The Societal and Family Lifetime Cost of Dementia

A Dissertation
SUBMITTED TO THE FACULTY OF
UNIVERSITY OF MINNESOTA
BY

Eric Jutkowitz

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

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May 2017

Acknowledgements

My academic advisors (Dr. Karen M. Kuntz and Dr. Robert L. Kane) and dissertation committee (Dr. Karen M. Kuntz, Dr. Robert L. Kane, Dr. Joseph E. Gaugler, Dr. Bryan Dowd, Dr. Richard F. MacLehose, and Dr. John A. Nyman) have provided tremendous academic and personal support. My committee also has provided me with a high level of training, and they have instilled within me the confidence and skills to make a meaningful contribution to public health.

Finally, this academic experience would not have been possible without the support and encouragement of my parents, brother, grandparents, Ariel, and the Pittner family.

Abstract

Dementia is a complex terminal disease that involves cognitive and functional declines and behavioral/psychological symptoms. Currently >5 million Americans suffer from dementia. The societal economic burden of dementia consists of different types of costs (value of informal care, out-of-pocket expenditures, Medicaid long-term care expenditures, and Medicare expenditures), and several payers (family, Medicaid, and Medicare) shoulder different amounts of the economic responsibility. To facilitate comprehensive planning at the family, state, and federal levels, policymakers must understand who incurs dementia costs over the course of the disease.

The objective of this study was to estimate the lifetime and annual cost of dementia care (value of informal care, out-of-pocket expenditures, Medicaid long-term care expenditures, and Medicare expenditures), and the extra cost of caring for someone with dementia compared to someone who did not exhibit dementia clinical features (net cost).

To estimate total and net lifetime and annual costs we developed an evidence-based mathematical model to simulate disease progression for newly diagnosed individuals with dementia. Data driven trajectories of three clinical features -cognition, function, and behavioral/psychological symptoms- were used to model disease severity. Personal characteristics, clinical features, place of residence, and dual enrollment status were used to estimate cost. Counterfactual

analysis was conducted to compare costs between those who did and did not exhibit clinical features (net cost).

From time of diagnosis (mean age of 83 years), discounted total cost of care for a person with dementia was $322,900. Families incurred 72% of the total cost burden ($144,160 for informal caregiving and $88,780 out-of-pocket payments). Medicaid accounted for 12% ($37,390) and Medicare accounted for 16% ($52,540) of total cost, respectively. In counterfactual analysis, net cumulative costs for a person with dementia were $194,890 greater over a lifetime than someone without dementia (85% of net cost incurred by families).

Our model extends previous studies by considering costs over the life course of the disease. We found that dementia results in $194,890 additional total care costs over an individual's lifetime. The extra cost associated with dementia is primarily borne by families (versus Medicare or Medicaid) due to time spent providing informal care and out-of-pocket expenditures.

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List of Abbreviations

ADAMS   Aging, Demographics, and Memory Study

ADCs   Alzheimer's Disease Centers

BPS   Behavioral and psychological symptoms

FAQ   Functional Activities Questionnaire

HRS   Health and Retirement Study

MMSE   Mini-Mental State Examination

NACC   National Alzheimer's Coordinating Center

NH   Nursing home

NPI-Q   Neuropsychiatric Inventory Questionnaire Version Q

UDS   Uniform Data Set

Chapter 1: Specific Aims

Dementia, a complex, neurodegenerative disease, affects more than 5 million Americans.[1] Persons with dementia experience progressive declines in cognitive and functional ability and a wide range of challenging behavioral/psychological symptoms resulting in the need for caregiving from families over time.[2,3] The intense caregiving needs of the disease often result in individuals with dementia being placed in long-term care facilities.[4,5] Consequently, dementia is the single greatest cause of disease burden exacting a substantial health-related toll on individuals with dementia and their families, and disproportionately higher health and social service related costs.[6] As the population ages over the next 25 years, there will be approximately 13 million dementia cases placing unprecedented economic burden on society.[7,8] Thus, there is a need to derive an accurate accounting of dementia costs from which effective interventions and policies can be developed and to help plan for future Medicare, Medicaid, and individual out-of-pocket spending.[9]

Previous attempts to monetize dementia care have involved two methodological approaches, regression and simulation, with each presenting significant limitations.[10-13] Both approaches have typically relied on a *single* indicator of disease severity, most often cognitive impairment. Yet functional dependence and behavioral/psychological symptoms are equally important markers of disease severity, and ignoring these symptoms may lead to an underestimation of cost.[10-12] Functional limitations and behavioral/psychological symptoms in particular are a significant driver of long-term care needs and

cost.[14-16] Furthermore, most regression studies provide estimates of the cost burden at a single point although dementia and associated care costs unfold over time.

To address these limitations and derive more accurate cost projections, we developed a data-driven microsimulation model that simulated a unique patient's progressions over the course of the disease and accounted for patient-specific characteristics (cognition, function, and behavioral/psychological symptoms) and their variation over time. Microsimulation methods more closely model the natural progression of dementia by relaxing the restrictive assumptions of traditional simulation models that assume a homogenous disease trajectory. Data from the National Alzheimer's Coordinating Center Uniform Data Set were used to estimate longitudinal disease trajectories (cognition, function, and behavioral/psychological symptoms). We linked cross-sectional data from the nationally representative Aging, Demographics, and Memory Study to CMS Medicare data to estimate the association between cognition, function, and behavioral/psychological symptoms and direct (e.g., medical costs, long-term care expenditures, expenditures for formal caregiving for activities of daily living) and indirect (e.g., time providing informal care for daily assistance) cost. The model synthesized trajectory and cost functions to estimate individual expenditures over the life course of the disease. Our specific aims were to:

Aim 1. Evaluate how three clinical features of dementia (cognition, function, and behavioral/psychological symptoms) change over time following a dementia diagnosis (**Chapter 3**).

Aim 2. Evaluate the independent contributions of three clinical features of dementia (cognition, function, and behavioral/psychological symptoms) to the direct (**Chapter 4**) and indirect (**Chapter 5**) costs of dementia.

Aim 3. Evaluate the lifetime and annual cost of dementia care, and the extra cost of caring for someone with dementia compared to someone who did not exhibit dementia clinical features (net cost) by using a microsimulation approach that takes account of clinical trajectories (**Chapter 6**).

This study is novel in its application of a microsimulation approach to derive the lifetime cost of dementia. Results can inform national policy and decision makers concerning how cognition, function, and behavioral/psychological symptoms impact costs over time by payer. This study is responsive to the goals of the National Alzheimer's Project Act and focuses on priority populations (the elderly) of the Agency for Healthcare Research and Quality.

Chapter 2: Significance and Background

Dementia, a neurodegenerative and terminal disorder that involves cognitive and functional declines and behavioral/psychological symptoms, is one of the most costly diseases in the US.[1,17,18] Over 5 million Americans suffer from dementia and more than 15 million people provide unpaid caregiving.[1] As the population ages over the next 25 years, there will be approximately 13 million dementia cases placing significant financial strain on Medicare, Medicaid, and families.[8,19] Accurately understanding the sources of costs and projecting costs over the life course of the disease will help in the development of effective interventions and financial planning.[9]

In 2010, an estimated $215 billion was spent on dementia care.[17] Costs, which vary by place of residence (e.g., the community), include both direct (i.e., medical costs paid by Medicare, out-of-pocket medical costs, long-term care expenditures, and paid caregiving for activities of daily living) and indirect (i.e., time value of informal caregiving for activities of daily living care).[17,20] The high cost of dementia is due to the disproportionate use of healthcare and long-term care services and the need for caregiving (formal and informal).[13,17,21] Long-term care and caregiving costs are incurred primarily by families and Medicaid.[17,22-25]

Previous research provides estimates of total (i.e., cost among those with dementia) and net (cost difference between those with and without dementia) direct and indirect costs of dementia; however, these prior studies have important methodological limitations including the use of small homogeneous samples.[13,26-40] More importantly, most regression-based studies evaluate total cost based on

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a single indicator of disease severity, primarily cognitive impairment.[13] These studies do not provide a comprehensive understanding of the direct and indirect costs of dementia as they exclude the functional consequences and behavioral/psychological symptoms that are common and potentially the most costly aspects of the disease.[41-45] Furthermore, functional ability and behavioral/psychological symptoms are better predictors of informal caregiving in dementia.[15,29,32,46] Finally, most prior studies use cross-sectional data and are unable to account for the significant variability in symptoms and their timing. For example, although behavioral/psychological symptoms are almost universal, they can come and go across the disease trajectory.[41] As disease trajectories vary, basing cost on cognitive status or one indicator of disease severity at one time point limits the accuracy of results, and does not provide policymakers with an avenue for evaluating interventions aimed at other dimensions of the disease.[40,47] This study overcomes previous limitations by modeling individual trajectories to infer cost over the course of the disease.

The most generalizable estimates of the net cost of dementia were recently reported by researchers from RAND and the University of Michigan.[17] However, the RAND study did not evaluate how costs accumulate over the course of the disease nor did it analyze the contributions of dementia-related symptoms that trigger expenditures.[17] We adapted the RAND methodology to evaluate the total and net costs of dementia. In contrast to the RAND study, we

evaluated the total and net lifetime cost of the disease and evaluate the relative contributions of dementia-related symptoms that trigger expenditures.

Simulation-based studies (e.g., Markov models) have extended results from regression-based studies to provide a more detailed estimate of costs on a population level.[10-12] However, modeling studies have been criticized for the use of cohort models that impose a standard disease trajectory and modeling disease progression based on cognitive status alone.[12,48-53] Modeling disease trajectory through multiple domains (e.g., cognition, function, and behavior) is important because the domains of disease severity may differentially impact cost and treatments intervene through different pathways.[10]

This study overcomes these limitations by using microsimulation methods, which relax the restrictive assumptions of traditional cohort models and explicitly take into account patient history and characteristics (e.g., cognition, function, and behavior) to inform cost over the life course of the disease. While these methods have been used to model complex health conditions such as cancer and depression, they have not been adequately applied to dementia.[54-56] Model results can help inform decision makers about how costs accumulate over time and the payers responsible for cost.

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Chapter 3: Cognitive, Functional, and Behavioral Trajectories

3.1 Overview

BACKGROUND: Dementia results in changes in cognition, function, and behavioral/psychological symptoms. We examine the effect of sociodemographic and clinical risk factors on cognitive, functional, and behavioral/psychological declines in incident dementia patients.

METHODS: We used longitudinal data from the National Alzheimer's Coordinating Center to evaluate cognitive (Mini-Mental State Examination [MMSE]), functional (Functional Activities Questionnaire [FAQ]), and behavioral/psychological (Neuropsychiatric Inventory Questionnaire [NPI-Q] severity score) trajectories for incident dementia patients over an 8-year period. We evaluated trajectories of 457 patients with mixed-effects linear regression models.

RESULTS: In the first year, cognition worsened by -1.518 (95% CI -1.745, -1.291) MMSE points (0 – 30 scale). Education, race, and region of residence predicted cognition at diagnosis. Age of onset, geographic region of residence, and history of hypertension and congestive heart failure predicted cognitive changes. Function worsened by 3.464 (95% CI 3.131, 3.798) FAQ points in the first year (0 – 30 scale). Cognition, gender, race, region of residence and place of residence, and a history of stroke and hypercholesterolemia predicted function at diagnosis. Place of residence and a history of diabetes predicted functional changes. Behavioral/psychological symptoms worsened by 0.354 (95% CI 0.123,

0.585) NPI-Q points in the first year (0 – 36 scale). Age of onset, region of residence, and history of hypertension and psychiatric problems predicted behaviors at diagnosis. Cognition explained changes in behavior.

CONCLUSIONS: Sociodemographic characteristics and clinical co-morbidities predict cognitive and functional changes. Only cognitive status explains behavioral/psychological decline. Results provide an understanding of the characteristics that impact cognitive, functional, and behavioral/psychological decline.

3.2 Introduction

Dementia is a complex neurodegenerative disease that affects over five million Americans.[57-59] The defining clinical features of dementia include progressive declines in cognitive and functional ability and a wide range of challenging behavioral/psychological symptoms that occur throughout the disease process.[60,61] While all persons with dementia experience cognitive, functional, and behavioral/psychological changes, transitions over time are not uniform.[41,60] Understanding which predictors accelerate or decelerate decline can help providers and families better prepare for caring of individuals with dementia. Unfortunately, the factors that impact changes in newly diagnosed dementia patients are poorly understood.

Previous studies evaluating cognitive, functional, and behavioral/psychological trajectories have significant limitations including limited patient follow up, combined incident and prevalent cases, failure to account for attrition, and evaluating functional decline and behavioral/psychological symptoms independent of cognitive status despite evidence of their interrelatedness.[41,62-66] Furthermore, these prior studies focused primarily on biomedical predictors of decline (e.g., vascular risk factors) and largely ignored sociodemographic characteristics including race, marital status, geographical region, and place of residence. Although these elements are risk factors for developing dementia, there is limited research concerning their impact on decline following a dementia diagnosis.[57-59]

Our study seeks to identify predictors of cognitive, functional, and behavioral/psychological declines in a diverse sample of newly diagnosed dementia patients. This study fills an important void in the literature by evaluating the role of dementia risk factors on decline after disease onset. We conducted an exploratory data analysis to evaluate the impact of sociodemographic and clinical risk factors on trajectories for cognition, function, and behavioral/psychological symptoms. Results may assist in care planning and help to focus future interventions on those factors that have the greatest effect on decline on these three areas.

3.3 Methods

3.3.1 Study Setting and Participants

We used data from the National Alzheimer's Coordinating Center (NACC), which serves as a data hub for 34 past and present Alzheimer's Disease Centers (ADCs).[60] Patients are enrolled in ADCs by clinical referral, self-referral, and active ADC recruitment. Depending on the ADC, a single clinician or consensus panel make a dementia diagnosis. ADCs attempt to follow all patients annually using a standardized protocol that includes cognitive, functional, and behavioral assessments. During annual assessments trained ADC clinicians and staff administer the data collection protocol in-person or over the phone to obtain data from patients and informants (e.g., spouse). The NACC combines patient data

across ADCs in a publically available longitudinal file called the Uniform Data Set (UDS). [60]

For this study, we used the UDS (March 2015 data freeze) and limited our analysis to newly diagnosed individuals >70 years old (i.e., incident dementia cases; **Figure A3.1**).[41,62-66] Although the UDS provides diagnostic categories (e.g., Alzheimer's dementia), we did not limit our analysis to a specific type of dementia because diagnosis is subject to a high degree of misclassification.[67-69] To evaluate disease progression over time within an individual and to account for non-linear change, we further limited our analysis to individuals with at least two observations post dementia diagnoses. Finally, we required individuals to have complete observations on variables of interest for their first observation.

3.3.2 Measures of Dementia

The progression of dementia was assessed in terms of cognition, function, and behavioral/psychological symptoms as these are the defining clinical features of the disease.[61] During annual ADC assessments cognitive status was measured using the Mini-Mental State Examination (MMSE).[70] The MMSE was completed by clinicians and scored from 0 to 30 with lower scores indicating greater cognitive impairment. Functional ability was assessed using the Functional Activities Questionnaire (FAQ). The FAQ was administered by clinicians to informants and was scored from 0 to 30 with higher scores indicating greater functional impairment.[71] behavioral/psychological symptoms were

assessed using the Neuropsychiatric Inventory Questionnaire (NPI-Q). The NPI-Q was administered by clinicians to informants and was scored from 0 to 36 with higher scores indicating greater severity of behavioral symptoms.[72]

3.3.3 Explanatory Variables

Sociodemographic risk factors available in the UDS include age at time of diagnosis, gender, educational attainment, race, marital status, geographic region, and place of residence (community, facility). Clinical risk factors include self-reported history of hypertension, diabetes, congestive heart failure, stroke, hypercholesterolemia, or psychiatric problems. All covariates except place of residence in the previous observation and marital status were coded as time-invariant.

3.3.4 Statistical Analysis

We used separate linear-mixed effects models to evaluate cognitive, functional, and behavioral/psychological trajectories of incident dementia patients. We initially constructed simple models where time, measured as years since a diagnosis of dementia, was the only predictor of change. To evaluate non-linear trajectories and individual deviation from the population mean trajectory, we tested the inclusion of a squared term for time and random effects terms for both intercepts and slopes. Akaike information criterion was used as a measure of fit to determine the best fitting simple models. Based on our analysis

of the simple models, all models included a term for time-squared and a random intercept and random slopes for both the linear and quadratic terms (**Equation A3.2**).

We extended this preliminary model to estimate the association between dementia risk factors and cognitive, functional, and behavioral/psychological change. Because previous models did not evaluate the effect of both sociodemographic and clinical factors on change and due to our a-priori interest in their associations, we included main effects (i.e., not interacted with time) for these predictors regardless of statistical significance. In models evaluating functional and behavioral/psychological trajectories, cognitive status was also included as a time-varying main effect. The functional and behavioral/psychological models also controlled for informant type (e.g., spouse) as these measures are based on informant input. We then used a model building approach (described below) to determine the inclusion of interactions between sociodemographic and clinical predictors with time (i.e., slope effects). We did not evaluate interactions with time-squared because preliminary analyses examining these interactions resulted in poor fit (e.g., wild fluxuations in the tails of predicted functional trajectories that are not representative of measurement error or normal variation). Poor model fit appeared to reflect sparse data over time for certain combinations of covariates. The model building process began with a model that included all predictors and the interaction of all predictors with time. Interactions with an alpha >0.10 were identified as potentially poor fitting

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and candidates for exclusion. Using the likelihood ratio test we tested the

reduced model (i.e., the model without the interaction) against the full model (i.e.,

the model with the interaction term). We retained the full model if the p-value of

the likelihood ratio test was <0.05. This strategy allowed for non-significant

interactions to remain in the model if their inclusion resulted in a better fitting

model. To aid in the comparison of trajectories we also used the final models to

estimate the effect of covariates on standardized cognitive, functional, and

behavioral/psychological decline (i.e., where only the outcome variable is

standardized by subtracting the mean value at baseline from an individual's

observed value and dividing by the baseline standard deviation). All analyses

excluded individuals that requested not to participate in follow up assessments

(i.e., dropouts; n = 96) as they had higher cognitive scores at time of diagnosis

(**Table A3.3**). In a sensitivity analysis, we included these individuals in our final

models.

Using the final models, we predicted the annual rate of change by year

and trajectories over 8 years. All statistical analyses were conducted using Stata

12.1 (College Station, Texas).

3.4 Results

3.4.1 Sample Characteristics

Of the 457 individuals who met the study inclusion criteria, the mean age

of individuals in the analytic sample at time of diagnosis was 79 years, 55% were

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male, and 8% were African American (**Table 3.6.1**). Due to few observations, American Indians, Alaskan Natives, Native Hawaiians, Asians, and individuals who identified as multiracial were grouped in the "other" racial category.

3.4.2 Cognitive Trajectories

As noted above, all models contained main effects for sociodemographic and medical predictors. The best fitting cognitive model included additional terms for the interaction of age of onset, region of residence, hypertension, and congestive heart failure with time (**Equation A3.4**). Holding all variables in the fully adjusted model at their sample mean, the average rate of cognitive decline in the first year was -1.518 (95% CI: -1.745, -1.291) MMSE points (**Table 3.6.2**). As depicted in **Figure 3.7.1 (Panel 1),** the rate of cognitive decline accelerated over time.

Results of the mixed effects model evaluating cognitive trajectories are reported in **Table 3.6.3** (**Table A3.5** reports standardized cognitive trajectories and results of the sensitivity analysis which included individuals that dropped out). In the table, negative coefficients indicate a predictor is associated with greater cognitive impairment. At time of diagnosis those with less education, African Americans compared to whites and individuals living in the West compared to the Northeast had lower cognitive scores. Older age of onset, residing in the Northeast compared to the West, and a history of hypertension and congestive heart failure were associated with slower decline.

3.4.3 Functional Trajectories

The best fitting functional model included additional terms for the interaction of cognition, education, place of residence, and diabetes with time (**Equation A3.6**). Holding all variables in the fully adjusted model at their sample mean, the average rate of functional decline in the first year was 3.464 (95% CI: 3.131, 3.798) FAQ points (**Table 3.6.2**). As depicted in **Figure 3.7.1 (Panel 2)**, the rate of functional decline slowed over time.

Results of the mixed effects model evaluating functional decline are presented in **Table 3.6.4** (**Table A3.7** reports standardized functional trajectories and results of the sensitivity analysis which included individuals that dropped out). In the table, positive coefficients indicate a predictor is associated with greater functional limitations. At time of diagnosis, higher cognitive status, males, African Americans compared to whites, residing in the Midwest compared to the Northeast, living in the community, and having a history of hypercholesterolemia were associated with fewer functional limitations. Place of residence and a history of diabetes had a significant effect on functional decline over time.

3.4.4 Behavioral/Psychological Trajectories

The best fitting behavioral/psychological model included additional terms for the interaction of cognition and stroke with time (**Equation A3.8**). Holding all variables in the fully adjusted model at their sample mean, the severity of

behavioral/psychological problems worsened by 0.354 (95% CI: 0.123, 0.585)

NPI-Q points in the first year (**Table 3.6.2**). As depicted in **Figure 3.7.1 (Panel**

3), the rate of behavioral/psychological decline accelerated over time.

Results of the mixed effects model evaluating behavioral/psychological

trajectories are presented in **Table 3.6.5** (**Table A3.9** reports standardized

behavioral/psychological trajectories and results of the sensitivity analysis which

included individuals that dropped out). In the table, positive coefficients indicate a

predictor is associated with more severe behavioral/psychological problems. Age

of dementia onset, residing in the South compared to the Northeast, and a

history of hypertension and psychiatric problems were significant predictors of an

individual's behavioral score at time of diagnosis. Only cognitive function had an

effect on behavioral trajectories over time.

3.5 Discussion

Our objective was to examine rates of decline over 8 years for three

defining clinical features of dementia (cognition, function, and

behavioral/psychological symptoms) in newly diagnosed dementia patients.

Previous studies have shown the effect of sociodemographic characteristics and

medical history on the risk of developing dementia.[58,59] However few studies

have explored whether these same risk factors influence decline once individuals

have a dementia diagnosis. Our study is a step towards filling that void and

expands on previous efforts to identify predictors of decline.

Consistent with other studies, our results indicate that African Americans compared to whites have greater cognitive impairment at the time of diagnosis. In our study, African Americans and whites have similar ages at time of diagnosis indicating African Americans may develop dementia at earlier ages. Others have noted that African Americans are more likely to be diagnosed later in the course of the disease and have a higher prevalence of dementia at all ages compared to whites.[58,73] Our results contribute to the literature identifying disparities in dementia care and highlight the need for additional research on the mechanisms through which race impacts dementia outcomes.

Racial differences persisted for the measure of functional ability but in the opposite direction. At time of diagnosis, African Americans had less functional dependence than whites. It is not entirely clear why this is the case. One explanation may be that as family caregivers assess functional ability, there may be different interpretations among African Americans and whites.[58] While we controlled for informant type, due to sparse data we were unable to determine the effect of an interaction between informant and race.

Region of residence was a significant predictor of change in the cognitive, functional, and behavioral/psychological models. Our measure of region is broad, but likely captures differences in the recruiting and referral practices of providers within an ADCs region.

In our study, the annual rate of change in cognition in the first year was -1.518 MMSE points. This is comparable to recently published findings from

Tschanz and colleagues which used population-based data from the Cache County Study on Memory in Aging to evaluate trajectories of dementia patients and reported a mean annual rate of change of -1.500 MMSE points.[41] However, unlike our study they did not account for racial differences or control for clinical factors.

MMSE changes >2 are considered clinically meaningful.[74] In our study, change in cognitive function in the first year is borderline clinically significant, but over time the cumulative effect is clearly clinically meaningful. By the third year post-diagnosis patients begin experiencing annual clinically meaningful cognitive declines.

Studies have reported conflicting results for the effect of vascular risk factors on cognitive decline.[64,75,76] Our results indicate that the presence of vascular risk factors (history of hypertension and congestive heart failure) result in a slower decline. This may be indicative of differences between individuals with Alzheimer's disease and vascular dementia.[76,77]

Functional ability worsened by 3.464 FAQ points in the first year. Without established clinical thresholds it is difficult to conceptualize what this change represents. One interpretation is that within the first year an average individual developed three additional functional limitations. In the immediate years post diagnosis individuals experienced steep functional declines, but over time the rate of decline decreased. This finding contrasts with the pattern observed for cognitive and behavioral/psychological trajectories. The pattern of functional

decline may be explained by the fact that the FAQ predominately measures instrumental activities of daily living which are complex and result in losses of independence earlier in the disease course compared to losses in activities of daily living.

Behavioral/psychological symptoms worsened by 0.354 NPI points in the first year. This represents a small change and is not likely to be clinically meaningful. The most troubling behavioral/psychological symptoms are more common in the moderate to advanced stages of the disease, which is illustrated by the sharp increase in the NPI-Q score as a patient's disease progresses.[57,78] Cognitive status was the only clinical characteristic to predict change in behavioral symptoms over time, but a history of psychiatric problems or hypertension was associated with more behavioral symptoms at diagnosis. To our knowledge the NPI-Q has not be used to evaluate behavioral trajectories in dementia, but conceptually our analysis differs from others by incorporating cognitive status and race as explanatory variables.[41,61,78]

Our study has some limitations. Although it uses national data from ADCs, it is not nationally representative. Compared to a nationally representative sample, our sample is more educated and white but the average age at time of diagnosis is similar.[41,62,79] Additionally, our cognitive trajectories are consistent with a study using a population-based sample lending support to the validity of our findings.[41,63-66] Other limitations were that we did not account for the effect of APOE ε4 allele. Finally, to evaluate non-linear change we limited our analysis to

individuals with at least three observations and complete data at baseline. This may limit the generalizability of results as patients with fewer observations maybe sicker.

In conclusion, our study finds that sociodemographic characteristics and clinical co-morbidities predict cognitive and functional changes over time in newly diagnosed dementia patients. Cognition status is the only factor to predict behavioral/psychological changes over time. Our results provide a means of identifying individuals at risk of faster decline and facilitate care planning by providers and caregivers for different dementia profiles.

3.6 Tables

Table 3.6.1 Baseline sample characteristics

Characteristics	n=457
Age in Years at Diagnosis, M (SD)	79.91 (6.26)
Male, N (%)	251 (55)
Years of Education, M (SD)	15.37 (2.91)
Race	
White, N (%)	396 (87)
African American, N (%)	39 (8)
Other, N (%)	22 (5)
Marital Status at Diagnosis	
Married, N (%)	327 (71)
Widowed, N (%)	100 (22)
Other, N (%)	30 (7)
Region of Residence	
Northeast, N (%)	85 (19)
South, N (%)	28 (6)
West, N (%)	120 (26)
Midwest, N (%)	51 (11)
Not Specified, N (%)	173 (38)
Place of Residence at Diagnosis	
Community Dwelling, N (%)	440 (96)
Facility, N (%)	17 (4)
Informant Relationship	
Spouse, N (%)	291 (64)
Other Family Member, N (%)	129 (28)
Other, N (%)	37 (8)
Comorbidities	

Ever Hypertension, N (%)	311 (68)
Ever Diabetes, N (%)	64 (14)
Ever Congestive Heart Failure, N (%)	29 (6)
Ever Hypercholesterolemia, N (%)	316 (69)
Ever Stroke, N (%)	47 (10)
Ever Psychiatric Problems, N (%)	50 (11)
MMSE at Diagnosis, M (SD)[‡]	24.22 (3.24)
FAQ at Diagnosis, M (SD)[§]	10.89 (7.12)
NPI-Q at Diagnosis, M (SD)[‖]	3.90 (3.99)
Clinical Dementia Rating Score	
None, N (%)	0 (0.00)
Very Mild, N (%)	275 (60.18)
Mild, N (%)	171 (37.42)
Moderate, N (%)	11 (2.41)
Severe, N (%)	0 (0.00)
Number of Follow up Visits, M (SD)[¶]	4.13 (1.20)

†Other racial category is comprised of American Indians, Alaskan Natives, Native Hawaiians, Asians, and individuals who identify as multiracial

‡MMSE = Mini-mental State Examination

§FAQ = Functional Activities Questionnaire

‖NPI-Q = Neuropsychiatric Inventory Questionnaire

¶ (39% of the sample had 3 observations; 27% of the sample had 4 observations; 19% of the sample had 5 observations; 15% of the sample had >5 observations)

Table 3.6.2 Average rate of change by year

Year	Cognition – MMSE (95% CI)	Function – FAQ (95% CI)	Behavior – NPI-Q (95% CI)
Diagnosis – Year 1	-1.518 (-1.745, -1.291)	3.464 (3.131, 3.798)	0.354 (0.123, 0.585)
Year 1 – Year 2	-1.748 (-1.914, -1.583)	3.111 (2.898, 3.322)	0.485 (0.338, 0.632)
Year 2 - Year 3	-1.979 (-2.173, -1.785)	2.778 (2.584, 2.972)	0.637 (0.483, 0.792)
Year 3 – Year 4	-2.209 (-2.495, -1.923)	2.467 (2.156, 2.778)	0.811 (0.558, 1.064)
Year 4 – Year 5	-2.440 (-2.840, -2.040)	2.178 (1.700, 2.660)	1.007 (0.624, 1.391)
Year 5 – Year 6	-2.671 (-3.193, -2.148)	1.911 (1.234, 2.588)	1.225 (0.695, 1.754)
Year 6 – Year 7	-2.901 (-3.549, -2.253)	1.666 (0.775, 2.557)	1.464 (0.776, 2.152)
Year 7 – Year 8	-3.132 (-3.907, -2.356)	1.441 (0.319, 2.564)	1.724 (0.867, 2.582)

Notes: Estimates are based on the fully adjusted trajectory model holding covariates at their sample mean. Negative MMSE (Mini-mental State Examination) slopes represent a decline in cognitive ability. Positive FAQ (Functional Activities Questionnaire) slopes represent a decline in functional ability. Positive NPI-Q (Neuropsychiatric Inventory Questionnaire) slopes represent an increase in behavioral/psychological symptoms.

Table 3.6.3 Parameter estimates of cognitive trajectories (n=457)

Effects	Unadjusted Cognition (MMSE)	Adjusted Cognition (MMSE)
Intercept	24.295***	20.328***
	(24.006, 24.585)	(15.849, 24.807)
Time	-1.374***	-3.847***
	(-1.652, -1.096)	(-6.049, -1.644)
Time^2	-0.127***	-0.115***
	(-0.193, -0.060)	(-0.181, -0.050)
Age of Onset (Years)		0.001
		(-0.046, 0.048)
Age of Onset (Years) * Time		0.031*
		(0.004, 0.058)
Male		0.231
		(-0.366, 0.827)
Years of Education		0.236***
		(0.141, 0.331)
Race (ref = White)		
African American		-1.629**
		(-2.640, -0.618)
Other		-0.274
		(-1.558, 1.010)
Marital Status (ref = Widowed)		
Married		-0.582
		(-1.241, 0.077)
Other		-0.039
		(-1.070, 0.991)
Region of Residence (ref = Northeast)		

South		0.025
		(-1.245, 1.294)
West		-1.192**
		(-2.015, -0.368)
Midwest		1.197*
		(0.166, 2.228)
Not Specified		-0.192
		(-0.971, 0.587)
Region of Residence (ref = Northeast) * Time		
South		-0.352
		(-1.109, 0.405)
West		-0.743**
		(-1.239, -0.247)
Midwest		0.082
		(-0.521, 0.686)
Not Specified		-0.281
		(-0.743, 0.180)
Community-dwelling in Previous Time Period (ref = Facility)		0.474
		(-0.393, 1.341)
Ever Hypertension		0.418
		(-0.193, 1.029)
Ever Hypertension * Time		0.371*
		(0.021, 0.721)
Ever Diabetes		-0.216
		(-1.030, 0.597)
Ever Congestive Heart Failure		0.207
		(-0.923, 1.337)
Ever Congestive Heart Failure * Time		0.698*

		(0.031, 1.366)
Ever Stroke		-0.315
		(-1.145, 0.515)
Ever Hypercholesterolemia		0.249
		(-0.362, 0.861)
Ever Psychiatric Problems		0.794
		(-0.086, 1.674)

Notes: MMSE = Mini-mental State Examination (scored 0–30). Higher scores indicate greater cognitive abilities.

* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

Table 3.6.4 Parameter estimates of functional trajectories (n=457)

Effects	Unadjusted Function (FAQ)	Adjusted Function (FAQ)
Intercept	10.852***	31.529***
	(10.207, 11.497)	(22.807, 40.251)
Time	3.907***	2.028**
	(3.491, 4.324)	(0.574, 3.481)
Time^2	-0.235***	-0.279***
	(-0.320, -0.149)	(-0.371, -0.187)
Cognitive Status (MMSE)		-0.404***
		(-0.520, -0.288)
Cognitive Status (MMSE) * Time		-0.031
		(-0.067, 0.004)
Age of Onset (Years)		-0.016
		(-0.101, 0.069)
Male		-2.273***
		(-3.375, -1.172)
Years of Education		-0.123
		(-0.324, 0.077)
Years of Education * Time		0.056
		(-0.004, 0.116)
Race (ref = White)		
African American		-3.520***
		(-5.329, -1.711)
Other		-0.106
		(-2.399, 2.188)
Marital Status (ref = Widowed)		
Married		-1.174
		(-2.554, 0.207)

Other		-0.326
		(-2.153, 1.502)
Region of Residence (ref = Northeast)		
South		-0.011
		(-2.273, 2.250)
West		1.779*
		(0.304, 3.253)
Midwest		-2.221*
		(-4.046, -0.396)
Not Specified		0.048
		(-1.331, 1.427)
Community-dwelling in Previous Time Period (ref = Facility)		-4.519***
		(-6.890, -2.147)
Community-dwelling in Previous Time Period (ref = Facility)* Time		1.096**
		(0.359, 1.833)
Informant Relationship (ref = Spouse)		
Other Family Member		-0.944
		(-2.210, 0.321)
Other		-1.677
		(-3.442, 0.088)
Ever Hypertension		0.018
		(-1.074, 1.111)
Ever Diabetes		1.057
		(-0.632, 2.746)
Ever Diabetes * Time		-0.535*
		(-1.062, -0.008)
Ever Congestive Heart Failure		0.307

		(-1.704, 2.318)
Ever Stroke		2.214**
		(0.798, 3.630)
Ever Hypercholesterolemia		-1.281*
		(-2.381, -0.181)
Ever Psychiatric Problems		-0.710
		(-2.288, 0.869)

Notes: FAQ = Functional Activities Questionnaire (scored 0–30). Higher scores

indicate more functional limitations.

* p <0.05. ** p<0.01. *** p<0.001.

Table 3.6.5 Parameter estimates of behavioral/psychological trajectories (n=457)

Effect	Unadjusted Behavior (NPI)	Adjusted Behavior (NPI)
Intercept	3.839***	10.593***
	(3.481, 4.198)	(5.364, 15.822)
Time	0.461**	1.256**
	(0.165, 0.757)	(0.488, 2.024)
Time^2	-0.001	0.002
	(-0.068, 0.066)	(-0.069, 0.073)
Cognitive Status (MMSE)		-0.073
		(-0.149, 0.003)
Cognitive Status (MMSE) * Time		-0.031*
		(-0.057, -0.006)
Age of Onset (Years)		-0.081**
		(-0.134, -0.029)
Male		0.168
		(-0.576, 0.911)
Male * Time		-0.258
		(-0.562, 0.046)
Years of Education		-0.045
		(-0.151, 0.060)
Race (ref = White)		
African American		-0.485
		(-1.601, 0.630)
Other		-0.123
		(-1.540, 1.295)
Marital Status (ref = Widowed)		
Married		0.100
		(-0.814, 1.014)

Other		0.945
		(-0.236, 2.127)
Region of Residence (ref = Northeast)		
South		1.776*
		(0.383, 3.170)
West		0.776
		(-0.132, 1.685)
Midwest		0.778
		(-0.357, 1.914)
Not Specified		1.269**
		(0.413, 2.124)
Community-dwelling in Previous Time Period (ref = Facility)		0.846
		(-0.111, 1.803)
Informant Relationship (ref = Spouse)		
Other Family Member		0.112
		(-0.810, 1.034)
Other		-0.352
		(-1.729, 1.025)
Informant Relationship (ref = Spouse) * Time		
Other Family Member		-0.304
		(-0.627, 0.019)
Other		-0.420
		(-0.894, 0.054)
Ever Hypertension		0.738*
		(0.064, 1.413)
Ever Diabetes		0.520

		(-0.375, 1.415)
Ever Congestive Heart Failure		0.624
		(-0.616, 1.864)
Ever Stroke		1.121
		(-0.156, 2.398)
Ever Stroke * Time		-0.516
		(-1.064, 0.032)
Ever Hypercholesterolemia		-0.617
		(-1.291, 0.056)
Ever Psychiatric Problems		1.319**
		(0.346, 2.291)

Notes: NPI-Q = Neuropsychiatric Inventory Questionnaire severity score (scored

0–36). Higher scores indicate more severe behavioral/psychological symptoms.

* *p* <0.05. ** *p*<0.01. *** *p*<0.001.

3.7 Figure

Panel 1: Cognitive Trajectory

Panel 2: Functional Trajectory

Panel 3: Behavioral Trajectory
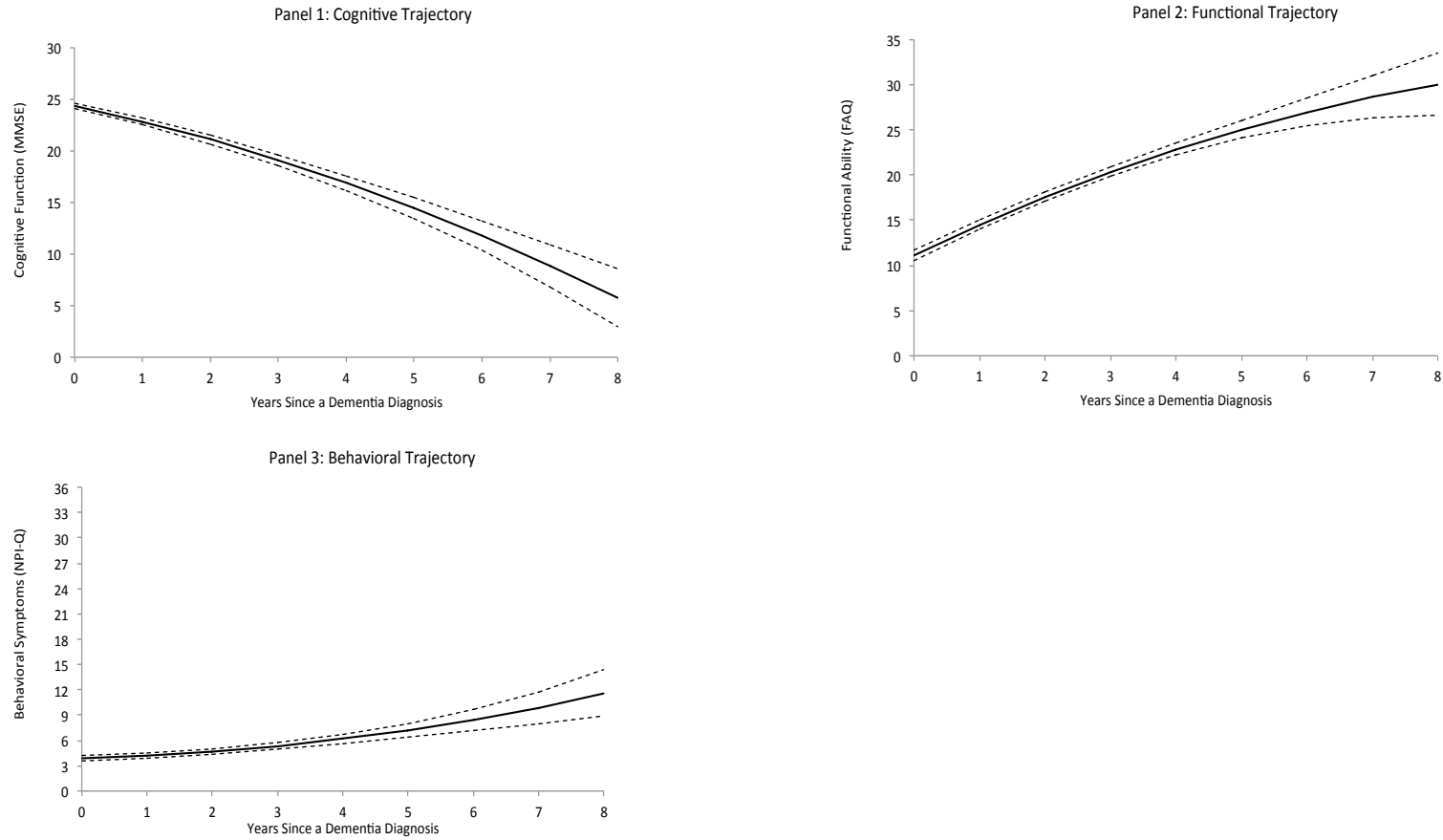
Figure 3.7.1 Predicted cognitive, functional, and behavioral trajectories

Figure 3.7.1 Legend: Fully adjusted model trajectories based on sample mean values for covariates (dashed-lines represent 95% CI) of cognition (1), function (2), and behavioral/psychological symptoms (3). Higher MMSE (Mini-mental State Examination) scores indicate greater cognitive abilities. Higher FAQ (Functional Activities Questionnaire) scores indicate more functional limitations. Higher NPI-Q (Neuropsychiatric Inventory Questionnaire) scores indicate greater severity of behavioral/psychological symptoms.

Chapter 4: Effects of Cognition, Function, and Behavior on Medicare Expenditures and Health Care Utilization

4.1 Overview

BACKGROUND: Clinical features of dementia (cognition, function, and behavioral/psychological symptoms) may differentially affect Medicare expenditures/health care utilization.

METHODS: We linked cross-sectional data from the Aging, Demographics, and Memory Study to Medicare data to evaluate the association between dementia clinical features among those with dementia and Medicare expenditures/health care utilization (n=234). Cognition was evaluated using the Mini-Mental State Examination (MMSE). Function was evaluated as the number of functional limitations (0-10). Behavioral/psychological symptoms were evaluated as the number of symptoms (0-12). Expenditures were estimated with a generalized linear model (log-link and gamma distribution). Number of hospitalizations, institutional outpatient visits, and physician visits were estimated with a negative binomial regression. Medicare covered skilled nursing days were estimated with a zero-inflated negative binomial model.

RESULTS: Cognition and behavioral/psychological symptoms were not associated with expenditures. Among individuals with <7 functional limitations, one-additional limitation was associated with $123 (95% CI: $19-$227) additional monthly Medicare spending. Better cognition and poorer function were associated with more hospitalizations among those with an MMSE<3 and <6 functional limitations, respectively. Behavioral/psychological symptoms had no effect on hospitalizations. Poorer function and fewer behavioral/psychological symptoms were associated with more skilled nursing among individuals with 1-to-

40

7 functional limitations and >4 symptoms, respectively. Cognition had no effect

on skilled nursing care. No clinical feature was associated with institutional

outpatient care. Of individuals with an MMSE <15, poorer cognition was

associated with fewer physician visits. Among those with >6 functional limitations,

poorer function was associated with fewer physician visits.

CONCLUSIONS: Poorer function, not cognition or behavioral/psychological

symptoms, was associated with higher Medicare expenditures.

4.2 Introduction

Dementia is one of the most costly diseases to society,[13,17,18,80] because persons with dementia can live more than 10 years with the disease while experiencing a complex set of clinical features including cognitive and functional decline and behavioral and psychological symptoms.[17,18,59,61,81]

Recent studies from RAND and others have demonstrated that persons with dementia have higher health care costs and use more health care services than those without dementia,[13,17,18,59,61,80,81] though less is known about how the clinical features of dementia affect the cost of dementia care. This study extends the literature by evaluating the association between the clinical features with cost among those with dementia. Understanding the separate contributions of cognition, function, and behavioral/psychological symptoms to the cost of dementia care and to the types of health care services used (e.g., number of hospitalizations) can provide insight into the possible mechanisms that drive higher costs, and informs the development of services, programs, and interventions to reduce such costs.

Prior studies have found that the total cost of caring for a person with dementia and the number of health care services used generally increases with disease severity.[13,16-18,35,45,46,80,82-85] Despite employing different methodologies, most prior studies have noted that poorer function is associated with more spending and more health care utilization (hospitalizations, emergency room visits, and outpatient treatment).[13,16,59,61,80,81] Several of those studies have shown that within a disease stage (e.g., mild, moderate, and severe) costs and

resource utilization are moderated by clinical features. For example, results from

a study using data from the National Long Term Care Survey found that within a

level of dementia severity (severe and moderate) costs were ten times greater

among those with five functional limitations compared to those with no limitations.

[13,17,18,80] Results are inconclusive regarding the effect of cognition and

behavioral/psychological symptoms with studies finding significant and

nonsignificant associations between these clinical features and cost/health care

utilization.[16,29,45,83] Many studies have important methodological limitations

including using non-representative data, relying on claims data to determine

dementia status, and not separating expenditures by payer (e.g., individual out-

of-pocket spending or Medicare expenditures). Relying on claims data to identify

dementia cases may result in an overestimation of Medicare cost attributable to

dementia.[86,87] Identifying the source of cost by payer is important for

policymaking and budgetary planning because the responsibilities and the

amount of cost vary by payer. Our study addresses these limitations by using

nationally representative data, identifying dementia cases based on a clinical

diagnosis, and evaluating cost from a Medicare perspective.

In a prior analysis, we used the nationally representative Aging,

Demographics, and Memory Study (ADAMS), a subsample of the Health and

Retirement Study (HRS), to evaluate the effect of cognition, function, and

behavioral/psychological symptoms on out-of-pocket expenditures and time

spent receiving informal care for persons with dementia.[88] We found that poorer

function was associated with more out-of-pocket spending and more caregiving,

and an increase in the number of behavioral/psychological symptoms was associated with more caregiving. In the current analysis, we use ADAMS to evaluate the effect of cognition, function, and behavioral/psychological symptoms on Medicare expenditures and health care utilization (number of inpatient admissions, number of Medicare covered skilled nursing facility days, number of outpatient institutional visits, and number of physician visits) for persons with dementia.

4.3 Methods

4.3.1 Study Design and Data

We used cross-sectional data from ADAMS (Wave A). The ADAMS subsample was drawn from HRS (individuals ≥70), and ADAMS was specifically designed to collect clinical measures related to cognitive health and dementia. Unlike the core HRS, ADAMS contains a clinical diagnosis of dementia and measures related to BPS.[89] ADAMS Wave A assessments were conducted between 2001 and 2003. During the ADAMS in-home assessment, a trained nurse and neuropsychology technician administered a standardized protocol that included measures to assess cognition, function, and behavioral/psychological symptoms. Following the ADAMS assessment, an independent consensus panel comprised of a geropsychiatrist, neurologist, neuropsychologist, and internists reviewed respondent medical records and responses to the in-home assessment to determine if an individual had normal cognitive function, cognitive impairment not dementia, or dementia. Diagnosis was based on published criteria including

DSM-III-R and DSM-IV.[89] Although diagnostic categories (e.g., Alzheimer's dementia) are provided in the data, we did not limit our analysis to a specific type of dementia because diagnosis is subject to misclassification.[68,69]

In addition to using the data in the ADAMS survey, we linked respondents to their nearest HRS survey (mean time between surveys 8.14 months) to obtain additional information on comorbidities that were not captured in the ADAMS survey (RAND HRS version N - the RAND HRS Data File is an easy to use data set based on the HRS data. The RAND HRS file combines multiple HRS files into a single data file and contains imputations for missing data. The RAND HRS file was developed at RAND with funding from the National Institute on Aging and the Social Security Administration).[89] That is, ADAMS provided a clinical diagnosis of dementia, measures for cognition, function, and behavioral/psychological symptoms, and demographic information. HRS provided detailed data on comorbidities.

More than 80% of ADAMS respondents consented to linking their survey data with CMS Medicare data. We combined ADAMS survey respondents with their corresponding CMS Medicare data. Specifically, we linked the cross-sectional ADAMS assessment with an annual summary Medicare file. We included only annual Medicare expenditures and health care utilization for the year in which the subject was interviewed in ADAMS. The summary Medicare file aggregates Part A & B claims and enrollment data on an annual basis and was developed for use with HRS/ADAMS.

Our sample was restricted to ADAMS respondents identified as having dementia with complete data on the variables of interest and who were continually enrolled in fee-for-service Medicare for the year of the ADAMS assessment. The University of Minnesota institutional review board approved this study.

4.3.2 Measures of Clinical Features of Dementia

Dementia was modeled using cognition, function, and behavioral/psychological symptoms.[59,61] All three clinical features were evaluated during the ADAMS in-home clinical assessment. Cognition was evaluated using the Mini-Mental State Examination (MMSE).[70] The MMSE is scored from 0–30 with lower scores indicating greater cognitive impairment.

Function was evaluated as the total number of functional limitations (0–10) an individual had difficulty performing (yes/no) among the following domains: 1) handling small sums of money, 2) handling complicated financial transactions, 3) shopping independently, 4) performing hobbies, 5) carrying out routine household tasks, 6) difficulty feeding self, 7) recalling recent events, 8) understanding what s/he reads or sees on television, 9) remembering things about family and friends, and 10) finding one's way around familiar streets. These domains were specifically chosen as they correspond with the functional domains assessed in the Functional Activities Questionnaire, one of the few standardized measures for assessing functional ability.[71]

Finally, the number of behavioral/psychological symptoms (0–12) was identified using the Neuropsychiatric Inventory Questionnaire (NPI).[72] The NPI asks caregivers to identify if the following behavioral/psychological symptoms occurred and if so, its frequency and severity: 1) delusions, 2) hallucinations, 3) agitation or aggression, 4) depression, 5) apathy, 6) elation, 7) anxiety, 8) disinhibition, 9) irritability, 10) motor disturbance, 11) nighttime behaviors, and 12) change in appetite and eating. For our analyses, we generated a summary score reflecting the total number of behavioral/psychological symptoms endorsed by a caregiver as being present. The number of behavioral/psychological symptoms is associated with resource utilization.[90]

4.3.3 Outcomes

We calculated average monthly Medicare expenditures (annual expenditures in the year of the ADAMS assessment/12). Medicare expenditures were converted to 2015 United States dollars using the medical care component of the Consumer Price Index. To provide insight into the potential drivers of Medicare expenditures we also evaluated average monthly Medicare health care utilization: number of inpatient admission, number of Medicare covered skilled nursing facility days, number of institutional outpatient visits, and number of physician visits. The number of inpatient admissions represents unique hospital stays in which an individual was designated as being an inpatient. To receive Medicare covered skilled nursing an individual had to have a qualifying inpatient stay and be hospitalized for ≥3 nights. We evaluated the number of inpatient

admissions since inpatient care is reimbursed based on an episode of care. In contrast, we evaluated the number of skilled nursing care days since Medicare reimburses for skilled nursing care based on days of care. Institutional outpatient utilization represents unique outpatient episodes of care for events such as observation services and outpatient surgery. The number of physician visits represents unique office visits for evaluation and management services. These unique physician visits can include care that occurs during an outpatient institutional visit.

4.3.4 Covariates

We controlled for confounders in our model to separate the extra Medicare cost associated with the clinical features from other factors that might impact cost. Confounders were identified from the literature based on their prior empirical associations with health care costs and the clinical features of dementia and included age, gender, race, marital status, and total number of chronic conditions (0–8) among the following: stroke, diabetes, heart problems, hypertension, lung disease, cancer, psychiatric problems, or arthritis.[17,46,83,91]

4.3.5 Statistical Analysis

We estimated separate adjusted multivariate regression models for each outcome of interest (five adjusted models in total): Medicare expenditures, number of inpatient admission, number of Medicare covered skilled nursing facility days, number of outpatient institutional visits, and number of physician visits.

Due to skewness in Medicare expenditures we estimated a generalized linear model with a log-link and gamma distribution. All measures of health care utilization, except the number of skilled nursing days, were estimated with a negative binomial regression. A zero-inflated negative binomial model was used to evaluate the number of skilled nursing days since the data exhibits excessive zeros. In preliminary analyses, the zero-inflated model failed to coverage when all covariates were included in the zero-inflation portion of the model. The final zero-inflated model included all covariates in the count portion of the model, and only individual demographic characteristics in the inflation portion of the model.

For each model, we separately predicted the outcome and calculated the average marginal effects at representative values for each clinical feature (e.g., marginal effects when number of functional limitations was 0, 1, 2,…,10) to provide insight into their differential effect on the outcome at levels of feature severity. That is, we sought to understand how a change in cognition (1 point decline), function (1 point increase), or behavioral/psychological symptoms (1 point increase) affected the outcome when the clinical features took on different values.

All analyses were conducted using ADAMS survey weights and Stata version 12 survey commands (Stata, College Station, TX).

4.4 Results

4.4.1 Sample Characteristics

Of the 308 individuals in ADAMS Wave A with a diagnosis of dementia, 234 had complete data on the variables of interest. Comparison between those excluded/included from the analysis showed no statistically significant differences (**Table A4.1; Figure A4.2** shows the derivation of the analysis sample). The mean age of the 234 individuals with dementia was 84.12 (SD 10.87) (**Table 4.6.1**); individuals had a mean MMSE score of 16.06 (SD 11.94), and had an average of 6.18 (SD 3.71) functional limitations and 2.63 (SD 4.23) behavioral/psychological symptoms.

4.4.2 Medicare Expenditures

An individual with dementia had average-adjusted monthly Medicare expenditures of $1,041 (95% CI: $771, $1,311). Cognition and behavioral/psychological symptoms were not significantly associated with Medicare expenditures and this was consistent across levels of severity (**Figure A4.3**). Poorer function was associated with significantly more Medicare spending (**Table 4.6.2**). The effect of function on Medicare expenditures increased with greater levels of functional impairment, but this effect was only significant among those with <7 functional limitations (**Figure A4.3**). Specifically, an increase from one to two functional limitations was associated with $75 (95% CI: $48, $102) additional Medicare spending per month, while an increase from five to six limitations was associated with $140 (95% CI: $22, $257) additional spending per month. The average marginal effect of one-additional functional limitation on

Medicare expenditures among those with <7 limitations was $123 (95% CI: $19, $227).

4.4.2 Health Care Utilization

On average, individuals had 0.05 (95% CI: 0.04, 0.06) inpatient admission per month. A one-unit decline in cognition was associated with -0.001 (95% CI: -0.003, 0.00) fewer inpatient admissions among those with an MMSE score <3 (**Figure A4.4**). One-additional functional limitation was significantly associated with 0.006 (95% CI: 0.001, 0.012) more inpatient admissions among those with <6 limitations (**Figure A4.4**). Behavioral/psychological symptoms were not associated with inpatient admissions (**Table 4.6.2**).

Individuals had an average of 0.42 (95% CI: 0.21, 0.63) Medicare covered skilled nursing care days per month. Cognition was not associated with skilled nursing care. Poorer function was associated with 0.10 (95% CI: 0.02, 0.18) more Medicare skilled nursing care days among those with 1-to-7 functional limitations (**Figure A4.5**). One-additional behavioral/psychological symptom was associated with -0.07 (95% CI: -0.12, -0.01) fewer Medicare covered skilled nursing days among those with >4 symptoms.

Individuals had an average of 0.44 (95% CI: 0.34, 0.54) institutional outpatient visits per month. No clinical feature was associated with institutional outpatient care (**Table 4.6.2, Figure A4.6**).

Finally, individuals had an average of 0.39 (95% CI: 0.32, 0.48) physician visits (evaluation and management services) per month. A one-unit decline in

cognition was associated with -0.01 (95% CI: -0.01, 0.00) fewer physical visits among those with an MMSE score <15 (**Figure A4.7**). Similarly, poorer function was associated with -0.02 (95% CI: -0.04, 0.00) fewer physician visits among those with >6 functional limitations. Behavioral/psychological symptoms were not associated with number of physician visits.

4.5 Discussion

We used nationally representative data to estimate the effect of three key clinical features of dementia - cognition, function, and behavioral/psychological symptoms – on Medicare expenditures and health care utilization. Poorer function, but not cognition or behavioral/psychological symptoms, was significantly associated with more Medicare spending. Our results complement prior studies that have found poorer function is associated with higher cost, and that among individuals with dementia, function is potentially a more important predictor of costs than cognition.[16,35,45,80,83] Unlike prior studies, we explicitly evaluated the differential effect of the severity of dementia clinical features on Medicare expenditures and health care utilization. We further extend results by using nationally representative data and not relying on claims data to determine if an individual has dementia.

The marginal effect of function on Medicare expenditures increased with greater levels of functional impairment; however, among those with ≥7 limitations the effect of an additional limitation on expenditures was no longer significant. The significant effect of poorer function among those with <7 limitations was

enough to generate an overall significant average effect. The reason for lack of significance of the marginal effect for more severe levels of functional impairment are not entirely clear, but may reflect sparse data for those with ≥7 limitations. Clinically, one potential explanation is that with more severe functional limitations, which may be associated with more severe dementia, medical care may be less aggressive reflecting advance care directives.[92]

The effect of function on Medicare expenditures appears to be driven, in part, through the effect of poorer function on more inpatient admissions among individuals with <6 limitations. While the effect of an additional functional limitation on inpatient admissions is low (0.006), this equates to a 12% increase in monthly inpatient admissions (0.05 average monthly inpatient admissions) and has potential cost implications. Others studies, including Zhu et al. and Small et al., also reported that poorer function was associated with more inpatient care.[16,45] Importantly, many dementia related hospitalizations are potentially avoidable.[93] Although we found that more sever cognitive limitations (MMSE<3) were associated with fewer hospitalizations, this finding is likely not clinically or policy significant given the small effect size (~2% decline in admissions) and narrow population for which findings apply (only individuals with MMSE<3).

Individuals with dementia utilize Medicare skilled nursing care at greater rates than individuals without dementia.[94] However, to our knowledge our study is first to investigate the relationship between dementia clinical features and Medicare covered skilled nursing utilization. The effect of function on Medicare expenditures also appears driven by the relationship between poorer function

and more skilled nursing care among individuals with 1-to-7 limitations. In contrast, among those with >4 behavioral/psychological symptoms, one-additional symptom was associated with less skilled nursing care. The negative effect of behavioral/psychological symptoms on Medicare skilled nursing care may reflect that a hospitalization triggered by a behavioral/psychological symptom makes a person with dementia a poorer candidate for Medicare covered skilled nursing care as opposed to placement in a nursing home. However, we were unable to test this hypothesis since our data was limited to observing only Medicare covered skilled care.

We did not find an effect between the clinical features and institutional outpatient care. However, unlike several other studies, we found that poorer cognition among those with an MMSE score <15 and poorer function among those with >6 limitations were associated with fewer physician visits.[16,45] Again it is important to note that physician visits can include care that occurs during institutional outpatient care. The average effect of cognition (-0.01) and function (-0.02) on physician visits were low and equate to a ~5% decline in visits. The negative association between physician care and more severe cognitive and functional limitations may be due to the previously stated hypothesis of the use of less aggressive care with more severe disease reflecting advance care directives.[92]

There are potential mechanisms for reducing Medicare spending, inpatient admissions, and skilled nursing care associated with poorer function in individuals with dementia. Foremost, functional limitations can be managed by

effective ambulatory care, and by formal and informal caregivers.[95-97] Better management of functional limitations may translate into lower Medicare expenditures through less inpatient and skilled nursing utilization. Additionally, ongoing post-acute care payment reform may result in a reduction in Medicare payments and overall skilled nursing utilization, and potentially render the effect of function on skilled nursing utilization null.[98]

We did not find a significant relationship between the number of comorbidities and Medicare spending. In the literature, the effect of comorbidities on Medicare spending among those with dementia is inconclusive. Some studies have found that among those with dementia comorbidities are not associated with more Medicare spending, some have found that only specific comorbidities are associated with spending, and some have found an association between any comorbidities and spending.[16,80,99] Future studies with larger sample sizes are needed to investigate the interaction between comorbidities and the clinical features.

Our study has several limitations. We used cross-sectional data, and were not able to evaluate the effect of the clinical features on costs over time within a person. Due to lack of data, our evaluation of Medicare expenditures did not include those for prescription medication (Part D). The likely result is an underestimation of total Medicare cost. Conceptually we believe we controlled for key confounders; however, it is possible that we may have omitted confounders from our analyses. If an omitted confounder is strongly correlated with the clinical features and outcomes then our results will be biased. Finally, in this analysis we

did not evaluate the effect of the clinical features of dementia on the health and Medicare expenditures of family caregivers.

In conclusion, poorer function, but not cognition or behavioral/psychological symptoms, was associated with more Medicare expenditures. The effect of function on Medicare expenditures was predominantly due to the effect of poorer function on expenditures among those with <7 limitations. Poorer function was also associated with greater inpatient and skilled nursing care among those with <6 and 1-to-7 limitations, respectively. Poorer cognition among those with an MMSE<3 was associated with fewer inpatient admission. Behavioral/psychological symptoms were not associated with inpatient admissions, but more behavioral/psychological symptoms among those with >4 symptoms were associated with less skilled nursing care. No clinical feature was associated with institutional outpatient care. Poorer cognition among those with an MMSE <15 and poorer function among those with >6 limitations were associated with less physician visits. Interventions that target function could reduce Medicare expenditures.

4.6 Tables

Table 4.6.1 Sample characteristics

	Demographic Characteristics* (n=234)
Mean cognition ± SD (range), *MMSE*	16.06 ± 11.94 (0-27)
Mean function ± SD (range)	6.18 ± 3.71 (0-9)
Mean number of behavioral/psychological symptoms ± SD (range)	2.63 ± 4.23 (0-10)
Mean age ± SD (range), *y*	84.12 ± 10.87 (70-110)
Male, *%*	35.37
Non-Caucasian, *%*	18.88
Married, *%*	21.76
Mean number of comorbidities ± SD (range)	2.96 ± 2.67 (0-7)

Notes. MMSE = Mini-Mental State Examination; *Aging Demographics and Memory Study sample weights were used.

Table 4.6.2 Regression coefficients (95% confidence interval) for monthly Medicare expenditures/health care utilization (n=234)*

	Medicare Expenditures	Number of Inpatient Admission	Number of Medicare Covered Skilled Nursing Facility Covered Days		Number of Institutional Outpatient Visits	Number of Physician Visits[†]
	(generalized linear model log link gamma distribution)	(negative binomial model)	(zero-inflated negative binomial model)		(negative binomial model)	(negative binomial model)
			Inflation Portion	Count Portion		
Intercept	6.37 (3.06, 9.68)	-4.09 (-7.91, -0.27)	5.76 (-2.84, 14.35)	-0.08 (-6.37, 6.22)	-1.66 (-5.75, 2.43)	-0.27 (-2.72, 2.18)
MMSE	0.03 (-0.01, 0.07)	0.04 (-0.03, 0.10)		-0.01 (-0.09, 0.06)	0.02 (-0.02, 0.06)	0.02 (0.00, 0.05)
Number of functional limitations	0.15 (0.02, 0.29)	0.17 (-0.02, 0.36)		0.39 (0.13, 0.66)	0.02 (-0.08, 0.13)	-0.06 (-0.11, -0.01)
Number of behavioral/psychological	0.03 (-0.05, 0.10)	0.01 (-0.09, 0.11)		-0.16 (-0.31, -0.01)	-0.01 (-0.12, 0.10)	0.02 (-0.05, 0.08)

symptoms

Age	-0.01	-0.01	-0.06	-0.02	0.00	-0.01
	(-0.05, 0.02)	(-0.05, 0.02)	(-0.17, 0.05)	(-0.08, 0.04)	(-0.05, 0.05)	(-0.04, 0.01)
Male	0.46	0.32	-26.01	-1.49	0.63	0.04
	(-0.07, 0.99)	(-0.29, 0.92)	(-28.74, -23.27)	(-2.60, -0.38)	(0.24, 1.01)	(-0.37, 0.45)
Non-Caucasian (ref = white)	0.06	0.04	-0.69	-0.73	0.12	0.03
	(-0.58, 0.69)	(-0.49, 0.56)	(-2.13, 0.74)	(-1.60, 0.13)	(-0.34, 0.58)	(-0.44, 0.50)
Married (ref = not married)	-0.41	-0.03	-0.91	-2.12	-0.15	0.67
	(-0.93, 0.10)	(-0.57, 0.51)	(-3.10, 1.28)	(-3.97, -0.27)	(-0.91, 0.62)	(0.25, 1.10)
Number of chronic conditions	0.07	0.10	0.10	0.26	0.08	0.06
	(-0.09, 0.22)	(-0.10, 0.31)	(-0.55, 0.76)	(-0.02, 0.53)	(-0.10, 0.25)	(-0.12, 0.24)

Notes. MMSE = Mini-Mental State Examination

*Aging Demographics and Memory Study sample weights were used.

[†]Physician visits are for evaluation and management services and can include care that occurs during an institutional outpatient institutional visit.

Chapter 5: Effects of Cognition, Function, and Behavior on Out-of-Pocket Medical and Nursing Home Expenditures and Time Caregiving

5.1 Overview

BACKGROUND: Clinical features of dementia (cognition, function, and behavioral/psychological symptoms) may differentially affect out-of-pocket medical and nursing home (NH) expenditures and informal care received (outcomes).

METHODS: We used cross-sectional data (Aging, Demographics, and Memory Study) to estimate probabilities of experiencing outcomes by clinical features. For those experiencing an outcome, we estimated effects of clinical features on the amount of the outcome.

RESULTS: No clinical feature predicted the probability of having out-of-pocket medical expenditures. For those with medical expenditures, higher cognition and poorer function were associated with more spending. Poorer function predicted having out-of-pocket NH expenditures. For those with NH expenditures, no clinical feature predicted the amount. Poorer function and a greater number of behavioral/psychological symptoms predicted the probability of receiving caregiving. For those receiving care, poorer function was associated with more caregiving.

CONCLUSIONS: Clinical features differentially impact outcomes with poorer function associated with all types of costs and caregiving received.

5.2 Introduction

Dementia affects more than five million Americans and results in cognitive and functional declines and behavioral and psychological symptoms.[1,59,61,81] Declines in cognition and function combined with behavioral/psychological symptoms result in a disproportionate use of formal and informal long-term care.[1,17,59,61,100] Given this increased reliance on care, the direct and indirect costs of dementia per patient to society can exceed $50,000 per year.[17] A significant portion of costs are incurred by families and Medicaid.[1,17,18,22,101,102]

The most reliable estimates for the total net cost and net out-of-pocket cost of dementia come from two RAND studies that used data from the Health and Retirement Study (HRS).[17,22] However, these studies did not evaluate the independent contributions of each key clinical feature – cognition, function, and behavioral/psychological symptoms – to out-of-pocket cost. These clinical features may impact out-of-pocket spending by requiring more care to manage symptoms, and causing caregivers to spend more time in supervision. Prior studies evaluating effects of clinical features on total cost suggest that function is an important predictor.[16,35,46,83,103] However, results have been inconsistent and conflicting for the effects of cognition and behavioral/psychological symptoms. Moreover, previous cost studies have important limitations including the use of non-representative data sources, lack of a clinical diagnosis of dementia to identify the analytic sample, not separating medical expenditures from nursing home expenditures, and not disaggregating out-of-pocket expenditures from those covered by insurance.[13,16,29,35,45,46,83,103]

Understanding the type of out-of-pocket cost (medical or nursing home expenditure) based upon clinical features can assist in care planning and developing targeted interventions.

To address previous research limitations, this study used data from a subsample of HRS, the Aging, Demographics, and Memory Study (ADAMS), a nationally representative survey of cognitive impairment, to evaluate the effects of cognition, function, and behavioral/psychological symptoms on out-of-pocket medical and nursing home expenditures and time spent receiving informal caregiving.

5.3 Methods

5.3.1 Study Design and Data

HRS is a nationally representative longitudinal survey of adults ≥51 years.[104] While the core HRS has measures evaluating cognition and function, the survey lacks a clinical diagnosis of dementia and does not contain measures related to behavioral/psychological symptoms. Rather than impute dementia status in the full HRS and not have access to measures of behavioral/psychological symptoms, we used ADAMS data instead. The ADAMS subsample was drawn from HRS (individuals ≥70 years) and was developed to provide population-based data on risk factors, prevalence, outcomes, and costs of cognitive impairment and dementia in the US.[89] ADAMS respondents participated in an in-home clinical assessment during which a trained nurse and neuropsychology technician administered a standardized protocol to collect

cognitive, functional, and behavioral/psychological measures. Following the in-home assessment, an independent consensus panel determined if the individual had dementia, cognitive impairment not dementia, or normal cognitive function.[89]

We linked ADAMS respondents to their HRS survey to obtain sociodemographic variables that were not collected in ADAMS (RAND HRS version N - the RAND HRS Data File is an easy to use data set based on the HRS data. The RAND HRS file combines multiple HRS files into a single data file and contains imputations for missing data. The RAND HRS file was developed at RAND with funding from the National Institute on Aging and the Social Security Administration).[89] Specifically, in addition to identifying a sample of individuals with a dementia diagnosis, ADAMS provided measures for cognition, function, and behavioral/psychological symptoms and estimates of time spent receiving informal care (**Table A5.1** details the data source of model variables). HRS data provided estimates of out-of-pocket medical and nursing home expenditures and additional sociodemographic information.

We restricted our sample to ADAMS respondents (Wave A) identified as having dementia with complete data on variables of interest (**Figure 5.7.1**). Although our analyses are cross-sectional, there was a lag between the ADAMS and HRS assessments (**Table 5.6.1** mean lag 7.42 months). To minimize potential bias associated with the lag and to maximize the available sample size, we linked ADAMS respondents to their closest available HRS wave (HRS wave 2000, 2002, or 2004). For out-of-pocket medical and nursing home expenditure analyses, but not time receiving care analyses, we excluded individuals who

were linked to the 2000 HRS wave (n=18), as HRS combined out-of-pocket spending for medical and nursing home care in that wave. After the 2000 wave, HRS distinguished between out-of-pocket medical and nursing home expenditures. To determine if the linking method impacted the analytic sample, we linked ADAMS respondents to the next HRS wave. Comparisons of the analytic sample based on linking method revealed no statistically significant differences in terms of outcome measures, clinical features, and key confounders (**Table A5.2 and A5.3**)

5.3.2 Measures of Clinical Features of Dementia

Dementia was modeled using three clinical features, cognition, function, and behavioral/psychological symptoms, evaluated in the ADAMS clinical assessment.[59,61] Cognition was measured using the Mini-Mental State Examination (MMSE),[70] scored 0–30 with higher scores indicating greater cognitive function.

Function was assessed using an investigator-modified version of the Functional Activities Questionnaire (FAQ)**.** The FAQ is a standardized measure to evaluate function that is used in other dementia surveys.[60] However, as it was not used in ADAMS, we identified survey questions that were administered and corresponded with the ten functional domains assessed in the FAQ. For each domain, we evaluated if the individual had difficulty performing the representative tasks (yes/no): 1) handling small sums of money, 2) handling complicated financial transactions, 3) shopping independently, 4) performing hobbies, 5)

carrying out routine household tasks, 6) difficulty feeding self, 7) recalling recent events, 8) understanding what s/he reads or sees on television, 9) remembering things about family and friends, and 10) finding one's way around familiar streets. For our analyses, we counted the number of "yes" responses to generate a summary score (0–10). **Table A5.4** compares the measures used in the FAQ with the investigator-developed version from ADAMS.[71]

Finally, we evaluated the number of behavioral/psychological symptoms that caregivers endorsed as occurring in the past month using the Neuropsychiatric Inventory Questionnaire which captures 12 symptoms: 1) delusions, 2) hallucinations, 3) agitation/aggression, 4) depression, 5) apathy, 6) elation, 7) anxiety, 8) disinhibition, 9) irritability, 10) motor disturbance, 11) sleep, and 12) appetite [72]. For each domain, caregivers indicated if the behavior occurred (yes/no), and if yes, its frequency and severity. For our analyses, we counted the number of "yes" responses to generate a summary score reflecting total number of behaviors endorsed (0–12). The number of behavioral/psychological symptoms has been associated with caregiver burden and resource utilization.[90,105-107]

5.3.3 Outcomes

We evaluated average monthly out-of-pocket medical care spending, average monthly out-of-pocket nursing home spending, and average monthly time in receipt of informal caregiving. All costs were converted to 2015 United States dollars using the medical care portion of the Consumer Price Index.

In the HRS, respondents or proxy respondents, reported out-of-pocket expenditures over the previous two-years for nursing home stays, hospital stays, medical visits, outpatient surgery, home health care, special services, and dental visits. Respondents or proxy respondents also reported out-of-pocket prescription drug spending over the previous month. Proxies responded for individuals who were unable to complete the survey without assistance (n=103).

All spending (expect drug spending) was divided by 24 to estimate average monthly out-of-pocket spending. Measures of out-of-pocket medical spending (all categories expect nursing home spending) were summed together. Out-of-pocket nursing home spending was kept as a separate outcome measure.

ADAMS evaluated time individuals with dementia received informal caregiving (informants were queried) in the previous month. The informal time caregiving analyses were limited to community-dwelling persons with dementia that had a caregiver provide information on time caregiving (**Figure 5.7.1, Panel B**). Three measures of informal time caregiving were evaluated: 1) time spent receiving active help for assistance with functional tasks (e.g., cooking meals), 2) time spent receiving supervision to ensure safety, and 3) time spent receiving active care and supervision combined. Some informants reported providing one type of care (e.g., active help) but then had missing responses for the other type of care (e.g., supervision). When this occurred, the dyad was included in the analysis for which data were available. Consistent with other cost studies, we assumed caregivers could provide a maximum of 16 hours of care per day [17]. To

evaluate the value of informal caregiving, we multiplied the market wage rate of a home health aide ($21 per hour) by time spent receiving care.[108]

5.3.4 Statistical Analysis

We estimated separate regression models for each outcome of interest: out-of-pocket medical expenditures, out-of-pocket nursing home expenditures, and time spent receiving active care, supervision, or both. A two-part modeling approach was used for all analyses as more than 25% of individuals had zero expenditures or received zero hours of caregiving.[109] First, we used logistic regression to estimate the probability of experiencing the outcome of interest (i.e., any out-of-pocket medical expenditures, any out-of-pocket nursing home expenditures, or any informal caregiving). Second, we estimated the continuous outcome of interest among those who experienced that outcome using a generalized linear model with a log-link and gamma distribution.[109]

All models included main effects for cognition, function, and behavioral/psychological symptoms. Based on a review of the literature, we identified potential confounding variables. The two-part model evaluating out-of-pocket medical expenditures controlled for age, gender, race, marital status, Medicaid status, supplemental insurance, household income, number of children, and an indicator for the total number of chronic conditions (0–8) among the following: stroke, diabetes, heart problems, hypertension, lung disease, cancer, psychiatric problems, or arthritis. The model also included terms for if an individual had a proxy respondent, and time between the ADAMS and HRS

assessments. In a sensitivity analysis, we excluded terms for insurance status to evaluate their potential confounding effect on the relationship between clinical features and out-of-pocket spending.

Due to small samples sizes, the second part of the two-part models evaluating out-of-pocket nursing home expenditures (>$0 n=45) and time caregiving (>0 hours caregiving n=91) did not include all potential confounders. Rather, based on theoretical and empirical considerations, we *a-priori* identified confounders that we believed were most strongly associated with the clinical features and outcome. For the nursing home analysis, we included indicators for Medicaid and long-term care insurance status. For the time caregiving analysis, we included predictors for age, Medicaid status, number of chronic conditions, relationship between the caregiver and person with dementia (spouse, child, or other), and an indicator for whether the caregiver lived with the person with dementia. In another sensitivity analysis, we evaluated the effect of adding an additional covariate on the average marginal effects of the clinical features. The first part of the models had sample sizes sufficient to include all potential confounders. Finally, for the nursing home analysis, we conducted a similar sensitivity analysis (described above) where we excluded terms for insurance status.

All analyses were conducted using ADAMS survey weights and Stata version 12 survey commands (Stata, College Station, TX).

5.4 Results

5.4.1 Sample Characteristics

Of individuals with dementia that met inclusion criteria for out-of-pocket expenditure analyses (n=215), the mean age was 83.42 years (SD 10.16); 35.13% were male, and 80.43% were white (**Table 5.6.1; Table A5.2 compares those included/excluded in the expenditure analysis**). A subsample of individuals with dementia resided in the community and had a caregiver informant provide information on time caregiving (n=131). The mean age of individuals with dementia in the time caregiving analyses was 83.36 years (SD 10.42); 40.12% were male, and 26.88% were cared for by a spouse (**Table 5.6.1; Table A5.3 compares those included/excluded in the time caregiving analysis**).

5.4.2 Out-of-Pocket Medical Expenditures

The average (obtained from regressions) probability of having any out-of-pocket medical spending (n=215) was 0.77 (95% CI: 0.67, 0.88) with average spending among those with these expenditures (n=155) of $252.23 (95% CI: $195.50, $308.97) per month.

Cognition, function, and number of behavioral/psychological symptoms did not significantly predict if a person with dementia had out-of-pocket medical expenditures (**Table 5.6.2**). However, not being on Medicaid, non-whites, and having comorbidities were associated with a higher probability of having expenditures (**Table A5.5 reports complete results of the two-part model**).

In the second part of the model, cognition and function significantly predicted the amount of out-of-pocket medical expenditures (**Table 5.6.2**). A one-unit improvement in cognition was associated with $8.90 (95% CI: $1.18, $16.62) additional spending per month. Conversely, one-additional functional limitation was associated with $24.68 (95% CI: $1.11, $48.25) additional spending per month. More household income also was significantly associated with spending (**Table A5.5**). The inclusion/exclusion of the insurance covariates did not alter effects of the clinical features on spending.

5.4.3 Nursing Home Expenditures

The average probability of having any out-of-pocket nursing home spending (n=215) was 0.26 (95% CI: 0.15, 0.37), with average spending for those with these expenditures (n=43) being $2,494.40 (95% CI: $863.20, $4,126.17) per month.

One-additional functional limitation was associated with a 0.05 (95% CI: 0.01, 0.09) increase in the probability of having out-of-pocket nursing home expenditures in a month. Neither cognition nor number of behavioral/psychological symptoms significantly predicted the probability of having nursing home expenditures; however, being white and not being married increased the risk of having expenditures (**Table 5.6.2**; **Table A5.6 reports complete results of the two-part model**). Among those with nursing home expenditures, no clinical feature predicted the amount. Being on Medicaid and having long-term care insurance were associated with less out-of-pocket

spending. In the sensitivity analysis, the inclusion of additional confounders, and the inclusion/exclusion of insurance covariates did not alter effects of the clinical features on spending.

5.4.4 Time Spent Caregiving

On average, the probability of receiving informal caregiving was 0.50 (95% CI: 0.37, 0.63) for active care (n=129), 0.46 (95% CI: 0.32, 0.60) for supervision (n=124), and 0.52 (95% CI: 0.38, 0.66) for both (n=131). Average hours of informal caregiving received per month among those who received caregiving was 215.75 (95% CI: 169.51, 262.00) for active care (n=86), 228.06 (95% CI: 174.74, 281.38) for supervision (n=80), and 286.37 (95% CI: 245.26, 327.48) for both (n=91).

Function and number of behavioral/psychological symptoms, but not cognition, were significantly associated with an increase in the probability of receiving all types of informal caregiving (**Table 5.6.3**; **Tables A5.7, A5.8, and A5.9 report complete results of the two-part models**). Specifically, one-additional functional limitation and one-additional behavioral/psychological symptoms were associated with a 0.07 (95% CI: 0.01, 0.12) and 0.05 (95% CI: 0.00, 0.09) increase in the probability of receiving both types of care in a month, respectively. Function was the only clinical feature to significantly predict the amount of all types of caregiving. One-additional functional limitation was associated with 43.65 (95% CI: 18.19, 69.12) additional hours of receiving both types of care in a month (**Table 5.6.3**). Based on the replacement cost ($21 per

hour) of purchasing similar care in the market, one-additional functional limitation equals $916.65 worth of additional care being provided by a family caregiver in a month. In the sensitivity analysis, the inclusion of confounders did not change model conclusions.

5.5 Discussion

This is the first study of its kind to use nationally representative data with a sample that has a clinical diagnosis to estimate the effect of three important clinical features of dementia – cognition, function, and behavioral/psychological symptoms – on out-of-pocket medical and nursing home expenditures and time caregiving. We found differential effects of these clinical features on type of cost incurred and time caregiving.

Cognition, function, and behavioral/psychological symptoms did not predict if an individual incurred any out-of-pocket expenditure, but having comorbidities were associated with a greater risk of having expenditures. The presence of comorbidities may amplify the effect of clinical features on out-of-pocket expenditures[110,111] and speaks to the importance of identifying and managing comorbidities in individuals with dementia. Future studies with larger sample sizes are warranted to investigate the combined effect of comorbidities and clinical features on expenditures.

Among those with any out-of-pocket expenditure, better cognition and poorer function, but not number of behavioral/psychological symptoms and comorbidities, predicted more spending. Others have similarly reported this

differential effect.[16,83] With greater cognitive impairment, medical care may be less aggressive reflecting either advance care directives, or clinical judgment concerning the marginal value of aggressive care, especially in the context of limited interventions for treating cognitive decline.[92] In contrast, functional limitations can be managed throughout the disease with formal caregiving such as home care.[112]

Poorer function predicted having nursing home expenditures, but no clinical feature significantly predicted the amount of such expenditures. While other studies show that cognition, function, and behavioral/psychological symptoms predict nursing home placement, this is the first study to our knowledge to evaluate their independent effect on actual out-of-pocket nursing home payments.[5] In our analysis, the probability of experiencing nursing home expenditures represents the probability of being in and paying out-of-pocket for the stay in the past two years. This is different than the probability of being institutionalized at a given point in time. The clinical features may not have predicted the amount of nursing home expenditures because individuals in our sample had been living in a facility over a long period of time (>1 year) leading to possibly lack of variation in expenditures. We were unable to distinguish between out-of-pocket payments for sub-acute care and long-term nursing home stays. However, given the long duration of nursing home stays of this sample, and limited Medicare nursing home benefit, the observed out-of-pocket spending is most likely due to long-term stays.

Poorer function and a greater number of behavioral/psychological symptoms significantly increase the probability of receiving informal care. Additionally, function predicted the amount of informal care that was received. As some interventions have been shown to improve or maintain daily function and reduce occurrences of behavioral/psychological symptoms, they may also impact the need for informal care and the amount provided.[95-97,113-117] With few exceptions trials have not evaluated the effect of interventions on time spent caregiving.[118,119] Future cost-effectiveness studies can use the information in our analyses to connect the clinical benefits of interventions with associated reductions in time caregiving, and hence related costs.

In our analyses, poorer function was a leading predictor of out-of-pocket expenditures suggesting that functional decline is an important target for interventions.[96] Little is known about the effect of function on costs across other diseases and how it compares to individuals with dementia. A recent study by Zhang et al. found that community-dwelling adults >50 years old with three or more functional limitations incurred $48.54 more in out-of-pocket expenditures per month than those without limitations.[120] Conversely, we found that one-additional functional limitation resulted in $24.68 additional out-of-pocket medical spending. Three limitations would result in $74.04 of additional spending. Thus, the effect of a functional limitation in a person with dementia is likely greater than the same limitation in someone without dementia.

Our objective was to evaluate the effect of each clinical feature on out-of-pocket spending, but Medicare and Medicaid expenditures represent other

important components of the total cost of dementia care as well. While less is

known about the effect of each key feature on Medicaid expenditures, others

have found that functional limitations are associated with more Medicare

spending.[91] Future studies should continue to investigate the relationship

between each clinical feature and Medicare and Medicaid expenditures to

identify specific intervention targets for care planning and projecting care costs.

Our study is not without limitations. We rely on reported data from

individuals with dementia (47% of the sample had a proxy respondent during the

core HRS survey from which out-of-pocket spending data were obtained) and

consequently we may underestimate out-of-pocket spending. However, HRS has

validated procedures to limit under reporting of spending.[22] While our results

provide a basis for understanding out-of-pocket nursing home expenditures and

time caregiving, we were unable to control for all potential confounders due to

small sample sizes. Nevertheless, in sensitivity analyses our results were robust

to the inclusion of additional confounders and overall conclusions did not change.

Due to missing data (**Figure 5.7.1, Panel A and B**) on outcomes of interest and

key covariates, we were unable to use all ADAMS participants identified as

having dementia. This may limit the generalizability of findings. Yet, comparisons

between those included to those excluded in the out-of-pocket expenditure

analyses revealed few statistically significant differences (**Table A5.2**).

Compared to those with dementia excluded from the time receiving caregiving

analyses, those with dementia included were slightly younger, more cognitively

intact, and had fewer functional limitations. This is not surprising given the time

caregiving analyses were limited to those residing in the community. Finally, we used cross-sectional data and did not have information on total time living with dementia. This may limit our view of the long-term implications of costs of dementia care such that our figures are underestimations.

In conclusion, poorer function is associated with more of out-of-pocket medical spending, an increase in the risk of having out-of-pocket nursing home expenditures, and an increase in the risk and amount of informal caregiving received. Better cognition predicted more out-of-pocket medical spending, but cognition did not predict any other outcome. A greater number of behavioral/psychological symptoms predicted an increase in the risk of receiving all types of caregiving. Thus, behavioral/psychological symptoms and function should be targeted by interventions.

5.6 Tables

Table 5.6.1 Sample characteristics

	Out-of-Pocket and Nursing Home Expenditures (n = 215)	Informal Caregiving Sample (n = 131)
Characteristics of Persons with Dementia *		
Mean cognition (SD), *MMSE*†	16.05 (10.54)	17.89 (9.96)
Mean number of functional limitations (SD) ‡	6.02 (3.49)	5.48 (3.61)
Mean number of behavioral/psychological symptoms (SD)§	2.68 (3.78)	2.40 (3.88)
Mean age (SD), *y*	83.42 (10.16)	83.36 (10.08)
Male, %	35.13	38.22
Non-Caucasian, %	19.57	17.57
Married, %	24.60	29.84
Long-term care insurance, %	2.72	3.94
Medicaid, %	27.31	23.00
Supplemental Insurance (e.g., Medigap),%	24.86	26.51
Mean household income (SD), *$, in thousands*	21.30 (32.24)	23.67 (34.34)
Mean number of children (SD)	2.87 (4.47)	3.07 (3.70)
Mean number of comorbidities (SD)	2.92 (2.28)	2.66 (2.13)
HRS proxy respondent, %‖	47.69	35.27
Mean months between ADAMS and HRS assessments (SD)	7.42 (4.63)	7.57 (5.76)
Caregiver Characteristics ¶		

Relationship		
Spouse, %	21.86	26.88
Child, %	46.66	56.45
Other, %	31.48	16.67
Live with person with dementia, %	46.11	60.36

MMSE = Mini-Mental State Examination

*Aging Demographics and Memory Study sample weights were used.

†MMSE is scored from 0-30 with lower scores indicating greater cognitive impairment

‡Measure of function is based on a modified version of the Functional Activities Questionnaire and is scored from 0-10 with higher scores indicating greater functional impairment

§Number of behavioral and psychological symptoms identified on Neuropsychiatric Inventory Questionnaire (NPI) and is scored from 0-12 with higher scores indicating more symptoms.

‖Represents the proportion of the sample that had a proxy respondent during the core HRS survey.

¶The proportions in the expenditure sample may not sum to 1 due to missing data. The informal caregiving sample is a subsample of the expenditure sample and does not have missing caregiver characteristics.

Table 5.6.2 Two-part model results for average monthly out-of-pocket medical and nursing home expenditures

	Out-of-Pocket Medical Expenditures (Part 1 n = 215; Part 2 n = 155)		Out-of-Pocket Nursing Home Expenditures (Part 1 n = 215; Part 2 n = 43)	
	Coefficient (95% CI)	Marginal Effect (95% CI)	Coefficient (95% CI)	Marginal Effect (95% CI)
Part 1 (logistic regression): probability of having a positive expenditure				
Cognition	0.06 (-0.02 , 0.14)	0.01 (-0.01 , 0.01)	-0.08 (-0.21 , 0.05)	-0.01 (-0.03 , 0.01)
Function	-0.04 (-0.39 , 0.31)	0.00 (-0.04 , 0.03)	0.36 (0.05 , 0.67)	0.05 (0.01 , 0.09)
Behavioral and Psychological Symptoms	-0.22 (-0.47 , 0.03)	-0.02 (-0.05 , 0.00)	-0.11 (-0.31 , 0.09)	-0.01 (-0.04 , 0.01)
Part 2 (generalized linear model log link and gamma distribution): expenditures conditional on positive expenditures				
Cognition	0.04 (0.01 , 0.06)	$8.90 ($1.18 , $16.62)	-0.03 (-0.11 , 0.05)	-$75.11 (-$297.44 , $147.22)
Function	0.10 (0.01 , 0.18)	$24.68 ($1.11 , $48.25)	-0.13 (-0.88 , 0.61)	-$336.60 (-$2,329.57 , $1,656.36)

Behavioral and Psychological Symptoms	0.02 (-0.06 , 0.09)	$4.21 (-$15.15 , $23.57)	0.00 (-0.38 , 0.38)	-$6.27 (-$953.41 , $940.87)

Notes: Cognition is evaluated using the Mini-Mental State Examination (MMSE scored 0-30). Higher MMSE scores indicate greater cognitive abilities. Function (scored 0-10) is evaluated as the number of functional limitations. Higher functional scores indicate more limitations. Behavioral and psychological symptoms are evaluated as the number of symptoms endorsed by caregivers as occurring using the 12 items of the Neuropsychiatric Inventory Questionnaire. Higher behavioral/psychological scores indicate more symptoms. Marginal effects in the first part (second part) represent the change in probability (out-of-pocket expenditures) given a change in a measure of clinical feature. Both parts of the out-of-pocket medical expenditure models adjusted for age, gender, race, marital status, Medicaid status, supplemental insurance, household income, number of children, number of comorbidities, if respondent had an HRS proxy, and time between the ADAMS and HRS assessment. The first part of the out-of-pocket nursing home model adjusted for age, gender, race, marital status, Medicaid status, long-term care insurance, supplemental insurance, household income, number of children, number of comorbidities, if respondent had an HRS proxy, and time between the ADAMS and HRS assessment. The second part of out-of-pocket nursing home model adjusted Medicaid status and long-term care insurance.

Table 5.6.3 Two-part model results for average monthly time spent caregiving

	Time Providing Active Help (Part 1 n = 129; Part 2 n = 86)		Time Providing Supervision (Part 1 n = 124; Part 2 n = 80)		Time Providing Any Help (Part 1 n = 131; Part 2 n = 91)	
	Coefficient (95% CI)	Marginal Effect (95% CI)	Coefficient (95% CI)	Marginal Effect (95% CI)	Coefficient (95% CI)	Marginal Effect (95% CI)
Part 1 (logistic regression): probability of any time-spent caregiving						
Cognition	-0.02 (-0.20 , 0.16)	0.00 (-0.03 , 0.02)	-0.07 (-0.25 , 0.12)	-0.01 (-0.03 , 0.02)	-0.05 (-0.23 , 0.14)	-0.01 (-0.03 , 0.02)
Function	0.45 (0.03 , 0.87)	0.07 (0.01 , 0.13)	0.52 (0.12 , 0.91)	0.07 (0.01 , 0.13)	0.44 (0.03 , 0.84)	0.07 (0.01 , 0.12)
Behavioral and Psychological Symptoms	0.37 (0.15 , 0.60)	0.05 (0.02 , 0.09)	0.34 (0.01 , 0.66)	0.05 (0.00 , 0.09)	0.30 (0.03 , 0.57)	0.05 (0.00 , 0.09)
Part 2 (generalized linear model log link and gamma distribution): time caregiving conditional on any caregiving						
Cognition	-0.03 (-0.08 , 0.01)	-7.17 (-16.81 , 2.48)	-0.01 (-0.06 , 0.04)	-2.54 (-13.32 , 8.24)	-0.03 (-0.08 , 0.01)	-9.58 (-22.58 , 3.05)
Function	0.19 (0.06 , 0.32)	40.68 (10.10 , 71.26)	0.27 (0.19 , 0.36)	61.72 (40.87 , 82.56)	0.15 (0.06 , 0.24)	43.65 (18.19 , 69.12)

Behavioral and Psychological Symptoms	-0.02	-3.68	-0.01	-2.20	0.01	2.44
	(-0.10 , 0.07)	(-21.84 , 14.48)	(-0.10 , 0.08)	(-23.16 , 18.75)	(-0.08 , 0.09)	(-22.18 , 27.07)

Notes: Cognition is evaluated using the Mini-Mental State Examination (MMSE scored 0-30). Higher MMSE scores indicate greater cognitive abilities. Function (scored 0-10) is evaluated as the number of functional limitations. Higher functional scores indicate more limitations. Behavioral and psychological symptoms are evaluated as the number of symptoms endorsed by caregivers as occurring using the 12 items of the Neuropsychiatric Inventory Questionnaire. Higher behavioral/psychological scores indicate more symptoms. Marginal effects in the first part (second part) represent the change in probability (number of hours caregiving) given a change in clinical feature. The first part of all time spent caregiving models adjusted for age, gender, race, Medicaid status, household income, number of children, number of comorbidities, caregiver relationship to person with dementia, and if the caregiver lives with the person with dementia. The second part of the models adjusted for age, Medicaid status, number of comorbidities, caregiver relationship to person with dementia, and if the caregiver lives with the person with dementia.

5.7 Figure

Panel A: Out-of-Pocket
Expenditure Analyses

Panel B: Time Receiving
Caregiving Analyses

856 Aging Demographics and Memory Study Participants (Wave A Assessment)

856 Aging Demographics and Memory Study Participants (Wave A Assessment)

548 Excluded with Normal Cognition

548 Excluded with Normal Cognition

308 Participants with Dementia

308 Participants with Dementia

93 Excluded
  75 Missing Data on Covariates

  18 Linked to HRS 2000 Wave

177 Excluded
  130 Missing Data on Covariates

  47 Living in Facility

215 Included in Out-of-Pocket and Nursing Home Expenditure Analyses

131 Included in Time Receiving Caregiving Analyses

Figure 5.7.1 Participation cohort, Aging, Demographics, and Memory Study

Figure 5.7.1 Legend: Among those in the out-of-pocket medical and nursing home expenditure analyses 155 and 43 persons with dementia had expenditures >$0, respectively. The time receiving caregiving analyses were limited to

community-dwelling persons with dementia that had a caregiver provide information on time caregiving. Sample size in

Panel B is for those with data on time spent receiving active care and supervision combined (91 persons with dementia

received >0 hours of active help and supervision combined).

Chapter 6: Societal and Family Lifetime Cost of Dementia: Implications for Policy

6.1 Overview

BACKGROUND: The longitudinal effect of dementia on costs to families, Medicaid, and Medicare is unknown. We estimated the lifetime and annual cost of dementia and the extra cost of caring for someone with dementia compared to someone without dementia.

METHODS: We developed an evidence-based mathematical model to simulate disease progression for newly diagnosed individuals with dementia. Data driven trajectories of cognition, function, and behavioral/psychological symptoms were used to model disease severity and predict costs. Counterfactual analyses were conducted to evaluate costs between those who did and did not exhibit clinical features (net cost) and to evaluate the effect of reducing functional decline or behavioral/psychological symptoms by 10% for 12 months (implemented when Mini-Mental State Examination≤21).

RESULTS: From time of diagnosis (mean age of 83 years and 60 month life expectancy) discounted total lifetime cost of care for a person with dementia was $322,900 (2015 dollars). Families incurred 72% of the total cost burden ($144,160 in value of informal caregiving and $88,780 in out-of-pocket payments). Medicaid accounted for 12% ($37,390) and Medicare accounted for 16% ($52,540) of total cost, respectively. Costs for a person with dementia over a lifetime were $194,890 greater (85% incurred by families) than for someone without dementia. Compared to natural disease progression, reducing functional

decline or behavioral/psychological symptoms by 10% resulted in $4,020 and $720 lower lifetime costs, respectively.

CONCLUSIONS: Dementia substantially increases the lifetime costs of care. Long lasting effective interventions are needed to support families as they incur the most dementia cost.

6.2 Introduction

More than 5 million Americans live with dementia.[1] As the population ages, this number will increase placing an even greater burden on families, the long-term care system, and the economy.[1] The societal economic burden of dementia consists of different types of costs (value of informal care, out-of-pocket expenditures, Medicaid long-term care expenditures, and Medicare expenditures), and several payers (family, Medicaid, and Medicare) bear various amounts of the economic responsibility. To facilitate planning at the family, state, and federal levels policymakers must better understand who incurs dementia costs over the life course of the disease.[121]

Two recent studies highlight the economic burden of the disease over short periods of time. One found that in the last five years of life, a person with dementia receives more than $250,000 worth of care.[18] The other found that those with dementia receive more than $56,000 in additional care in any given year compared to those without dementia.[17] In both studies, families incurred the greatest cost burden due to informal caregiving and out-of-pocket payments for formal long-term care services. However, neither study accounted for the dynamic processes and substantial variations that occur in symptom presentation (cognitive and functional decline and behavioral/psychological symptoms of dementia) over the course of dementia.

We estimated the total lifetime and annual costs of dementia care and the extra cost of caring for someone with dementia compared to someone without

dementia (net cost) using a comprehensive US dementia microsimulation model. Our model overcomes the limitations of previous dementia models by synthesizing data from a clinical registry, a nationally representative survey, and CMS Medicare data to model cognitive, functional, and behavioral/psychological trajectories and associated resource utilization.

6.3 Methods

6.3.1 Model Design

Our evidence-based individual-level model simulated a newly diagnosed dementia patient's disease progression (cognition, function, and behavioral/psychological symptoms), place of residence (community or long-term care facility), and Medicaid status (i.e., dual enrollment), in order to estimate lifetime and the full range of annual costs of care.

Specifically, an individual entered the model as a community-dwelling incident case (**Figure 6.7.1**). At the point of entry (i.e., diagnosis of dementia), and prior to disease progression, the person with dementia's personal characteristics (e.g., age, gender, race) and the characteristics of a primary caregiver were randomly generated from published incident statistics or derived from observational data (data sources described below; **Table A6.1 details the baseline characteristics**).[89,122] This allowed the simulated population to be as representative as possible of the general population. As described in detail below, when the person with dementia aged (i.e., progressed through the model in monthly increments), their cognition, function, and behavioral/psychological

symptoms (i.e., clinical features) changed and they could experience transitions

between places of residence (community and long-term care facility), transitions

from Medicare-only to dual enrollment, and death due to dementia or other

causes.[123-126] Personal characteristics, the clinical features, place of residence,

and insurance status, were used to predict cost of care.

6.3.2 Measures of Disease Progression: Cognition, Function, and Behavioral/Psychological Symptoms

Dementia progression was modeled using three key clinical features -

cognition, function, and behavioral/psychological symptoms.[61] Cognition was

modeled using the Mini-Mental State Examination, which is scored from 0-30

with lower scores indicating greater cognitive impairment.[70] Function was

modeled as the number of 10 functional limitations present and is scored from 0-

10 with higher scores indicating more limitations (**Table A6.2**).

Behavioral/psychological symptoms were modeled as the number of 12

symptoms present based on symptoms in the Neuropsychiatric Inventory

Questionnaire Version Q (**Table A6.3**). These measures of the clinical features

were chosen as they are consistent with the measures available in the data used

to predict clinical trajectories, transitions in place of residence, and cost

(prediction equations described below).[81,127,128]

6.3.3 Modeling Disease Progression

To model disease progression over time, we adapted previously developed cognitive, functional, and behavioral/psychological mixed effect regression trajectory models of incident dementia cases (**Table 6.6.1**).[81] These models used longitudinal data from the Uniform Data Set (March 2015 data freeze) of the National Alzheimer's Coordinating Center to estimate separate trajectories of the three clinical features over time.[122] The National Alzheimer's Coordinating Center combines data from 34 past and present Alzheimer's Disease Centers (ADCs) into the Uniform Data Set. During annual assessments, trained ADC providers administered a standardized protocol that includes cognitive, functional, and behavioral/psychological assessments. The trajectory models included explanatory variables believed to be risk factors of disease onset and decline (**Tables A6.4, A6.5, and A6.6 report model coefficients for each trajectory model**).

6.3.4 Transitions Between Place of Residence, Medicare-only to Dual Enrollment, and Death

Risk of transitioning to a long-term care facility was modeled using the Uniform Data Set. These long-term care admissions were assumed to be independent of Medicare-covered skilled nursing admissions as our estimates of Medicare expenditures (described below) included those for skilled nursing care. This assumption is supported by the few observed transitions in the data of individuals

moving from the facility back to the community indicating that most of the long-term care admissions were likely for non-Medicare covered care. To model long-term care admissions, we developed a parametric survival model to enable extrapolation beyond the available data and to predict the absolute risk of being institutionalized. We chose to use a Weibull survival model compared to an exponential or Gompertz models based on visual inspection of the hazard functions, and because the Weibull model had the lowest Akaike Information Criterion.[129] Our long-term care facility risk model included lagged terms for the clinical features and potential confounders (**Table 6.6.1; Table A6.7 reports Weibull model coefficients**).

Although individuals can transition from a long-term care facility to the community, as noted above few such transitions occurred in the Uniform Data Set. Therefore, we used published estimates of long-term care facility discharge rates to model transition back to the community (**Table 6.6.1**).[130]

For persons with dementia not dually enrolled at disease onset, the risk of transitioning to Medicare-Medicaid varied by place of residence. Individuals in the community had a lower monthly risk (0.00206) of transitioning to Medicare-Medicaid compared to those in a long-term care facility (0.01056)(**Table 6.6.1**).[131,132] Individuals with dementia who transitioned from a long-term care facility to the community continued to face an increased Medicare-Medicaid risk for six months.

Finally, mortality was modeled using background age-, sex-, and race-mortality rates obtained from US life tables.[126] We then used a generalized reduced gradient method to calibrate age-, sex-, and race- specific hazard ratios to match published median dementia survival times based on age of disease onset (≤75, 76 – 80, 81 – 85, > 85).[123,133]

6.3.5 Costs and Time Spent Caregiving

We used published regression equations based on data from the Aging, Demographics, and Memory Study,[89] a subsample of the Health and Retirement Study[104] and linked to CMS Medicare data, to predict monthly hours spent receiving informal care, monthly out-of-pocket medical expenditures and monthly Medicare expenditures.[127,128] Using the same data, we estimated a regression equation to predict monthly hours spent receiving formal community based caregiving (**Table 6.6.1; Table A6.8 report model coefficient for formal community based caregiving**). All the regression models included main effects for the clinical features (same measures used to model disease progression) and potential confounding variables.

The value of informal and formal caregiving was estimated by multiplying monthly hours of caregiving by $21, which is equivalent to the national average cost of a home health aide.[108] In our base-case, approximately 11 hours of informal caregiving a day ($21/hr) is equivalent to the daily private nursing home pay rate ($231/day)(**Table 6.6.1**).

To model long-term care facility expenditures, we multiplied time spent in the facility by the daily pay rate taking into account differences in pay rate for private pay and Medicaid covered individuals (**Table 6.6.1**).[108,134] Costs were discounted by 3% annually over an individual's lifetime following a diagnosis of dementia and are reported in 2015 dollars.

6.3.6 Statistical Analysis

In the base-case analysis we simulated individual incident dementia cases to estimate mean lifetime and annual (conditional on surviving the entire year) total cost of care (value of informal care, Medicaid long-term care expenditures, Medicare expenditures, and individual out-of-pocket expenditures [medical care, long-term care, and formal care]), and the distribution of lifetime and annual cost by component.

We conducted a counterfactual analysis to determine what would have happened to the same simulated person had they not experienced any cognitive deficits, functional limitations, behavioral/psychological symptoms, an excess Medicaid transition risk, or excess mortality due to dementia. We then compared expected costs between the simulated person with dementia and their counterfactual dementia free version (i.e., net cost). We also conducted a series of counterfactual analyses to determine the extra cost of caring for someone with dementia compared to individuals with 1, 3, and 5, functional limitations and no

cognitive deficits, no behavioral/psychological symptoms, and no excess Medicaid or morality risk due to dementia.

Policymakers need a framework to be able to estimate the potential economic impact of policies/interventions that support individuals with dementia.[121] To that end, we demonstrated the application of the model as a tool to evaluate the effects of interventions that can alter the trajectory of functional declines or behavioral/psychological symptoms. Specifically, we used the model to evaluate what would happen if an intervention were introduced that reduced functional decline by 10% or reduced the increase in number of behavioral/psychological symptoms by 10%. In this analysis, we assumed the hypothetical intervention was implemented during the early stage of the disease (MMSE ≤21) and that treatment effects lasted for 12 months. After 12 months individuals experienced the same trajectories as those in the base-case.

Sub-analyses were performed to determine outcomes by age of dementia onset (75 and 90). There are computational challenges with evaluating uncertainty in microsimulation models.[135,136] Therefore, to assess the effect of uncertainty on the total and net cost of dementia we evaluated outcomes when select parameters were set to their best/worst case (**Table A6.9 details parameters varied in best/worst case sensitivity analysis**).

The model was programed in TreeAge Pro 2016 and a deterministic version of the model was validated in Microsoft Excel 2011. Output from the model was analyzed in Stata version 12.

6.4 Results

From the time of diagnosis (base-case mean age 83 years and life expectancy 60 months; **Figure A6.10 reports distribution of survival time by place of residence and insurance status**), mean discounted lifetime total value of care was $322,900 per person with dementia (**Figure 6.7.2 Panel 1**). Families incurred 72% of the total cost burden ($144,160 in the value of informal care and $88,780 in cash out-of-pocket payments). Medicaid payments ($37,390) accounted for 12% of total cost and Medicare payments ($52,540) accounted for 16% of total cost. The *annual* total cost of dementia was not constant and peaked at six years ($90,920) post dementia onset (**Figure A6.11**).

In counterfactual analysis, someone without dementia incurred $128,000 in expenditures. Thus, an individual with dementia experienced $194,890 more cost over a lifetime than someone without dementia (**Figure 6.7.2 Panel 1**). Families shouldered the largest net cost burden (85% of net cost incurred by all parties) due to excess informal caregiving ($141,540 more caregiving received) and out-of-pocket payments ($24,150 more out-of-pocket spending). Medicaid ($9,300) and Medicare ($19,890) payments accounted for 5% and 10% of net dementia cost, respectively. The annual net cost of dementia peaked in the fifth year post dementia onset (compared to the sixth year for total annual cost) at $74,960 (**Figure 6.7.2 Panel 2**). Compared to individuals with 1, 3, and 5, functional limitations (but no cognitive limitations or behavioral/psychological

symptoms) an individual with dementia received $179,030, $139,970, and $79,090 more care over a lifetime, respectively (**Table A6.12**).

Finally, a hypothetical intervention (implemented when MMSE ≤21 and with a 12 month treatment effect) that reduced the rate of functional decline by 10% resulted in $4,020 less lifetime cost than someone who received usual dementia care (**Table A6.12**). An intervention that reduced the number of behavioral/psychological symptoms by 10% resulted in $720 less lifetime cost.

In sub-analyses, the mean total (net) value of care for a 75-year-old incident case was $530,220 ($281,480). A 90-year-old dementia incident case incurred $249,360 (net $189,730) worth of care. Finally, in sensitivity analyses the total (net) cost of dementia in the best and worst case was $258,060 ($158,180) and $405,740 ($163,360), respectively (**Figure A6.13**).

6.5 Discussion

The economic burden of Alzheimer's disease and related dementias and who pays such costs over the course of these conditions are of great policy relevance but cannot be directly estimated from existing data. This study presents a novel dementia policy model that syntheses data from a clinical registry, a nationally representative survey, and CMS Medicare data to model dementia clinical features, living arrangements, and insurance status over the life expectancy of an individual with dementia to inform policymakers of dementia cost. We found that total and net cost of dementia over a lifetime of dementia

(mean age of dementia onset 83 years with life expectancy of 60 months) was $322,900 and $194,890, respectively.

Our evaluation of the annual net cost of dementia revealed that total cost increased for the first five years post onset and then began to slowly decrease. At the same time, out-of-pocket and Medicaid expenditures increased with time. This pattern is attributable to several dynamic processes. In the early years following dementia onset, individuals in our model resided in the community. During this period, the amount of informal caregiving increased leading to greater cost. Eventually, individuals in the model began entering long-term care facilities. This resulted in an increase in net out-of-pocket and Medicaid expenditures, but on average this increase was less than the value of the substituted informal care (11 hours of informal care valued at $21/hr is equivalent to daily nursing home private pay rate of $231). Simultaneously, costs in the dementia free (counterfactual) individuals were increasing over time. The shift in locus of care combined with increasing cost in the counterfactual resulted in reduced cumulative net expenditures.

Our results highlight how the financial burden of dementia varies based on the payer. How/who pays for cost over time change from being attributable to informal care to out-of-pocket and Medicaid long-term care facility payments. At all times families incur the largest financial burden highlighting the importance and value of informal caregiving for individuals with dementia.[3,137] From a government budgetary perspective informal caregiving is often viewed as a free

or low-cost source of care. Yet, there are potentially unintended long-term consequences for caregivers associated with providing informal care (e.g., loss of retirement benefits and long-term health consequences).[138] Moreover, due to a number of demographic trends the potential number of family caregivers available to provide such care to persons with dementia may decrease considerably in the upcoming decades.[3,137]

There is continued enthusiasm from policymakers to implement policies and interventions that reduce long-term care facility admissions and length of stay.[139-141] With reductions in long-term care facility utilization (and perhaps acute/rehabilitative care as well), informal caregivers will be relied upon to shoulder even more care. If policymakers are going to continue to rely on informal caregivers, then they should provide them with effective and proven support.[3] Effective long-term care policy should reduce ineffective or wasteful care and promote high quality care (e.g., family-centered models that include rich sources of community-based support). Sometimes high quality care costs more, but as the results here suggest, such costs largely rely on the perspective of the payer.

A review of model inputs indicates that potential reductions in all costs can be generated from proven interventions that effectively alter functional and behavioral/psychological trajectories, but the magnitude of savings will depend on effect sizes and their duration.[96,116,117,142] Our evaluation of hypothetical treatments found that reducing the rate of functional decline (implemented when

MMSE ≤21) or number of behavioral/psychological symptoms by 10% for 12 months reduced lifetime costs by $4,020 and $720, respectively. These savings are small relative to the total disease burden, but they still may represent important savings depending on the perspective of the payer.

Although we approach the modeling of dementia cost differently, we derive similar estimates to others in the literature for annual net cost supporting the validity of our model.[17,18,37] For example, from the second to tenth year, annual net costs in our model fall within the confidence interval of the net cross-sectional cost of dementia reported by the RAND study (values in RAND analysis updated from 2010 to 2015 dollars for comparison with our results $64,750 95% CI: $49,170, $80,330).[17] We extend results from prior studies by modeling disease progression from incidence to death to accurately account for the accumulation of outcomes over the entire course of the disease.[10-12,143] Most importantly, our dementia policy model serves as a flexible tool to evaluate treatments and their effects on policy-relevant outcomes that are not normally captured in randomized trials (e.g., long-term care facility admission).

Our study has several limitations. Due to limited data, our estimates of the cost of dementia do not consider lost productivity of informal caregivers or the long-term health consequences of caregiving. If a caregiver had to stop working to take care of a person with dementia, the opportunity cost of giving up a job might be greater than the value we assigned to informal care ($21/hr). Due to limited data, our estimate of Medicaid expenditures is for long-term care facilities

and may underestimate total Medicaid spending. Our simulation model uses several risk equations each with a number of parameters. If parameters are incorrectly specified in the original risk equations then our predicted values may be biased. At times the simulation model may extrapolate beyond the original data and this may result in unrepresentative predictive values. Despite these potential limitations, our results of annual net cost from the second to tenth year match those of the RAND study.

In conclusion, individuals with dementia receive $322,900 worth of total care over the course of the disease, which equates to $194,890 more than if they did not have dementia. The vast majority of the total and net costs are borne by families for informal care and out-of-pocket payments. Policy and services should be implemented to support family members in the community.

6.6 Tables

Table 6.6.1 Model inputs

Model Estimate	Monthly Point Estimate	Source
Disease Progression		
Cognition, MMSE	f(time$_t$, time$_t^2$, incident age$_t$, incident age$_t$ * time$_t$, gender$_t$, education$_t$, race$_t$, marital status$_t$, region$_t$, region$_t$ * time$_t$, place of residence$_{t-1}$, hypertension$_t$, hypertension$_t$ * time$_t$, diabetes$_t$, congestive heart failure$_t$, congestive heart failure$_t$ * time$_t$, stroke$_t$, hypercholesterolemia$_t$, psychiatric problems$_t$)	[81,144]
Function, number of functional limitations	f(time$_t$, time$_t^2$, mmse$_t$, mmse$_t$ * time$_t$, incident age$_t$, gender$_t$, education$_t$, education$_t$ * time$_t$, race$_t$, marital status$_t$ + region$_t$, place of residence$_{t-1}$, place of residence$_{t-1}$ * time$_t$, informant relationship$_t$, diabetes$_t$, diabetes$_t$ * time$_t$, congestive heart failure$_t$, stroke$_t$, hypercholesterolemia$_t$, psychiatric problems$_t$)	[81,144]
Behavioral and psychological symptoms, number of symptoms	f(time$_t$, time$_t^2$, mmse$_t$, mmse$_t$ * time$_t$, incident age$_t$, gender$_t$, gender$_t$ * time$_t$, education$_t$, race$_t$, marital status$_t$, region$_t$, place of residence$_{t-1}$, informant relationship$_t$, informant relationship$_t$ * time$_t$, hypertension$_t$, diabetes$_t$, congestive heart failure$_t$, stroke$_t$, stroke$_t$ * time$_t$,	[81,144]

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	hypercholesterolemia$_t$, psychiatric problems$_t$)	
Transitions		
Community to long-term care facility[1]	f(mmse$_{t-1}$, function$_{t-1}$, behavioral/psychological symptoms$_{t-1}$, live with someone$_t$, gender$_t$, education$_t$, race$_t$, region$_t$, hypertension$_t$, diabetes$_t$, congestive heart failure$_t$, stroke$_t$, hypercholesterolemia$_t$, psychiatric problems$_t$)	[144]
Probability of long-term care facility to community[2]		
0 – 90 days	0.13	[130]
90 – 180 days	0.009	[130]
180 – 365 days	0.003	[130]
Probability of Medicare-Medicaid		
Community-dwelling[3]	0.00206	[131,132]
Residing in long-term care facility	0.01056	[131]
Time Spent Caregiving and Expenditures		
Time receiving informal caregiving[4]	f(MMSE$_t$, function$_t$, behavioral/psychological symptoms$_t$, age$_t$, Medicaid$_t$, number of comorbidities$_t$, caregiver relationship$_t$, caregiver live with the person with dementia$_t$)	[127]

Medicare expenditures	f(MMSE$_t$, function$_t$, behavioral/psychological symptoms$_t$, age$_t$, gender$_t$, race$_t$, martial status$_t$, number of comorbidities$_t$)	[128]
Out-of-pocket medical expenditures[5]	f(MMSE$_t$, function$_t$, behavioral/psychological symptoms$_t$, age$_t$, gender$_t$, race$_t$, martial status$_t$, Medicaid$_t$, supplemental insurance$_t$, household income$_t$, number of children$_t$, number of comorbidities$_t$, proxy respondent$_t$, time between ADAMS and HRS assessment$_t$)	[127]
Time receiving formal caregiving[6]	f(MMSE$_t$, function$_t$, behavioral/psychological symptoms$_t$)	[89]
Monthly private nursing home expenditures	$7,270	[108]
Monthly Medicaid nursing home expenditures	$6,236	[108,134]

Abbreviations: MMSE = Mini-Mental State Examination

[1]Models the risk of long-term care facility admissions excluding admissions for Medicare covered skilled nursing care.

[2]If a person with dementia did not leave the long-term care facility within a year it was assumed they remain in the facility for life.

[3]Once an individual was dual-eligible it was assumed they would enroll in Medicaid and remain on Medicaid for life. Background Medicaid transition risk for community-dwelling individuals without dementia was 0.0008. Individuals with

dementia had an excess transition risk (hazard ratio 2.575). All individuals residing in a facility had a 0.0085 added Medicaid transition risk.

[4]Time receiving informal caregiving was modeled with a two-part model. In the first part, a logistic regression was used to estimate if a person received caregiving. In the second part of the model a log-link gamma distribution model was used to estimate the amount of caregiving received. The first part of the model included additional terms for gender, race, supplemental insurance, household income, and number of children. Value of informal caregiving was $21/hour.

[5]Out-of-pocket medical expenditures were modeled with a two-part model. In the first part, a logistic regression was used to estimate if a person had any out-of-pocket expenditures. In the second part, a log-link gamma distribution model was used to estimate the amount of out-of-pocket expenditures.

[6]Value of formal caregiving was modeled with a two-part model. In the first part, a logistic regression was used to estimate if a person received any formal caregiving. In the second part, a log-link gamma distribution model was used to estimate the amount of out-of-pocket expenditures. Due to small sample size the second part only included main effects for the clinical features. The first part of the model included additional terms for age, gender, race, Medicaid status, household income, number of children, number of comorbidities, and if the caregiver lives with the person with dementia. Value of formal caregiving was $21/hour.

6.7 Figures
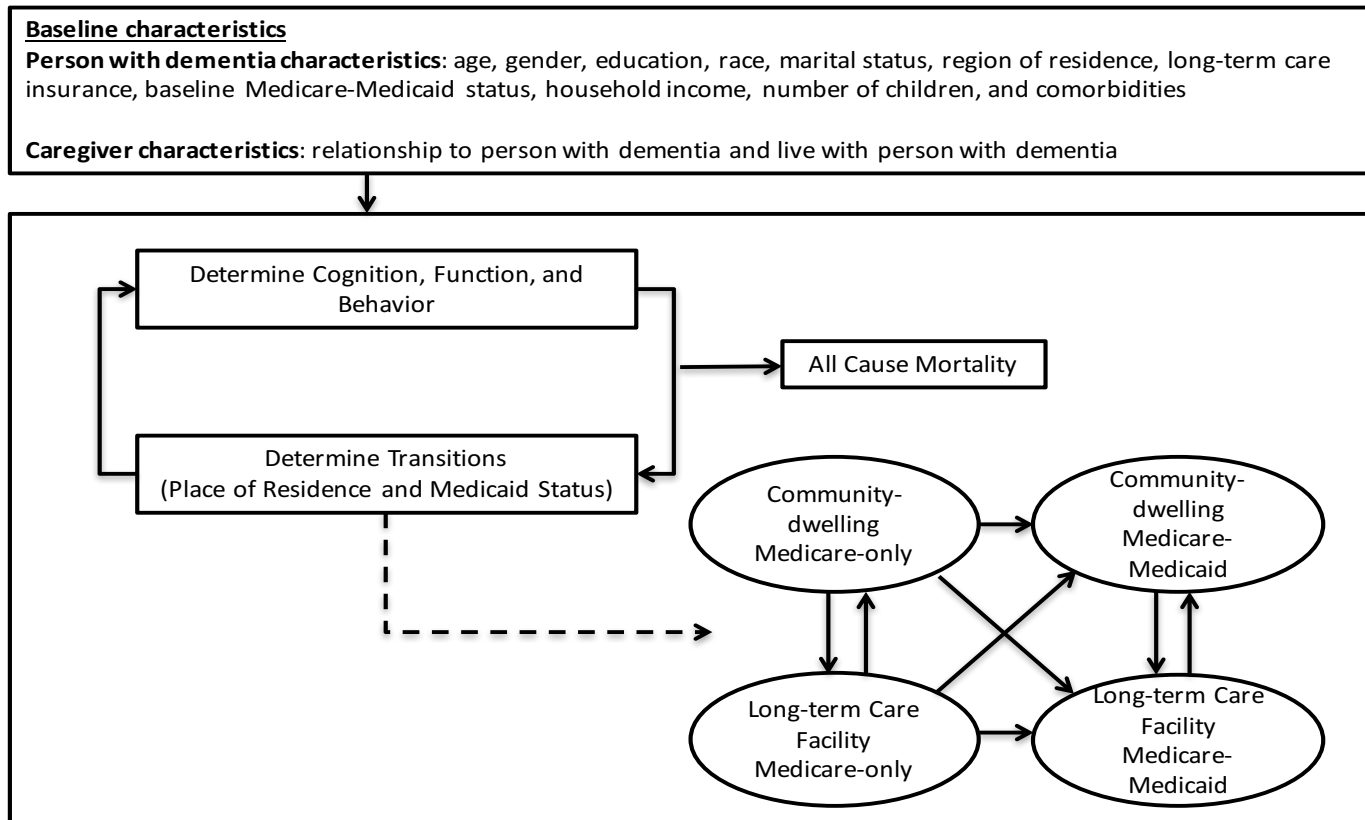
Figure 6.7.1 Dementia policy model structure

Figure 6.7.1 Legend: Persons with dementia are individually simulated. At point of entry (i.e., diagnosis) personal characteristics are generated. During each monthly cycle an individual's cognitive and functional abilities and number of behavioral and psychological symptoms are determined. The clinical features and personal characteristics are used to determine transitions between the community and long-term care facility. Place of residence informs risk of transiting to Medicaid. Personal characteristics, the clinical features, place of residence, and insurance status, were used to estimate cost of care.

Panel 1 Total and Net Lifetime Cost of Dementia

Total Cost 90-year-old Incident Case

Net Cost

Total Cost 83-year-old Incident Case (Base-Case)

Net Cost

Total Cost 75-year-old Incident Case

Net Cost

$0 $50,000 $100,000 $150,000 $200,000 $250,000 $300,000 $350,000 $400,000 $450,000 $500,000 $550,000

Cost of Care

☐ Value of informal caregiving   ☐ Out-of-pocket expenditures   ☐ Medicaid long-term care facility expenditures   ☐ Medicare expenditures
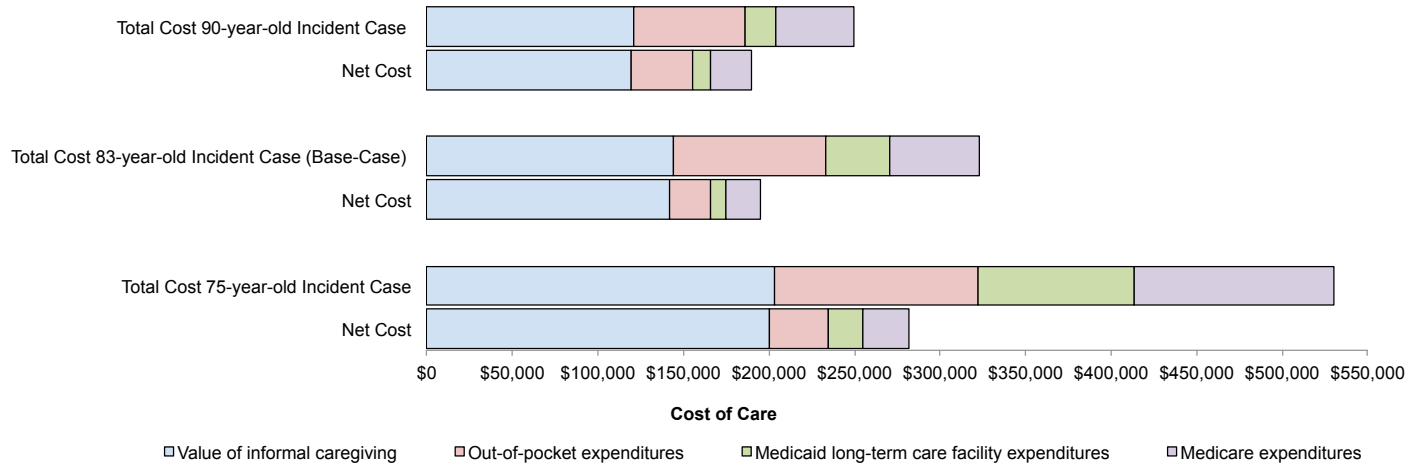
Panel 2 Annual Net Cost of Dementia

Annual Net Expenditures

$80,000

$70,000

$60,000

$50,000

$40,000

$30,000

$20,000

$10,000

$0

1   2   3   4   5   6   7   8   9   10

Year Post Dementia Onset (83-year-old Incident Case Base-Case)

☐ Value of informal caregiving   ☐ Out-of-pocket expenditures   ☐ Medicaid long-term care facility expenditures   ☐ Medicare expenditures
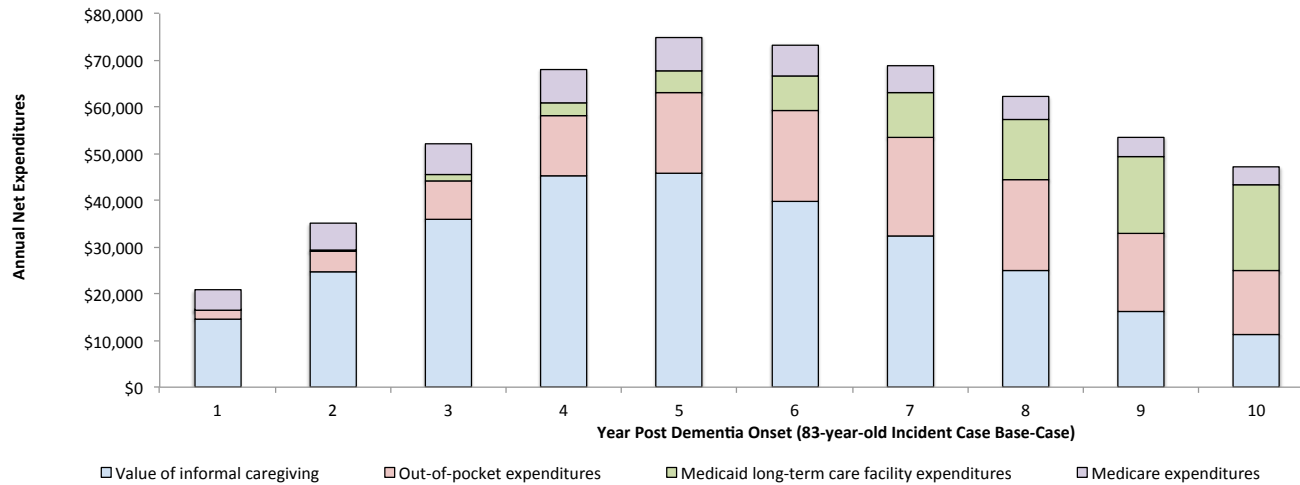
Figure 6.7.2 Distribution of expected total and annual cost

Figure 6.7.2 Legend: Panel 1: Discounted average total and net lifetime cost of dementia by cost type. The value of informal caregiving is $21/hour. Out-of-pocket expenditures include those for medical care, long-term care facility, and formal caregiving. The length of the bar is equal to average lifetime expenditures. Net cost represents the difference in expenditures between dementia cases and counterfactual dementia free cases. Panel 2: Discounted average annual net cost of dementia by cost type for an 83-year-old incident case (base-case). Annual costs are calculated for those conditional on surviving the entire year.

Chapter 7: Summary

The purpose of our study was to inform policymakers as to how cost accumulate over the course of an individual's dementia and who pays for such costs. To accomplish this, we constructed a novel dementia microsimulation model that synthesized data from the National Alzheimer's Coordinating Center Uniform Data Set, the Aging, Demographics, and Memory Study (ADAMS), the Health and Retirement Study (HRS), CMS Medicare, and estimates from the literature.

In **Chapter 3** (aim 1), we used data from the National Alzheimer's Coordinating Center Uniform Data Set to evaluate cognitive, functional, and behavioral/psychological trajectories of newly diagnosed individuals with dementia.[81] Key predictors of cognitive decline included age of dementia onset, geographic region of residence, and history of hypertension and congestive heart failure. Predictors of functional decline included place of residence in the previous observation and a history of diabetes. Finally, cognition was the only variable to explain changes in behavioral/psychological symptoms. Independently, this chapter provides insight into potential sociodemographic and clinical factors that may be associated with accelerated/decelerated decline in the clinical features of dementia. Results from this portion of the analysis were used in the dementia simulation model to predict declines in cognition, function, and behavioral/psychological symptoms.

In **Chapter 4** (aim 2), we used data from ADAMS, part of the HRS, linked to CMS Medicare data to evaluate the independent contributions of cognition,

function, and behavioral/psychological symptoms to Medicare expenditures and Medicare utilization.[128] Poorer function, but not cognition or behavioral/psychological symptoms, was associated with more Medicare spending. The effect of function on Medicare expenditures was driven, in part, through the effect of poorer function on more hospitalizations and skilled nursing care. Interventions that seek to maintain or improve function could reduce Medicare expenditures for individuals with dementia. Results from this portion of the analysis were used in the dementia simulation model to predict Medicare expenditures associated with cognition, function, and behavioral/psychological symptoms.

In **Chapter 5** (aim 2), we used ADAMS data to evaluate the independent contributions of cognition, function, and behavioral/psychological symptoms to out-of-pocket medical expenditures and time caregiving.[127] No clinical feature predicted if an individual had any out-of-pocket medical expenditure, but among those with out-of-pocket expenditures higher cognition and poorer function were associated with more spending. Poorer function and more behavioral/psychological symptoms were associated with a greater risk of receiving informal caregiving, and poorer function also was associated with more informal caregiving. Interventions that maintain or improve function could result in large savings to families. Results from this portion of the analysis were used in the dementia simulation model to predict out-of-pocket expenditures and time

caregiving associated with cognition, function, and behavioral/psychological symptoms.

In **Chapter 6** (aim 3), the trajectory (**Chapter 3**) and cost (**Chapters 4 and 5**) estimates were incorporated as inputs in a US dementia simulation model that simulated a newly diagnosed dementia patients' disease progression and associated cost. Clinical trajectories were also used to inform transitions between places of residence (community or long-term care facility) that in turn informed transitions in insurance status (Medicare-only or dual enrollment). Mean life expectancy for a newly diagnosed dementia case (base case mean age of diagnosis 83 years) was 70 months. The average lifetime cost of care was $322,900. Families incurred 73% of the total cost burden ($144,160 for informal caregiving and $88,780 in out-of-pocket payments). Costs for a person with dementia were $194,890 more over a lifetime than for someone without dementia (85% of net cost incurred by families).

In summary, families bare the largest financial burden associated with dementia. Family financial obligations are predominately due to informal caregiving and out-of-pocket payments for long-term care services. As policymakers continue to rely on informal family caregivers to provide a majority of dementia care, they must also provide them with effective and proven support. Potentially large reductions in costs to all payers can be achieved by managing functional declines and behavioral symptoms. Several nondrug interventions have been shown to effectively control functional decline and behavioral

symptoms. However, the effects of these interventions on policy relevant

economic outcomes (e.g., time caregiving) are unknown. Future studies can use

our US dementia simulation model as a tool to evaluate the economic effects of

interventions that address cognitive, functional, and behavioral symptoms of

dementia.

References

1.	Alzheimer's Association. 2016 Alzheimer's disease facts and figures. *Alzheimer's & Dementia*. 2016;12(4):459–509.

2.	Schulz R, Martire LM. Family caregiving of persons with dementia. *American Journal of Geriatric Psychiatry*. 2004;12(3):240–249.

3.	National Academies of Sciences, Engineering, and Medicine. Families caring for an aging America. Washington, DC: The National Academies Press. 2016.

4.	Yaffe K, Fox P, Newcomer R, et al. Patient and caregiver characteristics and nursing home placement in patients with dementia. *JAMA*. 2002;287(16):2090–2097.

5.	Gaugler JE, Yu F, Krichbaum K, Wyman JF. Predictors of nursing home admission for persons with dementia. *Med Care*. 2009;47(2):191–198.

6.	Dementia: a public health priority. World Health Organization. 2012. (http://apps.who.int/iris/bitstream/10665/75263/1/9789241564458_eng.pdf?ua=1)

7.	Ferri CP, Prince M, Brayne C, et al. Global prevalence of dementia: a Delphi consensus study. *The Lancet*. 2006;366(9503):2112–2117.

8.	Hebert LE, Weuve J, Scherr PA, Evans DA. Alzheimer disease in the United States (2010–2050) estimated using the 2010 census. *Neurology*. 2013;80(19):1778–1783.

9.	US Department of Health and Human Services. National Plan to Address Alzheimer's Disease National Plan to Address Alzheimer's Disease: 2013 Update. (http://aspe.hhs.gov/daltcp/napa/natlplan.shtml)

10.	Cohen JT, Neumann PJ. Decision analytic models for Alzheimer's disease: state of the art and future directions. *Alzheimer's & Dement*. 2008;4(3):212–222.

11.	Green C, Shearer J, Ritchie CW, Zajicek JP. Model-based economic evaluation in Alzheimer's disease: a review of the methods available to model Alzheimer's disease progression. *Value in Health*.

2011;14(5):621–630.

12.   Green C. Modelling disease progression in Alzheimer's disease. *Pharmacoeconomics*. 2007;25(9):735–750.

13.   Quentin W, Riedel Heller SG, Luppa M, Rudolph A, König HH. Cost-of-illness studies of dementia: a systematic review focusing on stage dependency of costs. *Acta Psychiatr Scand*. 2010;121(4):243–259.

14.   Herrmann N, Lanctôt KL, Sambrook R, et al. The contribution of neuropsychiatric symptoms to the cost of dementia care. *Int J Geriat Psychiatry*. 2006;21(10):972–976.

15.   Schnaider Beeri M, Werner P, Davidson M, Noy S. The cost of behavioral and psychological symptoms of dementia (BPSD) in community dwelling Alzheimer's disease patients. *Int J Geriat Psychiatry*. 2002;17(5):403–408.

16.   Zhu CW, Scarmeas N, Torgan R, et al. Clinical features associated with costs in early AD: baseline data from the Predictors Study. *Neurology*. 2006;66(7):1021–1028.

17.   Hurd MD, Martorell P, Delavande A, Mullen KJ, Langa KM. Monetary costs of dementia in the United States. *N Engl J Med*. 2013;368(14):1326–1334.

18.   Kelley AS, McGarry K, Gorges R, Skinner JS. The Burden of Health Care Costs for Patients With Dementia in the Last 5 Years of Life. *Annals of Internal Medicine*. 2015;163(10):729-736.

19.   Plassman BL, Langa KM, Fisher GG, et al. Prevalence of dementia in the United States: the aging, demographics, and memory study. *Neuroepidemiology*. 2007;29(1-2):125–132.

20.   Kane RL, Atherly A. Medicare expenditures associated with Alzheimer disease. *Alzheimer Dis Assoc Disord*. 2000;14(4):187–195.

21.   Thies W, Bleiler L, Alzheimer's Association. 2013 Alzheimer's disease facts and figures. *Alzheimer's & Dementia*. 2013;9(2):208–245.

22.   Delavande A, Hurd MD, Martorell P, Langa KM. Dementia and out-of-pocket spending on health care services. *Alzheimer's & Dementia*. 2013;9(1):19–29.

23.   Gilligan AM, Malone DC, Warholak TL, Armstrong EP. Health Disparities in Cost of Care in Patients With Alzheimer's Disease An

Analysis Across 4 State Medicaid Populations. *Am J Alzheimers Dis Other Demen*. 2013;28(1):84–92.

24.   Feder J, Komisar HL, Niefeld M. Long-term care in the United States: An overview. *Health Affairs*. 2000;19(3):40–56.

25.   Bharmal MF, Dedhiya S, Craig BA, et al. Incremental dementia-related expenditures in a Medicaid population. *American Journal of Geriatric Psychiatry*. 2012;20(1):73–83.

26.   Fillit H, Hill JW, Futterman R. Health care utilization and costs of Alzheimer's disease: the role of comorbid conditions, disease stage, and pharmacotherapy. *Family Med*. 2002;34(7):528–535.

27.   Leon J, Cheng C-K, Neumann PJ. Alzheimer's disease care: costs and potential savings. *Health Affairs*. 1998;17(6):206–216.

28.   Newcomer RJ, Clay TH, Yaffe K, Covinsky KE. Mortality risk and prospective Medicare expenditures for persons with dementia. *Journal of the American Geriatrics Society*. 2005;53(11):2001–2006.

29.   Murman DL, Chen Q, Powell MC, Kuo SB, Bradley CJ, Colenda CC. The incremental direct costs associated with behavioral symptoms in AD. *Neurology*. 2002;59(11):1721–1729.

30.   Zhu CW, Scarmeas N, Torgan R, et al. Clinical characteristics and longitudinal changes of informal cost of Alzheimer's disease in the community. *Journal of the American Geriatrics Society*. 2006;54(10):1596–1602.

31.   Mauskopf J, Mucha L. A review of the methods used to estimate the cost of Alzheimer's disease in the United States. *Am J Alzheimers Dis Other Demen*. 2011;26(4):298–309.

32.   Albert SM, Sano M, Bell K, Merchant C, Small S, Stern Y. Hourly care received by people with Alzheimer's disease: results from an urban, community survey. *Gerontologist*. 1998;38(6):704–714.

33.   Leon J, Neumann PJ. The cost of Alzheimer's disease in managed care: a cross-sectional study. *Am J Manag Care*. 1999;5(7):867.

34.   Rice DP, Fox PJ, Max W, et al. The economic burden of Alzheimer's disease care. *Health Affairs*. 1993;12(2):164–176.

35.   Zhu CW, Torgan R, Scarmeas N, et al. Home health and informal care utilization and costs over time in Alzheimer's disease. *Home*

Health Care Serv Q. 2008;27(1):1–20.

36.   Zhu CW, Leibman C, Townsend R, et al. Bridging from clinical endpoints to estimates of treatment value for external decision makers. *J Nutr Health Aging*. 2009;13(3):256–259.

37.   Yang Z, Zhang K, Lin PJ, Clevenger C, Atherly A. A longitudinal analysis of the lifetime cost of dementia. *Health Serv Res*. 2012;47(4):1660–1678.

38.   Handels RL, Wolfs CA, Aalten P, Verhey FR, Severens JL. Determinants of care costs of patients with dementia or cognitive impairment. *Alzheimer Dis Assoc Disord*. 2013;27(1):30–36.

39.   Oremus M. Systematic review of economic evaluations of Alzheimer's disease medications. *Expert Review of Pharmacoeconomics & Outcomes Research*. 2008;8(3):273–289.

40.   Knapp M, Iemmi V, Romeo R. Dementia care costs and outcomes: a systematic review. *Int J Geriat Psychiatry*. January 2013:28(6):551-61

41.   Tschanz JT, Corcoran CD, Schwartz S, et al. Progression of cognitive, functional and neuropsychiatric symptom domains in a population cohort with Alzheimer's dementia the Cache County Dementia Progression study. *Am J Geriatr Psychiatry*. 2011;19(6):532.

42.   Mohs RC, Schmeidler J, Aryan M. Longitudinal studies of cognitive, functional and behavioral change in patients with Alzheimer's disease. *Stat Med*. 2000;19(11–12):1401–1409.

43.   Hill J, Fillit H, Thomas SK, Chang S. Functional impairment, healthcare costs and the prevalence of institutionalization in patients with Alzheimer's disease and other dementias. *Pharmacoeconomics*. 2006;24(3):265–280.

44.   Mauskopf J, Racketa J, Sherrill E. Alzheimer's disease: the strength of association of costs with different measures of disease severity. *J Nutr Health Aging*. 2010;14(8):655–663.

45.   Small GW, McDonnell DD, Brooks RL, Papadopoulos G. The impact of symptom severity on the cost of Alzheimer's disease. *Journal of the American Geriatrics Society*. 2002;50(2):321–327.

46.   Zhu CW, Scarmeas N, Torgan R, et al. Longitudinal study of effects of patient characteristics on direct costs in Alzheimer's disease.

Neurology. 2006;67(6):998–1005.

47.   Miles TP, Froehlich TE, Bogardus ST, Inouye SK. Dementia and race: are there differences between African Americans and Caucasians? *Journal of the American Geriatrics Society*. 2001;49(4):477–484.

48.   Loveman E, Green C, Kirby J, et al. The clinical and cost-effectiveness of donepezil, rivastigmine, galantamine and memantine for Alzheimer's disease. *Health Technol Assess*. 2006;10(1):1-160.

49.   Caro JJ. Pharmacoeconomic analyses using discrete event simulation. *Pharmacoeconomics*. 2005;23(4):323–332.

50.   Neumann PJ, Hermann RC, kuntz KM, et al. Cost-effectiveness of donepezil in the treatment of mild or moderate Alzheimer's disease. *Neurology*. 1999;52(6):1138–1138.

51.   Kinosian BP, Stallard E, Lee JH, Woodbury MA, Zbrozek AS, Glick HA. Predicting 10-year care requirements for older people with suspected Alzheimer's disease. *Journal of the American Geriatrics Society*. 2000;48(6):631.

52.   Spackman DE, Kadiyala S, Neumann PJ, Veenstra DL, Sullivan SD. Measuring Alzheimer disease progression with transition probabilities: estimates from NACC-UDS. *Curr Alzheimer Res*. 2012;9(9):1050–1058.

53.   Caro JJ, Möller J, Getsios D. Discrete event simulation: the preferred technique for health economic evaluations? *Value in Health*. 2010;13(8):1056–1060.

54.   Fone D, Hollinghurst S, Temple M, et al. Systematic review of the use and value of computer simulation modelling in population health and health care delivery. *Journal of Public Health*. 2003;25(4):325–335.

55.   Kuntz KM, Lansdorp-Vogelaar I, Rutter CM, et al. A systematic comparison of microsimulation models of colorectal cancer the role of assumptions about adenoma progression. *Med Decis Making*. 2011;31(4):530–539.

56.   Kruijshaar ME, Barendregt J, Vos T, de Graaf R, Spijker J, Andrews G. Lifetime prevalence estimates of major depression: an indirect estimation method and a quantification of recall bias. *European Journal of Epidemiology*. 2005;20(1):103–111.

57.   Alzheimer's Association. 2015 Alzheimer's disease facts and figures.

Alzheimer's & Dement 2015:11(3):1–88.

58.   Chin AL, Negash S, Hamilton R. Diversity and disparity in dementia. *Alzheimer Dis Assoc Disord*. 2011;25(3):187–195.

59.   Mayeux R, Stern Y. Epidemiology of Alzheimer disease. *Cold Spring Harbor Perspectives in Medicine*. 2012;2(8):a006239–a006239.

60.   Morris JC, Weintraub S, Chui HC, et al. The Uniform Data Set (UDS): clinical and cognitive variables and descriptive data from Alzheimer Disease Centers. *Alzheimer Dis Assoc Disord*. 2006;20(4):210–216.

61.   Grand JH, Caspar S, MacDonald SW. Clinical features and multidisciplinary approaches to dementia care. *J Multidiscip Healthc*. 2011;4:125-147.

62.   Plassman BL, Langa KM, McCammon RJ, et al. Incidence of dementia and cognitive impairment, not dementia in the United States. *Ann Neurol*. 2011;70(3):418–426.

63.   Cortes F, Nourhashémi F, Guérin O, et al. Prognosis of Alzheimer's disease today: A two-year prospective study in 686 patients from the REAL-FR Study. *Alzheimer's & Dementia*. 2008;4(1):22–29.

64.   Helzner EP, Luchsinger JA, Scarmeas N, et al. Contribution of vascular risk factors to the progression in Alzheimer disease. *Arch Neurol*. 2009;66(3):343–348.

65.   Han L, Cole M, Bellavance F, McCusker J, Primeau F. Tracking cognitive decline in Alzheimer's disease using the mini-mental state examination: a meta-analysis. *Int Psychogeriatr*. 2000;12(2):231–247.

66.   Delva F, Auriacombe S, Letenneur L, et al. Natural history of functional decline in Alzheimer's disease: a systematic review. *J Alzheimers Dis*. 2014;40(1):57–67.

67.   Bradford A, Kunik ME, Schulz P, Williams SP, Singh H. Missed and delayed diagnosis of dementia in primary care. *Alzheimer Dis Assoc Disord*. 2009;23(4):306–314.

68.   Beach TG, Monsell SE, Phillips LE. Accuracy of the clinical diagnosis of Alzheimer disease at National Institute on Aging Alzheimer Disease Centers, 2005–2010. *J Neuropathol Exp Neurol*. 2012;71(4):266-73.

69.   Slavin MJ, Brodaty H, Sachdev PS. Challenges of diagnosing dementia in the oldest old population. *The Journals of Gerontology*

Series A: Biological Sciences and Medical Sciences. 2013;68(9):1103–1111.

70.   Folstein MF, Folstein SE, McHugh PR. Mini-Mental State: a practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res*. 1975;(3):189–198.

71.   Pfeffer RI, Kurosaki TT, Harrah CH, Chance JM, Filos S. Measurement of functional activities in older adults in the community. *Journal of Gerontology*. 1982;37(3):323–329.

72.   Cummings JL, Mega M, Gray K, Rosenberg-Thompson S, Carusi DA, Gornbein J. The Neuropsychiatric Inventory comprehensive assessment of psychopathology in dementia. *Neurology*. 1994;44(12):2308–2308.

73.   Lines L, Sherif N, Wiener J. Racial and ethnic disparities among individuals with Alzheimer's disease in the United States: a literature review. RTI Press publication No. RR-0024-1412. Research Triangle Park (NC): RTI Press. 2014.

74.   Hensel A, Angermeyer MC, Riedel-Heller SG. Measuring cognitive change in older adults: reliable change indices for the Mini-Mental State Examination. *Journal of Neurology, Neurosurgery & Psychiatry*. 2007;78(12):1298–1303.

75.   Bellew KM, Pigeon JG, Stang PE, Fleischman W, Gardner RM, Baker WW. Hypertension and the rate of cognitive decline in patients with dementia of the Alzheimer type. *Alzheimer Dis Assoc Disord*. 2004;18(4):208–213.

76.   Groves WC, Brandt J, Steinberg M. Vascular dementia and Alzheimer's disease: is there a difference? *J Neuropsychiatry Clin Neurosci.* 2000;12(3):305-15/

77.   Gure TR, Kabeto MU, Plassman BL, Piette JD, Langa KM. Differences in functional impairment across subtypes of dementia. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*. 2010;65A(4):434–441.

78.   Lopez OL, Becker JT, Sweet RA, et al. Psychiatric symptoms vary with the severity of dementia in probable Alzheimer's disease. *The Journal of Neuropsychiatry and Clinical Neurosciences*. 2003;15(3):346–353.

79.   Kokmen E, Özsarfati Y, Beard CM, O'Brien PC, Rocca WA. Impact of

referral bias on clinical and epidemiological studies of Alzheimer's disease. *Journal of Clinical Epidemiology*. 1996;49(1):79–83.

80.   Taylor DH, Schenkman M, Zhou J, Sloan FA. The relative effect of Alzheimer's disease and related dementias, disability, and comorbidities on cost of care for elderly persons. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*. 2001;56(5):S285–S293.

81.   Jutkowitz E, MacLehose RF, Gaugler JE, Dowd B, Kuntz KM, Kane RL. Risk factors associated with cognitive, functional, and behavioral trajectories of newly diagnosed dementia patients. *J Gerontol A Biol Sci Med Sci*. 2017;72(2):251-258

82.   Zhu CW, Cosentino S, Ornstein K, et al. Medicare utilization and expenditures around incident dementia in a multiethnic cohort. *J Gerontol A Biol Sci Med Sci*. 2015;70(11):1448–1453.

83.   Gustavsson A, Brinck P, Bergvall N, et al. Predictors of costs of care in Alzheimer's disease: A multinational sample of 1222 patients. *Alzheimer's & Dementia*. 2011;7(3):318–327.

84.   Zhu CW, Leibman C, McLaughlin T, et al. The effects of patient function and dependence on costs of care in Alzheimer's disease. *Journal of the American Geriatrics Society*. 2008;56(8):1497–1503.

85.   Sloan FA, Taylor DH. Effect of Alzheimer's disease on the cost of treating other diseases. *Alzheimer Dis Assoc Disord*. 2002;16(3):137–143.

86.   Taylor DH, Østbye T, Langa KM, Weir D, Plassman BL. The accuracy of Medicare claims as an epidemiological tool: the case of dementia revisited. *J Alzheimers Dis*. 2009;17(4):807–815.

87.   Taylor DH Jr, Fillenbaum GG, Ezell ME. The accuracy of Medicare claims data in identifying Alzheimer's disease. *Journal of Clinical Epidemiology*. 2002;55(9):929–937.

88.   Jutkowitz E, Kuntz KM, Gaugler JE, MacLehose RF, Kane RL. Effects of cognition, function, and behavior on out-of-pocket medical and nursing home expenditures and time caregiving for persons with dementia. 2017;S1552-5260(17)30002-X

89.   Langa KM, Plassman BL, Wallace RB, et al. The Aging, Demographics, and Memory Study: study design and methods. *Neuroepidemiology*. 2005;25(4):181–191.

90.   Onder G, Finne-Soveri H, Soldato M, et al. Distress of caregivers of older adults receiving home care in European countries: results from the AgeD in HOme Care Study. *American Journal of Geriatric Psychiatry*. 2009;17(10):899–906.

91.   Zhu CW, Cosentino S, Ornstein K, Gu Y, Andrews H, Stern Y. Use and cost of hospitalization in dementia: longitudinal results from a community-based study. *Int J Geriat Psychiatry*. 2015;30(8):833–841.

92.   Nicholas LH, Bynum JPW, Iwashyna TJ, Weir DR, Langa KM. Advance directives and nursing home stays associated with less aggressive end-of-life care for patients with severe dementia. *Health Affairs*. 2014;33(4):667–674.

93.   Phelan EA, Borson S, Grothaus L, Balch S, Larson EB. Association of incident dementia with hospitalizations. *JAMA*. 2012;307(2):165–172.

94.   Lin PJ, Zhong Y, Fillit HM, Chen E, Neumann PJ. Medicare expenditures of individuals with Alzheimer's disease and related dementias or mild cognitive impairment before and after diagnosis. *Journal of the American Geriatrics Society*. 2016;64(8)

95.   Gitlin LN, Winter L, Dennis MP, Hodgson N, Hauck WW. A biobehavioral home-based intervention and the well-being of patients with dementia and their caregivers. *JAMA*. 2010;304(9):983.

96.   Gitlin L, Hodgson N, Choi S, Marx KA. Interventions to address functional decline in persons with dementia: closing the gap between what a person "does do" and what they 'can do.' In: Park Z, Bondi J, eds. *Neuropsychology of Alzheimer's Disease and Other Dementias.* 2nd ed. New York, NY: Oxford University Press: In Press.

97.   McLaren AN, LaMantia MA, Callahan CM. Systematic review of non-pharmacologic interventions to delay functional decline in community-dwelling patients with dementia. *Aging Ment Health*. 2013;17(6):655–666.

98.   MedPac. March 2015 report to the Congress: Medicare Payment Policy. Washington DC: Medicare Payment Advisory Commission; 2015. http://www.medpac.gov/docs/default-source/reports/mar2015_entirereport_revised.pdf?sfvrsn=0.

99.   Goldfeld KS, Stevenson DG, Hamel MB, Mitchell SL. Medicare expenditures among nursing home residents with advanced dementia. *Arch Intern Med*. 2011;171(9):824-30.

100.   Langa KM, Chernew ME, Kabeto MU, et al. National estimates of the quantity and cost of informal caregiving for the elderly with dementia. *Journal of General Internal Medicine*. 2001;16(11):770–778.

101.   Friedman EM, Shih RA, Langa KM, Hurd MD. US prevalence and predictors of informal caregiving for dementia. *Health Affairs*. 2015;34(10):1637–1641.

102.   Moore MJ, Zhu CW, Clipp EC. Informal costs of dementia care: estimates from the National Longitudinal Caregiver Study. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*. 2001;56(4):S219–S228.

103.   Rattinger GB, Schwartz S, Mullins CD, et al. Dementia severity and the longitudinal costs of informal care in the Cache County population. *Alzheimer's & Dementia*. 2015;11(8):946–954.

104.   Juster FT, Suzman R. An overview of the Health and Retirement Study. *Journal of Human Resources*. 1995;30;S7–S56.

105.   Matsumoto N, Ikeda M, Fukuhara R, et al. Caregiver burden associated with behavioral and psychological symptoms of dementia in elderly people in the local community. *Dement Geriatr Cogn Disord*. 2007;23(4):219–224.

106.   Sink KM, Covinsky KE, Barnes DE, Newcomer RJ, Yaffe K. Caregiver characteristics are associated with neuropsychiatric symptoms of dementia. *Journal of the American Geriatrics Society*. 2006;54(5):796–803.

107.   Cerejeira J, Lagarto L, Mukaetova-Landinska EB. Behavioral and psychological symptoms of dementia. Front Neurol. 2012;3(73):1–21.

108.   MetLife Mature Market Institute. Market survey of long-term care costs 2012. Available at: https://www.metlife.com/assets/cao/mmi/publications/studies/2012/studies/mmi-2012-market-survey-long-term-care-costs.pdf. Accessed March 1, 2016.

109.   Deb P, Manning W, Norton E. Modeling health care costs and counts. 8th World Congress on Health Economics 2006.

110.   Hill JW, Futterman R, Duttagupta S, Mastey V, Lloyd JR, Fillit H. Alzheimer's disease and related dementias increase costs of comorbidities in managed Medicare. *Neurology*. 2002;58(1):62–70.

111. Kuo TC, Zhao Y, Weir S, Kramer MS, Ash AS. Implications of comorbidity on costs for patients with Alzheimer disease. *Med Care*. 2008;46(8):839–846.

112. A NICE-SCIE Guideline on Supporting People With Dementia and Their Carers in Health and Social Care. National Collaborating Center for Mental Health (UK). Leicester (UK): British Psychological Society; 2007.

113. Gitlin LN, Kales HC, Lyketsos CG. Managing behavioral symptoms in dementia using nonpharmacologic approaches: an overview. *JAMA*. 2012;308(19):2020.

114. Dysken MW, Sano M, Asthana S, et al. Effect of vitamin E and memantine on functional decline in Alzheimer disease. *JAMA*. 2014;311(1):33-44.

115. Jutkowitz E, Brasure M, Fuchs E, et al. Care-delivery interventions to manage agitation and aggression in dementia nursing home and assisted living residents: a systematic review and meta-analysis. *Journal of the American Geriatrics Society*. 2016;64(3):477–488.

116. Brasure M, Jutkowitz E, Fuchs E, et al. Nonpharmacologic interventions for agitation and aggression in dementia. Comparative Effectiveness Review No. 177. (Prepared by the Minnesota Evidence-based Practice Center under Contract No. 290-2012-00016-I.) AHRQ Publication No.16-EHC019-EF. Rockville, MD: Agency for Healthcare Research and Quality; March 2016. www.effectivehealthcare.ahrq.gov/reports/final.cfm.

117. Brodaty H, Arasaratnam C. Meta-analysis of nonpharmacological interventions for neuropsychiatric symptoms of dementia. *Am J Psychiatry*. 2012;169(9):946–953.

118. Gitlin LN, Hodgson N, Jutkowitz E, Pizzi L. The cost-effectiveness of a nonpharmacologic intervention for individuals with dementia and family caregivers: the tailored activity program. *Am J Geriatr Psychiatry*. 2012;18(6):510–519.

119. Jutkowitz E, Gitlin LN, Pizzi LT. Evaluating willingness-to-pay thresholds for dementia caregiving interventions: application to the tailored activity program. *Value Health*. 2010;13(6):720–725.

120. Zhang J, Lee UJ, Meltzer DO. The effect of functional limitations and hospitalization on out-of-pocket medical payments in older adults. *Annals of Community Medicine and Practice*. 2015:1(1):1–4.

121.   US Department of Health and Human Services. National Plan to
         Address Alzheimer's Disease National Plan to Address Alzheimer's
         Disease: 2016 Update.
         (https://aspe.hhs.gov/system/files/pdf/205581/NatlPlan2016.pdf)

122.   Beekly DL, Ramos EM, Lee WW, et al. The National Alzheimer's
         Coordinating Center (NACC) database: the uniform data set.
         Alzheimer Dis Assoc Disord. 2007;21(3):249–258.

123.   Brookmeyer R, Corrada MM, Curriero FC, Kawas C. Survival
         following a diagnosis of Alzheimer disease. *Arch Neurol*.
         2002;59(11):1764-7.

124.   Larson EB, Shadlen MF, Wang L, et al. Survival after initial diagnosis
         of Alzheimer disease. *Ann Intern Med*. 2004;140(7):501–509.

125.   Cho H, Klabunde CN, Yabroff KR, et al. Comorbidity-adjusted life
         expectancy: a new tool to inform recommendations for optimal
         screening strategies. *Ann Intern Med*. 2013;159(10):667–676.

126.   Arias E, Heron M, Tejada-Vera B. United States life tables eliminating
         certain causes of death, 1999-2001. *National vital statistics reports*.
         2008;57(1). Hyattsville, MD: National Center for Health Statistics.

127.   Jutkowitz E, Kuntz KM, Dowd B, Gaugler JE, MacLehose RF, Kane
         RL. Effects of cognition, function, and behavioral and psychological
         symptoms on out-of-pocket medical and nursing home expenditures
         and time spent caregiving for persons with dementia. *Alzheimers
         Dement*. 2017: S1552-5260(17)30002-X

128.   Jutkowitz E, Kane RL, Dowd B, Gaugler JE, MacLehose RF, Kuntz
         KM. Effects of cognition, function, and behavioral and psychological
         symptoms on Medicare expenditures and healthcare utilization for
         persons with dementia. *The Journals of Gerontology Series A:
         Biological Sciences and Medical Sciences*. In Press.

129.   Latimer N. NICE DSU technical support document 14: survival
         analysis for economic evaluations alongside clinical trials-
         extrapolation with patient-level data. *Sheffield: Report by the Decision
         Support Unit*. 2011.

130.   Arling G, Castelluccio P, Kane RL, Bershadsky J. Targeting residents
         for transition from nursing home to community. Prepared for the Area
         Agency on Aging of Northwest Arkansas 2008.

131.   Lim W, Irvin CV, Borck R. Factors Predicting Transitions From

Medicare-Only to Medicare-Medicaid Enrollee Status. Mathematica Policy Research; 2014: (https://aspe.hhs.gov/system/files/pdf/77001/MMTransV2.pdf)

132.   Spillman B, Waidmann T. Rates and Timing of Medicaid Enrollment among Older Americans. Office of Disability, Aging and Long-Term Care Policy Office of the Assistant Secretary for Planning and Evaluation U.S. Department of Health and Human Services Contract #HHSP23337033T. 2014. (https://aspe.hhs.gov/system/files/pdf/134546/timing.pdf)

133.   Vanni T, Karnon J, Madan J, White RG. Calibrating models in economic evaluation: a seven-step approach. *Pharmacoeconomics*. 2011;29(1):35-49.

134.   A Report on Shortfalls in Medicaid Funding for Nursing Center Care. 2012. (https://www.ahcancal.org/research_data/funding/Documents/2012%20Report%20on%20Shortfalls%20in%20Medicaid%20Funding%20for%20Nursing%20Home%20Care.pdf)

135.   Briggs AH, Claxton K, Sculpher MJ. *Decision Modelling for Health Economic Evaluation*. Oxford University Press, USA, 2006.

136.   Briggs AH, Weinstein MC, Fenwick EAL, Karnon J, Sculpher MJ, Paltiel AD. Model parameter estimation and uncertainty: a report of the ISPOR-SMDM modeling good research practices task force-6. *Value in Health*. 2012;15(6):835–842.

137.   Gaugler JE, Kane RL. *Family Caregiving in the New Normal*. Academic Press, USA, 2015.

138.   Adelman RD, Tmanova LL, Delgado D, Dion S, Lachs MS. Caregiver Burden. *JAMA*. 2014;311(10):1052-60.

139.   Shirk C. The Role of the Medicaid HCBS Waiver Program. 2006 (http://www.w.nhpf.org/library/background:papers/BP_HCBS.Waivers_03:03:06.pdf)

140.   Mor V, Zinn J, Gozalo P, Feng Z, Intrator O, Grabowski DC. Prospects for transferring nursing home residents to the community. *Health Affairs*. 2007;26 (6):1762–1771.

141.   Robison J, Porter M, Shugrue N, Kleppinger A, Lambert D. Connecticut's "money follows the person"yields positive results for transitioning people out of institutions. *Health Affairs*.

2015;34(10):1628–1636.

142.   O'Neil ME, Freeman M, Portland VA. A systematic evidence review of non-pharmacological interventions for behavioral symptoms of dementia. Department of Veterans Affairs. 2011. (http://www.hsrd.research.va.gov/publications/esp/Dementia:Nonpharm.pdf)

143.   Hernandez L, Ozen A, DosSantos R, Getsios D. Systematic Review of Model-Based Economic Evaluations of Treatments for Alzheimer's Disease. *Pharmacoeconomics*. 2016;34(7):681–707.

144.   Weintraub S, Salmon D, Mercaldo N, et al. The Alzheimer's disease centers' uniform data set (UDS): the neuropsychological test battery. *Alzheimer Dis Assoc Disord*. 2009;23(2):91.

Appendix for Chapter 3
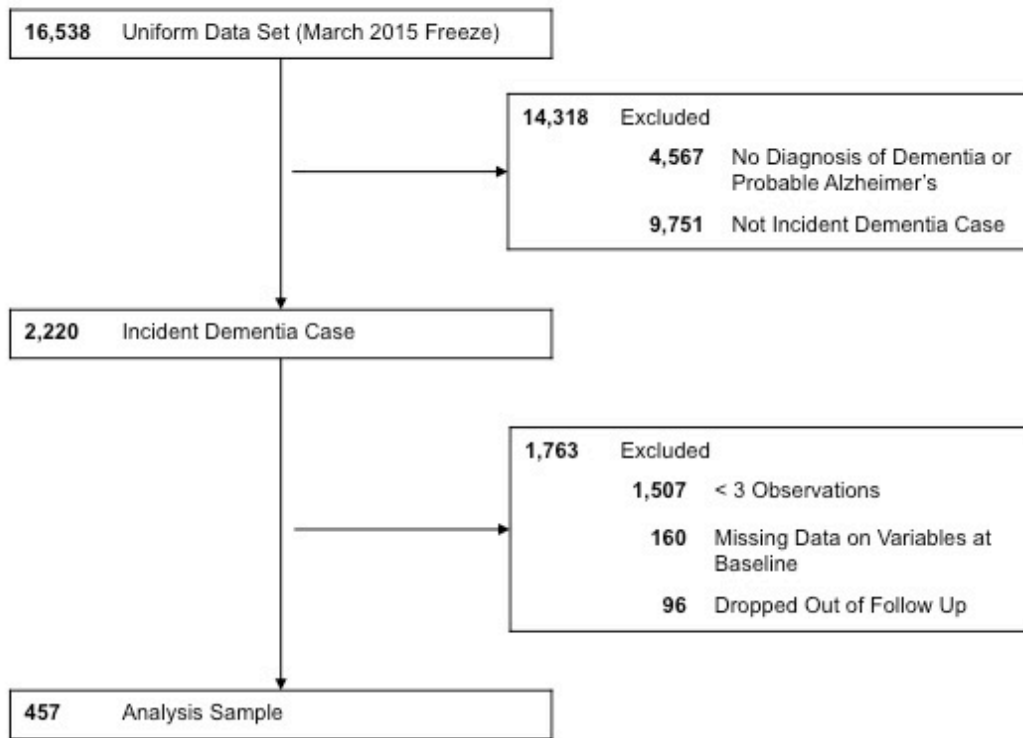
Figure A3.1 Participation cohort

Figure A3.1 Legend: The National Alzheimer's Coordinating Center provided

the investigators with data from the Uniform Data Set (March 2015 Freeze) that

met the following criteria: individuals >70 years old with a clinical diagnosis of

probable Alzheimer's Disease or dementia; or a Clinical Dementia Rating Scale

Score >0 or Mini-Mental State Exam Score ≤ 25. Using this data file we applied

the study inclusion criteria to obtain the analysis sample.

Equation A3.2 Simple trajectory model equation:

$$Y_{ij} = \beta_0 + \beta_1 Time_{ij} + \beta_2 Time^2_{ij} + \zeta_{1j} + \zeta_{2j} Time_{ij} + \zeta_{3j} Time^2_{ij} + u_{ij}$$

Notes: Y_{ij} (i indexes individuals and j indexes time) represents the outcome of interested (i.e., cognition, function, or behavior). ζ_{1j} represents a random intercept, $\zeta_{2j} Time_{ij}$ and $\zeta_{3j} Time^2_{ij}$ represent random slopes, and u_{ij} represents and individuals specific error term.

Table A3.3 Baseline sample characteristics of non-dropouts and dropouts

	Dropouts and Non-Dropouts (n = 553)	Non-Dropouts[*] (n = 457)	Dropouts (n = 96)[†]	P-value[‡]
Age in Years at Diagnosis, M (SD)	79.59 (6.19)	79.91 (6.26)	78.07 (5.70)	0.008
Male, N (%)	293 (53)	251 (55)	42 (44)	0.042
Years of Education, M (SD)	15.39 (3.02)	15.37 (2.91)	15.48 (3.52)	0.752
Race				0.384
Caucasian, N (%)	476 (86)	396 (87)	80 (84)	
African American, N (%)	47 (9)	39 (8)	8 (8)	
Other, N (%)	30 (5)	22 (5)	8 (8)	
Marital Status at Diagnosis				0.251
Married, N (%)	392 (71)	327 (71)	65 (68)	
Widowed, N (%)	120 (22)	100 (22)	20 (21)	
Other, N (%)	41 (7)	30 (7)	11 (11)	
Region of Residence				0.001
Northeast, N (%)	129 (23)	85 (19)	44 (46)	
South, N (%)	36 (7)	28 (6)	8 (8)	
West, N (%)	138 (25)	120 (26)	18 (19)	
Midwest, N (%)	56 (10)	51 (11)	5 (5)	

Not Specified, N (%)	194 (35)	173 (38)	21 (22)	
Place of Residence at Diagnosis				0.777
Community Dwelling, N (%)	533 (96)	440 (96)	93 (97)	
Facility, N (%)	20 (4)	17 (4)	3 (3)	
Informant Relationship				0.719
Spouse, N (%)	349 (63)	291 (64)	58 (60)	
Other Family Member, N (%)	157 (28)	129 (28)	28 (29)	
Other, N (%)	47 (9)	37 (8)	10 (11)	
Comorbidities				
Ever Hypertension, N (%)	373 (67)	311 (68)	62 (65)	0.510
Ever Diabetes, N (%)	80 (14)	64 (14)	16 (17)	0.501
Ever Congestive Heart Failure, N (%)	34 (6)	29 (6)	5 (5)	0.673
Ever Hypercholesterolemia, N (%)	382 (69)	316 (69)	66 (69)	0.939
Ever Stroke, N (%)	58 (10)	47 (10)	11 (11)	0.733
Ever Psychiatric Problems, N (%)	61 (11)	50 (11)	11 (11)	0.883
MMSE at Diagnosis, M (SD)[§]	24.38 (3.21)	24.22 (3.24)	25.03 (2.96)	0.028
FAQ Score at Diagnosis, M (SD)[‖]	10.90 (7.10)	10.89 (7.12)	10.95 (7.04)	0.947
NPI Total Score at Diagnosis, M (SD)[¶]	3.74 (3.85)	3.90 (3.99)	2.98 (3.07)	0.033

Clinical Dementia Rating Score				0.831
None, N (%)	0 (0.00)	0 (0.00)	0 (0.00)	
Very Mild, N (%)	330 (59.67)	275 (60.18)	55 (57.29)	
Mild, N (%)	209 (37.79)	171 (37.42)	38 (39.58)	
Moderate, N (%)	14 (2.53)	11 (2.41)	3 (3.12)	
Severe, N (%)	0 (0.00)	0 (0.00)	0 (0.00)	
Number of Follow up Visits, M (SD)	4.08 (1.17)	4.13 (1.20)	3.88 (1.02)	0.055

*Non-dropouts is the sample used for analyses in the main text

†Dropouts consisted of individuals who requested not to participate in follow up assessments

‡Comparison of non-dropouts and dropouts

§MMSE = Mini-mental State Exam

‖FAQ = Functional Activities Questionnaire

¶ NPI-Q = Neuropsychiatry Inventory Questionnaire

Equation A3.4 Cognition trajectory model equation:

$Y_{ij} = \beta_0 + \beta_1 Time_{ij} + \beta_2 Time^2_{ij} + \beta_3 Age\ of\ Onset_{ij} + \beta_4 Age\ of\ Onset_{ij} * Time_{ij} +$

$\beta_5 Male_{ij} + \beta_6 Education_{ij} + \beta_7 Race_{ij} + \beta_8 Marital\ Status_{ij} + \beta_9 Region\ of$

$Residence_{ij} + \beta_{10} Region\ of\ Residence_{ij} * Time_{ij} + \beta_{11} Place\ of\ Residence_{ij} +$

$\beta_{12} Hypertension_{ij} + \beta_{13} Hypertension_{ij} * Time^2_{ij} + \beta_{14} Diabetes_{ij} + \beta_{15} Congestive$

$Heart\ Failure_{ij} + \beta_{16} Congestive\ Heart\ Failure_{ij} * Time_{ij} + \beta_{17} Stroke_{ij} +$

$\beta_{18} Hypercholesterolemia_{ij} + \beta_{19} Psychiatric\ Problems_{ij} + \zeta_{1j} + \zeta_{2j} Time_{ij} + \zeta_{3j} Time^2_{ij}$

$+u_{ij}$

Notes: Y_{ij} (i indexes individuals and j indexes time) represents cognition. ζ_{1j}

represents a random intercept, $\zeta_{2j} Time_{ij}$ and $\zeta_{3j} Time^2_{ij}$ represent random slopes,

and u_{ij} represents and individuals specific error term.

Table A3.5 Supplemental analyses of cognitive trajectories

Effects	Parameter Estimates of Cognitive Trajectories: Standardized MMSE (n = 457)	Parameter Estimates of Cognitive Trajectories Including Dropouts (n = 553)
Intercept	-1.201	20.603***
	(-2.584, 0.181)	(16.598, 24.608)
Time	-1.187***	-4.692***
	(-1.867, -0.508)	(-6.719, -2.665)
Time^2	-0.036***	-0.111***
	(-0.056, -0.015)	(-0.172, -0.050)
Age of Onset (Years)	0.000	0.002
	(-0.014, 0.015)	(-0.041, 0.044)
Age of Onset (Years) * Time	0.010*	0.038**
	(0.001, 0.018)	(0.013, 0.063)
Male	0.071	0.158
	(-0.113, 0.255)	(-0.384, 0.699)
Years of Education	0.073***	0.219***
	(0.044, 0.102)	(0.136, 0.302)
Race (ref = White)		
African American	-0.503**	-1.325**
	(-0.815, -0.191)	(-2.229, -0.421)
Other	-0.085	-0.487
	(-0.481, 0.312)	(-1.581, 0.607)
Marital Status (ref = Widowed)		
Married	-0.180	-0.690*
	(-0.383, 0.024)	(-1.288, -0.093)
Other	-0.012	0.169
	(-0.330, 0.306)	(-0.745, 1.082)

Region of Residence (ref = Northeast)		
South	0.008 (-0.384, 0.399)	0.286 (-0.802, 1.375)
West	-0.368** (-0.622, -0.114)	-1.016** (-1.722, -0.310)
Midwest	0.369* (0.051, 0.688)	1.173* (0.251, 2.095)
Not Specified	-0.059 (-0.300, 0.181)	-0.225 (-0.883, 0.434)
Region of Residence (ref = Northeast) * Time		
South	-0.109 (-0.342, 0.125)	-0.216 (-0.890, 0.459)
West	-0.229** (-0.383, -0.076)	-0.500* (-0.938, -0.063)
Midwest	0.025 (-0.161, 0.212)	0.279 (-0.276, 0.834)
Not Specified	-0.087 (-0.229, 0.056)	-0.087 (-0.490, 0.317)
Community-dwelling in Previous Time Period (ref = Facility)	0.146 (-0.121, 0.414)	0.530 (-0.255, 1.315)
Ever Hypertension	0.129 (-0.060, 0.318)	0.522 (-0.031, 1.074)
Ever Hypertension * Time	0.114* (0.007, 0.222)	0.410* (0.087, 0.732)
Ever Diabetes	-0.067 (-0.318, 0.184)	-0.661 (-1.386, 0.063)
Ever Congestive Heart Failure	0.064	0.155

	(-0.285, 0.413)	(-0.870, 1.180)
Ever Congestive Heart Failure * Time	0.216*	0.699*
	(0.010, 0.422)	(0.070, 1.329)
Ever Stroke	-0.097	-0.488
	(-0.353, 0.159)	(-1.239, 0.262)
Ever Hypercholesterolemia	0.077	0.288
	(-0.112, 0.266)	(-0.266, 0.842)
Ever Psychiatric Problems	0.245	0.690
	(-0.026, 0.517)	(-0.099, 1.479)

Notes: MMSE = Mini-mental State Exam (scored 0–30). Higher scores indicate greater cognitive abilities.

$* p < 0.05$. $** p < 0.01$. $*** p < 0.001$.

Equation A3.6 Function trajectory model equation

$$Y_{ij} = \beta_0 + \beta_1 Time_{ij} + \beta_2 Time^2_{ij} + \beta_3 Cognitive\ Status_{ij} + \beta_4 Cognitive\ Status_{ij} * Time_{ij} +$$

$$\beta_5 Age\ of\ Onset_{ij} + \beta_6 Male_{ij} + \beta_7 Education_{ij} + \beta_8 Education_{ij} * Time_{ij} + \beta_9 Race_{ij} +$$

$$\beta_{10} Marital\ Status_{ij} + \beta_{11} Region\ of\ Residence_{ij} + \beta_{12} Place\ of\ Residence_{ij} +$$

$$\beta_{13} Place\ of\ Residence_{ij} * Time_{ij} + \beta_{14} Informant\ Relationship_{ij} + \beta_{15} Hypertension_{ij} +$$

$$\beta_{16} Diabetes_{ij} + \beta_{17} Diabetes_{ij} * Time_{ij} + \beta_{18} Congestive\ Heart\ Failure_{ij} + \beta_{19} Stroke_{ij} +$$

$$\beta_{20} Hypercholesterolemia_{ij} + \beta_{21} Psychiatric\ Problems_{ij} + \zeta_{1j} + \zeta_{2j} Time_{ij} + \zeta_{3j} Time^2_{ij}$$

$$+ u_{ij}$$

Notes: Y_{ij} (i indexes individuals and j indexes time) represents function. ζ_{1j} represents a random intercept, $\zeta_{2j} Time_{ij}$ and $\zeta_{3j} Time^2_{ij}$ represent random slopes, and u_{ij} represents and individuals specific error term.

Table A3.7 Supplemental analyses of functional trajectories

Effects	Parameter Estimates of Functional Trajectories: Standardized FAQ (n =457)	Parameter Estimates of Functional Trajectories Including Dropouts (n = 553)
Intercept	2.899***	29.866***
	(1.674 , 4.124)	(22.025 , 37.707)
Time	0.285**	1.930**
	(0.081 , 0.489)	(0.566 , 3.293)
Time^2	-0.039***	-0.278***
	(-0.052 , -0.026)	(-0.368 , -0.189)
Cognitive Status (MMSE)	-0.057***	-0.433***
	(-0.073 , -0.041)	(-0.541 , -0.325)
Cognitive Status (MMSE) * Time	-0.004	-0.021
	(-0.009 , 0.001)	(-0.054 , 0.013)
Age of Onset (Years)	-0.002	-0.004
	(-0.014 , 0.010)	(-0.081 , 0.073)
Male	-0.319***	-2.229***
	(-0.474 , -0.165)	(-3.229 , -1.230)
Years of Education	-0.017	-0.103
	(-0.045 , 0.011)	(-0.278 , 0.072)
Years of Education * Time	0.008	0.058*
	(-0.001 , 0.016)	(0.003 , 0.112)
Race (ref = White)		
African American	-0.494***	-3.744***
	(-0.748 , -0.240)	(-5.365 , -2.124)
Other	-0.015	0.803
	(-0.337 , 0.307)	(-1.149 , 2.755)

Marital Status (ref = Widowed)		
Married	-0.165 (-0.359 , 0.029)	-0.959 (-2.245 , 0.327)
Other	-0.046 (-0.302 , 0.211)	-0.643 (-2.300 , 1.014)
Region of Residence (ref = Northeast)		
South	-0.002 (-0.319 , 0.316)	0.426 (-1.523 , 2.375)
West	0.250* (0.043 , 0.457)	2.032** (0.768 , 3.296)
Midwest	-0.312* (-0.568 , -0.056)	-2.149* (-3.786 , -0.511)
Not Specified	0.007 (-0.187 , 0.200)	0.552 (-0.618 , 1.722)
Community-dwelling in Previous Time Period (ref = Facility)	-0.635*** (-0.968 , -0.302)	-3.824*** (-6.019 , -1.628)
Community-dwelling in Previous Time Period (ref = Facility)* Time	0.154** (0.050 , 0.257)	0.882* (0.190 , 1.575)
Informant Relationship (ref = Spouse)		
Other Family Member	-0.133 (-0.310 , 0.045)	-0.760 (-1.948 , 0.428)
Other	-0.236 (-0.483 , 0.012)	-1.126 (-2.791 , 0.539)
Ever Hypertension	0.003	-0.206

	(-0.151 , 0.156)	(-1.194 , 0.782)
Ever Diabetes	0.148	1.088
	(-0.089 , 0.386)	(-0.422 , 2.597)
Ever Diabetes * Time	-0.075*	-0.429
	(-0.149 , -0.001)	(-0.923 , 0.066)
Ever Congestive Heart Failure	0.043	-0.699
	(-0.239 , 0.326)	(-2.525 , 1.128)
Ever Stroke	0.311**	2.241***
	(0.112 , 0.510)	(0.940 , 3.542)
Ever Hypercholesterolemia	-0.180*	-1.125*
	(-0.334 , -0.025)	(-2.122 , -0.128)
Ever Psychiatric Problems	-0.100	-0.594
	(-0.321 , 0.122)	(-2.011 , 0.822)

Notes: FAQ = Functional Activities Questionnaire (scored 0 – 30). Higher scores indicate more functional limitations.

* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

Equation A3.8 Behavioral/psychological symptoms trajectory model equation

$Y_{ij} = \beta_0 + \beta_1 Time_{ij} + \beta_2 Time^2_{ij} + \beta_3 Cognitive\ Status_{ij} + \beta_4 Cognitive\ Status_{ij} * Time_{ij} +$

$\beta_5 Age\ of\ Onset_{ij} + \beta_6 Male_{ij} + \beta_7 Male_{ij} * Time_{ij} + \beta_8 Education_{ij} + \beta_9 Race_{ij} + \beta_{10} Marital$

$Status_{ij} + \beta_{11} Region\ of\ Residence_{ij} + \beta_{12} Place\ of\ Residence_{ij} + \beta_{13} Informant$

$Relationship_{ij} + \beta_{14} Informant\ Relationship_{ij} * Time_{ij} + \beta_{15} Hypertension_{ij} +$

$\beta_{16} Diabetes_{ij} + \beta_{17} Congestive\ Heart\ Failure_{ij} + \beta_{18} Stroke_{ij} + \beta_{19} Stroke_{ij} * Time_{ij} +$

$\beta_{20} Hypercholesterolemia_{ij} + \beta_{21} Psychiatric\ Problems_{ij} + \zeta_{1j} + \zeta_{2j} Time_{ij} + \zeta_{3j} Time^2_{ij}$

$+ u_{ij}$

Notes: Y_{ij} (i indexes individuals and j indexes time) represents severity of behavioral/psychological symptoms. ζ_{1j} represents a random intercept, $\zeta_{2j} Time_{ij}$ and $\zeta_{3j} Time^2_{ij}$ represent random slopes, and u_{ij} represents and individuals specific error term.

Table A3.9 Supplemental analyses of behavioral/psychological trajectories

Effect	Parameter Estimates of Behavioral Trajectories: Standardized NPI-Q (n =457)	Parameter Estimates of Behavioral Trajectories Including Dropouts (n = 553)
Intercept	1.678*	9.558***
	(0.367 , 2.988)	(4.948 , 14.167)
Time	0.315**	1.258***
	(0.122 , 0.507)	(0.544 , 1.972)
Time^2	0.000	-0.001
	(-0.017 , 0.018)	(-0.069 , 0.066)
Cognitive Status (MMSE)	-0.018	-0.062
	(-0.037 , 0.001)	(-0.131 , 0.007)
Cognitive Status (MMSE) * Time	-0.008*	-0.030*
	(-0.014 , -0.001)	(-0.054 , -0.007)
Age of Onset (Years)	-0.020**	-0.066**
	(-0.034 , -0.007)	(-0.112 , -0.019)
Male	0.042	0.143
	(-0.144 , 0.228)	(-0.521 , 0.806)
Male * Time	-0.065	-0.222
	(-0.141 , 0.012)	(-0.500 , 0.055)
Years of Education	-0.011	-0.041
	(-0.038 , 0.015)	(-0.132 , 0.050)
Race (ref = White)		
African American	-0.122	-0.572
	(-0.401 , 0.158)	(-1.554 , 0.410)
Other	-0.031	0.169

	(-0.386 , 0.324)	(-1.020 , 1.357)
Marital Status (ref = Widowed)		
Married	0.025	-0.003
	(-0.204 , 0.254)	(-0.827 , 0.821)
Other	0.237	0.554
	(-0.059 , 0.533)	(-0.490 , 1.598)
Region of Residence (ref = Northeast)		
South	0.445*	1.744**
	(0.096 , 0.794)	(0.568 , 2.920)
West	0.195	0.634
	(-0.033 , 0.422)	(-0.131 , 1.400)
Midwest	0.195	0.780
	(-0.090 , 0.480)	(-0.222 , 1.781)
Not Specified	0.318**	1.114**
	(0.104 , 0.532)	(0.401 , 1.826)
Community-dwelling in Previous Time Period (ref = Facility)	0.212	0.515
	(-0.028 , 0.452)	(-0.347 , 1.376)
Informant Relationship (ref = Spouse)		
Other Family Member	0.028	0.065
	(-0.203 , 0.259)	(-0.774 , 0.904)
Other	-0.088	-0.583
	(-0.433 , 0.257)	(-1.826 , 0.661)
Informant Relationship (ref = Spouse) * Time		
Other Family Member * Time	-0.076	-0.335*
	(-0.157 , 0.005)	(-0.629 , -0.042)
Other * Time	-0.105	-0.358

	(-0.224 , 0.014)	(-0.794 , 0.078)
Ever Hypertension	0.185*	0.539
	(0.016 , 0.354)	(-0.061 , 1.139)
Ever Diabetes	0.130	0.641
	(-0.094 , 0.355)	(-0.146 , 1.428)
Ever Congestive Heart Failure	0.156	0.566
	(-0.154 , 0.467)	(-0.542 , 1.674)
Ever Stroke	0.281	0.962
	(-0.039 , 0.601)	(-0.182 , 2.106)
Ever Stroke * Time	-0.129	-0.442
	(-0.267 , 0.008)	(-0.934 , 0.051)
Ever Hypercholesterolemia	-0.155	-0.579
	(-0.323 , 0.014)	(-1.180 , 0.023)
Ever Psychiatric Problems	0.331**	1.395**
	(0.087 , 0.574)	(0.536 , 2.253)

Notes: NPI-Q = Neuropsychiatric Inventory Questionnaire severity score (scored

0 – 36). Higher scores indicate more severe behavioral/psychological symptoms.

* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

Appendix for Chapter 4

Table A4.1 Sample characteristics of individuals' included/excluded from analysis

Variable	Respondents included in out-of- analysis (n = 234)	Respondents with dementia excluded from analysis due to missing data (n = 74)	P-value
Mean cognition (SD), MMSE	16.06 (11.94)	15.67 (11.80)	0.855
Mean number functional limitations (SD)	6.18 (3.71)	6.78 (4.14)	0.243
Mean number of behavioral/psychological symptoms (SD)	2.63 (4.23)	2.32 (3.25)	0.460
Mean age (SD), *y*	84.12 (10.87)	84.36 (12.61)	0.889
Male, %	35.37	17.21	0.065
Non-Caucasian, %	18.88	24.13	0.651
Married, %	21.76	27.16	0.461
Mean number of chronic conditions	2.96 (2.67)	2.81 (2.03)	0.518

Notes. MMSE = Mini-Mental State Examination

Continuous variables were compared using two-sided Students t-test and categorical variables were compared using chi-square test. Data for those excluded from analyses are presented for those with data available on the variable of interest.

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┌─────────────────────────────────────────┐
│ 856   Aging Demographics and            │
│       Memory Study Participants          │
│       (Wave A Assessment)                │
└─────────────────────────────────────────┘
                    │
                    │
┌───────────────────────┐      │
│ 548  Excluded with     │ ◄────┤
│      Normal Cognition  │      │
└───────────────────────┘      │
                               ▼
        ┌──────────────────────────────────┐
        │ 308   Participants with Dementia  │
        └──────────────────────────────────┘
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┌──────────────────────────┐  │
│ 74   Excluded             │  │
│   40   Missing Data on    │  │
│        Covariates         │  │
│                           │  │
│   3    Medicare Data      │  │
│        Not Available      │ ◄┤
│                           │  │
│   31   Not Continually    │  │
│        Enrolled in Fee-   │  │
│        for-service        │  │
│        Medicare           │  │
└──────────────────────────┘  │
                               ▼
        ┌──────────────────────────────────┐
        │ 234   Included in Analyses        │
        └──────────────────────────────────┘
```
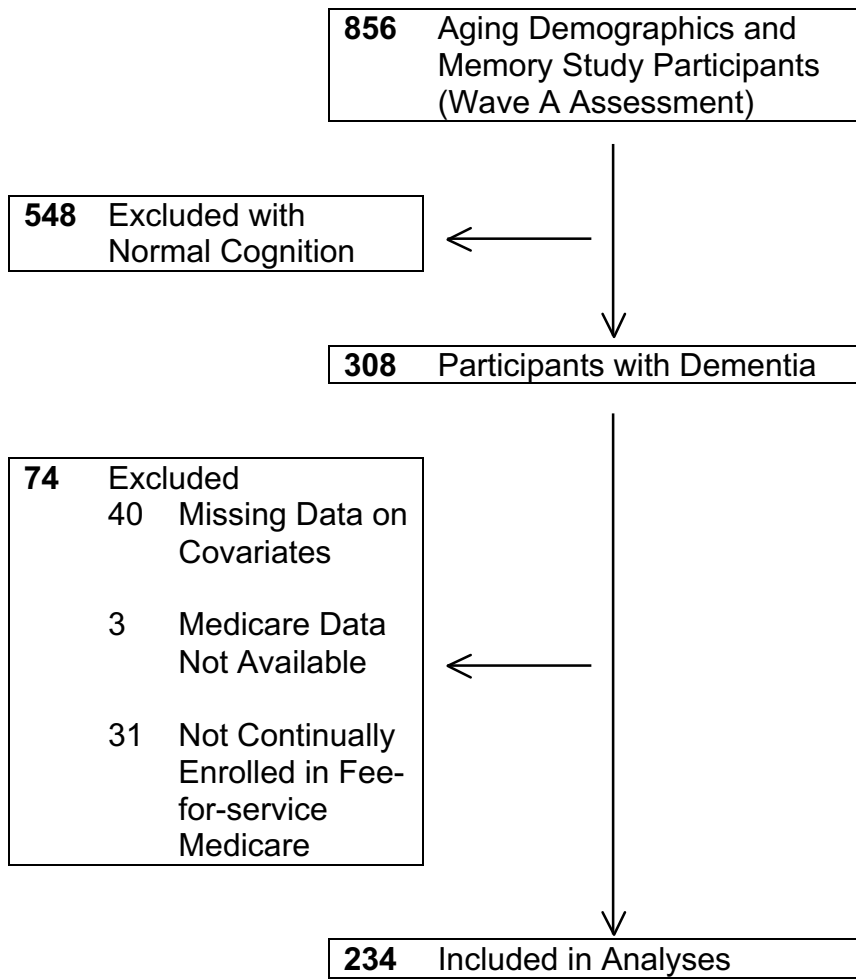
Figure A4.2 Analysis sample from Aging, Demographics, and Memory Study
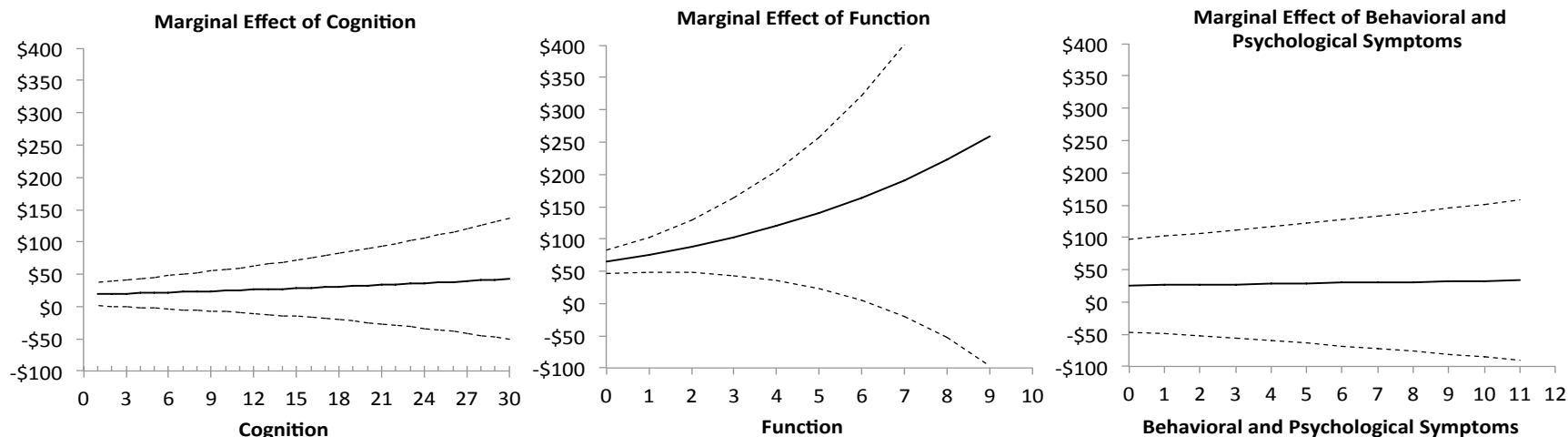
Figure A4.3 Marginal effects of clinical features on Medicare expenditures

Figure A4.3 Legend. Dashed lines represent 95% confidence interval. Marginal effects represent the change in Medicare expenditures associated with a change (1 point decline in cognition, or 1 point increase in function and behavioral/psychological symptoms) from better to poorer for each clinical feature. Higher cognitive scores indicate greater cognitive abilities. Higher functional scores indicate more functional limitations. Higher behavioral/psychological scores indicate more symptoms.
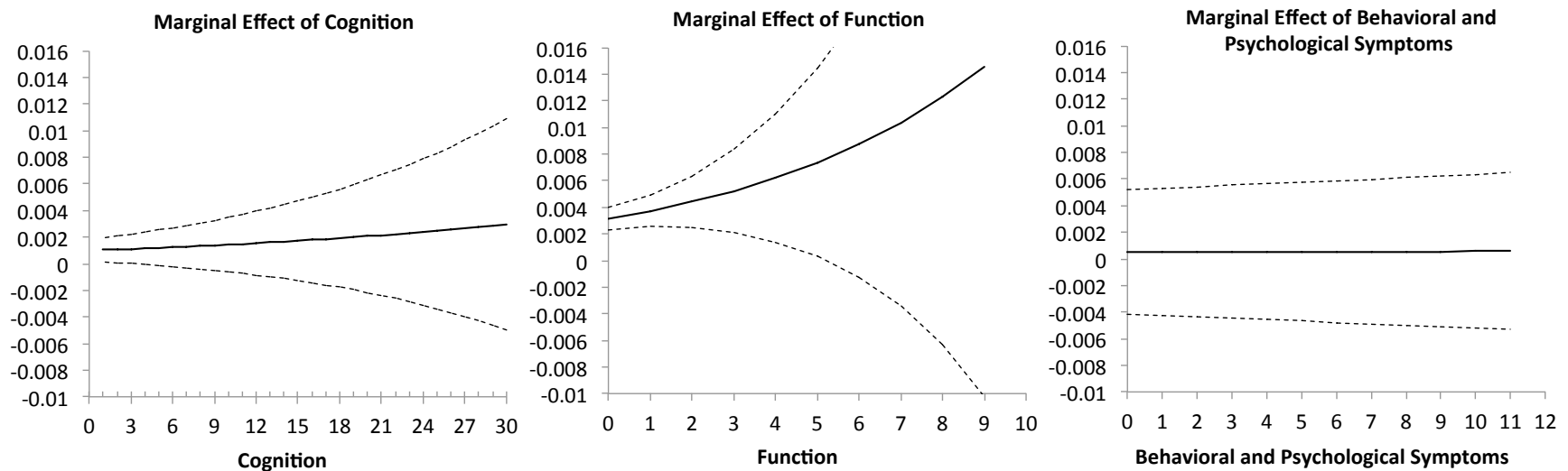
Figure A4.4 Marginal effects of clinical features on number of inpatient admissions

Figure A4.4 Legend. Dashed lines represent 95% confidence interval. Marginal effects represent the change in number of inpatient admission associated with a change (1 point decline in cognition, or 1 point increase in function and behavioral/psychological symptoms) from better to poorer for each clinical feature. Higher cognitive scores indicate greater cognitive abilities. Higher functional scores indicate more functional limitations. Higher behavioral/psychological scores indicate more symptoms.
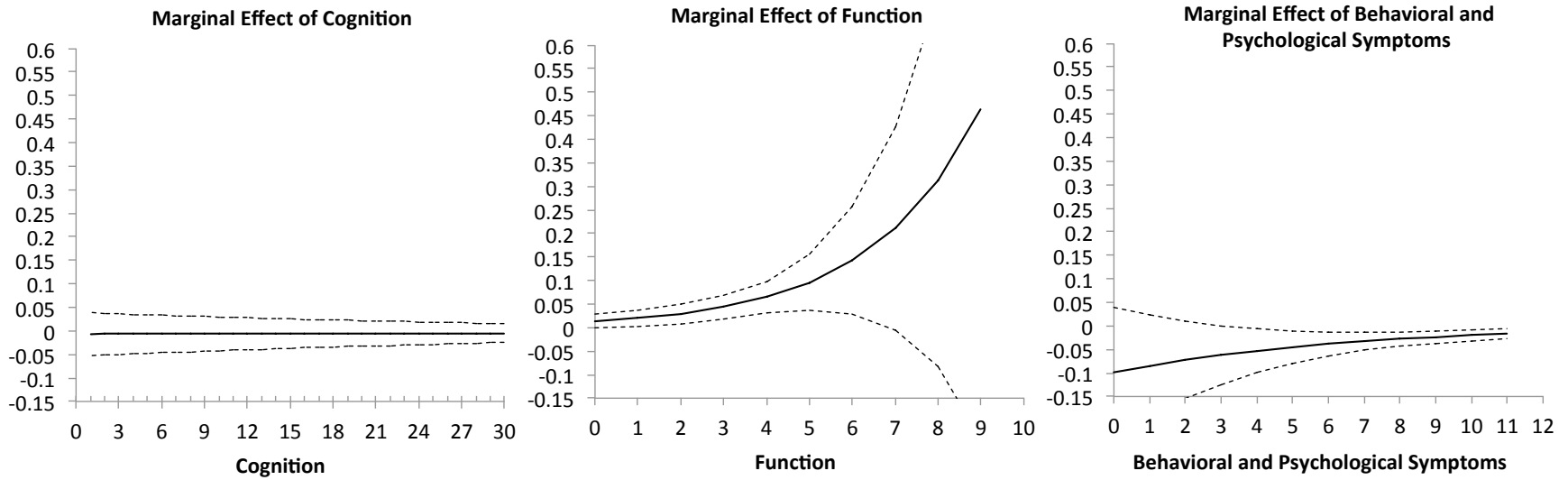
Figure A4.5 Marginal effects of clinical features on number of Medicare covered skilled nursing days

Figure A4.5 Legend. Dashed lines represent 95% confidence interval. Marginal effects represent the change in number of Medicare covered skilled nursing days associated with a change (1 point decline in cognition, or 1 point increase in function and behavioral/psychological symptoms) from better to poorer for each clinical feature. Higher cognitive scores indicate greater cognitive abilities. Higher functional scores indicate more functional limitations. Higher behavioral/psychological scores indicate more symptoms.
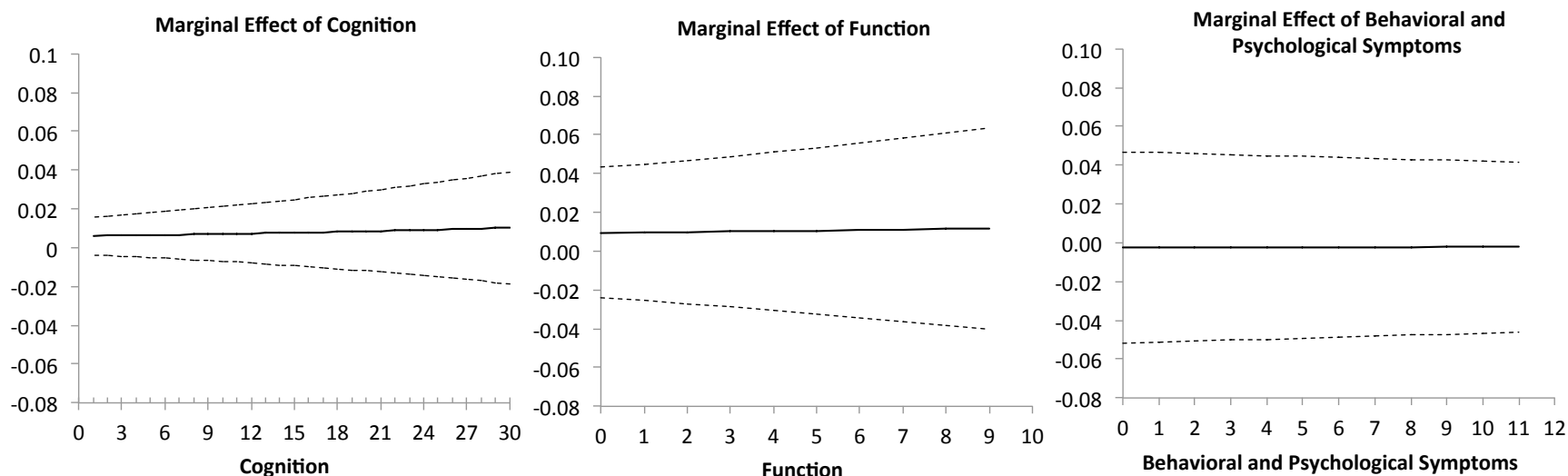
Figure A4.6 Marginal effects of clinical features on number of institutional outpatient visits

Figure A4.6 Legend*. Dashed lines represent 95% confidence interval. Marginal effects represent the change in institutional outpatient visits associated with a change (1 point decline in cognition, or 1 point increase in function and behavioral/psychological symptoms) from better to poorer for each clinical feature. Higher cognitive scores indicate greater cognitive abilities. Higher functional scores indicate more functional limitations. Higher behavioral/psychological scores indicate more symptoms.
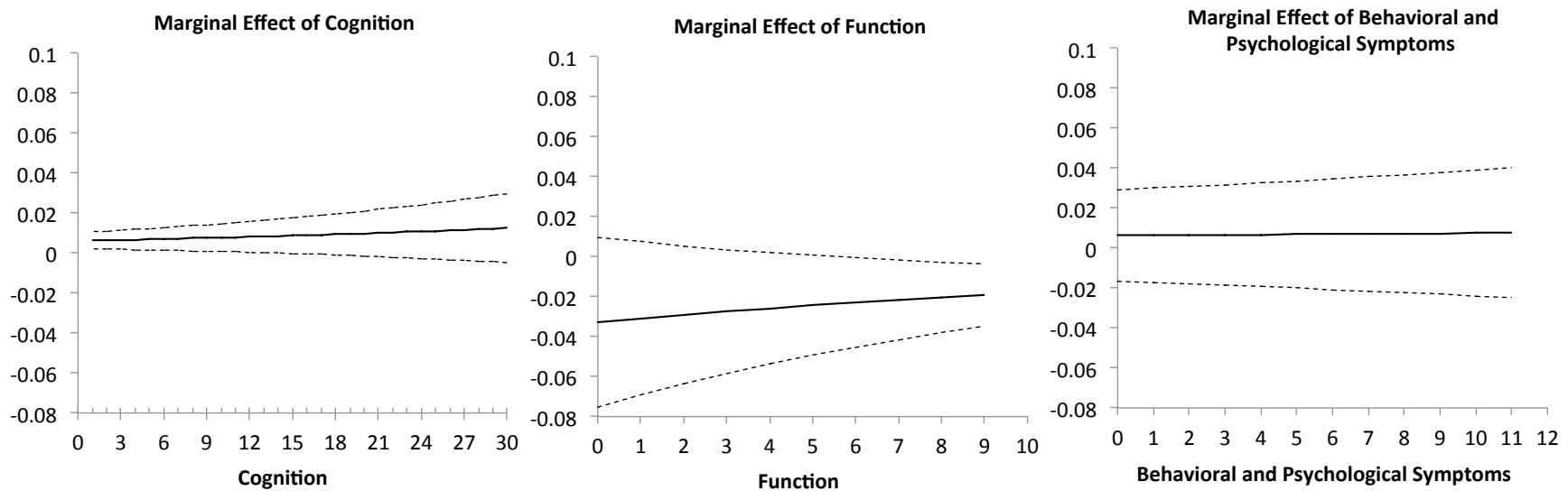
Figure A4.7 Marginal effects of clinical features on number of physician visits

Figure A4.7 Legend. Dashed lines represent 95% confidence interval. Marginal effects represent the change in number of physician visits (evaluation and management) associated with a change (1 point decline in cognition, or 1 point increase in measure of function and behavioral/psychological symptoms) from better to poorer for each clinical feature. Higher cognitive scores indicate greater cognitive abilities. Higher functional scores indicate more functional limitations. Higher behavioral/psychological scores indicate more symptoms.

Appendix for Chapter 5

Table A5.1 Data source of variables used in regression models

Variable	Data Source
Outcome Measures	
Out-of-pocket medical and nursing home expenditures	HRS
Time spent caregiving	ADAMS
Main Effects	
Mini-Mental State Examination	ADAMS
Number of functional limitations	ADAMS
Number of behavioral and psychological symptoms	ADAMS
Control Variables	
Age	ADAMS
Gender	ADAMS
Race	ADAMS
Marital status	ADAMS
Medicaid	HRS
Long-term care insurance	HRS
Supplemental insurance	HRS
Household income	HRS
Number of children	HRS
HRS-proxy respondent	HRS
Time between ADAMS and HRS assessment	ADAMS/HRS
Caregiver relationship	ADAMS
Caregiver live with person with dementia	ADAMS

Table A5.2 Baseline sample characteristics of individuals included/excluded from expenditure analysis

Variable	Linking ADAMS to nearest available HRS Wave			Linking ADAMS to following HRS Wave		
	All ADAMS respondents identified as having dementia (n = 308)	Respondents with dementia excluded from out-of-pocket spending analysis due to missing data (n = 93)	Respondents included in out-of-pocket spending analysis (n = 215)	All ADAMS respondents identified as having dementia (n = 308)	Respondents with dementia excluded from out-of-pocket spending analysis due to missing data (n = 123)	Respondents included in out-of-pocket spending analysis (n = 185)
Mean cognition (SD), MMSE	16.01 (11.11)	15.82 (12.68)	16.05 (10.54)	16.01 (11.11)	15.58 (12.77)	16.18 (10.42)
Mean number functional limitations (SD)	6.32 (3.53)	7.08 (3.27)	6.02 (3.49)*	6.32 (3.53)	6.81 (3.66)	6.04 (3.36)
Mean number of behaviors/psychological symptoms (SD)	2.56 (3.72)	2.24 (3.43)	2.68 (3.78)	2.56 (3.72)	2.29 (3.61)	2.71 (3.72)

Mean age (SD), *y*	84.18 (10.36)	86.09 (10.20)	83.42 (10.16)*	84.18 (10.36)	85.91 (10.21)	83.19 (10.07)*
Male, %	31.10	21.00	35.13	31.10	26.70	33.63
Non-Caucasian, %	20.11	21.50	19.57	20.11	20.37	19.97
Married, %	23.02	19.02	24.60	23.02	23.32	22.85
Long-term care insurance, %	3.32	4.99	2.72	5.30	9.11	4.60
Medicaid, %	30.50	40.90	27.31[†]	33.19	33.74	33.11
Supplemental Insurance (e.g., Medigap),%	26.68	31.84	24.86	20.72	9.85	22.48
Mean household income (SD), *$, in thousands*	20.58 (31.07)	18.73 (27.20)	21.30 (32.24)	20.86 (33.91)	18.52 (29.87)	21.37 (33.47)
Mean number of children (SD)	2.76 (4.30)	2.44 (3.62)	2.87 (4.47)	2.91 (4.59)	2.54 (3.24)	2.98 (4.60)
Mean number of comorbidities (SD)	2.92 (2.33)	2.93 (2.45)	2.92 (2.28)[†]	2.32 (2.87)	1.17 (2.95)	2.99 (2.21)*
Proxy respondent, %	46.88	44.84	47.69	35.02	15.62	46.13*

Mean months between ADAMS and HRS assessments (SD)	8.18 (6.36)	10.10 (8.88)	7.42 (4.63)*†	10.64 (8.99)	10.39 (9.12)	10.69 (8.69)
Mean monthly out-of-pocket medical expenditures (SD), $	231.21 (596.72)	329.76 (921.37)	192.39 (405.84)	273.00 (880.76)	540.88 (1522.37)	214.76 (625.46)*
Mean monthly out-of-pocket nursing home expenditures (SD), $	632.36 (2991.61)	649.77 (3130.09)	625.50 (2936.60)	681.85 (3042.08)	752.88 (2772.56)	666.50 (2990.44)

Notes: Two comparisons were made. First, we compared those included/excluded within the same linking method.

Second, we compared those included across linking methods. Continuous variables were compared using two-sided

Students t-test and categorical variables were compared using chi-square test.

*Indicates there is a statistically significant difference ($p < 0.05$) between those included/excluded from the analysis.

†Indicates there is a statistically significant difference ($p < 0.05$) between those included in the analysis based on sample

selection method.

Table A5.3 Baseline sample characteristics of individuals included/excluded from time caregiving analysis

Variable	Linking ADAMS to nearest available HRS Wave			Linking ADAMS to following HRS Wave		
	All ADAMS respondents identified as having dementia (n = 308)	Respondents with dementia excluded from time spent caregiving analysis due to missing data (n =177)	Respondents included in the time spent caregiving analysis (n = 131)	All ADAMS respondents identified as having dementia (n = 308)	Respondents with dementia excluded from time spent caregiving analysis due to missing data (n = 196)	Respondents included in the time spent caregiving analysis (n = 112)
Mean cognition (SD), MMSE	16.01 (11.11)	14.47 (11.13)	17.89 (9.96)*	16.01 (11.11)	14.63 (11.36)	18.17 (9.35)*
Mean number of functional limitations (SD)	6.32 (3.53)	6.88 (3.17)	5.48 (3.61)*	6.32 (3.53)	6.79 (3.31)	5.43 (3.47)*
Mean number of behaviors/psychological symptoms (SD)	2.56 (3.72)	2.68 (3.58)	2.40 (3.88)	2.56 (3.72)	2.68 (3.70)	2.36 (3.71)
Mean age (SD), y	84.18 (10.36)	84.72 (10.42)	83.36 (10.08)*	84.18	84.77 (10.46)	83.06 (9.88)*

				(10.36)		
Male, %	31.10	26.36	38.22	31.10	28.73	35.58
Non-Caucasian, %	20.11	21.80	17.57	20.11	21.09	18.26
Married, %	23.02	18.48	29.84	23.02	21.58	25.74
Long-term care insurance, %	3.32	2.88	3.94	5.30	1.57	9.67*
Medicaid, %	30.50	36.00	23.00	33.19	38.15	27.61
Supplemental Insurance (e.g., Medigap),%	26.68	26.80	26.51	20.72	17.18	24.86
Mean household income (SD), *$, in thousands*	20.58 (31.07)	18.52 (28.40)	23.67 (34.34)*	20.86 (33.91)	17.97 (26.16)	24.42 (40.42)*
Mean number of children (SD)	2.76 (4.30)	2.53 (4.60)	3.07 (3.70)	2.91 (4.59)	2.80 (5.08)	3.03 (3.63)
Mean number of comorbidities (SD)	2.92 (2.33)	3.10 (2.40)	2.66 (2.13)	2.32 (2.87)	2.09 (3.08)	2.78 (2.18)*
Proxy respondent, %	46.88	54.61	35.27	35.02	34.71	35.60
Mean months between	8.18 (6.36)	8.58 (6.60)	7.57 (5.76)[†]	10.64 (8.99)	10.01 (8.08)	11.43 (9.63)

ADAMS and HRS assessments (SD)						
Mean time providing any caregiving (SD)	125.63 (305.86)	112.06 (274.66)	138.99 (322.31)	125.63 (305.86)	122.93 (294.20)	129.12 (307.37)
Caregiver Characteristics						
Relationship						
Spouse, %	19.67	13.87	26.88*	19.67	16.12	25.30*
Child, %	48.90	42.81	56.45	48.90	42.39	59.22
Other, %	31.42	43.32	16.67	31.42	41.48	15.48
Live with person with dementia, %	42.64	26.42	60.36*	42.64	30.80	58.70*

Notes: Two comparisons were made. First, we compared those included/excluded within the same linking method.

Second, we compared those included across linking methods. Continuous variables were compared using two-sided

Students t-test and categorical variables were compared using chi-square test.

*Indicates there is a statistically significant difference (p < 0.05) between those included/excluded from the analysis.

[†]Indicates there is a statistically significant difference (p < 0.05) between those included in the analysis based on sample

selection method.

Table A5.4 Comparison between Functional Activities Questionnaire and investigator modified version of Functional

Activities Questionnaire

Functional Activities Questionnaire		Investigator modified version of Functional Activities Questionnaire based on survey items in Aging, Demographics, and Memory Study	
Question Stem: "In the past four weeks, did the subject have any difficulty or need help with"	Response	Question Stem:	Response (Coded: 0 = no limitation; 1 = limitation
1. Writing checks, paying bills, or balancing a checkbook.	Normal; Has difficulty, but does by self; Requires assistance; Dependent	1. Rate her/his ability to handle small sums of money (e.g. making change, leaving a small tip, shopping)	No loss (0); Some loss (1); Severe loss (1)
2. Assembling tax records, business affairs, or other papers.		2. Rate her/his ability to handle complicated financial or business transactions (e.g., balancing a checkbook, paying bills, doing banking, handling investment)	No loss (0); Some loss (1); Severe loss (1)
3. Shopping alone for clothes, household necessities, or		3. Is (s/he) able to independently shop for her/his needs?	Usually (0); Sometimes (1); Rarely (1)

groceries.			
4. Playing a game of skill such as bridge or chess, working on a hobby.		4. Does (s/he) have more difficulty than in the past performing her/his hobbies? Hobbies may include things like sewing, painting, handicrafts, reading, entertaining, photography, gardening, going to theater or symphony, woodworking, participating in sports.	No (0); Little (1); Some (1); Much (1)
5. Heating water, making a cup of coffee, turning off the stove.		5. First, does (s/he) have more difficulty than in the past carrying out routine household tasks, such as cooking, cleaning, laundry, taking out garbage, yard work, simple maintenance and home repair?	No (0); Little (1); Some (1); Much (1)
6. Preparing a balanced meal.		6. Does (s/he) have difficulty with feeding her/himself?	No (0); Yes (1)
7. Keeping track of current events.		7. Rate subject's LOSS of ability to: Recall recent events	None (0); Some (1); Severe (1)
8. Paying attention to and		8. Does (s/he) seem less able to	No (0); Little less (1);

		understand what (s/he) reads? **Or** Does (s/he) seem less able to understand what (s/he) sees on TV?	Much less (1)
9. Remembering appointments, family occasions, holidays, medications.		9. Compared with two years ago, how is your friend or relative at remembering things about family and friends, such as occupations, birthdays and addresses?	Much better (0); A bit better (0); Not much change (0); A bit worse (1); Much worse (1)
10. Traveling out of the neighborhood, driving, or arranging to take public transportation.		10. Let(s talk about her/his ability to find her/his way around places. Does (s/he) have more difficulty than in the past with finding his/her way around familiar streets outside the neighborhood?	No (0); Yes (1)

Table A5.5 Regression coefficients from two-part model for average monthly out-of-pocket health care expenditures

(excluding nursing home expenditures)

	Logistic Regression – Any out of pocket expenditures (n = 215)		Generalized Linear Model (log link gamma distribution) – Positive expenditures (n = 155)	
	Unadjusted	Adjusted	Unadjusted	Adjusted
Intercept	-0.19	-6.35	4.05	6.75
	(-2.09 , 1.70)	(-14.46 , 1.77)	(3.19 , 4.91)	(3.71 , 9.80)
Cognition	0.13	0.06	0.05	0.04
	(0.04 , 0.22)	(-0.02 , 0.14)	(0.02 , 0.08)	(0.01 , 0.06)
Function	0.02	-0.04	0.09	0.10
	(-0.19 , 0.23)	(-0.39 , 0.31)	(0.01 , 0.16)	(0.01 , 0.18)
Behavioral/psychological symptoms	-0.18	-0.22	0.03	0.02
	(-0.38 , 0.03)	(-0.47 , 0.03)	(-0.07 , 0.12)	(-0.06 , 0.09)
Age		0.09		-0.03
		(-0.01 , 0.19)		(-0.06 , 0.01)
Male		0.22		-0.15
		(-0.70 , 1.14)		(-0.50 , 0.20)
Non-Caucasian (ref = white)		1.23		-0.30

		(0.01 , 2.45)		(-0.75 , 0.16)
Married (ref = not married)		0.26		-0.45
		(-0.45 , 0.98)		(-0.91 , 0.01)
Medicaid (ref = no)		-2.11		-0.09
		(-3.21 , -1.01)		(-0.48 , 0.30)
Supplemental insurance (ref = no)		1.17		0.13
		(-0.26 , 2.60)		(-0.29 , 0.55)
Household income (per $1,000)		0.02		0.01
		(-0.03 , 0.06)		(0.00 , 0.02)
Number of children		-0.17		0.03
		(-0.36 , 0.03)		(-0.07 , 0.14)
Number of comorbidities		0.37		0.02
		(0.09 , 0.64)		(-0.08 , 0.12)
Proxy Respondent (ref = no)		-0.76		-0.21
		(-1.89 , 0.37)		(-0.62 , 0.21)
Time between ADAMS and following HRS assessment		0.00		0.00
		(-0.01 , 0.00)		(-0.00 , 0.00)

Table A5.6 Regression coefficients from two-part model for average monthly out-of-pocket nursing home expenditures

	Logistic Regression – Any out of pocket nursing home expenditures (n = 215)		Generalized Linear Model (log link gamma distribution) – Positive expenditures (n = 43)	
	Unadjusted	Adjusted	Unadjusted	Adjusted
Intercept	-2.54	0.23	6.20	9.45
	(-5.48 , 0.40)	(-6.75 , 7.22)	(2.13 , 10.26)	(3.90 , 15.01)
Cognition	-0.07	-0.08	-0.01	-0.03
	(-0.15 , 0.02)	(-0.21 , 0.05)	(-0.10 , 0.09)	(-0.11 , 0.05)
Function	0.40	0.36	0.29	-0.13
	(0.08 , 0.72)	(0.05 , 0.67)	(-0.29 , 0.88)	(-0.88 , 0.61)
Behavioral/psychological symptoms	-0.05	-0.11	-0.15	0.00
	(-0.24 , 0.13)	(-0.31 , 0.09)	(-0.56 , 0.25)	(-0.38 , 0.38)
Age		-0.03		
		(-0.10 , 0.04)		
Male		0.54		
		(-0.55 , 1.62)		
Non-Caucasian (ref = white)		-1.67		
		(-2.89 , -0.45)		

Married (ref = not married)		-1.74		
		(-3.12 , -0.36)		
Medicaid (ref = no)		-0.87		-1.91
		(-2.14 , 0.39)		(-3.36 , -0.45)
Long-term care insurance (ref = no)		-0.37		-3.45
		(-2.67 , 1.92)		(-5.33 , -1.58)
Supplemental insurance (ref = no)		-0.71		
		(-1.61 , 0.19)		
Household income (per $1,000)		0.02		
		(0.00 , 0.03)		
Number of children		0.04		
		(-0.14 , 0.21)		
Number of comorbidities		0.17		
		(-0.20 , 0.54)		
Proxy Respondent (ref = no)		0.82		
		(-0.74 , 2.39)		
Time between ADAMS and following HRS assessment		0.00		
		(-0.01 , 0.00)		

Table A5.7 Regression coefficients from two-part model for average monthly time spent providing active help

	Logistic regression – any time providing active help (n = 129)		Generalized Linear Model (log link gamma distribution) – positive time providing active help (n = 86)	
	Unadjusted	Adjusted	Unadjusted	Adjusted
Intercept	-1.51	-8.46	4.74	1.54
	(-5.37 , 2.35)	(-17.89 , 0.97)	(2.95 , 6.52)	(-0.79 , 3.87)
Cognition	-0.05	-0.02	-0.03	-0.03
	(-0.21 , 0.11)	(-0.20 , 0.16)	(-0.08 , 0.03)	(-0.08 , 0.01)
Function	0.30	0.45	0.17	0.19
	(-0.04 , 0.65)	(0.03 , 0.87)	(-0.01 , 0.35)	(0.06 , 0.32)
Behavioral/psychological symptoms	0.33	0.37	-0.04	-0.02
	(0.08 , 0.58)	(0.15 , 0.60)	(-0.11 , 0.02)	(-0.10 , 0.07)
Age		0.03		0.03
		(-0.06 , 0.11)		(-0.01 , 0.06)
Male		-0.66		
		(-1.89 , 0.56)		
Non-Caucasian (ref = white)		0.32		

		(-1.30 , 1.94)		
Medicaid (ref = no)		-0.93		0.37
		(-2.59 , 0.72)		(-0.11 , 0.86)
Household income (per $1,000)		0.00		
		(-0.02 , 0.02)		
Number of children		-0.01		
		(-0.23 , 0.21)		
Number of comorbidities		0.44		0.02
		(-0.01 , 0.89)		(-0.11 , 0.14)
Caregiver relationship (ref = spouse)				
Child		1.81		-0.08
		(-0.25 , 3.86)		(-0.85 , 0.68)
Other		2.78		0.02
		(0.29 , 5.27)		(-0.78 , 0.83)
Caregiver live with person with dementia (ref = does not live with person)		1.78		1.04
		(-0.18 , 3.74)		(0.52 , 1.56)

Table A5.8 Regression coefficients from two-part model for average monthly time spent providing supervision

	Logistic regression – any time providing supervision (n = 124)		Generalized Linear Model (log link gamma distribution) – positive time providing supervision (n = 80)	
	Unadjusted	Adjusted	Unadjusted	Adjusted
Intercept	-0.59	-5.79	3.97	1.55
	(-4.11 , 2.93)	(-17.36 , 5.78)	(2.14 , 5.79)	(-1.10 , 4.21)
Cognition	-0.10	-0.07	0.00	-0.01
	(-0.25 , 0.04)	(-0.25 , 0.12)	(-0.05 , 0.05)	(-0.06 , 0.04)
Function	0.30	0.52	0.24	0.27
	(-0.06 , 0.66)	(0.12 , 0.91)	(0.06 , 0.41)	(0.19 , 0.36)
Behavioral/psychological symptoms	0.28	0.34	-0.04	-0.01
	(0.01 , 0.55)	(0.01 , 0.66)	(-0.12 , 0.04)	(-0.10 , 0.08)
Age		0.01		0.02
		(-0.10 , 0.12)		(-0.01 , 0.05)
Male		0.02		
		(-1.50 , 1.54)		
Non-Caucasian (ref = white)		1.13		
		(-0.39 , 2.64)		

Medicaid (ref = no)		-0.33		0.41
		(-1.94 , 1.28)		(-0.01 , 0.82)
Household income (per $1,000)		-0.01		
		(-0.05 , 0.02)		
Number of children		-0.24		
		(-0.56 , 0.08)		
Number of comorbidities		0.60		0.01
		(0.04 , 1.16)		(-0.09 , 0.11)
Caregiver relationship (ref = spouse)				
Child		1.00		-0.43
		(-0.95 , 2.94)		(-0.94 , 0.08)
Other		1.21		-0.24
		(-0.90 , 3.31)		(-0.71 , 0.24)
Caregiver live with person with dementia (ref = does not live with person)		1.44		1.07
		(-0.07 , 2.95)		(0.57 , 1.56)

Table A5.9 Regression coefficients from two-part model for average monthly time spent providing any caregiving

	Logistic regression – any time providing any caregiving (n = 131)		Generalized Linear Model (log link gamma distribution) – positive time providing any caregiving (n = 91)	
	Unadjusted	Adjusted	Unadjusted	Adjusted
Intercept	-0.70	-5.44	5.31	2.53
	(-4.46 , 3.06)	(-16.14 , 5.25)	(3.86 , 6.75)	(0.28 , 4.79)
Cognition	-0.08	-0.05	-0.03	-0.03
	(-0.24 , 0.09)	(-0.23 , 0.14)	(-0.08 , 0.02)	(-0.08 , 0.01)
Function	0.29	0.44	0.12	0.15
	(-0.05 , 0.63)	(0.03 , 0.84)	(-0.01 , 0.25)	(0.06 , 0.24)
Behavioral/psychological symptoms	0.28	0.30	-0.01	0.01
	(0.02 , 0.54)	(0.03 , 0.57)	(-0.07 , 0.05)	(-0.08 , 0.09)
Age		0.01		0.02
		(-0.09 , 0.11)		(-0.00 , 0.05)
Male		-0.42		
		(-1.86 , 1.02)		
Non-Caucasian (ref = white)		0.98		
		(-0.50 , 2.46)		

Medicaid (ref = no)		-0.71		0.43
		(-2.32 , 0.90)		(0.07 , 0.79)
Household income (per $1,000)		0.00		
		(-0.04 , 0.03)		
Number of children		-0.09		
		(-0.44 , 0.25)		
Number of comorbidities		0.49		0.04
		(-0.03 , 1.00)		(-0.05, 0.13)
Caregiver relationship (ref = spouse)				
Child		1.12		-0.05
		(-0.81 , 3.05)		(-0.62 , 0.53)
Other		1.75		-0.07
		(-0.07 , 3.58)		(-0.79 , 0.65)
Caregiver live with person with dementia (ref = does not live with person)		1.57		0.83
		(-0.16 , 3.29)		(0.38 , 1.28)

Appendix for Chapter 6

Table A6.1 Baseline demographic characteristics

	Estimate	Source[1]
Characteristics of person with dementia		
Mean age of dementia onset (SD), *y*	83.67 (5.26)	ADAMS
Male, *%*	33.00	ADAMS
Mean education[2] (SD), *y*	10.87 (4.16)	ADAMS
Race, *%*		
White	85.00	NACC-UDS
African American	9.00	NACC-UDS
Other	6.00	NACC-UDS
Marital Status, *%*		
Married	34.00	ADAMS
Widowed	55.00	ADAMS
Other	11.00	ADAMS
Region of residence, *%*		
Northeast	30.00	NACC-UDS
South	10.00	NACC-UDS
West	46.00	NACC-UDS
Midwest	14.00	NACC-UDS
Long-term care insurance, *%*	19.00	ADAMS
Medicaid[3], *%*	15.00	ADAMS
Mean household income[4] (SD), *$*	30,827 (28,008)	ADAMS
Mean number of children[5] (SD)	3.12 (1.81)	ADAMS
Comorbidities, *%*		
Hypertension	68.00	NACC-UDS
Diabetes	16.00	NACC-UDS
Congestive heart failure	7.00	NACC-UDS
Stroke	11.00	NACC-UDS
Hypercholesterolemia	66.00	NACC-UDS
Psychiatric problems	11.00	NACC-UDS

Characteristics of caregiver		
Caregiver relationship to person with dementia[6], %		
Child	53.00	ADAMS
Other family	19.00	ADAMS
Other	28.00	ADAMS
Caregiver lives with person with dementia[7], %	39.00	ADAMS
Model specific parameters[8]		
Proxy-respondent, %	9.00	ADMAS
Mean number of days between ADAMS and HRS assessment (SD)	186.33 (130.37)	ADAMS

Abbreviations: ADAMS = Aging, Demographics, and Memory Study; NACC = National Alzheimer's Coordinating Center Uniform Data Set; HRS = Health and Retirement Study.

[1]ADAMS survey weights were used.

[2]Number of years of education was bound between 5 and 18 years.

[3]Medicaid status at time of diagnosis. The probability of transitioning to Medicaid was modeled as a separate risk (Table 1).

[4]For individuals on Medicaid mean household income was $9,452 (SD = 4,500)

[5]We assumed the maximum number of kids per family was 5. The model rounded the predicted number of kids to the nearest integer.

[6]In the model, if a person with dementia was predicted to be married we assumed the spouse was the primary caregiver. The percentages represent the conditional proportions assuming the person with dementia is not married.

[7]In the model, if a person with dementia was predicted to be married we assumed they lived with someone. The percentage represent the conditional proportion assuming the person with dementia is not married.

[8]The regression equations predicting out-of-pocket expenditures controlled for if a proxy-respondent provided answers to survey questions and the time between the core HRS survey and ADAMS survey.

Table A6.2 Functional domains

Functional Domains
1. Writing checks, paying bills, or balancing a checkbook
2. Assembling tax records, business affairs, or other papers
3. Shopping alone for clothes, household necessities, or groceries
4. Playing a game of skill such as bridge or chess, working on a hobby
5. Heating water, making a cup of coffee, turning off the stove
6. Preparing a balanced meal
7. Keeping track of current events
8. Paying attention to and understanding a TV program, book, or magazine
9. Remembering appointments, family occasions, holidays, or medications
10. Traveling out of the neighborhood, driving or arranging to take public transportation

Notes: Measure of function is scored from 0-10 with high scores indicating more limitations. If a limitation is present for a given domain than an individual receives a score of 1 otherwise they receive a score of 0.

Table A6.3 Behavioral/psychological symptom domains

Behavioral Psychological Symptoms of Dementia Domains
1. Delusions
2. Hallucinations
3. Agitation or aggression
4. Depression or dysphoria
5. Anxiety
6. Elation or euphoria
7. Apathy or indifference
8. Disinhibition
9. Irritability or lability
10. Motor disturbance
11. Nighttime behaviors
12. Changes in appetite and eating

Notes: Domains are based on Neuropsychiatric Inventory Questionnaire version Q. The measure of behavioral/psychological symptoms is scored from 0-12 with high scores indicating more symptoms. If a behavior is present for a given domain than an individual receives a score of 1 otherwise they receive a score of 0.

Table A6.4 Linear mixed effects regression model coefficients for cognitive trajectories

Variable	Coefficient (95% Confidence Interval)
Intercept	20.328
	(15.849 , 24.807)
Time	-0.321
	(-0.504 , -0.137)
Time^2	-0.001
	(-0.001 , -0.001)
Age of Onset (Years)	0.001
	(-0.046 , 0.048)
Age of Onset (Years) * Time	0.003
	(0.001 , 0.005)
Male	0.231
	(-0.366 , 0.827)
Years of Education	0.236
	(0.141 , 0.331)
Race (ref = White)	
African American	-1.629
	(-2.640 , -0.618)
Other	-0.274
	(-1.558 , 1.010)
Marital Status (ref = Widowed)	
Married	-0.582
	(-1.241 , 0.077)
Other	-0.039
	(-1.070 , 0.991)

Region of Residence (ref = Northeast)	
South	0.025
	(-1.245 , 1.294)
West	-1.192
	(-2.015 , -0.368)
Midwest	1.197
	(0.166 , 2.228)
Not Specified	-0.192
	(-0.971 , 0.587)
Region of Residence (ref = Northeast) * Time	
South	-0.029
	(-0.092 , 0.034)
West	-0.061
	(-0.103 , -0.021)
Midwest	0.007
	(-0.043 , 0.057)
Not Specified	-0.023
	(-0.061 , 0.015)
Community-dwelling in Previous Time Period (ref = Facility)	0.474
	(-0.393 , 1.341)
Hypertension at Diagnosis	0.418
	(-0.193 , 1.029)
Hypertension at Diagnosis * Time	0.031
	(0.002 , 0.060)
Diabetes at Diagnosis	-0.216
	(-1.030 , 0.597)
Congestive Heart Failure at Diagnosis	0.207

	(-0.923 , 1.337)
Congestive Heart Failure at Diagnosis * Time	0.058
	(0.003 , 0.114)
Stroke at Diagnosis	-0.315
	(-1.145 , 0.515)
Hypercholesterolemia at Diagnosis	0.249
	(-0.362 , 0.861)
Psychiatric Problems at Diagnosis	0.794
	(-0.086 , 1.674)

Notes: Model is estimated using data from the National Alzheimer's Coordinating Center Uniform Data Set. Cognition is evaluated using the Mini-mental State Exam (scored 0 – 30). Coefficients were used to predict monthly change in cognition. Higher scores indicate greater cognitive abilities. Model is based on Jutkowitz, E, et al. "Risk Factors Associated with Cognitive, Functional, and Behavioral Trajectories of Newly Diagnosed Dementia Patients." The Journals of Gerontology Series A: Biological Sciences and Medical Sciences (2016).

Table A6.5 Linear mixed effects regression model coefficients functional

trajectories

Variable	Coefficient
	(95% Confidence Interval)
Intercept	12.031
	(8.588 , 15.475)
Time	0.056
	(0.008 , 0.104)
Time2	-0.001
	(-0.001 , -0.001)
Cognitive Status	-0.176
	(-0.223 , -0.129)
Cognitive Status * Time	0.000
	(-0.001 , 0.001)
Age of Onset (Years)	-0.010
	(-0.043 , 0.023)
Male	-0.791
	(-1.220 , -0.362)
Years of Education	-0.051
	(-0.133 , 0.031)
Years of Education * Time	0.002
	(0.000 , 0.004)
Race (ref = White)	
African American	-1.067
	(-1.768 , -0.365)
Other	-0.062
	(-0.948 , 0.823)
Marital Status (ref = Widowed)	

Married	-0.642
	(-1.189 , -0.095)
Other	-0.150
	(-0.870 , 0.569)
Region of Residence (ref = Northeast)	
South	-0.194
	(-1.070 , 0.682)
West	0.537
	(-0.032 , 1.107)
Midwest	-0.937
	(-1.640 , -0.234)
Not Specified	-0.182
	(-0.712 , 0.348)
Community-dwelling in Previous Time Period (ref = Facility)	-1.287
	(-2.261 , -0.314)
Community-dwelling in Previous Time Period (ref = Facility) * Time	0.027
	(0.002 , 0.051)
Informant Relationship (ref = Spouse)	
Other Family Member	-0.479
	(-0.983 , 0.025)
Other	-0.637
	(-1.336 , 0.063)
Hypertension at Diagnosis	-0.029
	(-0.452 , 0.393)
Diabetes at Diagnosis	0.261
	(-0.432 , 0.955)
Diabetes at Diagnosis * Time	-0.014

	(-0.031 , 0.003)
Congestive Heart Failure at Diagnosis	0.060
	(-0.719 , 0.838)
Stroke at Diagnosis	0.895
	(0.333 , 1.456)
Hypercholesterolemia at Diagnosis	-0.456
	(-0.884 , -0.029)
Psychiatric Problems at Diagnosis	-0.210
	(-0.820 , 0.401)

Notes: Data for the model is from the National Alzheimer's Coordinating Center
Uniform Data Set. Function is evaluated as the number of functional limitations
(scored 0 – 10). Coefficients were used to predict monthly change in function.
Higher scores indicate more functional limitations. Model is based on Jutkowitz,
E, et al. "Risk Factors Associated with Cognitive, Functional, and Behavioral
Trajectories of Newly Diagnosed Dementia Patients." The Journals of
Gerontology Series A: Biological Sciences and Medical Sciences (2016).

Table A6.6 Linear mixed effects regression model coefficients behavioral and

psychological symptoms trajectories

Variable	Coefficient (95% Confidence Interval)
Intercept	6.722
	(3.910 , 9.534)
Time	0.048
	(0.017 , 0.079)
Time2	0.000
	(0.000 , 0.000)
Cognitive Status	-0.044
	(-0.084 , -0.004)
Cognitive Status * Time	-0.001
	(-0.002 , 0.000)
Age of Onset (Years)	-0.048
	(-0.076 , -0.019)
Male	0.101
	(-0.307 , 0.510)
Male * Time	-0.014
	(-0.027 , -0.001)
Years of Education	-0.015
	(-0.072 , 0.042)
Race (ref = White)	
African American	-0.336
	(-0.936 , 0.264)
Other	-0.045
	(-0.808 , 0.718)
Marital Status (ref = Widowed)	

Married	0.123
	(-0.365 , 0.612)
Other	0.661
	(0.031 , 1.291)
Region of Residence (ref = Northeast)	
South	1.128
	(0.378 , 1.879)
West	0.342
	(-0.148 , 0.832)
Midwest	0.282
	(-0.328 , 0.892)
Not Specified	0.654
	(0.194 , 1.114)
Community-dwelling in Previous Time Period (ref = Facility)	0.382
	(-0.120 , 0.885)
Informant Relationship (ref = Spouse)	
Other Family Member	-0.053
	(-0.552 , 0.445)
Other	-0.273
	(-1.019 , 0.474)
Informant Relationship (ref = Spouse) * Time	
Other Family Member	-0.009
	(-0.023 , 0.004)
Other	-0.015
	(-0.034 , 0.004)
Hypertension at Diagnosis	0.332
	(-0.031 , 0.695)

Diabetes at Diagnosis	0.402
	(-0.081 , 0.885)
Congestive Heart Failure at Diagnosis	0.380
	(-0.288 , 1.047)
Stroke at Diagnosis	0.475
	(-0.199 , 1.149)
Stroke at Diagnosis * Time	-0.017
	(-0.038 , 0.004)
Hypercholesterolemia at Diagnosis	-0.406
	(-0.769 , -0.043)
Psychiatric Problems at Diagnosis	0.832
	(0.307 , 1.356)

Notes: Data for the model is from the National Alzheimer's Coordinating Center Uniform Data Set. Behavior and psychological symptoms is evaluated as number of symptoms (scored 0 – 12). Coefficients were used to predict monthly change in behavioral and psychological symptoms. Higher scores indicate more symptoms. Model is based on Jutkowitz, E, et al. "Risk Factors Associated with Cognitive, Functional, and Behavioral Trajectories of Newly Diagnosed Dementia Patients." The Journals of Gerontology Series A: Biological Sciences and Medical Sciences (2016).

Table A6.7 Weibull model regression coefficients for time to long-term care

facility placement

Variable	Coefficient (95% Confidence Interval)
Intercept	-10.32
	(-11.62 , -9.02)
Cognitive Status in Previous Time Period	-0.03
	(-0.04 , -0.02)
Functional Limitations in Previous Time Period	0.08
	(0.05 , 0.11)
Behavioral and Psychological Symptoms in Previous Time Period	0.09
	(0.06 , 0.12)
Live With Someone Alone (ref = Lives Alone)	-1.06
	(-1.24 , -0.87)
Age of Onset (Years)	0.02
	(0.01 , 0.04)
Male	-0.19
	(-0.36 , -0.03)
Years of Education	0.05
	(0.03 , 0.07)
Race (ref = White)	
African American	-0.59
	(-0.88 , -0.30)
Other	-0.52

	(-0.90 , -0.14)
Region of Residence (ref = Northeast)	
South	0.12
	(-0.32 , 0.56)
West	0.78
	(0.56 - 1.00)
Midwest	0.60
	(0.27 , 0.93)
Not Specified	0.45
	(0.23 , 0.67)
Hypertension at Diagnosis	-0.06
	(-0.22 , 0.10)
Diabetes at Diagnosis	0.00
	(-0.22 , 0.22)
Congestive Heart Failure at Diagnosis	0.16
	(-0.15 , 0.48)
Stroke at Diagnosis	-0.13
	(-0.39 , 0.13)
Hypercholesterolemia at Diagnosis	-0.11
	(-0.28 , 0.05)
Psychiatric Problems at Diagnosis	0.24
	(0.01 , 0.47)
Weibull shape parameter	1.80
	(1.72 , 1.88)

Notes: Data for the model is from the National Alzheimer's Coordinating Center

Uniform Data Set. Coefficients were used to predict monthly risk of entering a

long-term care facility.

Table A6.8 Two-part model regression coefficients for time spent receiving

formal caregiving

Variable	Logistic Regression – Probability of Receiving Formal Caregiving	Generalized Linear Model (log link gamma distribution) – Amount of Formal Caregiving Received
Intercept	-14.05	3.74
	(-29.21 , 1.12)	(-1.20 , 0.07)
Cognition	0.065	-0.01
	(-0.02 , 0.15)	(-0.08 , 0.07)
Function	0.29	0.20
	(-0.09 , 0.68)	(0.47 , 0.87)
Behavioral and Psychological Symptoms	-0.05	0.15
	(-0.21 , 0.11)	(-0.01 , 0.30)
Age	0.09	
	(-0.07 , 0.25)	
Male	0.13	
	(-1.46 , 1.72)	
Non-Caucasian (ref = white)	0.52	
	(-0.46 , 1.50)	
Medicaid (ref = no)	1.68	
	(0.61 , 2.74)	
Household income (per $10,000)	0.12	
	(-0.13 , 0.36)	
Number of children	0.00	
	(-0.18 , 0.17)	

Number of comorbidities	-0.24	
	(-1.07 , 0.59)	
Caregiver live with person with dementia (ref = does not live with person)	-0.53	
	(-1.86 , 0.80)	

Data for this model is from the Health and Retirement Study and Aging, Demographics and Memory Study subsample. Coefficients were used to predict hours of formal caregiving received in a month. Regression model used to predict time caregiving and out-of-pocket medical expenditures is published in Jutkowitz, E, et al. "Effects of cognition, function, and behavioral and psychological symptoms on out-of-pocket medical and nursing home expenditures and time spent caregiving for persons with dementia." Alzheimer's & Dementia (2017). Regression model used to predict Medicare expenditures is published in Jutkowitz, E, et al. "Effects of cognition, function, and behavioral and psychological symptoms on Medicare expenditures and health care utilization for persons with dementia." The Journals of Gerontology Series A: Biological Sciences and Medical Sciences (2017).

Table A6.9 Parameter values in best-case/worst-case sensitivity analysis

| Model Estimate[1]	Best-case	Worst-case
Disease Progression		
Cognition, MMSE	Parameters not varied in best-case/worst-case sensitivity analysis	
Function, number of functional limitations	Parameters not varied in best-case/worst-case sensitivity analysis	
Behavioral and psychological symptoms, number of symptoms	Parameters not varied in best-case/worst-case sensitivity analysis	
Transitions		
Probability of moving from community to long-term care facility	Parameters not varied in best-case/worst-case sensitivity analysis	
Probability of moving from long-term care facility to community		
0 – 90 days	0.20	0.07
90 – 180 days	0.0135	0.005
180 – 365 days	0.0045	0.0015
Probability of Medicare-Medicaid		
Community-dwelling	0.001	0.0031

Residing in long-term care facility	0.0095	0.0116
Time Spent Caregiving and Expenditures		
Time receiving informal caregiving	Parameters not varied in best-case/worst-case sensitivity analysis	
Medicare expenditures	Parameters not varied in best-case/worst-case sensitivity analysis	
Out-of-pocket medical expenditures	Parameters not varied in best-case/worst-case sensitivity analysis	
Time receiving formal caregiving	Parameters not varied in best-case/worst-case sensitivity analysis	
Monthly private nursing home expenditures	$5,089	$9,415
Monthly Medicaid nursing home expenditures	$4,365	$8,107

[1]Due to the large number of parameters, for the sensitivity analysis we *a-priori* identified those parameters believed to

have large impacts on the cost of care. For the parameters estimating the risk of transiting to Medicare-Medicaid the

best/worst case value depends on the perspective of the payer. For example, a higher probability of transiting to Medicaid

may represent a best-case scenario from an individual perspective. Conversely, from a Medicaid perspective this

represents a worst-case scenario. In the sensitivity analysis we adopted a Medicaid perspective and assumed a higher

probability of transition to Medicaid represented a worst-case scenario.
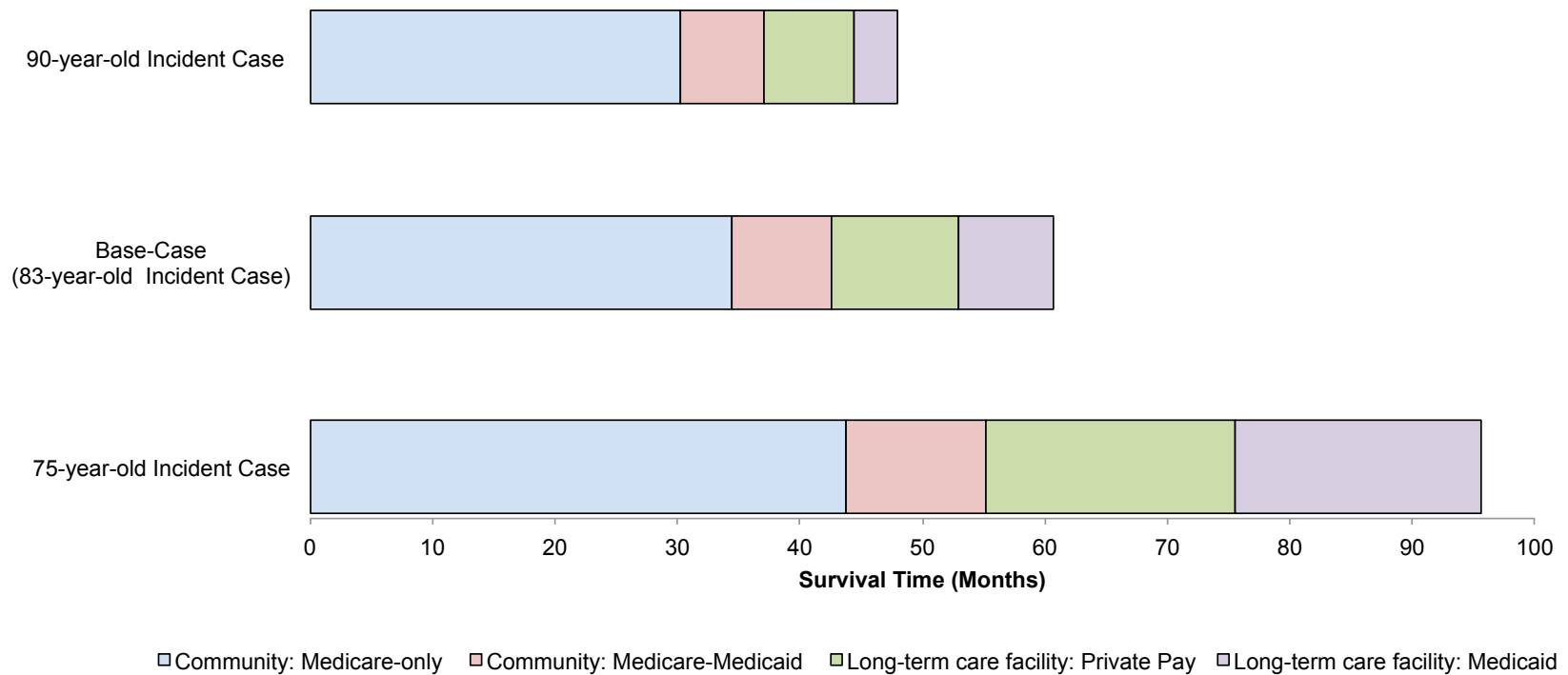
Figure A6.10 Distribution of survival time

Figure A6.10 Legend: Distribution of survival time for an average incident dementia case. Length of the bar is equal to average life expectancy.
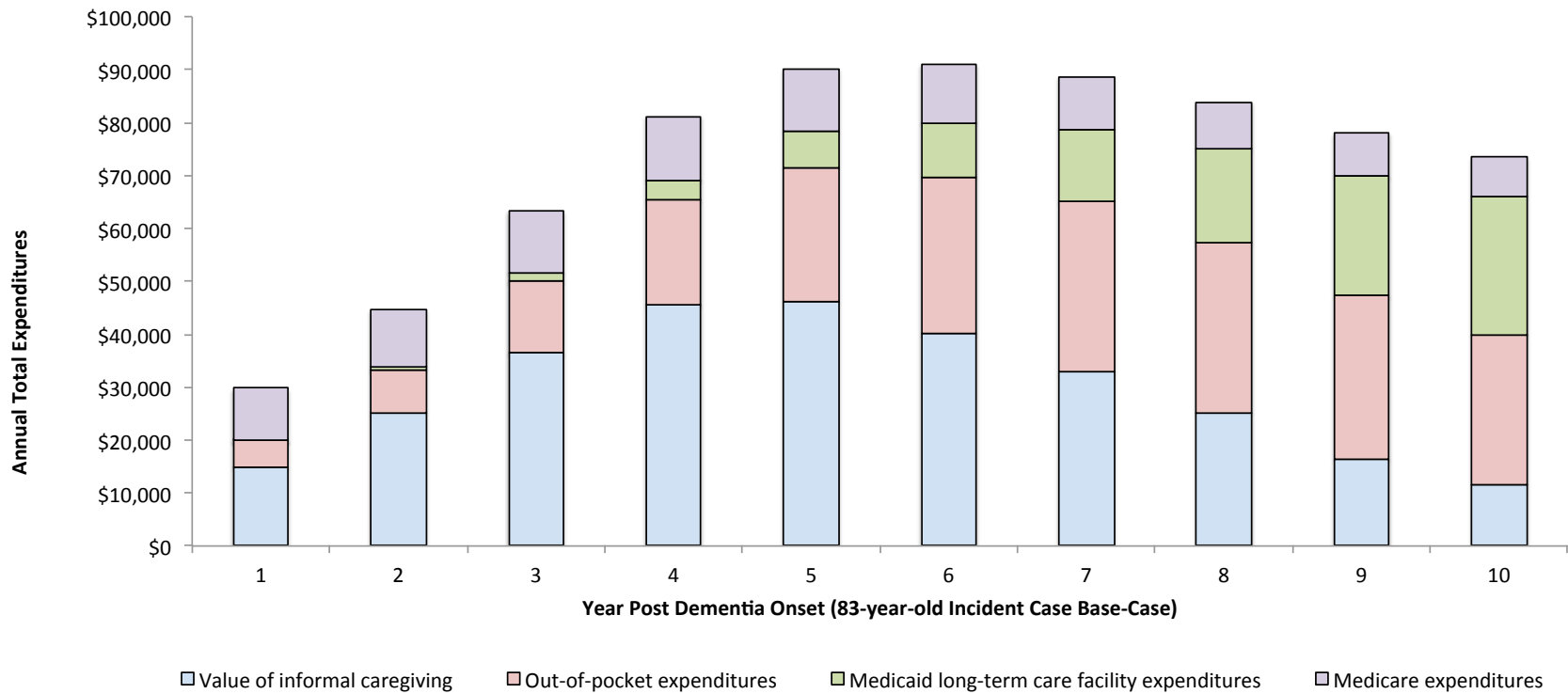
Figure A6.11 Annual total cost of dementia

Figure A6.11 Legend: Discounted annual total cost of dementia for an 83-year-old incident case (base-case) by cost type. The value of informal caregiving is $21/hour. Out-of-pocket expenditures include those for medical care, long-term care facility, and formal caregiving. Annual costs are calculated for those conditional on surviving the entire year.
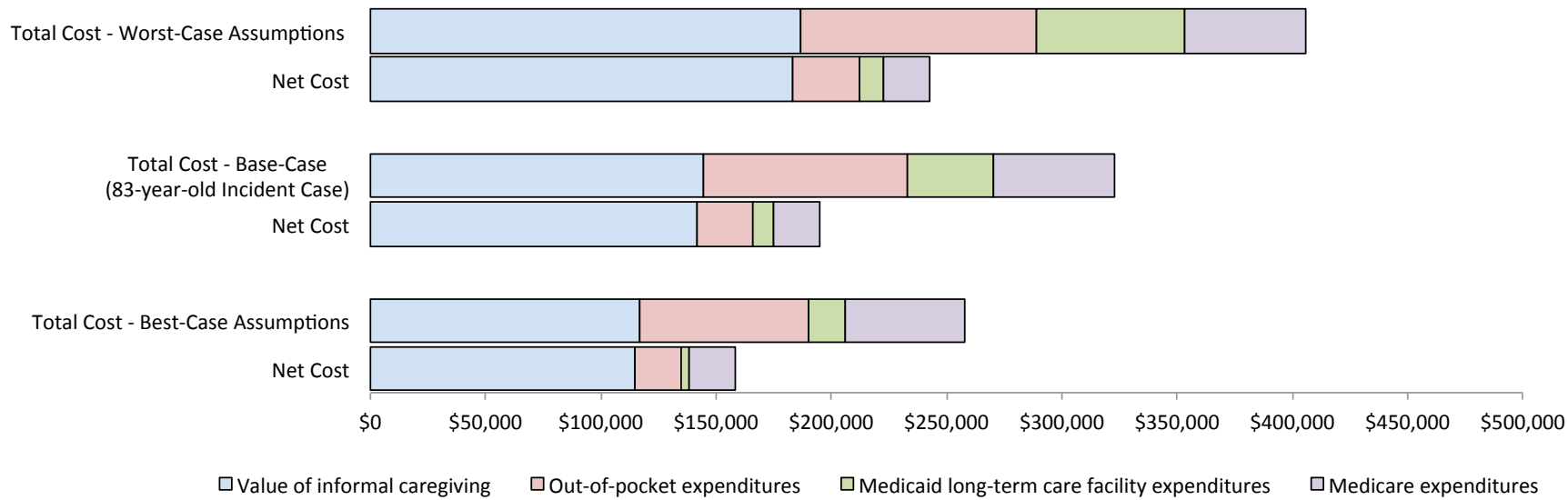
Figure A6.12 Best-case/worst-case sensitivity analysis total and net cost of dementia

Figure A6.12 Legend: Discounted total and net lifetime cost of dementia by cost type. Out-of-pocket expenditures include those for medical care, long-term care facility, and formal caregiving. The length of the bar is equal to average lifetime expenditures. Net cost represents the difference in expenditures between dementia cases and counterfactual dementia free cases.

Table A6.13 Counterfactual analyses

	Value of informal caregiving	Out-of-pocket expenditures	Medicaid long-term care facility expenditures	Medicare expenditures	Total value of care
Base-Case (83-year-old incident dementia case)	$144,160	$88,800	$37,390	$52,540	$322,900
Non-demented Counterfactuals[1]					
Counterfactual Dementia Free	$2,620	$64,640	$28,090	$32,650	$128,000
Counterfactual Dementia Free with 1 Functional Limitation	$4,540	$68,860	$32,090	$38,360	$143,860
Counterfactual Dementia Free with 3 Functional Limitations	$12,850	$81,110	$36,780	$52,180	$182,920
Counterfactual Dementia Free with 5 Functional Limitations	$33,070	$98,260	$41,490	$70,980	$243,800
Hypothetical Treatment Effect[2]					

10% Reduction in Functional Decline	$141,630	$88,020	$37,240	$51,980	$318,870
10% Reduction in Number of Behavioral and Psychological Symptoms	$143,740	$88,660	$37,280	52,490	$322,170

Notes: The value of informal caregiving is $21/hour. Out-of-pocket expenditures include those for medical care, long-term care facility, and formal caregiving. Costs of counterfactuals can be compared to the base-case to determine cost differences.

[1]The counterfactual dementia free group was identical to the dementia group in terms of all demographic characteristics (e.g., age, gender, race), but the counterfactual did not experience cognitive deficits, functional limitations (unless otherwise noted), behavioral/psychological symptoms, an excess Medicaid transition risk, or excess mortality due to dementia.

[2]Hypothetical treatment was assumed to reduce rate of functional decline by 10% or reduce the increase in behavioral/psychological symptoms by 10%. Treatment was assumed to be implemented when MMSE≤21. Treatment effect was assumed to last for 12 months after which individuals experienced the same rate of decline as those in the base-case.