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Trends in the Prevalence and Mortality of Cognitive Impairment in the United States: Is There Evidence of a Compression of Cognitive Morbidity?

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Abstract

Background—Recent medical, demographic, and social trends may have had an important impact on the cognitive health of older adults. To assess the impact of these multiple trends, we compared the prevalence and 2-year mortality of cognitive impairment (CI) consistent with dementia in the United States in 1993-1995 and 2002-2004.

Methods—We used data are from the Health and Retirement Study (HRS), a nationally representative population-based longitudinal survey of U.S. adults. Individuals aged 70 or older from the 1993 (N=7,406) and 2002 (N=7,104) waves of the HRS were included. CI was determined using a 35-point cognitive scale for self-respondents, and assessments of memory and judgment for respondents represented by a proxy. Mortality was ascertained using HRS data verified by the National Death Index.

Results—12.2% of those aged 70 or older in 1993 had CI compared to 8.7% in 2002 (P<.001). CI was associated with a significantly higher risk of 2-year mortality in both years. The risk of death for those with moderate / severe CI was greater in 2002 compared to 1993 (unadjusted hazard ratio [HR] 4.12 in 2002 vs. 3.36 in 1993 [P=.08]; age- and sex- adjusted HR 3.11 in 2002 vs. 2.53 in 1993 [P=.09]). Education was protective against CI, but among those with CI, more education was associated with higher 2-year mortality.

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Conclusions—These findings suggest a compression of cognitive morbidity between 1993 and 2004, with fewer older Americans reaching a threshold of significant CI, and a more rapid decline to death among those who did. Societal investment in building and maintaining cognitive reserve through formal education in childhood, and continued cognitive stimulation during work and leisure in adulthood, may help limit the burden of dementia among the growing number of older adults worldwide.

Introduction

Dementia, a decline in memory and other cognitive functions that leads to a loss of independent function,[1] is a common geriatric syndrome that exacts considerable impact on individuals, families, and government programs. There has been progress over the last 25 years in identifying medical, lifestyle, and demographic factors that may affect either the risk of developing dementia or its rate of progression. In addition, social and cultural events have raised awareness of cognitive health and that dementia is a terminal illness. What is not known is the collective impact of these trends on America's overall cognitive health.

As the number of older Americans, especially the oldest-old (those aged 85 or older), has grown in recent decades, several key developments likely have had an important impact on "brain health." New medications and other therapies for cardiovascular and cerebrovascular disease introduced since the early 1990's (e.g., wider use of antihypertensive and HMG-CoA reductase inhibitor [statin] medications) may have contributed to a reduction in myocardial infarction, stroke, and vascular dementia over the past 15 years.[2,3] However, an increased prevalence of diabetes during this time period (from about 12.8% of older adults in 1992 to 15.1% in 2002[4]) may have led to an accompanying increase in the prevalence of dementia, given the growing evidence of an association between diabetes and cognitive decline.[5,6]

In addition to these trends in control of cardiovascular and cerebrovascular risk factors, there have been major changes in the management of persons with dementia over the past 15 years. Cholinesterase inhibitors (ChIs) were introduced in the mid-1990's for the treatment of Alzheimer's disease. Short term studies report improvements in cognitive test scores among those with dementia taking ChIs compared to those taking placebo,[7-10] but whether there is a delay to important clinical outcomes, such as severe disability, nursing home placement, or death, is still debated.[11-16]

Rising levels of education among older adults over the past 15 years may have influenced the prevalence and outcomes of dementia. The proportion of adults age 65 or older with a high school diploma increased from 53% in 1990 to 72% in 2003, while the proportion with a college degree increased from 11% to 17% during this same time period.[17] More years of formal education is associated with a reduced risk of dementia,[18-20] likely through multiple causal pathways, including a direct effect on brain development and function (i.e., the building of "cognitive reserve"[21]), better health behaviors, and the general health advantages of having more wealth and social opportunities.[3,22-24] However, higher levels of education are also associated with a more rapid decline in cognitive function after the onset of dementia,[25,26] which may translate to increased mortality[22,27,28] among those with dementia.

Wealth of older adults has also risen significantly, with median household net worth for those age 65 or older increasing (in constant 2001 dollars) from $108,000 in 1989 to $180,000 in 2001.[29] Like education, greater wealth is associated with lower levels of disability throughout the life course, likely through multiple causal pathways[30,31] and may have contributed to declining levels of dementia over the past 15 years.

In order to investigate the impact of these multiple trends on dementia prevalence and mortality, we used a large nationally representative study of older Americans to identify individuals with cognitive impairment consistent with dementia in 1993 and 2002, and then followed each cohort to determine 2-year mortality for those with and without impairment.

Methods

Data and Study Population

We used data from the 1993 and 2002 waves of the Health and Retirement Study (HRS).[32] In selecting our study samples from the HRS, our main analytic goal was to identify two similar nationally representative cohorts of older individuals (age 70 or older) in 1993 and 2002, characterize their cognitive function using the same cognitive tests in each year, and then follow each cohort for 2 years to determine mortality for individuals with: 1) normal cognitive function; and 2) cognitive impairment (CI) consistent with dementia. The CI category was further sub-divided into mild CI and moderate / severe CI (described more fully below).

The HRS is a biennial, longitudinal, nationally representative survey of US adults, but new cohorts have been entered into the study at different times.[33] As a result, 3,419 individuals in our analysis were included in both the 1993 and 2002 cohorts, while 4,024 were included only in 1993, and 4,205 only in 2002. All statistical tests comparing results across the 1993 and 2002 cohorts were adjusted for this overlap in samples.[34]

The 1993 wave of the HRS was limited to individuals who were living in the community (i.e., not residing in nursing homes). Of the 7,443 HRS respondents who were 70 or older at the time of their 1993 interview, 793 (10.7%) had died by the 1995 interview and 24 (0.3%) had unknown status. The 2002 wave of the HRS included both community-dwelling and institutionalized adults. Of the 7,624 respondents who were 70 or older at the time of the 2002 interview, 473 (6.2%) were in a nursing at the time of interview. These respondents were excluded from the analysis to insure comparable community-dwelling cohorts in both years. Of the remaining 7,151 respondents, 722 (10.1%) died by the 2004 interview and 33 (0.5%) had unknown status. We excluded the small number of respondents with unknown vital status at the 2-year follow-up.

The Social Sciences IRB at the University of Michigan approved the HRS, and the Medical School IRB approved the use of HRS data for the current study.

Measurement of Cognitive Function and Cognitive Category Definitions

The HRS assesses cognitive function with a 35-point scale that includes: an immediate and delayed 10-noun free recall test to measure memory; a serial seven subtraction test to measure working memory; a counting backwards test to measure speed of mental processing; an object naming test to measure knowledge and language; and recall of the date, the president, and the vice-president to measure orientation.[35,36] For self-respondents, the presence and severity of CI were defined using this 35-point cognitive scale. A score of 11 or above was defined as "normal" cognitive function and a score of 10 or below was defined as "cognitive impairment." The CI category was further sub-divided into "mild CI" for those with a score of 8 to 10, and "moderate / severe CI" for those scoring from 0 to 7.

The 35-point cognitive scale was not administered to respondents represented by a proxy (about 10% of the HRS sample in each cohort), but each proxy was asked: "How would you rate [the respondent's] memory at the present time?", and "How would you rate [the respondent] in making judgments and decisions?" If a respondent's memory was assessed as "excellent," "very good," or "good" they were considered to have "normal" cognitive function, while those with "fair" or "poor" memory were considered to have CI. Proxy assessments of judgment were used to further stratify those with CI into mild CI (judgment assessed as “excellent,” “very good,” or “good”) and moderate / severe CI (judgment assessment as “fair” or “poor”).

Our definitions and cut-points for these categories were based on our prior studies with the HRS data,[37] as well as the methods used for the Aging, Demographics, and Memory Study (ADAMS), a supplemental study of dementia in the HRS.[38] The validity of these categories is supported by the clear trends in functional limitations with which they are associated. We assessed the mean number of limitations in instrumental activities of daily living (IADLs; preparing meals, grocery shopping, making phone calls, taking medications, managing money) and found that those in the normal, mild CI, and moderate / severe CI categories had an average of 0.4, 1.1, and 2.5 IADL limitations, respectively (P<.001). Similar trends were found for both self- and proxy-respondents when we analyzed these groups separately. More detail on the HRS self-report and proxy cognitive measures is available at the HRS web site.[39]

Independent Variables Used as Covariates

The following sociodemographic measures were included in the analyses as independent variables: age (70 – 79, 80 – 89, ≥ 90), race (white, black, other), gender, education (<12 years; 12 years; 13 to 15 years, and ≥ 16 years), potential caregiver network (a spouse and/or living children) and net worth (tertiles; 1993 dollars). The self-reported chronic medical conditions included were stroke, diabetes, heart disease, hypertension, lung disease, cancer, psychiatric problems, smoking status, and obesity (self-reported height and weight resulting in a body mass index [BMI] ≥ 30).

Determining Mortality and Date of Death

Vital status and date of death were ascertained using the HRS tracker and exit files, and were verified using the National Death Index.[33] For the 1993 cohort, the number of days between the 1993 interview and the date of death was calculated for all respondents who died prior to the 1995 interview. For those who were alive at the time of the 1995 interview, we calculated the number of days between the 1993 and 1995 interview dates. The same method was used for the 2002 cohort.

Analytic Framework

Trend in the Prevalence and Predictors of Cognitive Impairment between 1993 and 2002—We pooled data from 1993 and 2002 and estimated logistic regression models with a dichotomous dependent variable indicating whether an individual had CI (mild, moderate, or severe). A linear trend variable that took the value of 0 in 1993 and 1 in 2002 was included in the logistic regression models. An odds ratio (OR) less than 1 for this trend variable would indicate a decrease in the prevalence of CI between 1993 and 2002.[40] We estimated seven separate logistic regression models with different sets of independent variables (e.g., demographic variables, education, cardiovascular risks, and other chronic conditions) in order to determine which variables were most significantly associated with change in the prevalence of CI between 1993 and 2002.

Two-year mortality in 1993 and 2002—To examine changes in mortality from 1993 to 2002, we estimated separate Cox proportional hazards models for 1993 and 2002 to determine the unadjusted and adjusted hazard ratio (HR) of baseline cognitive category for subsequent 2-year mortality. For each year, we estimated a model containing only the cognitive categories as an independent variable (unadjusted HR of cognitive category for 2-year mortality) and a second model that added age and gender (age- and gender-adjusted HR). We then estimated a fully adjusted model that included all covariates, as well as interactions for cognitive category and education level. Statistical significance of changes in the HRs between years was assessed using bootstrapping methods to estimate standard errors.

We repeated all of the prevalence and mortality regression analyses after inclusion of an indicator variable for self- or proxy-respondent. This did not significantly change the coefficient estimates or across-year trends, so we report the results from the original analyses that do not include the self- or proxy-respondent indicator variable.

Statistical analyses were performed using STATA (Release 8.0, Stata Corp, College Station, TX) and SUDAAN (Release 9.0, Research Triangle Institute, Research Triangle Park, NC). All results were adjusted for the complex sampling design of the HRS survey.

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Results

Characteristics of the Study Population

Table 1 shows the characteristics of the 1993 and 2002 study cohorts. Compared to the 1993 cohort, the 2002 cohort was slightly older (mean of 77.8 years vs. 77.5), had significantly more years of education, and had higher net worth (in constant 1993 dollars). Individuals with less than a high school diploma (12 years of education) comprised 42% of the sample in 1993, but only 31% in 2002. On average, individuals in the 2002 cohort had almost 1 more year of education compared to those in the 1993 cohort (11.8 years vs. 11.0 years). The 1993 and 2002 cohorts had the same likelihood of being married, but those in the 2002 cohort were more likely to have a living child.

Those in the 2002 cohort had significantly fewer IADL limitations, but higher rates of cardiovascular risk factors and cardiovascular disease, including diabetes, hypertension, obesity, and heart disease. The proportion of the HRS sample represented by a proxy respondent was the same (10%) in both the 1993 and 2002 cohorts.

Trend in Prevalence and Adjusted Odds of Cognitive Impairment

Table 2 shows the unadjusted proportion of individuals in each cognitive function category in 1993 and 2002, and displays a significant decrease in the proportion of individuals who had CI consistent with dementia between 1993 and 2002 (12.2% had CI in 1993 compared to 8.7% in 2002 [P<.001]).

Table 3 reports the results of 7 different logistic regression models with the presence of CI (mild, moderate, or severe) as the outcome variable, using pooled 1993 and 2002 data. The trend variable in the first row of the table represents the odds of CI in 2002 compared to 1993. Model 1 shows the statistically significant decline (OR = 0.68) in unadjusted CI prevalence already noted in Table 2. When adjusting for age and sex differences between the two cohorts (Model 2), the trend toward decreased CI prevalence was slightly larger (the trend OR drops from 0.68 to 0.65), due to the older age of the 2002 cohort and the strong association of older age with increased odds of CI. Higher levels of education (Model 3) and net worth (Model 4) were associated with significantly lower odds of CI, and the higher levels of education and net worth in the 2002 cohort accounted for about 43% (15 percentage points) of the decrease in CI prevalence between the years (i.e., the trend OR increased from 0.65 to 0.80 with adjustment for education and net worth). In the fully adjusted model (Model 7), stroke was associated with increased odds of CI and hypertension with lower odds of CI, but the other cardiovascular risks did not show a significant association with CI. After adjustment for education and net worth, additional independent variables (Models 5 through 7) did not explain more of the decrease in CI prevalence between 1993 and 2002.

Two-Year Mortality: 1993-1995 and 2002-2004

Table 4 shows the unadjusted two-year mortality for individuals in each cognitive function category in 1993 and 2002. In both years, cognitive function was clearly related to risk of death, with significantly higher mortality among those with worse cognitive function.

Table 5 shows the unadjusted and adjusted hazard ratios (HRs) for two-year mortality (with normal cognitive function as the reference group). CI was associated with increased 2-year mortality in both 1993 and 2002. Mortality among those with moderate / severe CI in 2002 was higher than in 1993 (unadjusted HR 4.12 vs. 3.36 [P=.08]; age-and sex-adjusted HR 3.11 vs. 2.53 [P=.09]). To determine whether more years of education were associated with an increased risk of death among those with CI, we tested for a significant interaction between cognitive function category and education in the fully adjusted model. More years of education were generally associated with an increased risk of death among those with CI (ORs > 1 for the CI X education interaction). The magnitude of this interaction was larger in the 2002 cohort compared to the 1993 cohort, suggesting an increasing risk of mortality for those with CI and more years of education in 2002 compared to 1993.

Discussion

In a large nationally representative survey of older Americans we found that, between 1993 and 2002, the prevalence of cognitive impairment consistent with dementia decreased from 12.2% to 8.7%, representing an absolute decrease of 3.5 percentage points, and a relative decrease of nearly 30%. In addition, we found an increased risk of death among those with moderate or severe CI, and this increased mortality was most evident among those with CI who had higher levels of education.

The decline in the prevalence of CI suggests that, overall, the combined impact of recent trends in medical, lifestyle, demographic, and social factors has been positive for the cognitive health of older Americans. Although the prevalence of some cardiovascular risks that are also associated with a higher risk of dementia[15] increased significantly, other factors showed trends that favored a reduced prevalence of CI. Most importantly, we think, individuals who were 70 or older in 2002 had significantly higher levels of education, on average, than those who were 70 or older in 1993. Our trend analyses suggest that increasing levels of education and net worth among older Americans explained about 40% of the observed relative decrease in CI prevalence between 1993 and 2002.

Higher levels of education are likely associated with greater "cognitive reserve," in that brains of the more educated are able to sustain greater damage (e.g., AD pathology or ischemia) before reaching the threshold of clinically significant CI.[21,26] However, at the time this threshold is finally crossed, brain pathology is more advanced in those with more education, resulting in a more rapid cognitive decline[2226] and greater risk of mortality.[22,27] Our findings support the cognitive reserve hypothesis in that we found a significant protective effect of education on CI risk in both the 1993 and 2002 cohorts, and increased risk of 2-year mortality among those with CI who had higher levels of education in both the 1993 and 2002 cohorts. Our findings of a declining prevalence of CI between 1993 and 2002, and the strong association of education with decreased risk for CI, are consistent with similar trends found between 1982 and 1999 in a recent study using data from the National Long Term Care Survey,[3] and our findings extend those of Freedman and colleagues who also found a decline between 1993 and 1998 in "severe cognitive impairment" using HRS data.[23,41]

Potential mechanisms leading from more education to better cognitive function and reserve include a direct positive effect of schooling on brain development,[3,24,26] greater mental stimulation throughout the life course due to more cognitively demanding occupations[42,43] and leisure time activities,[20,24,44] and more "brain healthy" lifestyles such as better control of cardiovascular and cerebrovascular risk factors, as well as better access to health care interventions that may help preserve cognitive function.[30,31]

Our finding that the increasing prevalence of cardiovascular risks was not accompanied by an increasing prevalence of CI suggests that these risks were treated more successfully in 2002 compared to 1993. For instance, a recent analysis of Medicare Current Beneficiary Survey (MCBS) data showed that the use of statin medications to treat high cholesterol increased from 4% to 22% of older individuals with heart disease between 1993 and 2002, while use of any antihypertensive medication increased from 46% to 62%.[45] This more intensive treatment was accompanied by significantly better blood pressure control and improved cholesterol profiles among those 65 to 84 years old, as measured in the National Health and Nutrition Examination Survey (NHANES). In sum, both more intensive and successful treatment of cardiovascular risks in 2002 compared to 1993 may have had a "spill-over" benefit for population cognitive health. The association of self-reported hypertension with lower risk of dementia in our study is consistent with a possible protective effect of antihypertensive medications,[46,47] however we were unable to test this hypothesis directly.

There have been significant changes in the treatment of Alzheimer's disease, the most common cause for dementia, during the time period of our study. Since 1993, cholinesterase inhibitor medications have been approved for treatment of mild to moderate AD. The use of these medications has increased rapidly since their introduction; about 25% of patients with AD were using a ChI in the late 1990's in one population-based study,[48] and prescriptions have increased steadily since then.[49] Since these medications are used mainly only after diagnosis of dementia, and since their impact on cognitive function is modest, it is highly unlikely that they are an important explanation for the decreased prevalence of CI that we found in our study between 1993 and 2002.

One prior study using HRS data to study trends in cognitive function did not show the same results as our study. Rodgers and colleagues found no significant decline in the proportion of those with CI, after adjusting for a number of survey design issues, including whether respondents had taken the HRS cognitive test at a prior wave.[50] The exclusion from that study of proxy respondents, a significant proportion of whom have CI, may be one source for the difference in findings. However, Freedman and colleagues found a significant decline in "severe cognitive impairment" in the community-dwelling sample (both self respondents and proxy respondents) between 1993 and 1998,[23] and these findings were robust to various assumptions regarding loss to follow-up, trends in the size and composition of the nursing home population, and the handling of item non-response on the HRS cognitive scale.[41] Our study adds to this prior work by tracking important changes in the mortality associated with CI during this time period, and by using more recent HRS data.

This study has at least two potential limitations. The HRS cognitive measures provide an assessment of cognitive function, but they do not allow the determination of a clinical diagnosis of dementia. We used cognitive categories and cut-off scores that have shown good correlation with dementia in prior studies; specifically, limitations in ADLs and IADLs,[37] extent of informal caregiving,[37] and the likelihood of nursing home admission.[51] Another limitation is that we did not have data on the use of cardiovascular and dementia medications, so we could not directly assess how the increasing use of these agents during the time period of our study may have affected overall brain health.

The strengths of this analysis include its large nationally representative samples of U.S. adults using the same cognitive tests in both years. In addition, the HRS measured cognitive function directly and in a consistent way, and also utilized a proxy informant to provide an assessment of memory and judgment for those respondents unable to participate. These features overcome the shortcomings of using dementia diagnoses obtained from administrative data and excluding those who are significantly impaired because data are not gathered from a proxy. The representative community sample of the HRS included a wide range of educational attainment, allowing a better assessment of the relationship of education to CI and mortality than most clinical samples where individuals with low levels of education are often under-represented. We also had nearly complete 2-year mortality follow-up of the more than 7,000 individuals in each cohort. Hence, our mortality analyses are unlikely biased by non-random attrition from the cohorts.

In summary, our findings engender optimism regarding trends in the overall cognitive health and quality of life of older Americans. There appears to have been a “compression of cognitive morbidity” between 1993 and 2004, with fewer older Americans reaching a threshold of significant cognitive impairment, and a more rapid decline to death among those who did. Societal investment in building and maintaining cognitive reserve through formal education in childhood, as well as continued cognitive stimulation during work and leisure in adulthood, may help limit the burden of dementia among the growing number of older Americans, especially the oldest-old.

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Table 1

Characteristics of the 1993 and 2002 Study Cohorts

Variable	1993 (N=7,406)	2002 (N=7,104)	P value*
Age			.08
70 - 79	4,860 (67.0)	4,494 (64.6)	
80 - 89	2,248 (29.1)	2,258 (31.2)	
≥ 90	298 (3.9)	352 (4.3)	
Mean ± SE	77.5 ± 0.1	77.8 ± 0.9	.02
Race			.004
White	6,237 (90.2)	6,096 (89.4)	
Black	1,014 (8.0)	793 (7.7)	
Other	154 (1.8)	207 (2.9)	
Gender			.1
Male	2,886 (40.0)	2,990 (40.8)	
Female	4,520 (60.0)	4,114 (59.2)	
Education (years)			<.001
< 12	3,337 (42.0)	2,350 (31.2)	
12	2,151 (30.6)	2,370 (34.1)	
13 – 15	1,055 (14.8)	1,194 (17.2)	
≥ 16	863 (12.7)	1,190 (17.4)	
Mean ± SE	11.0 ± .09	11.8 ± .10	<.001
Net Worth (1993 dollars)			<.001
≤ 43,500	2,668 (32.5)	1,968 (26.8)	
43,500 – 167,100	2,667 (36.8)	2,202 (30.7)	
> 167,100	2,071 (30.6)	2,934 (42.5)	
Mean ± SE	179,000 ± 8,400	284,000 ± 10,900	<.001
Potential Caregiver Network			
Spouse present	3,625 (50.4)	3,745 (50.1)	.9
Living child	6,433 (87.1)	6,484 (90.4)	<.001
# of ADLs† Impaired			.7
0	5,160 (70.8)	4,989 (70.9)	
1 - 3	1,751 (23.0)	1,676 (23.3)	
4 – 6	495 (6.2)	439 (5.8)	
Mean ± SE	.67 ± .02	.66 ± .02	.7
# of IADLs‡ Impaired			<.001
0	5,112 (70.3)	5,631 (80.0)	
1 - 3	1,955 (25.5)	1,141 (15.9)	
4 – 5	339 (4.2)	329 (4.2)	
Mean ± SE	.56 ± .02	.44 ± .02	<.001
Chronic Conditions			
Stroke	785 (10.5)	774 (10.7)	.7
Diabetes	987 (12.4)	1,310 (17.8)	<.001
Heart disease	2,339 (32.0)	2,448 (34.1)	.005
Hypertension	3,694 (49.1)	4,228 (59.6)	<.001
Lung disease	842 (11.9)	768 (11.0)	.1
Cancer	1,014 (14.0)	1,287 (18.4)	<.001
Psychiatric problem	805 (10.8)	942 (13.2)	<.001
BMI			<.001
< 18.5	295 (4.0)	243 (3.4)	
18.5 – 24.9	3,320 (46.6)	2,858 (41.1)	
25.0 – 29.9	2,637 (35.7)	2,653 (37.7)	
≥ 30.0	1,050 (13.7)	1,261 (17.8)	
Smoking Status			<.001
Never	3,508 (47.8)	3,128 (44.6)	
Former	3,113 (42.5)	3,381 (47.6)	
Current	729 (9.7)	541 (7.7)	
Respondent Type			.7
Self	6,621 (89.7)	6,295 (89.9)	
Proxy	785 (10.3)	809 (10.1)	

* P value for chi-square or t-test for a significant difference in proportion or mean between years.

† ADLs indicates Activities of Daily Living (eating, transferring, toileting, dressing, bathing, and walking across a room).

‡ IADLs indicates Instrumental Activities of Daily Living (preparing meals, grocery shopping, making phone calls, taking medications, managing money).

Values in parentheses are weighted percentages derived using the HRS respondent population weights to adjust for the complex sampling design of the HRS survey.

Table 2

Cognitive Function at Baseline, 1993 and 2002 Cohorts

Cognitive Function	1993 (N=7,393)	2002* (N=7,083)
Normal	6,354 (87.8)	6,413 (91.3)
Mild Cognitive Impairment	440 (5.2)	257 (3.5)
Moderate / Severe Cog Impairment	599 (7.0)	413 (5.2)

Values in parentheses are weighted percentages derived using the HRS respondent population weights to adjust for the complex sampling design of the HRS survey.

Cognitive function data were missing for 13 respondents in 1993 and 21 respondents in 2002. These respondents were excluded from this analysis.

*P<.001 for differences in weighted percentages across study years.

Table 3

Odds Ratios for Presence of Cognitive Impairment in 1993 and 2002 (N=14,476)

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Trend (2002 vs. 1993)	0.68 (0.60 – 0.77)	0.65 (0.58 – 0.73)	0.76 (0.67 – 0.86)	0.80 (0.70 – 0.91)	0.77 (0.67 – 0.87)	0.74 (0.64 – 0.86)	0.72 (0.62 – 0.83)
Age							
70 - 79		Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
80 - 89		2.38 (2.08 – 2.73)	2.21 (1.93 – 2.52)	2.11 (1.84 – 2.41)	2.30 (1.98 – 2.67)	2.27 (1.98 – 2.61)	2.34 (2.07 – 2.72)
≥ 90		6.82 (5.67 – 8.21)	5.56 (4.57 – 6.75)	5.00 (4.11 – 6.08)	5.86 (4.71 – 7.29)	5.63 (4.51 – 7.04)	6.01 (4.84 – 7.46)
Female gender		0.83 (0.72 – 0.95)	0.83 (0.72 – 0.96)	0.72 (0.62 – 0.82)	0.77 (0.66 – 0.89)	0.79 (0.66 – 0.94)	0.76 (0.64 – 0.90)
Education (years)							
< 12			Ref.	Ref.	Ref.	Ref.	Ref.
12			0.32 (0.28 – 0.38)	0.40 (0.35 – 0.47)	0.44 (0.38 – 0.51)	0.44 (0.38 – 0.51)	0.45 (0.39 – 0.52)
13 – 15			0.24 (0.19 – 0.29)	0.32 (0.26 – 0.40)	0.35 (0.28 – 0.43)	0.35 (0.28 – 0.44)	0.36 (0.29 – 0.45)
≥ 16			0.19 (0.15 – 0.24)	0.29 (0.22 – 0.37)	0.30 (0.23 – 0.39)	0.30 (0.23 – 0.39)	0.30 (0.23 – 0.39)
Net Worth (1993 $s)							
≤ 43,500				Ref.	Ref.	Ref.	Ref.
43,500 – 167,100				0.50 (0.43 – 0.57)	0.55 (0.47 – 0.63)	0.58 (0.50 – 0.66)	0.59 (0.51 – 0.68)
> 167,100				0.34 (0.28 – 0.41)	0.38 (0.33 – 0.46)	0.42 (0.35 – 0.51)	0.44 (0.36 – 0.53)
Race							
White					Ref.	Ref.	Ref.
Black					2.38 (1.97 – 2.86)	2.52 (2.11 – 3.02)	2.61 (2.19 – 3.12)
Other					2.35 (1.70 – 3.26)	2.60 (1.88 – 3.61)	2.60 (1.85 – 3.67)
Caregiver Network							
Spouse present					1.17 (1.01 – 1.36)	1.19 (1.03 – 1.38)	1.19 (1.03 – 1.37)
Living child					1.02 (0.82 – 1.28)	1.01 (0.81 – 1.25)	1.02 (0.83 – 1.26)
Cardiovascular Risks							
Stroke						2.86 (2.49 – 3.29)	2.86 (2.48 – 3.29)
Diabetes						1.08 (0.92 – 1.26)	1.07 (0.91 – 1.25)
Hypertension						0.84 (0.73 – 0.96)	0.82 (0.71 – 0.94)
Obesity						0.90 (0.73 – 1.11)	0.90 (0.73 – 1.11)
Heart disease						0.94 (0.81 – 1.10)	0.92 (0.79 – 1.07)
Smoking Status							
Never						Ref.	Ref.
Former						0.99 (0.83 – 1.18)	0.98 (0.83 – 1.13)
Current						1.14 (0.85 – 1.54)	1.12 (0.83 – 1.52)
Other Chronic Conditions							
Lung disease							0.97 (0.80 – 1.17)
Cancer							0.92 (0.77 – 1.12)
Psychiatric problem							1.86 (1.62 – 2.14)

Cognitive impairment includes those with mild, moderate, or severe cognitive impairment.

95% Confidence intervals are in parentheses.

Adjusted odds ratios derived using a logistic regression model with pooled 1993 (N=7,393) and 2002 (N=7,083) data with cognitive impairment (mild, moderate, or severe) as the dependent variable. Values greater than 1 indicate increased odds of cognitive impairment.

Table 4

Unadjusted 2-year Mortality, by Cognitive Function Category, 1993 and 2002 Cohorts

Cognitive Function	**1993 (N=7,393)**	**2002 (N=7,098)**
	% Dead at 2-year Follow-up	
Normal	8.6 (7.6 – 9.6)	8.2 (7.5 – 8.9)
Mild Cognitive Impairment	18.5 (14.8 – 22.1)	16.8 (12.4 – 21.1)
Moderate / Severe Cog Impairment	25.9 (21.5 – 30.3)	29.8 (24.9 – 34.6)

Values are weighted percentages derived using the HRS respondent population weights to adjust for the complex sampling design of the HRS survey.

95% Confidence intervals are in parentheses

Table 5

Unadjusted and Adjusted Hazard Ratios for 2-Year Mortality, 1993 and 2002 Cohorts

	1993			2002		
	Unadjusted	**Age- and Sex-Adjusted**	**Fully-Adjusted†**	**Unadjusted**	**Age- and Sex-Adjusted**	**Fully-Adjusted†**
Cognitive Function						
Normal	Ref.	Ref.	Ref	Ref.	Ref.	Ref.
Mild CI	2.24 (1.85 – 2.72)	1.90 (1.56 – 2.30)	1.57 (1.23 – 2.00)	2.16 (1.59 – 2.94)	1.82 (1.34 – 2.47)	1.03 (0.65 – 1.65)
Mod / Sev CI	3.36 (2.74 – 4.13)	2.53 (2.04 – 3.14)	1.84 (1.41 – 2.40)	4.12* (3.22 – 5.26)	3.11‡ (2.34 – 4.12)	1.88 (1.33 – 2.65)
Education (years)						
< 12			Ref.			Ref.
12			0.86 (0.70 – 1.04)			0.82 (0.66 – 1.02)
13 – 15			0.85 (0.68 – 1.06)			0.64 (0.51 – 0.81)
≥ 16			0.84 (0.59 – 1.21)			0.88 (0.66 – 1.19)
Cog Function X Education						
Mild CI X 12			1.44 (0.70 – 2.95)			3.65 (1.74 – 7.67)
Mild CI X 13 – 15			0.63 (0.06 – 6.59)			2.87 (1.05 – 7.90)
Mild CI X ≥ 16			2.25 (0.95 – 5.34)			0.40 (0.04 – 3.73)
Mod / Sev CI X 12			1.85 (1.05 – 3.28)			1.71 (0.85 – 3.44)
Mod / Sev CI X 13 – 15			2.69 (1.20 – 6.00)			2.93 (1.06 – 8.07)
Mod / Sev CI X ≥ 16			1.14 (0.32 – 4.05)			2.44 (0.78 – 7.62)

† Fully-adjusted model includes cognitive function, age, race, gender, net worth, education, potential caregiver network, chronic conditions, smoking status, and cognitive function X education level interaction terms.

CI is cognitive impairment.

95% Confidence intervals are in parentheses.

* P=0.08 for comparison of unadjusted HR in 2002 vs. 1993 (4.12 vs. 3.36).

‡ P=0.09 for comparison of age- and sex-adjusted HR in 2002 vs. 1993 (3.11 vs. 2.53).