# Quantifying the Relationships: Aging, Driving Cessation, Health, and Costs

**A Project Memorandum**

*Sponsored by US DOT*
*Office of the Secretary*
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DRAFT

# 1. Introduction

The purpose of this effort was to explore the complex interrelationships among health, economics, and driving cessations in the older adult population. While there is a significant body of literature for each of these areas there is not an established methodology to objectively explore the impact of changes in demographics, health, and driving and predict potential future impacts. Specifically this technical memorandum proposes a conceptual basis for a methodology to:

- Examine the impact of loss of "out of home" mobility (mobility that permits contact with the external world and leads to interaction with people outside the home), due to driving cessation, on health and health care costs. "Out of home" mobility makes it possible to contact with people, obtain services, and participate in activities.
- Identify methods to quantify economic impacts of loss of contact with the larger world on the individual, family, community, and society.

The goals of this effort were to:

- Identify and catalog promising data sources and methodologies to quantify the relationship among external mobility, health status, and health costs.
- Summarize, in a project memorandum, the conclusions that can be drawn regarding:
    - The relationship between health and mobility.
    - The economic impacts of driving cessation and the resulting loss of contact with the outside world to the individual, family, community, and society.

To accomplish this, a U.S. Department of Transportation team with representatives from the Office of the Secretary, National Highway Traffic Safety Administration, and the Volpe National Transportation Systems Center did the following:

- Reviewed the pertinent literature
- Identified the most promising data sources
- Convened and met with panels of international experts
- Proposed a methodology that could be used to quantify the aging/mobility/health/cost relationships.

# 2. Background

The 1999 TRB International Meeting on Transportation and Aging identified the impact of loss of mobility on health as a key research issue. Given that automobile travel is the primary source of mobility for Americans, the cessation of driving is likely to be an event that curtails a large portion of older Americans' contact with the larger society.

It has been hypothesized that the cessation of driving has significant direct and indirect health impacts. In addition to the loss of contact, these impacts have economic consequences. However developing objective quantitative estimates of the health and economic consequences is problematic because a person's declining physical condition can be both a cause and a

consequence of loss of mobility. The US Department of Transportation's Office of the Secretary's Office for Transportation Policy initiated a project with the Volpe National Transportation Systems Center to identify and/or develop methods for arriving at estimates of the economic impacts of driving cessation, the major cause of loss of external mobility.

The Volpe Center organized and convened a meeting of experts in aging and driving cessation during the 2002 Annual Meeting of the Transportation Research Board to identify the data and research protocols that could address this issue (Committee on Safe Mobility of Older Persons, 2002). The participants made the following recommendations:

- There is a need to specify the required research and to identify candidate data sources.
- The confounding of the impact of loss of contact, or "out-of-the-home" mobility, due to driving cessation, on health, as well as the impact of health on mobility, represent a significant obstacle, but it is possible to discover potential methodologies.
- To date, depressive symptoms are the only objectively established medical impact of driving cessation (Marottoli et al., 1997).
- The impact of loss of external mobility is likely to differ as a function of age, gender, wealth, ethnic background, and/or region of residence.
- Although experimental field studies are desirable, their implementation is challenging and, probably, impractical.
- Analyses of data from longitudinal databases may be the most promising approach. However, the databases that focus on health contain few, if any, transportation items, and the databases focused on transportation contain few health items.
    - It is possible to request that items be added to longitudinal studies. This approach is costly and the data would not become available for years.
- Analyses that quantify the economic impacts are important in developing policy.
    - For example, it would be useful to quantify the transportation costs incurred by providing the life sustaining treatment of dialysis.

The consequences of driving cessation were discussed in more depth at a meeting held in Phoenix, AZ, in March 2002, as part of the "National Conference on Aging & Mobility" sponsored by the Maricopa Association of Governments. At this meeting, participants discussed the impact of loss of external mobility and methods to improve understanding of the issue. Participants agreed that there is a relationship among a person's sense of autonomy, driving status, and health but agreed that the relationship has yet to be objectively confirmed or quantified. Participants also discussed how lost contacts can lead to a sense of isolation, depression, and associated illnesses.

The following topics were addressed at this meeting:

- Demographic descriptors of aging and mobility in the United States.
- Three seminal papers on driving cessation:
    - "Driving Cessation in Late Life: A Socially Induced Disability?" (Barr, 2001)
    - "Changes in Driving Patterns and Worsening Depressive Symptoms Among Older Adults. " (Fonda, Wallace, & Herzong, 2001)
    - "Statistical Relationships Between Vehicle Crash Rates, Driving Cessation, and Age-Related Physical or Mental Limitations." (Hu, Lu, & Trumble, 1997)

- A proposed framework for developing quantitative estimates of the economic impact of driving cessation and resulting loss of external mobility.

## 3. Demography of Aging in America

In 2000, one out of eight Americans, 35 million or 12.5%, were age 65 and older. The proportion of the population age 65 and older is going to increase, relative to the other age groups, for the foreseeable future. In the year 2030 when the last of the baby boom generations reaches age 65, there will be 70 million Americans age 65 and older, one out of five, as shown in Figure 1.

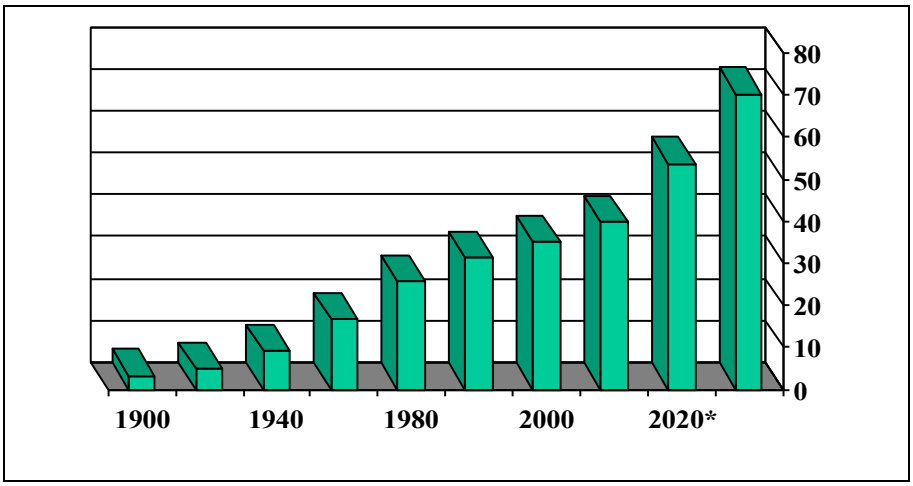


**Figure 1. Number of Americans 65 and older (in millions) by year (Current Population Reports, 2000)**

Females are over represented in the 65 and older population. In 2000, there were 143 women for every 100 men age 65 and older, or 21 million women vs. 14 million men. The sex ratio increases in the older age groups.

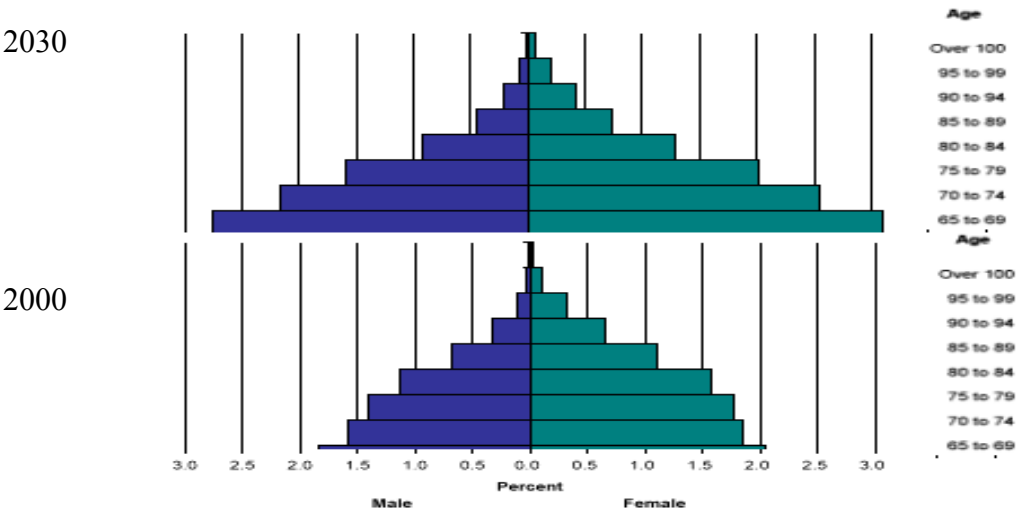


**Figure 2. Projected US population over 65 by gender for year 2025 compared to year 2000. (U. S. Bureau of the Census)**

For example, in 2000, there were 245 women to 100 men for age 85 and older. (Figure 2) As the relative proportion of the population age 65 and older increases, the gender differential becomes more striking as Figure 2 shows.

In 1997 in the United States, men age 65 and older were more likely to have a driver's license; 92% of the men had driver's licenses as compared to 67% of the women (Organization for Economic Co-operation and Development, 2001). With the expansion in women's expectations and opportunities in recent decades, it is likely that women's driving behavior will become more similar to that of men. Many more women in the younger age cohorts hold drivers' licenses and are driving more. As a result older women in the future will do much more driving.

**Mobility and Income**

In 2000, 4.2 million Americans age 65 or older were employed, 2.4 million men and 1.8 million women. Employed older Americans represented 13% of the age 65 and older population and 3% of the U.S. labor force. This proportion has increased in recent years (Older Americans 2000: Key Indicators of Well-Being, 2000). In 2001, the civilian non-institutional population age 65 and older represented 13% of the population and 12.7% of this population was employed; 24.7% of people age 65 to 69, 14.1% of people age 70-74, and 5.4% of people age 75 and over were employed (Household Data Annual Averages. Table 3. Employment Status of the Civilian Noninstitutional Population by Age, Sex, and Race). With the increase in the age for eligibility for Medicare beginning to impact the older population, it is likely that these levels of employment among older people will continue if not increase. Loss of external mobility could affect employment opportunities among those able to work. The impact of loss of external mobility will vary by income level to the degree that older Americans depend on employment to sustain them economically.

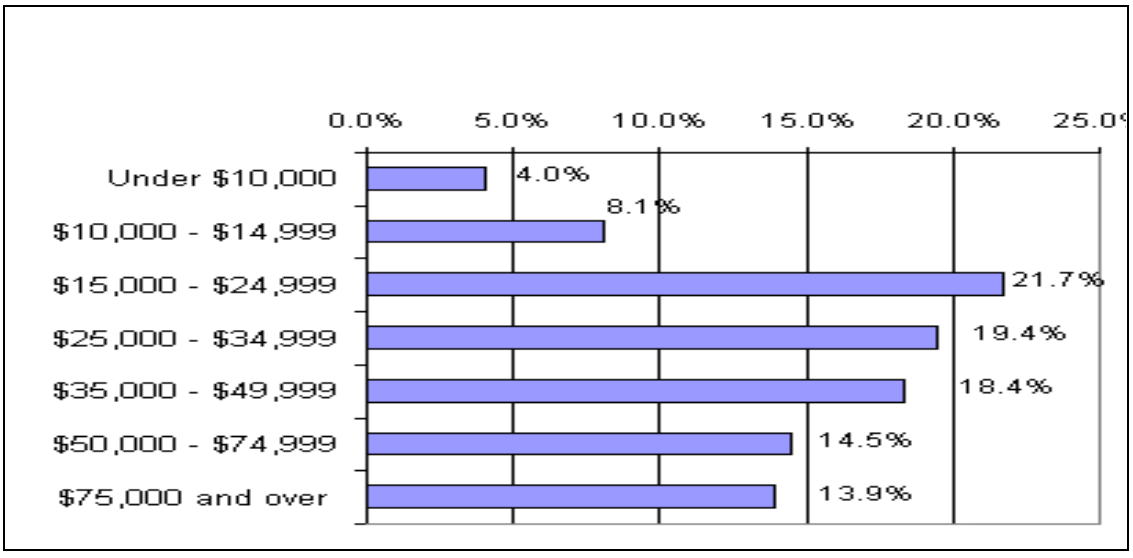


**Figure 3. Income Distribution for Households Headed by Person Age 65 or Older in 2000, (U.S. Bureau of the Census, 2001a)**

Figure 3 depicts the distribution of income for households of people age 65 and older. In 2000, income "Below the Poverty Level" for one-person age 65 or older was $8,259 and for a household (2 persons) age 65 and older was $10,419 (U.S. Bureau of the Census, 2001b). Nationally, 11.3% of the society lived below the poverty level as compared to 10% of those age 65 and older. However, 19% of people age 65 and older that lived alone had incomes below the poverty level. Twelve per cent of women age 65 and older had incomes below the poverty level in 2000 as compared to 8 % of the men (Dalaker, 2001).

**Health and Disabilities**

With regard to health problems and disabilities (defined as a substantial limitations in a major life activity), slightly more than half, 55%, of Americans age 65 and older have at least one disability and 38% of them report at least one severe disability. Gender is related to the distribution of disability. In 1994, 25% of women age 65 and older, 4,907,790, had at least one chronic disability as compared to 15.5% of men or 2,078,000 (Older Americans 2000: Key Indicators of Well-Being, 2000).

The percent of Americans 65 or older needing assistance increases with age. In 1998, the incidence of disabilities by age that restricted activities was 29% for people age 65-74, 51% for people age 75 and older and 74% for people age 80 and older (Administration on Aging). Using 1994-1995 data on respondents reporting difficulty performing any of the Instrumental Activities of Daily Living (IADL's)[1] and Activities of Daily Living (ADL's),[2] 16,421,000, or 52%, of people age 65 and older, reported at least one disability. There are 4.5 million Americans age 65+ who have difficulty with ADL's and 6.9 million who have difficulty with Instrumental Activities of Daily Living IADL's.(U. S. Bureau of the Census, 1998) People, age 65 and older, with lower income levels and educational attainment, are much more likely to report severe disabilities.

**Place of Residence**

The residential location of Americans age 65 and older is mainly in the metropolitan area. More than three-quarters (77%) of the population age 65 and older live in metropolitan areas. However the largest group, 50% lives in the suburbs and the remainder is split between central cities 27% and non-metropolitan areas. (23%) One half of the population age 65 and older currently lives in suburbs and 23% in non-metropolitan areas. This distribution of residential locations means that three-quarters of the older people live in the low-density settings. A low-density lifestyle makes the need to drive and to continue to drive more critical.

The trip making and travel rate of Americans age 65 and older continues to increase. In 1995 they made 9.4% of all daily trips in the United States, an increase from 7.8% in 1990 and 7.2%

[1] Instrumental Activities of Daily Living (IADL's): Activities pertaining to daily living needs such as shopping, using the telephone, cooking, housekeeping and taking medications. Source: (http://www.arizonacaregivers.org/features_glossary.html)

[2] Activities of daily living (ADL's) refer to an individual's daily routine of bathing, eating, dressing, grooming, toileting, ambulating, and other similar tasks. (http://www.seniorres.com/common_pages/glossary.html).

in 1983. In 1995 they accounted for 7.5% of miles traveled, an increase from 6.6% in 1990, and 5.6% in 1983 (Hu & Young, 1999). By 2030, Americans 65 and older are forecast to account for 18.9% of miles traveled, almost tripled the 1990 level (Burkhardt, Berger, Creedon, & McGavock, 2002).

There are variations in lifestyle between cohorts due to cohort differences in life experiences. Only 67% of women age 65 and older compared with 92% of men have a driver's license (Organization for Economic Co-operation and Development, 2001). As a result older women are disproportionately affected when their spouse ceases to drive. The proportion of women with driver licenses increases in each younger cohort (Barr, 2001).

## 4.0 Aging In Place

People tend to stay in their current setting, or "age in place," until they, and/or others, recognize that they are experiencing increasing difficulty performing their daily activities. In many cases driving cessation presents a barrier to aging in place. The current practice is to propose that the older person change his/her residence and move to a location that offers more support to perform these daily activities. Such moves can be disruptive, wrenching, costly, and usually occur when an individual is most vulnerable.

The residential location of older people who are no longer able to drive, and/or lose their mobility, could contribute to the level of social and economic costs they must bear. With a more diffuse residential pattern, there are longer distances to social, recreational, and commercial activities. Distance to, and from, social, recreational, and commercial activities translates into resource and time costs to mobility providers and society. It becomes more costly to provide substitutes to individuals with mobility deficits. Conversely, when individuals with mobility deficits are in closer proximity to activities necessary for maintaining quality of life, it is more economical to provide these activities.

It can be extrapolated that there may be local, regional, and national economic effects if older adults reduce, or cease, their consumption of goods and service after losing their mobility. Goods and services brought to individuals become more costly as the distances to their residences increase. The growing trend for businesses to offer home delivery of goods and services will face the challenge of providing their products at an affordable price.

An alternative to the home delivery of services is to augment the domestic setting to compensate for decreased competence in performing the activities of daily living. To the extent this is possible, more aging in place could occur. Mynatt, Essa, et al. (2000) suggest that an augmented environment using computers, capable of recognizing potential crises and offering remedial measures, could enhance dwelling units to provide older residents more support. They propose installing sensors to monitor the older person's condition in case other parties need to be alerted. The alerts should be appropriate and effective for an older person. This alternative, adapting the residence rather than uprooting an older person, addresses the safety and comfort but does not substitute for needed mobility outside the home.

## 5.0 Proposed Relationships: Aging, Driving Cessation, and Health

Hu, Lu, and Trumble (Hu et al., 1997) examined the relationship among safety, driving cessation, and age to determine:

- How functional limitations influence older drivers decisions to cease driving
- Whether drivers with age related limitations pose a risk to themselves or the public, and
- Which limitations place older drivers at unacceptable risk.

They used data from the *Iowa 65+ Rural Health Study* for the years 1981-1993 and they found that:

- Age influences driving cessation decisions in both males and females, but is more determinative for females.
- Older females were more likely to stop driving than their male counterparts.
- Five chronic conditions were explicitly associated with voluntary cessation decisions:
    - Arthritis,
    - Parkinson's disease,
    - Cataracts,
    - Stroke(s), and
    - Heart attack.

However none of the chronic medical conditions listed above were associated with higher vehicle crash rates. The only medical condition associated with increased crash risk was glaucoma and this association was most pronounced for older men. However, for older men the amount of driving exposure and the use of anti depressants were the most influential risk factors. The authors commented that, due to data limitations, conclusions on the influence of drug use on crash rates for older drivers should be examined in future studies.

They report that functional limitations, rather than the diagnosis of a condition, influenced the cessation. Driving cessation was more likely to be governed by incapacitation due to a physical manifestation of a condition than by the diagnosis of the presence of a syndrome or condition. They also report the following:

- Driving cessation is often not a single event but is episodic. Episodic cessation occurs when the appearance of a physical symptom causes a person to stop driving; when the symptom is alleviated, driving is resumed.
- The decision to cease and resume driving is often caused by life requirements (e.g. place of residence, employment, place chosen for retirement) rather than choice.
- Males tend to postpone cessation longer than women.

Robin Barr of the National Institute on Aging examined the interrelationships between declining health and driving cessation (Barr, 2001). His paper raises the following questions:

- Are the social and economic conditions of the United States generating a new public health problem that results from the consequences of driving cessation?

- Should driving be considered an ADL? If so does driving cessation result in the negative health effects similar to those associated with the inability to perform the ADLs and IADLs?
- Can we consider loss of the ability to drive a disability?

Barr notes that, to answer these questions, we must determine if driving cessation should be considered a disability or the loss of an important resource.

Barr offered two hypotheses:

- "If driving is …[an] internal resource then it is possible to replace that resource with alternative forms of transportation. The alternative services may also reduce the risk of a crash that injures or kills the affected older adult … [resulting in] a net reduction in health risk."
- "If driving is itself part of independence then … [driving cessation is the] same as the loss of other abilities … [Driving is] critical to independence. The loss represents part of a cascade towards increasing dependence and death."

Based on a review of the literature, Barr concluded that driving cessation can be considered a disability in itself because of the broad range of effects on the former driver. This is particularly true when the individual's residence location doesn't provide other transportation alternatives. He also commented that an individual's decision to cease driving is a trade-off that has profound consequences for many areas of life and is embedded in other life choices.

Mechanisms have been proposed that might relate changes in driving to mental well-being. There is evidence that driving reduction and cessation among older adults leads to depressive symptoms. With regard to the health effects of driving cessation on older Americans, Marottoli (Marottoli et al., 1997) analyzed the statistical relationship between driving cessation and the incidence of depressive symptoms. They found that driving cessation was associated with an increased incidence of depressive symptoms. This relationship was empirically supported after adjusting for the potentially confounding influence of social, demographic and health related factors.

The subjects in this study (Marottoli et al., 1997) were selected from a probability sample of non-institutionalized adults age 65 and older in New Haven, Connecticut called the New Haven Established Populations for Epidemiological Studies of the Elderly (EPESE) cohort. Using three waves of data collection, this study measured the incidence of depressive symptoms among three groups of subjects, i.e., subjects who continued to drive during the seven-year duration of the study, those who stopped driving during this interval, and subjects who stopped driving prior to measurement or who had never driven. The results show that subjects who ceased driving during the study's duration reported the highest level of most depressive symptoms. Depressive symptoms were measured using the Center for Epidemiological Studies-Depression (CES-D) Scale.[3] This research builds on prior research that reported that that depression and depressive

[3] The Center for Epidemiological Studies-Depression Scale (CES-D) is a 20-item scale for epidemiological research that was developed by The National Institute of Mental Health. Respondents are asked to choose from four possible

symptoms are associated with disability and mortality.

Fonda, Wallace, and Herzog (Fonda et al., 2001) conducted research to investigate whether driving cessation or driving reduction increased the likelihood of depressive symptoms and whether such consequences were lessened by the presence of a spouse that continued to drive. Using the Asset and Health Dynamics Among the Oldest Old (AHEAD) national database, they evaluated the potential relationships among driving reduction, driving cessation, and depression. This national database is longitudinal in nature and follows non-institutionalized Americans born in 1923 or earlier and their spouses (if born in 1923 or earlier). At the time of the study individuals born in 1923 would have been 70 years old. The prime dependent variable was an increase in depressive symptoms as measured on the CES-D Scale (Hohout, Berkman, Evans, & Cornoni-Huntley, 1993).

Based on the results of their work, they reached the following conclusions:

- People who stopped driving were at greater risk for depression than those that didn't stop driving.
- People who stopped driving were at greater risk for depression than those who restricted their driving.
- People who restricted their driving distances were not initially at greater risk for depressive symptoms as those that continued their normal driving practices, but people who had maintained these restrictions for more than two years prior were at greater risk for depression than those who had not restricted their driving.
- People who ceased driving but had spouses that continued to drive were at greater risk of depression than those who continued to drive.
- People with access to auto transportation through other drivers were at lesser risk for depression than those without access.

Fonda et. al. interpreted these seminal results to mean that driving is a "self defining" activity. The cessation of driving was a "sentinel" event associated with: a loss of autonomy resulting from a reduced ability to accomplish both required and recreational activities; the stigma associated with dependency, and the approach of the end of life. They feel driving cessation can be considered a clear sign of a transition representing a decline in physical and mental capabilities leading to an inexorable dependence on others, a loss of personal freedom, and death.

The loss of autonomy may be evident in the relationship between trip type and the availability of transportation from voluntary providers. They noted that individuals who relied on other drivers found it much easier to ask for, and get, support for mandatory trips such as doctors visits and much harder to ask for, and get, support for elective trips such as social visits. They also noted that the failure of transportation provided by a spouse to mitigate the impact of driving cessation calls into question the usefulness of transportation programs that are mainly focused on older persons maintaining their well being.

responses in a Likert format, where "0" is "rarely or none of the time (less than 1 day)", and "4" is "almost or all of the time (5-7 days)". Scores range from 0 to 60 with higher scores reflecting greater levels of depressive symptoms while lower scores reflect lower levels of symptoms. The CES-D has 4 separate factors: Depressive affect, somatic symptoms, positive affect, and interpersonal relations.

Driving cessation resulting from loss of driving privileges is a concomitant of Alzheimer's disease and related dementias. Cessation resulting from these causes was studied by Taylor and Tripodes (Taylor & Tripodes, 2001) using data from approximately 900 California residents. They note that loss of mobility in such cases is a particular problem. Substitute transportation providers are almost always limited to family members due the custodial requirements associated with such conditions. Such individuals become almost totally dependent on their household for mobility and support. They rarely use public transit or transportation services. These family caregivers are not only inconvenienced in a social sense, they may have strongly reduced opportunities to work or have to give up work entirely. It is estimated that 10% of individuals 65 or older have or will develop these problems (National Academy on an Aging Society, 2000).

These studies suggest that driving cessation has a major impact on older people. They may be less able to manage their "out of home" mobility as well as their overall health. Clearly there is a need for better understanding of the cost of this transition and new stage of life.

## 6.0 A Methodology for Estimating Social and Economic Costs of Driving and Mobility Cessation

The literature on the relationship between aging and mobility lacks a methodology for estimating the many components of the costs resulting from reducing or stopping driving for age-related reasons. There is a need for such a methodology that would account for the consequences of inadequate transportation alternatives, reducing or losing external mobility, and social interaction.

Older drivers experience the cost of driving cessation in a number of ways. For example, they may have to pay for goods and service delivery, find ways to substitute for inaccessible preferred goods and services, or go without some goods and services. Additionally, the lack of mobility -- and the loss of its benefits -- may accelerate the aging process and/or bring on physical, medical, emotional conditions that require care. This too has its costs.

Other people also bear the costs, e.g., voluntary caregivers, the community, and society. Volunteer caregivers incur out-of-pocket costs for expenses, such as gasoline, and opportunity costs for time not working while providing care giving, or the loss of employment. (Taylor & Tripodes, 2001) found that 13% of family caregivers to individuals with age related dementia gave up work entirely.[4] The community in which the older driver resides may lose the value of the work or the social activity previously pursued. The local economy may experience a reduction in demand associated with shopping. The community and the society may have to provide ways for older persons to access necessary services, particularly but not limited to medical care.

[4] This estimate has been found on other studies. For example, the National Alliance for Caregiving and Alzheimer's Association, 1999, reported in (Tennstedt) that up to 11% of the non-dementia caregivers and up to 13% of the dementia caregivers reported a change in employment associated with caregiving.

Driving reduction and cessation may have some benefits. Older people are at higher risk both to be involved and injured in a motor-vehicle crash. Any reduction and/or cessation lowers the number of crashes and resulting trauma, and potential permanent loss of functionality.

The core issue that needs to be addressed is what does it cost to family and society if there are no supplementary and substitute transportation services available to an older population as they need them. The likely costs, due to deficient transportation substitutes, will accrue to the society as well as the older person. Policy makers need to recognize all the costs involved and upon whom the cost burden is likely to fall when older people reduce or cease driving without mobility substitutes. The costs range from direct, out-of-pocket costs to opportunity costs and indirect costs.

There is a need for information to identify the costs and who will bear the burden of the cost of mobility substitutes. The elements needed to understand the cost impacts of driving cessation on health and health care include:

- The reasons for driving cessation.
- How financial, social, and other resources impact mobility choices.
- What mobility options are realistically available given potential residential arrangements.
- Expectations for current and future cohort groups.

Any effort to estimate the costs and health effects of driving cessation must recognize that they embody a complex set of variables that reflects a range of circumstances and living arrangements as broad as in any human activity. How to reduce these variables to a manageable set for which data exists represents a formidable problem. Matrix 1 represents an "n-dimensional" array of ways an older individual may fulfill his or her transportation requirements.

It illustrates the intersection of health, social structure, and income variables generally, but it in itself is a substantial simplification. For some of the cells represented, modifications would be made to match the data that is or could be made available. For purposes here, however, they must initially be folded into an even more limited set to get to a manageable exposition. This trade-off is reflected in the simplifying *prototypes* discussed below.

To quantify the interrelationships, it is necessary to answer the following questions:

- What are the best sources of data that combine age-related heath status, mobility, and health care costs?
- How do we evaluate the relationships among driving cessation, reduced mobility, health status, and health care costs?
- How do we evaluate the economic impacts of non-mobility to the individual, family, community, and society?

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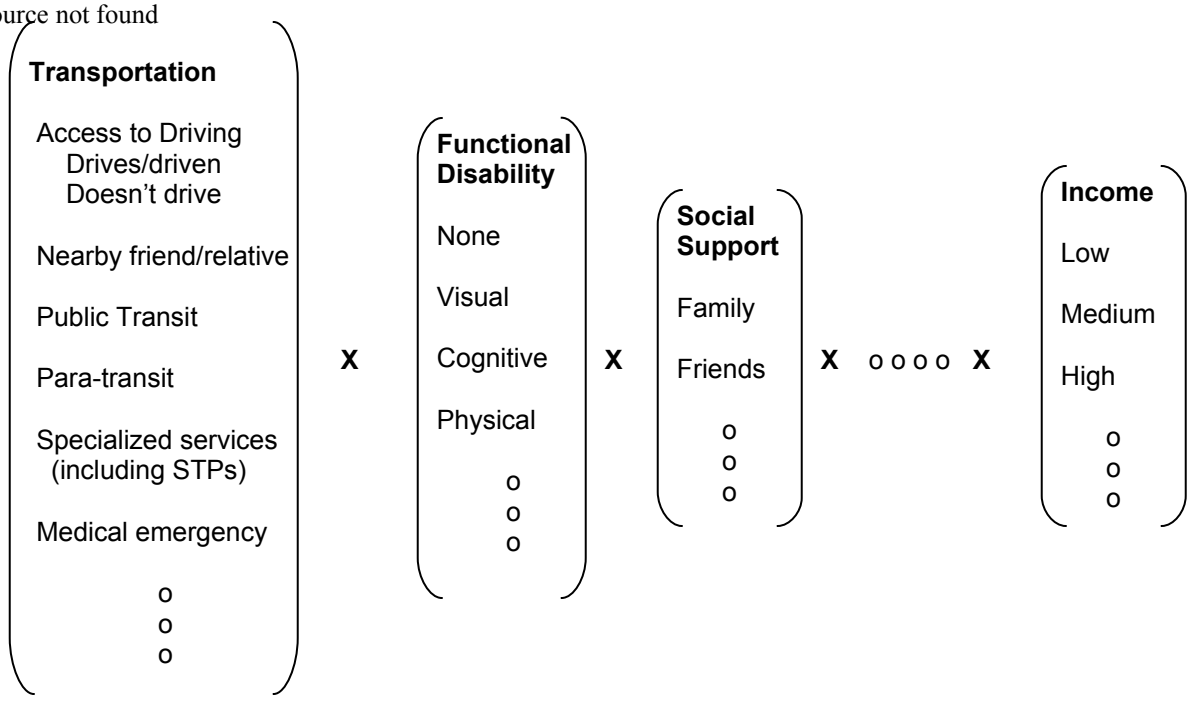


**Matrix 1. Sample variables to be considered covering ways an older individual may fulfill his or her transportation requirements**

Given the information identified above, it is possible to specify steps to estimate the full economic costs -- direct, opportunity, and indirect -- of driving cessation and mobility loss. To begin this procedure, the analysis will make assumptions about the level of mobility possessed by older Americans by age category. These assumptions will be corrected as more data becomes available about the health status of older Americans and the differential effects of cohort experiences bring changes in older Americans, both in terms of health status and financial resources. The following steps describe a methodology to quantify the relationship between driving cessation and aging, health status, and costs.

**Step 1: Define the temporal course of driving cessation**

Although the rate of driving and mobility cessation among older persons is complex, three time sequences are assumed for the purposes of estimating costs:

- **Gradual:** as through the general aging process, limiting first driving at nighttime, on interstate highways, congested roads, etc.
- **Episodic:** as by limiting driving for a while as from a medical condition then resuming.
- **Permanent:** as from debilitating medical condition or the later stages of dementia.

These sequences express how individuals might reduce their driving. However loss of driving requires finding mobility substitutions or doing without. The percentage of Americans falling into each category must be established. Data on ADLs and IADLs are a helpful source.

**Step 2: Identify substitutions for driving cessation**

Older people experience different amounts of mobility as their capabilities and resources change over time. This memorandum proposes five levels of mobility. When a person cannot provide their desired level of mobility, they need a substitute form of mobility. The following five prototypes are postulated as follows:

- **Prototype 1.** This prototype refers to the ability to maintain established mobility patterns. It is "base case" mobility or a static condition**.** Here the person continues to drive, or never drove and has established mobility substitutes available, e.g., public transportation, spouse, friends. Note, at any point in time and for any age cohort, there will be a segment of older people who continue to drive or have mobility provided to them.

- **Prototype 2:** The person lives in his or her own residence. Family, friends, or other voluntary caregivers supply mobility for essential trips, e.g., medical appointments, and limited mobility for social/recreational trips. Voluntary caregivers also may shop for individual. In this prototype the individual receives all needed mobility.

- **Prototype 3** The person lives in his or her own residence and purchases or receives mobility from external outside sources, i.e., from professional providers (such as taxis) or public agencies for essential trips, but not, to any extent, for social and recreational trips. Goods and services are delivered to the home (presumably at a premium.) This prototype requires an estimate of the costs associated with purchased transportation such as taxi and paratransit usage.

- **Prototype 4:** The person lives in his or her own residence but does not have access to voluntary mobility provider to supply mobility and is not able to purchase or acquire mobility beyond that required for emergency medical needs. This mobility state is transient.

- **Prototype 5:** The person enters residential facility, either assisted living or skilled care, and substitutes for mobility are provided at various levels.[5]

**Step 3: Estimate the Magnitude of the Population by Prototype**

After classifying prototypes conveying varying amounts of external mobility, for people age 65 or older, it is necessary to estimate the proportion of the older population that falls into each prototype. Table 1.0 distributes the age 65 and older population in 1995 using a number of sources to estimate the size of each category. This stratification serves as a first estimate that

[5] This prototype requires an estimate of the proportion of people in assisted living who drive their own vehicles and who have mobility provided by family and friends.

should be further refined. The HRS/AHEAD (University of Michigan, 2003) data, representing a national sample, will provide a better estimate of the joint distribution of functional capability and living arrangements of the 65 and older population. These distributions are the basis of the five Prototypes. In Table 1, Prototype 5, 'a person enters a residential facility', has been partitioned into 'assisted living' and 'skilled care' because the costs differ.

Because the number of older people will increase with improvements in health care and population changes such as the results of the "baby boom," the numbers in these boxes will differ over time. Similarly, due to the increasing number of women driving in the younger age cohorts, the percent of older people in each of the three driving status boxes will also change. Obviously, the number of women 'not a driver' will decline. So, depending whether current costs of lack of mobility are to be estimated, or future costs, the population information used needs to coincide.

**Table 1. Estimates of Population Age 65 and Older, by Mobility Prototype, by Help Required**

| | | **"Base Case" Prototype 1** | **Prototype 2** | **Prototype 3** | **Prototype 4** | **Prototype 5** | |
|---|---|---|---|---|---|---|---|
| | Total | Home | Home | Home | Home | 5a. Assisted Living | 5 b. Skilled Facility |
| **Transportation Help Required** | | None | Limited | Complete | Complete | Complete | N/A |
| **Receives Transportation Help** | | no | yes | Yes | no | Yes | N/A |
| **Est. Percentage** | 100% | 72 | 18 | 2 | 2.3 | 1.4 | 4.5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Est. Population** | 35,000,000[6] | 25,270,000[7] | 6,294,000[8] | 546,000[9] | 805,000[10] | 500,000[11] | 1,575,000[12] |

**Step 4: Identify Costs for Each Prototype**

It is important to identify and estimate the full costs brought about by an older person who reduces, or stops altogether, driving for age-related reasons. There are at least four considerations in producing this estimate.

- Type of cost. Costs include direct 'out-of-pocket' costs as well as opportunity costs. For example, opportunity costs occur when a volunteer caregiver foregoes employment earnings for the time spent in volunteer caregiving. There is another category of cost due to loss of social interaction from reduced or loss of mobility outside the home. There is evidence that diminished social interaction and social support can lead to an increased likelihood of depression. In turn, depression has somatic consequences because depression has a physiological effect on the hypothalamic-pituitary-adrenal axis in the body (Thakore, 2001). This is the physiological link to the immune system, which makes people more prone to illness.

- Allocation of cost. In Table 2, these costs can be placed on persons, enterprises, community, and society. Other classifications are possible. It may be helpful to break out the medical cost component of community and social costs.

- A third consideration is the time span during which costs appear whether short or long. For example, if an older person pays to have goods and services brought to them, the premium paid is a short run cost. A long run cost occurs if an older person loses mobility without effective substitution and subsequently experiences a more rapid decline in health.

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[6] In 2000 there were an estimated 35 million people in the United States age 65 or older. (Older Americans 2000: Key Indicators of Well-Being, 2000)

[7] From the population age 65 and older in 2000, 35 million, Prototype 1 is estimated using the proportion of people age 65 and older reporting excellent health in 1996, 72.2%. (Older Americans 2000: Key Indicators of Well-Being, 2000)

[8] The estimate for the total size of Prototypes 2-4 is extrapolated to be 7 million based on the percentage of the age 65 and older population in 1990 defined as functionally dependent. (Hing & Bloom, 1990; Hobbs & Damon, 1996; Older Americans 2000: Key Indicators of Well-Being, 2000)

[9] This proportion is based on the percentage of Medicare beneficiaries who reported only receiving formal care. (Older Americans 2000: Key Indicators of Well-Being, 2000)

[10] The estimate of the proportion of the age 65 and older population with no way to obtain care is based on the "percent reporting difficulty obtaining care" in the Medicare Current Beneficiary Survey as reported in (Older Americans 2000: Key Indicators of Well-Being, 2000) This estimate may be low. (National Center for Health Statistics, 1999) reports that 1.4 million people age 70 and older, contacted between 1994 and 1996, reported that they had "unmet needs" related to ADL's and IADL's.

[11] Is assisted living the right choice? Consumers Reports, Feature Report January 2001 Http://www.consumerreports.org/main

[12] In 1997 the nursing home residence rate for people age 65 and over was 45 per 1,000. (Older Americans 2000: Key Indicators of Well-Being, 2000)

- A final consideration is whether costs are net of benefits that might accrue from an older person *not* driving. For example, if an older person who drives is at a *high* risk of a crash due to age-related deficits, then, by not driving, there is an expected benefit to the person and to the community and society.

To the extent these four considerations can be addressed, the better the estimation of the true, full costs of mobility loss for age-related reasons.

**Table 2: Matrix of Mobility Prototypes by Costs**

| COSTS | Mobility Prototypes | | | |
|---|---|---|---|---|
| | (2) | (3) | (4) | (5a,b) |
| | **Volunteers Provide Limited Mobility** | **Purchases Mobility From Professional Providers** | **No Mobility Provided** | **Residential Living/ Mobility Provided** |
| **Domicile** | Home | Home | Home | **Residential living** |
| **Costs to individual** | | | | |
| Cost of bringing goods/services to people | | | | |
| Lost income to person from not being able to work | | | | |
| Not able to engage in social/recreational activities. Possible loss in health status and onset of depressive symptoms | | | | |
| Cost of bringing goods and services to people | | | | |
| Costs to society of transporting persons to medical facilities | | | | |
| Loss of ability for self care | | | | |
| **Costs To Voluntary Mobility Provider** | | | | |
| Out of pocket costs to voluntary mobility providers | | | | |
| Lost income and work opportunities for voluntary providers | | | | |
| **Costs To Society From Older Persons' Lost Mobility** | | | | |
| Loss of older person's participation in economy. Impact on local, regional, and national economy | | | | |
| Necessity of providing appropriate public transportation | | | | |
| Impact on local, regional, and national social services and healthcare sectors | | | | |
| **Benefits, Societal, And Economic** | | | | |
| Avoidance of motor vehicle-related trauma costs | | | | |
| Growth of residential living industry | | | | |

## Step 5: Re-analyze Established Data Source to Extract Cost Information

It is necessary to examine a number of data sets to identify a source that contains enough variables and data to make it possible to estimate the costs of reduced and lost mobility. Based

on this review, it appears that the University of Michigan's Health and Retirement Study (HRS)/Assets and Health Dynamics Among the Oldest Old (AHEAD) dataset is the most promising source. These two data sets, combined in 1998, provide a national longitudinal sample documenting the experiences of more than 22,000 Americans over the age of 50. The subjects have been surveyed every two years since 1992, with the support of the National Institute on Aging.

There are a number of reasons for selecting HRS/AHEAD as a source:

- For the purposes of this study, it is comprehensive, having three important information elements: (1) driving and mobility status; (2) health status; and (3) income and consumption expenditures. The classification of costs depends considerably of each of these three elements.

- It is a demographically representative, national sample making it possible to extrapolate results to the national population.

- Being a sample, the precision of any estimate can be determined. This is an important consideration. Not only can the point estimate of a cost be determined but its confidence interval as well. It is also preferable to obtain as much information as possible from one source as possible, with known statistical properties to avoid estimates constructed from multiple sources.

Information about the HRS/AHEAD database:

- **Organizations:** Sponsored by NIA and other agencies and conducted by the University of Michigan.
- **Purpose:** Interplay of financial resources, retirement, and health.
- **Sample:** National, initially 12,600 people from 7,600 households; now 22,000 households.
- **Frequency:** 1992, 1994, 1996, 1998, 2000. Have applied for funding to conduct 3 additional waves of data collection.
- **Health:** ADLs, IADLs, cognitive information, physical ailments.
- **Transportation:** Driving reduction and cessation questions, as well whether spouse drives.
- **Comments:** 398 journal articles and other publications have used the HRS/AHEAD data. Data contains spending and other financial information.

**Access and Use of the HRS/AHEAD Data**

The structure of the AHEAD (which is part of the HRS project at Michigan) data is set up so it could be linked to access the Health Care Financing Administration (HCFA) data (Medicare and Medicaid expenditures recorded by the ICD9 diagnosis code.) The two data sets can be linked using the subject's Social Security number. The HCFA data reports the underlying condition that led to the need for medical care. If someone requires medical care due to an emergency such as an automobile crash, the information is entered as an ICD9 code. The HFCA data

records whether a person is being treated for an automobile crash and makes it possible to assign the cost of care due to a motor vehicle crash. It is also possible to link to spouse data.[13]

**Information to be obtained from the HRS/AHEAD database for each Prototype includes:**

**Prototype 1:** 'Base Case Prototype.' Person continues to drive or never drove and has established mobility substitutes, e.g., public transportation, spouse, friends. At any point in time and for any age cohort, there will be a segment of older people who continue to drive or have mobility provided to them. They include the older persons who drive as well as older persons who have never driven but have adequate mobility substitutes.

The spending patterns of the older persons in Prototype 1 who retain self-provided mobility serve as a benchmark against which to compare the spending patterns of the remaining categories of older persons who have lost their ability to provide their own mobility.

**Prototype 2:** Older person lives in own residence.[14] Family, friends, or other voluntary caregivers supply limited mobility for essential trips, e.g., medical appointments, and some social and recreational trips. Voluntary caregivers also may shop for individual. Although services may be provided, it is likely that older person experiences indirect costs associated with the emotional impact of driving cessation on health. These costs may be reflected in treatment of depression or other physical, emotional, and mental that can be linked to loss of mobility.

The voluntary caregivers, i.e., spouse/family/friends able to drive, for this segment of the older population incur direct costs. Some caregivers also incur opportunity costs in loss in earnings. It is estimated that between 11 and 13% of caregivers reduce or give up work to care for elder dependents (Tennstedt). The data on these costs may be able to be obtained from HRS/AHEAD as well as from experts on caregiving.

Analysis should be designed to show what the net cost is to society. There may be savings associated with the loss of mobility for older persons at high risk of causing a motor vehicle crash. This is to be balanced against the caregivers' opportunity costs and the older persons' incidence of physical and mental ailments associated with diminished self-mobility.

**Prototype 3:** An older person lives in his/her own residence and purchases mobility from professional providers for essential trips, has goods and services delivered, but lacks for social and recreational trips, often including shopping. It is necessary to estimate how many older people fall into this prototype where there are few or no family/friends that can provide voluntary mobility services as well as what they would purchase if they had mobility.

Any analysis should compare the estimated demands for goods and services for the people in this prototype with what they purchased, including any premium paid for such purchase. The premium would be a direct cost of loss of mobility. Additionally, the value of goods and services

[13] A special issue of the Journal of Gerontology, May 1987, describes the AHEAD data set.

[14] Provide data for household size for older people in Prototype 2 as well as number of people in household of driving age and whether the spouse drives.

foregone (particularly those related to recreational and social activities) may be an indication of the costs of loss of mobility. However, a person may substitute other goods and services for those ideally desired but foregone. Thus, there needs to be some adjustment made to the value of the desired but foregone purchases.

**Prototype 4:** Person lives in own residence but does not have access to voluntary mobility providers to supply mobility and is not able to purchase, or acquire, mobility except for emergency health related trips. This mobility state is transient.

**Prototype 5:** Person in residential facility that provides mobility substitutes. Because facility costs vary, it is desirable to partition those costs for both assisted-living and skilled-care facilities

**Conclusion**

There is no systematic process for the estimation of the many costs that accrue from age-related driving cessation. This memorandum describes a methodology that could be implemented to produce such estimates. These would be valuable input to local, state, and national policies on age-related issues. The methodology proposed can provide a quantifiable link between mobility and health care costs for the more than 35,000,000 older Americans and their families in our population.

One of the key steps will be to establish the various proportions of persons 65 and older that have similar attributes (age defined cohort), and, hence, similar needs relative to mobility. Another important step will be to establish the relationship between driving status, mobility alternatives, and health. For example, an expanding body of research indicates that no longer being able to operate a motor vehicle brings on depressive symptoms, even in the presence of other mobility alternatives. However, objective evidence of other mental, emotional, and physical impairments in addition to depression that are due to licensing and/or mobility shortcomings still must be established.

The methodology must be populated with data. The HRS/AHEAD data, a national sample of persons 65 and older, is arguably the best single source for the types of information needed: licensing, mobility options, health status, and spending patterns. There are other data sets that may supply additional data to estimate the full costs of loss of mobility. These data sets are described below in the Appendix.

We expect that many of the cohorts about to enter the US aging pool will be healthier and wealthier, possess near universal licensing, and have transportation alternatives. There are also likely to be groups with poor health, limited financial resources, and limited mobility. The social, health and lifestyle characteristics of successive cohorts turning age 65 can only be predicted imperfectly but we can be sure that they will continue to change.

This memorandum has identified the scope of the issue, i.e., what are the health and cost consequences of driving cessation among elderly, and outlined a methodology to address it. While the Department of Transportation initially recognized this issue, it will be necessary to seek the involvement of other federal agencies to address the issue effectively. It is likely that the

anticipated results will have consequences for the missions of a number of federal agencies. For example, the Administration on Aging (AOA), the National Institute of Aging (NIA), and the Centers for Disease Control (CDC) may have relevant data as well as an interest in the results of analysis of this issue. This issue has consequences also for advocacy groups and private sources concerned with transportation safety and the national health such as the Transportation Research Board (TRB) and the American Association of Retired People (AARP).

The proposed methodology will provide the tools needed to understand, plan for, and address these changes at the national, local, and individual level. Due to the need to use multiple sources of data and the complexity of the research recommended by this methodology, there is a need to create a consortium of parties to address this issue and produce significant results. It is apparent that the next step in the process of implementing this methodology is to establish cooperation with interested parties in addition to the DOT.

## Appendix

The following are the key data sets reviewed for this memorandum:

HRS/AHEAD
Seattle Longitudinal Study
National Household Travel Survey (formerly NPTS)
National Health Interview Survey, 1994
Rehabilitation Engineering Research Center (RERC) on Aging, University of Buffalo, the State University of New York.

Their key characteristics are described below.

**HRS/AHEAD**

- **Organizations:** Sponsored by NIA and other agencies and conducted by the University of Michigan.
- **Purpose:** Interplay of financial resources, retirement, and health.
- **Sample:** National, initially 12,600 people from 7,600 households; now 22,000 households.
- **Frequency:** 1992, 1994, 1996, 1998, 2000. Have applied for funding to conduct 3 additional waves of data collection.
- **Health:** ADLs, IADLs, cognitive information, physical ailments.
- **Transportation:** Driving reduction and cessation questions, as well as whether spouse drives.
- 398 journal articles and other publications have used the HRS/AHEAD data. Data contains spending and other financial information.

**Seattle Longitudinal Study:**

- **Organizations:** Penn State and University of Washington.
- **Purpose:** Determine how people age and mechanisms for dealing with aging.
- **Sample:** Originally 4,957 Seattle, WA, residents.
- **Frequency:** Every 7 years.
- **Health:** ADLs, IADLs, cognitive information.
- **Transportation:** Can study subject manage transportation outside the home by self or does she/he need assistance?
- **Comments:** Limited transportation information. Would have to infer from health status all other transportation information.

**National Household Travel Survey: 2003**

- **Organizations:** U.S. Department of Transportation, Westat
- **Purpose:** Determine characteristics of trip taking.
- **Sample:** National sample of 25,000 households but not specific to older persons.
- **Frequency:** Every 5 years.
- **Health:** Asks if a person has a health condition that reduces mobility.
- **Transportation:** Driving status, number of drivers in household, and trip taking.

- **Comments:** Limited health information.

**National Health Interview Survey, 1994 Second Supplement on Aging**:

- **Organizations:** CDC, National Center for Chronic Disease Prevention and Health Promotion.
- **Purpose:** Determine if there had been changes in disability among older persons since first SOA have changed.
- **Sample:** National, cohort 70 years and older.
- **Frequency:** 1984, 1994.
- **Health:** Cognitive and depression, extensive physical health, activity levels.
- **Transportation questions:** Frequency of driving, health impairment for not driving, use of public transportation, level of social activity.
- **Comments:** Could determine how aging cohorts (1984 vs.1994) are changing.

**Rehabilitation Engineering Research Center (RERC) on Aging**

- **Organizations:** University of Buffalo, the State University of New York. http://cat.buffalo.edu/rerc-aging/rerca-research.php
- **Purpose:** Consumer Assessments Study (CAS) has explored the functional needs of older persons living *in the home* relative to assisting technology and home modifications. Findings have been translated into new device development, policy changes, dissemination activities, and education programs.
- **Sample:** 300 home-based older persons and close to 100 persons living in nursing homes.
- **Frequency:** Longitudinal, 1996-2001
- **Health:** Information for each participant, including use of assisting devices and difficulties with functional tasks.
- **Transportation:** Focus on identifying assisting technologies for maintaining personal mobility within and outside residence
- **Comments:** Collected longitudinal data about problems of older persons living independently as well as problems faced by those who move to nursing homes and adult residences. Initiated in Western New York and replicated in Florida.

## References