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Changes in the Prevalence of Cognitive Impairment among Older Americans, 1993-2004: Overall Trends and Differences by Race/Ethnicity and Socioeconomic Status

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Changes in the Prevalence of Cognitive Impairment among Older Americans, 1993-2004: Overall Trends and Differences by Race/Ethnicity and Socioeconomic Status

by

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Dedication

This work is dedicated to my parents, Ed and Leigh Hopper, who provided the foundation and love of learning that led to my pursuit of a doctoral degree. This work is also dedicated to my husband, Alan, who saw me through the ups and downs of graduate school and encouraged me the entire way.

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Changes in the Prevalence of Cognitive Impairment among Older Americans, 1993-2004: Overall Trends and Differences by Race/Ethnicity and Socioeconomic Status

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Research indicates that the health of the older population in the United States, as measured by most dimensions, has improved over the past two decades. Population-level changes in health have been attributed to increases in education and income and improvements in the treatment and control of disease. Recent research suggests that rates of cognitive impairment have declined as well; however, results have been inconsistent and most studies have included only two time points in the analysis. This project used data from six waves of the Health and Retirement Study to achieve the following aims: 1) determine if the prevalence of cognitive impairment among older adults declined from 1993 to 2004, and 2) determine if the pattern of change in cognitive impairment was consistent across racial/ethnic and socioeconomic groups. Analyses investigated whether changes in demographic, socioeconomic, and health status and behavior variables contributed to overall and group-specific trends. Sampling weights applied to each wave of data enabled merged waves to represent comparable cross-sections of the community-dwelling older population in the United States in each respective year of study. Logistic regression analyses employing cognitive impairment as the dependent variable and a time trend variable as the key independent variable were used to analyze trends. Results showed an annual decline in the prevalence of cognitive impairment of -3.4% per year, adjusting for changes in the age and gender distributions of the population as well as prior test exposure. Increases in educational attainment in the population accounted for the trend. Racial/ethnic and socioeconomic disparities in the prevalence of cognitive impairment decreased considerably between 1993 and 2004. Declines in the prevalence of cognitive impairment were greater for blacks and Hispanics compared to whites and for lower education and wealth groups compared to more advantaged groups. Overall and group-specific trends did not appear to be due to selection bias resulting from changes in rates of mortality or attrition of HRS respondents over time. Improvements in the socioeconomic status of the population have contributed to declines in the prevalence of cognitive impairment among older adults—particularly blacks and Hispanics—in the United States.

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Chapter 1: Introduction

Improvements in health and increases in life expectancy have contributed to the expansion of the older population over the past century. Moreover, the number and proportion of older adults in the United States will increase dramatically during the 2010-2030 period, as the generation known as the Baby Boomers (born between 1946 and 1964) start turning 65 (Federal Interagency Forum on Aging Related Statistics, 2008). In 2030, the older population is projected to be twice as large as in 2000, 71.5 million compared to 35 million, and represent 20% of the total U.S. population (He, Sengupta, Velkoff, & DeBarros, 2005). As the older population grows, it will also become more diverse. Projections suggest that by 2050 the older population will be 61% non-Hispanic white, compared with 81% in 2006 (Federal Interagency Forum on Aging Related Statistics, 2008).

The aging of the population has vast implications for society, including widespread health-related consequences. Older adults are at increased risk for a number of chronic diseases and conditions, which carry direct as well as indirect economic and social costs. Cognitive disorders, such as cognitive impairment and dementia, are among the most common, debilitating, and expensive age-related conditions. Cognitive impairment contributes to disability, inability to care for oneself, and diminished quality of life (Suthers, Kim, & Crimmins, 2003). In addition, a significant portion of health care resources is spent caring for adults with cognitive impairment (Langa et al., 2001).

A central question emerging with increased life expectancy and associated population aging in the United States is whether the additional years of life are accompanied by good health and independence or disease and disability. A great deal of research has investigated trends in the health of older adults in the United States and described the mortality and disease patterns arising with demographic change, shifts in socioeconomic status, and medical advances. Results vary depending on the definition and measurement of health, the time period of interest, and the study population; however, generally most dimensions of health appear to have improved during the last two decades (Crimmins, 2004). Although the prevalence of certain chronic diseases has increased among older adults, there has been a delay in the progression of disease to disability, due in part to improved treatment and diagnosis (Crimmins, 2004; Freedman, Schoeni, & Martin, 2007).

Population-level Trends in Cognitive Impairment

As the number and proportion of older adults in the United States increases, cognitive impairment and dementia may place a great burden on the medical care and public health systems in this country. Some research has estimated that the number of adults with dementia will increase 2.5-4 fold (to 8.5-13 million) by the year 2050, due to the aging of the population (Evans, 1990; Hebert, Scherr, Bienias, Bennett, & Evans, 2003; Brookmeyer, Gray, & Kawas, 1998). However, such projections assume age-specific rates of cognitive impairment remain constant, and even modest delays in age-specific onset of dementia can have huge public health implications (Brookmeyer et al., 1998). In addition, these studies are not nationally representative. Instead, they combine U.S. census data with population-based prevalence estimates from studies of a single community or group of communities.

Cognitive impairment has not received much attention as an outcome in research investigating trends in the health of older adults, potentially due to limitations of available national data sets. A few recent studies have examined population-level changes in the prevalence of cognitive impairment in the 1980s and 1990s using nationally representative samples of older U.S. adults (Freedman, Aykan, & Martin, 2001; Langa et al., 2008; Manton, Gu, & Ukraintseya, 2005; Rodgers, Ofstedal, & Herzog, 2003). However, due to measurement issues, researchers do not agree on whether or not there have been declines in the prevalence rate of cognitive impairment. This has been described as an important gap in the knowledge of trends in the health of older adults (Kramarow et al., 2007).

Preliminary evidence suggests an overall reduction in the proportion of older adults with cognitive impairment, and improvements appear to be somewhat larger in terms of percent change than those observed for measures of physical disability (Langa et al., 2008; Freedman et al., 2001; Manton et al., 2005). However, results have not been consistent. Two studies using the Health and Retirement Study (HRS) reported significant declines in the prevalence of cognitive impairment from 1993 to 1998 and from 1993 to 2002 (Freedman et al., 2001; Langa et al., 2008). These studies included only two time points in their analyses, and changes between any two waves of data may not provide an accurate trend estimate. A third study using the HRS analyzed four waves of data and found no evidence of trends after adjusting for several design effects (Rodgers et al., 2003). A study using data from the National Long Term Care Survey showed that the age standardized prevalence of cognitive impairment declined among disabled older adults from 1982 to 1999 (Manton et al., 2005). Most recently, a study of two cohorts of black older adults in Indiana reported that the prevalence rates of dementia and Alzheimer disease did not change between 1992 and 2001 (Hall et al., 2009).

The studies cited above provide some evidence of overall trends in cognitive impairment in the population; however, they did not investigate trends in disparities in cognitive impairment across demographic or socioeconomic groups. Research has identified a variety of sociodemographic, lifestyle, and medical risk factors that are associated with both the risk of developing cognitive impairment and the rate of decline in function. In particular, racial/ethnic and socioeconomic disparities in cognitive impairment have been widely documented (Sloan & Wang, 2005). For example, prevalence and incidence studies of cognitive impairment and dementia have found that blacks have higher rates than whites (Mehta et al., 2004; Gurland, 1999; Perkins, 1997). Previous research on trends in disability has shown inequality in health progress, with disability rates decreasing only among the most advantaged groups. It is unclear whether a similar pattern of change has occurred for cognitive impairment or whether improvements have been experienced more broadly. The elimination of racial/ethnic disparities in health remains a top priority of the Healthy People 2010 program. Progress toward this goal involves monitoring health indices at the population level and comparing them across racial/ethnic or socioeconomic subpopulations (Mendes de Leon et al., 2005).

In summary, only a limited number of studies have investigated trends in the prevalence rate of late-life cognitive impairment. Previous studies have had limitations, and this dissertation aimed to address these gaps in research. For example, results have been inconsistent and most studies have only examined changes between two time points. In addition, trends in disparities among socioeconomic and racial groups have not been examined. The purpose of this research project was to investigate recent trends in cognitive impairment in a nationally representative sample of older adults, establish whether socioeconomic and racial/ethnic disparities have widened or narrowed, and explore the contributions of demographic, socioeconomic, health behavior and health status variables to overall and group-specific trends. The ultimate purpose was to assess changes in population health in order to help inform the current and potential health status and health care needs of the U.S. population.

This project used data from six waves (1993, 1995, 1998, 2000, 2002, & 2004) of the Health and Retirement Study (HRS), a nationally representative longitudinal survey of older adults in the United States. The HRS was initially designed as two separate but related panel studies, the HRS and the Assets and Health Dynamics of the Oldest Old (AHEAD), which merged in 1998 into a single survey representative of the entire U.S. population aged 51 and older. New cohorts are aged into the sample at 6 year intervals. The six waves of data in this project were used as repeated cross-sections, rather than longitudinal observations, in order to examine changes in the prevalence rate of cognitive impairment in the United States over time. The sample at each wave was restricted to adults aged 70 years and older, and sample sizes ranged from about 6,000 to 7,600 in each wave.

SPECIFIC AIMS

The specific aims of this dissertation research seek to advance existing knowledge of population-level health trends, specifically trends in cognitive impairment and race/ethnic and socioeconomic disparities, as well as address limitations of previous research. The specific aims and representative hypotheses are described below.

Specific Aim I

Determine if the prevalence of cognitive impairment among older adults declined from 1993 to 2004 and explore the associations of demographic, socioeconomic, health behavior, and health status variables with changes in prevalence over time.

Description of Specific Aim I

Population-level changes in the health of older adults are a function of incidence, recovery, and mortality processes that are multifactorial. Shifts in social, economic, behavioral, medical, and environmental risk factors in previous years and decades may have influenced recent cognitive impairment trends. Specifically, widespread increases in education and income (Federal Interagency Forum on Aging Related Statistics, 2008), improvements in the treatment and control of disease, and changes in health behaviors and late-life chronic disease profiles may have reduced the proportion of older Americans reaching a threshold of cognitive impairment. For example, treatments for heart and circulatory diseases have improved (Schoeni, Freedman, & Martin, 2008), and the effects of conditions related to cognitive impairment, such as hypertension and stroke, are better controlled (Manton, Corder, & Stallard, 1997). Thus, changes in the composition of the population (for example, increases in educational attainment) may have resulted in a greater proportion of the population in low risk groups. In addition, risk factors for cognitive impairment, such as hypertension, may have become less debilitating, due to improvements in diagnosis, treatment, or control of chronic disease.

Representative Hypotheses

1a. The proportion of the noninstitutionalized population aged 70 and older with cognitive impairment decreased from 1993 to 2004, independent of changes in the age and gender distributions of the population.

1b. Increases in the educational attainment and net worth of the population from 1993 to 2004 will partially account for observed trends in cognitive impairment.

1c. Declines in the prevalence of chronic conditions (e.g., hypertension, stroke, psychiatric disorder, and sensory impairment) and smoking will partially account for observed trends in cognitive impairment.

1d. The association between chronic conditions and cognitive impairment will decrease over time, such that in 2004 the risk of cognitive impairment associated with a given chronic condition is less than the risk observed in 1993.

1e. Changes in the association between chronic conditions and cognitive impairment will partially account for trends in cognitive impairment from 1993 to 2004.

Specific Aim II

Determine if trends in cognitive impairment are consistent across racial/ethnic and socioeconomic groups, and explore to what extent demographic, socioeconomic, health behavior, and health status variables account for group differences in trends.

Description of Specific Aim II

Previous research on cognitive impairment has not investigated trends in disparities for major demographic and socioeconomic groups. However, research documenting disparities in disability trends may indicate what to expect regarding trends in cognitive impairment. Such research has shown that improvements in disability appear to be concentrated among the most advantaged groups, with the greatest declines observed for those with higher education and those with higher incomes (Schoeni, Freedman, & Wallace, 2001; Schoeni, Martin, & Andreski, 2005). Regarding racial/ethnic trends, disability increased among blacks during the 1980s, however, larger declines were observed for blacks than for whites during the 1990s, although a significant deficit remained (Manton & Gu, 2001; Arbeev, Butov, Manton, Sannikov, & Yashin, 2004). Some research has attributed the persistence of racial/ethnic disparities over time to the widening gaps between socioeconomic groups, as minorities are more likely to be in disadvantaged groups (Schoeni et al., 2005).

Potential explanations of observed trends are important, as they have implications for interventions and can aid projections of future changes. Educational attainment, a component of SES strongly associated with cognitive functioning, has increased among older adults in recent decades. However, substantial race/ethnic differences remain. Research examining trends in racial/ethnic disparities in health status and health behaviors is somewhat limited. Therefore, it is unclear which risk factors may explain group-specific trends in cognitive impairment.

Representative Hypotheses

2a. Trends in the prevalence of cognitive impairment will vary by race/ethnicity, education, and net worth, such that declines are largest for the most advantaged groups and disparities widen.

2b. When differential trends by race/ethnicity, education, and net worth are considered simultaneously (i.e. included in the same model), trends by education and net worth will largely account for racial/ethnic disparities in trends.

2c. Changes in health status and health behaviors will partially account for trends in disparities between racial/ethnic and socioeconomic groups.

Additional Goals for Specific Aims I and II

Additional descriptive and explanatory analyses were conducted to augment the results from Specific Aims I and II, to help clarify observed trends, and to determine risk factors for cognitive impairment. Changes in mortality rates and rates of attrition and institutionalization were examined in 2-year intervals over the study period. Rates were examined for the total sample, as well as for subgroups. Moreover, longitudinal analysis was conducted to establish longitudinal relationships between demographic, socioeconomic, health behavior, and health status variables and cognitive impairment.

RESEARCH SIGNIFICANCE

Understanding trends in late-life cognitive impairment is of scientific importance and essential to both public health planning and health care practice. The older adult population in the United States is rapidly growing, and it is estimated that by the year 2040, the number of adults aged 65 and older is expected to double (Social Security Administration, 1998; Suthers et al., 2003). Given current mortality trends and age-specific rates of cognitive impairment remaining constant, the length of cognitively impaired life would be expected to increase and the number of cases of cognitive impairment to triple by 2040 (Suthers et al., 2003). An understanding of past trends in cognitive impairment could aid predictions of future changes and give researchers, policy makers, and clinicians an estimate of the future burden of disease for public health planning and health care purposes.

Declines in prevalence rates of cognitive impairment similar to that observed for other health outcomes would be important for several reasons. Cognitive impairment contributes to a number of negative outcomes (Suthers et al., 2003) and significant health care resources are spent caring for adults with cognitive impairment (Langa et al., 2001). Cognitive trends may provide insights into recent national trends in disability, and an understanding of the causal forces behind the trends may indicate where interventions might be most effective and the costs and prospects for additional reductions (Schoeni et al., 2008). Differential trends in cognitive impairment by race/ethnicity or socioeconomic status are important in that they provide evidence of inequality in health progress and indicate that improvements in health have not been experienced broadly (Freedman, Martin, & Schoeni, 2002). Understanding trends in disparities is necessary to identify subgroups of the population that may benefit from targeted interventions and also for projecting future trends in population health (Freedman et al., 2002). As the older population becomes more racially and ethnically diverse, trends in disparities by race/ethnicity have greater implications for the health of the total population.

STRUCTURE OF DISSERTATION

The dissertation is presented as follows. Chapter 2 reviews the epidemiology of and risk factors for cognitive impairment, as well as evidence of racial/ethnic and socioeconomic disparities. Potential reasons for group differences in cognitive impairment are discussed. Chapter 3 provides a review of the evidence of trends in health status and disability in older adults, with a focus on changes in the prevalence of cognitive impairment. Racial/ethnic and socioeconomic differences in trends are also noted, and hypothesized mechanisms underlying trends are reviewed. Chapter 4 describes the study sample, design, independent and dependent measures, and statistical approach used to address the specific aims. Chapters 5 and 6 detail the results of the analyses of Specific Aims I and II. Finally, Chapter 7 provides a discussion and summary of results, strengths and limitations of the dissertation project, and directions for future research.

Chapter 2: Cognitive Impairment: Risk Factors and Disparities

In an aging population, the public health impact of cognitive impairment is an increasing concern. Cognitive impairment and dementia place a burden on the medical system, patients, caregivers and families, and society. This chapter describes cognitive function and impairment, both in general and within the context of epidemiologic research, and reviews medically diagnosable forms of impairment. Risk and protective factors for cognitive impairment are discussed, and finally, racial/ethnic and socioeconomic disparities are examined, with a particular focus on potential reasons for observed group differences.

DEFINING COGNITIVE FUNCTION AND IMPAIRMENT

Cognitive function is a system of abilities that may be grouped into general domains such as learning, short-term and long-term memory, reasoning, orientation, calculation, language, and knowledge (Perlmutter, 1988). These components are included in measurements of cognitive function for the purposes of both clinical diagnosis and epidemiologic research. Conducting comprehensive and standardized clinical examinations of large numbers of older adults, as in an epidemiologic study, can be prohibitively expensive. Thus, generating estimates of cognitive impairment and dementia from large population-based studies is difficult, as there is a tradeoff between sample representativeness and accuracy of classification or diagnosis (Ostbye, Taylor, Clipp, Van Scoyoc, & Plassman, 2008). Measurement of cognitive function and impairment in research is discussed in more detail in the following sections.

It is important to discuss cognitive function and impairment within the context of typical aging. While cognitive functioning generally declines with age, the degree and timing of decline, as well the cognitive domains showing deficits, vary greatly among individuals (Satariano, 2006). Cognitive impairment and associated symptoms are not inevitable consequences of aging (Knopman, Boeve, & Petersen, 2003). Studies of older adults have shown that when individuals at high risk of developing dementia are excluded, the remaining adults experienced few decrements in cognitive functioning abilities with age (Sliwinski, Lipton, Buschke, & Stewart, 1996; Wilson, Beckett, Bennett, Albert, & Evans, 1999). Evidence from neuropsychology and experimental psychology indicates that cognitive decline reflects disease, rather than the process of typical aging (Knopman et al., 2003). Variation in cognitive decline may be due to demographic, social, behavioral, biologic, and environmental factors. The sections below review in greater detail the different forms of cognitive impairment and factors associated with patterns of cognitive function.

Cognitive Impairment

Cognitive impairment is more of a symptom than a diagnosis, though it is often a precursor of dementia in later life (Leifer, 2003; Panza et al., 2005). Cognitive impairment can be determined by clinical observation, respondent or proxy report, or through assessment with a measure of cognitive function. As a general term, cognitive impairment describes difficulty in functioning that may range from mild to severe. Diagnosed forms of cognitive impairment include mild cognitive impairment, dementia and dementia subtypes, such as Alzheimer's disease and vascular dementia.

Mild Cognitive Impairment

Older adults can manifest cognitive deficits without crossing the threshold for dementia. The range of cognitive function status occurring between normal and demented is referred to as mild cognitive impairment, though other terms include cognitively impaired not demented, possible dementia prodrome, age-associated memory impairment, and age-associated cognitive impairment (Knopman et al., 2003; Fratiglioni, Grut, Forsell, Viitanen, & Winblad, 1992). Mild cognitive impairment is often viewed as a precursor to dementia because individuals with mild cognitive impairment are at a much higher risk of developing dementia, especially Alzheimer's disease, than cognitively healthy individuals (Knopman et al., 2003; Petersen et al., 1999).

Mild cognitive impairment is defined as the absence of dementia meeting Diagnostic Standard Manual IV criteria with the presence of memory deficits, normal general cognitive functioning, and normal functional abilities (Haan & Wallace, 2004; Larrieu et al., 2002). The criteria used to characterize mild cognitive impairment specify memory impairment in the absence of impairment in other cognitive functions (Knopman et al., 2003; Lopez et al., 2003a). However, this specification may be too restrictive, as many adults with cognitive decline exhibit a wider range of cognitive deficits than simply memory loss (Knopman et al., 2003; Lopez et al., 2003a). Mild cognitive impairment is a clinical diagnosis that requires a clinical neuropsychological examination, making identification and classification of mild cognitive impairment in population studies a major challenge.

Cognitive Impairment in Research

Researchers typically measure cognitive function using assessment instruments designed to represent the main dimensions of cognitive functioning and identify respondents who experience impaired cognitive function (Ofstedal et al., 2005; Suthers et al., 2003; Satariano, 2006). Measures have been developed to characterize both the current state of cognitive function, as well as the change in cognitive function among different population groups (Satariano, 2006). Impairments in cognitive functioning such as mild cognitive impairment, dementia, and Alzheimer's disease are clinical diagnoses that are difficult to identify in population-based survey research. Therefore, for the purposes of research, cognitive impairment is often defined as the inability to perform multiple tasks of cognitive skills as measured in assessment instruments (Suthers et al., 2003). Researchers identify a threshold or cutoff score on the instrument, below which individuals are considered to have cognitive impairment (Satariano, 2006). The threshold is validated by comparing performance on the cognitive measure to clinical diagnoses of cognitive impairment and dementia. The cognitive instrument and threshold score used to indicate cognitive impairment in the present research project will be discussed in detail in the methods section of this proposal.

Prevalence of Cognitive Impairment

Prevalence estimates of cognitive impairment in the United States have come most frequently from small community-based studies. Researchers estimate the prevalence of cognitive impairment in a community or group of communities and then apply those estimates to U.S. population data. Not surprisingly, estimates of the prevalence of cognitive impairment have varied greatly, ranging from as low as 3% to high as 29% (Larrieu et al., 2002; Ritchie, 2004). Such variation is likely due to differences in classification criteria for cognitive impairment and characteristics of the study samples. Community studies differ in terms of the demographic and socioeconomic characteristics of the sample, raising questions about the generalizability of results (Bernstein & Remsburg, 2007; Suthers et al., 2003).

Three recent studies have estimated the prevalence of cognitive impairment using data from nationally representative samples of community-dwelling and institutionalized older adults. Plassman and colleagues (2008) reported the prevalence of cognitive impairment without dementia using data from the Aging, Demographics, and Memory study (2002), a longitudinal survey of adults drawn from the HRS. Participants underwent neuropsychological testing and examination, and were asked for a clinical and medical history. Approximately 22% of adults aged 71 and older had cognitive impairment without dementia, including 8% with Alzheimer disease and 6% with cerebrovascular disease. Bernstein and Remsburg (2007) estimated the national prevalence of cognitive impairment using data from the 1999-2001 National Health Interview Survey and the 1999 National Nursing Home Survey. Among the noninstitutionalized population, the percentage of adults with cognitive impairment was 7.1% for those over 65 and 11.1% for those over 75. Among the nursing home resident population, the prevalence of cognitive impairment was 42.4% for adults 65 and older. In a study using nationally representative data from the AHEAD and HRS, Suthers, Kim, and Crimmins (2003) found a cognitive impairment prevalence rate of 5.5% to 6.5% for people aged 70 and older who were living in the community in 1993 and a rate of 50% among institutionalized older adults in 1998.

Dementia

Dementia is a syndrome characterized by global loss of cognitive function, particularly memory, sufficient to impair physical, social, and intellectual function (Haan & Wallace, 2004; Larson, Kukull, & Katzman, 1992). There are over 200 types of dementia, however, most are uncommon. The main subtypes of dementia are Alzheimer's disease and vascular dementia.

Diagnostic evaluation of dementia typically involves a general medical history, physical, neurological, and neuropsychological evaluation, and laboratory investigation to help determine subtype (Larson, Kukull, & Katzman, 1992). Dementia is difficult to diagnose, especially in the early stages, and evidence suggests that mild and even moderate dementia are underrecognized in clinical practice (Cummings & Cole, 2002; Callahan, 1995). Factors such as lack of health care access, residence in long-term care settings, and substantial comorbidity may contribute to under-diagnosis of dementia in older adults (Haan & Wallace, 2004).

Dementia is a major cause of disability and leads to significant health care and other costs. In 2003, the World Health Organization reported that dementia contributed 11.2% of years lived with disability in adults aged 60 and older (World Health Organization, 2003). Dementia contributed more to disabled life years than stroke, musculoskeletal disorders, cardiovascular disease, and cancer. Adults with dementia are heavy consumers of health services, resulting in direct costs such as that for acute-care hospitals (Ferri et al., 2005). However, the costs of dementia mostly arise from formal care, estimated to cost $27,672 per patient per year in the United States, with long-term care being the most expensive component (Rice et al., 2001). Indirect costs such as lost wages and productivity also contribute to the cost of dementia (Haan & Wallace, 2004).

A recent study estimated the global prevalence of dementia for each World Health Organization region of the world (Ferri et al., 2005). A group of international experts on dementia used the Delphi consensus method to determine dementia incidence and prevalence using evidence from a systematic review of published studies on dementia (Ferri et al., 2005). For North America, the panel estimated a prevalence of 6.4% and annual incidence of 10.5 per 1000 for adults aged 60 and older. This translated to 560,000 new dementia cases per year, and 3.4 million people with dementia in 2001. Projections of the future burden of dementia assumed current prevalence, and results suggested that 5.1 million adults would have dementia in North America in 2020, and 9.2 million in 2040.

Alzheimer Disease

Alzheimer's disease is the most common subtype of dementia (Evans, 1990), accounting for 60-70% of cases of progressive cognitive impairment in older adults

(Cummings & Cole, 2002). The assessment and diagnosis of Alzheimer's disease require identifying core clinical criteria and excluding alternative types of dementia and other causes of dementia (Cummings & Cole, 2002). Diagnostic criteria for Alzheimer's disease include the presence of major impairments in learning and retaining new information and impairments with at least 1 other cognitive ability, that are sufficient to interfere with work or social activities, represent decline from previous functioning, are insidious at onset and progressive, and are not the result of delirium, major psychiatric diagnosis, or other disease (McKhann, et al., 1984; Knopman et al., 2003). Rather than a single disease, Alzheimer's disease may be a multifactorial syndrome (Sloane et al., 2002).

The specific cause of Alzheimer's disease is unknown, although research has identified a number of epidemiological risk and protective factors (Sloane et al., 2002). Older age and family history of dementia are the strongest risk factors (Sloane et al., 2002). The prevalence of Alzheimer's disease increases exponentially with age. Other putative risk factors from a variety of studies include female sex, presence of the apolipoprotein E4 allele, head injury, low education and socioeconomic status, low serum folate and vitamin B12, and elevated plasma and total homocysteine levels (Cummings & Cole, 2002; Sloane et al., 2002). Higher education is associated with lower risk of Alzheimer's disease, and dietary factors such as moderate wine consumption and higher fish consumption may be protective (Cummings & Cole, 2002).

Vascular Dementia

Vascular dementia is an umbrella term that describes impairments in cognitive function resulting from cerebrovascular disease. Vascular dementia accounts for about 15% of all dementia (Fratiglioni et al., 2000). The diagnostic criteria for vascular dementia include the development of multiple cognitive deficits manifested by both memory impairment and at least one other disturbance such as aphasia, apraxia, agnosia, or executive dysfunction, sufficient to cause impairment in social or occupational activity. The cognitive deficits must represent a decline from previous functioning, and there should be evidence of focal neurological signs judged to be related to the decline (Knopman et al., 2003; American Psychiatric Association, 2000). Still, diagnostic criteria remain controversial, as they have been generally inconsistent in predicting pathological findings (Knopman et al., 2003).

The cognitive deficits occurring as a result of vascular dementia should be of sudden onset, rather than gradually progressive (Knopman et al., 2003). The prognosis of vascular dementia is worse than that of Alzheimer's disease. Median survival for patients with vascular dementia is 3 years, compared to 6 years for those with Alzheimer's (Knopman, Rocca, Cha, Edlan, & Kokmen, 2002). However, vascular dementia is believed to be preventable through the reduction and control of risk factors, and offers the most significant expectation for the primary prevention of dementia (Haan & Wallace, 2004).

Risk and Protective Factors

A great deal of research has investigated variability in the risk of cognitive impairment associated with sociodemographic characteristics, medical conditions, genetics, environmental exposures, and lifestyle and behaviors. Studies have identified a number of putative risk and protective factors. This section reviews several of the more established predictors of cognitive function in older adults. A review of recent trends in these variables, specifically changes in the sociodemographic composition of the population and the prevalence of certain medical conditions and health behaviors, is discussed in Chapter 3.

Sociodemographic Characteristics

Sociodemographic characteristics, such as age, race and ethnicity, education, and economic status, are highly correlated with cognitive function and decline. Age is the strongest epidemiological risk factor for cognitive impairment and dementia. The prevalence rate of cognitive impairment increases rapidly with advancing age, such that each older age group has a prevalence approximately 1.7 times the next younger group (Suthers et al., 2003). Educational attainment is another very important predictor of cognitive performance. Education has both direct and indirect effects on cognitive function and impairment and also influences the measurement of cognitive performance. Racial and ethnic disparities in cognitive impairment and performance on tests of cognitive function also have been well documented. Disparities are mostly attributable to differences in the socioeconomic compositions of different racial/ethnic groups, as well as test bias. The relationships among race/ethnicity, socioeconomic status, and cognitive function will be discussed in greater detail in the section "Race/ethnicity, Socioeconomic Status, and Cognitive Function."

Health Status

Adverse health events, such as neurological and psychiatric syndromes and conditions or diseases of other organ systems, are associated with an increased risk of cognitive impairment (Lopez et al., 2003b). Older adults with depression often present with cognitive deficits (O'Brien, Lloyd, McKeith, Gholkar, & Ferrier, 2004) and experience faster rates of cognitive decline (Wilson, Mendes de Leon, Bennett, Bienias, & Evans, 2004). Diabetes mellitus is associated with cognitive decline (Anstey & Christensen, 2000) and risk of cognitive impairment (Lopez et al., 2003b). There is considerable evidence linking stroke to cognitive decline and impairment. Stroke is included as a comorbidity or etiological factor for vascular dementia and Alzheimer's disease in a large number of studies (Haan & Wallace, 2004). Hypertension, especially in midlife, is associated with cognitive decline and dementia (Haan & Wallace, 2004; Lopez et al., 2003b; Anstey & Christensen, 2000). Neuropathological and neuroimaging studies have shown that hypertension is associated with subclinical changes in brain morphology, such as atrophy and white matter hypertensities (Anstey & Christensen, 2000). Finally, research has shown that low high-density lipoprotein (HDL) cholesterol is associated with increased likelihood of dementia (van Exel et al., 2002), and inflammatory factors like homocysteine and C-reactive protein have been implicated as risk factors for cognitive decline and dementia (Kuo, Yen, Chang, Kuo, & Chen, 2005; McCaddon et al., 2001; Elias et al., 2005).

Increasing research evidence implicates vascular disease as playing a significant role in the etiology of dementia. There is considerable research linking vascular disease and vascular risk factors (e.g., hypertension, stroke, diabetes, exercise) to cognitive decline and both vascular dementia and Alzheimer's disease (Kivipelto et al., 2005; Kivipelto et al., 2006; Mielke et al., 2007; Haan & Wallace, 2004). Fortunately, health and medical interventions have shown that vascular disease is preventable, and research has identified modifiable vascular risk factors. In terms of medications, for example, statins impede atherosclerosis, and may lower the risk of Alzheimer's disease (Crisby, Carlson, & Winblad, 2002). If, in fact, vascular disease is a major culprit for dementia, then improvements in the treatment and control of the disease, as well as changes in risk factors, could help prevent dementia and lead to downward trends in prevalence over time.

Health Behaviors

Health behaviors and lifestyle factors such as physical and intellectual activity, smoking and drinking, and diet are associated with cognitive function. Exercise is believed to have direct effects on cognitive function via improved cerebral blood flow and neurotransmitter metabolism, as well as indirect effects by preventing diseases that contribute to cognitive decline (Anstey & Christensen, 2000; Haan & Wallace, 2004; Pereira et al., 2007). A number of studies investigating dietary factors have shown that total fat, saturated fat, and total cholesterol increase risk of cognitive impairment, while fish intake and moderate wine consumption may be protective (Anstey & Christensen, 2000; Haan & Wallace, 2004).

RACE/ETHNICITY, SOCIOECONOMIC STATUS, AND COGNITIVE IMPAIRMENT

This section reviews racial/ethnic and socioeconomic disparities in cognitive impairment and performance on cognitive tests. A particular focus is placed on differences between the three major racial/ethnic groups in the United States: non-Hispanic whites, non-Hispanic blacks, and Hispanics (hereafter whites, blacks, and Hispanics). Potential explanations for observed disparities are discussed, including social and economic disadvantage over the lifecourse, health status and health behaviors, and measurement quality and assessment bias.

Disparities in Cognitive Function and Impairment

Racial/Ethnic Differences

Research has consistently documented differences in cognitive test scores across racial/ethnic groups, with older black and Hispanic adults having lower scores than whites (Mehta et al., 2004; Sloan & Wang, 2005; Lyketsos, Chen, & Anthony, 1999; Manly et al., 1998; Zsembik & Peek, 2001; Schwartz et al., 2004). Prevalence and incidence studies of cognitive impairment and dementia have also typically found that blacks and Hispanics have higher rates than whites (Lopez et al., 2003c; Gurland, 1999; Perkins, 1997), although some results have not shown significant differences after adjustment for age and education (Fitzpatrick et al., 2004). Racial/ethnic variations in rates of cognitive decline have been documented as well. Some studies have found that older black (Lyketsos, Chen, & Anthony, 1999; Sachs-Ericsson & Blazer, 2005) and Hispanic adults (Alley, Suthers, & Crimmins, 2007) had significantly greater rates of cognitive decline compared to older whites; however, other research has documented slower rates of decline among black adults, which partially offset initial disadvantage in scores (Sloan & Wang, 2005; Alley et al., 2007; Karlamangla et al., 2009). These studies typically adjusted for several indicators of socioeconomic status, such as education and income. Accounting for socioeconomic variables is crucial given racial/ethnic differences in socioeconomic status and the association between socioeconomic advantage and late-life cognitive status. Nevertheless, significant racial/ethnic differences remained. The following sections will discuss further potential reasons for disparities.

Socioeconomic Differences

Socioeconomic disparities in cognitive function, decline, and impairment have been well-documented in older adult populations. Several large longitudinal studies have demonstrated a link between individual-level socioeconomic position in adulthood or late life and level of cognitive functioning, rate of cognitive decline, and risk for cognitive decline (Zhao et al., 2005; Lee, Buring, Cook, & Goldstein, 2006; Wilson et al., 2002; Kaplan et al., 2001; Everson-Rose, Mendes de Leon, Bienias, Wilson, & Evans, 2003; Lee, Kawachi, Berkman, & Grodstein, 2002). Education, a key component of socioeconomic status, predicts prevalent dementia, including vascular dementia (Mortel et al., 1995; De Ronchi et al., 1998) and Alzheimer's disease (Mortel et al., 1995; De Ronchi et al., 1998; Gatz et al., 2001), as well as incident dementia (Evans et al., 1997; Karp et al., 2004). Some research has failed to find a significant association between socioeconomic status and rate of cognitive decline in older adults (Karlamangla et al., 2009; Rabbitt et al., 2004). Nevertheless, such results do not contradict the repeatedly demonstrated relationship between socioeconomic status and cognitive impairment and dementia. Low socioeconomic status adults, starting at a lower level of functioning but declining at the same rate, are likely to reach levels of functioning meeting dementia criteria earlier than more advantaged adults (Karlamangla et al., 2009).

Explanations for socioeconomic disparities in cognitive function have primarily concerned the mechanisms linking education to cognition and include: direct effects of education on the functioning and physiology of the brain (Lee, Kawachi, & Berkman, 2003; Wight et al., 2006; Lee, Buring, & Cook, 2006); beneficial neurochemical effects of continuing mental stimulation sought by educated individuals (Albert, 1995; Lee, Kawachi, & Berkman, 2003); test-taking ability and assessment bias; and better health or other behavioral choices of educated individuals (Albert, 1995). Education is believed to increase the degree of brain pathology required to produce the initial cognitive changes associated with dementia, a concept known as "cognitive reserve" (Stern, 2009). Educational experiences may stimulate changes in the brain such as increased dendritic speed and growth, number of synapses, cerebral blood flow, and neurochemical structural alterations that protect cognitive functional processes even in the face of pathology (Anstey & Christensen, 2000; Stern, 2009). Education likely has indirect effects on cognitive function as well via pathways such as health behaviors, exposure to stress, especially occupational stress and hazards, and diet and nutrition (Anstey & Christensen, 2000).

Research has also examined other components of socioeconomic status, such as post-educational training, occupational status, and wealth. In one study, post-educational training was related to slower rate of cognitive decline among older men, independent of education (Wight, Aneshensel, & Seeman, 2002). Other studies attempting to disentangle the effects of education from economic status have shown that there is little independent effect of wealth, income, or occupational status once education is considered (Cagney & Lauderdale, 2002; Evans et al., 1997). Conversely, education remained significantly associated with cognitive function after adjusting for the other socioeconomic measures.

Potential Explanations for Disparities

Racial and ethnic disparities in cognitive aging may be separated into 1) true disparities in cognitive outcomes resulting mainly from disparate social exposures over the lifecourse, and 2) apparent differences in functioning due to measurement error and assessment bias (Glymour & Manly, 2008). To a large extent, racial/ethnic differences in cognitive functioning and impairment may be attributed to socioeconomic disadvantages—especially differences in level and quality of education and literacy—experienced by older blacks and Hispanics compared to whites (Mehta et al., 2004; Sachs-Ericsson & Blazer, 2005). Health risks may also contribute to racial differences in cognition, as blacks have higher rates of vascular diseases and other chronic disease, and poorer physical functioning compared to whites (Mehta et al., 2004, Sloan & Wang, 2005). Finally, there may be cultural biases in cognitive testing, as cognitive tests have been created and standardized on white samples, and less advantaged groups tend to have less experience with the testing process (Sachs-Ericsson & Blazer, 2005).

Differences in Education and Social Conditions Across the Lifecourse

Race and ethnicity serve as proxies for, and are confounded by, more meaningful variables such as socioeconomic conditions and other correlates of health and cognitive function (Manly, 2006). Social conditions such as socioeconomic status have been described as "fundamental causes" of health and disease that represent access to important resources and consequently affect a wide range of disease outcomes through multiple pathways (Link & Phelan, 1995). In addition, although intervening pathways may change, social conditions maintain an association with disease. The social conditions of different racial/ethnic groups in the United States diverge very early in life. Glymour and Manly (2008) offered a model of cognitive aging that showed socially patterned racial exposures over the lifecourse and the pathways linking them to cognitive aging. In the model, race/ethnicity shapes distal socially patterned factors (geographic exposures/immigration, socioeconomic status, group resources and ties) that influence individual factors (material conditions, stressors, cognitive engagement, test taking skills) that, in turn, affect proximal factors (medical access, health status, health behaviors) and cognitive function and change (Glymour & Manly, 2008).

The experiences and social conditions of older black and Hispanic adults over the lifecourse differ drastically from those of older whites. Most older black adults in the United States, regardless of current residence, were born and spent most of their formative years in the South (Glymour & Manly, 2008). They experienced widespread inequality and attended segregated schools that were of much lower quality than those of their white counterparts (Glymour & Manly, 2008). Hispanic older adults have also experienced very different social conditions over the lifecourse. Approximately 40% of Mexican Americans and 68% of other Hispanics over age 65 are foreign born and immigrated to the United States (Hummer, Benjamins, & Rogers, 2004). Many immigrated as young adults or older, receiving their educations and spending their formative years outside of the U.S. According to data from the National Health Interview Survey, older Mexican Americans have the lowest educational attainment of any racial/ethnic groups, with around 72% having 8 or fewer years of education (Hummer, Benjamins, & Rogers, 2004).

There are considerable differences in educational attainment among racial/ethnic groups in the United States, particularly among older adults. In 2003, 76.1% of whites aged 65 and over were high school graduates or more, compared with 51.6% of blacks and 36.3% of Hispanics (any race) (He et al., 2005). As discussed above, education is strongly associated with performance on cognitive tests and is believed to be protective against cognitive decline and impairment. In addition, education initiates a trajectory of socioeconomic conditions over the lifecourse by influencing, for example, occupational, training, and other opportunities (Glymour & Manly, 2008). Furthermore, the training or engagement pathways spurred by education may provide the link between other social exposures, such as income or occupation, and late life cognitive function (Glymour & Manly, 2008).

Cumulative socioeconomic disadvantage, starting early in life, may affect health and disease in later life. There is evidence from animal models and epidemiological research indicating that early life exposures and conditions throughout the lifecourse influence late life cognitive function (Glymour & Manly, 2008). Results show that higher socioeconomic status in childhood is associated with better cognitive functioning in old age (Luo & Waite, 2005; Zhang, Gu, & Hayward, 2008). Some evidence from lifecourse research supports the notion that childhood socioeconomic status affects late life cognitive function indirectly via adult socioeconomic status (Luo & Waite, 2005; Singh-Manoux, Richards, & Marmot, 2005).

Given the strong relationship between race/ethnicity and socioeconomic status, information on these variables must be considered when examining disparities in health. Several studies have shown that cognitive function differentials decrease considerably after adjusting for differences in demographic and socioeconomic characteristics (Mehta et al., 2004; Sachs-Ericsson & Blazer 2005). However, adjusting for one or two rough indicators of adult socioeconomic status is unlikely to fully adjust for the racially patterned differences in social exposures, and many studies showing racial/ethnic disparities include inadequate controls for socioeconomic conditions (Glymour & Manly, 2008). Moreover, there is a great deal of discordance between number of years of education and quality of education, especially among blacks and Hispanics (Manly, 2006). For example, older blacks have reading skills below their reported level of education, and adjusting for reading level attenuated racial/ethnic differences in test performance to nonsignificance in a study by Manly and colleagues (2002). Statistical adjustment for years of education and income may not be adequate, and measures such as assets and debt may be more appropriate than traditional assessment of social status (Manly, 2006).

Health Status and Health Behaviors

Health behaviors and physical health appear to be important proximal factors in the pathway linking race/ethnicity and cognitive aging. Vascular risk factors, in particular, appear to contribute to race/ethnic disparities in cognitive function and impairment. The prevalence of vascular risk factors is higher among older Hispanics and blacks compared to whites. There is considerable evidence linking vascular risk factors, including obesity, hypercholesterolemia, hypertension, smoking, atrial fibrillation, and angina, to rate of cognitive decline and risk of dementia (Kivipelto et al., 2005; Kivipelto et al., 2006; Mielke et al., 2007). Thus, the higher prevalence rates of vascular dementia reported for Hispanics and blacks are largely attributable to higher rates of vascular risk factors, as well as differences in socioeconomic status and access to care (Froelich, Bogardus, & Inouye, 2001). Nevertheless, including physical health measures has been shown to reduce, but not eliminate, measured disparities (Sloan & Wang, 2005; Lopez et al., 2003b). Research has shown that blacks and Mexican Americans are also more likely to have low serum vitamin D, a risk factor for hypertension, diabetes, and obesity (Martins, Wolf, & Pan, 2007). In addition, rates of physical inactivity are highest among Mexican American men and women and black women (Crespo, Keteyian, Heath, & Sempos, 1996), and increased physical activity has been linked with a delay in onset of dementia (Larson et al., 2006).

Measurement Quality and Assessment Bias

Some explanations of disparities in cognitive function attribute differences to assessment bias, rather than causal sources (Glymour & Manly, 2008). Performance on tests of cognitive function is influenced by many factors other than actual cognitive ability. In addition to education and social status, cultural experiences, native language, prior testing experience, current emotional and physical well-being, and measurement error may influence performance (Satariano, 2006). It can be difficult to differentiate between factors associated with the etiology of cognitive impairment and those that simply influence test performance (Satariano, 2006).

Education increases experience with testing and improves performance on cognitive assessment, which can result in measurement bias. Those with less education may not be as familiar with the implicit and explicit requirements of cognitive testing, and as a result, two individuals with different levels of education, but the same level of "true" function, would be expected to score differently on a cognitive assessment (Manly, 2006; Glymour & Manly, 2008). Many assessments over-diagnose cognitive impairments in those with low education (Manly, 2006).

Cultural differences between groups may also result in assessment bias. For example, competition on tests may be more valued and expected in certain cultures, such as white American culture (Manly, 2006). In addition, certain cognitive tasks may not have much salience in the lives of certain groups, and individuals may not give their best effort (Manly, 2006). Differential item functioning, which occurs when individuals from different groups with the same level of cognitive function exhibit different probabilities of success on an item, also contributes to some extent to group differences in performance on cognitive tests (Manly, 2006). Finally, stereotype threat, a type of confirmation bias, may attenuate the performance of racial/ethnic minority groups on cognitive tests. Stereotype threat occurs when respondents, concerned that their performance will confirm a negative stereotype about a group to which they belong, divert attention from the task and perform below their ability (Manly, 2006). Differential sensitivity or specificity can result when measurement tools operate differently for racial/ethnic minority groups compared to whites (Glymour & Manly, 2008), and efforts should be made to consider potential sources of assessment bias when conducting research on racial/ethnic disparities.

CHAPTER SUMMARY

Cognitive performance in late life reflects a number of different influences accumulated over the life course, from childhood socioeconomic status, to education and occupational experiences or training, to health behaviors and health status in midlife and later. Cognitive impairment refers to difficulty in cognitive functioning ranging from mild to severe and includes medically diagnosed disorders like Alzheimer's disease and vascular dementia. The prevalence and incidence of cognitive impairment varies considerably according to racial/ethnic group and education. A number of factors have been identified that appear to influence cognitive functioning, including health behaviors such as physical activity and adverse health events, especially those related to vascular disease. Racial/ethnic differences in late-life cognitive functioning may be attributed to socioeconomic disparities, differences in health behaviors and health status, and assessment bias. It is important to understand the predictors of cognitive function and impairment, in order to investigate potential population-level trends.

The following chapter examines trends in the health of older adults. The theory and mechanisms hypothesized to effect change in the health status of the older population in the United States are discussed. Evidence of trends in health, particularly trends in chronic disease and disability, are examined, and research concerning trends in cognitive impairment is carefully reviewed.

Chapter 3: Trends in Health of Older Adults

Population-level trends in mortality and various dimensions of health have received a great deal of attention over the past two decades, particularly in the United States, because of the rising cost of medical and long-term care. In the year 2000, long-term care expenditures for older persons reached $123 billion, not including costs associated with informal care provided by families (Freedman et al., 2004). As the number and proportion of older adults in the United States increases, it is important to determine whether future care needs will follow demographic prognoses. This chapter provides a review of the theory and evidence of health trends in older adults, with a focus on changes in the prevalence of cognitive impairment. Racial/ethnic and socioeconomic differences in trends are also noted, and hypothesized mechanisms underlying trends are reviewed.

THEORY AND MEASUREMENT OF TRENDS IN HEALTH

Mortality among older adults in the United States declined on average about 1% per year during the entire 20th century, including some years of more rapid decline (1968-1980s, 1990s) and some of slower decline (1954-1968) (Crimmins, 2004; Oeppen & Vaupel, 2002). With increases in life expectancy, a fundamental question in the literature on aging has been whether the years added to life are accompanied by good health and independence or disease and disability. Several models of population health change have been put forth to predict and explain the health consequences associated with the mortality decline among older adults.

The process of population health change depends on relative trends in morbidity and mortality. Three scenarios, in particular, have gained prominence. The first, termed "the failure of success," was posited by Gruenberg in 1977 (Gruenberg, 1977).

Gruenberg believed that an extension in life expectancy, unaccompanied by declines in incidence of disease, would result in deterioration in population health, as those with chronic disease lived longer. Fries presented a contrasting hypothesis, known as the "compression of morbidity," which suggested that the lifetime burden of illness would be reduced as life expectancy reached a limit and the age of disability onset continued to increase (Fries, 1980). Rather than expansion or compression of morbidity, Manton (1982) hypothesized that "dynamic equilibrium" would occur. The severity and progression of chronic disease are related to mortality changes; therefore, reductions in mortality would be accompanied by increases in the prevalence of disease in the population, but the disease would be at a lower level of severity.

The dynamics of health change in the older population have varied depending on the time period of interest. The 1970s were a period of expansion of morbidity, when life expectancy increased but health deteriorated, as evidenced by increases in disability (Crimmins, 2004; Crimmins, Saito, & Ignegneri, 1997). Health appeared to improve according to most indicators beginning in the 1980s and continuing through the 1990s, and disease was not as closely linked to debilitation, providing support for theory of dynamic equilibrium (Crimmins, 2004; Jagger et al., 2007). Nevertheless, it is not clear what patterns of health change may characterize future periods. Different trends in population health may result, depending on which phases of disease, disability, and mortality processes are changing most rapidly (Crimmins, 2004).

Measurement of Trends

A great deal of research has described trends in the health of older adults by examining the mortality and morbidity patterns arising in the population over the past 25 years. Trends in the health of the population may be characterized using measures of change in mortality rates, healthy or active life expectancy, rates of onset, recovery, and mortality from disease, and change in the prevalence of disease. These measurement approaches may provide different estimates of levels and trends, as well as different answers about health trends (Freedman et al., 2004; Crimmins, 2004). Measures of healthy or active life expectancy combine measures of mortality and morbidity to indicate the amount of life spent in a healthy state. They provide an indication of quality of life and help to address the issue of whether older adults are living healthier lives as well as longer lives (Robine & Romieu, 1998). Many studies have defined health trends as changes over time in the prevalence rates of various health dimensions. The proportion of the population with disease is an indicator of population health at a particular time point (Crimmins, 2004). Prevalence is a function of age-specific incidence of disease, recovery, and mortality rates. Changes in the prevalence of disease indicate changes in health at the level of the population.

Key Issues in Survey Design and Measurement of Trends

The measurement of health trends is affected by features of survey design and analysis, and even small differences in methodology can influence results. A panel of experts, meeting to resolve previously published differences in disability trends, investigated several methodological sources of inconsistency (Freedman et al., 2004). They identified various survey design features and analytic decisions that influence estimates of trends. For example, the type and coverage of the sample frame, inclusion or exclusion of the institutionalized population, mode of interview (e.g. telephone or in-person), frequency of interviews, and survey design (panel study versus repeated cross-sectional) are some of the survey features that can contribute to differences in results between studies. In terms of analytic decisions, the treatment of missing data, measurement of the outcome, and choice of statistical modeling can also contribute to inconsistencies between studies.

Trends studies place enormous demands on survey data, and changes over time in question wording, survey administration, and sample characteristics (for example, the use of proxy respondents) represent potential sources of bias (Wolf, Hunt, & Knickman, 2005). Other sources of bias include changes over time in response rates, loss to follow-up, and item nonresponse. These issues and the above survey design features are discussed in detail in Chapter 4 with regard to this dissertation project and the Health and Retirement Study. In addition, the Results and Discussion chapters explain sensitivity analyses that were performed in order to assess potential bias.

TRENDS IN HEALTH STATUS AND DISABILITY

A growing body of research has investigated trends in the incidence and prevalence of disease occurring with the epidemiological transition, improvements in health care, and changes in risk factors. In general, older adults today appear to be healthier than previous cohorts (Crimmins, 2004). Improvements have been observed in most health dimensions, but not all dimensions have changed in the same direction or at the same time (Crimmins, 2004). Research suggests that significant shifts in socioeconomic status, as well as advances in the technology of care, may have improved the quality of life and functional independence of older adults in the United States (Mor, 2005; Freedman & Martin, 1998; Freedman & Martin, 1999; Liao et al., 2000). There has been a decrease in risk factors such as high cholesterol, hypertension, and smoking, which represent markers of underlying health and risk of disease. On the other hand, the prevalence of certain chronic diseases (e.g., arthritis, some cancers, cardiovascular disease, diabetes) has increased in recent decades (Crimmins, 2004); however, there has been a delay in the progression of disease to disability. Chronic conditions may have become less debilitating due to earlier detection and diagnosis, improved treatment and management, and increased awareness and reporting (Crimmins, 2004; Freedman et al., 2007; Freedman & Martin, 2000). Such changes would likely inflate the prevalence of disease, but cause the average severity of conditions to decrease.

Rates of disability, functional limitations, and underlying physical and sensory limitations have declined substantially since the 1980s (Crimmins, 2004; Freedman et al., 2007; Freedman et al., 2002; Manton, 2008). Late-life disability declines appear to have been concentrated among limitations in basic physical tasks and instrumental activities of daily living (IADL) such as housekeeping, using the telephone, and managing money (Crimmins, 2004; Freedman et al., 2002; Waidmann & Liu, 2000). Trends in disability in activities of daily living (ADL) have been more inconsistent, showing a reduction sometime in the 1990s but no clear decline before that time (Freedman et al., 2004). IADL performance is strongly correlated with general cognitive functioning and predictive of cognitive impairment and dementia (Peres et al., 2008; Barberger-Gateau, Fabrigoule, & Helmer, 1999), indicating that the observed declines in IADL disability in the United States may be accompanied by downward trends in cognitive impairment.

TRENDS IN COGNITIVE IMPAIRMENT

In 2005, a group of experts from Alzheimer's Disease International met to estimate the global prevalence of the dementia. Included in their report was a call to researchers in all regions of the world to monitor trends in the incidence and prevalence of dementia associated with the aging of the population and changes in medical care (Ferri et al., 2005). Interventions and changes in risk factors that delay the onset of cognitive impairment would have great potential to reduce age-specific prevalence. Otherwise, increases in life expectancy, accompanied by constant age-specific prevalence, would result in increased length of life with cognitive impairment (Suthers et al., 2003). Evidence regarding trends in cognitive impairment has not been entirely consistent. The results from relevant research are reviewed below.

Evidence of Trends in Cognitive Impairment.

Several recent studies have examined population-level changes, or trends, in the prevalence of cognitive impairment in the 1980s and 1990s using nationally representative samples of older U.S. adults. Preliminary evidence suggests an overall reduction in the proportion of older adults with cognitive impairment, and improvements appear to be somewhat larger in terms of percent change than those observed for measures of physical disability (Langa et al., 2008; Freedman et al., 2001; Manton et al., 2005). However, due to measurement issues, researchers do not agree on whether or not there have been changes in the prevalence of cognitive impairment. This has been described as an important gap in the knowledge of trends in the health of older adults (Kramarow et al., 2007).

Three studies used the 1993 Asset and Health Dynamics of the Oldest Old (AHEAD) study in combination with later waves of the Health and Retirement Survey (HRS) to examine trends in impairment. Freedman, Aykan, & Martin (2001) found that the percentage of older Americans with severe cognitive impairment significantly decreased from 6.1% to 3.6% from 1993 to 1998, and trends were slightly attenuated after adjusting for changes in demographic and socioeconomic factors or prevalence of stroke and sensory impairments. Approximately 16% of the observed relative decline in cognitive impairment could be attributed to these factors. Analyzing the same data, Rodgers and colleagues (2003), found no evidence of improvement in cognitive function after adjusting for survey design features such as prior exposure to cognitive tests and changes in the demographic composition of the sample. Most recently, Langa et al. (2008) examined trends in cognitive impairment from 1993 to 2002. The prevalence of cognitive impairment significantly declined over this time period from 12.2% to 8.7%

(7.0% to 5.2% for severe impairment), and 40% of the observed decline was attributable to increases in educational attainment and net worth.

There are considerable methodological differences among the studies that may account for the inconsistent conclusions. Freedman et al. (2000) and Langa et al. (2008) included only two time points in their analyses, which may be problematic, as prevalence estimates tend to vary from year to year and changes between any two waves may not provide an accurate approximation of the general trend over the study period. Rodgers et al. (2003) included 4 waves of data, adjusting for repeated exposure to cognitive tests, but did not include proxy respondents in the analysis. Freedman et al. (2001) included proxy respondents and stratified all analyses according to proxy status, while Langa et al. (2008) included proxy respondents and adjusted for proxy status using an indicator variable in the analyses. Finally, Rodgers et al. (2003) used a modified version of the AHEAD cognitive measure that excluded the Vice President question and used a higher threshold score to indicate cognitive impairment.

Studies by Manton et al. (2005) and Liao et al. (2000) provide additional evidence of a decrease in cognitive impairment. Using data from the National Long Term Care Survey (NLTCS), Manton et al. (2005) assessed trends in severe cognitive impairment over a 17-yr period in older disabled adults. The age standardized prevalence of cognitive impairment decreased significantly for both males and females, from 5.7% to 2.9%, and results suggest that the decline was due to a decreasing prevalence of vascular and mixed dementias. Liao et al. (2000) examined trends in cognitive function from 1986 to 1993 using data from the National Mortality Followback Surveys, which ask next of kin about the health status of decedents in the year before death. Among men and women aged 65-84, prevalence of normal cognitive function significantly increased from 1986 to 1993.

Two area studies in Northern California and Indiana have also investigated trends in cognitive impairment. Sauvaget and colleagues (1999) used longitudinal data from two chronological cohorts of adults who were members of Kaiser Permanente Medical Care Program in 1971 and 1980 to examine trends in life expectancy without dementia. Among men, life expectancy increased at a higher rate than dementia-free life expectancy, resulting in a longer period of life with dementia. Among women, dementia-free life expectancy increased at a higher rate than total life expectancy, resulting in a shorter duration of life with dementia. Hall and associates (2009) compared prevalence rates for dementia and AD in two population based cohorts of older African American adults in Indianapolis, Indiana in 2001 and 1992. Results showed no significant differences in prevalence between cohorts, despite significant differences in demographic variables, medical history, and treatment between these two groups.

Trends in Disparities in Cognitive Impairment

Previous research on cognitive impairment did not examine trends in disparities for major demographic and socioeconomic groups. Therefore, it remains unclear whether recent changes in overall prevalence of cognitive impairment have led to a concomitant reduction in racial/ethnic or socioeconomic disparities. Freedman et al. (2001) stratified cognitive impairment trends by race and ethnic group and found that prevalence of impairment decreased more steeply for non-whites (15.9% to 7.6%) than for whites (3.3% to 1.8%), suggesting that the disparity between races may be narrowing. The prevalence of cognitive impairment decreased among both Hispanics (11.7% to 6.7%) and non-Hispanics (4.5% to 2.2%), but the improvement among Hispanics was not statistically significant, potentially due to small sample size and insufficient power. These trends were not adjusted for demographic shifts, and a statistical test for trend disparities was not performed. In addition, potential explanatory variables were not examined. Other studies (Manton et al., 2005; Liao et al., 2000; Langa et al., 2008) did not examine race/ethnicity- or socioeconomic-specific trends in cognitive impairment.

Trends in Racial/Ethnic and Socioeconomic Health Disparities

Research documenting racial/ethnic and socioeconomic disparities in disability trends may provide an indication of what to expect with regard to trends in cognitive impairment. In the 1980s the prevalence of disability increased among blacks while decreasing among whites, widening the gap in disability disparities between the races (Clark, 1997; Manton & Gu, 2001; Arbeev et al., 2004). In the 1990s, disability declined among blacks, and although the improvements were larger for black than for nonblack Americans, a significant deficit remained (Manton & Gu, 2001; Arbeev et al., 2004). Other research examining trends in racial/ethnic disparities in disability over the past 20 years did not find statistically significant differences in trends across groups (Schoeni et al., 2001; Schoeni et al., 2005) and disparities by race and ethnicity largely persisted. However, these studies did not examine trends by decade and significant differences in trends may have been obscured.

Research examining trends in disability by socioeconomic status has found significant differences in trends among subgroups. Declines in disability appear to be concentrated among the most advantaged groups. For example, the most educated older adults experienced the largest declines in disability from 1982 to 1996 (Schoeni et al., 2001). In fact, older adults with more than a high school degree were the only group to experience improvements (Schoeni et al., 2001). In another study, the age- and gender-adjusted prevalence of any disability declined for all groups from 1982 to 2002, but declines were greatest for the most educated and those with the highest income (Schoeni et al., 2005). The persistence of racial/ethnic disparities over time was attributed to the widening gaps in disability between education and income groups, as minorities were concentrated in disadvantaged groups (Schoeni et al., 2005). In another study, increases in healthy life expectancy were concentrated among those with the highest levels of education, while those in lower categories experienced declines in healthy life expectancy over the 20 year study period (Crimmins & Saito, 2001).

Potential Explanations for Population-level Changes in Cognitive Impairment

It is important to identify and understand the mechanisms responsible for population-level changes in the health of older adults. The incidence, recovery, and mortality processes underlying shifts in the health of the population are multifactorial. Changes in a number of social, behavioral, medical, and environmental risk factors over the past few decades may have reduced the prevalence of cognitive impairment in recent years and may continue to do so in the future. One way to gain insight into current and future trends in prevalence rates of cognitive impairment is to examine the factors believed to be contributing to recent shifts in population health.

Changes in the Socioeconomic Composition of the Population

Research indicates that shifts in the socioeconomic status of the population have played a role in improvements in the health of older adults (Schoeni, Freedman, & Martin, 2008; Freedman & Martin, 1999). Education is a component of socioeconomic status that is strongly associated with health and predictive of cognitive functioning and impairment. The educational attainment of older adults has increased significantly in recent decades and is projected to continue increasing (Freedman & Martin, 1999). For example, in 1980, 39% of older Americans had completed high school, compared with nearly 66% in 2000 (US Bureau of the Census, 1984; Gist & Hetzel, 2004).

Increases in educational attainment have occurred at a faster rate among blacks than among whites, resulting in a narrowing in educational disparities. The difference in average years of education completed by blacks and whites declined over the first half of the 20th century, from 3.46 for those born in the early 1900s to 0.83 for those born in the 1950s (Kalmijn & Kraaykamp, 1996). Despite the long term decline in educational inequality, a racial gap remains. Educational disparities that are small in absolute value (e.g., < 1 year) are created by large underlying disparities in high school and college completion (Kalmijn & Kraaykamp, 1996). In 2003, 76.1% of non-Hispanic whites aged 65 and over were high school graduates or more, compared with 51.6% of non-Hispanic blacks and 36.3% of Hispanics (any race) (He et al., 2005). Completion of educational programs is likely to have more practical significance in society than actual number of years of education; therefore, even small disparities may represent large socioeconomic disadvantages.

It is uncertain whether the advantage conveyed by additional years of education will dissipate as the high school graduate population becomes larger (Freedman & Martin, 1999). That is, relative education status may be more important than absolute status, and additional years of education will confer less advantage as education levels increase in the general population as well (Freedman & Martin, 1999). Thus, changes in the relationship between education and cognitive function may also contribute to changes in the prevalence of impairment. This supposition is consistent with research indicating growing disparities between socioeconomic groups, despite increases in education in the overall population (Schoeni et al., 2005).

Changes in Health Behaviors and Health Status.

Changes in health behaviors and health status may have influenced recent trends in cognitive impairment. Chronic disease risk factors such as smoking, hypercholesteremia and hypertension declined over four National Health and Nutrition Examination Surveys conducted between 1960 and 1990 (Manton et al., 1997). Declines in the prevalence of hypertension may reduce the risk of microinfarct dementia (Manton et al., 1997). Physical inactivity, which is also believed to be associated with late-life cognitive function, has been declining as well (DiPietro, 2001; Freedman et al., 2006).

In addition to changes in the prevalence of disease and associated risk factors, changes in the relationship between chronic conditions and impairment may also contribute to trends in health. Improvements in diagnosis, treatment, and management of disease, as well as change in health behaviors may have attenuated the risk of impairment among those with health conditions (Freedman et al., 2007). For example, treatments for heart and circulatory disease have improved significantly (Schoeni et al., 2008), and the effects of conditions related to cognitive impairment, such as hypertension and stroke, are better controlled (Manton et al., 1997). There has been an increase in use of statins, non-steroidal anti-inflammatory drugs, and hormone replacement therapy, all of which are thought to reduce the likelihood of onset of cognitive impairment, although this is an unintended consequence of treatment and the effects are not proven in experimental research (Suthers et al., 2003). Treatment of depression, a condition highly associated with cognitive impairment (Potter & Steffens, 2007), has also been rising (Harman et al., 2003; Freedman et al., 2006). It is important to note, however, that although improvements in medical treatment and health behaviors have occurred, the prevalence of certain chronic conditions, such as obesity, has been increasing and may counteract positive changes (Freedman et al., 2006).

Race/Ethnicity, Cognitive Impairment, and Trends in Risk Factors

Several risk factors and conditions have been identified as contributing to disparities in cognitive impairment at a point in time. However, research is somewhat limited concerning trends in racial/ethnic differences in health conditions and behaviors related to cognitive impairment. A special excerpt from *Health, United States, 2006* included trend tables for adults aged 65 and older by gender, race and ethnicity, and other select characteristics (National Center for Health Statistics, 2007). The direction of changes in health status and risk factors appeared to be fairly consistent across groups for several outcomes. Age-adjusted death rates for diseases of the heart and cerebrovascular disease declined from 1990 to 2003 for all race/ethnic groups except Hispanics, for whom cerebrovascular death rates were flat. From 1988-2004, hypertension among persons 20 years and older (defined as systolic or diastolic pressure ≥ 140 mmHg or 90 mmHg, respectively, and/or taking antihypertensive medication) increased for all groups except for Mexican American males. On the other hand, elevated blood pressure, which does not include usage of antihypertensive medication in its definition, declined for all males and Mexican American females, but increased slightly for black and white females. According to data from the National Health and Nutrition Examination Survey, treatment of hypertension has increased for all racial/ethnic groups from 1988-2004, and control of hypertension increased among non-Hispanic white men (Ostchega et al., 2007). The percent of older adults with high serum total cholesterol declined for all groups during this time period as well (National Center for Health Statistics, 2007). Smoking declined among older males and females for both whites and blacks from 1990-2004, with larger percentage point declines for blacks (National Center for Health Statistics, 2007). Rates of physical inactivity for older adults decreased somewhat from 1998-2004, while prevalence of overweight increased for all groups. It is unclear what the net effect of these trends will be for racial/ethnic disparities in cognitive impairment.

CHAPTER SUMMARY

The measurement of health trends in older adults is important for determining public health and policy priorities and is especially relevant given the aging of the United States population. Life expectancy among older adults in the United States steadily increased over the 20th century with improvements in sanitation, nutrition, socioeconomic status, and health care. Researchers have proposed several models of population health change to explain potential relative trends in morbidity and mortality. Overall, the health of older adults appears to have improved in recent decades according to most health dimensions. Rates of disability and activity limitations have declined since the 1980s. While the prevalence of certain chronic conditions has increased, severity appears to have declined so that conditions are less debilitating. Limited evidence suggests that the prevalence of cognitive impairment may be declining. However, results have been inconsistent and studies have not investigated trends in disparities. Declines in cognitive impairment would have implications for disability rates and future health and long-term care expenditures, as cognitive impairment contributes to lower levels of functioning, disability, and the need for care. Measuring trends in disparities in cognitive impairment among racial/ethnic and socioeconomic groups is important for detecting inequality in health progress. Healthy People 2010 called for the elimination of health disparities, and advancement towards that goal requires the monitoring of disparities at the level of the population.

The following chapter describes the Health and Retirement Study and Assets and Health Dynamics of the Oldest Old Study samples and details the methodology and statistical approach used in the dissertation.

Chapter 4: Methods

INTRODUCTION

This chapter provides details concerning the study sample, design, independent and dependent measures, and statistical approach and analyses used to address the specific aims. Data for this project came from the Health and Retirement Study and the Assets and Health Dynamics of the Oldest Old Study. The purpose and design of these studies are described, as well as the strengths and limitations of the data with regard to the analysis of trends in cognitive impairment. The analysis plan provides explanations of the analytical techniques used to evaluate changes in the prevalence of cognitive impairment from 1993 to 2004 (Aim I), determine if the pattern of change was consistent across racial/ethnic and socioeconomic groups (Aim II), and explore to what extent demographic, socioeconomic, health behavior, and health status variables explain trends.

STUDY POPULATION

Description of the Health and Retirement Study and Assets and Health Dynamics of the Oldest Old Samples

The Health and Retirement Study (HRS) is an ongoing study of older adults sponsored by the National Institute on Aging and conducted by the University of Michigan. The study was created to provide a detailed overview of the physical and mental health status, insurance coverage, financial state, work status, and retirement planning of the older adult population in the United States (Heeringa & Connor, 1995). The HRS was initially designed as two distinct though closely related panel studies but has evolved into a single study representative of the entire U.S. adult population aged 51 years and older, with new cohorts aged into the sample at 6-year intervals.

The original HRS study was a longitudinal survey initially administered in 1992 to a nationally representative sample of Americans born between 1931 and 1941 (ages 51 to 61) and their spouses (of any age). The sample was selected under a multistage area probability sample design including 4 distinct selection stages: 1) selection of U.S. Metropolitan Statistical Areas (MSAs) and non-MSA counties using probability proportionate to size (PPS); 2) sampling of area segments (SSUs) within sampled primary stage units (PSUs); 3) systematic selection of housing units from the housing unit listings for sample SSUs; and 4) selection of the household financial unit within a sample housing unit (Heeringa & Connor, 1995). Respondents continue to be contacted every 2 years as part of the ongoing HRS.

The second study was the Assets and Health Dynamics of the Oldest Old (AHEAD), a longitudinal survey of a nationally representative sample of adults aged 70 years and older who were living in the community at the time of the baseline interview in 1993/1994. Sampled respondents and their spouses were re-interviewed in 1995 as part of the AHEAD and in later years as part of the ongoing HRS study. The AHEAD cohort was based on the HRS multistage area probability sampling frame plus Medicare enrollment files (Heeringa, 1995). In 1998, the two studies were merged and the sample was expanded to include those born during 1924-1930 and 1942-1947 so as to be representative of the entire U.S. household population aged 51 and older in 1998 (Health and Retirement Study, 2008a). Baseline interviews were conducted in person and follow-up interviews generally administered by telephone at 2 year intervals.

Data from six waves of interviews were employed for the current research: AHEAD 1993, AHEAD 1995, and HRS 1998, 2000, 2002, and 2004. The response rate for the AHEAD sample at baseline was 80%, with re-interview response rates exceeding 94% in follow-up waves. Re-interview response rates were reported separately for each study cohort. However, a similar pattern was observed across cohorts. Rates ranged from 92-94% at the first follow-up, with a slightly upward trend over subsequent waves to about 95-96% in 2004. Overall interview response rates, which take into account the response of re-interview cases, re-contact cases, newly age-eligible spouses, and exit interviews, ranged from 87% to 89% after 1993 (Health and Retirement Study, 2008b). Table 4.1 displays the data collection paths for the HRS and AHEAD and the birth cohorts comprising the study population.

Table 4.1 Birth cohorts, sample sizes, and years of data collection in the Health and Retirement Study and Assets and Health Dynamics of the Oldest Old Survey (1992-2004).

Survey Cohort	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
HRS	→		→		→		→		→		→		→
(1931-1941)	12,521		11,596		10,964		10,865		10,045		9,725		9,362
AHEAD		→		→			→		→		→		→
(< 1924)		8,222		7,802			6,947		5,000		4,107		3,365
CODA							→		→		→		→
(1924-1930)							2,320		2,215		1,951		1,777
WB							→		→		→		→
(1942-1947)							2,529		2,410		2,384		2,295
EBB													→
(1948-1953)													3,330

Abbreviations: HRS-Health and Retirement Survey; AHEAD-Assets and Health Dynamics of the Oldest Old
CODA-Children of the Depression; WB-War Baby; EBB-Early Boomers

Study Sample Size

The six waves of data available for analysis were treated as repeated cross-sections, rather than longitudinal observations. Therefore, respondents who participated in any given wave of the study were included in the analysis for that year. The analysis sample for each wave was restricted to respondents aged 70 years and older at the time of interview. Respondents' spouses who were younger than 70 years old at the time of interview were likewise excluded. In 1998, the HRS/AHEAD (henceforth, HRS) began including both community-dwelling and institutionalized adults in the sample. Respondents who were institutionalized at the time of interview were excluded from the present analysis to maintain comparability with community-dwelling samples in earlier waves. In addition, respondents who identified as "American Indian," "Alaska Native," "Asian," "Pacific Islander," or "Other," but did not identify as Hispanic or Latino, were excluded due to small sample sizes. The same exclusion criteria were employed for each wave of the study. Table 4.2 shows the number of respondents interviewed for each year of the HRS and the age-eligible sample size by respondent status (self or proxy) and race/ethnicity for each wave of data. Sample sizes ranged from 5,911 (1995) to 7,490 (1998). The total sample size for the analyses with merged waves of data was 42,804.

Table 4.2. Sample size by wave, race/ethnicity, and respondent status in the Health and Retirement Study from 1993-2004.

	Wave 1 1993	Wave 2 1995	Wave 3 1998	Wave 4 2000	Wave 5 2002	Wave 6 2004
Interviewed	8,222	7,027	21,384	19,579	18,167	20,129
Aged ≥ 70 at interview	7,443	6,236	8,011	7,896	7,912	8,039
Non-institutionalized	7,443	5,988	7,618	7,470	7,435	7,549
Race/ethnicity						
White, not Hispanic	5,916	4,807	6,133	6,022	5,977	5,981
Black, not Hispanic	1,011	768	900	829	827	893
Hispanic	418	336	457	487	499	543
Total (W, B, Hisp)	7,345	5,911	7,490	7,338	7,303	7,417
Respondent status						
Self-respondent	6,580	5,281	6,715	6,550	6,504	6,761
Proxy respondent	765	630	775	788	799	656

*Sample size shown reduced by the following sequential restrictions: age-eligibility, institutionalization, race/ethnicity identified as white, black, or Hispanic.

Adjustments for Subpopulation Analysis

As noted above, the sample for each wave of data was restricted to a specific population subgroup: persons aged 70 and older who are non-Hispanic white, non-Hispanic black, or Hispanic. Persons younger than 70, respondents residing in a nursing home, and those who did not self-identify in the above race/ethnic categories were excluded. In addition, analyses were conducted separately by proxy status, thereby restricting the analysis sample to either self-respondents or proxy respondents. When complex survey data are subsetted to include only a subgroup of interest, the sample design structure is often compromised because complete design information is not available for variance estimation. This can produce invalid variance estimates, confidence intervals, and tests of hypothesis (Lohr, 1999). Therefore, subpopulation analyses were performed by first creating an indicator variable for subpopulation membership (e.g., 1= Aged 70+; non-Hispanic white, non-Hispanic black, or Hispanic; self-respondent; 0= Aged < 70, or "Other" race, or proxy respondent or nursing home resident). Then analyses were conducted using the full data file, with the subset indicator variable included in a subpopulation statement. This allowed Stata to use information from every observation to compute the variance, standard errors, and confidence intervals of point estimates.

It is also necessary to consider the relationship between sampling weights and subpopulation analyses. Respondents living in nursing homes and age-ineligible respondents were assigned sampling weights of zero by the HRS. Some statistical software packages, such as SAS, exclude observations with missing or nonpositive weights from the analysis. In Stata, only observations with nonzero weights are used to calculate point estimates, similar to SAS; however, all observations are used in variance computation. Using the subpopulation statement with a subset indicator variable in Stata effectively makes the sampling weights zero for everyone not in the subpopulation. Point estimates are thus calculated using only observations in the subpopulation of interest, while the variance, standard errors, and confidence intervals of point estimates are computed using information from all observations.

Data Weighting

HRS Weights

The HRS is a multi-stage probability sample that included oversamples of blacks, Hispanics, and Florida residents as supplements to the core nationally representative sample. Therefore, the use of sampling weights is required to produce unbiased estimates of population parameters. HRS sampling weights compensate for the differential probabilities of selection and are poststratified to the March Current Population Survey (for the year of data collection) by age, sex, race, ethnicity, and marital status groups to account for differential non-response (Health and Retirement Study, 2008a). Poststratification adjustments are made at both the household and respondent level. The respondent-level analysis weight was created as a product of three weights per respondent that addressed household oversampling, eligible members per household, and post-stratification of the data set based on region, race/ethnicity, and marital status. The respondent-level analysis weights for each wave were used in all analyses of the survey data.

Cross-sectional sample weights (household- and respondent-level) are available for each wave of the HRS. For this analysis, respondent-level cross-sectional weights for 1993-2004 were drawn from the HRS Tracker file (Health and Retirement Study, 2008c; Tracker 2006, Version 3.0). In any given wave, the respondent-level weight is zero when the respondent 1) is not cohort eligible during that wave, 2) is residing in a nursing home, or 3) is deceased. Cross-sectional sample weights adjust for non-response and loss-to-follow-up, and were constructed to match the non-institutionalized population for that year. Thus, weighted panels approximate comparable cross-sections of the community-dwelling population of older Americans in the years 1993, 1995, 1998, etc.

Limitations of the Health and Retirement Study Data

Studies that evaluate trends in population health place very high demands on the data in terms of a number of survey features that affect consistency of measurement over time (Freedman & Martin, 2006). Survey design, population coverage, frequency and timing of interviews, mode of interview, proxy rates, and wording changes are several criteria that may affect estimation of trends and represent potential threats to the validity of comparisons over time (Freedman & Martin, 2006; Freedman et al., 2002). The HRS was given a rating of "fair" in a recent systematic review of trends in disability and functioning. The following are limitations of the HRS with regard to investigating trends in cognitive impairment over time:

Survey design

The HRS is a panel survey with aged-in cohorts. Panel designs with replenishment may be used to evaluate trends, and they offer more statistical power and the ability to conduct both cross-sectional and longitudinal analyses (Freedman et al., 2004). However, independent repeated cross-sectional designs have the advantages of no loss to follow-up or repeated exposure to questions, making them more appropriate for the purposes of analyzing trends (Freedman et al., 2004).

Repeated exposure to cognitive function measures

As mentioned above, most respondents in the HRS have been surveyed before, sometimes repeatedly. Respondents in the baseline wave (AHEAD 1993) had never been exposed to the cognitive test, whereas most of those in later waves of the HRS had answered the cognitive tests in prior interviews. Repeated exposure to cognitive measures can result in learning effects. Respondents in later waves have had multiple testing occasions (from 1 to fully 5 exposures), and improvements in scores resulting from repeated exposure to the cognitive measure could potentially confound comparisons over time. This is a major concern with the analysis of trends in cognitive impairment and represents an important limitation of using panel data to study population changes in the prevalence of cognitive impairment. The present research attempted to address threats to the validity of trend estimates resulting from repeated exposure to cognitive testing in 3 ways. First, a cutoff score of 8 out of 35 was chosen to indicate severe cognitive impairment, which is less likely to be affected by repeated exposure than an overall test score. Second, multivariate analyses included prior exposure to a cognitive test as a control variable to adjust for potential effects of repeated exposure. Third, sensitivity analyses employing alternate operationalizations of the prior exposure variable were conducted in an attempt to further explore potential training effects. The measurement of prior test exposure in this project is discussed more fully in the measures section below.

Proxy respondents

The HRS interviews proxy respondents when selected respondents are unable or unwilling to participate themselves. Approximately 10% of the HRS respondents are represented by a proxy. Fluctuations over time in the proportion of proxy respondents in a survey may bias the estimates of trends. Cognitively impaired respondents are more likely to be represented by a proxy, and changes in proxy rates over time may produce a spurious change in the apparent prevalence of cognitive impairment among self-respondents. Analyses examined changes in the proportion of proxy respondents over the study period, and trend results were estimated for both self and proxy respondents.

Population coverage

The institutionalized population was excluded from the HRS until later waves of the study. Therefore, the current research will evaluate trends in cognitive impairment among the community-dwelling population of older adults. Changes in rates of institutionalization of older adults in the United States during the study period may affect estimates of trends in prevalence of cognitive impairment, as cognitive impairment may lead to institutionalization. Analyses examined changes in rates of institutionalization of HRS respondents over the study period.

Strengths of the Health and Retirement Study Data

Despite the limitations enumerated above, the HRS likely represents the best national data set available for the study of trends in late-life cognitive impairment. The HRS was one of the first national health surveys to measure cognitive health and risk factors for cognitive impairment at the population level, and it is one of two to use direct measures of cognition drawn from established clinical instruments. The National Long Term Care Survey also employed direct measures drawn from established instruments; however, cognitive tests were not administered to non-disabled respondents. Cognitive measures in the 1993 and 1995 AHEAD and the HRS were consistent across all study waves, and proxy informants were used to provide an assessment of cognition for those respondents unable to participate.

The HRS is a nationally representative survey of non-institutionalized older adults, enabling results to be generalized to the community-dwelling older population in the United States. Because the HRS represents the United States as a whole, it allows researchers to examine and compare health across income, race/ethnic, and other subgroups. Oversamples of black and Hispanic respondents helped to ensure sufficient sample size in these subgroups. The sample size of the HRS at each wave is large enough to detect, with generally acceptable power of 0.80 and alpha=0.05, small changes in prevalence of disease at the population level (on average, approximately 1-2% change per year), even after accounting for complex survey design (Freedman et al., 2002).

Interviews are conducted every 2 years and sample is periodically replenished with incoming cohorts and spouses who age-in to the sample. Because of the frequency of measurement in the HRS, the current research will be able to employ 6 time points over an 11-year time frame. Estimates of prevalence of disease may fluctuate from year to year, and multiple time points provide for a more accurate estimate of overall trends in health. Finally, the HRS includes a wide variety of variables that may be used to characterize the economic circumstances, occupation and employment, health and health care, living arrangements, and demographic and family relationships of respondents and, in the current research, may be used to account for observed trends and trends in disparities.

MEASURES

Table 4.3 displays the independent and dependent variables used in the analyses. The coding and definition for each variable is included, as well as the years that the variable was examined.

Table 4.3. Variables from the Health and Retirement Study used to examine trends in the prevalence of cognitive impairment among older adults (1993-2004).

Variable	Definition
Dependent variables:	
Self-respondents (1993-2004)	
Cognitive impairment	Summary measure of immediate and delayed recall and mental status items, with total score ranging from 0-35, with higher scores indicating better functioning. Impairment defined as score of ≤ 8.
Proxy respondents	
Cognitive impairment (1993-2002) Global ratings and behavioral symptoms	Respondents classified as cognitive impaired if memory and judgment rated poor, or if they exhibited ≥ 2 behavioral symptoms.
Cognitive impairment (1995-2004) Jorm IQCODE	Informant-rated respondent ability regarding different aspects of memory and intelligence, compared to 2 years ago. Total of 16 items rated from 1 (much better) to 5 (much worse). Average score of ≥ 3.38 indicates cognitive impairment.
Explanatory variables:	

Variable	Definition
Year of wave	Trend variable takes the value of 0 in 1993 and increases by 1 in each subsequent calendar year. Ranges from 0-11, and was coded as a continuous variable.
Demographic characteristics	
Age	Respondents' age at time of interview. Only those aged 70 or older included. Coded as continuous and in 5-year age groups.
Gender	Coded 1 if respondent is female, 0 if male.
Race/ethnicity	
Non-Hispanic White (ref)	Coded 1 if the respondent self-identified as NH White, 0 otherwise.
Non-Hispanic Black	Coded 1 if the respondent self-identified as NH Black, 0 otherwise.
Hispanic	Coded 1 if the respondent self-identified as Hispanic (any race), 0 otherwise.
Marital status	Married/has partner (ref), not married/partnered
Birthplace	Northeast (ref), Midwest, South, West, U.S. territory/outside U.S., or unknown
Veteran status	Coded 1 if respondent indicated he/she was a veteran
Socioeconomic status	
Education	Highest grade of school or year of college completed. Responses classified as 0-8, 9-11, 12, and > 12, and continuous
Net worth	The net value of total wealth (excluding second home) calculated by the sum of 12 assets or wealth components less all debt. Values for each wave are adjusted to 1993 dollars and stratified into tertiles.
Mother's education	Indicator of early life socioeconomic status coded as < 8 or ≥ 8 years.
Health Status and Health Behavior	
Chronic conditions	Has a doctor told you that you have [chronic condition] . Coded as 1 for yes, 0 otherwise. Chronic conditions examined include: high blood pressure, diabetes, cancer, lung disease, heart condition, stroke, psychiatric disorder.
Obese	Calculated with respondents' self report height and weight. BMI of ≥ 30 kg/m2 considered obese.
Smoking status	Categorized as never (ref), current, or former.
Vision impairment	Self-rated vision classified as excellent, very good, good, fair, or poor.
Hearing impairment	Self-rated hearing classified as excellent, very good, good, fair, or poor.
Other Adjustment Variables	
Prior test exposure	Measured as a dichotomous variable indicating whether or not a respondent had been previously tested.

Dependent Variables

Cognitive Functioning and Impairment

The measurement of cognitive status in the HRS/AHEAD differed for self- and proxy respondents. The cognitive functioning measures for self-respondents were consistent across all six waves of data to be included in the proposed analysis. There were a few minor changes implemented beginning in AHEAD 1995, which will be explained below in the description of the cognitive test components. The cognitive measures included for proxy respondents varied somewhat across waves. The changes will be explained below.

<u>Self-respondents</u>

Cognitive functioning of self-respondents was assessed using a multidimensional measure based on a modified version of the Telephone Interview Cognitive Screen (TICS), and tests of immediate and delayed verbal recall. The cognitive measures in the HRS/AHEAD were selected to 1) represent the major dimensions of cognitive functioning and differentiate across the full range of cognitive abilities, even at the higher end of functioning, and 2) provide differentiation at the low functioning end of cognitive abilities, in order to identify respondents who experience cognitive impairment (Ofstedal et al., 2005).

The total cognition score comprised four areas of functioning. Memory was assessed with an immediate word recall list of 10 nouns and a 5-minute delayed word recall task in which respondents were asked to recall the nouns presented as the immediate recall task. Beginning in 1995, four different noun lists were employed (compared to one list in 1993) to allow alternating of lists over waves and the administration of different lists to respondents in the same household. Working memory was assessed using the Serial 7's subtraction test in which respondents were asked to subtract 7 from 100 and continue subtracting 7 from each successive number. Mental status was assessed with a backward count from 20 and date naming. Respondents were asked to report "today's date", including month, day, year, and day of the week. Beginning in 1995, respondents were instructed to count backwards "as quickly as possible" so the measure would be a better indicator of information processing speed, and two trials were used to increase reliability of the measure. In the object naming task, respondents were asked to give the name of the "prickly plant that grows in the desert" (cactus) and "sharp item used to cut paper" (scissors), and they were also asked to name the President and Vice President of the United States. See Appendix for measurement details.

Scores from each of the component measures (memory, working memory, mental status, and object naming) were combined into a single summary measure of cognitive function scaled from 0 to 35, with higher scores representing better functioning. The internal consistency reliability of the test was examined for all six waves of data prior to analyses, and results indicated that the reliability was adequate, though lower than expected. More detailed results will be reported in Chapter 5.

Cognitive impairment was defined as a score of 8 or less on the summary measure, according to the practice of AHEAD investigators and previous research (Herzog & Wallace, 1997; Freedman et al., 2001; Suthers et al., 2003). This threshold has been tested in prior validation studies, which showed that it is a sensitive and specific indicator of clinical dementia (Plassman et al., 1993; Welsh et al., 1993). In addition, this threshold is consistent with methods used for the Aging, Demographics, and Memory Study (ADAMS), a supplemental study of dementia in the HRS (Langa et al., 2005). Moreover, there is evidence that this threshold yields a community prevalence of dementia consistent with other population estimates (United States General Accounting Office, 1998). Cognitive impairment as indicated by a score of 8 or less on the AHEAD measure is also predictive of risk of institutionalization (Banaszak-Holl et al., 2004). The sensitivity of the analyses to this cut-off value was explored by assuming alternate cut-offs, and results of the sensitivity analyses are included in Chapter 5.

Proxy Respondents

A different set of measures was used in the proxy interview to assess the respondent's present cognitive status. Proxy respondents were asked to assess respondents' overall memory and judgment skills as excellent, very good, good, fair, or poor. Proxy respondents were also asked to report on the frequency of the following behavioral symptoms: getting lost in familiar environments, wandering off and not returning, having hallucinations, inability to be left alone for an hour or so, becoming angry without reason, having difficulty sleeping, doing things that are dangerous, pacing or rocking, mentioning that people are plotting against him/her, and drinking too much alcohol. Finally, proxy respondents were asked about the change (compared with 2 years ago) in the respondent's ability to remember various types of information. The 16 questions were adapted from the short form of the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE; Jorm, 1994). See Appendix for measurement details. The cognitive measures included in the survey varied from wave to wave. Table 4.4 below indicates the waves that a particular measure was included in the survey.

Table 4.4 Proxy cognitive measures by wave of survey, Health and Retirement Study (1993-2004)

Year	1993	1995	1998	2000	2002	2004
Global Ratings						
Memory at present time	X	X	X	X	X	X
Making judgments/decisions	X	X	X	X	X	
Behavioral Symptoms						
Lost in familiar environment	X	X	X	X	X	X
Wander off and not return	X	X	X	X	X	X
Can be left alone for an hour	X	X	X	X	X	X
See/hear things not there	X	X	X	X	X	X
Angry/hostile	X	X	X	X	X	
Difficulty falling asleep	X	X	X	X	X	
Dangerous behavior	X	X	X	X	X	
Pacing/rocking	X	X	X	X	X	
Thinks ppl plotting/harming	X	X	X	X	X	
Excessive alcohol consumption	X	X	X	X	X	
JORM IQCODE		X	X	X	X	X

Since proxy measures of cognitive status varied across waves, the classification of cognitive impairment varied according to the time interval being examined. From 1993-2002, respondents were classified as cognitively impaired if their memory and judgment were rated poor, or if they exhibited 2 or more behavioral symptoms (Suthers et al., 2003). From 1995-2004, respondents who scored 3.38 or higher on the Jorm IQCODE were classified as cognitively impaired, according to established norms and cut-offs for community-dwelling populations (Jorm, 2004). Research shows that the Jorm IQCODE discriminates well between those with and without diagnosed dementia (Jorm, 1994; Jorm, 2004). Recent results from the Aging, Demographics, and Memory Study (ADAMS) show that approximately 60% of the age 70 or older respondents who were represented by a proxy in the 2002 HRS had cognitive impairment (including both community-dwelling and institutionalized respondents) (Langa et al., 2005).

Missing Data

A small percentage of respondents in each wave (0.8% to 5.7%) did not respond to the tests of immediate and delayed recall and Serial 7's. Respondents who do not respond to cognitive test questions perform significantly worse on the questions they did answer compared to those who completed the task (Herzog & Wallace, 1997). It is necessary to account for missing responses on cognitive tests because missing answers from low-functioning respondents will bias prevalence estimates derived from the survey towards a cognitively well-functioning population.

In the present analyses, respondents refusing to perform a task were assigned a score for that task according to recommendations from Herzog and Wallace (1997) and the practice of other AHEAD investigators (Freedman et al., 2001): 2 out of 10 for immediate recall, 0 out of 10 for delayed recall, 1 out of 5 for Serial 7's, and 0 for those who refused or responded "don't know" for an item within a subscale. Two alternative methods for dealing with missing data were also examined: 1) deleting respondents with missing items and 2) assigning a score of 0 to the items or subscales with missing items. Alternative methods for dealing with refusals and missing data are reviewed in Chapter 5.

Independent Variables

Year of Wave

The key independent variable in the analysis was a linear trend variable representing survey year. The "year" variable takes the value of 0 in 1993 and increases by 1 in each subsequent calendar year to 11 in 2004. The linear trend variable assumes linearity of slope; therefore, second- and third-order polynomial terms of the year of wave were also explored.

Race/Ethnicity

To determine respondents' self-identified racial/ethnic groups, they were first asked, "Would you say you are Mexican American, Puerto Rican, Cuban American, or something else?." Second, they were asked, "Do you consider yourself primarily white or Caucasian, black or African American, American Indian, or Asian, or something else?" Respondents who identified as American Indian, Asian or other were excluded from the sample, and race/ethnicity was categorized as non-Hispanic white, non-Hispanic black, and Hispanic. The following race/ethnic categorizations were also explored: non-Hispanic white and all other racial/ethnic groups; non-Hispanic black and all other groups.

Demographic Variables

Analyses were adjusted for other demographic variables, including age, gender, and marital status. Age was specified as continuous and categorical (70-74, 75-79, 80-84, and 85+). It was necessary to adjust trend analyses for age of respondents, as the age distribution of the sample could vary somewhat across waves, and age is highly associated with cognitive impairment. Marital status was categorized as married/has partner and not married/partnered. Analyses were also adjusted for place of birth.

Socioeconomic Status

Education and net worth were used to indicate the socioeconomic status of respondents. Respondents were asked about the highest grade of school or year of college they completed, and responses were classified as 0-8, 9-11, 12, and more than 12. Education was also used as a continuous variable. Net worth was calculated by subtracting the sum of 3 different debts from the sum of a list of 10 assets. Net worth was adjusted to 1993 dollars and stratified into tertiles. Mother's education (<8 vs. at least 8 years) was included as an early-life indicator of socioeconomic status.

Missing values for asset, income, and debt variables were imputed by the RAND Corporation for the RAND HRS Data file using a consistent method for each wave of data. RAND developed a progressive imputation process: first, ownership of the asset or income type; second, given ownership, brackets indicating the range of value; and third, given brackets, an exact dollar amount (RAND Center for the Study of Aging, 2009). For income imputations, explanatory covariates included husband and wife employment status, education, health status, age, race, marital status, occupation class, cognition, bequest motive. For wealth imputations, explanatory covariates included the same set as above, but including income amounts and indicators of pension or government benefit receipt and excluding employment status.

Health Status and Health Behavior Variables

Respondents reported whether a doctor had ever told them that they had high blood pressure, diabetes, cancer, lung disease, heart disease, a stroke, or psychiatric disorder. Responses for each condition were classified as yes/no. Respondents were classified as obese if they had a body mass index of at least 30 kg/m^2. Smoking status was categorized as never, current, or former. Two measures of sensory impairment were included, vision impairment and hearing impairment, based on self-rated vision and hearing.

Other Adjustment Variables

Multivariate analyses included a variable indicating prior exposure to the cognitive test. As mentioned previously, most respondents in the HRS have had repeated exposure to the cognitive measure over the study period. Repeated assessment with the same cognitive instrument can result in an improvement in performance—a practice or learning effect—confounding comparisons over time. Prior test exposure was included as a covariate in order to adjust for the potential effects of repeat testing in this sample. For each wave of data, prior test experience was measured as a dichotomous variable indicating whether or not a respondent had been previously tested. This is consistent with the way that other researchers have adjusted for retesting effects (Rodgers et al., 2003). However, a simple dichotomous variable indicating whether or not a respondent has been previously exposed to the cognitive measure does not capture the full effects of multiple testing sessions. Therefore, sensitivity analyses were conducted which included dichotomous variables with progressively higher contrasts (≥ 2 tests vs. < 2 tests; ≥ 3 tests vs. < 3 tests; ≥ 4 tests vs. < 4 tests) in all trend analyses to investigate whether these alternate indicators of multiple testing meaningfully diminish the trend variable import. First, a dichotomous variable indicating ≥ 2 test exposures vs. < 2 test exposures was included in the trend analyses. Then, in separate models, a dichotomous variable indicating ≥ 3 test exposures vs. < 3 test exposures was included in trend analyses. Finally, a dichotomous variable indicating ≥ 4 test exposures vs. < 4 test exposures was included in trend analyses. Unfortunately, due to study design, a variable indicating a count of prior test exposures could not be included in multivariate analyses; the coefficients for the count variable and the year trend variable were correlated at 0.86. The measurement of prior test exposure in this study is a limitation, which will be discussed in the study limitations section of the Discussion chapter. To the extent that the measurement of prior testing was inadequate and did not completely capture the effect of retesting on cognitive impairment, the reported trend results could be biased.

ANALYSIS PLAN

Measurement Properties

Prior to addressing the specific aims, analyses were conducted to assess the measurement properties of the cognitive scale in the total sample as well as within race/ethnic groups. First, the internal consistency reliability of the scale was estimated in order to determine the extent to which the items on the cognitive measure were interrelated and had high communalities. The internal consistency reliability of the test was assessed using Cronbach's alpha coefficients produced by the PROC CORR procedure in SAS. The reliability was calculated for each wave of data using three methods of dealing with missing cognitive data: 1) refusals/missing not included in analyses, i.e. unimputed data; 2) refusals/missing given low scores; and 3) refusals/missing given 0's for the items or subscale missing data. Exploratory factor analysis was also conducted on the cognitive test scores for wave 1 to investigate the underlying factor structure of the measure. The cognitive scale in the HRS is a multidimensional measure, and previous research has indicated that the scale may be used as a one factor (general cognitive functioning) and/or a two factor test (memory and mental status) (Herzog & Wallace, 1997; Ofstedal et al., 2005). The results in this project showed that the cognitive measure is best operationalized as two factors. However, for the purposes of this research in order to maintain consistency and comparability with prior studies, the cognitive measure was used as one factor indicating overall cognitive functioning. There are flaws to this approach. Therefore, sensitivity analyses were conducted to test the robustness of results and determine if similar patterns were observed for both factors as well as for the overall test. The psychometric limitations of the cognitive measure are reviewed in Chapter 7.

Overall Approach

Descriptive and bivariate analyses were performed to show the percentage distributions for demographic, socioeconomic, health behavior, and health status variables at each wave and over time. Chi-square tests were used to assess changes in sample characteristics over the six wave study period. Sensitivity analyses included an examination of trends in mortality, loss-to-follow-up, and institutionalization. Multinomial logit models with a continuous trend variable were used to test for changes over time in the risks of mortality, loss to follow-up, and institutionalization.

Overall prevalence of cognitive impairment was calculated for each wave, and the unadjusted trend was tested using logistic regression, with a linear trend variable as the key predictor. Logistic regression models were adjusted for age, gender, and prior test exposure, and interactions between the linear trend variable and race/ethnicity and socioeconomic variables were included to test disparities in cognitive impairment trends. Finally, analyses included demographic, socioeconomic, health status, and health behavior variables to determine which factors account for the overall and racial/ethnic and socioeconomic trends. All trend analyses were stratified by proxy status. Second- and third-order polynomial terms were included to test the assumption of linearity of the trend variable. As most respondents appear in more than one wave, observations are not independent and the errors within individuals are likely to be correlated. The survey procedures in Stata are very conservative and adjust for correlations among observations resulting from repeated observations (Statalist Users Site). Nevertheless, it is possible to specify two levels of clustering in Stata using the svset procedures. To adjust for the overlap in samples across waves, the respondent ID was set as a cluster variable. Analyses were repeated with and without this specification, and standard errors for parameter estimates were identical. All analyses adjusted for the complex survey design of the HRS. Data were weighted to account for oversampling and post-stratification adjustments to CPS estimates, and standard errors were adjusted to account for geographic clustering. The method of variance estimation was Taylor series linearization. The SAS system version 9.2 was employed to manage the data, and the Stata system version 11 was used to analyze the data using survey procedures.

Specific Aim I

Sampling weights in the HRS account for loss to follow-up and non-response to facilitate cross-sectional estimates, enabling merged waves to represent comparable cross-sections of the community-dwelling older adult population in the United States in each respective year of study. Therefore, in these analyses all six waves of data (1993, 1995, 1998, 2000, 2002, 2004) were merged and logistic regression models were used to assess trends in cognitive impairment. The dependent variable in all analyses was presence or absence of cognitive impairment (total cognition score $\leq$ 8). The key explanatory variable was the linear trend variable, which was represented as 0 in the base year (1993) and increased by 1 in each subsequent calendar year. An odds ratio (OR) of less than 1 for the trend variable would indicate a decrease in the prevalence of cognitive impairment over the study period. Subtracting the OR from 1 and multiplying by 100 [(1-OR)*100] yields the value of the percent decrease per year. The following models were used to assess changes in the prevalence of cognitive impairment over the study period. Model 1 provided an estimate of the unadjusted average annual change in cognitive impairment across the entire population aged 70 years and older during the 1993 to 2004 period. Model 2 provided an age-, gender, and prior testing-adjusted estimate of the average annual change in cognitive impairment across the entire population during the study period. The models are shown below:

Model 1: $Y_{\text{cognitive impairment}}$ = year

Model 2: $Y_{\text{cognitive impairment}}$ = year + age + gender + prior test

Model 3: $Y_{\text{cognitive impairment}}$ = year + age + gender + prior test + sociodemographics + health

Model 4: $Y_{\text{cognitive impairment}}$ = year + age + gender + prior test + health + health*year

Additional analyses were performed to determine the contributions of shifts in the sociodemographic composition of the population and changes in health behaviors to cognitive impairment trends. Analyses also explored the contributions of changes in the prevalence of chronic conditions and changes in the risk of cognitive impairment among those who report having a given condition. Logistic regression models were used to model the prevalence of cognitive impairment as a function of demographic, socioeconomic, health status, and health behavior variables. Two sets of models were analyzed. The first set of models examined to what extent compositional changes accounted for trends in impairment. The base model for the first set of analyses included a linear trend variable, age, gender, and prior test exposure. Demographic, socioeconomic, health behavior, and health status variables were added to this model sequentially as a block of variables and individually. As variables were entered into the model, changes in the strength, direction of influence, and significance of the linear trend variable were examined to determine to what extent the trend was attenuated or enhanced. The second set of models included interaction terms between health conditions and the year trend variable to determine if the association between a given health condition and cognitive impairment varied over time. Improvements in medical care, diagnosis, treatment, or control of disease could lead to changes over time in the risk of cognitive impairment associated with a particular health condition. In addition to analyses using pooled waves of data, the bivariate associations between cognitive impairment and sociodemographic, health behavior, and health status variables were examined for each wave of data separately.

Specific Aim II

To assess trends in racial/ethnic and socioeconomic disparities in cognitive impairment, interaction terms were added to the age- and gender-adjusted logistic regression model from Specific Aim I. Interaction terms allowed the trend in cognitive impairment to vary by race/ethnicity, education, and tertiles of net worth. All models containing interaction terms (e.g. race/ethnicity*year) also included direct effects of that factor (e.g. race/ethnicity). Interaction terms first were added separately to the models to determine the individual effects of each (Models 1-3). The final model included all three interaction terms and their respective direct effects. Allowing differential trends by race/ethnicity, education, and net worth groups simultaneously shows the extent to which the disparities in trends for each factor were accounted for by differential trends in the other 2 factors. The models are shown below:

Model 1: $Y_{\text{cognitive impairment}}$ = year + race/ethnicity + race/ethnicity*year + (age + gender + proxy)

Model 2: $Y_{\text{cognitive impairment}}$ = year + education + education*year + (age + gender + proxy)

Model 3: $Y_{\text{cognitive impairment}}$ = year + net worth + net worth*year + (age + gender + proxy)

Model 4: $Y_{\text{cognitive impairment}}$ = year + race/ethnicity + race/ethnicity*year + education + education*year + net worth + net worth*year + (age + gender + proxy)

If trends in cognitive impairment vary by racial/ethnic or socioeconomic group, additional analyses will be performed to explore whether sociodemographic or health variables attenuate trends in disparities. Analyses will be very similar to those described in Specific Aim I and will involve the inclusion of sociodemographic, health behavior, and health status variables, as well as interaction terms between health conditions and year, to the models shown above.

Chapter 5: Specific Aim I Results

Chapters 5 and 6 detail the results of analyses used to address Specific Aims I and II. Results are presented in several sections. First, the descriptive statistics are presented for each wave of the study. Next, multivariate logistic regression analyses are presented to determine whether including sociodemographic and health variables attenuate trends in cognitive impairment. Finally, longitudinal models examining predictors of incident cognitive impairment are presented, as well as sensitivity analyses.

DESCRIPTIVE STATISTICS

Sample Size

The sample at each wave of the study included non-Hispanic white, non-Hispanic black, and Hispanic adults aged 70 years and older at the time of interview. Respondents who were institutionalized at the time of interview were not included in the sample for that wave. Table 5.1 shows the sample size at each wave of the study by respondent status and race/ethnicity.

Table 5.1. Sample size by year of study, respondent status, and race/ethnicity in the Health and Retirement Study from 1993-2004.

Year	1993	1995	1998	2000	2002	2004
Self-respondent						
White	5,363	4,368	5,591	5,474	5,419	5,546
Black	877	652	757	690	696	767
Hispanic	340	261	367	386	389	448
Total	6,580	5,281	6,715	6,550	6,504	6,761
Proxy respondent						
White	553	439	542	548	558	435
Black	134	116	143	139	131	126
Hispanic	78	75	90	101	110	95
Total	765	630	775	788	799	656
Total	7,345	5,911	7,490	7,338	7,303	7,417

The sample size in 1995 is considerably lower compared to other years; this reflects the study design of the AHEAD, as no new cohorts were added in 1995. Therefore, the sample consisted of respondents from the 1993 AHEAD and spouses who had aged-in to the sample.

Changes in the Composition of the Population over Time

Demographic Variables

The composition of the older adult population changed between 1993 and 2004 in terms of sociodemographic characteristics as well as health risk profile. Table 5.2 below presents the weighted descriptive characteristics of the study samples for each year. The mean age of the samples varied over time, and the proportion of female respondents declined over the study period. The proportion of the sample that self-identified as Hispanic increased from 1993 to 2004, and there was a corresponding decrease in whites and blacks. Older adults in 2004 were more likely to be born in the West and less likely to be born in the South or a U.S. territory/outside the U.S. The proportion of the sample represented by a proxy respondent was approximately 9-10% from 1993 to 2002 but decreased to 8.13% in 2004.

Socioeconomic Status

The socioeconomic status of the older population steadily improved over time. Older adults in 2004 were less likely to report mothers having fewer than 8 years of education. The educational attainment of the respondents themselves likewise increased over time, from a mean of 11.05 years in 1993 to 12.01 years in 2004. This 1 year increase in mean years of education represents fairly large increases in the proportion of adults completing high school. In 1993, 58% of adults aged 70 and older had completed high school, and in 2004, 71% of older adults had completed high school. The percent of older adults with less than a high school education decreased from 42% to 29%, and those with more than high school increased from 27% to 35%. Later cohorts also had higher total wealth (in constant 1993 dollars). In 1993 35% of adults had total wealth of greater than $145,000 compared to 50% in 2004.

Table 5.2. Trends in demographic, socioeconomic, and health status and behavior variables in adults aged ≥ 70 years in the United States from 1993-2004, Health and Retirement Study.

Year	1993	1995	1998	2000	2002	2004	
Sample size	7,345	5,911	7,490	7,338	7,303	7,417	*P* value
Demographic variables							
Age (mean ± SE)	77.49 ± 0.10	79.23 ± 0.09	77.07 ± 0.10	77.23 ± 0.10	77.55 ± 0.09	77.65 ± 0.10	<0.001
Median year of birth	1917	1917	1921	1923	1925	1927	
Female	60.00	60.07	59.40	59.05	59.22	58.42	0.038
Race/ethnicity							
White, non-Hispanic	88.34	88.37	87.42	86.74	86.98	87.61	0.003
Black, non-Hispanic	8.03	8.01	8.02	8.27	7.85	7.61	
Hispanic	3.63	3.62	4.56	4.99	5.16	4.78	
Region of birth							
Northeast	22.95	22.88	22.08	22.30	22.64	23.20	0.049
Midwest	30.79	31.69	32.37	32.46	32.09	31.74	
South	30.81	30.23	30.41	30.05	29.60	29.28	
West	7.12	7.14	7.82	7.85	8.11	8.40	
U.S. terr./outside U.S.	8.33	8.05	7.31	7.34	7.56	7.39	
Marital status							
Married/has partner	52.47	51.91	52.25	52.89	52.87	53.22	0.185
Not married/partnered	44.29	45.27	44.91	44.38	44.50	44.21	
Never married	3.24	2.81	2.84	2.73	2.64	2.57	
Proxy respondent	10.11	10.17	9.35	9.78	9.83	8.13	0.001
Socioeconomic variables							
Mother's education							
Fewer than 8 years	40.05	39.68	33.05	30.34	28.25	25.90	<0.001
8 or more years	48.11	49.48	54.39	56.41	59.19	62.32	
Missing	11.83	10.84	12.56	13.25	12.56	11.78	
Education							
0-8 years	24.68	23.64	19.79	18.32	16.42	14.54	<0.001
9-11 years	17.20	16.45	16.01	15.32	14.78	14.63	
High school/GED	30.84	31.49	32.95	33.71	34.52	35.61	
More than high school	27.27	28.42	31.41	32.84	34.52	35.40	
Total wealth (in 1993 $)							
< $0--< $40,000	30.47	26.85	26.18	25.45	23.95	23.84	<0.001
$40,000--< $145,000	34.21	32.32	30.28	29.32	28.33	26.05	
≥ $145,000	35.31	40.83	43.54	45.23	47.72	50.11	

Table 5.2. Continued.

Year	1993	1995	1998	2000	2002	2004	
Sample size	7,345	5,911	7,490	7,338	7,303	7,417	*P* value
Health status and behavior							
Chronic conditions							
Hypertension	49.19	51.74	53.55	55.58	59.46	62.07	<0.001
Diabetes	12.36	13.76	15.11	16.06	17.71	19.09	<0.001
Cancer	14.06	16.14	15.83	16.71	18.39	19.62	<0.001
Lung disease	11.87	11.42	11.07	10.89	11.23	11.65	0.291
Heart disease	31.91	34.37	33.53	30.68	34.05	34.92	<0.001
Stroke	10.47	10.88	10.97	10.12	10.50	10.21	0.337
Psychiatric disorder	10.81	11.55	12.35	12.19	13.28	13.35	<0.001
Depressive symptoms	1.55 ± 0.03	1.39 ± 0.03	1.59 ± 0.04	1.58 ± 0.03	1.52 ± 0.03	1.46 ± 0.02	0.854
Obese (BMI ≥ 30 kg/m2)	13.13	12.43	15.16	16.18	17.91	18.66	<0.001
Smoking							
Current	9.81	7.37	9.27	8.61	7.77	7.42	<0.001
Former	42.81	44.77	45.23	46.24	47.37	48.13	
Never	47.38	47.86	45.50	45.15	44.86	44.45	
Self-rated vision							
Excellent/very good	37.76	27.79	30.58	32.11	32.18	31.06	<0.001
Good	35.99	39.50	41.69	41.89	43.22	43.52	
Fair/poor/legally blind	26.25	32.71	27.73	26.01	24.60	25.41	
Self-rated hearing							
Excellent/very good	37.08	35.13	35.90	36.38	35.49	34.27	0.006
Good	36.82	36.48	36.01	35.95	37.05	36.07	
Fair/poor	26.10	28.39	28.10	27.67	27.46	29.66	

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

Abbreviations: SE, standard error; BMI, body mass index.

P value for χ^2 or t test (for year trend variable from linear regression) for a significant difference in proportion or mean across years.

Health Status and Behavior

In terms of health status, prevalence rates of cardiovascular risk factors and cardiovascular disease, including hypertension, diabetes, heart disease, and obesity, increased in the older population from 1993 to 2004. There were also increases in reports of cancer, psychiatric disorder, and hearing problems. Smoking rates decreased from 1993 to 2004. The increasing prevalence of chronic conditions over time is counter to Hypothesis 1c., which posited that declines in the prevalence of chronic conditions and smoking would contribute to observed trends in cognitive impairment. However, the decline in smoking is consistent with Hypothesis 1c.

Self-respondents and Proxy Respondents

Trends in sample characteristics were also estimated separately for self-respondents and proxy respondents. Analyses for Specific Aims I and II were stratified by proxy status because cognitive measures differed for self-respondents and proxy respondents.

In general, the trend patterns were similar for self-respondents and proxy respondents, especially in terms of direction of change and statistical significance. The magnitude of change over time differed between self- and proxy respondents, which is to be expected given the important differences in sociodemographics and health status between these groups. Although patterns of change in sample characteristics were very similar, there were a few exceptions. The racial/ethnic composition of the proxy respondents changed over time so that proxy respondents in 2004 were more likely to be black and Hispanic than those in 1993. There was no increase in the prevalence of cancer among proxy respondents, and the changes in heart disease and declines in smoking were not statistically significant. Reports of psychiatric disorder increased among proxies. These tables are included in the Appendix (Tables A.1. and A.2.).

Cognitive Function Measure

Cognitive function was assessed using a summary measure of immediate recall, delayed recall, and mental status items. Potential scores on the cognitive measure range from 0-35, with higher scores indicating better functioning. The measurement properties of the cognitive measure were assessed using exploratory factor analysis and tests of reliability, described below.

Measurement Properties

Exploratory factor analysis using oblique rotation (which allowed the factors to be correlated as indicators of general cognitive functioning) was conducted to examine the factor structure underlying the cognitive measure. Results were consistent with those of HRS/AHEAD investigators as shown in the documentation report of cognitive functioning measures in the HRS (Ofstedal et al., 2005). The results of the analysis yielded two factors, a memory factor (immediate and delayed recall items) and a mental status factor (Serial 7s, counting backward, dates, word/object naming), that were moderately related to one another.

Table 5.3 shows the factor loadings, eigenvalues, and variance accounted for by the factors for three methods of dealing with missing data: 1) unimputed data, i.e. respondents with missing responses to cognitive items were not included in analyses; 2) respondents with missing responses to cognitive items given low scores (2/10 on immediate recall, 0/10 on delayed recall, 1/5 serial 7's, and 0 for any missing item within a subscale); and 3) respondents with missing data given score of 0 for the item. The method of assigning low scores to refusals is practiced by AHEAD investigators (Herzog & Wallace, 1997; Freedman, Aykan, & Martin, 2001) and was chosen for trend analyses in this project. (The sensitivity of trend results to alternative coding schemes for missing data is explored in the Specific Aim I results section.)

Table 5.3. Factor loadings of cognitive functioning items, eigenvalues, and variance accounted for by cognitive functioning factors according to missing data coding scheme in a sample of adults aged 70 and older, Health and Retirement Study (1993)

Coding scheme	Unimputed		Low scores for missing		Zero for missing	
	Factor 1	Factor 2	Factor 1	Factor 2	Factor 1	Factor 2
Immediate recall	0.91		0.90		0.89	
Delayed recall	0.91		0.90		0.91	
Serial 7s		0.51		0.49		0.50
Counting backward		0.46		0.57		0.56
Dates		0.58		0.58		0.58
Name cactus		0.41		0.46		0.47
Name scissors		0.05		0.23		0.20
Name President		0.67		0.66		0.68
Name Vice President		0.65		0.54		0.56
Eigenvalue (Variance)	2.7 (30%)	1.1 (12%)	3.2 (35%)	1.1 (12%)	3.2 (36%)	1.1 (12%)
Correlation between Factors (r)	0.46		0.53		0.54	

Note: Results from principal factor analysis using oblique rotation with weighted data among age-eligible self-respondents.

Factor loadings and eigenvalues were fairly similar across coding schemes. The factor loading for the scissors item was quite low for the unimputed data, and previous investigations have excluded the scissors item from factor analyses. However, after assigning low or zero scores for missing responses, the scissors item appeared to load better on the mental status factor. The variance accounted for by the two factors ranged from 42% for unimputed data to about 48% for the other two coding schemes. The two factors were moderately correlated with each other, with correlation coefficients ranging from 0.46 to 0.54.

Researchers have suggested that these results indicate that a composite or aggregate score of overall cognitive functioning may be formulated, as well as a two-factor measure (Ofstedal et al., 2005; Herzog & Wallace, 1997). For the purposes of this project examining changes in the population prevalence of cognitive impairment, it is more meaningful to use the test as a summary measure of general cognitive functioning, rather than examine the two components separately. However, the two dimensional nature of the cognitive measure is a limitation, and the cognitive measure may best be viewed as a count of 0-35 cognitive items rather than as a scale of general cognitive functioning.

Table 5.4. Factor loadings of cognitive functioning items, eigenvalue, and variance accounted for by cognitive functioning factor in a sample of adults aged 70 and older, Health and Retirement Study (1993)

Cognitive Items	Factor Loadings
Immediate recall	0.76
Delayed recall	0.73
Serial 7s	0.63
Counting backward	0.54
Dates	0.59
Name cactus	0.55
Name scissors	0.26
Name President	0.57
Name Vice President	0.59
Eigenvalue (Variance)	3.2 (35%)

Note: Results from principal factor analysis with weighted data among age-eligible self-respondents.

Exploratory factor analysis was repeated and the NFACTOR option was used to retain one factor rather than two. The retained factor had an eigenvalue of 3.2 and accounted for 35% of the variance. The scree plot, which graphs the eigenvalues for each extracted factor (including those not retained) in descending order resembled an ‘L’ shape, with the second factor forming the elbow. The first factor accounted for the most variance and successive factors accounted for smaller and smaller amounts of variance. The scree test guidelines indicate that factors above the elbow should be retained and those below it should be rejected; therefore, these results suggest that one factor may be appropriately retained. Table 5.4 shows factor loadings of cognitive test items on the retained factor. Factor loadings are acceptable, ranging from 0.54 to 0.76, except for the scissors item, which is lower. It is clear that the scissors item does not load onto the cognitive measure, likely due to the low variability of this item, which most respondents answered correctly. However, to maintain consistency and comparability with previous research (Freedman et al., 2001; Langa et al., 2008), the scissors item was retained in the total score for the cognitive measure. In addition, although the factor analysis showed that the cognitive measure is best used as two factors, in this project the cognitive measure was used as a single factor of overall cognitive functioning. There are flaws to this approach, and they will be discussed in the limitations section of Chapter 7. Analyses were conducted to test the sensitivity of results to differences in the measurement of cognitive function. The major trend analyses were repeated after excluding the scissors item from the cognitive measure. In addition, linear regression analyses were used to examine trends in the two factors, memory and mental status, to determine whether similar patterns were observed for each, as well as for the overall cognitive test. The results of these analyses are discussed in Chapter 7.

Cronbach α coefficients were used to provide estimates of the internal consistency reliability of the cognitive measure. Reliability coefficients for each year of data are presented in Table 5.5 by race/ethnicity and for each method of dealing with missing responses. Results were similar for each coding method, with somewhat lower reliability coefficients for the unimputed data. Reliability coefficients ranged from 0.65 to 0.70 for the total sample and were fairly similar across racial/ethnic groups, though reliability was somewhat lower for whites compared to blacks and Hispanics. Overall, the internal consistency reliability coefficients were lower than is recommended, and this also represents a limitation for the cognitive measure.

Table 5.5. Internal consistency reliability coefficients (Cronbach α) for cognitive functioning items by year of study and race/ethnicity, Health and Retirement Study (1993-2004).

Year	1993	1995	1998	2000	2002	2004
Race/ethnicity	**Cronbach coefficient alpha (α)**					
Low scores to missing responses						
All	0.70	0.68	0.67	0.65	0.67	0.67
White	0.67	0.66	0.64	0.63	0.64	0.65
Black	0.75	0.73	0.71	0.71	0.70	0.69
Hispanic	0.72	0.66	0.71	0.66	0.68	0.66
Missing responses given score of 0						
All	0.70	0.69	0.67	0.66	0.67	0.67
White	0.68	0.66	0.65	0.63	0.65	0.65
Black	0.75	0.74	0.71	0.72	0.70	0.69
Hispanic	0.73	0.66	0.71	0.67	0.68	0.66
Respondents with missing responses not included						
All	0.64	0.63	0.63	0.63	0.64	0.63
White	0.62	0.61	0.63	0.59	0.62	0.61
Black	0.69	0.68	0.70	0.67	0.67	0.66
Hispanic	0.68	0.63	0.69	0.64	0.68	0.61

Note: Coefficient alphas calculated on weighted data for age-eligible self-respondents.

SPECIFIC AIM 1 RESULTS

The goals of Specific Aim I were to: 1) determine if the prevalence of cognitive impairment declined from 1993 to 2004 among older adults in the United States, and 2) explore the contributions of changes in demographic, socioeconomic, health behavior, and health status variables to trends in impairment. It was hypothesized that the proportion of adults aged 70 and older with cognitive impairment decreased from 1993 to 2004, independent of changes in the age and gender distributions of the population. In addition, it was hypothesized that increases in the socioeconomic status of the population, changes in the prevalence of certain health conditions, and declines in smoking would contribute to observed trends. Analyses were stratified by proxy status. The descriptive results show unadjusted changes in the prevalence of cognitive impairment among adults aged 70 and older from 1993 to 2004. Multivariate analyses with a year trend variable adjust for age, sex, and include demographic, socioeconomic, and health status variables.

Descriptive Trends in Cognitive Test Scores and Prevalence of Impairment

Table 5.6 shows mean cognitive scores, prevalence of impairment, and annual mean or percent change in outcome for self- and proxy respondents for each year of the study. The prevalence of cognitive impairment among self-respondents declined from 4.17% to 2.00% ($P < 0.001$) between 1993 and 2004, representing an absolute decrease of 2.17 percentage points and a relative annual change of -4.34%. Proxy measures of cognitive status varied across waves. From 1993-2002, respondents were classified as impaired according to global ratings of memory and judgment and number of behavioral symptoms. From 1995-2004, respondents were classified as impaired according to scores on the Jorm IQCODE. Results showed significant declines for proxy respondents for both cognitive impairment measures and time periods. Using global ratings and behavioral symptoms as a measure, the prevalence of cognitive impairment declined from 44.98% to 39.12% ($P < 0.05$) between 1993 and 2002. Using the Jorm IQCODE, the prevalence of impairment declined from 37.69% to 30.82% ($P = 0.05$) between 1995 and 2004.

The improvements in cognitive scores among self-respondents do not appear to be due to increased scores in any particular subscale. Mean scores increased across time for each subscale (immediate recall, delayed recall, mental status, and serial 7’s) as well as total cognition score. Among proxy respondents, the declines in poor judgment and poor memory were not statistically significant, but the decline in 2 or more behavioral symptoms was significant. The Jorm IQCODE does not have subscales.

Table 5.6. Mean cognitive scores and percent with cognitive impairment, self- and proxy respondents aged 70 and older in the United States, Health and Retirement Study 1993-2004.

Year	1993	1995	1998	2000	2002	2004	Avg. Annual Mean Change, % Change	
Self-Respondents	6,580	5,281	6,715	6,550	6,504	6,761		
	M or %(SE)	*M* or %(SE)	*M* or %(SE)	*M* or%(SE)	*M* or %(SE)	*M* or %(SE)		*P* value
Immediate recall test (range 0-10)	4.51 (0.03)	4.64 (0.03)	4.88 (0.03)	4.78 (0.03)	4.89 (0.03)	4.82 (0.02)	0.0028	<0.001
Delayed recall test (range 0-10)	3.06 (0.04)	3.28 (0.04)	3.56 (0.03)	3.54 (0.03)	3.68 (0.03)	3.59 (0.03)	0.0032	<0.001
Mental status test (range 0-10)	8.94 (0.03)	8.99 (0.03)	9.24 (0.03)	9.34 (0.02)	9.13 (0.02)	9.20 (0.03)	0.0031	<0.001
Serial 7's (range 0-5)	3.22 (0.03)	3.22 (0.03)	3.31 (0.04)	3.35 (0.04)	3.40 (0.03)	3.43 (0.03)	0.0029	<0.001
Total cognition score (range 0-35)	19.73 (0.10)	20.14 (0.12)	20.99 (0.09)	21.02 (0.10)	21.10 (0.09)	21.05 (0.08)	0.0089	<0.001
Percent severe impairment (≤ 8 of 35)	4.17 (0.34)	3.30 (0.26)	2.55 (0.23)	2.19 (0.19)	2.15 (0.22)	2.00 (0.21)	-4.336	<0.001
Percent mild impairment (≤ 10 of 35)	7.02 (0.39)	6.15 (0.32)	4.19 (0.29)	3.97 (0.27)	4.13 (0.28)	3.72 (0.24)	-3.917	<0.001
Proxy Respondents	766	630	775	788	799	653		
Poor judgment	27.07 (0.02)	29.38 (0.02)	24.69 (0.02)	23.47 (0.02)	23.33 (0.02)			0.077
Poor memory	26.62 (0.02)	26.47 (0.02)	22.21 (0.02)	21.78 (0.01)	23.99 (0.01)			0.160
Behavioral symptoms ≥ 2 of 7	41.45 (0.02)	41.78 (0.02)	38.15 (0.02)	37.56 (0.02)	34.59 (0.02)			0.041
Global ratings poor or behavioral symptoms (≥ 2 out of 7)	44.98 (2.20)	47.41 (1.97)	41.44 (1.95)	41.56 (2.11)	39.12 (2.08)		-1.303	0.011
Jorm IQCODE ≥ 3.38		37.69 (2.27)	33.03 (1.74)	32.90 (2.03)	34.41 (2.03)	30.82 (1.95)	-1.823	0.050

Estimates are weighted using the HRS respondent population weights to adjust for the complex sampling design of the HRS survey.
Abbreviations: SE, standard error.
P value for χ2 test for trend or t test (for year trend variable from linear regression) for a significant difference in the proportion or mean across years.

Alternate Cut-off Scores and Coding Schemes for Refusals and Missing Data

Table 5.7 shows mean cognitive scores and prevalence of cognitive impairment from 1993 to 2004 for each of three methods of dealing with refusals and missing data: 1) refusals/missing given low scores; 2) refusals/missing not included in analyses; and 3) refusals/missing given zeroes for the items or subscale missing data. Trends in the prevalence of impairment persisted irrespective of the coding scheme used for refusals and missing data. For each method, the prevalence of impairment consistently declined over time, and the average annual change ranged from -3.69% (deleting refusals) to -4.57% (refusals given zeroes) for the cut-off score of 8 out of 35. In addition, mean scores on subscales and total cognition score increased over time for each coding method.

The level of impairment (1.76% in 1993) and annual percent change (-3.69%) were lowest for the method that deleted refusals. Respondents who do not respond to cognitive questions perform significantly worse on the questions they did answer compared to those who completed the task. Therefore, deleting respondents who are missing responses biases prevalence estimates toward a cognitively well-functioning population.

The trend results were not sensitive to alternative definitions of cognitive impairment. The level of cognitive impairment varied depending on the cut-off score; however, declines in the prevalence of impairment were observed over time irrespective of whether a cut-off of 8, 9, 10, or 11 was used. Table 5.7 includes the trend results of alternative cut-off scores for each method of dealing with missing data.

Table 5.7. Mean cognitive scores and percent with cognitive impairment under alternative missing data approaches and definitions of cognitive impairment, self-respondents aged 70 and older in the United States, Health and Retirement Study. 1993-2004.

Year	**1993**	**1995**	**1998**	**2000**	**2002**	**2004**	Avg. Annual Mean Change, % Change	
	M(SE) or n(%)							
Assign Low Scores to Refusals	6,580	5,281	6,715	6,550	6,504	6,761		*P* value
Immediate recall test (range 0-10)	4.51 (0.03)	4.64 (0.03)	4.88 (0.03)	4.78 (0.03)	4.89 (0.03)	4.82 (0.02)	0.029	<0.001
Delayed recall test (range 0-10)	3.06 (0.04)	3.28 (0.04)	3.56 (0.03)	3.54 (0.03)	3.68 (0.03)	3.59 (0.03)	0.049	<0.001
Mental status test (range 0-10)	8.94 (0.03)	8.99 (0.03)	9.24 (0.03)	9.34 (0.02)	9.13 (0.02)	9.20 (0.03)	0.024	<0.001
Serial 7's (range 0-5)	3.22 (0.03)	3.22 (0.03)	3.31 (0.04)	3.35 (0.04)	3.40 (0.03)	3.43 (0.03)	0.026	<0.001
Total cognition score (range 0-35)	19.73 (0.10)	20.14 (0.12)	20.99 (0.09)	21.02 (0.10)	21.10 (0.09)	21.05 (0.08)	0.122	<0.001
Percent severe impairment (≤ 8 of 35)	344 (4.17)	199 (3.30)	213 (2.55)	178 (2.19)	153 (2.15)	154 (2.00)	-4.34	<0.001
Percent moderate impairment (≤ 9 of 35)	450 (5.46)	262 (4.33)	276 (3.33)	233 (2.92)	199 (2.83)	209 (2.73)	-4.17	<0.001
Percent mild impairment (≤ 10 of 35)	572 (7.02)	371 (6.15)	350 (4.19)	312 (3.97)	290 (4.13)	281 (3.72)	-3.92	<0.001
Percent borderline impairment (≤ 11 of 35)	726 (8.95)	488 (8.09)	469 (5.84)	402 (5.23)	393 (5.60)	370 (4.84)	-3.83	<0.001
Delete Refusals	5,585	4,783	6,292	6,100	5,928	6,370		
Immediate recall test (range 0-10)	4.58 (0.03)	4.68 (0.03)	4.90 (0.03)	4.82 (0.03)	4.96 (0.03)	4.87 (0.02)	0.028	<0.001
Delayed recall test (range 0-10)	3.19 (0.03)	3.40 (0.04)	3.66 (0.03)	3.64 (0.03)	3.90 (0.03)	3.71 (0.02)	0.052	<0.001
Mental status test (range 0-10)	9.04 (0.03)	9.10 (0.03)	9.28 (0.02)	9.40 (0.02)	9.17 (0.02)	9.24 (0.03)	0.017	<0.001
Serial 7's (range 0-5)	3.46 (0.03)	3.36 (0.03)	3.41 (0.04)	3.45 (0.04)	3.49 (0.03)	3.52 (0.03)	0.010	0.001
Total cognition score (range 0-35)	20.79 (0.09)	20.92 (0.11)	21.50 (0.09)	21.55 (0.09)	21.76 (0.08)	21.51 (0.07)	0.078	<0.001
Percent severe impairment (≤ 8 of 35)	125 (1.76)	68 (1.17)	113 (1.37)	70 (0.96)	76 (1.15)	73 (0.98)	-3.69	0.008
Percent moderate impairment (≤ 9 of 35)	173 (2.47)	102 (1.80)	146 (1.77)	94 (1.31)	95 (1.44)	116 (1.57)	-3.04	0.002
Percent mild impairment (≤ 10 of 35)	228 (3.29)	168 (2.92)	191 (2.30)	146 (2.01)	154 (2.35)	168 (2.35)	-2.38	0.002
Percent borderline impairment (≤ 11 of 35)	293 (4.22)	248 (4.34)	276 (3.57)	207 (2.90)	217 (3.32)	227 (3.14)	-2.13	<0.001

Table 5.7. Continued. Mean cognitive scores and percent with cognitive impairment under alternative missing data approaches and definitions of cognitive impairment, self-respondents aged 70 and older in the United States, Health and Retirement Study. 1993-2004.

Year	**1993**	**1995**	**1998**	**2000**	**2002**	**2004**	Avg. Annual Mean Change, % Change	
	M(SE) or n(%)							
Set Refusals to Zero	6,580	5,281	6,715	6,550	6,504	6,761		*P* value
Immediate recall test (range 0-10)	4.45 (0.03)	4.61 (0.04)	4.86 (0.03)	4.76 (0.03)	4.85 (0.03)	4.79 (0.02)	0.030	<0.001
Delayed recall test (range 0-10)	3.06 (0.04)	3.28 (0.04)	3.56 (0.03)	3.54 (0.03)	3.68 (0.03)	3.59 (0.03)	0.049	<0.001
Mental status test (range 0-10)	8.94 (0.03)	8.99 (0.03)	9.24 (0.03)	9.34 (0.02)	9.13 (0.02)	9.20 (0.03)	0.024	<0.001
Serial 7's (range 0-5)	3.12 (0.04)	3.17 (0.04)	3.27 (0.04)	3.30 (0.04)	3.36 (0.03)	3.39 (0.03)	0.025	<0.001
Total cognition score (range 0-35)	19.58 (0.11)	20.06 (0.12)	20.94 (0.09)	20.95 (0.10)	21.02 (0.09)	20.98 (0.09)	0.127	<0.001
Percent severe impairment (≤ 8 of 35)	428 (5.22)	243 (4.04)	251 (3.02)	224 (2.78)	193 (2.82)	181 (2.36)	-4.57	<0.001
Percent moderate impairment (≤ 9 of 35)	550 (6.82)	302 (5.05)	309 (3.76)	274 (3.50)	245 (3.54)	247 (3.23)	-4.39	<0.001
Percent mild impairment (≤ 10 of 35)	696 (8.67)	402 (6.72)	390 (4.73)	348 (4.46)	333 (4.75)	324 (4.32)	-4.18	<0.001
Percent borderline impairment (≤ 11 of 35)	820 (10.20)	517 (8.57)	496 (6.20)	434 (5.63)	423 (6.02)	414 (5.58)	-3.77	<0.001

Estimates are weighted using the HRS respondent population weights to adjust for the complex sampling design of the HRS.
P value for $\chi 2$ test for trend or t test (for year trend variable from linear regression) for a significant difference in the proportion or mean across years.

Bivariate Associations

Table 5.8 shows the bivariate associations between cognitive impairment and demographic variables, socioeconomic status, and health status and behavior variables. Odds ratios for the associations between sample characteristics and impairment are shown for each year of the study. Among self-respondents, the odds of cognitive impairment were higher for older adults, blacks and Hispanics, those born in the South or in a U.S. territory/outside the U.S., and those not currently married or partnered. Individuals whose mothers had low education were more likely to be cognitive impaired. Respondents with less than a high school education and respondents who reported total wealth of less than $145,000 had higher odds of cognitive impairment compared to those with higher education and wealth. Stroke, psychiatric disorder, and depressive symptoms were associated with higher odds of cognitive impairment. Respondents who reported vision or hearing problems were more likely to be cognitively impaired.

The associations between sample characteristics and cognitive impairment appeared to be fairly consistent from 1993 to 2004, with a few exceptions. For example, hypertension was associated with lower odds of cognitive impairment only in the year 2000. In 2004, obesity was associated with lower odds of impairment; however, further investigation showed that adjusting for age accounted for the association. In 1993, smoking was associated with lower odds of impairment; however, adjusting for age reduced the association to nonsignificance.

Results for proxy respondents are included in Table A.3 in the Appendix. Older age, female gender, black race/ethnicity, being unmarried, lower total wealth, stroke, heart disease, psychiatric disorder, and impaired vision were associated with higher odds of cognitive impairment.

Table 5.8. Bivariate associations between sample characteristics and cognitive impairment , self-respondents aged 70 and older in the United States, Health and Retirement Study, 1993-2004.

Year	**1993**		**1995**		**1998**		**2000**		**2002**		**2004**	
Sample size	7,345		5,911		7,490		7,338		7,303		7,417	
Demographic variables	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Age (years)	1.14	1.12, 1.15	1.13	1.11, 1.15	1.13	1.11, 1.16	1.15	1.13, 1.18	1.11	1.09, 1.14	1.12	1.10, 1.15
Female	0.94	0.73, 1.21	1.23	0.85, 1.80	1.28	0.95, 1.73	1.01	0.75, 1.34	1.10	0.75, 1.60	1.04	0.74, 1.44
Race/ethnicity (white)												
Black	6.36	4.48, 9.04	6.18	4.24, 9.01	4.96	3.36, 7.34	5.51	3.68, 8.24	5.76	3.52, 9.45	4.01	2.78, 5.77
Hispanic	4.39	2.97, 6.49	2.59	1.73, 3.88	4.23	2.31, 7.74	2.33	1.23, 4.41	3.21	1.96, 5.24	3.34	2.21, 5.04
Region of birth (Northeast)												
Midwest	0.79	0.41, 1.49	1.44	0.65, 3.15	1.30	0.79, 2.15	1.64	0.91, 2.96	0.95	0.40, 2.22	1.13	0.59, 2.16
South/unknown	3.06	1.63, 5.76	4.05	2.08, 7.89	2.60	1.68, 4.02	3.95	2.39, 6.55	2.92	1.39, 6.16	2.95	1.56, 5.61
West	0.74	0.27, 2.03	1.02	0.38, 2.73	0.98	0.36, 2.65	2.69	1.64, 4.41	1.88	0.72, 4.90	0.81	0.33, 2.00
U.S. territory/outside U.S.	3.03	1.69, 5.45	5.16	2.40, 11.11	2.82	1.78, 4.46	3.06	1.31, 7.11	1.50	0.63, 3.55	3.30	1.72, 6.33
Not married	1.81	1.41, 2.32	1.54	1.10, 2.15	1.75	1.19, 2.58	1.67	1.26, 2.22	1.99	1.46, 2.71	1.31	0.95, 1.79
Socioeconomic variables												
Mother's education (≥ 8 yrs.)												
Fewer than 8 years	2.99	2.16, 4.14	2.33	1.73, 3.14	2.74	1.85, 4.06	2.41	1.69, 3.45	2.45	1.52, 3.96	3.10	1.98, 4.85
Education (years)	0.75	0.73, 0.77	0.76	0.73, 0.80	0.77	0.74, 0.80	0.79	0.76, 0.82	0.78	0.75, 0.81	0.76	0.73, 0.79
Education (more than high school)												
0-8 years	8.99	6.04, 13.38	10.91	6.29, 18.92	8.15	4.74, 14.01	7.47	4.37, 12.77	8.83	5.76, 13.53	9.03	5.36, 15.21
9-11 years	2.03	1.30, 3.17	5.04	3.02, 8.39	2.34	1.42, 3.85	1.92	1.00, 3.68	2.09	1.11, 3.91	2.38	1.21, 4.69
12 years	0.99	0.52, 1.86	1.69	0.86, 3.32	1.31	0.75, 2.30	1.36	0.77, 2.37	1.71	0.93, 3.13	1.40	0.82, 2.38
Total wealth in 1993$ (≥$145,000)												
<$0-<$40,000	7.81	5.30, 11.51	6.07	3.70, 10.03	5.89	3.55, 9.78	5.30	3.18, 8.84	4.78	2.97, 7.69	5.04	3.16, 8.03
$40000-<$145,000	2.71	1.92, 3.83	2.24	1.40, 3.57	2.42	1.50, 3.90	2.04	1.12, 3.71	2.06	1.19, 3.56	2.02	1.17, 3.48

Table 5.8. Continued.

Year	1993		1995		1998		2000		2002		2004	
Sample size	7,345		5,911		7,490		7,338		7,303		7,417	
Health status & behavior	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Chronic conditions												
High blood pressure	0.87	0.67, 1.12	0.92	0.64, 1.32	1.12	0.86, 1.45	0.73	0.54, 0.97	1.35	0.92, 1.98	1.02	0.72, 1.45
Diabetes	1.19	0.89, 1.61	1.11	0.81, 1.51	0.91	0.59, 1.40	1.13	0.81, 1.59	1.21	0.82, 1.79	1.24	0.80, 1.92
Cancer	0.88	0.56, 1.38	0.81	0.50, 1.32	0.66	0.39, 1.12	0.76	0.46, 1.24	0.61	0.35, 1.05	0.87	0.48, 1.57
Lung disease	0.78	0.52, 1.18	0.87	0.52, 1.46	0.70	0.37, 1.32	0.91	0.56, 1.48	1.15	0.71, 1.86	0.86	0.50, 1.46
Heart disease	1.13	0.88, 1.44	1.14	0.87, 1.45	1.12	0.81, 1.78	1.26	0.90, 1.76	1.02	0.64, 1.64	1.30	0.90, 1.88
Stroke	2.32	1.76, 3.06	2.17	1.42, 3.33	2.74	1.87, 4.02	2.02	1.31, 3.12	2.54	1.43, 4.50	1.75	1.05, 2.92
Psychiatric disorder	1.21	0.85, 1.72	2.15	1.54, 3.01	2.34	1.57, 3.49	1.75	1.23, 2.49	2.06	1.24, 3.42	2.24	1.40, 3.59
Depressive symptoms (0-8)	1.25	1.18, 1.32	1.24	1.17, 1.32	1.23	1.14, 1.31	1.15	1.08, 1.23	1.22	1.14, 1.30	1.20	1.11, 1.29
Obese (BMI ≥ 30)	0.87	0.59, 1.27	1.09	0.74, 1.62	0.80	0.50, 1.26	0.73	0.44, 1.21	0.84	0.51, 1.38	0.35	0.17, 0.73
Smoking (never)												
Current	0.63	0.40, 0.99	0.72	0.37, 1.39	1.23	0.78, 1.94	0.91	0.55, 1.53	0.73	0.32, 1.69	0.87	0.50, 1.51
Former	0.66	0.51, 0.85	0.72	0.48, 1.09	0.63	0.44, 0.91	0.86	0.62, 1.19	0.95	0.61, 1.48	0.90	0.60, 1.35
Self-rated vision (excellent/very good)												
Good	1.40	1.07, 1.82	1.44	1.03, 2.01	1.42	0.95, 2.14	1.38	0.90, 2.13	1.27	0.95, 1.71	1.47	0.91, 2.36
Fair/poor/legally blind	2.67	2.04, 3.51	2.35	1.63, 3.41	2.38	1.53, 3.71	2.84	1.73, 4.66	2.49	1.63, 3.81	2.72	1.76, 4.23
Self-rated hearing (excellent/very good)												
Good	1.33	1.03, 1.72	1.30	0.83, 2.03	1.40	0.91, 2.15	1.44	0.96, 2.16	1.48	0.88, 2.46	1.04	0.65, 1.64
Fair/poor	1.80	1.21, 2.68	1.97	1.29, 3.00	2.07	1.31, 3.29	2.02	1.29, 3.19	2.17	1.37, 3.45	1.71	1.04, 2.79

Estimates are weighted using the HRS respondent population weights to adjust for the complex sampling design of the HRS.

Abbreviations: CI, confidence interval; BMI, body mass index.

Multivariate Analyses

Overview

Multivariate logistic regression models were estimated to test for trends in the prevalence of cognitive impairment after adjusting for changes in the age and gender distribution of the population. Statistical tests for adjusted trends are based on the logistic regression models estimated from all years of data combined. The key explanatory variable is a linear trend variable that takes the value of 0 in 1993 and increases by 1 in each subsequent calendar year, with a maximum of 11 in 2004. Quadratic and cubic specifications of the trend variable were tested, and they were not statistically significant after adjusting for age, gender, and design effects. Analyses were repeated using linear probability models—which estimate absolute (percentage point) rather relative (percent) change in outcome—to assess trends and examine the effects of adjusting for demographic, socioeconomic, and health status and behavior variables. Results led to similar substantive conclusions compared to the logistic regression models.

All analyses adjusted for the complex survey design of the HRS, including stratification, geographic clustering, and correlations within primary sampling units (PSU), using STATA's svy commands with sampling weights, strata, and PSU indicators. As most respondents appear in more than one year of data, observations are not independent. STATA allows two levels of clustering to be specified. Therefore, an additional level of clustering, respondent ID, was added to account for correlations among repeat observations. However, the additional clustering did not change the magnitude or statistical significance of results. Results shown here adjust for correlations among observations.

Results for Self-Respondents

<u>Changes in Population Composition/Proportion of Individuals in High-Risk Groups</u>

Table 5.9 shows results from the multivariate trend analyses for self-respondents. The base model adjusting for age and gender showed a significant decline in cognitive impairment, amounting to 6.6% on average per year (OR= 0.934; 95% CI= 0.913, 0.956). Adjusting for prior exposure to the cognitive test reduced the trend to an average annual decline of 3.4% (OR= 0.966; CI= 0.941, 0.992). Including race/ethnicity, birthplace, and marital status slightly increased the trend to a 3.5% annual decline. Adding socioeconomic variables reduced the cognitive impairment trend to statistical insignificance (OR= 0.990; 95% CI= 0.961, 1.020), suggesting that improvements in socioeconomic status have contributed to changes in cognitive impairment prevalence over time. Together, mother's education, respondent's education, and total wealth attenuated the trend by 72.1%. Including health status variables did not change the trend, but health behavior variables (obesity and smoking) attenuated the trend approximately 10% (OR=0.991; 95% CI=0.961, 1.022).

Demographic, socioeconomic, and health status and behavior variables were added individually to the model with age, gender, and prior testing to investigate the influence of each factor on trends in cognitive impairment (results not shown in Table 5.9). Education attenuated the trend by 73.8%, and the year variable was no longer statistically significant. Mother's education attenuated the trend by 17.8% and total wealth by 22.3%.

Table 5.9. Odds ratios for prevalence of cognitive impairment, self-respondents aged 70 and older, Health and Retirement Study 1993-2004.

Variable	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Year trend	0.934	0.913, 0.956	0.966	0.941, 0.992	0.965	0.939, 0.991	0.990	0.961, 1.020	0.990	0.961, 1.020	0.991	0.961, 1.022
Prior test exposure			0.63	0.54, 0.74	0.65	0.55, 0.77	0.68	0.57, 0.81	0.67	0.56, 0.81	0.67	0.56, 0.81
Demographic variables												
Age	1.13	1.12, 1.14	1.13	1.12, 1.15	1.14	1.13, 1.15	1.12	1.11, 1.13	1.12	1.11, 1.14	1.12	1.11, 1.14
Female	0.96	0.81, 1.13	0.97	0.82, 1.14	0.93	0.77, 1.12	1.02	0.83, 1.26	1.03	0.81, 1.30	0.97	0.75, 1.24
Black, non-Hispanic					4.41	3.37, 5.77	2.31	1.82, 2.92	2.52	1.99, 3.20	2.46	1.91, 3.18
Hispanic					3.14	2.35, 4.18	0.88	0.65, 1.17	0.88	0.66, 1.17	0.83	0.62, 1.11
Born in Midwest					1.14	0.77, 1.69	1.16	0.79, 1.71	1.15	0.78, 1.70	1.15	0.77, 1.69
Born in South					2.00	1.41, 2.82	1.41	0.98, 2.02	1.38	0.97, 1.96	1.37	0.97, 1.95
Born in West					1.20	0.77, 1.89	1.54	0.95, 2.49	1.49	0.93, 2.40	1.48	0.92, 2.37
Born in U.S. territory/outside U.S.					1.78	1.21, 2.61	1.35	0.91, 2.03	1.35	0.90, 2.03	1.32	0.88, 2.00
Not married/partnered					0.96	0.80, 1.15	0.74	0.61, 0.89	0.74	0.61, 0.91	0.73	0.60, 0.90
Socioeconomic variables												
Mother's education ≤ 8 yrs.							1.06	0.87, 1.28	1.03	0.84, 1.26	1.03	0.84, 1.26
Mother's education missing							1.35	1.02, 1.78	1.29	0.98, 1.70	1.27	0.97, 1.67
Respondent education (years)							0.82	0.80, 0.85	0.83	0.80, 0.85	0.83	0.80, 0.86
Total wealth in 1993$												
<$0-<$40,000							1.93	1.54, 2.41	1.78	1.42, 2.23	1.79	1.43, 2.24
$40000-<$145,000							1.31	1.04, 1.67	1.28	1.01, 1.63	1.29	1.02, 1.64

Note: Odds ratios are from weighted logistic regression models adjusted for complex survey design of the HRS.
Reference categories are: white, non-Hispanic; born in Northeast; mother's education 8+ yrs.; total wealth ≥ $145,000; excellent vision, hearing; never smoked.

Table 5.9. Continued.

Variable	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Year trend	0.934	0.913, 0.956	0.966	0.941, 0.992	0.965	0.939, 0.991	0.990	0.961, 1.020	0.990	0.961, 1.020	0.991	0.961, 1.022
Health status and behavior												
High blood pressure									0.70	0.60, 0.80	0.72	0.62, 0.83
Diabetes									1.05	0.86, 1.28	1.07	0.88, 1.31
Cancer									0.88	0.70, 1.12	0.89	0.70, 1.13
Lung disease									0.80	0.62, 1.04	0.82	0.63, 1.07
Heart disease									0.90	0.78, 1.04	0.91	0.79, 1.05
Stroke									1.97	1.56, 2.51	1.99	1.56, 2.52
Psychiatric disorder									1.55	1.24, 1.99	1.52	1.20, 1.93
Depressive symptoms									1.06	1.03, 1.10	1.06	1.03, 1.10
Good vision									1.09	0.91, 1.29	1.08	0.91, 1.28
Fair/poor/legally blind									1.09	0.92, 1.30	1.08	0.90, 1.29
Good hearing									1.03	0.84, 1.27	1.02	0.83, 1.27
Fair/poor									1.06	0.88, 1.30	1.07	0.88, 1.30
Obese											0.75	0.59, 0.95
Current smoker											1.04	0.70, 1.53
Former smoker											0.89	0.71, 1.11

Note: Odds ratios are from weighted logistic regression models adjusted for complex survey design of the HRS.

Reference categories are: white, non-Hispanic; born in Northeast; mother's education 8+ yrs.; total wealth ≥ $145,000; excellent vision, hearing; never smoked.

Demographic and health status and behavior variables changed the trend by 10% or less. The inclusion of birthplace attenuated the trend by 6.2%. Adjusting for changes in race/ethnicity increased the trend 10.2%. The inclusion of vision impairment, cancer, and smoking resulted in attenuations of the trend estimate of 8.8%, 3.7%, and 2.1%, respectively. Finally, adding psychiatric disorder, obesity, stroke, hearing, and diabetes each increased the trend by 2-7%. The remaining variables had negligible effects on the trend variable.

Figure 5.1. Unadjusted and adjusted trends in probability of cognitive impairment among older adults, Health and Retirement Study, 1993- 2004.

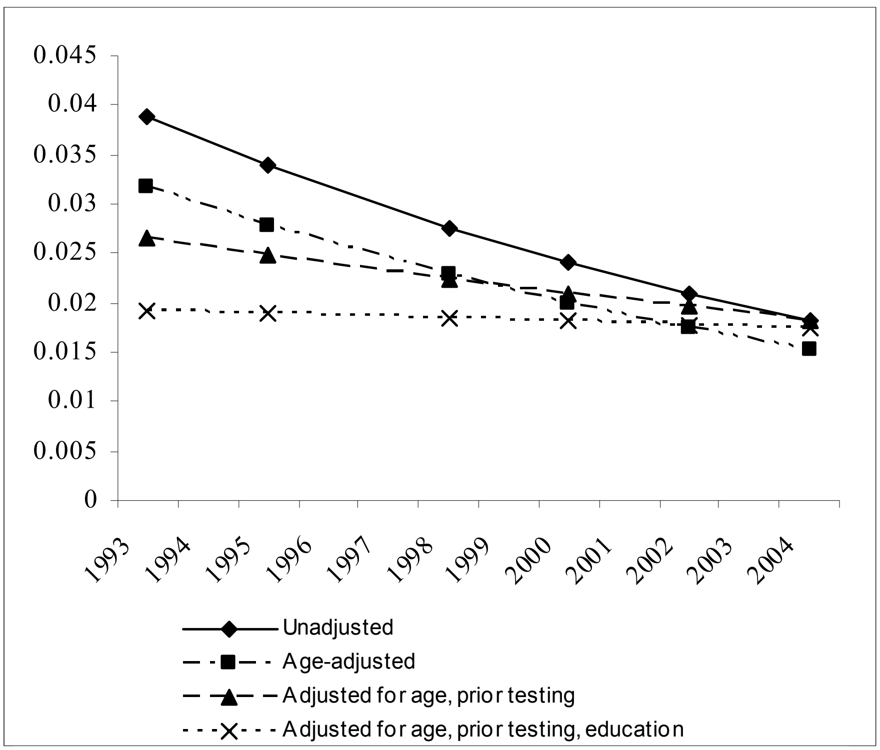


Figure 5.1 shows unadjusted and adjusted trends in the probability of cognitive impairment among older adults. The figure displays results from successive logistic regression models (unadjusted; adjusted for age; adjusted for age and prior testing; adjusted for age, prior testing, and education) with a year trend variable. When plotting

results, 78 years was substituted for age, 0.75 for prior testing (i.e. retesting for 75% of sample), and 11 years for education level. Including prior testing to the age-adjusted model attenuated the slope of the trend line. After adjusting for education, the slope of the trend line was nearly 0.

Prior Test Exposure Sensitivity Analysis

Multivariate trend analyses were repeated including prior exposure variables with progressively higher contrasts (e.g., ≥ 2 test exposures vs. < 2; ≥ 3 test exposures vs. < 3) in separate logistic regression models. These analyses were conducted to investigate whether trend results were sensitive to the measurement of prior exposure, especially given the possibility of training effects with multiple testing sessions and the considerable attenuation of the trend with adjustment for any prior testing. Adjusting for 2 test exposures attenuated the age- and gender-adjusted trend to -3.1% per year (OR= 0.969; 95% CI= 0.941, 0.998; *P*= 0.04). Including race/ethnicity, marital status, and birthplace in the model increased the trend to -3.5% per year (OR= 0.965; 95% CI= 0.935, 0.995; *P*= 0.02). Similar to the results shown above, adjusting for educational attainment attenuated the trend to -1.4% per year (OR= 0.986; 95% CI= 0.957, 1.017). In separate models, adjusting for 3 prior test exposures attenuated the age- and gender-adjusted trend to -3.6% per year (OR= 0.964; 95% CI= 0.935, 0.993; *P*= 0.02). Including race/ethnicity, marital status, and birthplace increased the trend to -4.5% per year (OR= 0.955; 95% CI= 0.927, 0.984; *P*= 0.00). Adjusting for changes in educational attainment attenuated the trend to -2.6% per year (OR= 0.975; 95% CI= 0.946, 1.005). Adjusting for 4 prior test exposures attenuated the age- and gender-adjusted trend to -5.3% per year (OR= 0.947; 95% CI= 0.923, 0.971; *P*= 0.00). Including race/ethnicity, marital status and birthplace increased the trend to -5.8% (OR= 0.942; 95% CI= 0.918, 0.966). Adjusting for education attenuated the trend to -3.6% (OR= 0.964; 95% CI= 0.938, 0.991). In sum, although adjusting for 2 prior test exposures did somewhat attenuate the magnitude of the trend variable, overall, these results suggest that adjusting for alternate indicators of prior test exposure with progressively higher contrasts did not meaningfully attenuate the import of the trend.

Changes in the Relationship between Risk Factors and Cognitive Impairment

Hypothesis 1d. stated that the association between chronic conditions and cognitive impairment would decrease over time, perhaps due to improvements in diagnosis, treatment, or control of disease. Therefore, multivariate analyses also explored changes over time in the odds of cognitive impairment associated with risk factors such as stroke and other health conditions. Interaction terms between health status variables and the year trend variable were estimated to determine if the association between a given risk factor and cognitive impairment varied significantly over time. The interaction terms were added to the base model adjusting for age, gender, and prior test exposure. None of the interaction terms were statistically significant. This suggests that the cross-sectional relationships between health status variables and cognitive impairment did not change from 1993 to 2004.

Results for Proxy Respondents

Table 5.10 shows multivariate trend analyses for proxy respondents from 1993-2002 for the global ratings and behavioral symptoms impairment outcome and from 1995-2004 for the Jorm IQCODE impairment outcome. The unadjusted model for the first impairment outcome shows a significant decline over time, amounting to 3.2% on average per year. After adjusting for age and gender, however, the trend was reduced to 2.2% per year, no longer statistically significant at the 0.05 level (OR= 0.978; 95% CI= 0.954, 1.002; *P*= 0.069). Demographic, socioeconomic, and health status and behavior variables were added to the base model in groups and individually (not shown). Socioeconomic variables attenuated the nonsignificant trend by 19.4% (OR=0.982; 95% CI= 0.956, 1.008), mostly due to increases in wealth. The inclusion of stroke attenuated the trend by 7.1%.

Table 5.10. Odds ratios for prevalence of cognitive impairment, proxy respondents aged 70 and older, Health and Retirement Study 1993-2004.

Outcome	**Global Ratings/Behavioral Symptoms**				**Jorm IQCODE**			
Years available	1993-2002				1995-2004			
Variable	Model 1		Model 2		Model 3		Model 4	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Year trend	0.968	0.945, 0.992	0.978	0.954, 1.002	0.972	0.945, 1.00	0.987	0.960, 1.014
Age			1.03	1.02, 1.04			1.06	1.05, 1.08
Female			1.51	1.28, 1.79			1.84	1.50, 2.26

Models 3 and 4 show results for the Jorm IQCODE impairment outcome. The unadjusted trend indicates a decline in impairment of 2.8% per year; however the trend was not statistically significant (OR=0.972; 95% CI=0.945, 1.000; *P*=0.05). Adjustment for age and gender attenuated the trend to 1.3% per year (OR=0.987; 95% CI= 0.960, 1.014; *P*= 0.32). The inclusion of wealth (not shown) attenuated the nonsignificant trend by 28.4% (OR= 0.990; 95% CI= 0.964, 1.018).

Sensitivity Analyses

Additional sensitivity analyses were performed to investigate the robustness of the trends in decline. The prevalence of cognitive impairment among adults aged 65 years and older was examined for the years 1998-2004. These age and survey year specifications were chosen for two reasons. First, the HRS cognitive measure is administered to adults aged 65 and older, and extending the trend analysis to adults aged 65-69 increased the sample size at each wave by nearly 3,000. Second, the 1993 and 1995 surveys were restricted to adults aged 70 years and older. Table 5.11 shows the sample sizes by respondent status and race/ethnicity for the each year.

Table 5.11. Sample size by year of study, respondent status, and race/ethnicity in the Health and Retirement Study from 1998-2004.

Year	1998	2000	2002	2004
Self-respondent				
White	7,812	7,702	7,619	7,860
Black	1,141	1,152	1,174	1,259
Hispanic	589	609	635	739
Total	9,542	9,463	9,428	9,858
Proxy respondent				
White	690	715	764	605
Black	173	188	176	178
Hispanic	120	128	149	132
Total	983	1,031	1,089	915
Total	10,525	10,494	10,517	10,726

Table 5.12 shows the unadjusted changes in the prevalence of cognitive impairment for self- and proxy respondents from 1998-2004. The prevalence of cognitive impairment declined on average 3.01% per year for self-respondents and 3.17% per year for proxy respondents.

Table 5.12. Percent with cognitive impairment, self- and proxy respondents aged 65 and older in the United States, Health and Retirement Study 1998-2004.

Year	1998	2000	2002	2004	Avg. Annual % Change	
	%(SE)	%(SE)	%(SE)	%(SE)		
Self-Respondents						*P* value
Percent severe impairment (≤ 8 of 35)	2.03 (0.17)	1.73 (0.15)	1.78 (0.17)	1.65 (0.16)	-3.01	0.062
Proxy Respondents						
Jorm IQCODE ≥ 3.38	28.80 (1.49)	29.81 (1.71)	28.28 (1.63)	24.97 (1.52)	-3.17	0.058

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

Abbreviations: SE, standard error.

P value for $\chi 2$ test for trend or t test (for year trend variable from linear regression) for a significant difference in the proportion across years.

Multivariate results (not shown) were very similar to those reported above for adults aged 70 and older from 1993-2004. The annual average percent decline was 4.6%, adjusting for age and gender (OR= 0.953; 95% CI= 0.923, 0.985). The inclusion of prior test exposure reduced the trend by 27.4% to 3.3% per year (OR= 0.966; 95% CI= 0.935, 0.998). Adding education to this model attenuated the trend by 86.0% (OR= 0.995; 95% CI= 0.961, 1.031). The trend was also attenuated by the inclusion of other variables to the base model, such as total wealth (29.0%), depression (17.0%), and stroke (8.9%).

LONGITUDINAL ANALYSES

Overview

Longitudinal analyses were performed to examine potential predictors of incident cognitive impairment during two follow-up periods, 1993-1998 and 2000-2004. Longitudinal analyses were meant to inform trends results and to establish predictors of cognitive impairment. The approximate length of time between waves was relatively similar between follow-up periods, 51 months for 1993-1998 and 49 months for 2000-2004, due to differences in starting months across survey waves.

Sample Cohorts

Respondents who were not cognitively impaired at baseline (1993 or 2000) were examined at follow-up for cognitive impairment. The following criteria were necessary to be included for follow-up: aged 70 and older at baseline; not institutionalized at baseline; self-respondent; race/ethnicity identified as non-Hispanic white, non-Hispanic black, or Hispanic; and not cognitively impaired at baseline (total cognitive score $\geq$ 8 out of 35). Analyses for both follow-up periods include only the 4,150 respondents in 1993-1998 and 4,506 respondents in 2000-2004 who have complete data at baseline and follow-up. Table 5.13 summarizes the sample sizes of the two cohorts as successive eligibility criteria are applied.

1993-1998 Cohort

There were 7,443 respondents in 1993; 6,654 were self-respondents and 789 were proxy respondents. Restricting the sample to whites, blacks, and Hispanics resulted in 6,580 self-respondents, of whom 6,236 were unimpaired at baseline. In 1998, 4,591 of the 6,236 respondents were alive and responded, of whom 4,150 were self-respondents and 441 were proxy respondents. Of the 6,236 respondents eligible for follow-up in 1993, 1,256 (20.1%) had died by 1998, 389 (6.2%) were lost to follow-up, and 441 (7.1%) became proxy respondents.

Table 5.13. Eligibility criteria, sample sizes, and follow-up of two cohorts of adults aged 70 and older at baseline, Health and Retirement Study, 1993-1998 and 2000-2004.

	1993-1998	2000-2004
Interviewed	8,222	19,579
Age-eligible	7,443	7,896
Non-institutionalized at baseline	7,443	7,470
Self-respondent at baseline	6,654	6,652
White, Black, or Hispanic	6,580	6,551
Unimpaired at baseline	6,236	6,373
Impaired at baseline	344	178
Eligible for follow-up	6,236	6,373
Self-respondent at follow-up	4,150	4,506
Proxy respondent at follow-up	441	319
Dead at follow-up	1,256	1,233
Lost to follow-up	389	315
In sample	4,150	4,506
Unimpaired at follow-up	4,006	4,386
Impaired at follow-up	144	120
Percent impaired	3.47	2.66

2000-2004 Cohort

There were 7,470 age-eligible and non-institutionalized respondents in 2000; 6,652 were self-respondents and 818 were proxy respondents. Restricting the sample to whites, blacks, and Hispanics resulted in 6,551 self-respondents, of whom 6,373 were unimpaired at baseline. In 2004, 4,825 of the 6,373 respondents were alive and responded, of whom 4,506 were self-respondents and 319 were proxy respondents. Of the 6,373 respondents eligible for follow-up in 2000, 1,233 (19.3%) had died by 2004, 315 (4.9%) were lost to follow-up, and 319 (5.0%) became proxy respondents. Approximately 45.7% (n = 2,058) of those included in the 2000-2004 cohort were in the AHEAD sample in 1993.

Attrition and Selection Bias

As indicated above, respondents had to satisfy several criteria (e.g., self-respondent, unimpaired at baseline) to be eligible for follow-up. Additionally, in order to be included in the analytic sample for evaluating onset of cognitive impairment, respondents had to be self-respondents with a cognitive score available at follow-up. The exclusion of certain groups, proxy respondents for example, may introduce selection bias, as self-respondents tend to be in better health and are less likely to be cognitive impaired. Loss to follow-up over the study period may introduce attrition bias. Data on cognitive impairment are only available for those self-respondents who were alive and responded at the beginning and end of the follow-up period. Of the 6,236 eligible respondents in 1993 and the 6,373 eligible respondents in 2000, approximately 67% and 71%, respectively, met these criteria and were included in the analytic sample focusing on incidence of cognitive impairment.

Propensity scores were used to adjust for potential selection and attrition bias due to exclusion criteria and attrition. The propensity score method adjusts the baseline sampling weights to distribute more weight to respondents who resemble those not included in the analytic sample. Logistic regression analyses were used to predict membership in the analytic sample, according to the following baseline independent covariates: age, gender, race/ethnicity, education, net worth, marital status, census region, hypertension, cancer, lung disease, diabetes, heart, stroke, psychiatric disorder, obesity, smoking, and depression. The propensity score models fit the data well for both 1993-1998 (*C*-statistic = 0.73; Hosmer-Lemeshow statistic *P* value = 0.59) and 2000-2004 (*C*-statistic = 0.75; Hosmer-Lemeshow statistic *P* value = 0.15). The probabilities of being included in the analytic samples were outputted from the logistic regression models and stratified into quintiles. Within each quintile, the participation rate (percentage of respondents included in the analytic sample) was calculated, and the inverse was used to weight the data. The baseline sampling weight for each respondent was multiplied by the inverse participation rate. Finally, the propensity score weights were adjusted so that the final weighted *N* was equal to that of the original sampling weights.

Descriptive Results

After adjusting the data using propensity score weights, approximately 4.1% of respondents in the 1993 cohort were cognitively impaired by 1998 and 3.9% of respondents in the 2000 cohort were cognitively impaired by 2004. Table 5.14 presents the prevalence of cognitive impairment at follow-up by baseline demographic, socioeconomic, and health status and behavior variables for the 1993-1998 and 2000-2004 cohorts. The percent of respondents with cognitive impairment at follow-up was higher among older age groups, blacks and Hispanics, respondents born in the South and outside of the U.S., and unmarried/unpartnered respondents. Respondents who reported low mother's education, those with low education themselves, and those in the lower tertiles of wealth had higher rates of cognitive impairment at follow-up. The prevalence of impairment was higher among respondents who reported having had a stroke, those with greater depressive symptoms, and those with sensory impairments.

Table 5.14. Baseline sample characteristics and prevalence of cognitive impairment at follow-up in adults aged 70 and older at baseline, Health and Retirement Study 1993-1998 and 2000-2004.

Year	**1993-1998**		**2000-2004**	
Sample size	4,150	*P* value	4,506	*P* value
Demographic variables				
Age		<0.0001		<0.0001
70-74	1.74		1.10	
75-79	3.39		3.42	
80-84	5.98		6.70	
85+	10.19		9.03	
Female	4.57	0.14	4.16	0.52
Male	3.36		3.62	
Race/ethnicity		<0.0001		0.00
White, non-Hispanic	3.37		3.42	
Black, non-Hispanic	9.41		6.72	
Hispanic	9.93		8.21	
Region of birth		0.05		0.13
Northeast	2.56		3.21	
Midwest	3.93		3.07	
South	5.18		5.22	
West	2.82		3.02	
U.S. territory/outside U.S.	6.49		5.87	
Married/has partner	3.21	0.01	3.28	0.09
Not married/partnered	5.10		4.64	
Socioeconomic variables				
Mother's education				
Fewer than 8 years	5.18	0.00	4.36	<0.0001
8 or more years	2.59		2.54	
Missing	7.07		9.26	
Education		<0.0001		<0.0001
0-8 years	8.45		10.79	
9-11 years	3.84		2.72	
High school/GED	2.51		2.57	
More than high school	2.25		2.09	
Total wealth		<0.0001		<0.0001
Lowest tertile	6.21		6.60	
Middle tertile	4.45		2.81	
Highest tertile	2.00		2.03	

Table 5.14. Continued.

Year	1993-1998		2000-2004	
Sample size	4,150	*P* value	4506	*P* value
Health status and behavior				
Hypertension	4.40	0.43	3.96	0.95
No hypertension	3.79		3.91	
Diabetes	4.12	0.83	5.89	0.04
No diabetes	3.86		3.55	
Cancer	3.65	0.68	3.88	0.95
No cancer	4.16		3.95	
Lung disease	3.79	0.79	5.35	0.26
No lung disease	4.13		3.76	
Heart disease	3.89	0.73	4.56	0.32
No heart disease	4.18		3.65	
Stroke	6.94	0.02	7.55	0.01
No stroke	3.77		3.48	
Psychiatric disorder	4.39	0.78	7.66	0.00
No psychiatric disorder	4.05		3.39	
Depressive symptoms ≥ 3	6.64	0.00	6.03	0.00
Depressive symptoms < 3	3.32		3.26	
Obese (BMI ≥ 30 kg/m^2)	3.12	0.38	2.12	0.04
Not obese	4.21		4.23	
Smoking		0.12		0.39
Current	2.44		4.11	
Former	3.74		3.32	
Never	4.77		4.53	
Self-rated vision		0.01		0.00
Excellent/very good	3.14		2.91	
Good	3.74		3.30	
Fair/poor/legally blind	6.30		6.55	
Self-rated hearing		0.01		0.09
Excellent/very good	3.16		2.95	
Good	3.72		4.98	
Fair/poor	6.12		3.78	

Estimates are weighted using the propensity score weights, which adjust for the complex sampling design of the HRS survey and potential attrition and selection bias.

Abbreviations: SE, standard error; BMI, body mass index.

P value for χ^2 for a significant difference in proportion across categories.

In the 2000 cohort, impairment at follow-up was also higher among respondents who reported having diabetes, psychiatric disorder, and those who were not obese.

Multivariate Predictors of Incident Cognitive Impairment

Multivariate logistic regression analyses were used to identify predictors of incident cognitive impairment over the follow-up periods. Results are presented in Table 5.15. Demographic, socioeconomic, and health status and behavior variables were added in blocks, and results were similar to the full models shown in Table 5.15.

In the 1993 cohort, older age, being black, and higher depressive symptoms are associated with increased odds of incident cognitive impairment, while education is associated with lower odds of cognitive impairment. In the 2000 cohort, older age, diabetes, stroke, psychiatric disorder, and depressive symptoms are associated with increased odds of incident cognitive impairment. Race/ethnicity was related to odds of cognitive impairment until the model was adjusted for education, at which point it was no longer a significant predictor. Higher education was associated with lower odds of incident cognitive impairment.

The longitudinal analyses were conducted to establish predictors of incident cognitive impairment among older adults and to help inform results from multivariate analyses of trends in cognitive impairment. Trend analyses indicated that declines in cognitive impairment may be attributable to increases in the socioeconomic status—particularly education levels—of the population from 1993 to 2004. Longitudinal analyses showed that education is associated with lower odds of incident cognitive impairment, providing support for this conclusion. As education levels increase in the population, the number and proportion of older adults in “high-risk” groups (i.e. with low levels of education) decrease, and the prevalence of cognitive impairment declines as well.

Table 5.15. Odds ratios showing associations between sample characteristics and cognitive impairment at follow-up among adults aged 70 and older, Health and Retirement Study 1993-1998 and 2000-2004.

Follow-up period	**1993-1998**		**2000-2004**	
Variable	OR	95% CI	OR	95% CI
Demographic variables				
Age	1.11	1.08, 1.15	1.15	1.12, 1.19
Female	1.31	0.78, 2.19	0.98	0.58, 1.63
Black, non-Hispanic	2.21	1.29, 3.80	0.95	0.44, 2.03
Hispanic	1.53	0.60, 3.91	1.04	0.33, 3.29
Born in Midwest	1.66	0.83, 3.31	0.99	0.49, 2.00
Born in South	1.15	0.63, 2.08	1.05	0.63, 1.75
Born in West	1.19	0.34, 4.19	1.05	0.43, 2.52
Born in U.S. territory/outside U.S.	1.27	0.49, 3.27	0.93	0.38, 2.28
Not married/partnered	0.84	0.50, 1.42	0.73	0.46, 1.17
Socioeconomic variables				
Mother's education ≤ 8 yrs.	1.15	0.72, 1.84	0.73	0.41, 1.30
Mother's education missing	1.44	0.65, 3.19	2.01	1.16, 3.49
Respondent education (years)	0.88	0.83, 0.94	0.82	0.74, 0.90
Total wealth				
Lowest tertile	1.25	0.72, 2.18	1.25	0.61, 2.53
Middle tertile	1.45	0.95, 2.23	1.02	0.49, 2.10
Health status and behavior				
High blood pressure	0.92	0.66, 1.30	0.69	0.45, 1.05
Diabetes	1.00	0.52, 1.89	1.82	1.02, 3.25
Cancer	1.02	0.50, 2.07	1.02	0.54, 1.91
Lung disease	0.87	0.42, 1.80	1.24	0.62, 2.47
Heart disease	0.67	0.41, 1.08	1.03	0.64, 1.66
Stroke	1.77	0.89, 3.54	2.02	1.14, 3.56
Psychiatric disorder	0.89	0.48, 1.64	1.84	1.10, 3.07
Depressive symptoms	1.13	1.00, 1.29	1.05	0.93, 1.18
Good vision	0.85	0.54, 1.33	0.93	0.51, 1.67
Fair/poor/legally blind	0.95	0.58, 1.55	1.25	0.71, 2.22
Good hearing	1.18	0.74, 1.88	1.13	0.69, 1.85
Fair/poor	1.46	0.93, 2.30	0.64	0.35, 1.17
Obese	0.69	0.42, 1.12	0.54	0.27, 1.17
Current smoker	0.66	0.32, 1.37	1.11	0.49, 2.50
Former smoker	0.97	0.61, 1.54	0.83	0.47, 1.47

Note: Odds ratios are from weighted logistic regression models adjusted for complex survey design of the HRS as well as potential selection and attrition bias.
Reference categories are: white, non-Hispanic; born in Northeast; mother's education 8+ yrs.; highest tertile of total wealth; excellent vision, hearing; never smoked.

CHANGES IN ATTRITION, MORTALITY, AND INSTITUTIONALIZATION

In order to investigate potential selection bias in the estimated cognitive impairment trends, and to explore factors that may affect the confidence in or interpretation of results, sensitivity analyses were conducted to explore changes in attrition, mortality, and institutionalization over the study period. Multinomial logistic regression models with a continuous trend variable were used to test for changes over time in attrition, mortality, and institutionalization over subsequent two-wave intervals of study, i.e., 1993-1995, 1995-1998, 1998-2000, 2000-2002, and 2002-2004. The approximate length of time between waves was relatively similar between follow-up periods, ranging from 24 months for 2002-2004 to 27 months for 1995-1998, due to differences in starting months across survey waves.

Table 5.16. Changes in mortality, attrition, and institutionalization rates over subsequent survey intervals among adults aged 70 and older, Health and Retirement Study, 1993-2004.

Survey interval	**1993-1995**		**1995-1998**		**1998-2000**		**2000-2002**		**2002-2004**		Annual % change
	n	%	n	%	n	%	n	%	n	%	Age-adj.
Eligible at start interval	7346		5912		7490		7338		7023		
Status at end of interval											
Alive, responded	6158	**84.14**	4876	**82.60**	6384	**85.94**	6199	**85.18**	6312	**86.68**	
Dead	781	**10.38**	773	**13.20**	788	**9.95**	817	**10.65**	711	**9.49**	-1.60**
NR alive or lost to follow	407	**5.48**	263	**4.20**	318	**4.11**	322	**4.17**	280	**3.83**	-3.60**
Institutionalized (% of Alive, responded)	246	**3.91**	249	**5.10**	243	**3.63**	264	**4.19**	230	**3.69**	-0.60
Avg. interval length (months)	24		27		25		26		23		

* P < 0.05; ** P < 0.01 based on linear trend.

Note: Annual percent change estimates for mortality and loss to follow-up are from multinomial logistic regression model with a continuous trend variable and adjusted for age.

Annual percent change estimate for institutionalization is from a separate logistic regression model.

Abbreviations: NR= non-response

Increases over time in attrition or mortality in the HRS could result in underestimation of the prevalence of cognitive impairment in later study years. However, this does not appear to be the case. In fact, the rates of mortality and loss to follow-up declined significantly over the study period. Age-adjusted multinomial logistic models showed annual declines of 1.6% and 3.6% for mortality and loss to follow-up, respectively. The rate of institutionalization did not change significantly over the study period, according to both unadjusted (not shown) and age-adjusted models.

The analyses were repeated after stratifying by cognitive status of respondents at the start of the interval. Because the HRS is a longitudinal survey that follows respondents over time, differential changes (by cognitive impairment status) in rates of mortality, attrition, or institutionalization could also bias the estimates of cognitive impairment prevalence in later years. However, changes over the study period were similar for both groups (impaired and unimpaired). Mortality declined by about 1% annually, loss to follow-up declined by about 4% annually, and institutionalization did not change over time.

SPECIFIC AIM I SUMMARY

The goals of Specific Aim I were to estimate trends in the prevalence of cognitive impairment among older adults in the United States and to explore the contributions of demographic, socioeconomic, health status and behavior variables to changes in prevalence over time. Results showed a downward trend in the prevalence of cognitive impairment from 1993-2004, independent of changes in the age and gender distribution of the population. After adjusting for prior exposure to the cognitive test, the trend was attenuated but remained statistically significant. These results support Hypothesis 1a., which posited that the proportion of the older population with cognitive impairment declined from 1993-2004. Analyses also showed that increases in educational attainment in the population accounted for the remainder of the trend in impairment. This is consistent with Hypothesis 1b., which stated that increases in socioeconomic status would partially account for observed trends. Hypothesis 1c. stated that declines in the prevalence of chronic conditions and smoking would contribute to observed trends in cognitive impairment. Overall, results did not support this hypothesis. The prevalence of chronic conditions increased over time, and the inclusion of health status and behavior variables did not attenuate trends in impairment. Hypotheses 1d. and 1e. were also not supported. These hypotheses posited that the association between cognitive impairment and chronic conditions would change over time, and these changes would partially account for cognitive impairment trends. Results did not show significant changes over time in the relationship between chronic conditions and cognitive impairment.

The results from Specific Aim I provide a conservative estimate of the changes in the prevalence of cognitive impairment in the older adult population in the United States from 1993 to 2004. Analyses were stratified by proxy status and adjusted for the overlap in samples and retesting effects. A number of sensitivity analyses were conducted to investigate the robustness of trend results. In addition, longitudinal analyses were conducted to establish predictors of incident cognitive impairment.

Chapter 6: Specific Aim II Results

Chapter 6 details the results of analyses investigating trends in disparities in cognitive impairment among socioeconomic and racial/ethnic groups. The purpose of Specific Aim II was to determine if trends in cognitive impairment are consistent across groups and to explore to what extent demographic, socioeconomic, health behavior and health status variables contribute to group differences in trends. Disparities are examined by race/ethnicity, education, and wealth. Unadjusted estimates of disparities in the prevalence of cognitive impairment are presented for each year from 1993 to 2004. Multivariate logistic regression analyses are used to determine whether the trends in impairment vary significantly by race/ethnicity, education, or wealth.

DESCRIPTIVE STATISTICS

Sample Distributions by Race/Ethnicity and Socioeconomic Status

Table 6.1 shows the sample sizes and weighted proportions of respondents in each racial/ethnic, education, and wealth group from 1993 to 2004. Results are presented for the total sample in Table 6.1. Table A.4 in the Appendix displays results separately for self-respondents and proxy respondents.

As noted in the previous chapter, the composition of the older adult population changed between 1993 and 2004 in terms of race/ethnicity, educational attainment, and total wealth. The proportion of the sample that identified as Hispanic increased over the study period, and there was a corresponding decrease in the proportion of whites and blacks. Educational attainment increased from 1993 to 2004. For example, the proportion of adults with less than 9 years of education decreased from 25% in 1993 to 15% in 2004. Total wealth (in constant 1993 dollars) also increased significantly from 1993 to 2004.

Table 6.1. Sample sizes and weighted proportions of respondents by race/ethnicity, education, and total wealth, among adults aged 70 and older in the Health and Retirement Study from 1993-2004.

Year	1993	1995	1998	2000	2002	2004	*P* value
Total sample size	7,345	5,911	7,490	7,338	7,303	7,417	
Race/Ethnicity							0.003
White	5,917 (88.34)	4,807 (88.37)	6,135 (87.42)	6,022 (86.74)	5,977 (86.98)	5,981 (87.61)	
Black	1,011 (8.03)	768 (8.01)	901 (8.02)	829 (8.27)	827 (7.85)	893 (7.61)	
Hispanic	418 (3.63)	336 (3.62)	457 (4.56)	487 (4.99)	499 (5.16)	543 (4.78)	
Education							<0.000
0-8 years	2,048 (24.68)	1,545 (23.64)	1,659 (19.79)	1,484 (18.32)	1,319 (16.42)	1,226 (14.54)	
9-11 years	1,262 (17.20)	976 (16.45)	1,202 (16.01)	1,130 (15.32)	1,091 (14.78)	1,099 (14.63)	
12 years	2,152 (30.84)	1,793 (31.49)	2,355 (32.87)	2,389 (33,61)	2,451 (34.40)	2,558 (35.52)	
> 12 years	1,884 (27.27)	1,597 (28.42)	2,277 (31.33)	2,335 (32.74)	2,442 (34.40)	2,534 (35.31)	
Total Wealth (1993$)							<0.000
<$0--<$40,000	2,499 (30.47)	1,779 (26.85)	2,099 (26.18)	1,958 (25.45)	1,847 (23.95)	1,906 (23.84)	
$40,000--<$145,000	2,479 (34.21)	1,927 (32.32)	2,260 (30.28)	2,169 (29.32)	2,093 (28.33)	1.956 (26.05)	
≥ $145,000	2,368 (35.31)	2,205 (40.83)	3,134 (43.54)	3,211 (45.23)	3,363 (47.72)	3,555 (50.11)	

Estimates are weighted using the HRS respondent population weights to adjust for the complex sampling design of the HRS survey.
P value for χ^2 for a significant difference in proportion or mean across years.

Changes in the Composition of the White, Black, and Hispanic Populations

Changes in sample characteristics from 1993 to 2004 were examined for each race/ethnicity to inform Specific Aim II analyses investigating disparities in trends. The composition of the older white, black, and Hispanic populations changed between 1993 and 2004, and there were similarities and differences in trends across racial/ethnic groups. Table 6.2 presents the weighted descriptive characteristics of the study samples for 1993 and 2004 for whites, blacks, and Hispanics. For the sake of parsimony, only

1993 and 2004 are presented; however, the *P* values in Table 6.1 represent changes in means or proportions across all the years of study (1993-2004).

Demographic Variables

The mean age of the samples varied over time. Linear regression analysis with age as the outcome and a continuous year trend variable indicated that mean age of the sample declined for whites, blacks, and Hispanics from 1993 to 2004. Among white respondents, the proportion of females declined over time, but there was no significant change among blacks and Hispanics. The proportion of the sample represented by a proxy respondent decreased from 9.38% to 7.06% among whites. Proxy rates fluctuated slightly for blacks and Hispanics, resulting in no significant change across time.

Socioeconomic Status

Socioeconomic status increased over time among all three racial/ethnic groups. Older adults in 2004 were less likely to report mothers having fewer than 8 years of education. Mean educational attainment of the respondents increased as well for all groups. Mean years of education increased from 11.50 in 1993 to 12.44 in 2004 among older white adults, from 8.30 to 9.92 among older black adults, and from 6.12 to 7.33 among older Hispanics. In 1993, 63% of whites, 27% of blacks, and 20% of Hispanics had completed high school, compared with 76%, 43%, and 28%, respectively, in 2004. Total wealth (in constant 1993 dollars) increased over time for whites, blacks, and Hispanics. In 1993 39% of older whites had total wealth of greater than $145,000 compared to 55% in 2004. The percent of older blacks with total wealth greater than $145,000 increased from 9.4% in 1993 to 10.6% in 2004, and the percent with wealth between $40,000-$145,000 increased from 25.9% in 1993 to 30.7% in 2004. In 1993 11% of Hispanics had total wealth greater than $145,000 compared to 22% in 2004.

Table 6.2. Trends in demographic, socioeconomic, and health status and behavior variables in adults ≥ 70 years in the United States by race/ethnicity, Health and Retirement Study, 1993-2004.

Race/ethnicity	White			Black			Hispanic		
Year	**1993**	**2004**		**1993**	**2004**		**1993**	**2004**	
Sample size	5,917	5,981		1,011	893		418	543	
Demographic variables									
Age (mean +/- SE)	77.49 ± 0.10	77.73 ± 0.11	***	77.59 ±0.24	77.01 ±0.28	*	77.17 ± 0.32	77.09 ± 0.33	*
Female	59.84	57.90	*	61.91	63.33		59.48	60.16	
Proxy respondent	9.38	7.06	***	14.20	15.02		18.90	16.83	
Region of birth			**						***
Northeast	25.41	26.06		5.37	4.18		1.99	10.40	
Midwest	34.43	35.56		4.38	5.58		0.69	3.17	
South	25.85	24.98		85.83	84.67		29.77	19.92	
West	7.53	8.30		0.60	1.41		11.55	21.34	
U.S. territory/ outside U.S.	6.79	5.10		3.82	4.15		56.00	54.53	
Veteran	24.55	31.80	***	18.07	20.24		9.89	11.54	
Marital status									
Married/has partner	54.05	55.01		36.80	34.93		48.55	49.63	
Not married/ partnered	42.79	42.64		59.63	60.88		47.00	46.41	
Never married	3.16	2.35		3.57	4.19		4.50	3.96	
Socioeconomic status									
Mother's education			***			***			*
Fewer than 8 years	38.12	23.02		48.32	36.85		68.77	61.28	
8 or more years	51.11	66.44		28.48	41.04		18.60	20.76	
Missing	10.77	10.54		23.20	22.10		12.63	17.96	
Education			***			***			**
0-8 years	20.33	10.45		50.82	32.72		72.77	60.46	
9-11 years	17.15	13.99		22.57	24.17		6.78	11.11	
High school/GED	33.00	37.42		15.51	24.34		12.17	18.58	
More than high school	29.52	38.14		11.10	18.77		8.27	9.85	
Mean +/- SE	11.50 ± 0.07	12.44 ± 0.06		8.30 ±0.26	9.92 ±0.21		6.12 ±0.60	7.33 ±0.50	
Total wealth (in 1993 $)			***			*			*
< $0--< $40,000	25.96	19.06		64.75	58.69		64.56	56.06	
$40,000--< $145,000	35.37	25.87		25.88	30.72		24.36	21.94	
≥ $145,000	38.67	55.08		9.37	10.58		11.08	22.00	

Table 6.2. Continued.

Race/ethnicity	White			Black			Hispanic		
Year	**1993**	**2004**		**1993**	**2004**		**1993**	**2004**	
Sample size	5,917	5,981		1,011	893		418	543	
Health status and behavior									
Chronic conditions									
Hypertension	47.75	60.94	***	64.23	74.58	***	50.81	62.84	***
Diabetes	11.07	17.57	***	22.44	29.93	***	21.40	29.79	*
Cancer	14.57	20.49	***	10.31	15.68	***	9.78	10.04	
Lung disease	12.40	12.27		6.96	8.24		9.71	5.64	*
Heart disease	32.69	35.91	***	26.89	30.59		24.12	23.52	
Stroke	10.43	9.97		12.01	13.58		8.05	9.14	
Psychiatric disorder	10.64	13.26	***	10.52	12.25		15.72	16.59	
Depressive symptoms	1.49 ±0.03	1.41 ±0.03		1.87 ± 0.8	1.85 ±0.07		2.34 ±0.14	1.83 ±0.74	
Obese (BMI ≥ 30 kg/m2)	12.04	17.45	***	22.89	29.89	*	18.22	23.02	
Smoking			***			**			
Current	9.51	7.31		12.53	9.31		11.27	6.34	
Former	43.29	48.55		37.20	46.49		43.37	43.03	
Never	47.20	44.14		50.27	44.20		45.35	50.63	
Self-rated vision			***			**			***
Excellent/very good	38.97	32.53		27.44	20.05		31.23	21.61	
Good	36.07	44.05		35.86	41.75		34.52	36.73	
Fair/poor/legally/ blind	24.96	23.42		36.71	38.20		34.25	41.67	
Self-rated hearing			*						
Excellent/very good	37.13	34.87		38.03	32.92		33.69	25.53	
Good	37.02	35.76		36.64	39.09		32.42	36.87	
Fair/poor	25.85	29.37		25.33	27.99		33.89	37.60	

*p < 0.05; **p < 0.01; ***p < 0.001

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

Abbreviations: SE, standard error; BMI, body mass index.

P value for $\chi 2$ or t test (for year trend variable from linear regression) for a significant difference in proportion or mean across years.

*Only estimates for 1993 and 2004 are shown here; however, reported *P* value is for all years.

Health Status and Behavior

Changes in health status and behavior were observed from 1993 to 2004 for each group. Prevalence rates of hypertension, diabetes, and obesity increased among whites, blacks, and Hispanics, although the change in obesity was not statistically significant for Hispanics. There were increases in reports of cancer for whites and blacks. Lung disease decreased among Hispanics. Heart disease increased among whites and blacks (not statistically significant), and smoking rates decreased for all groups from 1993 to 2004, but the change was not statistically significant for Hispanics (P = 0.07). There were increases in reports of psychiatric disorders and hearing problems among whites. Vision problems increased for blacks and Hispanics from 1993 to 2004.

The net effects of these changes in sociodemographics and health status will be investigated in the next section, which examines cognitive impairment trends by race/ethnicity, education, and wealth.

SPECIFIC AIM II RESULTS

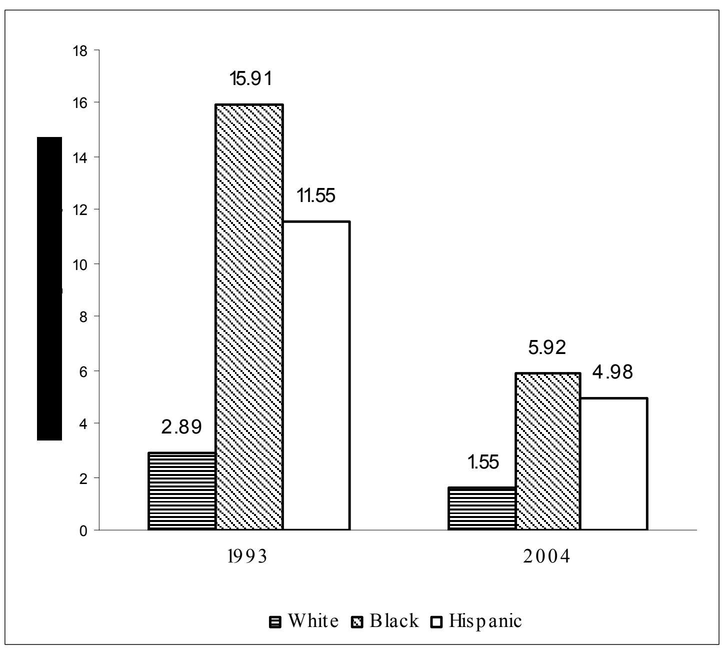
The goals of Specific Aim II were to: 1) determine if the patterns of change in cognitive impairment were consistent across racial/ethnic and socioeconomic groups, and 2) explore the contributions of changes in demographic, socioeconomic, health behavior, and health status variables to group differences in trends. Some previous research has shown that improvements in disability were concentrated among the most advantaged groups (Schoeni et al., 2001; Crimmins & Saito, 2001). Therefore, it was hypothesized that trends in the prevalence of cognitive impairment would vary by race/ethnicity, education, and wealth, with larger declines observed for the most advantaged groups. In addition, it was hypothesized that trends by education and wealth would largely account for racial/ethnic disparities in trends.

As Specific Aim I did not find evidence of significant declines in cognitive impairment among proxy respondents after adjusting for age and gender, this chapter focuses on results for self-respondents. The results for proxy respondents are briefly discussed.

Disparities in Prevalence of Cognitive Impairment

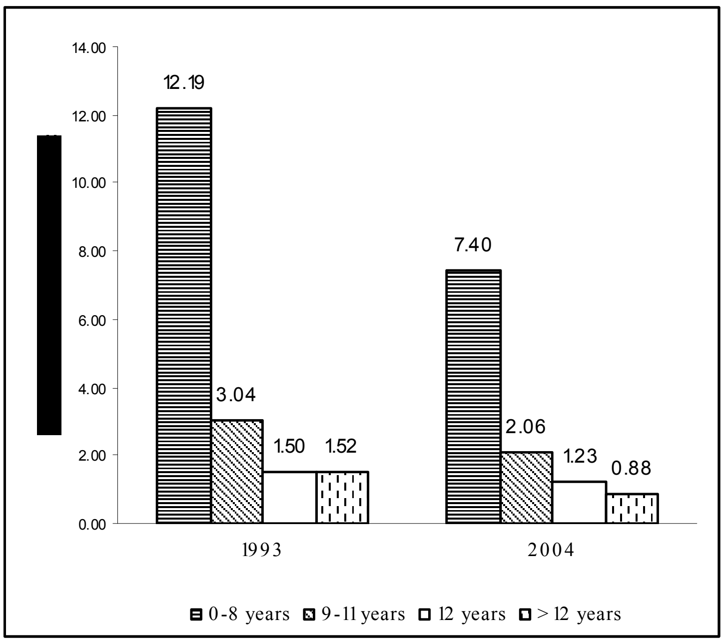
Racial/ethnic and socioeconomic disparities in cognitive impairment were evident in the older adult population in the United States. Figures 6.1, 6.2, and 6.3 display the percent of adults aged 70 and older who have cognitive impairment by race/ethnicity, education, and wealth groups. Prevalence estimates are unadjusted, and results are shown for the years 1993 and 2004.

Figure 6.1. Percent of adults aged 70 and older with cognitive impairment, by race/ethnicity, Health and Retirement Study 1993 and 2004.



Racial/ethnic disparities in cognitive impairment were quite substantial in 1993. Figure 6.1 shows that the prevalence of cognitive impairment was 15.91% among blacks and 11.55% among Hispanics in 1993, compared to 2.89% among whites. The magnitude of the differentials declined considerably between 1993 and 2004, primarily due to large absolute declines in percent impairment among blacks and Hispanics. The racial/ethnic disparity declined by 8.65 percentage points between whites and blacks and 5.23 percentage points between whites and Hispanics. Although disparities narrowed, the prevalence of cognitive impairment remained higher among blacks and Hispanics in 2004.

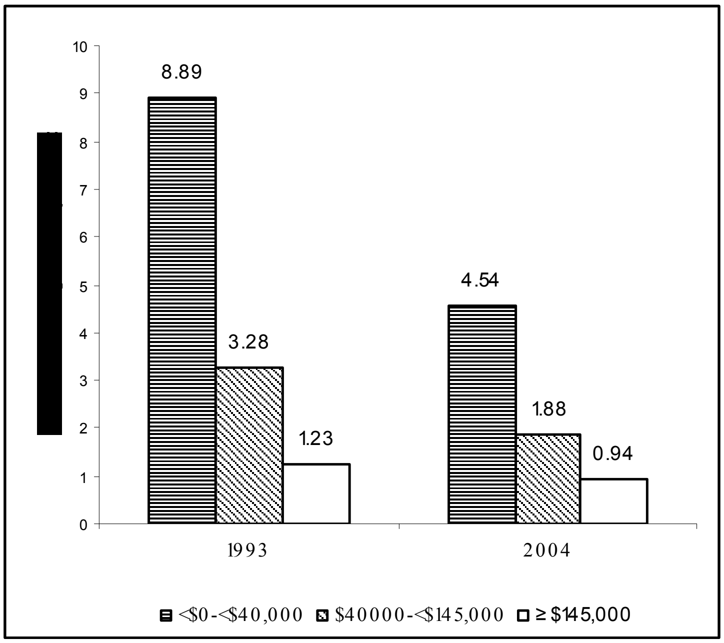
Figure 6.2. Percent of adults aged 70 and older who with cognitive impairment, by education, Health and Retirement Study 1993 and 2004.



Figures 6.2 and 6.3 (below) indicate that there were also large socioeconomic differentials in the prevalence of cognitive impairment. In 1993, 12.19% of respondents with 0-8 years of education were cognitively impaired, compared with 1.52% of those with more than 12 years. The prevalence of impairment was 8.89% among respondents in the lowest quartile of total wealth in 1993, compared to 1.23% among those in the highest quartile. For both education and total wealth, the magnitude of disparities decreased

between 1993 and 2004. The disparity between the highest and lowest groups declined by 4.15 percentage points for education and 4.06 percentage points for total wealth.

Figure 6.3. Percent of adults aged 70 and older with cognitive impairment, by total wealth, Health and Retirement Study 1993 and 2004.



Descriptive Trends in Impairment by Race/Ethnicity, Education, and Wealth

Table 6.3 shows the unadjusted prevalence of cognitive impairment and annual percent change in outcome according to age, gender, race/ethnicity, education, and wealth for each year of the study. The prevalence of cognitive impairment declined among all groups. Absolute declines in percent impairment varied somewhat across racial/ethnic and socioeconomic groups; however, relative annual percent declines were generally similar across subgroups, with a few exceptions.

The annual percent decline in impairment was approximately 4-5% for each age group and for both males and females. Cognitive impairment rates declined among all educational groups; however, the annual percent decline was only 1.5% for those with 12 years of education, compared with about 3% per year for other education levels. The prevalence of cognitive impairment decreased for all racial/ethnic groups, but improvements were larger for blacks and Hispanics. The annual percent decline in cognitive impairment was 3.9% for whites, 5.2% for blacks, and 4.7% for Hispanics. As a result, the racial/ethnic gap in cognitive impairment prevalence narrowed. Similarly, annual percent declines were somewhat larger for those in the lower wealth groups—approximately 3-4%—compared to about 2% for those in the highest group.

These results are counter to Hypothesis 2a., which stated that trends in the prevalence of cognitive impairment would vary by race/ethnicity, education, and wealth, such that declines are largest for the most advantaged groups. Descriptive trend results indicate that declines were larger for disadvantaged groups and show that disparities have declined substantially from 1993 to 2004. The next section details results from multivariate trend analyses, which test for statistically significant differences in cognitive impairment trends between racial/ethnic and socioeconomic subgroups after adjusting for age, gender, and prior exposure to the cognitive test.

Table 6.3. Percent with cognitive impairment by age, gender, race/ethnicity, education, and wealth, self-respondents aged 70 and older in the United States, Health and Retirement Study 1993-2004.

Year	1993	1995	1998	2000	2002	2004		
Self-Respondents							Avg. Annual % Change	
	%(SE)	%(SE)	%(SE)	%(SE)	%(SE)	%(SE)		*P* value
Aged 70-74	1.75 (0.24)	1.37 (0.25)	1.28 (0.23)	0.72 (0.13)	1.01 (0.22)	0.89 (0.19)	-4.095	0.006
Aged 75-79	2.93 (0.59)	1.95 (0.30)	1.55 (0.32)	1.55 (0.26)	1.45 (0.30)	1.14 (0.29)	-5.091	0.001
Aged 80-84	6.06 (0.59)	3.39 (0.56)	3.66 (0.58)	2.93 (0.52)	3.01 (0.47)	3.03 (0.51)	-4.167	0.001
Aged 85+	12.24 (0.93)	8.87 (0.82)	8.40 (0.89)	7.62 (1.00)	5.71 (0.76)	5.42 (0.92)	-4.643	<0.0001
Male	4.33 (0.53)	2.90 (0.42)	2.19 (0.34)	2.18 (0.25)	2.03 (0.33)	1.96 (0.33)	-4.561	<0.0001
Female	4.07 (0.35)	3.56 (0.37)	2.79 (0.24)	2.19 (0.24)	2.23 (0.26)	2.03 (0.21)	-4.177	<0.0001
Education								
0-8 years	12.19 (0.97)	8.80 (0.81)	7.85 (0.90)	6.96 (0.79)	7.30 (0.93)	7.40 (1.13)	-3.275	0.001
9-11 years	3.04 (0.51)	4.26 (0.68)	2.39 (0.38)	1.89 (0.44)	1.83 (0.41)	2.06 (0.44)	-2.686	0.003
12 years	1.50 (0.37)	1.47 (0.33)	1.35 (0.25)	1.34 (0.25)	1.51 (0.30)	1.23 (0.23)	-1.500	0.623
> 12 years	1.52 (0.29)	0.88 (0.23)	1.03 (0.25)	0.99 (0.21)	0.88 (0.21)	0.88 (0.19)	-3.509	0.110
White	2.89 (0.31)	2.38 (0.28)	1.83 (0.20)	1.60 (0.17)	1.52 (0.21)	1.55 (0.18)	-3.864	<0.0001
Black	15.91 (1.87)	13.09 (2.04)	8.47 (1.22)	8.20 (1.21)	8.15 (1.44)	5.92 (1.35)	-5.233	<0.0001
Hispanic	11.55 (1.93)	5.94 (1.10)	7.31 (1.84)	3.64 (1.14)	4.71 (1.01)	4.98 (0.93)	-4.740	<0.0001
Total wealth								
<$0-<$40,000	8.89 (0.81)	7.30 (0.87)	5.56 (0.71)	4.88 (0.56)	4.67 (0.66)	4.54 (0.69)	-4.078	<0.0001
$40000-<$145,000	3.28 (0.41)	2.82 (0.47)	2.36 (0.33)	1.94 (0.33)	2.07 (0.36)	1.88 (0.33)	-3.557	0.014
≥ $145,000	1.23 (0.25)	1.28 (0.25)	0.99 (0.20)	0.96 (0.20)	1.02 (0.21)	0.94 (0.19)	-1.965	0.246

Estimates are weighted using the HRS respondent population weights to adjust for the complex sampling design of the HRS.
P value from logistic regression analysis with year trend variable for a significant difference in the proportion across years.

Multivariate Analyses

Multivariate logistic regression models were estimated to test for trends in the prevalence of cognitive impairment after adjusting for age, gender, and prior test exposure. Interactions between the year trend variable and race/ethnicity and socioeconomic variables were included to test for differences in trends between groups. For each interaction model, the main effects were also included. Odds ratios indicating annual percent decline in cognitive impairment are presented for each group in the upper panel of Table 6.4. *P* values for the interaction terms are shown below the table.

As indicated in Chapter 5, there was a statistically significant decline in the proportion of older adults with cognitive impairment, amounting to 3.4% per year after adjusting for age, gender, and prior test exposure (Model 1). Models 2-4 show results for trends in disparities. The differences in trends across racial/ethnic, education, and wealth groups were not statistically significant (see *P* values included below Table 6.4). Results showed annual declines of 2.9% for whites, 5.7% for blacks, and 4.6% for Hispanics. For education groups, those with 0-8 and 9-11 years of education showed declines of 1.3% per year and 3.4% per year, while those with 12 or more years showed little change in cognitive impairment. For wealth groups, the lower two groups showed declines of 3.4% and 2.5% per year, respectively, while the highest wealth group showed little change.

Sensitivity Analyses

Several sensitivity analyses were conducted, and general conclusions were robust to alternative categorizations of race/ethnicity (black, nonblack; white, nonwhite) and education (<12 years, 12 years, 13-15 years, 16+ years). Analyses were also repeated using linear probability models, which provide estimates of absolute (percentage point change) rather than relative (percent change) decline over time.

Table 6.4. Trends in cognitive impairment by race/ethnicity, education, and total wealth, among adults aged 70 and older in the Health and Retirement Study, 1993-2004.

Variable	Model 1		Model 2		Model 3		Model 4	
Trend	0.966	0.941, 0.992						
Trend*Race/Ethnicity								
White			0.971	0.936, 1.006				
Black			0.943	0.914, 0.973				
Hispanic			0.954	0.912, 0.997				
Trend*Education								
0 to 8 years					0.987	0.955, 1.021		
9 to 11 years					0.966	0.924, 1.010		
12 years					1.005	0.958, 1.055		
≥ 12 years					0.994	0.948, 1.042		
Trend*Wealth								
<$0-<$40,000							0.966	0.936, 0.997
$40000-<$145,000							0.975	0.936, 1.017
≥ $145,000							0.991	0.947, 1.038
Covariates								
Age	1.130	1.12, 1.15	1.14	1.13, 1.15	1.12	1.11, 1.13	1.12	1.11, 1.13
Female	0.970	0.82, 1.14	0.94	0.79, 1.11	1.00	0.84, 1.20	0.77	0.64, 0.92
Prior test exposure	0.630	0.54, 0.74	0.65	0.55, 0.76	0.66	0.56, 0.78	0.69	0.58, 0.81
Main Effects								
Black			6.99	4.77, 10.24				
Hispanic			4.33	2.83, 6.63				
0 to 8 years					7.63	4.80, 12.11		
9 to 11 years					2.75	1.76, 4.28		
12 years					1.33	0.79, 2.23		
≥ 12 years								
<$0-<$40,000							5.70	4.00, 8.12
$40000-<$145,000							2.31	1.72, 3.11

Note: Odds ratios are from weighted logistic regression models adjusted for complex survey design of the HRS.

Test for equality of the trend between groups:

Race/ethnicity: Black = White, *P* = 0.187; Hispanic = White, *P* = 0.519

Education: 0-8 years = ≥ 12 years, *P* = 0.804; 9-11 years = ≥ 12 years, *P* = 0.367; 12 years= ≥ 12 years, *P* = 0.662

Wealth: < $40,000 = ≥ $145,000, *P* = 0.300; $40,000-<$145,000 = ≥ $145,000, *P* = 0.526

Trend Results from Linear Probability Models

Trends in cognitive impairment by race/ethnicity, education, and wealth were also investigated using linear probability models. Linear probability models estimate annual percentage point change and provide a different way of measuring trends compared to logistic regression models, which estimate annual percent change. Linear probability models were used to analyze trends because descriptive results showed large absolute declines in cognitive impairment among blacks and Hispanics and lower socioeconomic groups. Although differences in relative trends were not statistically significant, it is important to investigate differences between groups in terms of absolute change.

Results from linear probability models showed that interaction terms for race/ethnicity, education, and wealth were statistically significant. The rate of percentage point decline was significantly faster among blacks (b= -0.694, $P = 0.000$) and Hispanics (b= -0.360, $P= 0.011$) compared to whites (b= -0.008, $P = 0.827$), for whom the annual percentage point change in cognitive impairment was nearly 0. Rates of decline were significantly faster among the lowest education group (b= -0.272, $P= 0.019$) compared to those with more than 12 years of education (b= 0.066, $P= 0.055$). The lowest wealth group declined significantly faster (b= -0.270, $P= 0.001$) compared to the highest group (b= 0.048, $P= 0.091$).

Finally, all 3 sets of interactions were included together in the same model—allowing the trend to vary by race/ethnicity, education, and wealth. This was done in order to examine the extent to which disparities in trends for any given factor were accounted for by differential trends in the other factors. When including all 3 sets of interaction terms in the same model, the rate of decline among blacks remained significantly faster compared to whites ($P= 0.004$), but the rate of decline among

Hispanics did not (*P*= 0.601). Further analysis indicated that differential trends in education accounted for differences in trends between whites and Hispanics. The differences in trends across education and wealth groups were no longer statistically significant when all interaction terms were included in the model. Further adjustment for demographic, socioeconomic, and health variables did not attenuate the rate of decline among blacks.

<u>Prior Test Exposure Sensitivity Analysis</u>

Analyses were repeated including prior exposure variables with progressively higher contrasts (e.g., ≥ 2 test exposures vs. < 2; ≥ 3 test exposures vs. < 3) in separate models. These analyses were conducted to investigate whether trend results were sensitive to the measurement of prior exposure. Results were very similar to those reported above for both logistic regression and linear probability models.

In terms of relative trends, the differences in trends across racial/ethnic groups were not statistically significant. After adjusting for age, gender, and 2 prior test exposures, results showed annual declines of -2.7% for whites (OR= 0.973; 95% CI= 0.935, 1.012), -5.7% for blacks (OR= 0.943; 95% CI= 0.909, 0.978), and -4.6% for Hispanics (OR= 0.954; 95% CI= 0.910, 0.998). In terms of absolute change, after adjusting for age, gender, and 2 prior test exposures, the rate of percentage point decline was significantly faster among blacks (b= -0.664, *P* = 0.000) and Hispanics (b= -0.330, *P*= 0.012) compared to whites (b= 0.013, *P* = 0.723), for whom the annual percentage point change in cognitive impairment was nearly 0. For education groups, those with 0-8 and 9-11 years of education showed relative declines of -1.5% per year (OR= 0.985; 95% CI= 0.950, 1.021) and -3.6% per year (OR= 0.964; 95% CI= 0.924, 1.007), while those with 12 or more years showed little change in cognitive impairment. For wealth groups, the lower two groups showed relative declines of -3.0% (OR= 0.970; 95% CI= 0.937, 1.004) and -2.0% per year (OR= 0.980; 95% CI= 0.938, 1.025), respectively, while the highest wealth group showed little change. Neither the interaction terms for socioeconomic groups nor the trends among any of the education or wealth groups were statistically significant in logistic regression models. In terms of absolute change estimates from linear probability models, rates of decline were significantly faster among the lowest education group (b= -0.259, *P*= 0.003) compared to those with more than 12 years of education. The lowest wealth group declined significantly faster (b= -0.242, *P*= 0.009) compared to the highest group

Analyses were repeated including 3 prior test exposure (vs. < 3) and 4 prior test exposure (vs. < 4) variables in separate logistic regression and linear probability models. These variables did not attenuate the year trend variable to the extent that the 1 prior test exposure and 2 prior test exposure variables did. For example, adjusting for age, gender, and 3 prior test exposures yielded annual trends of -3.6% for whites (OR= 0.964; 95% CI= 0.925, 1.005), -6.7% for blacks (OR= 0.933; 95% CI= 0.903, 0.963), and -5.5% for Hispanics (OR= 0.944; 95% CI= 0.898, 0.993). Adjusting for age, gender, and 4 prior test exposures yielded annual trends of -5.0% for whites (OR= 0.950; 95% CI= 0.915, 0.986), -8.1% for blacks (OR= 0.919; 95% CI= 0.891, 0.948), and -6.9% for Hispanics (OR= 0.931; 95% CI= 0.890, 0.974). When adjusting for 3 and 4 prior test exposures, similar patterns were observed for socioeconomic trends, as well as for linear probability estimates of racial/ethnic and socioeconomic trends. Overall, the results of these sensitivity analyses indicate that adjusting for prior exposure variables with progressively higher contrasts did not meaningfully attenuate the racial/ethnic or socioeconomic trends. In addition, the substantive conclusions regarding racial/ethnic and socioeconomic trends and differences in trends were the same.

Trend Results for Proxy Respondents

Descriptive and multivariate trend analyses were repeated for proxy respondents from 1993-2002 for the global ratings and behavioral symptoms outcome and from 1995-2004 for the Jorm IQCODE outcome. Table 6.5 shows the unadjusted prevalence of cognitive impairment and annual percent change in outcome by subgroup.

Descriptive Results

For the global ratings and behavioral symptoms outcome, the annual percent decline in impairment was similar across education groups, ranging from approximately 0.98% to 1.99%. Annual percent decline was higher among blacks (2.84%) compared to whites (1.17%), while Hispanics had smaller annual percent declines (0.53%). The lowest and highest wealth groups showed larger annual percent declines, while the middle group showed little change in impairment. For the Jorm IQCODE outcome, the annual percent decline varied across education groups. Among those with 9-11 years of education, the annual percent decline in impairment was 5.32%, compared to 1.41% for those with 0-8 and more than 12 years and 0.88% for those with 12 years. Whites were the only racial/ethnic group to show decline (2.42% per year). Blacks showed little change in impairment, and the prevalence of impairment increased among Hispanics. Declines were larger for the lowest and highest wealth groups compared to the middle group.

Table 6.5. Percent with cognitive impairment by race/ethnicity, education, and wealth, proxy respondents aged 70 and older in the United States, Health and Retirement Study 1993-2004.

Year	1993	1995	1998	2000	2002	2004	Annual
Proxy Respondents	%(SE)	%(SE)	%(SE)	%(SE)	%(SE)	%(SE)	% Change
Global ratings and Behavioral Symptoms							
0-8 years	44.77 (2.68)	47.99 (3.22)	42.68 (3.65)	47.80 (3.48)	40.36 (3.59)		-0.985
9-11 years	42.92 (4.89)	49.36 (6.08)	42.54 (4.55)	35.84 (5.32)	38.12 (3.86)		-1.118
12 years	45.41 (3.80)	43.35 (3.71)	39.63 (3.54)	35.69 (3.64)	36.39 (3.17)		-1.986
> 12 years	47.39 (6.10)	50.94 (6.42)	39.89 (4.38)	39.99 (4.25)	41.24 (3.76)		-1.298
White	42.99 (2.41)	46.46 (2.49)	39.90 (2.19)	39.33 (2.23)	37.95 (2.24)		-1.172
Black	58.51 (4.44)	58.24 (4.51)	45.52 (3.48)	50.58 (3.83)	41.91 (3.64)		-2.837
Hispanic	46.58 (7.57)	40.33 (8.11)	48.76 (5.38)	45.89 (5.71)	44.10 (5.05)		-0.532
<$0-<$40,000	52.09 (2.53)	48.22 (3.14)	46.44 (3.30)	46.21 (5.10)	45.88 (3.82)		-1.192
$40000-<$145,000	42.63 (4.56)	49.45 (3.57)	45.55 (3.26)	42.90 (3.94)	42.24 (4.11)		-0.091
≥ $145,000	36.38 (4.34)	43.93 (4.47)	32.24 (3.13)	34.98 (2.82)	30.96 (2.10)		-1.490
Jorm IQCODE							
0-8 years		36.12 (2.87)	34.45 (2.93)	38.48 (4.02)	34.75 (3.16)	31.01 (2.60)	-1.415
9-11 years		39.74 (4.77)	31.12 (3.76)	32.05 (3.81)	35.74 (4.33)	18.58 (3.43)	-5.325
12 years		39.49 (4.22)	32.01 (3.80)	30.67 (3.14)	35.99 (3.68)	36.01 (5.26)	-0.881
> 12 years		40.04 (6.98)	36.55 (4.66)	27.72 (4.56)	30.38 (4.90)	34.39 (4.12)	-1.411
White		39.25 (2.56)	34.45 (1.99)	31.63 (1.94)	33.57 (2.22)	29.77 (2.31)	-2.415
Black		40.54 (3.91)	36.06 (3.78)	43.64 (6.24)	37.76 (4.72)	40.95 (3.79)	0.101
Hispanic		21.82 (5.49)	23.53 (2.94)	34.45 (5.64)	36.36 (3.50)	24.48 (3.58)	1.219
<$0-<$40,000		40.41 (3.57)	37.17 (2.86)	40.65 (4.29)	41.01 (3.68)	33.85 (3.34)	-1.623
$40000-<$145,000		36.31 (3.34)	37.71 (3.56)	35.79 (3.50)	38.90 (3.72)	33.14 (3.02)	-0.873
≥ $145,000		36.53 (4.09)	26.07 (2.58)	23.59 (2.58)	25.38 (2.77)	26.66 (3.51)	-2.702

Multivariate Results

Multivariate logistic regression analyses with interaction terms indicated that for the global ratings outcome, the prevalence of cognitive impairment declined significantly faster for blacks compared to whites. The annual percent decline was -2.0% for whites and -7.1% for blacks. Demographic, socioeconomic, and health variables did not attenuate the differences in trends between whites and blacks. Interaction terms for education and wealth variables were not statistically significant.

Multivariate logistic regression analyses for the Jorm IQCODE outcome showed that the prevalence of cognitive impairment declined significantly faster for whites compared to Hispanics. The annual percent decline was -2.4% for whites, while the prevalence of impairment actually increased among Hispanics. Interaction terms for education and wealth variables were not statistically significant. After adjusting for psychiatric disorder, the difference in decline between whites and Hispanics was no longer statistically significant. Increases in prevalence of psychiatric disorder from 1995-2004 may have contributed to increases in impairment among Hispanics.

CHANGES IN ATTRITION, MORTALITY, AND INSTITUTIONALIZATION

Additional analyses examined changes over the study period in rates of attrition, mortality, and institutionalization by race/ethnicity, education, and wealth. Differential changes over time could potentially bias results for trends in disparities. Multinomial logistic regression models with a continuous trend variable were used to test for changes over time in attrition, mortality, and institutionalization over subsequent two-wave intervals of the study, i.e., 1993-1995, 1995-1998, 1998-2000, and 2002-2004. Interaction terms between the year variable and group indicators were included to test for differences over time by race/ethnicity, education, or wealth.

Table 6.6. Changes in mortality, attrition, and institutionalization rates over subsequent survey intervals among adults aged 70 and older, Health and Retirement Study, 1993-2004.

Survey interval	1993-1995		1995-1998		1998-2000		2000-2002		2002-2004		Annual % change
	n	%	n	%	n	%	n	%	n	%	Age-adj.
Status at end of interval											
Whites	5,917		4,807		6,135		6,022		5,977		
Alive, responded	5,007	**84.71**	3,971	**82.60**	5,259	**86.32**	5,124	**85.55**	5,168	**86.72**	
Dead	602	**10.08**	624	**13.19**	627	**9.81**	635	**10.36**	578	**9.47**	-1.50*
NR alive or lost to follow	307	**5.22**	208	**4.21**	244	**3.87**	259	**4.08**	230	**3.80**	-3.40**
Institutionalized (% of Alive, responded)	200	**3.88**	204	**5.16**	205	**3.67**	212	**4.11**	193	**3.78**	-0.40
Blacks	1,011		768		901		829		827		
Alive, responded	810	**79.00**	621	**81.49**	731	**81.68**	673	**82.40**	701	**84.44**	
Dead	132	**13.29**	114	**14.73**	123	**12.68**	121	**13.33**	92	**10.94**	-2.10
NR alive or lost to follow	69	**7.71**	33	**3.77**	47	**5.64**	35	**4.26**	34	**4.62**	-4.70*
Institutionalized (% of Alive, responded)	42	**5.16**	34	**5.20**	29	**3.99**	41	**5.63**	28	**3.49**	-1.70
Hispanics	418		336		457		487		499		
Alive, responded	340	**81.75**	283	**84.96**	396	**86.17**	402	**83.23**	443	**89.37**	
Dead	47	**11.32**	35	**10.06**	39	**7.78**	61	**11.23**	41	**7.55**	-2.50
NR alive or lost to follow	31	**6.93**	18	**4.98**	21	**6.05**	24	**5.53**	15	**3.07**	-6.50**
Institutionalized (% of Alive, responded)	4	**1.81**	11	**3.41**	10	**2.33**	11	**3.31**	9	**2.59**	2.50
Avg. interval length (months)	24		27		25		26		23		

* P < 0.05; ** P < 0.01 based on linear trend.
Note: Annual percent change estimates for mortality and loss to follow-up are from multinomial logistic regression model with a continuous trend variable and adjusted for age.
Annual percent change estimate for institutionalization is from a separate logistic regression model.
Abbreviations: NR= non-response

Increases over time in attrition or mortality for blacks or Hispanics could produce selection bias, resulting in underestimation of the prevalence of cognitive impairment for these groups in later years. However, this does not appear to be the case. Table 6.6 shows that rates of mortality and loss to follow-up declined over the study period for each group. Age-adjusted multinomial logistic models showed annual declines in mortality of

1.5% for whites, 2.1% for blacks, and 2.5% for Hispanics, although declines were not statistically significant for blacks and Hispanics. Rates of attrition declined significantly over time for each group. Results showed annual changes in institutionalization rates of -0.40% for whites, -1.70% for blacks, and 2.50% for Hispanics, but none of these trends were statistically significant. None of the interaction terms included in the multinomial logistic regression models (not shown) were statistically significant, suggesting that the trends in mortality, attrition, and institutionalization did not vary by race/ethnicity.

Changes in mortality, attrition, and institutionalization were also examined for each education and wealth group (results not shown). Interaction terms between the year trend variable and education or wealth variables were included in separate multinomial logistic regression models. None of the interactions were statistically significant, indicating that trends in mortality, attrition, and institutionalization did not vary significantly by education or wealth. Results showed that rates of mortality and attrition declined over the study period for all education and wealth groups, though trends were not statistically significant for all groups.

SPECIFIC AIM II SUMMARY

The main goal of Specific Aim II was to assess whether trends in cognitive impairment were consistent across racial/ethnic and socioeconomic groups. That is, were declines in cognitive impairment occurring only within particular subgroups of the population? Descriptive results showed considerable decreases over time in racial/ethnic and socioeconomic disparities in the prevalence of cognitive impairment among older adults. Declines in absolute, or percentage point, change were greater for blacks and Hispanics compared to whites and for lower education and wealth groups compared to more advantaged groups. However, in terms of annual percent change or relative declines, the differences in trends were not statistically significant. Declines were observed for all racial/ethnic groups, though the trend for whites was of marginal statistical significance. Among the higher education and wealth groups, the prevalence of impairment showed little change. The results for proxy respondents showed differential trends across race/ethnicity. However, differences were inconsistent between the two outcomes and time periods. Improvements among blacks and Hispanics do not appear to be due to selection bias resulting from increased mortality and attrition over time.

The results for Specific Aim II were contrary to Hypothesis 2a., which stated that trends in impairment would vary by race/ethnicity and socioeconomic status such that declines would be largest for the most advantaged groups. Multivariate logistic regression models showed that relative declines in cognitive impairment were not significantly different across subgroups. Descriptive results and linear probability models, however, indicated that percentage point change was greater for disadvantaged groups, and racial/ethnic and socioeconomic disparities decreased substantially between 1993 and 2004. The next chapter will explore potential reasons for the large declines in the prevalence of impairment among blacks and Hispanics and lower socioeconomic groups.

Hypotheses 2b. and 2c. were explored using linear probability analysis because interaction terms included in linear probability models showed statistically significant differences in trends between groups. Hypothesis 2b. stated that when differential trends by race/ethnicity, education, and wealth were considered simultaneously, differential trends in socioeconomic status would largely account for racial/ethnic disparities in trends. Results showed that differential trends in education did account for differences in trends between whites and Hispanics, but not between whites and blacks. Hypothesis 2c. stated that health status and behaviors would partially account for trends in disparities. However, adjusting for these factors did not attenuate differential trends.

In summary, the results for Specific Aim II were somewhat mixed, depending on the method of analysis. Racial/ethnic and socioeconomic gaps in cognitive impairment decreased from 1993 to 2004. In terms of percentage point change, the prevalence of cognitive impairment declined faster for blacks and Hispanics and for the lower education and wealth groups. However, in terms of annual percent change in impairment, trends were not statistically significant across racial/ethnic and socioeconomic groups.

Chapter 7: Discussion

Introduction

This section discusses the results for Specific Aims I and II and interprets findings within the context of previous research concerning trends in the health of older adults in the United States. The implications of the research are considered, especially regarding the aging of the population. Finally, the strengths and limitations of the project are critically reviewed, and potential directions for future research are discussed.

Aim I: Trends in Cognitive Impairment

Summary of Results

The composition of the older adult population in the United States changed considerably between 1993 and 2004. The population became more diverse as the proportion of adults who self-identified as Hispanic increased. Socioeconomic status steadily improved. Between 1993 and 2004, the percent of older adults with less than a high school education decreased from 42% to 29%. Wealth, in constant 1993 dollars, also increased significantly. On the other hand, the prevalence of self-reported health conditions increased in the older population during this time period. There was an increase in cardiovascular disease and risk factors, including hypertension, diabetes, and obesity, from 1993 to 2004, and there were also increases in reports of cancer, psychiatric disorder, and hearing problems. Conversely, smoking rates decreased over the study period.

Multivariate logistic regression analyses showed a downward trend in the prevalence of cognitive impairment from 1993 to 2004, independent of changes in the age and gender distributions of the population. After adjusting for prior exposure to the cognitive test, the trend was attenuated to an annual decline of -3.4%. Socioeconomic variables attenuated the observed relative decline by about 72%, suggesting that improvements in socioeconomic status—particularly education—account for changes in the prevalence of cognitive impairment over time. Changes in health status and behavior did not appear to impact trends in cognitive impairment.

Trend analyses were stratified by proxy status because cognitive measures differed for self-respondents and proxy respondents. Results for proxy respondents showed annual declines in cognitive impairment of -2.2% from 1993-2002 (Global ratings and behavioral symptoms outcome) and -1.3% from 1995-2004 (Jorm IQCODE outcome) after adjusting for age and gender. However, the trends were not statistically significant.

Interpretation of Findings

On the whole, results indicate that the prevalence of cognitive impairment is declining among older adults in the United States, mostly due to increases in education levels in the population. The decline in the prevalence of cognitive impairment suggests that, overall, the net impact of recent changes in demographics and socioeconomic status has been positive for the cognitive health of older Americans. The proportion of the population with cognitive impairment is an indicator of population health (Crimmins, 2004). Changes in the prevalence of cognitive impairment in the noninstitutionalized population are a function of complex shifts in the incidence of and length of time lived in the community with cognitive impairment, the latter being determined by rates of recovery, institutionalization, and mortality (Freedman et al., 2001).

Prevalence estimates for the current project were based on the noninstitutionalized population. Therefore, changes in rates of institutionalization of older adults in the United States during the study period could affect trend estimates. Moreover, the HRS is a longitudinal survey with aged-in cohorts. Therefore, increases over time in loss to follow-up or mortality could bias prevalence estimates downward in later years, inflating trend estimates. To address this possibility, changes in rates of mortality, attrition, and institutionalization were examined over subsequent two-wave intervals of the HRS for the total sample and by cognitive impairment status. Mortality and attrition declined significantly, while institutionalization rates did not significantly change over the study period. These results suggest that survey design issues do not explain the observed declines in cognitive impairment from 1993 to 2004. Nevertheless, selection bias remains a concern to the extent that sample replenishment did not adequately replace those who were lost between waves or to the extent that the composition of the institutionalized population changed over time (e.g., becoming more impaired). Other analyses were conducted to further test the sensitivity of results. Observed trends were robust to alternative methods of dealing with missing data, as well as alternative cutoff scores for cognitive impairment.

The cognitive function measure used in these analyses identifies any type of cognitive impairment, or difficulty in functioning, among the older population. It is important to note that the cognitive measure indicates symptomatic cognitive impairment, rather than a clinical diagnosis. The identification and classification of diagnosed forms of cognitive impairment, including mild cognitive impairment, dementia, and dementia subtypes such as Alzheimer's disease and vascular dementia, in population-based survey research is a major challenge. These impairments are clinical diagnoses requiring clinical neuropsychological examinations. Even so, the cutoff score of 8 was chosen for the cognitive function measure in this study in order to identify cognitive impairment consistent with dementia. This threshold has been tested in prior validation studies, which show that it is a sensitive and specific indicator of clinical dementia (Plassman et al., 1993; Welsh et al., 1993). Nevertheless, trends in the prevalence of diagnosable forms of cognitive impairment may not parallel those observed for the cognitive impairment measure in this study and trends may differ across subtype of dementia.

Finally, it is important to note that results from Specific Aim II showed differential changes in cognitive impairment across racial/ethnic groups. While the prevalence of cognitive impairment declined in each group, larger declines were observed for blacks and Hispanics compared to whites. Substantial changes in the prevalence of cognitive impairment among these groups likely contributed greatly to the observed downward trend for the total population. The results from Specific Aim II, including potential reasons for the substantial changes among blacks and Hispanics, are discussed thoroughly in a later section of this chapter.

The next three subsections of this chapter discuss and interpret the effects of prior test exposure, increases in educational attainment, and changes in health status and behaviors on trends in cognitive impairment in the older population. In addition, trends in cognitive impairment among proxy respondents are discussed.

Effects of Prior Test Exposure

The longitudinal design of the HRS means that most respondents have been surveyed several times over the course of the study. New cohorts were added in to the sample in 1998 and 2004, and new respondents aged-in to the sample each year. However, respondents in 1993 had never been exposed to the cognitive test, whereas most of those in later years had answered the cognitive tests in prior interviews. Repeated exposure to cognitive measures may result in learning effects, which could improve scores of respondents in later years and confound comparisons over time.

The present analysis included a dichotomous variable indicating prior exposure to the cognitive test as a way to adjust trend estimates for potential learning effects.

Adjusting for prior test exposure in multivariate analyses reduced the trend considerably, from -6.6% per year to -3.4% per year. Though reduced, this trend is still a statistically significant decline in cognitive impairment. Nevertheless, these results illustrate both the complexities of using panel data to study trends in cognitive impairment, as well as the importance of adjusting for design features that can produce artifactual differences over the study period (Rodgers et al., 2003). Several previous studies have used data from panel surveys to investigate trends in cognitive impairment (Freedman et al., 2001; Rodgers et al., 2003; Manton et al., 2005; Langa et al., 2008); however, only one (Rodgers et al., 2003) attempted to adjust trend estimates for prior exposure to the cognitive test. Rodgers and colleagues found little change in cognitive functioning from 1993 to 2000 after adjusting for age and prior testing. Considering Rodgers' results and the results of the current project, other studies likely overestimated declines in cognitive impairment.

Retest effects resulting from prior exposure to a cognitive test reflect both the learning of specific cognitive tasks or items, as well as a growing familiarity with the general testing process and environment (Lemay, Bedard, Rouleau, & Tremblay, 2004; Rabbitt, Diggle, Holland, & McInnes, 2004). Typically, improvements in test performance are greatest between the first and second test administrations (Falleti, Maruff, Collie, & Darby, 2006; Rabbitt et al., 2004; Salthouse & Tucker-Drob, 2008). It has been hypothesized that gains occurring between the first and second assessments mostly reflect the extent to which respondents who are inexperienced at testing are able to understand and adhere to the requirements of the testing process (Falleti et al., 2006).

A number of studies have shown individual differences in the magnitude of retest effects (Salthouse & Tucker-Drob, 2008). The magnitude of retest effects may vary according to cognitive task and difficulty, length of time between testing periods, age of the respondent, and the general ability of the respondent and experience with testing (Falleti et al., 2006; Salthouse & Tucker-Drob, 2008). Some research suggests that retest effects may be minimized for some cognitive tasks by using alternate forms of the cognitive test (Rabbitt et al., 2004; Salthouse & Tucker-Drob, 2008); however, this would not minimize retest effects resulting from increased familiarity with the testing process. The HRS attempted to minimize retest effects on the immediate and delayed recall tasks by alternating word lists over waves. In the present study, improvements in cognitive scores were observed across for each subscale (immediate recall, delayed recall, mental status, and serial 7's) as well as total cognition score, suggesting that increased cognitive scores were not due to respondents learning specific cognitive tasks.

Sensitivity Analyses: Prior Exposure Variable

Respondents in later waves of the HRS have had multiple testing occasions (from 1 to fully 5 test exposures), and improvements in scores resulting from repeated exposure to the cognitive measure could potentially confound comparisons over time. As mentioned above, prior test exposure in this project was measured using a dichotomous variable with a value of 1 if the respondent had completed the cognitive test in any prior wave and 0 otherwise. Yet, further investigation of the retesting effect was warranted given the attenuation of the trend when including the prior exposure variable in the model, as well as the potential for training effects resulting from multiple testing occasions. As detailed in subsections of Chapters 5 and 6, additional analyses included dichotomous variables with progressively higher contrasts (e.g., ≥ 2 test exposures vs. < 2; ≥ 3 test exposures vs. < 3) in separate models to determine if trend results were sensitive to the definition and measurement of prior exposure. Adjusting for 2 test exposures (vs. < 2) attenuated the age- and gender- adjusted trend to -3.1% per year (*P*= 0.04), compared with -3.4% (*P*= 0.012) for the trend reported in Chapter 5 results.

Adjusting for 3 and 4 test exposures (in separate models) attenuated the trend to -3.6% (*P*= 0.02) and -5.3% per year (*P*= 0.00), respectively. This process was repeated for racial/ethnic and socioeconomic trends in cognitive impairment, and when adjusting for 2 prior test exposures, results were very similar in magnitude and statistical significance to the main results reported in Chapter 6 for both logistic regression models and linear probability models. When adjusting for 3 or 4 prior test exposures, trend results were larger in magnitude and statistical significance compared to the main results reported in Chapter 6. Overall, the results of these sensitivity analyses indicate that adjusting for alternative measures of prior test exposure did not meaningfully attenuate the trend variable and substantive conclusions were the same.

Increases in Education

Multivariate analyses showed that adjusting for education attenuated the trend in cognitive impairment by approximately 74%, and the year trend variable was no longer statistically significant. These results imply that increases in the education levels of older adults in the United States account for observed declines in the prevalence of cognitive impairment from 1993 to 2004. The interpretation of these results is somewhat complicated, however, because education is causally related to cognitive functioning (both directly and indirectly), as well as improves test-taking ability and represents a proxy for an array of available resources and opportunities over the lifecourse.

Education is associated with higher levels of cognitive functioning, slower rates of cognitive decline, and lower risk of developing dementia among older adults (Lee et al., 2006; Lee et al., 2002; Mortel et al., 1995; De Ronchi et al., 1998). Education is believed to have direct effects on the functioning and physiology of the brain (Lee et al., 2003; Wight et al., 2006; Lee et al., 2006). Educational experiences may stimulate changes in the brain such as increased dendritic speed and growth, number of synapses, cerebral blood flow, and neurochemical structural alterations (Anstey & Christensen, 2000; Stern, 2009). Education likely has indirect effects on cognitive function as well via pathways such as health behaviors, exposure to stress, especially occupational stress and hazards, other behavioral choices, and diet and nutrition (Anstey & Christensen, 2000). Given the socioeconomic advantages associated with higher education, it is likely that education level also functions as a proxy for general living conditions, opportunities, health, and resources experienced over the life course.

Increases in education among the older adult population may have influenced cognitive functioning both directly and indirectly. As education levels increased, the number and proportion of older adults in high-risk groups decreased, and the prevalence of cognitive impairment declined. Longitudinal analyses showed a relationship between education and lower odds of incident cognitive impairment, providing support for the conclusion that trends in cognitive impairment may be attributable to increases in education levels. It is possible that in addition to increases in the number of years of education, the quality of education may have improved over time. For example, changes in curriculum, class size, or teacher training could influence the effect of education.

The decline in the prevalence of cognitive impairment may represent real changes in the risk of cognitive impairment among the older adult population. However, education affects the *measurement* of cognitive performance as well as the actual level of cognitive functioning (Jones & Gallo, 2002). Two individuals with the same level of "true" cognitive ability but different levels of education will likely perform differently on a cognitive assessment (Glymour & Manly, 2008). Therefore, there is the possibility that some of the trend in cognitive impairment is due to improved test taking abilities accompanying increased education, in addition to actual changes in cognitive functioning. However, it is unclear to what extent assessment bias extends to measures used to screen cognitive impairment in older adults, especially given the low cutoff score used in this study.

If increases in education may be causing declines in the prevalence of cognitive impairment among the older adult population, can improvements expect to be sustained? The educational attainment of older adults has increased significantly in recent decades and is projected to continue increasing (Freedman & Martin, 1999). To the extent that increases in education are driving trends, this information suggests that the prevalence of cognitive impairment may continue to decline. However, some authors have suggested that it is possible that the advantage conveyed by additional years of education will dissipate as the high school or college graduate population becomes larger (Freedman & Martin, 1999). That is, relative education status could be more important than absolute status, and additional years of education may confer less advantage as education levels increase in the general population as well (Freedman & Martin, 1999). If this is the case, the relationship between education and cognitive impairment may change as levels of education increase in the general population and educational disparities narrow. Thus, it is unclear whether improvements may be expected to continue in the future.

Changes in Health Status and Behavior of the Population

The prevalence of most self-reported health conditions increased among older adults from 1993 to 2004, while smoking rates declined. However, changes in health status and associated risk factors did not appear to impact trends in cognitive impairment. In addition, the associations between cognitive impairment and chronic conditions did not significantly change over time. These results were contrary to hypotheses and deserve further examination.

It is possible that the measurement of health status and behaviors in the HRS limited the ability of analyses to detect the influence of these factors on trends in cognitive impairment. With the exception of obesity, health conditions and behaviors were measured by self-report rather than clinical indicators. Respondents reported whether a doctor had ever told them that they had [condition] and responses were coded as yes or no. The prevalence rate of health conditions may not capture the changes in health status over time that would be important for trends in cognitive impairment. Self-report measures provide no indication of the severity, management, treatment, or control of disease, and they are subject to error and recall bias. In addition to these limitations, the diagnostic criteria and indications to undertake diagnostic work-ups for health conditions are likely to change over time (Langa et al., 2008). These changes may have contributed to some of the increases in self-reported prevalence of chronic conditions observed among this population of older adults from 1993 to 2004.

Trends in Proxy Respondents

It is worth noting that results showed significant declines in the prevalence of cognitive impairment among self-respondents, but trends were not statistically significant among proxy respondents after adjusting for age and gender. It may be that the sample size for proxy respondents, while quite substantial at about 3,700 respondents, was not large enough to detect small changes of 1-2% per year after accounting for complex survey design and the overlap in samples. Another possibility is that the outcome measures for proxy respondents were not sensitive enough to register subtle changes in cognitive impairment.

Proxy respondents represent a select group: they are older, more likely to be black or Hispanic, less healthy, and more likely to be of low socioeconomic status. It is possible that proxy respondents have more severe cognitive impairment, compared to self-respondents, so they have not experienced changes in prevalence despite widespread increases in socioeconomic status. On the other hand, there were downward trends in the prevalence of cognitive impairment among proxy respondents, albeit not statistically significant trends. In addition, the proportion of proxy respondents *decreased* from 1993 to 2004. Given that proxy respondents are more likely than self-respondents to be cognitively impaired, such a change is consistent with improvements in cognitive functioning in the population.

Comparison to Previous Research

Although cognitive impairment has not received much attention as an outcome in research investigating trends in the health of older adults, a few recent studies have examined changes in the prevalence of cognitive impairment in the 1980s and 1990s using nationally representative samples of older U.S. adults (Freedman et al., 2001; Langa et al., 2008; Manton et al., 2005; Rodgers et al., 2003). Overall, evidence from these studies suggests that the proportion of older adults with cognitive impairment has declined (Freedman et al., 2001; Langa et al., 2008; Manton et al., 2005). Two studies using data from the HRS reported significant declines in the prevalence of cognitive impairment from 1993 to 1998 and from 1993 to 2002 (Freedman et al., 2001; Langa et al., 2008). A third study using the HRS analyzed four years of data and found no evidence of trends from 1993 to 2000 after adjusting for prior test exposure and changes in demographic composition of the sample (Rodgers et al., 2003). Finally, a study using data from the National Long Term Care Survey showed that the age standardized prevalence of cognitive impairment declined among disabled older adults from 1982 to 1999 (Manton et al., 2005).

Despite methodological differences between the present project and previous research studies, in general, conclusions regarding trends in cognitive impairment were similar. However, there were several noteworthy differences in results. This project showed an annual percent decline in cognitive impairment of -3.4% from 1993 to 2004, which was much lower than the -8% per year from 1993 to 1998 estimated by Freedman and colleagues (2001). The studies by Freedman et al. (2001) and Langa et al. (2008) used only two time points to analyze trends and could not adjust trend estimates for prior test exposure. Given the retesting effect observed in the present project, the trend estimates from these studies likely represent overestimates. Rodgers and colleagues (2003) found little change in cognitive functioning from 1993 to 2000 after adjusting for age and prior testing. However, the observation period was only 7 years, compared to 11 years for the current project. In addition, Rodgers et al. (2003) excluded 1 question from the cognitive measure (name U.S. Vice President) due to concern about the influence of election timing and political events, imputed missing answers to the cognitive measure using stable and time-varying covariates as well as covariation of the cognitive measures within and across waves, and used a higher threshold score to indicate cognitive impairment. These methodological and analytic differences may account for the different results between Rodgers et al. (2003) and the current project.

This project adds to prior research by examining a longer observation period and using more recent HRS data, adjusting for prior testing, including proxy respondents, and investigating changes in mortality, attrition, and institutionalization over the observation period. The results of this project weight the research evidence in favor of modest declines in the prevalence of cognitive impairment, most likely attributable to increases in socioeconomic status in the population. The next section discusses results from Specific Aim II regarding differences in trends across race/ethnicity, education, and wealth groups.

AIM II: TRENDS IN DISPARITIES

Summary of Results

Descriptive results showed considerable decreases in the magnitude of racial/ethnic and socioeconomic disparities in cognitive impairment between 1993 and 2004. Absolute, or percentage point, changes in the prevalence of cognitive impairment were larger for disadvantaged groups, causing disparities to narrow. However, multivariate logistic regression analyses showed that in terms of annual percent change, or relative declines, the differences in trends across racial/ethnic, education, and wealth groups were not statistically significant. Declines were observed for all racial/ethnic groups, though the trend for whites was of marginal statistical significance. Among the higher education and wealth groups, the prevalence of impairment showed little change. Linear probability models, which estimate annual percentage point change, were also used to analyze trends. Results indicated that percentage point change was significantly greater for blacks and Hispanics compared to whites and for the lowest education and wealth groups compared to higher socioeconomic groups.

Interpretation of Findings

On the whole, results suggest that declines in the prevalence of cognitive impairment were fairly widespread among the older adult population in the United States. The prevalence of cognitive impairment declined for men and women of all age groups and all race/ethnicities included in this project. The magnitude of improvements differed between more and less advantaged groups, with racial/ethnic and socioeconomic disparities generally narrowing. Overall, results imply that the net impact of changes in risk and protective factors for cognitive impairment has been favorable for less advantaged groups. Successive cohorts have had greater educational attainment and, likely, better opportunities across the lifecourse. This appears to have benefitted blacks particularly, as well as Hispanics. To the extent that these trends represent real changes, these results are encouraging for the state of health disparities in the United States and provide preliminary evidence of advancement toward one of the goals of Healthy People 2010: eliminating health disparities.

In this project, trends in disparities were analyzed using two measurement approaches: logistic regression analysis to estimate relative trends, and linear probability analysis to estimate absolute trends in probability of impairment. Trends in the health of the population can be characterized using various measurement approaches, which may provide different estimates of levels and trends, as well as different answers about health trends (Freedman et al., 2004; Crimmins, 2004). Results for this project showed that annual relative trends in cognitive impairment were not significantly different across racial/ethnic or socioeconomic groups, even though absolute changes were much larger for certain groups. These results occurred because the base for calculating annual percent decline (i.e. the prevalence of impairment in 1993) was much lower for whites and higher socioeconomic groups, so even very small percentage point improvements for these groups yielded relative annual trends similar to those of blacks and Hispanics and lower socioeconomic groups, for whom the base and absolute changes in cognitive impairment were much larger.

As the older population grows and becomes more racially and ethnically diverse over the next few decades (Federal Interagency Forum on Aging Related Statistics, 2008), trends in disparities by race/ethnicity have greater implications for the health of the total population. Measuring trends in disparities in cognitive impairment across racial/ethnic and socioeconomic groups is important for detecting inequality in health progress and determining whether improvements in health have been experienced broadly

(Freedman et al., 2002). In addition, it is necessary to understand trends in disparities in order to project future trends in population health (Freedman et al., 2002). The next section reviews potential reasons for observed trends and changes in disparities across racial/ethnic and socioeconomic groups.

Clinically Relevant Change

It is unclear to what extent the increases in mean cognitive score from 1993 to 2004 represent a level of change consistent with clinically relevant, as opposed to statistically significant, benefit. Table 7.1 shows the weighted means and standard deviations of cognitive scores in 1993 and 2004 and the increases in mean scores over that period. Mean cognitive score for the total population increased by 0.23 standard deviations (SD) between 1993 and 2004. The largest increase in mean score, 0.42 SD, was seen for blacks, followed by a 0.30 SD increase for Hispanics, and a 0.22 SD increase for whites.

Table 7.1. Means and standard deviations of cognitive scores, differences in means, and effect sizes by race/ethnicity, adults aged 70 and older, Health and Retirement Study, 1993 and 2004.

	1993		2004		Difference	Effect
	N	Mean (SD)	N	Mean (SD)	in means	size
Total	6580	19.73 (5.79)	6761	21.05 (5.19)	1.31	0.23
Whites	5363	20.31 (5.51)	5546	21.52 (4.98)	1.22	0.22
Blacks	877	14.72 (5.89)	767	17.20 (5.41)	2.48	0.42
Hispanics	340	15.85 (5.73)	448	17.56 (5.06)	1.71	0.30

Note: Effect size calculated as difference in means divided by SD in 1993
Abbreviations: SD= standard deviation

A great deal of literature has sought to determine the effect size indicating meaningful change on health-related quality of life instruments (Norman, Sloan, & Wyrwich, 2003). A meta-analysis of 38 studies found that the mean clinically relevant difference or effect size was 0.495 SD (Norman et al., 2003). Applying this definition of clinically relevant change, the increases in mean cognitive score in this project were not clinically relevant, though the increase in mean scores among blacks approached this threshold. However, the same meta-analysis indicated that population-based approaches showed smaller effect sizes compared to studies measuring longitudinal changes among individuals (Norman et al., 2003; Beaton, 2003). In addition, it may be inappropriate to equate clinically relevant changes for individuals with the importance of a change for populations (Testa, 2000). Even small changes in mean cognitive score for a population of older adults could mean significant improvements in public health. Nevertheless, with no evidence available establishing a meaningful effect size for population changes in cognitive function among older adults, the 0.5 SD may be a reasonable threshold with which to start.

Changes in Racial/Ethnic and Socioeconomic Disparities

The observed trends in disparities were counter to hypotheses, which posited that trends in cognitive impairment would vary by race/ethnicity and socioeconomic status and declines would be largest for the most advantaged groups. In fact, the prevalence of cognitive impairment declined more among blacks and Hispanics and lower socioeconomic groups, and disparities narrowed. These results were somewhat unexpected and deserve further examination to evaluate what factors may explain these changes in racial/ethnic and socioeconomic disparities.

Increases in Educational Attainment and Quality

Increases in the quantity and quality of education could be responsible for the downward trends in cognitive impairment among blacks and Hispanics relative to whites. Descriptive results showed that increases in educational attainment have occurred at a faster rate among blacks and Hispanics compared to whites. Between 1993 and 2004, the mean level of education increased by 0.94 years for whites, 1.62 years for blacks, and

1.21 years for Hispanics. Mean years of education increased approximately 20% for blacks and Hispanics and 9% for whites between 1993 and 2004. The gap in education between blacks and whites decreased from 3.2 years in 1993 to 2.5 years in 2004, and the gap between Hispanics and whites decreased from 5.4 years to 5.1 years. Other research has shown that the difference in mean years of education completed by blacks and whites declined from 3.46 for those born in the early 1900s to 0.83 for those born in the 1950s (Kalmijn & Kraaykamp, 1996), indicating that racial/ethnic disparities in education among older adults will continue to decline in the future.

When examining racial/ethnic differences in education, it is also important to consider potential changes in educational quality. Quantity and quality of education are discordant in the United States, particularly among minority groups (Manly, 2006). Therefore, increases in the number of years of education may not fully reflect concomitant improvements in the quality or nature of education available to blacks and Hispanics. In the early to mid 1900s, school term length (number of days school was held) was 50-100% longer for white children than for black children. Differences in school term length between blacks and whites decreased dramatically between 1919 and 1951, until the gap in term length was only a few days (Glymour & Manly, 2008). Other indicators of educational quality, such as physical infrastructure, teacher training, curriculum, funding, and hours in a school day, may have improved more rapidly among blacks compared to whites in the decades approaching legally imposed desegregation. Another possibility is that literacy levels among older blacks and Hispanics may have improved between 1993 and 2004. Literacy skills are an indicator of educational quality and have been shown to predict slower memory loss in old age (Manly, Touradji, Tang, & Stern, 2003).

Improved Socioeconomic Conditions over the Lifecourse

In addition to the direct effects of education on cognitive status, improvements in cognitive functioning among older blacks and Hispanics could be attributable to indirect effects of education. Education initiates a trajectory of socioeconomic conditions over the lifecourse (Mirowsky & Ross, 2005). Therefore, increases in educational attainment for blacks and Hispanics are likely to have benefitted these groups in terms of improved socioeconomic status in young adulthood, middle age, and older age. Education level also functions as a proxy for general living conditions, opportunities, resources, and health status experienced over the life course. There is evidence from animal models and epidemiological research indicating that early life exposures and conditions throughout the lifecourse influence late life cognitive function (Glymour & Manly, 2008).

Improved socioeconomic conditions may have influenced the cognitive status of older black and Hispanic adults via health status. There is a great deal of evidence linking exposures over the lifecourse to cardiovascular functioning in old age (Glymour & Manly, 2008). These exposures may influence cognitive impairment and dementia via vascular mechanisms (Kivipelto et al., 2005; Kivipelto et al., 2006; Mielke et al., 2007). Vascular risk factors are believed to contribute to race/ethnic disparities in cognitive function and impairment. For example, the higher prevalence rates of vascular dementia reported for Hispanics and blacks have been attributed to higher rates of vascular risk factors, as well as differences in socioeconomic status and access to care (Froelich et al., 2001). It is possible that health status, particularly vascular risk factors, have changed over time (e.g., better detection, treatment, and control), but the influence of these changes were not detected in multivariate analyses due to the measurement limitations mentioned previously.

There may be broad societal and contextual/environmental changes that were not captured in the multivariate models. The fact that larger declines in the prevalence of cognitive impairment were observed for lower education groups suggests that forces outside of school may have influenced the cognitive status of older adults (Freedman et al., 2001). For example, the workplace has changed over the last century from predominantly labor and low-tech jobs to service and high-tech jobs (Rodgers et al., 2003). Complex work is associated with higher cognitive functioning (Schooler, Mulatu, & Oates, 1999) and lower risk of dementia (Andel et al., 2005). Successive cohorts, including those in lower education groups, may have had more occupational training or other opportunities compared to earlier cohorts.

Potential Effects of Prior Test Exposure and Selection Bias

Other potential reasons for the observed trends in cognitive impairment concerned prior test exposure and selection bias resulting from attrition and mortality. Multivariate analyses adjusted for prior exposure to the cognitive measure. After adjusting for retesting, trends were somewhat attenuated; however, results were substantively equivalent to unadjusted models. Other analyses investigated whether differential changes over time in attrition, mortality, and institutionalization had biased results for trends in disparities. Increases over time in attrition or mortality for blacks or Hispanics could produce selection bias, resulting in the underestimation of the prevalence of cognitive impairment for these groups in later years. However, results indicated that this was not the case. Rates of mortality and attrition declined over time for each racial/ethnic group, suggesting that trends in disparities were not due to selection bias.

Comparison to Previous Research

Previous research on trends in cognitive impairment did not examine trends in disparities for major demographic and socioeconomic groups. However, results from the current project are consistent with descriptive results from the study by Freedman and colleagues (2001), which showed the prevalence of cognitive impairment in 1993 and 1998 by race and ethnicity. Results showed that the prevalence of impairment decreased more steeply for non-whites (15.9% to 7.6%) than for whites (3.3% to 1.8%). The prevalence of cognitive impairment decreased among both Hispanics (11.7% to 6.7%) and non-Hispanics (4.5% to 2.2%), but the improvement among Hispanics was not statistically significant. These trends were not adjusted for demographic shifts, and a statistical test for trend disparities was not performed. In addition, potential explanatory variables were not examined. Other studies (Manton et al., 2005; Liao et al., 2000; Langa et al., 2008) did not examine race/ethnicity- or socioeconomic-specific trends in cognitive impairment.

The results for the current project were not consistent with a community study of older black adults Indiana. Hall and associates (2009) compared prevalence rates for dementia and AD in two population based cohorts of older African American adults in Indianapolis, Indiana in 1992 and 2001. Results showed no significant differences in prevalence between cohorts, despite significant differences in demographic variables, medical history, and treatment between these two groups. Results may have differed between the current project and Hall et al. (2009) for several reasons. For example, the study by Hall and associates had smaller sample sizes, and confidence intervals for prevalence estimates were wide (e.g., ranging from 4.27 to 10.64% for dementia in the 2001 cohort). In addition, prevalence rates were representative of community-dwelling blacks in a city in Indiana, and this sample is likely to differ from a nationally representative sample of older black adults.

IMPLICATIONS

The measurement of health trends in older adults is important for determining public health and policy priorities and is especially relevant given the aging of the United States population. It is important to identify and understand the mechanisms responsible for population-level changes in the health of older adults. The current project provides evidence of downward trends in the prevalence of cognitive impairment among older adults in the United States from 1993 to 2004, mostly attributable to increases in educational attainment. Changes in prevalence were larger for blacks and Hispanics, and racial/ethnic and socioeconomic disparities have narrowed considerably. While these results are generally favorable, it is unclear whether the trend may be expected to continue and what patterns of health change may characterize future periods. Different trends in population health may result, depending on which phases of disease, disability, cognitive impairment, and mortality processes are changing most rapidly (Crimmins, 2004). Nevertheless, results from the present study indicate that the prevalence of cognitive impairment declined in the 1990s and early 2000s.

To the extent that increases in educational attainment in the older population are responsible for observed trends in cognitive impairment, declines may be expected to continue in the future. The educational attainment of older adults has increased significantly in recent decades and is projected to continue increasing (Freedman & Martin, 1999; He et al., 2005). For example, the proportion of the older population with high school diplomas is expected to reach 83% by 2030, compared with 66% in 2000 (Gist & Hetzel, 2004; He et al., 2005). Education level also functions as a proxy for general living conditions, opportunities, resources, and health status experienced over the life course. In addition to increases in formal education and socioeconomic status, ongoing engagement in intellectual and social activities may have the potential to delay the onset of cognitive impairment and further reduce disparities (Scarmeas & Stern, 2003). Lifelong education and other opportunities could also have the potential to further reduce disparities among disadvantaged groups. Successive cohorts, including those in lower education groups, may have had more occupational training or other opportunities compared to earlier cohorts. Increases in educational attainment for blacks and Hispanics are likely to have benefitted these groups in terms of improved socioeconomic status and opportunities and resources over the lifecourse.

The results of the current project suggest that, all else being equal, future changes in education will continue to contribute to improvements in cognitive impairment. However, other population changes are occurring that may impact the cognitive status of older adults. For example, there were increases in cardiovascular disease and diabetes among older adults in the United States in the 1980s and 1990s, potentially due to increased duration of disease resulting from improvements in treatment and earlier diagnosis. Rises in obesity also threaten improvements in health, as obesity is related to poor health outcomes including diabetes, arthritis, and stroke. Increases in diabetes and obesity could have the potential to change trends in cognitive impairment and revise gains in cognition. These health changes would be especially troubling if larger increases were observed for disadvantaged racial/ethnic and socioeconomic groups, potentially diminishing cognitive gains in these groups. In this study, percentage point increases in diabetes were somewhat larger for blacks and Hispanics, and the increase in obesity was somewhat larger among blacks.

The older adult population in the United States is growing, and it is estimated that the number of adults aged 65 and older will double by the year 2040, representing about

20% of the total U.S. population (Social Security Administration, 1998; He et al., 2005). Moreover, the older population will also become more racially and ethnically diverse. As the number and proportion of older adults in the United States increases, cognitive impairment and dementia may place a great burden on the medical care and public health systems in this country, as well as on patients, caregivers and families, and society. However, declining trends in the prevalence of cognitive impairment among older adults may help to offset the effects of the aging population and reduce the burden of cognitive impairment. Unfortunately, it is beyond the scope of this analysis to estimate the number of cognitively impaired older adults expected in the future according to population projections and current trends in prevalence of cognitive impairment and mortality. Nevertheless, the results from this project may aid predictions of future changes and burden of impairment. Previous research projections have assumed that age-specific prevalence rates of dementia remain constant. However, even modest delays in age-specific onset of dementia can have huge public health implications (Brookmeyer et al., 1998). The results from the current project suggest that previous projections likely overestimate the future burden of cognitive impairment in the United States.

Declines in the prevalence of cognitive impairment may also have implications for disability rates and future health and long-term care expenditures, as cognitive impairment contributes to lower levels of functioning, disability, and the need for care. For example, in 2003, the World Health Organization reported that dementia contributed 11.2% of years lived with disability in adults aged 60 and older (World Health Organization, 2003). Dementia contributed more to disabled life years than stroke, musculoskeletal disorders, cardiovascular disease, and cancer. A good deal of research has shown that rates of disability and functional limitations among older adults in the United States have declined substantially since the 1980s. The results of the present study suggest that improvements in disability may have been accompanied by changes in the prevalence of cognitive impairment in the 1990s. This is good news for the health of older adults.

It is important to note that the Hispanic ethnicity group in this study included all Hispanic population subgroups in the United States. In addition, there was an oversampling of Florida residents; therefore, Cuban Americans may be overrepresented. Caution should be exercised in generalizing the HRS study results for Hispanics to the Mexican American and Hispanic populations in the United States, as these groups may have different sociodemographic composition and health profiles. In addition, the improvements in cognitive impairment observed for Hispanics in this study period may not apply to the future Hispanic population in the United States due to changes in the proportions of various subgroups (e.g., increases in the proportion of Mexican Americans).

STRENGTHS AND LIMITATIONS

Study Strengths

The HRS is a nationally representative survey of non-institutionalized older adults, enabling results to be generalized to the community-dwelling older population in the United States. The HRS includes a wide variety of variables that were used in the present project to characterize the socioeconomic circumstances, health and health behaviors, and demographic characteristics of respondents from 1993 to 2004 and to account for observed trends and trends in disparities. Because the HRS represents the United States as a whole, the present project was able to examine trends in cognitive impairment across racial/ethnic, education, and other subgroups. This analysis turned out to be important, as overall trends appear to have been driven by substantial declines in prevalence of cognitive impairment among blacks and Hispanics, and previous research had not investigated racial/ethnic or socioeconomic differences in trends.

The HRS conducted interviews every two years, and the sample was replenished with incoming cohorts and those who age-in to the sample. The present project was able to use six time points over an 11-year time frame. Estimates of the prevalence of disease may fluctuate from year to year; therefore, multiple time points provide a more accurate estimate of general trends. Few studies have used more than four time points to examine trends in disability or cognitive impairment.

Cognitive measures for self-respondents were consistent across all time points, and cognitive function was assessed using direct measures of cognition drawn from established clinical instruments. Using a direct measure of cognitive function, rather than dementia diagnoses from administrative data, avoids spurious trends resulting from changes in diagnostic criteria, clinical practice, and awareness in the population.

A proxy informant was used to provide an assessment for those unable or unwilling to respond for themselves. Proxy respondents represent a select group who are less healthy and more likely to be severely impaired. It is important to include results from proxy respondents in analyses of trends, as cognitively impaired respondents are more likely to be represented by a proxy, and changes in proxy rates over time could produce a spurious change in the apparent prevalence of cognitive impairment among self-respondents.

Although independent repeated cross-sectional designs are most appropriate for the analysis of trends, panel data also have several strengths when used for this purpose. Panel data allow for both cross-sectional and longitudinal analyses. In this study, longitudinal analyses were used to link risk and protective factors to incident cognitive impairment. Other longitudinal analyses were conducted to examine changes over the survey period in 2-year rates of institutionalization, attrition, and mortality among survey respondents. These analyses gave further insight into what factors may be influencing changes in the prevalence of impairment.

This project investigated potential sources of bias or threats to the validity of trend results and made statistical adjustments when possible. For example, the design of the HRS resulted in repeated testing, and learning effects could confound trend results. Therefore, multivariate trend analyses adjusted for prior exposure to the cognitive measure. Sensitivity analyses were conducted to test the effects of alternate coding schemes and cutoff scores on trend results. Finally, analyses were conducted to assess potential shifts in the institutionalized population outside the scope of the survey, as well as differential loss to follow-up and mortality by cognitive status and race/ethnicity.

Study Limitations

Studies that evaluate trends in population health place very high demands on the data in terms of a number of survey features that affect consistency of measurement over time (Freedman & Martin, 2006). Limitations of the current project include: measurement properties of the cognitive measure, survey design, population coverage, and measurement of health conditions.

Cognitive Function Measure

The psychometric properties of the cognitive measure represent a limitation of this project. Exploratory factor analysis of the cognitive function measure showed two factors—mental status and memory—that were moderately related to each other. HRS investigators have suggested these results indicate that the cognitive measure may be analyzed as a composite or aggregate score of overall cognitive functioning as well as a two-factor measure (Herzog & Wallace, 1997; Ofstedal et al., 2005); however, the results seem to indicate that the cognitive measure is best used as two factors. In this project, the cognitive measure was used as a composite score of general cognitive functioning. Consequently, the two-dimensional structure of the cognitive measure is a limitation because this project aimed to measure severe impairment in general cognitive functioning among older adults. Exploratory factor analysis was repeated forcing the cognitive items onto 1 factor, and results showed adequate factor loadings for all the cognitive items except the scissors item. It is clear that the scissors item does not load onto the cognitive measure, likely due to the low variability of this item. The scissors item was retained in the total score for the cognitive measure to maintain consistency and comparability with previous research. Trend analyses (not shown) were repeated after excluding the scissors item from the cognitive measure and results were very similar to those reported in Chapters 5 and 6 in terms of both magnitude and statistical significance. In addition, linear regression analyses were used to examine trends in the two factors, memory and mental status, to determine whether similar patterns were observed for each. Results showed significant yearly increases in mental status scores ($b = 0.015$; $P = 0.01$) after adjusting for age, gender, and prior testing. Including socioeconomic status in the model attenuated the trend variable ($b = 0.002$; $P = 0.73$). Similar results were observed for memory. The year trend variable was significantly associated with higher memory scores ($b = 0.026$; $P = 0.00$) after adjusting for age, gender, and prior test exposure. Including socioeconomic status attenuated the trend variable ($b = 0.001$; $P = 0.95$). These results indicate that similar patterns of improvement were observed for the two factors of the cognitive test, and improvements in both factors may be attributed to increases in socioeconomic status. The internal consistency reliability coefficients of the cognitive measure, though similar across racial/ethnic groups and waves of the survey, ranged from 0.63 to 0.75. The low reliability coefficients are a limitation, though they may be accounted for, in part, by the two-dimensional structure of the cognitive measure. Together, the results of factor analyses and tests of reliability seem to indicate that the items in the cognitive measure may not function well together as a scale.

The HRS cognitive measure provides an assessment of cognitive functioning but does not allow determinations of a clinical diagnosis of dementia. The threshold score chosen for this project has been shown to be a sensitive and specific indicator of clinical dementia in prior validation studies (Plassman et al., 1993; Welsh et al., 1993). Nevertheless, it is unclear whether trends in dementia may be similar to those observed for cognitive impairment in this project. The Aging, Demographics, and Memory Study (ADAMS), a longitudinal supplement to the HRS from 2001 to 2005, aimed to estimate the prevalence of clinically diagnosed dementia in the U.S. elderly population. A secondary aim of ADAMS is to establish validity of the HRS cognitive functioning measure as a screening tool for cognitive impairment or dementia (Ofstedal et al., 2005; Langa et al., 2005); however, validation studies have not yet been conducted.

Another limitation related to measurement of the outcome variable is that different cognitive measures were used for self- and proxy respondents in the HRS. Moreover, proxy measures of cognitive status varied across years of the survey. As a result of these survey features, it was necessary for all descriptive and multivariate analyses to be stratified by proxy status. In addition, the proxy measures of cognitive impairment may indicate a more severe level of impairment than self-respondent measures, and therefore, trends results may not be completely comparable between self-respondents and proxy respondents. Nevertheless, despite the difficulties these measurement differences introduce, analyzing trend results for both self- and proxy respondents is preferable to the omission of proxy respondents.

Survey Design

The HRS is a panel survey with aged-in cohorts. While panel designs may be used to evaluate trends, there are several limitations associated with using longitudinal data to measure trends in health. Independent repeated cross-sectional designs have the advantages of no loss to follow-up or repeated exposure to questions. Prevalence estimates from panel data may be subject to bias due to differential loss to follow-up or mortality. In addition, repeated exposure to cognitive measurements could result in learning effects, confounding comparisons over time. This is a major concern with the analysis of trends in cognitive impairment and represents an important limitation of using panel data to study population changes in the prevalence of cognitive impairment. The current project made statistical adjustments and conducted sensitivity analyses in an attempt to address potential sources of bias resulting from the longitudinal survey design. In an attempt to address threats to the validity of trend estimates resulting from repeated exposure to cognitive testing, multivariate analyses included a variable indicating prior exposure to the cognitive test in order to adjust trend estimates for retesting effects. Adjusting for a dichotomous measure of prior test exposure considerably attenuated the trend variable. However, a simple dichotomous variable indicating whether or not a respondent has been previously exposed to the cognitive measure does not capture the full effects of multiple testing sessions. Therefore, additional sensitivity analyses were conducted using dichotomous variables with progressively higher contrasts in separate models to further explore potential training effects and to investigate whether alternate indicators of multiple testing meaningfully diminish the import of the trend variable. Overall, alternative operationalizations of the prior test exposure variable yielded results that were substantively similar to the main results from Chapters 5 and 6. Nevertheless, to the extent that the measurement of prior test exposure was inadequate and did not completely capture the retesting effect, the reported trend results may have been biased upward or overestimated. Unfortunately, due to the design of the survey, a variable indicating number of prior test exposures could not be included in multivariate analyses; the coefficients for the count variable and the year trend variable were correlated at 0.86. The measurement of prior test exposure is a limitation in this study. Longitudinal analyses of 2-year rates of mortality and attrition were used to estimate changes over time and evaluate the potential influence of these changes on trends in cognitive impairment.

The institutionalized population was excluded from the HRS until 1998, and sampling weights for the nursing home population are only available for the years 2000 and 2002. Therefore, the current project evaluated trends in cognitive impairment among the community-dwelling population of older adults. Prevalence estimates of cognitive impairment among community-dwelling adults underestimate the true prevalence of cognitive impairment in the United States, as cognitive impairment is a strong predictor of nursing home admission (Gaugler, Duval, Anderson, & Kane, 2007). In addition, significant changes in rates of institutionalization of older adults over the survey period could affect trends in the prevalence of cognitive impairment. However, results of sensitivity analyses indicate that this was not the case; two-year rates of institutionalization among HRS respondents did not significantly change over time.

Other Study Limitations

As mentioned previously, health conditions were measured by self-report rather than clinical indicators. Information on the severity, treatment, management, or control of conditions was not available. Self-reported health conditions are subject to error and may not capture the changes in health status over time that would be important for trends in cognitive impairment. The prevalence of self-reported conditions may have increased over time due to changes in diagnostic criteria or indications to undertake diagnostic work-ups (Langa et al., 2008). Changes in health status may have influenced trends in the prevalence of cognitive impairment, but measurement issues may have limited the ability of analyses to detect the influence of these factors.

DIRECTIONS FOR FUTURE RESEARCH

Perhaps the most important task of future research is to replicate these findings using future waves of the HRS, repeated cross-sectional studies, and other longitudinal studies in the U.S. Replication of results with other data sources and analytical methodologies is important before firm conclusions may be drawn about trends in cognitive impairment among older adults in the U.S. In addition, efforts should be made to monitor future trends in impairment, especially as the population ages. Trends in cognitive impairment may change as educational status increases or plateaus in the general population and in racial/ethnic subgroups, and as changes occur in health status and medical care. Ideally, future trends studies would include both the institutionalized and non-institutionalized populations and provide clinical diagnoses of mild cognitive impairment and forms of dementia. An important next step after ascertaining the existence and magnitude of trends in cognitive impairment is to simulate or project the future burden of dementia in the population (e.g., percent change in number of older adults with dementia, or trends in dementia-free life expectancy), given current mortality trends.

Future research could also examine cohort differences in the rate of cognitive decline. Increased education could result in higher average performance on cognitive measures, but aging trajectories may be the same in successive cohorts despite differences in education. Initial cohort differences in cognitive performance would be maintained throughout the aging process, a concept known as preserved differentiation (Salthouse, 2006). Such an occurrence would not contradict the trend results from the current project. Less educated adults from earlier cohorts, starting at a lower level of functioning but declining at the same rate, would be more likely to reach levels of functioning classified as impaired earlier than more educated adults from successive cohorts (Karlamangla et al., 2009). Some research from the Swedish Adoption/Twin Study compared cognitive functioning across two cohorts, 1900-1925 and 1926-1948 and showed significant cohort differences in average performance but no differences in slopes of cognitive decline (Finkel, Reynolds, McArdle, & Pedersen, 2007). Nevertheless, the factors that affect average cognitive performance, education in particular, are also believed to contribute to more successful maintenance of cognitive function in older age. This could result in different rates of cognitive decline between successive cohorts, a phenomenon known as differential preservation (Finkel et al., 2007; Salthouse, 2006).

Finally, investigating the relationship between trends in disability and trends in cognitive impairment may provide an important area for future research. Performance on IADL tasks is strongly correlated with general cognitive functioning and predictive of cognitive impairment and dementia (Peres et al., 2008; Barberger-Gateau, Fabrigoule, & Helmer, 1999). It is interesting to consider whether changes in cognitive impairment may be contributing to improvements in IADL disability (Freedman et al., 2001). Disentangling the complex relationships among increases in socioeconomic status, improvements in disability, and changes in the prevalence of cognitive impairment may be an interesting topic for future research.

CONCLUSIONS

The purpose of this project was to investigate trends in the prevalence of cognitive impairment among older Americans from 1993 to 2004. In doing so, this project aimed to estimate trends in the general population, determine whether demographic, socioeconomic, or health status variables contributed to observed changes, and examine trends among population subgroups. Results suggested that fairly rapid increases in educational attainment among successive cohorts of the population have led to downward trends in the prevalence of cognitive impairment. Changes were largest for blacks and Hispanics, and consequently, racial/ethnic disparities narrowed.

Successive cohorts of older adults may differ from their predecessors in terms of a variety of social, historical, cultural, and socioeconomic conditions over the lifecourse, and such factors may impact the cognitive aging process (Finkel et al., 2007). Educational attainment continues to increase among older adults in the United States, and trends in cognitive impairment may continue to decline. The prevalence of cognitive impairment among black older adults especially may be expected to continue declining as cohorts who benefitted from educational desegregation grow old. Similarly, the level of education among older Hispanic adults will continue to increase.

The current project attempted to minimize threats to the validity of trend estimates; nevertheless, results should be interpreted cautiously. Further research needs to be conducted as more appropriate data become available. The growth in the elderly population in upcoming decades makes the study of trends in health ever more timely and important. Improvements in the socioeconomic status and health of the population may help offset the burden of impairment projected based on demographic prognoses and epidemiological estimates of prevalence.

Appendix

SELF AND PROXY MEASURES OF COGNITIVE FUNCTION USED TO EXAMINE TRENDS IN COGNITIVE IMPAIRMENT AMONG OLDER AMERICANS IN THE HRS, 1993-2004

SECTION C. COGNITION BY R
(Self Respondents)

Immediate Recall (Wave 1)

I'll read a set of 10 words and ask you to recall as many as you can. We have purposely made the list long so that it will be difficult for anyone to recall all the words -- most people recall just a few.

Please listen carefully as I read the set of words. When I finish, I will ask you to recall aloud as many of the words as you can, in any order. Do you have any questions?

LAKE	BIRD
CAR	WINTER
ARMY	DOOR
FOREST	MOUNTAIN
TICKET	PLANT

Now please tell me the words you can recall.
PERMIT AS MUCH TIME AS R WISHES -- UP TO ABOUT 2 MINUTES.

Immediate Recall (Waves 2-6)

I'll read a set of 10 words and ask you to recall as many as you can. We have purposely made the list long so that it will be difficult for anyone to recall all the words -- most people recall just a few. Please listen carefully as I read the set of words. When I finish, I will ask you to recall aloud as many of the words as you can, in any order. Do you have any questions?

PROBE AS NEEDED FOR UNDERSTANDING OF TASK. READ THE ITEMS AT A SLOW, STEADY RATE AS THEY COME UP ON THE SCREEN, APPROXIMATELY ONE WORD EVERY TWO SECONDS

One of the following four word lists was randomly assigned to be read to the respondent.

SET 1	SET 2	SET 3	SET 4
1. HOTEL	11. SKY	21. WOMAN	31. WATER
2. RIVER	12. OCEAN	22. ROCK	32. CHURCH
3. TREE	13. FLAG	23. BLOOD	33. DOCTOR
4. SKIN	14. DOLLAR	24. CORNER	34. PALACE
5. GOLD	15. WIFE	25. SHOES	35. FIRE
6. MARKET	16. MACHINE	26. LETTER	36. GARDEN
7. PAPER	17. HOME	27. GIRL	37. SEA
8. CHILD	18. EARTH	28. HOUSE	38. VILLAGE
9. KING	19. COLLEGE	29. VALLEY	39. BABY
10. BOOK	20. BUTTER	30. ENGINE	40. TABLE

Delayed Recall

A little while ago, I read you a list of words and you repeated the ones you could remember. Please tell me any of the words that you remember now.
PERMIT AS MUCH TIME AS R WISHES -- UP TO 2 MINUTES.

Telephone Interview for Cognitive Status Items

We're interested in how memory actually works. We find that even people with very good memories seem to forget some things from time to time.

The next questions are a little different, but are often asked on studies about memory.
IWER: DO NOT PROBE DK IN SECTION C (COGNITION

1) Please tell me today's date. PROBE MONTH, DAY, YEAR, DAY OF WEEK. (0-4 pts.)
2) For this next question, please try to count backward as quickly as you can from the number I will give you. I will tell you when to stop. Start at: 20. Let's try again. The number to count backwards from again is: 20. (0-2 pts.)
3) Now I'm going to ask you for the names of some people and things. What do people usually use to cut paper? (0-1 pt.)
4) What do you call the kind of prickly plant that grows in the desert? (0-1 pt.)
5) Who is the President of the United States right now? (0-1 pt.)
6) Who is the Vice President? (0-1 pt.)

Serial 7's

Now let's try some subtraction of numbers. One hundred minus 7 equals what? (continue for five trials)

PROXY SECTION PC. COGNITION BY PROXY
(Asked only of Proxy Respondents)

MEMORY: RATE NOW

Part of this study is concerned with people's memory, and ability to think about things. First, how would you rate [NAME'S] memory at the present time? Would you say it is excellent, very good, good, fair or poor?

RATE JUDGMENT NOW

How would you rate [NAME] in making judgments and decisions? Would you say (he/she) is excellent, very good, good, fair, or poor?

Behavioral Symptoms

1) Does (he/she) ever wander off and not return by (himself/herself)?
2) Can (he/she) be left alone for an hour or so?
3) Does [NAME] ever see or hear things that are not really there?
4) (During the past week) how often has (he/she) become angry or hostile without reason? Was it most of the time, some of the time, or never?
5) (During the past week) How often has (he/she) had difficulties falling asleep or waking frequently during the night?
6) (During the past week) How often has (he/she) done things that are dangerous to (himself/herself) or others?
7) (During the past week) How often has (he/she) paced around or made unexplained rocking movements while sitting?
8) (During the past week) How often has (he/she) mentioned that people are plotting against or trying to harm (him/her)?
9) (During the past week) How often has (he/she) drunk too much alcohol?

JORM IQ CODE

Now we want you to remember what [FIRST NAME] was like two years ago and to compare it with what (he/she) is like now. I will read situations where [FIRST NAME] has to use (his/her) memory or intelligence and we would like you to indicate whether this has improved, stayed the same, or gotten worse in that situation over the past two years. Note the importance of comparing (his/her) present performance with two years ago. So if two years ago [FIRST NAME] always forgot where (he/she) had left things, and (he/she) still does, then this would be considered "not much change".

Compared with two years ago, how is [FIRST NAME] at: Remembering things about family and friends, such as occupations, birthdays, and addresses. Has this improved, not much changed, or gotten worse? Is it much improved or a bit improved?

Repeat for: Remembering things that happened recently; recalling conversations a few days later; remembering own address and phone number; remembering what day and month it is; remembering where things are usually kept; remembering where to find things which have been put in a different place than usual; knowing how to work familiar machines around the house; learning to use a new gadget or machine around the house; learning new things in general; following a story in a book or on TV; making decisions on everyday matters; handling money for shopping; handling financial matters, that is, the pension or dealing with the bank; handling other everyday arithmetic problems, such as, knowing how much food to buy, knowing how long between visits from family or friends; using intelligence to understand what's going on and to reason things through.

SUPPLEMENTARY TABLES

Table A.1. Trends in demographic, socioeconomic, and health status and behavior variables in self-respondents aged ≥ 70 years in the United States from 1993-2004, Health and Retirement Study.

Self-Respondents

Year	**1993**		**1995**		**1998**		**2000**		**2002**		**2004**		
Sample size	7,345		5,911		7,490		7,338		7,303		7,417		*P* value
Demographic variables	N	Mean or %	N	Mean or %	N	Mean or %	N	Mean or %	N	Mean or %	N	Mean or %	
Age													
70-74	2559	39.64	1392	25.71	2658	41.54	2482	40.05	2509	38.04	2677	37.33	
75-79	1875	29.17	1838	33.85	1991	30.00	1922	29.28	1750	28.17	1783	28.89	
80-84	1327	19.35	1230	23.71	1202	17.67	1269	18.93	1364	21.18	1357	20.56	
85-89	819	11.85	821	16.74	867	10.80	877	11.75	881	12.62	944	13.22	
Mean +/- SE		77.18 ± 0.09		78.94 ± 0.08		76.81 ± 0.10		77.01 ±0.11		77.36 ±0.10		77.44 ±0.10	<0.001
Median year of birth		1917		1917		1921		1923		1925		1927	
Female	4093	61.18	3295	60.86	4000	60.73	3923	60.83	3887	60.93	3987	59.56	0.054
Race													
White, non-Hispanic	5363	89.06	4368	89.29	5593	88.40	5474	87.89	5419	88.11	5546	88.63	0.012
Black, non-Hispanic	877	7.67	652	7.55	758	7.54	690	7.63	696	7.37	767	7.04	
Hispanic	340	3.27	261	3.16	367	4.07	386	4.48	389	4.52	448	4.33	
Region of birth													
Northeast	1429	23.16	1172	23.29	1445	22.47	1444	22.89	1438	23.30	1427	23.45	0.135
Midwest	1900	32.04	1593	33.04	2095	33.27	2078	33.46	2039	33.07	2093	32.78	
South/unknown	2289	30.14	1746	29.15	2165	29.50	2023	28.78	2016	28.52	2157	28.42	
West	411	7.23	341	7.21	504	8.03	504	8.09	515	8.21	553	8.56	
U.S. territory/outside U.S.	551	7.43	429	7.31	509	6.73	501	6.78	495	6.90	528	6.79	

Table A.1. Continued.

Self-Respondents

Year	**1993**		**1995**		**1998**		**2000**		**2002**		**2004**		
Sample size	7,345		5,911		7,490		7,338		7,303		7,417		*P* value
Socioeconomic variables	N	Mean or %	N	Mean or %	N	Mean or %	N	Mean or %	N	Mean or %	N	Mean or %	
Mother's education													
Fewer than 8 years	2699	39.11	2111	38.55	2254	32.09	1999	28.94	1825	26.97	1788	24.84	<0.001
8 or more years	3120	50.11	2606	51.34	3646	56.07	3730	58.5	3890	61.21	4180	63.86	
Missing	761	10.78	564	10.1	818	11.84	821	12.56	789	11.82	793	11.3	
Education													
0-8 years	1679	22.40	1234	21.14	1315	17.59	1137	15.78	1001	14.19	976	12.70	<0.001
9-11 years	1147	17.41	877	16.39	1074	15.84	1002	15.19	932	14.26	979	14.36	
High school diploma/GED	1960	31.23	1649	32.20	2181	33.85	2211	34.70	2265	35.57	2395	36.41	
More than high school	1794	28.96	1521	30.27	2148	32.84	2200	34.32	2306	36.16	2411	36.71	
Mean +/- SE		11.26 ± 0.09		11.40 ± 0.09		11.71 ± 0.09		11.90 ±0.09		12.08 ±0.08		12.18 ±0.08	
Veteran	1447	23.44	1206	23.59	1864	27.52	1865	28.25	1889	28.80	1987	29.78	<0.001
Marital status													
Married/has partner	3291	51.83	2578	51.78	3684	51.54	3593	51.93	3556	51.98	3805	52.93	0.185
Divorced/separated/widowed	3078	44.84	2545	4.53	2857	45.48	2805	45.27	2791	45.32	2797	44.44	
Never married	211	3.33	155	2.92	173	2.98	148	2.80	151	2.70	155	2.63	
Total wealth (in 1993$)													
<$0-<$40,000	2153	29.14	1495	25.26	1801	25.21	1642	24.12	1550	22.77	1648	22.73	<0.001
$40000-<$145,000	2241	34.55	1735	32.45	2024	30.19	1938	29.29	1882	28.55	1797	26.23	
≥ $145,000	2186	36.31	2051	42.29	2893	44.60	2970	46.59	3072	48.68	3316	51.04	

Table A.1. Continued.

Health status and behavior													
Chronic conditions													
High blood pressure	3292	49.34	2766	51.80	3606	53.58	3653	55.48	3902	60.05	4228	62.11	<0.001
Diabetes	858	12.08	763	13.41	1051	15.02	1076	15.79	1164	17.25	1327	18.64	<0.001
Cancer	910	14.13	845	16.43	1059	15.81	1094	16.74	1188	18.59	1331	20.17	<0.001
Lung disease	724	11.54	569	11.29	718	10.95	678	10.53	706	11.08	758	11.58	0.219
Heart disease	2047	31.45	1746	33.63	2221	32.74	1975	29.92	2213	33.73	2330	34.60	<0.001
Stroke	605	9.05	486	9.45	665	10.00	600	8.99	613	9.35	629	9.22	0.266
Psychiatric disorder	702	10.55	594	10.76	780	11.63	762	11.46	796	12.56	860	12.84	<0.001
Depressive symptoms		1.61 ± 0.03		1.43 ± 0.03		1.66 ± 0.04		1.64 ±0.03		1.57 ±0.04		1.50 ±0.03	
Obese (BMI ≥ 30)	908	13.22	715	12.74	1051	15.63	1082	16.48	1216	18.32	1337	18.99	<0.001
Smoking													
Current	655	9.76	422	7.40	597	9.20	536	8.46	488	7.60	494	7.42	<0.001
Former	2812	42.92	2357	44.87	3088	45.42	3076	46.57	3117	47.40	3261	48.07	
Never	3112	47.32	2502	47.73	3033	45.38	2937	44.97	2899	45.00	3002	44.52	
Self-rated vision													
Excellent/very good	2485	39.07	1493	28.65	2075	31.36	2155	33.15	2111	32.93	2095	31.69	<0.001
Good	2422	36.55	2130	40.31	2809	42.40	2748	42.54	2847	44.01	2938	44.32	
Fair/poor/legally blind	1668	24.39	1655	31.04	1833	26.24	1641	24.31	1539	23.06	1719	23.99	
Self-rated hearing													
Excellent/very good	2550	38.86	1976	36.68	2467	37.16	2472	38.12	2403	36.98	2339	35.32	0.002
Good	2443	37.18	1965	37.17	2480	36.93	2384	36.43	2439	37.69	2519	36.71	
Fair/poor	1585	23.96	1340	26.15	1767	25.91	1688	25.45	1658	25.33	1897	27.97	

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

Abbreviations: SE, standard error; BMI, body mass index.

P value for χ^2 or t test (for year trend variable from linear regression) for a significant difference in proportion or mean across years.

Table A.2. Trends in demographic, socioeconomic, and health status and behavior variables in proxy respondents aged ≥ 70 years in the United States from 1993-2004, Health and Retirement Study.

Year	**1993**		**1995**		**1998**		**2000**		**2002**		**2004**		
Sample size	765		630		775		788		799		656		*P* value
Demographic variables	N	Mean or %	N	Mean or %	N	Mean or %	N	Mean or %	N	Mean or %	N	Mean or %	
Age													
70-74	197	27.94	98	15.23	220	30.02	233	30.94	249	32.51	186	28.11	
75-79	184	22.65	169	25.9	197	25.72	199	25.27	193	24.98	146	24.38	
80-84	178	22.59	167	26.24	149	19.17	155	19.05	157	19.18	139	21.02	
85-89	207	26.82	196	32.64	209	25.09	201	24.74	200	23.33	185	26.49	
Mean +/- SE		80.20 ± 0.41		81.75 ± 0.39		79.59 ± 0.28		79.30 ±0.30		79.26 ±0.31		79.98 ±0.34	<0.001
Median year of birth		1914		1914		1919		1921		1923		1924	
Female	387	49.46	336	53.05	360	46.5	333	42.71	344	43.62	296	45.61	0.002
Race													
White, non-Hispanic	554	81.94	439	80.25	542	77.99	548	76.16	558	76.68	435	76.04	0.025
Black, non-Hispanic	134	11.27	116	12.05	143	12.66	139	14.17	131	12.27	126	14.05	
Hispanic	78	6.79	75	7.7	90	9.35	101	9.67	110	11.05	95	9.9	
Region of birth													
Northeast	142	21.02	108	19.27	132	18.29	119	16.84	119	16.58	110	20.39	0.169
Midwest	131	19.64	102	19.79	150	23.66	155	23.2	162	22.98	114	19.92	
South/unknown	308	36.81	280	39.85	337	39.34	351	41.82	336	39.59	276	39.01	
West	48	6.41	37	6.46	42	5.71	45	5.59	57	7.2	44	6.6	
U.S. territory/outside U.S.	137	16.39	103	14.63	111	12.99	114	12.55	120	13.66	109	14.09	
Veteran	168	24.02	136	22.47	229	31.17	251	32.3	254	32.92	195	31.88	<0.001
Marital status													
Married/has partner	436	58.14	321	53.09	472	59.11	489	61.81	491	60.98	377	56.58	0.046
Divorced/separated/widowed	311	39.45	297	45.02	294	39.42	285	36.13	294	37.01	269	41.6	
Never married	19	2.41	12	1.89	9	1.47	14	2.05	14	2.01	10	1.82	

Table A.2. Continued.

Socioeconomic variables													
Mother's education													
Fewer than 8 years	385	48.46	328	49.62	348	42.31	358	43.27	342	39.97	267	37.89	<0.001
8 or more years	220	30.35	194	33.03	280	38.14	279	37.16	307	40.7	277	44.97	
Missing	161	21.19	108	17.35	147	19.56	151	19.57	150	19.33	112	17.14	
Education													
0-8 years	369	44.99	311	45.69	344	41.12	347	41.79	318	36.87	250	35.34	0.002
9-11 years	115	15.34	99	17.00	128	17.64	128	16.53	159	19.52	120	17.67	
High school diploma/GED	192	27.37	144	25.23	174	24.15	178	23.74	186	24.78	163	26.65	
More than high school	90	12.30	76	12.09	129	17.47	135	18.33	136	19.3	123	20.62	
Mean +/- SE		9.18 ± 0.14		9.02 ±0.23		9.53 ± 0.21		9.53 ±0.22		9.85 ±0.20		10.03 ±0.21	
Total wealth (in 1993$)													
<$0-<$40,000	346	42.36	284	40.91	298	35.55	316	37.72	297	34.76	258	36.37	<0.001
$40000-<$145,000	238	31.19	192	31.23	236	31.20	231	29.61	211	26.32	159	24.00	
>=$145,000	182	26.45	154	27.86	241	33.24	241	32.58	291	38.92	239	39.63	

Table A.2. Continued.

Health status and behavior													
Chronic conditions													
High blood pressure	377	47.81	332	51.25	418	53.31	454	56.45	438	54.03	404	61.61	<0.001
Diabetes	118	14.76	114	16.85	135	15.98	151	18.59	175	21.97	154	24.21	<0.001
Cancer	104	13.45	85	13.6	121	16.06	127	16.41	135	16.63	94	13.42	0.173
Lung disease	107	14.73	77	12.55	92	12.25	111	14.16	99	12.59	79	12.39	0.566
Heart disease	272	36.03	253	40.87	310	41.25	298	37.72	297	36.97	246	38.46	0.279
Stroke	174	23.07	144	23.51	156	20.37	160	20.58	165	21.05	139	21.38	0.051
Psychiatric disorder	98	13.20	120	18.54	153	19.36	153	18.96	161	19.83	126	19.02	0.019
Depressive symptoms		n/a		n/a		n/a		n/a		n/a		n/a	
Obese (BMI ≥ 30)	97	12.35	64	9.61	87	10.60	102	13.33	119	14.19	99	15.01	0.015
Smoking													
Current	80	10.30	50	7.07	77	9.96	81	10.02	80	9.34	48	7.42	0.086
Former	315	41.82	271	43.92	338	43.42	346	43.19	371	47.08	314	48.82	
Never	369	47.88	309	49.01	359	46.62	361	46.78	348	43.58	294	43.76	
Self-rated vision													
Excellent/very good	194	26.09	124	20.21	169	22.90	170	22.43	197	25.29	149	23.95	0.123
Good	234	31.08	199	32.34	270	34.85	277	35.87	287	35.97	220	34.59	
Fair/poor/legally blind	335	42.83	307	47.44	333	42.25	340	41.70	313	38.74	287	41.46	
Self-rated hearing													
Excellent/very good	171	21.26	146	21.46	187	23.60	150	20.29	173	21.85	144	22.46	0.434
Good	255	33.62	188	30.33	215	27.07	258	31.47	244	31.14	188	30.44	
Fair/poor	340	45.12	296	48.21	372	49.33	378	48.24	380	47.01	323	47.76	

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

Abbreviations: SE, standard error; BMI, body mass index.

P value for χ^2 or t test (for year trend variable from linear regression) for a significant difference in proportion or mean across years.

Table A.3a. Bivariate associations between sample characteristics and cognitive impairment (global ratings and behavioral symptoms) in proxy respondents aged 70 and older, Health and Retirement Study, 1993-2002.

Year	**1993**		**1995**		**1998**		**2000**		**2002**	
Sample size										
Demographic variables										
Age (years)	1.03	1.01, 1.05	1.06	1.03, 1.08	1.03	1.00, 1.05	1.04	1.02, 1.06	1.06	1.04, 1.07
Female	1.39	1.03, 1.87	2.39	1.77, 3.22	1.58	1.13, 2.21	1.70	1.26, 2.29	1.75	1.25, 2.44
Race/ethnicity (white)										
Black	1.87	1.23, 2.85	1.61	1.03, 2.52	1.26	0.91, 1.73	1.58	1.20, 2.07	1.18	0.88, 1.59
Hispanic	1.16	0.65, 2.05	0.78	0.39, 1.55	1.43	0.92, 2.22	1.31	0.79, 2.18	1.29	0.85, 1.95
Region of birth (Northeast)										
Midwest	1.11	0.67, 1.81	0.60	0.36, 1.00	0.55	0.34, 0.90	0.97	0.64, 1.45	0.93	0.56, 1.54
South/unknown	1.22	0.76, 1.97	0.85	0.58, 1.24	0.96	0.57, 1.62	1.47	0.93, 2.32	1.37	0.85, 2.22
West	0.86	0.34, 2.16	0.77	0.38, 1.53	1.19	0.61, 2.30	1.04	0.44, 2.47	1.90	0.94, 3.83
U.S. territory/outside U.S.	1.28	0.84, 1.96	0.64	0.40, 1.02	1.06	0.56, 2.00	1.16	0.78, 1.73	1.60	0.95, 2.69
Veteran	0.60	0.44, 0.81	0.54	0.37, 0.77	0.68	0.48, 0.98	0.64	0.45, 0.93	0.79	0.57, 1.08
Not married	1.46	1.04, 2.06	1.95	1.50, 2.55	1.42	0.99, 2.05	1.76	1.22, 2.55	2.04	1.40, 2.97
Socioeconomic variables										
Mother's education (≥ 8 yrs.)										
Fewer than 8 years	1.25	0.82, 1.90	1.05	0.72, 1.53	0.96	0.65, 1.42	1.10	0.75, 1.37	1.08	0.81, 1.44
Education (years)	0.99	0.85, 1.02	0.99	0.95, 1.04	0.99	0.95, 1.03	0.96	0.92, 1.00	0.99	0.95, 1.02
Education (more than high school)										
0-8 years	1.04	0.63, 1.70	0.90	0.48, 1.67	1.07	0.61, 1.87	1.18	0.72, 1.94	1.00	0.64, 1.55
9-11 years	0.77	0.44, 1.34	0.90	0.49, 1.66	1.20	0.74, 1.94	1.25	0.76, 2.06	0.92	0.64, 1.32
High school diploma/GED	0.92	0.59, 1.46	0.74	0.41, 1.32	0.99	0.61, 1.61	0.83	0.50, 1.39	0.81	0.52, 1.27
Total wealth in 1993$ (≥ $145,000)										
<$0-<$40,000	1.90	1.31, 2.75	1.19	0.74, 1.91	1.82	1.23, 2.70	1.60	0.98, 2.60	1.89	1.40, 2.55
$40000-<$145,000	1.30	0.78, 2.17	1.25	0.85, 1.82	1.76	1.20, 2.58	1.40	0.89, 2.17	1.63	1.12, 2.38

Table A.3a. Continued.

Year	1993		1995		1998		2000		2002	
Sample size										
Health status and behavior										
Chronic conditions										
High blood pressure	1.12	0.84, 1.50	1.01	0.74, 1.40	0.88	0.62, 1.24	1.16	0.86, 1.56	0.91	0.69, 1.21
Diabetes	1.55	1.00, 2.39	1.09	0.70, 1.70	0.76	0.46, 1.25	1.01	0.62, 1.63	1.30	0.88, 1.92
Cancer	0.88	0.55, 1.41	0.81	0.46, 1.44	1.04	0.70, 1.54	1.56	0.93, 2.61	1.40	0.93, 2.08
Lung disease	1.15	0.78, 1.70	0.94	0.57, 1.55	1.15	0.68, 1.95	1.13	0.79, 1.63	1.04	0.66, 1.64
Heart disease	1.20	0.93, 1.55	1.24	0.88, 1.76	1.21	0.89, 1.63	1.25	0.94, 1.68	1.28	0.98, 1.68
Stroke	2.30	1.64, 3.21	1.93	1.22, 3.05	2.32	1.54, 3.51	2.58	1.70, 3.91	2.00	1.40, 2.86
Psychiatric disorder	4.20	2.36, 7.46	2.48	1.58, 3.89	2.18	1.55, 3.06	2.72	1.81, 4.09	3.42	2.23, 5.23
Obese (BMI ≥ 30)	1.18	0.67, 2.08	0.78	0.45, 1.35	0.64	0.37, 1.10	0.77	0.50, 1.18	0.72	0.45, 1.16
Smoking (never)										
Current	0.93	0.55, 1.59	0.91	0.49, 1.70	2.06	1.32, 3.21	1.37	0.79, 2.40	0.71	0.44, 1.15
Former	0.86	0.62, 1.19	0.57	0.41, 0.78	0.89	0.61, 1.31	1.01	0.76, 1.35	1.04	0.77, 1.40
Self-rated vision (excellent/very good)										
Good	1.67	1.15, 2.43	1.33	0.82, 2.16	1.57	1.06, 2.34	1.46	0.88, 2.43	1.56	1.04, 2.36
Fair/poor/legally blind	2.75	1.80, 4.20	2.58	1.52, 4.38	2.63	1.80, 3.85	2.95	1.95, 4.45	2.59	1.73, 3.86
Self-rated hearing (excellent/very good)										
Good	1.55	1.03, 2.32	0.81	0.53, 1.26	1.11	0.73, 1.67	1.06	0.63, 1.77	0.82	0.48, 1.38
Fair/poor	1.78	1.31, 2.43	1.19	0.82, 1.73	1.45	0.98, 2.14	1.75	1.13, 2.69	1.53	0.95, 2.48

Estimates are weighted using the HRS respondent population weights to adjust for the complex sampling design of the HRS.

Abbreviations: CI, confidence interval; BMI, body mass index.

Table A.3b. Bivariate associations between sample characteristics and cognitive impairment (Jorm IQCODE) in proxy respondents aged 70 and older, Health and Retirement Study, 1995-2004.

Year	**1995**		**1998**		**2000**		**2002**		**2004**	
Sample size										
Demographic variables										
Age (years)	1.07	1.04, 1.10	1.06	1.03, 1.08	1.06	1.03, 1.08	1.11	1.09, 1.13	1.10	1.07, 1.13
Female	2.35	1.58, 3.50	2.14	1.55, 2.95	2.27	1.62, 3.18	2.45	1.66, 3.63	2.58	1.90, 3.50
Race/ethnicity (white)										
Black	1.05	0.76, 1.46	1.07	0.77, 1.50	1.67	1.03, 2.73	1.20	0.79, 1.83	1.64	1.15, 2.34
Hispanic	0.43	0.23, 0.81	0.58	0.42, 0.81	1.14	0.68, 1.89	1.13	0.83, 1.55	0.76	0.51, 1.15
Region of birth (Northeast)										
Midwest	0.70	0.42, 1.15	0.95	0.56, 1.62	1.10	0.61, 1.99	1.21	0.73, 2.02	0.74	0.41, 1.35
South/unknown	0.91	0.58, 1.43	0.99	0.61, 1.60	1.32	0.75, 2.31	1.21	0.76, 1.94	1.03	0.64, 1.65
West	0.94	0.48, 1.83	1.34	0.62, 2.91	1.24	0.55, 2.81	2.05	1.10, 3.84	1.50	0.86, 2.61
U.S. territory/outside U.S.	0.58	0.32, 1.05	1.08	0.63, 1.85	1.13	0.62, 2.07	1.13	0.73, 1.74	0.85	0.49, 1.47
Veteran	0.38	0.24, 0.61	0.61	0.43, 0.86	0.54	0.38, 0.76	0.50	0.33, 0.75	0.48	0.33, 0.69
Not married	1.97	1.42, 2.73	2.03	1.52, 2.72	2.36	1.64, 3.93	3.06	1.97, 4.76	2.72	1.86, 3.98
Socioeconomic variables										
Mother's education (≥ 8 yrs.)										
Fewer than 8 years	1.02	0.68, 1.52	0.92	0.67, 1.26	1.28	0.88, 1.88	1.65	1.21, 2.26	1.09	0.71, 1.66
Education (years)	1.03	0.99, 1.07	1.02	0.98, 1.05	0.96	0.92, 1.02	0.98	0.94, 1.02	1.03	0.98, 1.07
Education (more than high school)										
0-8 years	0.85	0.47, 1.54	0.92	0.57, 1.49	1.66	0.92, 3.00	1.24	0.72, 2.13	0.87	0.57, 1.32
9-11 years	1.10	0.51, 1.93	0.79	0.44, 1.40	1.70	1.02, 2.82	1.27	0.72, 2.27	0.76	0.44, 1.31
High school diploma/GED	0.98	0.55, 1.75	0.82	0.46, 1.44	1.15	0.65, 2.03	1.29	0.76, 2.18	1.07	0.61, 1.89
Total wealth in 1993$ (≥ $145,000)										
<$0-<$40,000	1.18	0.75, 1.85	1.66	1.19, 2.31	2.22	1.42, 3.46	2.02	1.31, 3.13	1.40	0.90, 2.19
$40000-<$145,000	0.99	0.69, 1.41	1.70	1.15, 2.53	1.81	1.16, 2.81	1.86	1.24, 2.78	1.37	0.90, 2.10

Table A.3b. Continued.

Year	1995		1998		2000		2002		2004	
Sample size										
Health status and behavior										
Chronic conditions										
High blood pressure	0.98	0.72, 1.33	0.93	0.68, 1.27	1.03	0.79, 1.35	1.03	0.77, 1.39	1.42	0.94, 2.14
Diabetes	1.30	0.85, 1.98	1.07	0.93, 1.45	0.93	0.61, 1.43	0.97	0.67, 1.42	0.88	0.54, 1.45
Cancer	0.96	0.55, 1.67	0.90	0.59, 1.37	1.55	1.02, 2.35	1.48	1.01, 2.19	0.83	0.45, 1.51
Lung disease	0.85	0.48, 1.50	1.54	0.90, 2.64	2.42	1.61, 3.63	1.23	0.78, 1.93	0.51	0.29, 0.91
Heart disease	1.47	0.99, 2.18	1.10	0.77, 1.57	1.71	1.33, 2.20	1.65	1.22, 2.24	1.32	0.90, 1.93
Stroke	2.68	1.68, 4.28	2.36	1.61, 3.47	1.88	1.35, 2.63	2.40	1.69, 3.39	1.70	1.14, 2.53
Psychiatric disorder	2.85	1.86, 4.36	2.47	1.72, 3.54	2.73	2.06, 3.61	3.55	2.38, 5.29	2.98	2.07, 4.31
Obese (BMI ≥ 30)	0.38	0.20, 0.69	0.63	0.36, 1.12	0.75	0.40, 1.41	0.75	0.44, 1.28	0.67	0.36, 1.23
Smoking (never)										
Current	0.72	0.36, 1.47	0.88	0.46, 1.68	0.77	0.45, 1.33	0.54	0.32, 0.90	0.39	0.17, 0.90
Former	0.59	0.42, 0.82	0.76	0.55, 1.04	0.82	0.54, 1.23	0.60	0.43, 0.84	0.65	0.49, 0.86
Self-rated vision (excellent/very good)										
Good	1.30	0.78, 2.15	1.07	0.62, 1.83	1.06	0.63, 1.78	1.24	0.82, 1.88	0.81	0.51, 1.28
Fair/poor/legally blind	2.14	1.31, 3.48	2.04	1.26, 3.30	2.61	1.64, 4.14	2.68	1.74, 4.11	2.06	1.31, 3.25
Self-rated hearing (excellent/very good)										
Good	1.02	0.70, 1.51	0.68	0.44, 1.04	0.95	0.58, 1.54	1.39	0.88, 2.19	0.91	0.55, 1.51
Fair/poor	1.22	0.86, 1.75	0.87	0.58, 1.29	1.06	0.76, 1.47	1.82	1.14, 2.90	1.21	0.82, 1.76

Estimates are weighted using the HRS respondent population weights to adjust for the complex sampling design of the HRS.

Abbreviations: CI, confidence interval; BMI, body mass index.

Table A.4a. Sample sizes and weighted proportions of self-respondents by race/ethnicity, education, and total wealth, adults aged 70 and older in the Health and Retirement Study from 1993-2004.

Year	1993	1995	1998	2000	2002	2004
Self-respondent	6,580	5,281	6,715	6,550	6,504	6,761
Race/Ethnicity						
	5,363	4,368	5,591	5,474	5,419	5,546
White	(89.06)	(89.29)	(88.40)	(87.89)	(88.11)	(88.11)
	877	652	757	690	696	767
Black	(7.67)	(7.55)	(7.54)	(7.63)	(7.37)	(7.03)
	340	261	367	386	389	448
Hispanic	(3.27)	(3.16)	(4.06)	(4.48)	(4.52)	(4.33)
Education						
	1,679	1,234	1,315	1,137	1,001	976
0-8 years	(22.40)	(21.14)	(17.59)	(15.78)	(14.19)	(12.70)
	1,147	877	1,074	1,002	932	979
9-11 years	(17.41)	(16.39)	(15.84)	(15.19)	(14.26)	(14.36)
	1,960	1,649	2,181	2,211	2,265	2,395
12 years	(31.23)	(32.20)	(33.79)	(34.70)	(35.48)	(36.32)
	1,794	1,521	2,148	2,200	2,306	2,411
> 12 years	(28.96)	(30.27)	(32.78)	(34.32)	(36.07)	(36.62)
Total Wealth (1993$)						
	2,153	1,495	1,801	1,642	1,550	1,648
<$0---<$40,000	(29.14)	(25.26)	(25.21)	(24.12)	(22.77)	(22.73)
	2,241	1,735	2,024	1,938	1,882	1,797
$40,000--<$145,000	(34.55)	(32.45)	(30.19)	(29.29)	(28.55)	(26.23)
	2,186	2,051	2,893	2,970	3,072	3,316
≥ $145,000	(36.31)	(42.49)	(44.60)	(46.58)	(48.68)	(51.04)

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

Table A.4b. Sample sizes and weighted proportions of proxy respondents by race/ethnicity, education, and total wealth, adults aged 70 and older in the Health and Retirement Study from 1993-2004.

Year	1993	1995	1998	2000	2002	2004
Proxy respondent	765	630	775	788	799	656
Race/Ethnicity						
	553	439	542	548	558	435
White	(81.94)	(80.25)	(77.99)	(76.16)	(76.68)	(76.04)
	134	116	143	139	131	126
Black	(11.27)	(12.05)	(12.66)	(14.16)	(12.27)	(14.05)
	78	75	90	101	110	95
Hispanic	(6.79)	(7.70)	(9.35)	(9.67)	(11.05)	(9.90)
Education						
	369	311	344	347	318	250
0-8 years	(44.99)	(45.69)	(41.12)	(41.79)	(36.87)	(35.34)
	115	99	128	128	159	120
9-11 years	(15.34)	(17.00)	(17.64)	(16.53)	(19.52)	(17.67)
	192	144	174	178	186	163
12 years	(27.37)	(25.23)	(23.93)	(23.52)	(24.51)	(26.49)
	90	76	129	135	136	123
> 12 years	(12.30)	(12.09)	(17.31)	(18.16)	(19.10)	(20.50)
Total Wealth (1993$)						
	346	284	298	316	297	258
<$0---<$40,000	(42.36)	(40.91)	(35.55)	(37.72)	(34.76)	(36.37)
	238	192	236	231	211	159
$40,000--<$145,000	(31.19)	(31.23)	(31.20)	(29.61)	(26.32)	(24.00)
	182	154	241	241	291	239
≥ $145,000	(26.45)	(27.87)	(33.24)	(32.68)	(38.92)	(39.63)

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

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