Driving Life Expectancy of Persons Aged 70 Years and Older in the United States

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Objectives. We estimated total life expectancy and driving life expectancy of US drivers aged 70 years and older.

Methods. Life table methods were applied to 4699 elderly persons who were driving in 1993 and reassessed in a 1995 survey.

Results. Drivers aged 70 to 74 years had a driving life expectancy of approximately 11 years. A higher risk of mortality among men as a cause of driving cessation offset a higher risk of driving cessation not related to mortality among women that resulted in similar driving life expectancies.

Conclusions. Nationwide, many elderly drivers quit driving each year and must seek alternative sources of transportation. Because of differences in life expectancy, women require more years of support for transportation, on average, than men after age 70. (*Am J Public Health.* 2002;92:1284–1289)

The health and longevity of the elderly population in the United States are at unprecedented levels, and many older persons continue to drive throughout their eighth and ninth decades of life.[1,2] Both the aging of the post–World War II "baby boom" generation and an increasing proportion of women who drive among those turning 65 years old will contribute to a rapidly growing number of older drivers in the US population in the years ahead. In addition, driving exposure in the elderly population is at an all-time high. Male drivers aged 65 years and older average about 10 000 miles of driving per year, an increase of 74% over the last 3 decades. In contrast, elderly female drivers average 5000 miles per year, a 31% increase in driving exposure over the same period.[3]

Compared with middle-aged drivers, older drivers have about a 3-fold increased risk of crashing per mile driven. However, older persons drive markedly fewer miles annually than middle-aged drivers, resulting in an equivalent annualized risk for crashing.[4] Consequently, older drivers, on average, have little increase in their annual cost of automobile insurance during their transition from middle age. In contrast, teenaged drivers, on average, have a very high risk of crashing on an annual basis, regardless of miles driven, and pay much higher premiums for their automobile insurance. The greater threat to an older driver is the risk of fatality from an automobile crash. Although the annual risk of crashing remains fairly stable over the years of driving, the risk of dying after involvement in an automobile crash increases significantly with age. Compared with middle-aged drivers of the same sex and involved in the same severity of crash, older drivers are 3 times more likely to die as a result of the crash.[5] Nearly 5000 drivers aged 70 years and older were involved in fatal crashes in 1999, a 42% increase in the number over the preceding decade.[6] This trend for an increasing number of elderly driver fatalities is expected to continue as long as the proportion of all drivers who are aged 70 years and older continues the rise observed over the past few years—for example, from 8% in 1989 to 9% in 1999.

In general, older drivers decide for themselves when to quit, a decision that often stems from the onset and progression of medical conditions that affect visual, physical, and cognitive functioning and consequently driving skill.[7–10] In addition, studies show that cessation is not an easy decision and may have consequences such as depressed mood and less social engagement due to loss of mobility.[11,12] The role of health professionals in assisting with this decision continues to be discussed, as does the role of state policies for license renewal.[13,14] Of paramount concern to the older driver who is pondering cessation is the availability and cost of alternative sources of transportation.[15] Such sources may include formal services such as public transportation systems, taxis, and community-sponsored or church-sponsored van services. More informal support typically comes from family and friends who live nearby and can drive.

Few epidemiological studies have addressed the implications of this transition to dependency on others for transportation among elderly drivers in the context of public health planning and provision of services. We used data from a longitudinal study of aging in a nationally representative sample of older adults to estimate both total life expectancy and driving life expectancy, which can be used to project the number of years of life, on average, in which older persons will be dependent on alternative sources of transportation. In addition, we estimated the number of elderly persons nationwide who do not drive and the number who quit driving each year, and we assessed the effect of visual, physical, and cognitive impairments on their risk for driving cessation.

METHODS

Data are from the first and second waves of interviews in the Asset and Health Dynamics Among the Oldest Old study conducted in 1993 and 1995, respectively. This study was designed to assess health, socioeconomic changes, and other transitions in a nationally representative sample of community-dwelling men and women aged 70 years and older in the continental United States and has been described elsewhere.[16] Briefly, respondents for the Asset and Health Dynamics Among the Oldest Old study came from a sample of households selected with a complex, multistage area probability design that included oversampling of Blacks, Hispanics, and Florida residents. Population estimates from the

Assets and Health Dynamics Among the Oldest Old study were based on sampling weights that compensated for the differential probabilities of selection and for the differential response rates among groups and were poststratified to known population totals provided by the US Bureau of the Census by age, race, ethnicity, and marital status.

Interviews were conducted with the age-eligible household head and that respondent's spouse or partner. A few spouses were younger than 70 years and were excluded from the analyses. Persons younger than 80 years in the Asset and Health Dynamics Among the Oldest Old study were interviewed preferably by telephone, and those aged 80 years and older were interviewed preferably in person. About 10% of the interviews were conducted with a proxy for the eligible participant, and about 70% were completed in the preferred mode. On average, the baseline interview lasted approximately 1 hour and covered 10 subject areas, including demographics, health, cognition, family structure, use and cost of health services, job status, income, net worth, subjective expectations of assets and health, and insurance coverage. A total of 8222 persons participated in the 1993 baseline interview for the Asset and Health Dynamics Among the Oldest Old study (80% of the eligible sample), and 7447 were aged 70 years or older.

At baseline, participants were asked whether they were able to drive and whether they had a car available to use when they needed one. Those who were 70 years of age or older and were able to drive and had a car available (n=4699) were included in the follow-up analysis of mortality (n=338) and driving cessation (n=387). About 5% of the drivers survived but refused to participate in the follow-up survey or were unable to be located in follow-up (n=238). Weights for driving time over the follow-up interval were assigned on the basis of the respondent's outcome and in accordance with standard life table methods: persons who quit driving over the 2-year interval were assigned 1.0 year of driving, persons who died between waves were assumed to have survived 1 year and driven 0.5 years, and those who refused to participate or could not be located were assigned 1.85 years of driving, the average for the cohort (including 2.0 years for those who were still driving at follow-up).

In addition to their baseline age group (70–74, 75–79, 80–84, and 85 years or older) and sex, drivers were classified according to whether they had poor vision, limitations in activities of daily living (ADLs), memory impairment, or depressed mood. Poor vision was based on a self- or proxy report of having fair or poor vision status. Persons who reported having difficulty in any of 6 tasks (walking, dressing, eating, bathing, toileting, or getting into or out of bed) or who were unable to do any of the tasks were categorized as having an ADL limitation.[17] Persons who could not recall 3 or more words after a 5-minute delay in a free recall of 10 short and concrete words were classified as having poor memory. Those participating by proxy were classified as having poor memory if the proxy reported that the subject had a poor memory status.[18] Persons with depressed mood included those with a score of 3 or greater on an 8-item abbreviated version of the 20-item Center for Epidemiological Studies Depression Scale.[19,20] A variable indicating "proxy participation" was used to represent the proxy respondents when no Center for Epidemiological Studies Depression Scale score was available.

Statistical Methods

In the analyses, weighted data with standard errors of the estimates were used to adjust for the complexities of the sample design. Estimates of population percentages and totals were obtained from the software package SUDAAN, which provides appropriate estimates of the standard errors of those statistics with a Taylor series approximation.[21] Similarly, SUDAAN was used for fitting multiple logistic regression models of driving cessation that also properly accounted for the sample design with weighted data.

Standard current abridged life tables were computed on the basis of weighted estimates of survival probabilities, resulting in appropriately adjusted estimates of life expectancy and driving life expectancy.[22,23] Because SUDAAN does not provide a procedure for estimating standard errors of life table functions, the standard errors of the life expectancy estimates were calculated with a statistical method (i.e., a jackknife estimator) that properly accounted for the sample design.[24] The accuracy of the jackknife estimator was successfully assessed by calculating standard errors of percentages that could be compared with estimates of the same characteristics obtained with SUDAAN.

RESULTS

In 1993, approximately 13.7 million persons aged 70 years or older were driving. This number represents about two thirds of the community-dwelling population of persons aged 70 years and older nationwide (Table 1). Overall, 82% of the men aged 70 years or older were driving, compared with only 55% of the women. As expected, the prevalence of driving declined sharply with increasing age, ranging from 88% of men in their early 70s to 55% of those aged 85 years or older. Among women, the prevalence of driving ranged from 70% among those aged 70 to 74 years of age to 22% among those aged 85 years or older.

Over the 2-year period of follow-up, approximately 7% of the 13.7 million drivers died, and another 9% survived but quit driving (Table 2). About 5% of the baseline cohort refused to participate in the follow-up study or could not be located at follow-up. In general, mortality and driving cessation rates increased among the older age groups, in contrast to the refusal and lost to follow-up rates, which did not vary significantly by age group or sex. Overall, the mortality rate among male drivers (89 deaths per 1000 drivers) was 62% higher than that among female drivers (55 deaths per 1000 drivers). In contrast, the driving cessation rate among female drivers (112 per 1000 drivers) was 78% higher than the rate among male drivers (63 per 1000 drivers). The offsetting risks for mortality and driving cessation between men and women resulted in an equivalent proportion who continued to drive after 2 years of follow-up, ranging from approximately 90% among those aged 70 to 74 years to about 60% among those aged 85 years and older (Figure 1). These 2-year transition rates indicate that each year, more than 600 000 persons aged 70 years and older nationwide stop driving and become

TABLE 1—Prevalence of Driving, by Age and Sex: Asset and Health Dynamics Among the Oldest Old (AHEAD) Study, 1993

	AHEAD Drivers (Sample Size)	Estimated No. of Drivers Nationwide, in 1000s	US Population Aged 70 and Older,[a] in 1000s	Prevalence of Driving in 1993, % (SE)
Both sexes	4699	13 661	21 028	65.0 (0.9)
Men 70 and older	2330	6519	7963	81.9 (0.7)
70–74	1017	2969	3372	88.0 (1.0)
75–79	683	2036	2431	84.4 (1.1)
80–84	443	1081	1385	78.1 (1.8)
≥85	187	433	793	54.6 (3.1)
Women 70 and older	2369	7142	13 065	54.7 (1.1)
70–74	1077	3288	4710	69.8 (1.2)
75–79	726	2196	3633	60.4 (2.1)
80–84	412	1212	2707	44.8 (1.7)
≥85	154	447	2015	22.2 (1.9)

[a]AHEAD weighted population of community-dwelling elderly persons aged 70 years and older.

TABLE 2—Follow-Up Status of Elderly Drivers: Asset and Health Dynamics Among the Oldest Old (AHEAD) Study, 1993–1995[a]

	AHEAD Sample Size	% Died (SE)	% Refused Follow-Up (SE)	% Stopped Driving (SE)
Both sexes	4699	7.1 (0.5)	4.9 (0.4)	8.9 (0.6)
Men 70 and older	2330	8.9 (0.6)	4.8 (0.5)	6.3 (0.6)
70–74	1017	4.8 (0.6)	4.1 (0.6)	2.9 (0.6)
75–79	683	10.4 (1.3)	5.0 (1.0)	6.2 (1.1)
80–84	443	14.1 (1.8)	5.8 (1.1)	11.2 (1.5)
≥85	187	16.7 (2.8)	6.3 (2.1)	21.9 (3.2)
Women 70 and older	2369	5.5 (0.6)	5.1 (0.5)	11.2 (0.9)
70–74	1077	3.2 (0.6)	5.6 (0.7)	5.9 (0.8)
75–79	726	7.2 (1.2)	4.5 (0.8)	11.0 (1.3)
80–84	412	5.9 (1.2)	5.0 (0.9)	19.3 (2.5)
≥85	154	12.7 (3.7)	4.5 (1.6)	31.7 (4.2)

[a]Estimates are based on weighted data.

dependent on others to meet their transportation needs, whereas another 400 000 of these older drivers will die within the year.

Use of these rates in a life table application showed that male drivers who were aged 70 to 74 years at baseline would have a total life expectancy of approximately 18 years and a driving life expectancy of about 11 years (Table 3, last column). In contrast, although the total life expectancy for women aged 70 to 74 years would be approximately 21 years, their driving life expectancy would be similar to men's, only 11 years. These findings suggest that, on average, male drivers aged 70 to 74 years will be dependent on alternative sources of transportation for approximately 7 years and that female drivers of the same age will be dependent on alternative sources of transportation for approximately 10 years. Among the oldest old drivers in this cohort (those aged 85 years and older), driving life expectancy was approximately 2 years, and this remaining period of driving covered about one-third of the total life expectancy for men and about one-fourth of the total life expectancy for women. Stratification of the drivers by standard metropolitan statistical area residence resulted in similar estimates of driving life expectancy.

Factors associated with driving cessation among those who survived the 2-year period of follow-up included older age, sex, and poor functional status (Table 4). Although women were 3 times more likely than men to quit driving, the single most important factor determining who quit driving was participation by proxy in the baseline survey. These drivers had a 10-fold increased risk of driving cessation compared with self-reporting drivers. In comparison with drivers reporting no vision, ADL, or memory problems or those reporting only 1 of these problems at baseline but not at follow-up (i.e., the reference group), drivers who reported 1 or more of these problems at follow-up but not at baseline (incident problems) had significantly higher odds ratios for driving cessation. Furthermore, drivers who reported these problems at both baseline and follow-up (chronic problems) had the highest odds ratios for no longer driving. In contrast, incident depressed mood was more strongly associated with driving cessation than was chronic depressed mood. This finding may reflect the possibility that persons who quit driving during the 2-year period of follow-up were more likely to report symptoms of depression at the time of their participation in the follow-up survey than were those who continued to drive.

DISCUSSION

Estimates from the baseline Asset and Health Dynamics Among the Oldest Old study showed that two thirds of the US population aged 70 years and older who had a car available were driving in 1993. This represents approximately 13.7 million drivers in 1993, reflecting about 82% of the men and about 55% of the women in that age group. The National Highway Traffic Safety Administration reported that in 1993, approximately 15.6 million persons aged 70 years and older were licensed to drive.[25] However, because most states' Department of Motor Vehicles require license renewal every 4 years,[13] a substantial number of these older persons may have quit driving despite still having a valid driver's license.

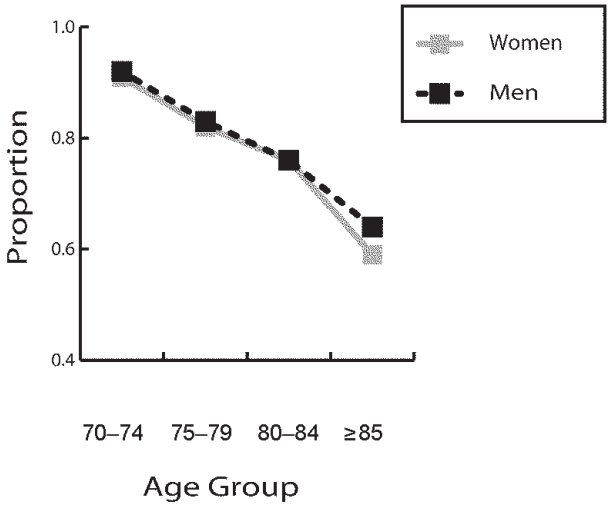

FIGURE 1—Proportion of drivers who survive and continue to drive after 2 years of follow-up: Asset and Health Dynamics Among the Oldest Old Study, 1993–1995.

TABLE 3—Total Life and Driving Life Expectancies of Drivers, by Age and Sex: Asset and Health Dynamics Among the Oldest Old Study, 1993–1995

Age Group, y	Mean Years[a]	${}_nq_x$[b]	l_x	d_x	L_x	e_x[c] (SE)
Men's total life expectancy						
70–74	1.00	0.0476	100 000	4757	488 109	17.7 (0.57)
75–79	1.00	0.1037	95 243	9878	451 522	13.5 (0.50)
80–84	1.00	0.1409	85 366	12 026	396 764	9.8 (0.69)
≥85	1.00	1.0000	73 340	73 340	438 082	6.0 (1.01)
Men's driving life expectancy						
70–74	1.90	0.1194	100 000	11 938	445 649	11.5 (0.10)
75–79	1.78	0.2086	88 062	18 365	351 831	8.0 (0.10)
80–84	1.69	0.2882	69 697	20 089	252 105	5.0 (0.07)
≥85	1.57	1.000	49 607	49 607	97 685	2.0 (0.10)
Women's total life expectancy						
70–74	1.00	0.0318	100 000	3178	492 054	20.6 (3.84)
75–79	1.00	0.0720	96 822	6973	466 675	16.2 (4.11)
80–84	1.00	0.0585	89 848	5254	436 105	12.2 (4.87)
≥85	1.00	1.0000	84 594	85 594	664 155	7.9 (5.41)
Women's driving life expectancy						
70–74	1.89	0.1440	100 000	14 400	438 390	11.2 (0.17)
75–79	1.79	0.2144	85 600	18 354	341 626	7.9 (0.07)
80–84	1.73	0.2825	67 245	19 000	250 198	5.0 (0.04)
≥85	1.54	1.0000	48 245	48 245	85 467	1.8 (0.09)

Note. l_x = number in the hypothetical population; d_x = number of events (based on ${}_nq_x$) in the hypothetical population; L_x = number of person-years of survival in the hypothetical population.
[a]Mean years of survival for those dying within the 2-year period of follow-up in the total life expectancy calculations and mean years of driving for the driving life expectancy calculations, with assignments of 0.5 year for those dying, 1.0 year for those who quit, and 1.85 years for those who refused to participate or were lost in the follow-up.
[b]Represents the mortality rate in total life expectancy calculations and represents the combined mortality, driving cessation, and loss to follow-up rate in the driving life expectancy calculations.
[c]Expected years and the SE of the estimated expected years.

The Asset and Health Dynamics Among the Oldest Old longitudinal study data also showed that male and female drivers aged 70 to 74 years had equivalent driving life expectancies of approximately 11 years. This figure resulted from the finding that men and women had an equivalent probability of driving cessation after mortality differences in their risks for cessation were taken into account. Several longitudinal studies of driving in late life have reported higher rates of driving cessation among women compared with men.[26,27] These studies, however, failed to consider the effect of the competing risk of cessation due to mortality that is higher among men. When the Asset and Health Dynamics Among the Oldest Old analyses were limited to those surviving the 2-year period of follow-up, women were 3 times more likely to report driving cessation.

A comparison of the men's and women's driving life expectancies with total life expectancies found that subsequent to driving cessation, men will have about 6 years of dependency on alternative sources of transportation, compared with about 10 years of dependency for women. The total life expectancies of male and female drivers aged 70 to 74 years in this cohort were approximately 17.7 years and 20.6 years, respectively. For the entire Asset and Health Dynamics Among the Oldest Old cohort, the estimated total life expectancies for men and women in this age group were 15.4 years and 17.4 years, respectively. These differences reflect the poorer health of the men and women in the cohort who were not driving at the time of the baseline survey. In contrast, the total life expectancies for the entire Asset and Health Dynamics Among the Oldest Old cohort exceed the published US population life expectancies of 12.2 years for men and 15.3 years for women, because this cohort was designed to represent only community-dwelling persons aged 70 years and older.[28]

In the United States, nearly 5% of the population aged 65 years and older resides in nursing homes and other long-term care facilities.[29] Similar to the total life expectancy gains over the years stemming from reduced mortality rates in the elderly population, recent reports of reduced rates of physical and cognitive impairments in the elderly popula-

TABLE 4—Multiple Logistic Regression of Driving Cessation According to Age, Sex, and Health Conditions at Baseline: Asset and Health Dynamics Among the Oldest Old Study, 1993–1995

Characteristic[a] (n = 4123)	%	Odds Ratio for Cessation	95% Confidence Interval
Age 75–79[b]	30.5	1.62	1.15, 2.27
Age 80 and older	22.0	2.76	1.86, 4.08
Female driver	53.2	3.03	2.19, 4.19
Chronic poor vision	10.5	4.19	2.92, 6.02
Incident poor vision	14.2	2.72	2.05, 3.62
Chronic ADL limitation	2.9	5.91	4.02, 8.68
Incident ADL limitation	9.9	3.59	2.61, 4.94
Chronic poor memory	6.5	2.25	1.45, 3.49
Incident poor memory	9.4	1.79	1.28, 2.48
Chronic depressed mood	8.4	1.50	1.02, 2.18
Incident depressed mood	8.7	2.22	1.52, 3.25
Had proxy participation	8.5	9.56	6.70, 13.62

Note. ADL = activity of daily living.
[a]A chronic characteristic indicates present at both baseline and follow-up; an incident characteristic indicates present at follow-up only. Not present either time or present only at baseline is the reference group.
[b]Age 70 to 74 is the reference group.

tion may contribute to future gains in driving life expectancy.[1,30,31] Whether increases in driving life expectancy will occur at a faster rate than gains in total life expectancy and thus reduce the average number of years of transportation dependency will require further investigation.

Studies of crashes and driving cessation among elderly drivers have shown stronger associations with measures of visual, physical, and cognitive functioning than with diagnoses of specific medical conditions and diseases.[8,10,26,31–33] The Asset and Health Dynamics Among the Oldest Old study indicated that poor vision, limitations in ADLs, poor memory, and depressed mood were independent risk factors for cessation and that, with the exception of depressed mood, the point estimate for the risk of quitting was higher among persons with chronic limitations, compared with those who had more recent incident limitations or with those who had former limitations or no limitations. In contrast, the duration of depressed mood was inversely related to driving cessation, because persons with incident depressed mood were more likely than either those with chronic depressed mood or those with neither chronic nor incident depressed mood to have quit driving. This finding is consistent with that of another study in which persons who quit driving were more likely than those who continued driving to subsequently report symptoms of depressed mood.[11] However, the precise temporal relation between the onset of problems with vision, ADLs, memory, and depressive symptoms and driving cessation over the 2-year period of follow-up in this study is unknown because of a lack of information about specific dates of onset.

Several other limitations are notable in this analysis of the Asset and Health Dynamics Among the Oldest Old study data. The calculation of driving life expectancy assumed that driving cessation was an absorbing state with no possibility for resumption of driving, an assumption that may not be true. Some of the nondrivers at baseline who were excluded may have started to drive during the course of the follow-up either as newly licensed drivers or as medically rehabilitated drivers. These contributions, however, would not likely be large enough to substantially alter the driving life expectancy estimates, because fewer than 3% of the nondrivers in this cohort reported driving at follow-up. In addition, the exclusion of nondrivers from the analyses results in an underestimation of years of transportation dependency for the total population aged 75 years and older, especially among women, because only 55% were driving in this age group, compared with 82% of the men. Developing a complete life table approach that took into account both increments and decrements in time spent driving over a specific period and included nondrivers at baseline would require more frequent and detailed follow-up surveys than the 2 waves of data used in this analysis.

The strengths of the Asset and Health Dynamics Among the Oldest Old study include its relatively large sample size of nearly 5000 drivers and its representativeness of older drivers nationwide. Although the sample was large and generally allowed for reliable estimates of age- and sex-specific rates of mortality and driving cessation within the cohort, the estimated total life expectancy for the female drivers had greater variability across sampling strata and was less reliable than either their driving life expectancy or the total life expectancy and driving life expectancy for the male drivers. Studies with larger sample sizes or more waves of follow-ups could potentially yield more reliable total life expectancy and driving life expectancy estimates than those based on this longitudinal study.

In summary, each year hundreds of thousands of older drivers across the country must face the reality of driving cessation and of becoming transportation dependent. This significant life event has been overlooked in much of the literature as a routine consequence of the aging process, particularly in the construct of instrumental ADLs assessing, for example, the ability to prepare meals, shop, use the telephone, manage money, and take medications.[34–36] Among the oldest old (persons aged 85 years or older), the difference between driving and not driving typically reflects a sharp contrast in level of physical fitness and mental functioning.[37] Although many of the women in this current generation of the Asset and Health Dynamics Among the Oldest Old cohort never drove, younger women in the emerging "baby boom" cohort are as likely to be licensed to drive as men.

Hence, it is appropriate to regard driving as a pervasive task of independence for both men and women that is subject to change in late life in association with age-related changes in health and functioning. The health and social consequences of driving

cessation need to be recognized and addressed by health professionals, transportation planners, and policymakers. Failure to fully recognize the magnitude and importance of this transition among elderly adult drivers will compromise goals of improving the quality of life in old age, both now and in the foreseeable future. ■

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Contributors

D.J. Foley conceived the hypotheses and methods and wrote the article. J.M. Guralnik assisted in the formulation of the methods and in writing the article. D.B. Brock and H.K. Heimovitz conducted the data analyses and assisted in writing the article.

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Human Participant Protection

This study was approved by the institutional review board of the University of Michigan School of Medicine.

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