, local, and individual. Planning experts and institutions are quite capable in terms of analyzing data, predicting future conditions and outcomes, and developing solutions. However, their recommendations are ultimately subject to a political process that makes decisions incrementally and is subject to political trade-offs (Cobb and Coughlin 2004).

Many proposed initiatives, such as building safer roads and vehicles and reinventing licensing agencies, will take many years to design and implement effectively and successfully. The planning process is a crucial first step. For example, careful land use planning could result in at least three desirable options for seniors: more pedestrian-friendly communities, communities with convenient transportation options, and communities designed to include basic life-supporting and social services. The process, however, requires collaboration and cooperation among a variety of agencies and the private sector. Such partnerships are not commonly found in this culture; progress will be slow and, in some cases, require entirely new ways of thinking, planning, and operating.

At the very least, older persons can be encouraged to plan for their future transportation needs—something that far too few are currently doing—at the same time that they plan for retirement housing, health insurance, medical care, and the eventual disposition of their assets. Lawyers, physicians, and others can be brought into the mix of advocates to assist seniors in planning for their future transportation needs.

The costs of elder isolation in terms of health care, personal well-being, human capital, social connectivity, and the stress and productivity losses of caregivers are pressing societal issues that demand attention.

COST–BENEFIT CONSIDERATIONS

Maximizing personal mobility carries both costs and benefits. It is enlightening to examine the costs and benefits of maintaining mobility as people age, whether by continuing to drive or by seeking alternatives to driving. For example, while roadway enhancements and vehicle design improvements that specifically target older road users are costly, such enhancements ultimately can yield significant cost savings because of the safety benefits accruing to all road users. However, it must be recog-

nized that the benefits of maintaining driving in the face of age-associated functional declines often come at a cost in terms of safety. While no one would deny the importance of driving as the premier means of mobility for all adults, not just older adults, driving will be accompanied by crashes, injuries, and deaths. The primary purpose of the transportation system is mobility; however, for the sake of safety, mobility is limited by speed limits, required stops at red lights, suspension of the licenses of those who drive while under the influence of alcohol, and so forth. Society places great value on the level of personal mobility afforded by the private automobile, and most people, older adults included, are willing to accept a certain level of risk to maintain this high level of mobility. For older adults facing declining functional abilities, the question is at what point the cost of increased crash risk exceeds the benefit of continued freedom of mobility and the opportunity to continue contributing to society.

The functional changes that increase with age, certain medical conditions, and certain treatment regimens can produce mobility losses associated with a number of negative consequences that must be adequately addressed. What happens when driving oneself is no longer a viable option? Just as there are costs associated with continued driving in terms of increased crash risk, there are costs associated with limiting or stopping driving. The result of driving restriction or cessation is often a reduction in overall mobility, which has been associated in the literature with decreased activity levels, increased loneliness and depression, increased incidence of certain negative health outcomes, and lower life satisfaction (Marottoli et al. 1997). Thus, once again, there are trade-offs between personal safety and personal mobility.

The suburbanization of America and the phenomenon known as “aging in place” have resulted in the majority of older persons living out of the range of public transportation alternatives. Even when these alternatives are accessible, many older persons are uncomfortable or physically unable to take advantage of them. In many instances, the situation is further complicated by fears for personal safety. Yet it is essential to understand the cross-sector benefits of senior mobility options in order to comprehend their importance. A 1994 British study showed that the savings in health care and social service costs achieved by making transport fully accessible to older and disabled persons might reach as much as \$55,000 per 1,000 people per year, ignoring any additional transport costs (Carr et al. 1994). Training and accompanied practice in the use of public transit have increased its use among the older population in some communities. Such approaches will undoubtedly be identified, studied, and documented for technology transfer to other areas.

Using friends and family (when in proximity) for transportation may well become part of any universal policy on transportation alternatives for older persons, since reports show that riding with friends and family is the first transportation alternative of choice. The associated costs include the costs and inconvenience to the “chauffeur” and the feelings of inadequacy felt by the driver-turned-rider. Current young and middle-aged adults have become known as the “sandwich generation” because they are responsible for their elder parents as well as their children. Providing transportation for

older relatives can become extremely burdensome when it is mixed with home, work, and other responsibilities. At the same time, older persons report that they are uncomfortable relying on others to meet their transportation needs and are reluctant to do so, even at the expense of their own mobility. In some cases, the personal and social costs may simply be too high for both the older adult and his or her family members.

Paratransit or door-to-door on-demand transportation is the mostly highly desired transit option. However, there are many problems associated with this alternative, including the lack of regional coordination, the lack of sufficient personnel and vehicle capacities, the cost and difficulty of providing the service, and the limited purposes for which it may be provided (e.g., only for medical appointments and grocery shopping). Some champions of paratransit services believe that a local policy based on sophisticated technology, public funding, and volunteerism can provide these services effectively and efficiently (Freund 2004). This option deserves further investigation; its implementation will depend on (a) clearly stated and supported policy decisions, (b) an effective communication and dispatching system supported by a mobility manager, (c) efficient coordination to preserve resources and promote sustainability, and (d) impassioned leadership at the local level.

As described earlier, the Maryland MVA Older Driver Program encourages a commonsense approach to understanding the needs of its citizens, regardless of age, and recognizes the benefits of safe mobility for life. Future discussions might profitably focus on changing existing public perceptions of older-driver competency, shifting the focus from driving cessation to maintaining independence while helping aging drivers and their families prepare for stages of driving cessation, and promoting alternative transportation resources as aging drivers become unable to remain independent through driving. Supplemental transportation programs for drivers who may be restricted or are unable to continue driving could be augmented by programs to assist low-income drivers with the costs of driver assessment and remediation.

TECHNOLOGY

The past decade has been marked by technological advances in assessment and intervention approaches aimed at extending safe driving among older adults.

Technological advances have occurred in the assessment of higher-order information processing, other functional abilities, and driving behaviors via increasingly refined and computer-based measurement tools as well as simulator-based technology. In addition, major developments have occurred in the area of intervention approaches since *Special Report 218* was published, including cognitive rehabilitation approaches and the rapid growth in ITS research and development.

As discussed previously, degradation in visual information processing skills has emerged as a strong predictor of unsafe driving. These skills have long been suspected to play a role in automobile crashes, and this relationship has been extensively explored in recent years with the use of automated testing (Ball et al. 2002; Ball and Owsley

1991; Owsley et al. 1998). Through advances in the use of computerized testing to measure functional abilities in drivers, new tests have been developed that have proved much better at identifying crash-involved drivers than screening tests of the past. Indeed, where preference was given a decade ago to paper and pencil-based approaches to assessment, the prevalence of technology today in virtually every setting has led many investigators to transform these tests into an automated format. For example, the screening battery currently in use in the Maryland MVA Older Driver Program is entirely automated, which streamlines the data collection and analysis functions.³

Technological advances have also had an impact in remediation approaches for the functional abilities associated with increased crash risk. For example, the significance of UFOV performance to driving has led to an intervention approach that is based on UFOV assessment technology. Known as speed of processing training, this intervention uses a 10-session, computer-based program targeting improvement in the speed with which older adults can process information in a variety of everyday contexts, including driving (Ball et al. 2002; Edwards et al. 2002; Roenker et al. 2003). This approach has been shown to improve the UFOV, choice reaction time, and the time taken to perform instrumental activities of daily living, and has also been shown to reduce the number of dangerous maneuvers committed on the road by older adults with pretraining impairments in the UFOV.⁴ These effects have been shown to endure for at least 18 months to 2 years (Roenker et al. 2003). Other cognitive training protocols have been designed for improving memory and problem-solving skills. Recent research has shown that improvements in these abilities that are related to certain demands of the driving task are indeed possible (Ball et al. 2002), although no transfer of these improvements to mobility improvements has been indicated. These training programs are now also under development in an automated format.

Many mobility and safety problems result from a poor fit between the older roadway user and the highway infrastructure. Such problems may be amenable to remediation through the strategic application of ITS technology, which synthesizes advances in wireless communication, computing, and GPS. However, ITS technology offers the potential to increase the burden of older travelers if the information-processing demands of in-vehicle interfaces are engineered without regard for their emerging needs and changes in capacity. Special care is needed to ensure that older road users are not engineered out of next-generation vehicle-highway systems (Schieber 2004).

The automobile industry has responded to the needs of older drivers through a variety of initiatives. In-vehicle navigation, automated emergency response, night vision

³ This screening battery is called the DrivingHealth Inventory. Additional information on this battery can be found at www.drivinghealth.com.

⁴ The interventions, however, have not been tested extensively on older adults with dementia. The interventions have been shown to work on older adults with processing speed impairments but without dementia.

enhancement, crash avoidance warning signals, and improved occupant protection are some of the innovations produced in recent years. Few ITS applications are now used by drivers and fewer still are used by older drivers, but this situation is likely to change in coming decades. These improvements can assist older persons in driving longer and improve the crashworthiness of the vehicle, which increases the likelihood of survival and reduces the incidence and severity of injury in the event of a crash. However, for new technologies to be truly effective and enhance the safe mobility of older persons, manufacturers must provide education and instruction to facilitate safe use. While some older adults welcome new technologies, many are less confident in their abilities to operate new technologies. Fear of technology, difficulty in operating a device while driving, display information legibility, and the need for specific training are likely to be persisting difficulties for older drivers using ITS technologies (Caird 2004). Furthermore, there are serious and unanswered questions about the workload capacity of all drivers. These technologies may overload the driver and result in inattention or distraction, factors that are associated with many accidents. Thus, while the number of ITS applications continues to grow, the value and functional advantage of new driver information, for older drivers in particular, have yet to be determined.

CONCLUSION

Policy makers at all levels of government in the United States must seriously consider and decide when, what, and where safe mobility options for older persons will be provided. They must understand that the cost of providing services to help maintain safe mobility may occur in an arena different from the benefits. For example, savings in health care costs to the nation as the result of maintained mobility will not directly benefit driver assessment or remediation practices. In the near term, coordination of services and widespread communication about available services, technology options, and other assistance are necessary. For the future, comprehensive public policy and sustained, forceful leadership will be required to address and provide solutions for the safe travel of the nation's older citizens. There will most certainly be trade-offs in the allocation of resources; however, some options can enhance the welfare of not only older persons but also society in general. It is wise to identify these options and use them as the foundation for other building blocks to develop a comprehensive set of policies and strategies that will keep America's older citizens on the move.

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Summary of Research Recommendations from Technical Papers

Conference Proceedings 27: Transportation in an Aging Society: A Decade of Experience

Mobility of the Elderly: Good News and Bad News (Rosenbloom)

- Investigate the extent to which older drivers reduce, as opposed to modify, driving activities.
- Examine the extent to which older persons drive themselves or depend on other care providers to engage in activities.
 - Investigate the relationship between older persons' living arrangements and their dependence on friends and family for providing transport.
 - Create a comprehensive national strategy that includes attention to effective driver evaluation and retraining programs, crashworthy vehicles and improved signage and information systems, user-friendly public transport networks, transportation alternatives, well-designed land use and housing choices, cost-effective delivery of private and public services, and coordination in the delivery of human and social services.

Safety of Older Persons in Traffic (Hakamies-Blomqvist)

- Shift the research emphasis from *why* older drivers are at higher crash risk to *which* older drivers are at higher crash risk
 - Examine quality of exposure versus quantity of exposure.
 - Increase the sample size of the very old (80 and above), particularly in travel surveys, to enable researchers to disaggregate risk by variables such as health conditions and quality rather than quantity of exposure.
 - Identify the health variables that correlate with accident rates.

Adaptive Strategies of Older Drivers (Smiley)

- Conduct field tests with ITS technology on drivers prepared to use it.
- Identify the causes of driving self-restriction and cessation to determine whether changes are due to lifestyle or functional ability, and examine the implications for mobility.

- Identify groups to assist with training and education.
- Extend research beyond visual acuity to other vision measures.
- Develop and evaluate the effectiveness and cost–benefit relationships of screening tests in various settings, such as departments of motor vehicles, malls, and physicians’ offices.
 - Conduct research to develop specific advice on the best methods for reducing risk.
 - Study the role and effectiveness of coping strategies to determine what influences their effectiveness, for whom they work, and how to encourage people to use them.
 - Investigate the decision-making processes that result in driver adaptation.
 - Since changes in operational choices are difficult to bring about and are likely to require expensive one-on-one retraining, focus research on strategic and tactical, rather than operational, choices.
 - Create effective strategies for providing strategic advice to older persons on the use of seat belts and reducing driving at night, in poor weather, and after drinking alcohol. Include advice on when drivers should restrict their own driving in various ways and when drivers should give up their licenses entirely.
 - Create additional strategies for offering tactical advice on subjects such as appropriate positioning in intersections for a better view of oncoming traffic when turning left, entering into traffic more quickly once the turn is initiated, and directing attention more consciously to the driving task as opposed to conversing with passengers while negotiating intersections.
 - Make older drivers aware of specific limitations that develop with age, such as poorer ability to estimate the speed of approaching traffic.
 - Develop educational material on older drivers for family members alerting them to appropriate adaptations and to the fact that older drivers do adapt where intervention is required.

Driver Capabilities (Owsley)

- Clarify the distinction between disease-oriented impairment and cognitive functional impairment due to the normal aging process.
 - Evaluate and demonstrate the effectiveness and cost–benefit of safety interventions.
 - Evaluate the effectiveness of coping strategies in terms of how they work, their effectiveness, and strategies for encouraging people to use them.
 - Continue in-service medical education for professionals in driver assessment, rehabilitation, and referral options.
 - Deploy multidisciplinary teams for assessment, remediation, and counseling.

- Conduct further research into the relationship between crash risk and visual contrast-sensitivity, especially due to cataract.
- Determine which screening tests or combinations of tests are the best predictors of crash risk.
- Extend research beyond visual acuity into higher-order visual-processing skills in screening at-risk older drivers.
- Investigate and document the progression of cognitive impairment and determine the stage at which it becomes a threat to safe driving.
- Determine whether physical difficulties in everyday-life activities serve as markers for physical difficulties in operating a vehicle safely.
- Investigate minimum levels of physical function necessary for safe driving and the extent to which compensatory behaviors such as driving more slowly and avoiding heavy-traffic areas minimize crash risk among older persons.
- Rigorously evaluate and document the effectiveness of interventions for reducing crash risk by overcoming functional impairments such as treatment of eye conditions, training in specific cognitive skills related to driving, physical training, exercise regimens, and driver education programs.

Age-Related Disease, Mobility, and Driving (O'Neill and Dobbs)

- Conduct research on the relationship between disease and driving and other forms of mobility.
- Use dementia as a paradigm for cognitive conditions.
- Develop literature on fitness to drive that emphasizes enabling strategies as well as barriers to driving.
- Provide education in assessing fitness to drive for specialists dealing with older people and those with disabilities.
- Develop specialist centers allied to departments of geriatric medicine and psychiatry to catalogue the development of the skill base required for safe mobility.
- Lobby health care insurers to provide coverage for interdisciplinary driver assessment and conduct research that establishes the validity and effectiveness of the process.
- Link medical sections of departments of motor vehicles with both public health and medical specialists dealing with older people.
- Enlist the support of area agencies on aging to promote a positive agenda and ensure that local guidelines are both evidence based and enabling where possible.
- Ensure access to adequate, affordable, and acceptable alternative transportation.

Driver Programs (Staplin and Hunt)

- Explore financing arrangements, including the role of insurance companies, for assessment and rehabilitation programs.
- Develop effective tools for heightening awareness of driver education solutions.
- Increase the number and availability of driver safety interventions.
- Encourage the participation of occupational therapists in medical advisory boards.
- Provide incentives to increase the number of certified driving rehabilitation specialists.
- Design older-driver assessments to identify the best methods for keeping individuals mobile and participating in activities.
- Evaluate interventions as they are developed to ensure effectiveness and cost–benefit.
- Create multidisciplinary teams to assess, remediate, counsel, and train older drivers.
- Modify licensing programs to reflect an emphasis on functional assessments.
- Utilize medical advisory boards to assess, remediate, and extend driving time under restricted or limited driving.
- Heighten public awareness by developing and disseminating information on effective driver education tools.
- Expand the number of programs that provide interventions to increase driver safety.
- Catalogue the laws and capture the actual practices concerning physician reporting of impaired drivers in the states.

Mobility Options for Seniors (Suen and Sen)

- Conduct a demonstration trial focusing on families in the continuum of mobility services provided to older persons.
- Test the effectiveness of street crossings with people detectors to extend the pedestrian phase of street crossing for slow walkers.
- Quantify the importance of mobility to well-being.
- Investigate and document the reasons for low transit use among seniors.
- Examine census data and forecasts on future geographic distributions of older persons to predict future problem areas.
- Study the compatibility of powered wheelchairs with respect to pedestrians and other road users. Develop an effective strategy for protecting these road users from traffic.
- Define travel options for seniors on the basis of functional ability.

- Critically examine travel needs and abilities from older persons’ perspectives.
- Evaluate the effectiveness of travel training and mobility managers.
- Document the liability issues related to volunteer drivers and identify strategies for overcoming legal barriers.
 - Encourage local and state governments to provide transit, paratransit, and taxi services; include public education campaigns to inform seniors of service availability, eligibility, and cost; include vehicles that cater to older persons with features such as low-floor buses and wheelchair ramps; and establish reasons why seniors do not use transit where it is available and the steps needed to overcome these barriers.
 - Codify research on mobility and mobility options into guidelines to assist state and local planners in developing, implementing, and managing services. Document and disseminate best practices.
 - Conduct research to establish the level of mobility required for convenient independent living.
 - Define the term “well-being” and quantify the importance of driving for well-being.
 - Examine geographic information on older persons to project future growth areas and the accompanying mobility needs.
 - Identify and document sustainable transit solutions for older persons.
 - Provide sensitivity training on the needs of older road users for management, operations, and frontline staff in transportation services.
 - Investigate the role of mobility managers and the one-stop shopping approach to driving and alternative mobility options.
 - Encourage older drivers to plan for transportation needs at the time they plan for retirement.

Surviving Without Driving: Policy Options for Safe and Sustainable Senior Mobility (Freund)

- Encourage a variety of transportation to meet the needs of older persons.
- Continue funding with public resources and develop incentives to attract personal and charitable private resources.
 - Increase reliance on volunteers as an integral part of the transportation service.
 - Analyze and respond to consumer preference in developing transportation alternatives.
 - Incorporate modern independent lifestyles into marketing programs to adjust for resource or logistical trade-offs in service characteristics and payment choices.

Highway Research to Enhance Safety and Mobility of Older Road Users (Schieber)

- Develop performance-based requirements for highway sign legibility and use these parameters to establish and validate minimum retroreflectivity requirements. Document cost–benefit analyses and trade-off studies used to justify any specifications that fail to meet the performance-based requirements of the design older driver fully.
- Develop performance-based requirements for roadway delineation and use these parameters to establish and validate minimum retroreflectivity requirements for roadway markings.
- Carefully evaluate the conceptual and methodological basis of gap acceptance models for highway geometric design relative to the characteristics of the 85th percentile 75-year-old design driver.
- Model and evaluate the performance of older drivers while making left turns to determine how vehicular control and focus of attention, “functional risk factors,” may influence their overinvolvement in left-turn crashes.
- Conduct studies that use state-of-the-art eye-tracking techniques to ascertain and model how older and younger drivers scan their visual environment. Determine what visual information drivers use and when they need it.
- Conduct research to ascertain how geometric design, traffic control devices, and ITS can be modified or used to accommodate merging into high-speed or high-density highway traffic situations.
- Evaluate the impact of small target visibility models of highway lighting design on performance, comfort, and fatigue among older drivers.
- Investigate the extent to which driver fatigue may disproportionately influence performance in the older population.
- Evaluate the performance of proposed traffic-calming techniques and their workload demands on older drivers and pedestrians, and incorporate the findings into the development of regulations and guidelines.
- Develop a system-level approach to the design, placement, and maintenance of highway signs.
- Model and evaluate the reluctance of older drivers to execute right-turn-on-red operations in urban areas.
- Evaluate the impact of various levels of street lighting on the current mobility of older drivers. Conduct cost–benefit analyses to determine whether larger investments in highway lighting infrastructure are needed to accommodate nighttime visibility problems.
- Further study and quantify the role of durable fluorescent colors in improving the conspicuity and legibility of highway signs among older drivers.

Safety of Older Pedestrians (Oxley, Fildes, and Dewar)

- Conduct a more detailed investigation of crash involvement patterns.
- Examine older-pedestrian performance in complex settings and the role of inappropriate behavior in older-pedestrian crashes.
- Evaluate the effectiveness of speed reduction and median strips for older pedestrians.
- Examine the suitability of road and highway design for older pedestrians and mount a greater effort to provide a safe traffic environment for older pedestrians, especially in high-density pedestrian areas.
- Create adequate crossing time guidelines for older pedestrians and promote better maintenance of sidewalks and street lighting.
- Assess the mobility needs and patterns of older pedestrians.
- Develop safer access for older people at tram and bus stops.
- Develop alternative mobility options for older pedestrians.

Land Use and Travel Patterns Among the Elderly (Giuliano)

- Create scenarios of “driver-friendly” as well as pedestrian- and transit-friendly urban design alternatives: streets widths that protect pedestrians, more and better signage and traffic control, easily negotiated parking facilities, and so forth.
- Supplement current research and knowledge on the relationship between land use planning and senior mobility. Investigate how older persons adapt to declining driving skills in low-accessibility areas, whether those who reside in such areas are significantly more mobility disadvantaged than those who live in neighborhoods with higher accessibility, how much consideration is given to future mobility needs when they move, how sensitive the developers of senior communities are to mobility and accessibility, and what cities are doing to encourage location of senior communities in appropriate places.
- Conduct longitudinal case studies of residents in different neighborhoods to trace shifts in travel behavior over time and how these vary across neighborhood/community types.
- Conduct cross-sectional studies of senior community residents in various locations to determine how different levels of accessibility affect travel patterns and car use.
- Study urban planning practice related to senior housing development and mixed-use development to examine who locates in such developments and why.

Reducing Injuries and Fatalities to Older Drivers: Vehicle Concepts (Pike)

- Quantify and compare the changes, as well as the variation, that occur within older-person age groups.

- Identify vehicle and highway features that address at-risk road users.
- Formulate intervention strategies, including driver testing, training, education, and licensing.
 - Investigate the potential of adaptation techniques for safety features and concepts to address the special needs of older drivers and occupants.
 - Identify adaptation techniques and concepts that older road users will accept.
 - Determine whether current test procedures, devices, and criteria can be scaled to reflect the older population or whether unique features are needed.
 - Determine which aspects of aging are associated with fatal and injury-producing crashes.
 - Determine the need for additional driver training on the proper use of new technologies.
 - Develop intersections that utilize electronic interaction between vehicles and roadways to reduce crashes.
 - Quantify driving-related changes that occur with aging and identify vehicle–highway modifications to address these changes.
 - Improve testing devices and criteria for evaluating occupant protection devices for older drivers and passengers.
 - Explore the usefulness of a different owner manual format for older vehicle users.

Automotive Adaptive Equipment and Vehicle Modifications (Koppa)

- Develop assistive devices for easing the effort of fastening safety belts for those with movement and dexterity limitations.

In-Vehicle Intelligent Transportation Systems: Safety and Mobility of Older Drivers (Caird)

- Account for older-driver capabilities in the design, modification, and evaluation of ITS technologies.
 - Develop guidelines that can assist designers in achieving legibility, comprehension, minimal attention, ease of use, and so forth for older drivers, and give illustrative case examples.
 - Develop training for older drivers in the use of ITS devices and systems.
 - Conduct long-term measurement of driver use and performance with an ITS-related system focusing on the principle of convergent empirical evidence from objective and subjective sources.
 - In evaluating ITS devices, consider individuals who may have difficulty using in-vehicle displays (older drivers), the fit of a presentation modality to drivers' sensory capabilities (auditory, visual, and multimodal), limiting tasks

that divide attention (braking and object recognition), optimizing the form that display images take (size, color, location, etc.), and determining whether the systems can be safely operated in a wide range of traffic contexts (emergencies).

- Evaluate appropriate as well as inappropriate behavioral adaptation in the use of ITS applications (e.g., whether drivers adopt higher speeds at night because they can see further ahead by using ITS applications).
- Analyze and apply basic empirical knowledge of driver behavior and adaptive strategies to the development of ITS technologies.
- Evaluate the extent to which ITS technologies offset declines in safety and mobility due to aging processes.

Impact of Public Information on Safe Transportation of Older People (Milton)

- As older persons experience the initial problems of aging that begin to affect driving and trigger self-compensation, provide information that acknowledges that gradual physical and mental changes are normal and that continuing adjustment of driving behavior often can extend safe driving for many years. Endorse acceptance of the need for change as the key to safe operation.
- As older persons experience additional symptoms of aging that may make driving unsafe, provide information about available evaluation and rehabilitation opportunities and vehicular adaptive devices.
- Develop an active presence and involvement of “early warning” networks, including family, friends, police, doctors, and the health care community. Educate all segments in awareness of aging symptoms that may require intervention.
- Identify and document incentives and messages that trigger the interest and action of families and friends to help an older person make wise choices about driving.
- Conduct research to determine motivation strategies that encourage physicians to address patient driving capabilities, and identify their information needs to supplement their recommendations about driving. Determine the effectiveness of information concerning rehabilitation and evaluation services in terms of encouraging doctors to incorporate these services more frequently into their treatment regimens.
- Determine what incentives and training will encourage the broader health care network to assess driving capabilities as a regular facet of examinations and to identify what kinds of information they would find useful in assisting patients.

- Provide information that helps older drivers shift to another form of transportation (including a change in lifestyle) as they become incapable of safe driving.
 - Develop materials that present the transition in constructive terms, and motivate the support network to facilitate change.
 - Create materials that identify assistance available to older persons who are no longer driving.
 - Describe transportation options and motivate participation of the support network to help older persons negotiate and become comfortable with the idea of alternatives.
 - Address remedial opportunities for those whose recuperation may eventually allow resumption of driving.
 - Conduct focus groups of men determined to remain drivers at any cost to learn what motivations might alter their perspective.
 - Stratify research demographically to ensure that all socioeconomic groups are represented and can be disaggregated.

Transportation Policy for an Aging Society: Keeping Older Americans on the Move (Cobb and Coughlin)

Agenda Setting and Education

- Educate state policy makers about aging.
- Promote alternative transportation as a mode, not solely as a social policy tool.
- Reinvent licensing bureaus as mobility resource centers.
- Earmark funding/fees to build organizational capacity.
- Encourage automakers to provide education in new technologies.
- Implement the highway design guidelines recommended by the Federal Highway Administration.

Technological Innovation

- Invest in research and development for new automobile technologies to address unique safety and operational issues associated with older drivers and passengers (e.g., driver workload, safety of older women, and passenger ingress/egress).
 - Define a cost-effective test regime to sample all drivers for fitness.
 - Demonstrate and evaluate the White House National Science and Technology Council's 1997 recommendations to develop a regional mobility management system to provide a basis for the next-generation paratransit system for all ages.

Market Leverage and Stimulation

- Promote industry research and development and the affordability of new technologies through federal tax incentives.
- Urge the insurance industry to provide technology discounts for use of “safety technologies.”
- Amend state liability statutes to extend protection to volunteer driver networks and educate volunteers about these protections.
- Conduct research assessing the efficacy and market potential of transit-oriented development and “livable communities” for middle-aged and young-old persons seeking new homes to age in place.
- Encourage individuals to plan and save for their future mobility needs, thereby creating new markets for both private and public services.

Committee Member

Biographical Information

Richard A. Marottoli, *Chair*, is Associate Professor in the Yale University School of Medicine, Department of Internal Medicine, specializing in geriatrics. He is a practicing and teaching physician at VA (Veterans Administration) Connecticut, where he is Director of the Geriatrics and Extended Care section. His published research includes work on screening functional ability in the elderly, crash risk and experience of older drivers and pedestrians, older-person driving skill and assessment, the effects of driving cessation on older individuals, and counseling older persons about driving. He has conducted sessions on older-person driving at the Transportation Research Board (TRB) Human Factors in Transportation Workshop. He served two terms as Chair of the TRB Safe Mobility of Older Persons Committee. In addition to an M.D. degree with certification in geriatrics, Dr. Marottoli holds a master's degree in public health and a B.A. degree in molecular biophysics and biochemistry.

Karlene K. Ball is a Professor of Psychology at the University of Alabama at Birmingham (UAB). She is the Director of UAB's Edward R. Roybal Center for Translational Research on Aging and Mobility and Associate Director of the UAB Center for Aging. Dr. Ball has served on committees of TRB, the National Research Council (NRC), the National Academy of Sciences, and the National Institutes of Health. She has served as Chair of the Human Factors and Ergonomics Society Technical Group on Aging and is a Fellow of the American Psychological Association. She is frequently asked to consult on projects and expert panels concerning the setting of standards for commercial drivers and has provided expert testimony for the Equal Employment Opportunity Commission. Dr. Ball has authored numerous publications on visual, attentional, and other cognitive changes that occur with age, as well as on identification of high-risk drivers. She has received awards from the National Institutes of Health, UAB, and Nationwide Mutual Insurance Company. She holds a Ph.D. in experimental psychology and aging from Northwestern University.

Christopher G. B. Mitchell is the retired Head of the Environmental Centre, Transport Research Laboratory (TRL), in the United Kingdom. He is a mechanical engineer and scientist with expertise in vehicle dynamics, the environmental and social effects of road transportation, and transport for the disabled. During a 30-year

tenure at TRL he served as Head of three divisions: Environmental Centre, Vehicle Engineering, and Access and Mobility. His experience covers the gamut of public transit, mobility and accessibility, and vehicle factors involved with providing transportation for older or disabled persons. He holds a Ph.D. in engineering from Cambridge University. His research is published as TRL technical reports and in the academic literature. He served on a variety of government advisory panels during his career. He is now an overseas director of the International Centre for Accessible Transport, Montreal, Canada. Currently he is active in the TRB Accessible Transportation and Mobility Committee.

Anne Long Morris established Elder Care Consulting, an occupational therapy practice, in 1999. Before that she was a Practice Associate with the American Occupational Therapy Association (AOTA), where she was responsible for the AOTA geriatric programs. Before joining AOTA, Dr. Morris was a Geriatric Consultant to the Virginia Health Department, Research Coordinator for the Fairfax County (Virginia) Area Agency on Aging, and a Geriatric Contractor for INOVA Health Care. Recognizing the special needs of older persons, she developed and promoted geriatric programs within AOTA. She has also been active in tracking and encouraging research for older persons in general and older drivers specifically. She has been active on the TRB Safe Mobility of Older Persons Committee for 8 years, served the National Institutes of Health on a Special Proposal Review Panel, and was an alternate delegate to an American National Standards Institute Committee (ANSI 117.1) for 5 years. She is Board Certificated in Gerontology and is a Fellow of AOTA. In 2003 she became certified as an Aging in Place Specialist by the National Association of Home Builders. In 2004 she accepted a 5-year appointment to the AOTA Specialty Certification Board. In that role, she serves as the AOTA Liaison to the Driving and Community Mobility Certification Panel and the Environmental Modification Certification Panel. She holds a B.S. degree in occupational therapy, an M.P.A. in public administration, and the Ed.D. in adult/continuing education.

Robert Raleigh is the retired Director of Driver Safety Research and the Chief of the Medical Advisory Board for the Maryland Motor Vehicle Administration. He continues to cochair the Maryland Research and Development Consortium on Older Drivers. The consortium is currently involved in running a model older-person mobility program in the state. Dr. Raleigh was leader of the session “Toward Standardizing the Evaluations of Drivers with Cognitive Impairments” for the 32nd Human Factors in Transportation Workshop, January 1999. He is an M.D. and a Certified Specialist of the American Board of Preventive Medicine. Earlier experience includes 14 years as Corporate Director of the Health and Environmental Laboratories, Eastman Kodak, and 10 years as Clinical Professor of Environmental Medicine at the University of Rochester School of Medicine and Dentistry.

Peter F. Rusch is the Safety Engineer at the Federal Highway Administration Midwest Resource Center. He retired from the Wisconsin Department of Transportation, where he was the State Traffic Engineer. He had responsibility for overseeing application of traffic engineering functions of the state highway system. Also within his purview was the department's Safety Section. As part of these responsibilities Mr. Rusch developed and applied the *Wisconsin Manual on Uniform Traffic Control Devices* and work zone traffic control strategies. He worked on the design, installation, and maintenance of traffic control devices and represented the department before the legislature concerning traffic/operations laws and regulations. Specific activities for older drivers include upgraded signing, plowable raised pavement markers, shoulder rumble strips on all 65-mph facilities, and additional intersection or interchange lighting. He currently serves on the American Association of State Highway and Transportation Officials Standing Committee on Highway Traffic Safety and the Subcommittee on Traffic Engineering. For TRB he served as chairman of the National Cooperative Highway Research Program (NCHRP) Panel on Traffic Control Device Design and Redundancy to Aid the Older Driver and is a member of the Panel on Geometric Design Consistency. He also served on two previous NCHRP project panels. He is chairman of the National Committee on Uniform Traffic Control Devices' Subcommittee on Regulatory, Warning, and Technical and Guide Signs.

Jane C. Stutts is Manager of the Social and Behavioral Studies Division at the Highway Safety Research Center, University of North Carolina at Chapel Hill. During the past 5 years her research activities have centered on driver distraction, pedestrian/bicycle projects, and older drivers. Her older-driver work involves both consequences of cessation of driving and cognitive and visual performance and crash risk of older drivers. She holds a Ph.D. in epidemiology from the University of North Carolina. Dr. Stutts served two terms as chair of the TRB Bicycling Committee. She currently serves on the TRB System Users Group Council.

Martin Wachs is Professor of Civil and Environmental Engineering and City and Regional Planning at the University of California, Berkeley, where he is currently Acting Director of the Institute of Transportation Studies and Director of the University of California Transportation Center. He moved to Berkeley in 1996 after spending 25 years as a member of the faculty of Urban Planning at the University of California, Los Angeles (UCLA), where he served three terms as department chair and founded the UCLA branch of the Institute of Transportation Studies. In addition to his wide-ranging transportation expertise, he provides continuity with the original committee that produced *Special Report 218: Transportation in an Aging Society: Improving Mobility and Safety for Older Persons*, of which he was a member. Dr. Wachs has served on numerous TRB committees and panels. He chaired the TRB/Commission on Behavioral and Social Sciences and Education study on urban

transportation congestion pricing and has been a member of the TRB Executive Committee. He is the author of many articles on urban transportation, public transportation, transportation finance, and the relationships between transportation and air quality. He holds Ph.D. and M.S. degrees in civil engineering from Northwestern University.

Patricia F. Waller (deceased) was retired as Director of the University of Michigan Transportation Research Institute (UMTRI). Prior to her tenure at UMTRI she was founding Director, Injury Prevention Research Center, and Associate Director for Driver Studies at the Highway Safety Research Center, University of North Carolina at Chapel Hill. She served on TRB's Motor Vehicle Size and Weight Committee; Alcohol, Other Drugs, and Transportation Committee; and Research and Technology Coordinating Committee (Highways). She chaired TRB's Group 3 and Group 5 Councils and received the Roy W. Crum Distinguished Service Award from TRB in 1994. She received the National Safety Council Distinguished Service Safety Award in 2003. She was a member of NRC Committees on Injury in America and Injury Control. She held a Ph.D. in psychology from the University of North Carolina.

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