HEALTHY LIFESTYLE, DISEASE PREVENTION AND HEALTH CARE

UTILIZATION

By

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HEALTHY LIFESTYLE, DISEASE PREVENTION AND HEALTH CARE UTILIZATION

Abstract

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This dissertation consists of three independent but related essays in the field of health economics. The two main focus areas of my dissertation include prevention through healthy lifestyle and dementia caregiving in the United States-implications for long-term care decisions. The first essay presents a theoretical characterization of individual investments in self-protection that mitigates the risk of future ill health and the interaction between market insurance and self-protection in reducing uncertain financial losses. It also examines the role of self-insurance (through saving) in offsetting future health costs. The results suggest that self-protection can be a substitute or complement for market insurance, and self- insurance and market insurance can coexist in lowering the severity of a potential future loss. The findings of this paper have implications for policymakers who want to encourage self-protective behavior to reduce the burdens of chronic and preventable illnesses.

The second essay examines a set of lifestyle characteristics that are potential protective or risk factors for dementia and other cognitive impairments among older individuals in the U.S.

The use of instrumental variables technique provides evidence in favor of a causal relationship between education and the risk of dementia. From a policy perspective the causality question is important for evaluation of the effectiveness of public expenditures on education. Some important lifestyle related risk factors are advancing age, an incidence of stroke, and a specific genetic make up.

The final essay analyzes a sequence of individual characteristics of patients and family caregivers that jointly predict the optimal mix of informal and formal health care services utilized by dementia patients in this country. In addition, this study investigates the effect of a caregiver's satisfactions and gratifications on the provision of informal and formal care services. Results indicate that a measure of 'altruism' is associated with an increased level of informal care and delays institutionalization. A patient's need for supervision help is an important predictor for both informal and all types of formal care services. These findings have profound social and health implications for extending publicly funded long-term care (LTC) resources and developing appropriate intervention policies to promote the well-being of patients and caregivers.

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I dedicate this dissertation to my parents and family.

CHAPTER ONE

INTRODUCTION

The aging of world population is triggering a higher demand for health care resources and social services. The global prevalence of all chronic diseases is increasing and projected to increase substantially in next two decades (Yach et al. (2006)). A healthy lifestyle is a valuable resource for reducing the incidence and impact of health problems, and for improving quality of life. Illness is costly. It consumes considerable family and public resources to cope with and to ameliorate health problems. Therefore, prevention through adherence to a healthy lifestyle is an effective way to reduce the burdens (both economic & social) of illness and disability associated with health risks (Chiuve et al. 2006). Because of the relatively low costs and high long-term benefits of preventive health behaviors, a set of prevention practices is considered as one of the four public health priorities for the U.S. Department of Health and Human Services in improving the health of the nation[1].

The first essay investigates a life-cycle model of health investment behavior under uncertainty of the incidence of illness. This paper develops a simple two period model of demand for self-protection to mitigate uncertain future health risks. Self-protection is an activity that reduces the probability of occurrence of a loss (Elrlich and Becker, 1972). In this study we define self-protection as an investment in healthy lifestyle that reduces the probability of adverse health outcomes in the future. The interaction between self- protection and market insurance is also analyzed. We use a state-dependent preference to determine the optimal level of self-protection that mitigates financial loss as well as utility loss associated with the unhealthy state

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[1] http://www.surgeongeneral.gov/priorities

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in the future. In this context we also examine how individuals engage in self-insurance activity (through saving) to face potential medical expenditures in the future. Finally we discuss how self-insurance responds in presence of self protection and market insurance.

This study expands upon the existing Ehrlich and Becker (1972) model by analyzing an individual investment behavior for a commodity that is essentially unique and irreplaceable (for which there is no perfect market substitute) such as individual health stock. Given the characterization of utility in the first period (healthy state), we incorporate the two competing theories of utility[2] in the unhealthy state (second period) to capture income loss as well as utility loss associated with an adverse health outcome. In our model ill health imposes permanent health impairments that may alter the structure of the utility function, thus impacting individuals in a way that is not insurable (Courbage and Rey, 2006). Using this characterization of the state-dependent utility function in a life-cycle model, we find that self-protection and market insurance can be substitute or complement to each other. Furthermore, self-insurance can coexist with market insurance as they influence future expected cost of illness differently. The results will encourage policymakers who want to promote preventive health behavior to prevent chronic illness and lower health care costs across the full health care spectrum.

The second essay examines the relationship between a set of lifestyle related factors and the risk of dementia among the older US population using the population-based dataset-The Aging Demographic and Memory Study (ADAMS). One of the most important findings of this study is the causal impact of education on the risk of developing dementia. Previous studies

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[2] Two types of utility models used to describe an individual's preference in the unhealthy state are monetary loss equivalent model (MLE) and health-state (HE) model. According to the MLE model, an adverse health effect is considered as being a tantamount to a drop in wealth so that ill health imposes no permanent health impairment. While the HE model considers that ill health alters the structure of the utility function, i.e. ill health imposes permanent effect on agent's health status (Viscusi ,1978, Evans and Viscusi, 1991).

(Cobb et. al., 1995, Gatz et. al., 2001, Tyas et. al. 2001) found a protective effect of higher education on the risk of dementia. However, it is not clear whether there is a causal pathway between them. Controlling for unobserved variable bias this study demonstrates that the relationship between education and the risk of dementia is not an artifact of an incidental association. It rather found evidence in favor of a causal impact of education on the likelihood of dementia. The results also suggest that a rich social network, moderate alcohol drinking are potential protective factors for dementia while advancing age, an incidence of stoke, and Apolipoprotein (APOE)-e4 genotype are associated with an increased risk of dementia.

From a policy perspective the causal relationship is important in order to evaluate the effectiveness of public expenditures on education. This finding will also encourage policy makers in implementing the Higher Education Opportunity Act of 2008 to promote the higher education system.

The final essay of my dissertation analyzes a set of individual characteristics of care recipients, and caregivers that jointly predicts the optimal mix of informal and various types of formal health care services utilized by individuals with dementia in the United States. Understanding factors predicting the use of informal and formal health services is becoming increasingly important for those involved in caregiving as well as for policy makers for expanding long-term care resources for dementia patients. Following the Anderson & Aday (1978) model, we characterize these individual factors as *predisposing*, *enabling* and *need* variables that determine the amount of informal and formal care services used by dementia patients. *Predisposing* factors are defined by demographic and social characteristics that affect a person's inclination to use the services, *enabling* factors facilitate or inhibit the access to health care services once need is perceived and finally, *need* factors are defined by the severity of the

illness. Most studies in the caregiving literature (Bolin et al. 2008; Van Houtven & Norton 2004; Charles & Sevak 2005, Lo Sasso and Johnson, 2002) focused on explaining the relationship between informal and formal care provided to a disabled elderly given a fixed level of informal care supplied by adult children. These studies predominantly ignored the influence of caregiver characteristics on the optimal care. But a caregiver's characteristics influence both types of care given to dementia patients when the decision is made by a caregiver (Gauler et. al. 2000). Moreover we explicitly measure an impact of a caregiver's satisfactions and gratifications on the use of both informal and formal health care services.

The findings of this study indicate a variety of patient and caregiver characteristics that are important for predicting the appropriate mix of both types of care and for formulating public policies to improve the well-being of patients and caregivers. For example, we found a strong and positive association between a patient's supervision need and the use of informal and formal care services. From a policy perspective, this result will help policy makers in addressing the eligibility issues and assessing the long-term care services available to dementia patients. A positive relationship between a caregiver's emotional stress and the use of formal paid home care services indicates that the burden in caregiving is an important predictor of a patient's use of domestic paid care services. Living in a same household positively associated with the higher provision of informal care. Therefore development of proper intervention policies and strong social support programs can alleviate distress and reduce negative health effects. Finally, there are some important demographic characteristics (e.g. caregiver's age, race, patient's race, marital status) that play significant role in predicting the optimal mix.

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CHAPTER TWO

Healthy Lifestyle and Disease Prevention

Abstract

This paper analyzes how the likelihood of future illness impacts lifestyle choices and discusses the role of insurance on individual behavior. Using a state-preference model under uncertainty we find the optimal level of investment in self-protection that mitigates the risk of future ill health and the interactions between market insurance and self-insurance to play a role in reducing uncertain financial losses. We find self-protection can be a substitute or complement for insurance, depending on several factors, and self insurance and market insurance can coexist as they affect future expected costs of illness differently.

Keywords: uncertainty, healthy lifestyle, investment in health.

1. Introduction

Lifestyle can affect an individual's probability of future illness.[3] Nonetheless a significant proportion of people fail to adhere to a healthy lifestyle. For example, obesity is a major risk factor for premature mortality, cardiovascular disease, type-2 diabetes mellitus, osteoarthritis, certain cancers and other medical conditions, yet recent estimate indicate that two out of three US adults are overweight or obese (Manson and Bassuk, 2003 and CDC). In this paper we explore how the likelihood of future ill health influences individual investment in healthy lifestyle[4] to lower the probability of getting sick in the future.

Ill health has two effects. First, people lose utility. Even if income is enhanced so consumption after paying for medical care is the same, most people would consider their "state of happiness" as lower than if the ill health did not occur. Most people suffer some financial consequences as well. Income may fall and treatment is costly. Insurance can mitigate the financial consequences, but unless a swift and comprehensive cure exists for the disease, the utility effect likely remains. Thus, a second purpose of this paper is to explore to what extent and under what conditions healthy lifestyle and insurance are substitutes or complements.

We use a state-preference model of behavior under uncertainty that incorporates individual decision making about healthy lifestyles to mitigate the probability of having a disease

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[3] It has been well documented that for cardiovascular disease, some types of cancers, health related problems due to obesity (Must et al. 1999), and Alzheimer's Disease(AD) (Pope et al. 2003) healthy lifestyle choices play an important role in lowering risk of disease incident.

[4] The World Health Organization (1986) provided a broader understanding of the determinants of a healthy lifestyle. Based on this definition lifestyle is a way of living based on identifiable patterns of behavior that are determined by an interplay between an individual's personal characteristics, social interactions and socioeconomic and environmental living conditions. In this study we define a "healthy lifestyle" as a set of behaviors that are considered to influence health based on individual choices. We consider an economic approach that recognizes that individuals make decisions to reflect the constraints as well as their preferences (Contoyannis & Jones, 2004). For the purpose of this study healthy lifestyle is considered as an investment in self-protection where self-protection is defined as an activity that reduces the probability of occurrence of a loss.

in the future. We then add the possibility of insurance that lowers the financial risk of getting sick. Insurance can substitute for healthy lifestyle against the financial consequences but not the utility consequences of future ill health. This allows us to see under what conditions lifestyle and insurance may coexist and how market insurance changes individual investment in self-protection.

The remainder of this paper is organized as follows. The next section provides a discussion of the existing literature on investment in self-protection. We then present several versions of a model of self-protection which differ in the ability of individuals to self-insure and availability of an external insurance market. We close the paper with a summary and implications for policy.

2. Literature Review

The literature exploring health as an investment in human capital started with Grossman (Grossman, 1972). In his seminal paper health serves as human capital, which improves both labor market and non-labor market productivity. Health is considered as both an investment and consumption good and individuals invest in health to produce "healthy days". The optimal amount of investment in human capital is determined by the relative costs, which are short term, and benefits, which accrue in the future.

Cropper (Cropper, 1977) adds uncertainty to the Grossman framework. In her model individuals invest in health to avoid the disutility associated with being ill. Uncertainty is introduced through randomly occurring illness, the likelihood of which depends on an individual's exposure to germs and viruses and size of his or her stock of health. Because illness has no permanent or long-term consequences in her model, Cropper acknowledges that it is best

suited for mild illness such as colds, viruses and influenza, and it may not be appropriate for analyzing severe, long term, or major illness.

Liljas (Liljas, 1998) also studies health investment model under uncertainty and examines how the optimal level of investment in health changes when the depreciation of health capital depends upon the level of health. Like Grossman, his analysis assumes that the motivation for investing in health is to derive direct utility, not for lowering the future probability of ill health. He concludes that marginal value of health capital, at optimum, is reduced (increased) if the initial level of health is high (low) as compared to Grossman model. A more recent paper by Courbage and Rey (Courbage and Rey, 2006) uses a one period model to explain why people invest different amounts for prevention and insurance and find the optimal level depends on both the fear of sickness and an agent's willingness to accumulate wealth when faced with financial risk.

When faced with uncertainty agents may also invest in health as a hedge against financial loss. Picone et. al. (Picone et al., 1998) looks at the effect of uncertainty about the incidence of illness on the precautionary behavior of individuals in their retirement age. He finds that in the face of greater uncertainty people invest in self-insurance through precautionary savings to increase their stock of health capital. Chang (Chang, 1996) uses a two-period version of Grossman's pure investment model where the source of uncertainty are shocks to the income generating function which, in turn, depends on the health production function. Health again becomes a hedge against future income loss.

Health is only one way people hedge against future illness. Another is insurance, which will often change how people invest in health. Ehrlich and Becker (1972) discuss the interaction between the market insurance and prevention activities. They found that market insurance and

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self-insurance are substitutes but the market insurance and self-protection can be complements depending on the level of probability of a loss. In an empirical study Courbage and Coulon (Courbage and Coulon, 2004) find private insurance does not lead to less preventive activity, indicating an absence of moral hazard.

In this paper we present a theoretical model of individual demands for self-protection, self-insurance, and market insurance and the interactions among these activities to lower a utility loss in addition to an income loss due to ill health. While Ehrlich and Becker (1972) model is mostly relevant in case of commodities that are valued appropriately in the market (Cook & Graham 1977), our model is developed for the commodity for which there is no perfect substitute i.e. the commodity which is unique and irreplaceable such as a person's health stock. A life-cycle model allows us to examine how the uncertainty of future ill health provides a strong motive for investing in a healthy lifestyle, which may, however, be influenced in the presence of self-insurance and market insurance. Most of this literature focuses on financial risks (risks that are insurable) of an adverse future outcome and does not capture situations where risks are not monetary such as health risk. In our model ill health impacts utility beyond the income loss, thus impacting individuals in a way that is not insurable. We found that self-protection and market insurance can be substitutes or complements and self-insurance and insurance can coexist to mitigate future health risks.

3. A Two Period Pure Endowment Model with no Insurance

The use of the state-dependent approach (where the utility functions are allowed to vary with the state of nature) has developed in the analysis of health care and health insurance decisions. Therefore, the theory of state-dependent utility is well developed (Viscusi and Evans, 1990, Karni 1985, Viscusi 1978, Evans and Viscusi 1991, Cook and Graham 1977). The study

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of self-insurance and market insurance in a two period life cycle model was first introduced by

Kotlikoff (1989). He presented the first simulation analysis of a life-cycle model to study how

uncertainty with respect to future medical expenditures influence precautionary savings behavior

(i.e. self-insurance)and the effect of market insurance on such savings. We build our model

based on the above theoretical characterization to examine how healthy behavior (self-

protection) can play an important role in lowering future financial burden and disability

associated with ill health and the interactions among self-protection, self-insurance and market

insurance.

Assume a simple two period economy where each period the agent is endowed with a

fixed quantity of good with no possibility of borrowing or lending across periods. In the first

period the agent can consume the good, from which utility is derived, or spend some or all of it

on risk mitigating activities which reduce the probability of getting sick in the second period.

Agents get no utility from risk mitigating activities. In the second period the agent is either

healthy or sick. If healthy she gets the full utility from consuming her endowment. If sick she

faces two losses. First, some of the endowment is spent to mitigate the effects of being sick – for

example, on palliative or curative medical care. In addition, the individual's basic level of utility

is diminished just by being sick. In essence, this means that in addition to the loss from direct

medical costs individuals just don't like being sick[5]. The probability of getting sick in the

second period depends on how much risk mitigating spending takes place in the first period.

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[5] This theoretical characterization incorporates the two competing theories of utility in the unhealthy state:-monetary loss equivalent model (MLE) and health-state (HE) model. According to the MLE model, an adverse health effect is considered as being a tantamount to a drop in wealth so that ill health imposes no permanent health impairment. While the HE model considers that ill health alters the structure of the utility function, i.e. ill health imposes permanent effect on agent's health status (Karni, 1985, Viscusi ,1978, Evans and Viscusi, 1991).

Thus, the agent chooses risk mitigating spending in the first period to maximize lifetime expected utility

$$U[(C_1 - h)] + \beta p(h)U(C_2) + \beta(1 - p(h))\{(1 - v_1)U(C_2 - v_2)\} \qquad (1)$$

where C_1 is the first period consumption, h ($h \leq C_1$) is the amount of risk-mitigating spending, C_2 is second period consumption, v_1 ($0 < v_1 < 1$) is the diminished capacity of the agent to enjoy consumption if sick (a non-consumption utility loss) and v_2 ($0 < v_2 < C_2$) is the financial cost of being sick measured in terms of lost consumption possibility. These strict inequalities indicate that there is always some cost and utility consequences of getting sick, but never is the consequence all-consuming of the endowment. The probability of not getting sick, p(h) depends on the amount of risk mitigating spending, which can vary from 0 to the full amount of endowment in period 1, with p'(h)>0 and p''(h)<0. The rate of time preference is given by β ($0 < \beta < 1$). Utility, U($\bullet$), in each period comes from the (non-health related) consumption with U(0)=0, U(C_i)<∞, U$'$>0 and U$''$<0 over the range $[0, C_i]$ for i=1,2.

The optimum level of spending in self-protection can be found by maximizing (1) with respect to h as follows:

$$U'[(C_1 - h)] = \beta p'(h)[U(C_2) - (1 - v_1)U(C_2 - v_2))] \qquad (2)$$

The first term in equation (2) is the expected marginal cost (MC) for spending on h and the second term is the expected marginal benefit (MB) from the resulting decrease in the loss probability. This is equivalent to setting h so that the marginal utility from non-health consumption in period 1 is equal to the expected marginal utility (from spending on h) in period 2. Thus, the optimal level of self-protection, h[*] that maximizes the expected utility equates these two marginal levels and is shown graphically in Figure 1.

Insert Figure 1 here.

The optimal level of h is found at the intersection between the marginal benefit (the utility value of the marginal probability of being in the healthy rather than ill state in period 2) and marginal cost (the lost marginal utility of investing in healthy lifestyle in period 1) curves. The marginal benefit curve for h, given by $\beta p'(h)[U(C_2)-(1-v_1)U(C_2-v_2))]$, slopes downward because of diminishing marginal return on health investment in terms of the probability of getting sick ($p''(h)<0$), while the marginal cost curve, $U'[C_1-h]$ slopes upward because of diminishing marginal utility of consumption. Increasing h lowers net consumption in period 1, and thus the marginal cost (in terms of lost utility) of investing in health increases, as h gets larger.

Comparative static analysis allows us to see how the optimal h responds to changes in income or other model parameters. Given that both utility and marginal utility are positive, from figure 1 it is clear that an increase in v_1 or v_2 will increase spending on h, since higher values in either of these parameters shifts the marginal benefit curve of investing in h (the downward sloping curve in figure 1) upward. The individual offsets the greater expected (income and utility) loss from getting sick by taking more preventive measures. A higher time preference (that is, a lower value for β) lowers spending on h. Finally we note that an increase in C_1 will decrease the marginal utility term, $U'(C_1-h)$) by diminishing marginal utility, which causes the upward sloping curve to shift down and spending on h will increase. However, the change in h from a change in C_2 is uncertain. We can see this by comparing $\beta p'(h)[U(C_2)-(1-v_1)U(C_2-v_2))]$ to $\beta p'(h)[U(C_2+k)-(1-v_1)U((C_2+k-v_2))]$ and checking if the marginal benefit curve shifts unequivocally up or unequivocally down. We are essentially asking if the utility cost of getting sick is larger or smaller as second period endowment increases. Ignore $\beta p'(h)$ and compare these two statements term by term. Thus we have

$$U(C_2+k)-(1-v_1)U(C_2+k-v_2) \quad ? \quad U(C_2)-(1-v_1)U(C_2-v_2)$$

where the ? indicates we are looking for which is larger. Substituting and rearranging give

$$(1-v_1)[U(C_2+k-v_2)-U(C_2-v_2) \quad ? \quad U(C_2+k)-U(C_2).$$

The right-hand-side of this expression is the marginal utility of consumption in the second period if not sick while the left-hand-side is the marginal utility of consumption if the individual is sick. We know by diminishing marginal utility that $U(C_2+k-v_2)-U(C_2-v_2)>U(C_2+k)-U(C_2)$ but since $0<1-v_1<1$ we do not know how the two sides of this expression compare which is sufficient to tell us that the shift in the marginal benefit curve of h (the downward sloping curve in figure 1) is uncertain, and thus so is the change in h. It will depend on the level of C_2, the value of v_2 and level of irreplaceable utility loss v_1.[6] We do know that if $v_1=0$ an the utility loss from getting ill goes down by diminishing marginal utility which means unequivocally that increase in C_2 lowers optimal h. In this case agents have less to lose if they get sick, thus they invest less in to avoid getting sick.

3.1 Adding Self-Insurance

We now consider that the agent can invest in self-insurance activity to reduce the size of a loss, should it occur. Self-insurance is an important alternative to market insurance that reduces the severity of a loss (Ehrlich and Becker, 1972). We assume that the individual self-insure through precautionary savings (e.g. some of the endowment from period 1 as a hedge against illness in period 2). There exists a literature that looked at the optimal savings behavior in particular to health risks (Palumbo, 1999, Kotlikoff, 1989, Kimball, 1990, Japelli et al.,2007, Edwards, 2008). These studies mainly focused on how individuals self-insure future medical

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[6] We note that taking preventive measures cost an absolute amount of C_1 thus there is only an income effect. Additionally the direct cost of ill health, v_2, is also an absolute amount and thus has only an income effect. However, the presence of v_1 imposes a quasi substitution effect making the outcome of a change in C_2 uncertain.

expenditures to face uncertain health costs (or uninsured medical expenditures) through precautionary saving. We investigate how individuals engage in self-insurance activity (through saving) in response to uncertain future health risks in addition to the investment in self-protection. Suppose we denote this savings as S and without any borrowing, $S<C_1$, $h<C_1$, and $h+S<C_1$. Expected utility is now represented as

$$U[(C_1-h-S)]+\beta p(h)U(C_2+S)+\beta(1-p(h))\{(1-v_1)U(C_2+S-v_2)\} \qquad (3)$$

where the agent chooses both S and h. The first-order necessary condition with respect to h is

$$U'[(C_1-h-S)]=\beta p'(h)[U(C_2+S)-(1-v_1)U(C_2+S-v_2))] \qquad (4)$$

and with respect to S is

$$U'[C_1-h-S]=\beta[p(h)U'[C_2+S]+(1-p(h))(1-v_1)U'(C_2+S-v_2)] \qquad (5)$$

The left-hand-side of both (4) and (5) is the MU of consumption in period 1. For any given h, any S>0 will lower consumption, hence increase the marginal utility. Thus for a given S>0 the upward sloping line in the graph would shift upward. The term in brackets on the right hand side of (4) is the cost of being sick. Assuming S is less than or equal to v_2 then for any S>0 the cost of getting sick goes down at low incomes but up at higher incomes by the same argument we used for the comparative static on C_2 in the pure endowment model. Thus, again for any given S>0, the downward sloping line in the graph might shift up or down and the value of h here compared to the model without self-insurance is uncertain. Therefore, self-protection and self-insurance may be substitutes or complements.

This result is a bit counterintuitive as one would think that self-insurance, by offering an alternative way to hedge against the adverse outcome would clearly substitute for self-protection. However, allowing the individual to consume the savings whether sick or not also offers a way to transfer consumption to the future, confounding the effect. If savings are useful only for

offsetting the costs of illness, so any S>0 disappears if the individual is not ill, equations (4) and

(5) become

$$U'[(C_1 - h - S)] = \beta p'(h)[U(C_2) - (1 - v_1)U(C_2 + S - v_2))]$$ (4A)

and with respect to S is

$$U'[C_1 - h - S] = \beta[(1 - p(h))(1 - v_1)U'(C_2 + S - v_2)]$$ (5A).

From (4A) we see that for any positive S the left-hand-side is larger and the right-hand-side is

smaller when compared to (2) and thus h is unambiguously smaller. Self-insurance lowers self-

protection as it offers an alternative means to mitigate the loss.

Combining equations 4 and 5 we have

$$p'(h)[U(C_2 + S) - (1 - v_1)U(C_2 - v_2 + S)]$$
$$= [p(h)U'[C_2 + S] + (1 - p(h))(1 - v_1)U'(C_2 + S - v_2)]$$ (6)

The above equation implies that marginal benefits (in terms of lowering the future expected costs

of illness) of spending on self-protection and self-insurance are equal at optimum levels.

3.2 Market Insurance and Self-Protection

An alternative to self-protection and self-insurance is to purchase market insurance

against an adverse outcome in the second period. Like self-insurance, market insurance reduces

the severity of financial loss, but not the utility loss, if an individual gets sick in the second

period. In this model there is again no possibility of saving in period 1 as hedge for period 2 i.e.

we first disallow self-insurance. Instead we add the possibility of individuals purchasing market

insurance against getting sick in period two. We assume insurance pays a subsidy, which offsets

part or all of the financial costs of the disease in the second period, but pays only if the individual

gets sick.

Insurance requires an individual to pay *I* as an insurance premium to receive benefits of B

in period 2 if sick. If the individual buys the insurance and gets the disease the insurance pays

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the benefit of B, otherwise, the payment is 0. Expected utility following the purchase of

insurance is

$$U[(C_1 - I - h)] + \beta[p(h)U(C_2) + (1 - p(h))(1 - v_1)U[C_2 - v_2 + B)] \quad (7)$$

where we assume B<v_2. Borrowing is prohibited hence h$\leq$C$_1$, $I\leq$C$_1$ and h+I<C$_1$ so the total

amount allocated to preventive behavior and insurance is strictly less than the endowment. We

also assume that I=(1-p(h))*B which implies that the insurance is actuarially fair and the agent

knows it. For interior solution for both h and I we assume that h and I are both normal goods.

And we note that making the insurance market be actuarially fair and I fixed means that choosing

one of B or h determines the other. In essence, the consumer is choosing the optimal mix of B

and h subject to two constraints – the normal budget constraint, which is subsumed in first period

utility in equation (7), and a constraint representing the fair insurance market condition. The

agent chooses the optimal benefit B* to maximize the above expected utility.

The first order necessary conditions with respect to B, h and $\lambda$are

$$\beta(1 - p(h))(1 - v_1)U'(C_2 - v_2 + B) - \lambda(1 - p(h)) = 0 \quad\quad\quad (8)$$
Rearranging we have,

$$\beta(1 - v_1)U'(C_2 - v_2 + B) = \lambda \quad\quad\quad (9)$$

$$-U'[(C_1 - h - I)] + \beta p'(h)[U(C_2) - (1 - v_1)\{U(C_2 - v_2 + B)\}] + \lambda p'(h)B = 0 \quad (10)$$
$$I\text{-(1-p(h))B=0.} \quad\quad\quad (11)$$

where λ is the Lagrange multiplier on the constraint for the fair insurance market condition.

From (11) we have

$$B = \frac{I}{(1 - p(h))} \quad\quad\quad (12)$$

Substituting (9) into (10) for λ we have
$$U'(C_1 - h - I) = \beta p'(h)[U(C_2) - (1 - v_1)U(C_2 - v_2 + B)] + \beta p'(h)[(1 - v_1)U'(C_2 - v_2 + B)B]$$
$$\quad\quad\quad (13)$$

18

The left-hand-side of equation (13) is the MU of consumption in period 1. Clearly when I>0 for every value of h the marginal utility term is larger from diminishing marginal utility. Thus for a given I>0 the upward sloping line in the graph would shift upward. However, the effect of positive B on the marginal benefit given by the right hand side of (13) is uncertain[7]. Thus, adding insurance seems to have an indeterminate effect on self-protection, 'h'.

An appeal to the constraint that the insurance premium be actuarially fair provides further insight. Notice from equation (12) that for a given I, there is an inverse relationship between B and h. Adding to this the fact that having insurance available makes investing in h less compelling (as insurance coverage would compensate some of income losses), and we would expect that insurance allows agents to substitute it for some investment in self-protection and we would *expect* 'h' to fall, although, we emphasize this is not certain. This individual behavior can be attributed to the moral hazard problem of the market insurance. However, There is evidence that the extent of ex-ante moral hazard on health behavior is not large because uncompensated loss (or uninsured loss) of an adverse health outcome is so consequential (Cutler and Zeckhauser, 2000). Also health insurance coverage commonly provides incomplete coverage.[8] It is possible that any investment in insurance premium, *I,* comes at the expense of C_1 and not by decreasing h. Therefore, when the insurance market is actuarially fair, market insurance and self-protection can be substitutes or complements in lowering risks of future ill health.

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[7] It is clear from equation (13). The first term in the [] is the marginal benefit for B>0 is smaller than the right hand side of (2), but the second term is the expected marginal benefit from insurance coverage is positive, making the final outcome uncertain.

[8] While ex-ante moral hazard is considered as a potential consequence of health insurance, it is also equally mentioned that ex-ante moral hazard is unlikely to be a significant problem (Dave and Kaestner, 2006). Findings from the Rand Health Insurance Experiment (RHIE) and other articles found no significant effect of private health insurance on preventive health behavior -smoking, exercise and drinking (Newhouse 1993, Courbage and Coulon, 2004). Dave and Kaestner (2006) found limited empirical evidence that having health insurance (Medicare) reduces prevention and increases unhealthy behaviors among elderly persons.

3.3 Market Insurance and Self-Insurance

Consider when both self-insurance and market insurance are available in addition to self-protection. Thus expected utility is

$$U[(C_1 - h - I - S)] + \beta[p(h)U(C_2 + S) + (1 - p(h))(1 - v_1)U(C_2 + S + B - v_2)] \tag{14}$$

Expected utility again is maximized subject to the insurance fair market condition,

$I = (1 - p(h))B$

First order conditions with respect to h, S and B are, respectively:

$$U'(C_1 - h - I - S) = \beta p'(h)[U(C_2 + S) - (1 - v_1)U(C_2 + S + B - v_2)] + \lambda p'(h)B \tag{15}$$

where λ is the Lagrange multiplier on the constraint on insurance fair market condition,

$$U'(C_1 - h - I - S) = \beta[p(h)U'(C_2 + S) + (1 - p(h)(1 - v_1)U'(C_2 + S + B - v_2)] \tag{16}$$

and

$$\beta(1 - v_1)U'(C_2 - v_2 + S + B) = \lambda \tag{17}$$

The first order condition with respect to λ is the same as we have in equation (11).

Substituting (17) for value of λ and equating (15) and (16) we have

$$\beta[p(h)U'(C_2 + S) + (1 - p(h)(1 - v_1)U'(C_2 + S + B - v_2)] =$$
$$\beta(1 - v_1)U'(C_2 - v_2 + S + B)p'(h)B + \beta p'(h)[U(C_2 + S) - (1 - v_1)U(C_2 + S + B - v_2)] \tag{18}$$

The LHS of equation (18) is the magnitude of the potential marginal benefit from self-insurance and this must be at least equal to the cost of the increase in S at the margin (LHS of (16)). The RHS is the total marginal benefit from the insurance coverage and from the resulting decrease in loss probability (by investing in self-protection). The optimal condition implies that when both market insurance and self-insurance are available, in addition to self-protection, the agent would like to invest in self-insurance as long as the expected marginal benefit of this activity equates to the total expected benefits from market insurance and self-protection. This is an intuitive as investing in self-insurance is at the expense of current consumption.

Self-insurance and market insurance both affect second period expected utility by lowering the cost of illness. While self-insurance increases the expected utility in both states of the world in the second period, market insurance increases the expected utility by offsetting only the financial losses if adverse outcome occurs. Intuitively they both coexist because they contribute to the second period utility differently; in a sense they are not perfect substitutes for each other. Compared to market insurance, self-insurance increases expected consumption in addition to lowering future expected costs of illness. As constructed it is a type of savings as well as insurance. The price of market insurance (when the insurance market is actuarially fair) depends on probability of not getting sick, p(h). On the other hand, self-insurance comes at the expense of first period consumption, and therefore, its price depends on the marginal utility of C_1. Obviously, market insurance is cheaper than self-insurance and one would expect substitution between self-insurance and market insurance. But as they affect future expected utility differently, they can coexist.

Finally, we consider situation when self-insurance only offsets financial loss in the second period, that is, it is lost if one is healthy, so it acts the same as market insurance. In this restrictive situation, both self-insurance and market insurance lower future cost of illness by the respective magnitudes of S and B. The difference is that for each unit of additional consumption if sick in the second period, self-insurance costs a full unit of first period consumption while market insurance costs only (1-p(h)). As market insurance is cheaper than self-insurance, one would expect market insurance to dominate self-insurance. Equation (16) then becomes

$$U'(C_1 - h - I - S) = \beta(1 - p(h)(1 - v_1)U'(C_2 + S + B - v_2)] \tag{19}$$

and equation (18) would be

$$\beta(1 - p(h)(1 - v_1)U'(C_2 + S + B - v_2)] =$$
$$\beta(1 - v_1)U'(C_2 - v_2 + S + B)p'(h)B + \beta p'(h)[U(C_2 + S) - (1 - v_1)U(C_2 + S + B - v_2)] \tag{20}$$

4 Summary and Implications

Using a simple two period model under the state-preference approach this paper finds the optimal level of spending on health promotion to mitigate the probability of illness in the future and interaction among self-insurance, self-protection and market insurance in lowering the consequences of future ill health. While Ehrlich and Becker and Courbage and Rey find that availability of self-insurance discourages spending on self-protection, we find that self-protection and self insurance may be complements rather than substitutes because they contribute to future expected utility differently. We also find that self-protection and market insurance are likely substitutes when the insurance premium is actuarially fair. Moreover, self-insurance and market insurance can coexist although when self-insurance is only for offsetting financial loss and cannot also work as a vehicle for savings market insurance dominates self-insurance since it has a lower opportunity cost in terms of first period consumption.

These results have implications for policymakers who want to encourage self-protective behavior. Most previous theory has found insurance to be a substitute for self-protection, implying that as insurance markets develop self-protection would decrease – the essence of moral hazard. It meant that policies designed to extend health insurance, especially to the elderly, might decrease self-protection and lead to an increase in illness. We find that need not be the case, and often insurance and self-protection can coexist and may even act as complements, supporting the empirical results that Courbage and Rey found for the United Kingdom. Thus, policymakers need better empirical estimates of the complementarity or substitutability of self-protection and insurance, both self-insurance and market insurance, if they

are to optimize social welfare. An important additional implication of this result is that more

empirical analysis is needed.

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FIGURE 1: The Optimal Level of h

MC, MB

$\beta p'(h)[U(C_2)-(1-v_1)U(C_2-v_2))]$

$U'[(C_1-h)]$

h*

h
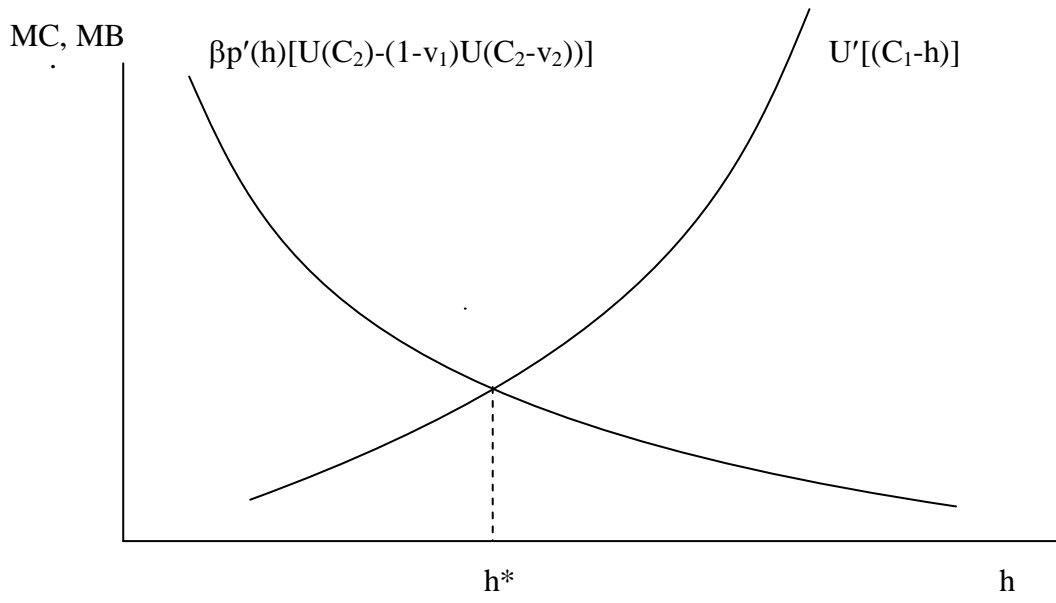
CHAPTER THREE

Lifestyle Choice, Education and Risk of Dementia Among Older Americans

Abstract

Using the Aging Demographic and Memory Study (ADAMS) dataset this paper examines the relationship between a set of lifestyle factors and the risk of dementia among older Americans. Controlling for unobserved variables bias, I found evidence that the inverse relationship between education and the likelihood of dementia is not merely associative but it is causal. Moreover, moderate alcohol drinking and a rich social network are identified as potential protective factors while an incidence of stroke and Apolipoprotein (APOE)-e4 genotype are associated with an increased risk of dementia. The causal relationship between education and dementia risk has important implications for the newly passed Higher Education opportunity Act of 2008 in lowering the prevalence of dementia in the future.

1. Introduction

The United States is in the midst of a profound demographic change: the rapid aging of its population. The 2000 Census estimates about 35 million people of age 65 or older, about one of every eight Americans. By 2030, one in five Americans will be at age 65 and older (US Census Bureau, 2008). The effects of this older age profile will reverberate throughout the US health care system in the next 50 years. The aging of the "baby boom" cohort is triggering a higher demand for health care resources and social services. Dementia is one of the most common diseases at this age cohort. The cause of dementia is unknown and there is no effective treatment. Identification of lifestyle related factors that influence the risk of developing dementia, however, may provide insight into its cause and offer potential strategies for prevention. Moreover, given the growing importance of dementia as a cause of disability among older adults, identification of risk factors is also important for informed health care planning and policy-making. Prevention research is therefore, considered as one of the most important developments in the dementia research arena. The primary objective of this study is to examine the association between a set of lifestyle characteristics and the likelihood of dementia among older Americans of age 70 and above. This paper also specifically investigates how education, an early life intervention, may ultimately be considered as a 'preventive medicine' in postponing dementia in the later life.

Dementia, a neurodegenerative disease, is characterized by increasing cognitive impairments that interfere with a person's independent functioning. Cognitive declines and functional limitations associated with dementia impose a substantial burden on individuals, their families and health care system (Langa et al., 2004). The most common type of dementia is

Alzheimer's disease (AD)[9] which accounts for 60 to 80 percent of all dementia cases

(Alzheimer's Association: Facts and Figures, 2009). The prevalence of dementia among

individuals aged 71 and older was 13.9% and AD accounted for 9.7% (Langa et al., 2005)[10](see

Figure 1). The number of individuals with AD in the US population will continue to increase

unless new prevention strategies are discovered (Hebert et al., 2003). Because of the relatively

low costs and high long-term benefits of preventive health behaviors, a set of prevention

practices is considered as one of the four public health priorities for the U.S. Department of

Health and Human Services in improving the health of the nation.[11]

According to the World health Organization (1986), "the term 'lifestyle' is taken to mean

a general way of living based on the interplay between living conditions in the wide sense and

individual patterns of behavior as determined by sociocultural factors and personal

characteristics". In this paper, I adopt a definition of lifestyle which focuses on health related

behavior (Contoyannis & Jones, 2004).

The greatest risk factor for dementia is advancing age. However, numerous

epidemiological studies suggest that a set of lifestyle factors including regular physical exercise,

higher education and other health behaviors may protect against dementia and other cognitive

impairment, no dementia (CIND) (Lindsay et al., 2002, Tyas et al., 2001, Laurin et a., 2001,

Fratiglioni et al., 1991, Cobb et al., 1995, Ott et al., 1999). These findings have important

implications for social and financial burdens to individual families and health care system. For

example, older individuals in the U.S are covered by public insurance programs (such as

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[9] AD is a progressive, debilitating and irreversible neurodegenerative disease and a most common type of dementia.

[10] In the United States, the prevalence of AD is projected to increase from 4.5 million in 2000 to 14 million in the next 50 years because of the rapid aging of the population and a large increase in the "oldest-old" (age 85 or older) who are at the high risk of AD (Langa et al., 2004).

[11] http://www.surgeongeneral.gov/priorities

Medicare) but long-term care is the most expensive component of all medical care costs for dementia patients and primarily the paid out-of-pocket expenditure (OOPE) by patient's family (Langa et al., 2004, Haan & Wallace, 2004)[12]. Therefore, thorough understanding of prevention strategies is perhaps beneficial to reduce the financial burden of individual families by lowering the probability of the disease in the future.

Existing epidemiological studies have many limitations[13] that make those study results difficult to generalize. Moreover, "education as a preventive medicine" has not gained much research attention as it deserves. The observed association between education and the risk of dementia may not be causal, as there may be some unobserved variables that influence both the choice of education and adult health behavior. Using the nationally representative Aging Demographic and Memory Study (ADAMS) data set and controlling for unobserved variables bias this study attempts to overcome some limitations of prior research. First, it overcomes the sample selectivity bias using the ADAMS which was derived from the Heath and Retirement Survey (HRS), a population-based longitudinal sample that facilitates to assess and correct for potential selection bias in the ADAMS sample.[14] Second, this study controls for unobserved variables bias in explaining the association between education and dementia risk. It therefore, provides an increased confidence about how the choice of education at early in life would have an impact late in life. This finding will have implications for potential benefits of education policies, especially the newly passed Higher Education Opportunity Act of 2008, in lowering the prevalence of dementia in the U.S. Finally, risk factors definitions and measurements used in

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[12] The comparison of OOPE among the three disease categories (dementia, CIND and normal) actually revealed a statistically significant difference in OOPE (see Table 1).

[13] Limitations with regard to sample selection bias, survival bias, definitions and measurements of risk factors (e.g. how risk factors are recalled) and finally unobserved variable bias in explaining the association between education and dementia risk.

[14] For a more general discussion on this see, Plassman et al., (2007).

this study are based on the standard official guidelines[15] that make the results easily interpretable.

The paper proceeds as follows: Section 2 discusses previous literature that examined potential protective or risk factors for dementia. Section 3 outlines the empirical model and the estimation method. Section 4 describes the data and variables used in the analysis. Section 5 presents important results. Finally, section 6 and 7 highlight limitations, policy implications, and conclude with possible future extension of this study.

2. *Related Literature*

This study is part of a literature that examines potential protective or risk factors for dementia among older individuals. A variety of epidemiological studies (Lindsay et. al., 2002, Laurin et. al., 2001, Launer et. al., 1999) observed a beneficial effect of regular exercise on the risk of dementia. However, design of these studies, various definitions of physical activity and a host of other methodological issues (mainly related to the sample selectivity problem) make results difficult to generalize. Moreover, some of these studies also suffer from the survival bias in the study sample[16].

Several other studies (Cobb et. al., 1995, Gatz et. al., 2001, Tyas et. al. 2001) examined the association between education and the risk of dementia. The major finding of these studies was the inverse relationship between education and dementia risk. It is not clear whether

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[15] For example, physical activity definition is compatible with the guidelines http://www.health.gov/PAGuidelines/guidelines/summary.aspx and alcohol consumption is categorized according to the guidelines established by http://pubs.niaaa.nih.gov/publications/aa16.htm.

[16] It has pointed out by the Canadian Study on Health and Aging that exclusion of 18% of sample members between the window of time (between sample selection and actual assessments), may distort the result because that group of sample included more men, was generally older, less educated and suffered more frequently from chronic diseases than subjects included in the study. Therefore, exclusion of those subjects may bias the result if, for example, those subjects were both more frequently exposed to a particular risk factor and at higher risk of developing AD. Also there may be the possibility of bias in assessing risk factors exposures because of preclinical cognitive declines, not detected at the baseline evaluation

education actually causes dementia or this relationship is a result of a spurious correlation between these two. However, none of these studies assessed this issue. But from a policy perspective the causality question is important in order to evaluate the effectiveness of public expenditures on education. Family background, childhood experiences, childhood health status and parent schooling have been found to influence health behavior and outcomes among adults (Leigh, 1998, Cutler and Muney 2006). This study examined this under-researched mechanism utilizing this background information as instruments for education and established a causal impact of education on the likelihood of dementia.

The published epidemiological evidence about impacts of health behaviors on the risk of dementia is not obvious. Some studies (Fratiglioni and Wang, 2000, Ott et al., 1998,) observed a significant association between smoking and AD, while others (Wang et al., 1998, Doll et al., 2000, Lindsay et al., 2002) observed no such effect. More limited studies (Deng et al., 2006, Luchsinger et al., 2004, Ruitenberg et al., 2002) suggest that moderate alcohol consumption reduces the risk of cognitive impairment and dementia. But various definitions of 'moderate drinking' (not adjusted for men and women) also limit the interpretation of this finding. A growing body of evidence suggests that management of cardiovascular risk factors[17] may help protect against cognitive declines. Also there is evidence that an incidence of stroke increases the risk of dementia but this result is difficult to generalize due to some methodological problems and clinical assessment tests for dementia (Ivan et al., 2004). In this study I also investigate effects of health behaviors (smoking and alcohol use) and chronic conditions on the likelihood of dementia. Due of lack of data on diet, I include the cardiovascular disease status as a proxy for

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[17] These include diabetes, hypertension and overweight. The empirical analysis includes chronic medical conditions such as heart disease, stroke, hypertension, diabetes, and bodyweight.

diet as there is converging evidence that composite dietary patterns impact the risk of

cardiovascular disease (Scarmeas et al., 2006).

3. *Empirical Analysis and Estimation Method*

First consider that the latent disease status, D^* is related to the observed individual

characteristics, X's through the structural model.

Equation 1
$$D^* = \beta'X + \varepsilon$$

Where β is a coefficient vector; X is a matrix of independent covariates and ε is an error

term. The latent variable D^* is linked to the observed variable D by the following measurement

relationship (D has 3 ordered categories):

D=1, if $0 \leq D^* < \alpha_1$,

D=2, if $\alpha_1 \leq D^* < \alpha_2$

D=3, if $D^* > \alpha_2$

The α values are unknown parameters to be estimated along with βs. The ordered logit is

appropriate to estimate the model since the disease status is clearly a ordered categorical

variable. The ordered logit model also known as proportional odds model (McCullagh, 1980)

can be written as follows:

Equation 2
$$\text{logit } [P(D \leq j \mid X)] = \ln[\frac{P(D \leq j \mid X)}{P(D > j \mid X)}] = \alpha_j - \beta'X , \qquad\qquad j=1,2, \quad K\text{-}1, \text{ where}$$

K is the number of categories in the ordinal outcome variable (in this case K=3).

3.1 Endogeneity and Selection Bias

Endogeneity may arise due to the problem of simultaneity between predictors (risk

factors exposures) and the disease status (outcome variable). Exposures to risk factors are

measured before the disease onset and therefore, cognitive impairments are unlikely to have

influenced health and lifestyle behavior at the baseline (before the disease onset). This excludes the possibility of the potential endogeneity problem due to simultaneity between health behavior or lifestyle habits and the disease status. Moreover, I assume that there are no unobserved factors that correlate both lifestyle habits and cognitive impairments simultaneously.[18]

Independent covariates X in Equation 1 include demographic and socioeconomic factors, lifestyle and health behaviors, genetic characteristics, and chronic medical conditions. A respondent's education has found to be strongly associated with the risk of dementia. This correlation could be caused by a third unobserved variable that affects both education and the disease status, for example, genetic characteristics or parental background or time preference (Muney 2005, Rodgers 2009). In this case a bias will afflict any single equation estimation to measure the effect of education on the likelihood of dementia. This is a self-selection bias. People may select more schooling and invest in health because some unobserved factors influence them to do so. To control for this unobserved variable bias education is instrumented on standard background variables (parent's education, socio economic status and financial stability during childhood) those are strongly correlated with education but not correlated directly with the risk of dementia. Moreover, the childhood health status is included to control for the effect of health on education.

Relationships explaining the educational attainment (EDU), measured by the number of years, and the disease status (D) in the post schooling period can be expressed as:

Equation 3
$$EDU = \alpha_1' Z + \alpha_2' R + \varepsilon$$
Equation 4

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[18] This excludes education, as there is overwhelming evidence that the correlation between education and health may not be causal because the choice of educational attainment is influenced by some unobserved factors that also affect a wide variety of health behavior and outcomes (Leigh 1998, Leigh & Dhir, 1997, Cutler & Muney, 2006).

$$\ln[\frac{P(D \leq j \mid X)}{P(D > j \mid X)}] = \beta_1{}'Z + \beta_2{}'W + \beta_3 EDU$$

Where Z is a vector of independent variables that influences both education and the disease status, R is a vector of variables that affects only educational attainment and W represents a vector of covariates that influences only the disease status.

The finding in all existing studies is that the estimated coefficient (β_3) in the equation 4 is statistically significant. The question here is whether this finding is a direct influence of education on the likelihood of dementia or this relationship is spurious for some reasons. The residual from education equation (Equation 3) is included as a separate covariate together with education variable in disease status equation (equation 4) to remove the unobserved variable bias (Leigh 1998, Leigh & Dhir 1997).[19]

Although there may be a possibility that unmeasured or unobserved variables influence smoking and drinking behavior and health, but there is no direct evidence that a 'third' unobserved variable affects both these health behaviors and the risk of dementia. If this effect exists, the most common approach to address this issue is the instrumental variable (IV) technique. In the literature, state-level price or tax data and tobacco or alcohol control policies have been found as good instruments for smoking and alcohol use (Powell et al. 2005, Leigh& Schembri, 2004), however, this does not appear to be the case in this study. Because of the potential weak instrument problem (as defined by the first-stage F-value must be greater than 10, Staiger and Stock, 1997), I chose not to use IV method as it is not recommended for making reliable inferences

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[19] This method is known as two-stage-residual inclusion (2SRI) and gained popularity because of greater consistency then usual two stage least square method, especially for non linear model (Terza et al. 2008). More application of this method in health service research can be found in Baser et al. (2004), Van Houtven & Norton (2006), Shea et al. (2007). The first stage regression results are included in the Appendix.

in case of weak instrument[20]. However, unhealthy behaviors such as smoking and excessive alcohol use constitute a cumulative risk and are translated into observable physical health status later in life (Hammond, 2002). From this point of view, including physical health status in the model perhaps removes some of this unobservable effects, if exist at all. I include smoking and alcohol use because my primary aim is to minimize the omitted variable bias.

Instruments used for education satisfied two qualifications of a good instrument. First, parental education and socio-economic status during childhood are strongly correlated with an individual's own education level. On the other hand, instruments do not appear to be directly related to an individual's disease status. The only logical connection here is an indirect one. These background variables therefore, are valid and strong instruments for education. Moreover, parental education is considered as a strong instrument for education because the relationship between an adult's health and his/her education is simply reflecting the legacy of a healthy childhood that is possible by well-educated parents (Leigh 1998). The first stage F-value of 38.33 ensures that the potential weak instrument problem should not be a concern (for single endogenous variable) in order to make reliable inferences. Instruments also passed the overidentification test[21] because there is not enough evidence to conclusively reject the null hypothesis that instruments are uncorrelated with the error term.

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[20] I found no correlation between smoking consumption and cigarette price-per-pack. One potential reason is the inability to use the state level cigarette price data. As HRS and ADAMS collapsed state categories into region to protect respondent confidentiality, in order to use the state level data I had to average state level price data based on the region which did not appear to be correlated with the cigarette consumption. Possibly, due to the same reason I could not use the comprehensiveness of state policies that aimed at reducing smoking. The first-stage F-value was 1.75 which clearly indicates the weak instrument problem and I chose not to use the IV method. The very same problem prevented using state level alcohol tax and policies as instruments for moderate drinking.

[21] The overidentification test was performed by regressing the residual from education equation on exogenous variables and obtaining R^2_e, under the null hypothesis instruments are orthogonal to the error, and low insignificant value of the overidentification statistic,(N $R^2_e \sim \chi^2_{(3)}$) implies that the overideridentification restrictions are not rejected at any reasonable level (Wooldridge, 2002). The small test statistic value of 0.1596 implies that we don't have enough evidence to reject our null hypothesis of instrument's orthonality assumption.

4. Data and variable Descriptions

The Aging Demographics and Memory Study (ADAMS) dataset is used to examine a set of potential protective or risk factors for dementia among older individuals in the U.S. The ADAMS is a cross-sectional data of a stratified random sample of 1,770 individuals of age 70 and above, selected from the Health and Retirement Survey (HRS-2000 wave) based on the self-or-proxy reported cognition score. The ADAMS phase-1 assessment occurred between July 2001 and December 2003 and clinical assessments tests were performed on 856 respondents (56% of nondeceased target sample). A consensus expert panel of neuropsychologists, neurologists, gerophsychiatrists, and internists reviewed all the clinical assessment tests and then assigned a diagnosis of normal cognition, CIND or dementia.[22] The ADAMS follow-up assessment, phase 2 (between November 2002 and March 2005) was completed on 252 subjects for whom reassessment would be useful to know the severity of dementia. The sample is the first nationally representative sample of individuals with dementia in this country. Full details of the ADAMS sample design and selection methods are described in other studies (Langa et al.; 2005, Plassman et al., 2007). The ADAMS includes extensive information about demographics, socio economic and health characteristics of individuals of age 70 and above.

An Important feature of the ADAMS for this study is the longitudinal nature of the HRS data on demographic information, socioeconomic, health behavior, chronic medical conditions that combine the full clinical assessment data from the ADAMS. Linking the ADAMS to the expansive longitudinal HRS data on demographic (age, gender, race), socioeconomic (education level, wealth), health behavior (smoking, alcohol use, and level of physical activity), chronic

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[22] Dementia diagnosis was based on Diagnostic and statistical Manual of Mental Disorders, Fourth Edition (DSM-IV;23) criteria and CIND was defined mild cognitive or functional impairment reported by the subject or informant that did not meet criteria for dementia or performance on neuropsychological measures that was both below expectation.

medical conditions and genetic (Apolipoprotein-APOE genotype) characteristics provides a

unique opportunity to study potential protective or risk factors for dementia. Importantly, the

ADAMS sample ensures that the natural process of mortality among the members of the original

sample (selected to be in the ADAMS) is not introducing significant survival bias into the final

sample of 856 ADAMS assessments for surviving members of the 70+ age cohort.[23]. This study

used the linked ADAMS –HRS 1998 data set.

4.1. *Variable Descriptions*

Dependent variable

The outcome variable of interest is the disease status. This status is expressed as an

ordinal categorical variable indicating whether a respondent has been assigned a confirmed

clinical diagnosis of AD (probable AD or possible AD)[24], other dementia, CIND or normal. I

used three ordered categories of the dependent variable as Dementia (AD and other dementias)

=1, CIND =2 and Normal =3. About 33% of the respondents had diagnosed with dementia

including AD, 29% had CIND and 38% of the respondents were normal.

Independent variables

Variables (denoted by vector R) unique to the education equation (see Equation 3) include

background covariates such as mother's and father's years of completed education, measures of

childhood socioeconomic status (SES) and financial stability when the respondent was young

(Leigh 1998). For the purpose of this study, the parental education is classified as "low

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[23] For further details about sample selection bias please see Heeringa et al.(2006).

[24] Definite way to diagnose AD is usually done after autopsy. However, through a complete medical evaluation (including a medical history, laboratory tests, neuropsychological tests, and brain scans), well-trained doctors can diagnose AD correctly up to 90 percent of the time. Doctors look to rule out other diseases and disorders that can cause the same symptoms of AD. If no other cause is identified, a person is said to have "probable" AD and when a patient has AD in association with another disease process that could by itself cause dementia, is diagnosed by "possible" AD.

education" (defined as less than 8 years of schooling) and 'high education" (defined as 8 or more years of schooling). This cut point is used to reflect historical levels of education in the United States at the end of the 1800s, when the parents of the ADAMS participants were schooled (Rogers et al., 2009). Of the elderly Americans 33% had parents who both received schooling for at least 8 years, 46 % had mother who received schooling 8 years or more and 40% had fathers received high education. The childhood SES and wealth measures in the HRS were dummy variables indicating whether the respondent thought his family was financially well-off, above average, or poor when he grew up, whether financial difficulties caused his family to move to a different place and whether his family received any financial help during that time. On an average their families' SES status was good, but families were not financially stable during the same period. Parents' wealth, SES and education levels are expected to be correlated with respondents' years of schooling. To explore the possibility that poor health causes lower educational attainment, I include childhood health status in the vector (R). Ninety-four percent of the respondents reported having good health status during childhood.

Variables (vector Z) that influence both education and the disease status include demographic factors such as age, gender, genetic characteristics and ethnic background. The average age of a respondent is 82 years and has less than a high school education. Many ADAMS participants started their schooling in the early 1900's and during 1910-1940, when secondary schooling in the U.S. experienced unprecedented growth: the percentage of young adults with a high school degree increased by five folds (Muney, 2001). It is therefore, expected that age would be negatively correlated with schooling completed. Race is entered to account for the education disparity between Whites and non-Whites. Fifty-eight percent of the respondents are female, 75% are Caucasians, 20% are African American, and 5% are Hispanic.

Covariates (vector W) unique to the disease status equation (equation 4) include marital

status, a list of risk factors exposures (regular physical activity, health behaviors and chronic

medical conditions), respondents' wealth and medical insurance status.

Thirty-nine percent of the respondents are married. Approximately, 34% of the

respondents reported that they engaged in regular vigorous physical exercise during the twelve

months preceding the survey.[25] To consider the potential effect of socio economic status on the

likelihood of dementia, I include a variable indicating a respondent's social network system.

About 87% of the respondents reported having a rich social network with friends and relatives[26]

and they engaged in regular social interactions. Accounting for wealth in the disease status

equation perhaps seem to introduce bias from reverse causality, however, the problem of reverse

causality is less likely to afflict individual wealth rather than individual income measure[27],

primarily because wealth accumulates over time and hence less affected by a single episode of a

disease (Feinstein, 1993). Health insurance characteristics reflect the universal coverage by

Medicare with 96% of the respondents receiving Medicare, about 19% received Medicaid and

17% received both Medicare and Medicaid. Among chronic medical conditions, stroke, heart

disease[28], diabetes, and hypertension are included in the model to control for the effects of

chronic medical conditions on cognitive impairments. Among health behaviors, current smoking

(measured by the number of packs consumed each day) and alcohol consumption are considered

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[25] Physical activity is measured by any activity that involves physical labor, sports or heavy house work and the intensity is defined according to the definition of vigorous exercise. This is a binary variable indicating whether the respondent has been participating in this activity during past 12 months- period prior to the HRS 1998 wave.
[26] A rich social network system is assumed to have a protective impact on the risk of dementia. This is measured by whether respondents have good friends or relatives and .engage in social activities frequently.
[27] For older adults wealth is more relevant than income and the measure of wealth is before the disease onset.
[28] Although there is no established association between low fat diet and risk of dementia, diet is an important lifestyle factor that is responsible for many chronic illnesses. In the regression, I use whether respondents have doctor diagnosed heart disease as a proxy for diet due to lack o finformation on diet. About 32 % of the respondents have heart disease, 23% have diabetes and 19% have stroke.

in the model. About 16% of the respondents drink alcohol moderately[29] and on an average respondents smoke 0.63 packs of cigarettes per day. The known genetic factor included here is the Apolipoprotein (APOE)-e4 genotype; about 3% of the respondents had the APOE-e4 genotype. The summary statistics (means standard deviations and ranges) of all demographic, socioeconomic, lifestyle variables and health data of the study sample is represented in Table **2**.

5 Results and Discussion

The ordered logit model is appropriate to utlize the ordinal nature of the response variable ("Dementia", "CIND", "Normal"). This model is also known as the proportional odds model as it assumes that the odds ratio is the same for all categories of the dependent variable. Therefore, the ordered logit model estimates one equation over all levels of the dependent variable. There are two formal tests that are generally used to examine the validity of this assumption. One is the Score test which examines whether all β_j's are equal across the j-1 regressions (where j=1, 2…K-1). The null hypothesis of this test is that all β_j's are equal across the levels of the dependent variable. A significant test statistic implies that we reject the null hypothesis that the j-1 regression equations are parallel. But the Score test is an omnibus test, in a sense; it does not indicate whether the parallel regression assumption is violated for all predictor variables or only for some individual variables. A Wald type of test proposed by Brant (1990) allows both an overall test that all β_j's are equal as well as tests of the equality of coefficients for all independent variables. The overall test is the same as the Score test. The test statistic value of 60.45 (from Table 4) indicates that there is sufficient evidence to reject the null hypothesis that all β_j's are equal across regressions. There is also enough evidence to reject the null hypothesis of equal coefficients for some of the predictor variables as shown in Table 4. Therefore, the rest result

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[29] The guidelines put forth jointly by the U.S. Department of Agriculture and the U.S. Department of Health and Human Services define moderate drinking as no more than one drink a day for most women, and no more than two drinks a day for most men (http://pubs.niaaa.nih.gov/publications/aa16.htm).

does not provide enough evidence to conclude that the proportionalodds assumption is satisfied

for the ordered logit model. To address this issue, a partial proportional odds model (also known

as generalized ordered logistic model) is estimated. This estimation technique relaxes the

proportional odds assumption for each independent covariate for which the assumption does not

hold while leaving it in place for other covariates for which it holds (William, 2006, Creamer

2009). The major strength of this model is that it can estimate most parsimonious model for

ordinal dependent variables. It is more parsimonious than multinomial logit (which ignores the

ordinal nature of the data and estimates more parameters than necessary) while not being

violating the model assumption (such as proportional odd assumption of the ordered logit

model). Results from the generalized ordered logistic model are given in Table 5.

Overall the model fit is quite good with the large likelihood ratio test statistic value of 269.42

with an extremely low p value ($p<0.0001$).The generalized ordered logit estimates two

regressions here: first regression is dementia verses the combined outcome of CIND and normal,

second is the combined outcome of dementia and CIND verses normal. The results can be

interpreted in the same way as ordered logit model, except that multiple coefficients need to be

estimated for each variable that violates the parallel regression assumption. This is because

when the proportional odds assumption is violated, the effect of an independent variable is not

constant across all regression equations. All variables, except gender, physical activity, heart

disease, smoking cigarettes per day, race and health status meet the parallel regression

assumption. Variables those meet the parallel regression assumption are called constrained

variables (Williams 2006, Inagami et al., 2007). The parameter estimates for these constrained

variables will be the same in both regressions. For unconstrained (i.e. for which there is enough

evidene to reject the parallel regression assumption) variables Table 5 lists two different

coefficients. The first coefficient (labeled 'a') predicts the odds of dementia versus the

combined outcome of CIND and normal and the second (labeled 'b') represents the odds of the

combined effect of dementia and CIND versus normal. Comparing these two coefficients for

unconstrained independent covariates allows tracing changes in the effect of these covariates

over the range of the ordinal dependent variable, disease status.

In every other respect, however, the interpretation of coefficients is the same as ordered

logit coefficients. For a higher value of an independent variable, positive coefficients indicate an

increase in the likelihood of being in a higher category of the disease status (i.e. normal) while

negative coefficients represent a decrease or being in a lower category of the disease status

(dementia or CIND). The magnitude of each independent variable's impact on the likelihood of

the disease status is calculated by a change in the odds for one unit increase in independent

variables.[30] All the independent variables are jointly significant with a very low p-value and

some of the lifestyle related variables individually are significant with a p-value of 0.1 or better.

The results indicate that advancing age, an incidence of stroke and APOE-e4 are associated with

an increased risk of dementia. For example, one year increase in age the odds of dementia

versus the combined outcomes of CIND and normal increases by 1.11. Because this is a

constrained variable, interpretation of this variable in the regression of dementia and CIND

versus normal would be the same: the odds of the combined outcomes of dementia and CIND

versus normal for one year increase in age is increased by 1.11. Compared to all other

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[30] In ordered logistic model, one unit increase in independent variable results in the odds of an outcome changed by the factor of $\exp(-\beta)$, holding all other covariates constant, compared to $\exp(\beta)$ for the binary logit model (Long, 1997)

genotypes, APOE-e4 is associated with an increased risk of dementia. This is perhaps due to an observed association of APOE-e4 with an increased risk of both Alzheimer's disease and vascular dementia. Importantly, the causal relationship between education and the likelihood of dementia is established after controlling for unobserved variables bias. It appears that higher education decreases the risk of dementia. For one year increase in education, the odds of dementia versus the combined outcomes of CIND and normal decreases by 0.90. The effect of this constraint variable would be the same in the regression of the combined outcomes of dementia and CIND versus normal. This finding suggests that the newly passed Higher Education Opportunity Act of 2008 could potentially lower the prevalence of dementia and CIND in the future.

Among chronic health conditions, the odds of dementia versus the combined outcomes of CIND and normal for those who had an incidence of stroke is 2.94 times higher than the odds for those who did not have a stroke incidence. An incidence of stroke is therefore, strongly associated with an increased risk of dementia. This suggests that primary or secondary prevention of stroke should be associated with a reduced risk of dementia and other cognitive impairments. This result also agrees with what Ivan et al. (2004) observed in the community based Framingham Study cohort. Moderate alcohol drinking appears to be inversely related to the risk of dementia. This is possibly because of beneficial health effects of moderate drinking. In middle-aged and older adults, a daily intake of one to two alcoholic beverages is associated with the lowest all-cause mortality. More specifically, compared to non-drinkers, adults who consume one to two alcoholic beverages a day appear to have a lower risk of coronary heart disease (Dietary Guidelines for Americans 2005, USDA)[31]. This finding agrees with other

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[31] The web site address is http://www.health.gov/DIETARYGUIDELINES/dga2005/document/html/chapter9.htm.

prospective studies (Deng et al. 2004, Luchsinger et al. 2004). Because of the cross-sectional design of this study this result does not prove the causal relationship between moderate drinking and lower risk of dementia. However, as mentioned earlier, this bias is minimized due to control for the observed physical health status. A rich social network (involving in mentally and socially stimulating activities) is inversely associated to the likelihood of dementia. Some possible mechanisms of this finding can be hypothesized. First, intellectually challenging activities may enhance cognitive performance and brain reserve. Participations in productive social activities have been found to be related to a high memory performance and prevent cognitive decline (Bassuk et al. 1999). This result also agrees with what Wang et al. (2002) found in the Kungholmen project, a longitudinal population-based study performed in a central area of Stockholm, Sweden. An increase in respondent's body weight is associated with a decreased risk of dementia. This finding may conflict with the observed association of higher body weight with the risk of vascular disease and hence stroke and dementia, perhaps a loss of body weight occurs before the clinical manifestation of dementia (Johnson et al. 2006). Finally, having Medicaid insurance is associated with a higher risk of dementia.

Comparing estimates of independent covariates that violate the proportional odds assumption facilitates to examine the effect of these variables over the range of the ordinal dependent variable. One such variable is gender. The effect of gender differs over the range of the disease status. The result indicates that the odds of the combined outcomes of dementia and CIND versus normal for female is 0.45 times the odds for male. This effect is significant and different from the regression of dementia versus the combined outcomes of CIND and normal. The beneficial effect of regular physical exercise increases in strength across the range of the disease status and becomes significant at the transition from dementia to normal. The odds of

the combined outcome of dementia and CIND versus normal for those who did regular exercise are 0.60 times the odds for those who did not. The effect of smoking is complicated. An increase in current smoking is more likely to be associated with an increased risk of dementia but it is less likely to be associated with the combined outcomes of dementia and CIND. Whether the later effect is due to protective effect of nicotine on cognitive health or poor survival bias among nonsmokers than smokers needs to be investigated in greater detail. There is evidence that cigarette smoking promotes and deters dementia occurrence (Haan & Wallace, 2004). Finally, respondents with very good or excellent health status are less likely to be diagnosed with dementia or CIND.

Some of the important results are also interpreted in terms of measures of a discrete change in the predicted probability of the outcome variable for a change in independent variables. For binary variables, a discrete change in the predicted probability is calculated when a variable changes from 0 to 1, holding all other variables at mean values. For continuous variables (e.g. age, education), changes in the predicted probability values are computed when the variable varies over a specified range (from its minimum to its maximum), while other independent variables are held constant at the mean values (Long, 1997). For continuous variables, predicted probability graphs show the impacts of these covariates on the likelihood of dementia. For example, the predicted probability of dementia (Figure 2) steadily increases with an advancing age. Similarly, as education (in years) increases, the predicted probability of dementia decreases consistently which indicates the protective effect of higher education on the likelihood of dementia (Figure 3).

For dummy independent variables, the discrete change in the predicted probability values indicates the effects of these variables on the likelihood of dementia. For example, the

probability of dementia is 0.21 higher for those who had an incidence of stroke than who did not, holding all other variables at their means. Similarly moderate alcohol drinking is also associated with a decrease in the predicted probability of dementia by 15%. In an exact similar manner the change in the predicted probability of the disease status can be obtained for other binary variables.

6. Limitations

This study has some limitations regarding the cross-sectional design and lack of data on family history and diet. First, the cross-sectional design of this study is not able to prove causation for all the lifestyle related variables, except education. Healthier people may choose to expose themselves to better lifestyle or healthy behavior that may be influenced by some unmeasured factors. The effect of these unmeasured factors, if any, can only be captured if we can observe the lifestyle behavior over time or if we can find proper instruments to remove this bias. But in a cross- sectional study it is almost impossible to find good and valid instruments for all of these lifestyle variables. Further research with the longitudinal dataset, which is not currently available in the U.S., will be able to establish causal relationships between these lifestyle variables and the likelihood of dementia. Second, due to lack of data on diet and family history of dementia, this study is unable to examine direct effects of diet and family history of memory related disease on the likelihood of dementia. Further research is needed to investigate effects of these two potential factors on the risk of dementia. However, the ADAMS will include the information on the family history variable shortly.

Despite the above limitations, this is the first study based on a population-based dataset in the U.S that provides in-depth information on the identification of potential protective or risk factors for dementia and other cognitive impairments. All prior studies of dementia in the U.S.

focused on clinical samples or community based sample from geographically confined areas, therefore, raising questions about the generalizability of findings. Finally this study is able to provide evidence that higher education is a protective factor in lowering the risk of dementia.

7 Implications and Conclusions

Using the population-based cohort this study examined the role of lifestyle related characteristics as a primary prevention of dementia among older Americans. Advancing age and APOE-e4 are the two non-modifiable factors associated with an increased risk of dementia while an incidence of stroke, a modifiable factor, has also identified as a potential risk factor for dementia. However, a set of other modifiable lifestyle factors such as higher education, moderate drinking are associated with a decreased risk. The finding that higher education lowers the risk of dementia has important implications as education can be viewed as a 'preventive medicine' for postponing the onset of dementia. The causality issue here is important not only for determining the exact relation between education and dementia risk but also from a policy point of view. This causal effect confirms that an increase in public expenditure on education would be effective in improving the level of education and lowering the risk of dementia. Further research can investigate whether a re-allocation of resources can be welfare improving if the impact of education on dementia risk is larger than the impact of healthcare on dementia. It therefore, not only matters whether the education effect is a causal effect, but also whether the effect is large enough to warrant additional expenditures on education. This result certainly would encourage policymakers to implement the Higher Education Opportunity Act of 2008, as an effective intervention policy that can potentially decrease the prevalence of dementia in the future years.

In the future this study can also be extended to a longitudinal framework where a change in cognitive status and other lifestyle behavior can be measured over time. Another possible extension could be disentangling the effects of early life verses late life exposures and their relative consequences dementia risk at old age.

Figure 1

Prevalence of dementia in People 71 and above, ADAMS, 2002
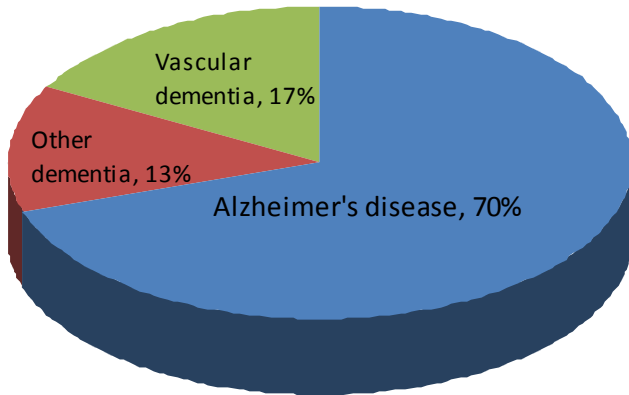
Table 1

Unadjusted yearly Out-of-Pocket Expenditures Among Those Reported Any
Expenditures, by Expenditure type and Disease Category (N=693)

Expenditure type ($)	Normal (N=277)	CIND (N=196)	Dementia (N=220)
Total expenditures			
N	192	143	169
%	69	73	76
Mean	644	1841	7616
SD	1808	5115	11288
Hospital			
N	20	20	35
%	7	10	16
Mean	1456	575	9885
SD	3825	627	9878
Nursing home			
N	2	8	49
%	0.7	4	22
Mean	125	11625	13211
SD	0	9624	9657
Home health care			
N	9	2	86
%	3	1	39
Mean	1986	3744	5638
SD	2343	4203	4160
Doctor/Prescription/Test			
N	189	137	156
%	68	69	71
Mean	404	585	706
SD	941	1393	1590

There is a significant difference in proportions reported OOPE in hospital/nursing home/home health care across dementia groups (p=0.02).
Also significant difference in OOPE was found before and after the diagnosis of the disease (p<0.001).

Table 2
Descriptive statistics of study variables (N=798)

Variables	Mean	S.D.	Min.	Max.
Age (in years)	82.61	6.87	70	110
Education (years completed)	10.03	4.36	0	17
Female	0.58	0.49	0	1
White	0.75	0.43	0	1
Black	0.20	0.40	0	1
Hispanic	0.05	0.20	0	1
Body weight (in pounds)	73.00	16	36	147
Married	0.39	0.48	0	1
Self-reported health (1, if excellent/very good/good)	0.63	0.48	0	1
Childhood health status (1, if excellent/very good/good)	0.94	0.23	0	1
ADPOE-E4	0.04	0.20	0	1
Physical activity	0.34	0.47	0	1
Heart disease	0.28	0.45	0	1
Stroke	0.14	0.34	0	1
Diabetes	0.17	0.37	0	1
Hypertension	0.05	0.22	0	1
Cancer	0.14	0.34	0	1
Current smoking	0.63	3.37	0	50
Moderate drinking	0.16	0.37	0	1
Wealth (per $10,000)	20.00	0.42	-6.27	532
Medicare	0.96	0.17	0	1
Medicaid	0.19	0.37	0	1
Mother's education	0.46	0.49	0	1
Father's education	0.33	0.47	0	1
Social network	0.87	0.33	0	1
Childhood SES	0.59	0.49	0	1
Financial stability	0.20	0.40	0	1

Table 3
First stage regression results.

Dependent variable: Education (# of years)

Independent variables	Estimates
Age	-0.05***
Female	0.03
White	2.78***
Mother's education	2.28***
Father's education	1.53***
APOE-e4	-1.12*
Childhood SES	0.89***
Financial stability	-0.37
Childhood health	0.34
Constant	9.30***

N=798, R^2=0.33, Adj-R^2=0.32, F-stat=38.33, *** significant at 1%, * significant at 10%

Table 4

Brant test for parallel regression assumption.

Variables	Chi-sq value
All	60.45***
Age	0.05
Female	7.02***
Married	0.77
Whites	3.80**
Education	0.48
Bodyweight	0.75
Physical activity	3.42**
Current smoking	12.95***
Moderate drinking	0.77
Heart disease	2.74*
Stroke	0.12
Diabetes	1.02
Hypertension	0.26
Wealth	0.74
Social network	0.47
Health status	4.00**
Medicare	0.32
Medicaid	0.04

*** significant at 1%, ** significant at 5%, * significant at 10%

Table 5 Generalized ordered logit model: Dependent variable: Disease status

	Coefficients	OR[c]
Age	-0.11[***]	1.11
Female	-0.02[a]	1.01
	0.79[b**]	0.45
Married	1.06	0.34
Race	-0.03[a]	1.03
	0.54[b]	0.58
Education	0.10[*]	0.90
Bodyweight	0.03[***]	0.97
APOE-e4	-1.01[*]	2.74
Physical Activity	-0.09[a]	1.09
	0.50[b**]	0.60
Moderate drinking	0.96[***]	0.38
Current smoking	-0.06[a*]	1.06
	0.09[b**]	0.90
Heart disease	0.13[a]	0.88
	-0.21[b]	1.23
Stroke	-0.88[***]	2.94
Hypertension	0.15	0.86
Diabetes	0.12	0.87
Health status	0.25[a]	0.76
	0.63[b***]	0.53
Wealth	0.00	1.00
Social network	0.50[*]	0.60
Medicare	0.03	0.97
Medicaid	-0.57[*]	1.76
Constant	5.56[a***]	0.00
	3.13[b]	0.04
LR test statistic=269.42[***], N=798, Pseudo R^2=0.21		

Dependent variable coding: 1=dementia, 2=CIND, 3=normal. For variables that violate the proportional odds assumption: [a]coefficients for dementia versus the combined outcome of CIND and normal; [b]coefficient for combined outcome of dementia and CIND versus normal. *** Significant at 1%,**significant at 5%, * significant at 10%. [c] In ordered logistic regression, an unit increase in covariate, x, results in the change in the odds of an outcome by the factor of exp(-β), holding all other variables constant (Long, 1997, p.139)

Figure 2
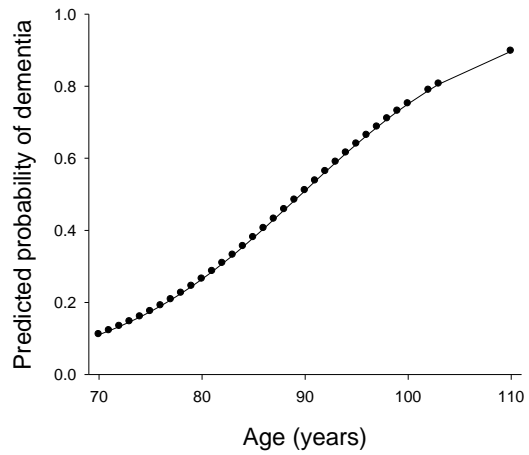Change in the predicted probability of dementia with age

Figure 3
Change in the predicted probability of dementia with education
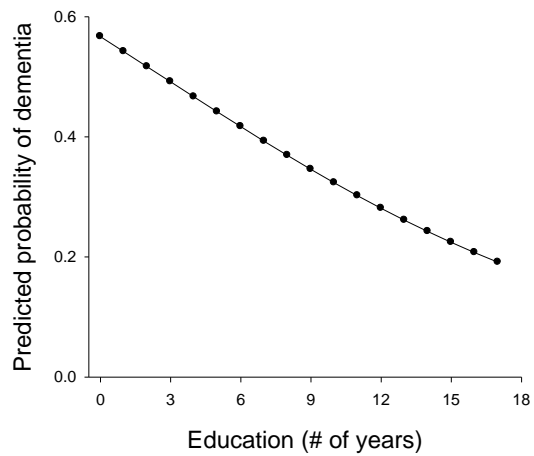
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CHAPTER FOUR

Altruism and Dementia Caregiving: Implications for Long-term Care Decisions

Abstract.

Informal care is an important source of long-term care (LTC) for persons with dementia. Using the Aging Demographic and Memory Study (ADAMS) dataset this study analyzes a sequence of individual characteristics of patients and their family caregivers that jointly predict the amount of informal and formal health care received by individuals with dementia in the U.S. We find that a measure of 'altruism' is positively associated with the level of informal care and delays institutionalization, but the burdens of caregiving have positive impact on the use of formal home health care services. We also find evidence that a caregiver's living arrangement choice increases the level of informal care while decreases the use of formal care services. The findings have profound social and health implications for expanding the publicly funded LTC needs for individuals with dementia in this country.

1. *Introduction*

The most dramatic change in the structure of the US population over last quarter century is the growing number of older persons, both in absolute numbers and percentage in the total population (Center for Disease Control, MMWR preview, 2003). According to the 2000 Census estimates, the elderly population (aged 65 and older) is expected to double from about 35 million to more than 70 million by 2030. With rising number of elderly in the US population there is a marked increase in the prevalence and incidence of dementia and other neurodegenerative diseases.[32] The most common type of dementia is Alzheimer's disease (AD), a progressive, debilitating and irreversible neurodegenerative disease. AD accounts for 60 to 80 percent of all dementia cases (Alzheimer's Association: Facts and Figure, 2008). According to the Aging Demographic and Memory Study (ADAMS), the prevalence of dementia among individuals aged 71 and above was 13.9% and the corresponding number for Alzheimer's disease was 9.7% in 2002 (Langa et al.; 2002).

Most people with dementia live at home, with informal help from family and friends. A primary informal caregiver[33] is responsible for day-to-day decision making and provision of care to the individual with dementia (Herbert et al., 2001). Understanding the factors that determine

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[32]Dementia is defined as acquired deterioration of memory and cognitive functions that impairs a person's ability to perform independent function of daily living. These functional limitations impose substantial burden on individuals, families and health care system. Cognitive Impairment Not Demented (CIND) is a transitional state between normal aging and dementia (Larrieu et al.; 2002). There is a prodormal phase during which individual's daily normal activities are impaired, yet the changes in cognition are insufficient to classify as dementia. But studies have shown that persons with CIND are at an increased risk of developing AD in future (Yuek at al; 2008, Yuek et al; 2006). The Cardiovascular Health Study of Cognition estimates a CIND prevalence rate of 22% among individuals of age 75 and above (Lopez et al., 2003).

[33]The primary informal caregiver is defined as anybody with primary responsibility for providing unpaid help for the care recipient within a social environment simply because the care recipient is unable to independently perform daily activities.

the use of formal health care services and the provision of informal care is important for predicting that use and formulating long-term care policy. Using the ADAMS dataset this study analyzes a framework of *predisposing*, *enabling* and *need* factors influencing the amount of informal and different types of formal health care services utilized by individuals with dementia. *Predisposing* factors are defined by demographic and social characteristics that affect a person's inclination to use the services, *enabling* factors facilitate or inhibit the access to health care services once need is perceived and finally, *need* factors are defined by the severity of the illness.

Informal caregivers spend significant amounts of time providing care for individuals with dementia and cognitive impairments due to progressive functional limitations and loss of independent functions (Langa et al., 2002). In 2008, 9.9 million unpaid caregivers provided 8.5 billion hours of informal care to individuals with AD and other types of dementias (ALZ Association: Facts and Figures, 2009). The economic value of this unpaid care is estimated at $94 billion[34] in 2008. As the prevalence of AD dramatically increases,[35] the scope of informal care and its importance to society and the health care system will continue to increase, as will the interest of researchers and policy makers alike.

Although the majority of care given to dementia patients is informal care, those suffering from dementia have a higher frequency of using formal health care services than normal Medicare beneficiaries and cost Medicare thrice as much (ALZ Association: Facts and Figures, 2009). Family members who provide the bulk of care for impaired elders are likely to determine

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[34] This number represents 8.5 billion hours of care valued at $11.10 per hour, which is the average of the minimum wage ($5.85 per hour) and the average wage of a home health aide in July 2008 ($16.35 per hour). This method is similar to what Arno et al. (1999) used in estimating economic value of informal caregiving.
[35] By 2050, the number of individuals age 65 and older with AD would approximately be 14 million, compared to 4.5 million in 2000(Hebert et al., 2003).

the elder's use of formal health care services (Bass & Noelkar, 1987). Therefore, the decision on the use of both cares, often times, is made jointly.

The remainder of this paper is organized as follows. The next section briefly discusses the existing literature on determinants of informal care and the use of formal care services and the relationship between these two types of care. Section 3 discusses the conceptual framework to explain the optimum decision problem of a family caregiver in making decisions regarding informal and various formal care services. Section 4 provides a description of the ADAMS data and the variables used in the empirical model. Section 5 explains the empirical model and discusses econometric issues. Section 6 represents important results. Finally section 7 highlights some important policy implications and concludes the paper.

2. Literature Review

The conceptual framework developed by Anderson and his colleague (Anderson and Aday 1978) explains how the individual determinants influence different types of formal care utilizations. But Anderson's model fails to acknowledge the importance of informal care services for older people. The conceptual expansion of Anderson framework was extended by Bass and Noelkar (1987) to include *predisposing*, *enabling* and *need* characteristics of both primary caregivers and elder care recipient. However they focus on only formal in home services and ignore the use of nursing home care, another form of long-term care service.

A variety of studies provide mixed evidence of the relationship between informal support by family member and the use of formal care services. Important factors underlying this relationship include individual determinants that influence the decision of how much of each type of care to use. Most of the literature (Bolin et al. 2008; Van Houtven & Norton 2004; Charles & Sevak 2005,Lo Sasso and Johnson, 2002) explaining the relationship between

informal and formal care examine the level of formal care use assuming a fixed level of informal care supplied by adult children. In addition, they predominantly ignore the influence of caregiver characteristics on the choice of formal care and consider only the patient characteristics. But Gauler et. al. (2000) finds that caregiver characteristics influence both types of care given to dementia patients when the decision is made by a caregiver.

Other studies (Langa et al., 2001; Liu et al., 2004) found that socioeconomic factors also impact care decisions, finding that more paid home care is associated with greater social support. Meanwhile changes in home health care policy shifted the distribution of paid care services towards elderly living with their children. Van Houtven & Norton (2004) and Bolin et al. (2008) found that informal care is a substitute to nursing home entry and formal home health care services.

Although a significant portion of informal care is provided by spouse or other family members or friends[36] most studies restrict the analysis of informal care giving to that provided by adult children. But there is evidence that who provides the care depends on who is receiving the care and why the care is needed. Adult children play the dominant role in the care of disabled women whereas wives play a more important role in the care of disabled men (Langa et al., 2001). Dementia caregivers are more likely than nondementia caregivers to be a spouse (R.Schulz,, 2000). Therefore restricting informal caregiving only to adult children may not truly uncover the effect of the caregiver level determinants on both types of cares.

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[36] Family Caregiver Alliance,(2000) reports more than 50% informal caregivers are spouse or other family members or friends.

3. Conceptual Model

Our conceptual model of caregiving focuses on how an informal caregiver chooses the mix of (purchased) formal health care services and informal care. We assume that the patient's well-being contributes to the caregiver's satisfaction when giving care (Wolf et al., 2001).

A representative caregiver chooses the amount of the informal care, t_{ic}, the hours spent on leisure, t_l and amount of formal care, F, to maximize her own utility,

$$U = U^c(C, t_l, h^p(t_{ic}, F; x)) + \gamma * t_{ic} \qquad (1)$$

We assume that the caregiver gets utility if any given care, formal or informal, improves the patient's health status, h^p (a function of t_{ic} and F) given the patient's characteristics, x which would include innate health, for example, fragility that does not depend on the amount of care received. In addition a highly *altruistic*[37] caregiver enjoys providing informal care. The degree of altruism is denoted in the additive term $\gamma * t_{ic}$ in the utility function (Fevang et al., 2008). The utility function of the caregiver (U^{ic}) is an increasing a strictly *quasi*-concave function and well-behaved only locally. The function satisfies the first-order conditions for maximization and the second order condition is ensured by the negative definiteness of the Hessian matrix. Similarly the patient's health production function is assumed to be a strictly concave function where the marginal products of health with respect to formal care and informal care are positive ($h_F^p > 0, h_{tic}^p > 0$) and the health increases at a decreasing rate as formal care and informal care are increased ($h_{FF}^p < 0, h_{tictic}^p < 0$). Moreover, the marginal benefit of formal care responds with respect to changes in informal care (i.e. positive cross-partial derivatives ($\partial^2 h^p / \partial t_{ic} \partial F > 0$) is

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[37] In this study altruism is defined as a caregiver derives utility from a patient's health. A highly altruistic caregiver receives direct utility from giving care which is captured by the additive term in the utility function.

positive. The parameter γ indicates the degree of altruism on the part of the caregiver. It is assumed to be positive with a possibility of being zero. It is useful to further clarify the rationale behind this assumption. If γ is positive, then the caregiver is assumed to be highly altruistic and gets specific pleasure from giving care. However, if γ=0, the caregiver gets no direct pleasure from providing care although does find her utility influenced by the health status of the patient. This assumption allows us to examine how the degree of altruism influences the level of informal care and various types of formal care services. Furthermore, one would expect a positive effect of γ on the level of informal care provided per month, because the survey question was focused towards caregivers' feelings about providing informal care. All decisions are made by the caregiver (the ill person is considered as passive recipient of caregiver's care). Labor income, earned at rate of w per unit of time spent in labor (t_{ls}), and other (nonlabor) income (y_0)are spent on formal care and consumption (C) giving a budget constraint of

$$C + p_f F = wt_{ls} + y_0 \qquad (2)$$

Total time is restricted as:

$$T = t_{ls} + t_l + t_{ic} \qquad (3)$$

Equations (2) and (3) can be combined to get the total income constraint

$$C + p_f F = w(T - t_{ic} - t_l) + y_0 \qquad (4)$$

The right hand side of (4) is the total income (nonlabor plus labor) of a representative caregiver and the left hand side is the total expenditure spent on consumption and formal care. We assume that patient characteristics enter into the problem through the health status equation, especially K, while caregiver characteristics help determine the functional form U^{ic}.

The Lagrange function for this optimization;

$$L = U = U^{ic}(C, t_l, h^p(t_{ic}, F) \mid K) + \gamma * t_{ic} + \lambda[p_f F + C + w(t_{ic} + t_l) - wT - y_0] \qquad (5)$$

gives the following first order conditions for maximization:

$$L_{t_{ic}} = (\frac{\partial U^{ic}}{\partial h^p} \frac{\partial h^p}{\partial t_{ic}}) + \gamma + \lambda w = 0 \qquad (6)$$

$$L_F = (\frac{\partial U^{ic}}{\partial h^p} \frac{\partial h^p}{\partial F}) + \lambda p_f = 0 \qquad (7)$$

$$L_{t_l} = \frac{\partial U^{ic}}{\partial t_l} + \lambda w = 0 \qquad (8)$$

$$L_\lambda = p_f F + C + wt_{ic} + wt_l - wT - y_o = 0 \qquad (9)$$

Solving the first-order conditions (6)-(9) would give the demands for informal care provided and formal care purchased from the market at the optimum in terms of exogenous variables and other parameters in the model.

Combining the marginal conditions (6) and (7) we derive

$$\frac{\dfrac{\partial U^{ic}}{\partial h^p} \dfrac{\partial h^p}{\partial t_{ic}} + \gamma}{\dfrac{\partial U^{ic}}{\partial h^p} \dfrac{\partial h^p}{\partial F}} = \frac{w}{p_f} \qquad (10)$$

Rearranging,

$$\frac{w}{p_f}(\frac{\partial U^{ic}}{\partial h^p} \frac{\partial h^p}{\partial F}) = (\frac{\partial U^{ic}}{\partial h^p} \frac{\partial h^p}{\partial t_{ic}}) + \gamma \qquad (11)$$

Equation (11) indicates that the optimal choice of t_{ic} and F will change depending if γ is positive or zero. It also indicates that when $\gamma = 0$, the usual marginal condition holds i.e. marginal utility per unit price of formal care is equal to marginal utility per unit price of informal care. When $\gamma = 1$, that is if a caregiver is highly altruistic, then the marginal utility of buying an hour of formal care must equal the marginal utility of an hour of informal care plus the degree of altruism at the margin. Given the fact that patient characteristics 'x' enter through the health

status function in equation (1) and caregiver's characteristics (z) that enter into the parameter γ in the utility function, the optimal levels of t_{ic} and F can be found by solving (6)-(9) and expressed generally as

$$t_{ic}^* = f(\gamma, p_f, x, z) \tag{12}$$

and

$$F^* = g(\gamma, p_f, x, z) \tag{13}$$

Where γ is the caregiver's altruistic attitude towards providing care and x and z are the vector of patient and caregiver characteristics including income, respectively, which, as we noted above, are classified into *predisposing*, *enabling,* and *need* factors, p_f is the price of formal care services. In general, the reduced forms do not separately identify elements relating to the utility function and the health production function (Contoyannis & Jones, 2004), unless the optimization is separable in terms of the choice variables. .The above linear demand system (equations 12 and 13) pertains to the existence of a well-behaved utility function (increasing and strictly quasi-concave, only locally). The demand equations derived above are assumed to be locally linear in a well defined range, as for all practical purposes it is sufficient that linearity is preserved only locally (Alperovich and Weksler, 1996).

4. *Data Description*

In this study, we use data from the Aging Demographics and Memory Study (ADAMS) to examine the impact of patient and caregiver characteristics on the use of informal and different types of formal care services among individuals with dementia in the U.S. The ADAMS is a cross-sectional study of a stratified random sample of 1,770 individuals of age 70 and above, selected from the Health and Retirement Survey, (HRS-2000 wave) based on the self-

or-proxy reported cognition score. The ADAMS phase-1 assessment occurred between July 2001 and December 2003 and clinical assessments tests were performed on 856 respondents (56% of nondeceased target sample). The ADAMS follow-up assessment, phase 2 (between November 2002 and March 2005) was completed for 252 subjects for whom reassessment would be useful to know the severity of dementia. The sample is the first nationally representative sample of individuals with dementia and other cognitive impairments in this country Full details of the ADAMS sample design and selection methods are described in other studies (Langa et al.; 2005, Plassman et al.; 2007).

An important feature of the ADAMS is its in-depth information about informal caregiving, utilizations of formal health care services, and socio-economic and demographic information that help in predicting the demand for formal health care services and informal care in future years. Linking the ADAMS to the expansive longitudinal HRS data on health, health care utilization, informal care and economic resources and behavior provides a unique opportunity to study factors influencing the demand for informal care and various types of formal care utilization in future years. The linked HRS-ADAMS data also facilitates in formulating public policies to extend the access to long-term care needs available to individuals with dementia and to improve lives of dementia caregivers in this country.

At the respondent level the ADAMS provides information on patients' limitations of independent functions of daily living,[38] utilization of formal health care services, including nursing home stays, inpatient hospital stays, home health care services and physician visits,

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[38]Independent functions of daily living are measured by difficulties with Activity of Daily Living (ADL) and Instrumental Activity of Daily Living (IADL). ADLs are measured in the following areas: problems with bathing, eating, dressing, getting across the room, toileting and getting out of bed. IADLs are measured in 5 categories: problems with preparing meals, grocery shopping, making phone calls, managing money and taking medications. While ADls are necessary for fundamental functioning (as defined by the above), IADLs are not necessary for fundamental functioning but enable individuals to live independently within a community.

patient's demographic and socioeconomic characteristics. At the caregiver level, the ADAMS includes information on caregivers' demographics, positive and negative experiences of informal caregiving, and changes in living arrangement that gives a comprehensive picture of a family's provision of informal care associated with CIND and dementia. In addition, the ADAMS also provides extensive information about caregivers' stress and strain, depression and other activity restrictions because of the caregiving responsibility, which are important in predicting patients' use of formal health care services.

4.1 Variable Description

It is useful at this point to further clarify the *predisposing*, *enabling* and *need* factors of both the impaired person and the caregiver. The use of health care services is dependent on, first, the predisposition of the individual as suggested by demographic and social characteristics and beliefs about health services.[39] These factors are known as *predisposing* variables. *Enabling* factors measure abilities that individuals have for the use of health services. The patient's state of illness (both self-perceived and evaluated) determines the *need* variables.

The *predisposing* variables include socio-demographic characteristics and health related attitudes that predict the use of formal care services as well as informal care (Anderson & Aday; 1978, Bass & Noelker, 1987). These factors are age, gender, race, and beliefs about the health care utilizations. The *enabling* factors include the characteristics of care recipient and caregiver that refer to the resources that promote or inhibit the access to use the services. Often some of these factors are found to be common for the impaired person and the caregiver. One of the most important *enabling* factors is identified by the availability of immediate family members. The empirical analysis uses whether the person is married or not. It can be expected that married

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[39] Health beliefs are attitudes, values, knowledge that individuals have about health and health care services that affect their subsequent perceptions of 'need' and the use of health services (Anderson, 1995).

people would be more likely to receive informal care from their spouses or other family members that enable them to remain in home for longer period (Lo Sosso & Jonson, 2002).

Another important enabling factor is whether the caregiver lives in the same household with the patient as it influences the level of informal care as well as the use of formal health care services (Greene 1983, Bass & Noelkar 1986). The living arrangement decision may be endogenous to the caregiving decision if a caregiver jointly determines the amount of informal care used and living arrangement. In this study we assume these two decisions are separate. The implication of this assumption is that the living arrangement decision is not influenced by the informal care decision. Because the informal care and living arrangement are not determined simultaneously, any factor that affects informal care hour does not affect the living arrangement choice. Here the direction of the association can be ascribed from living arrangement variable to the provision of informal care, not the opposite. Intuitively, this assumption can be valid because for adult children and other family caregivers[40], the living arrangement decision is a joint family decision (based on caregivers' financial and non-financial ties, family financial resources, career choice, time and other family commitments) that can be independent of whether or how much care an adult child needs to provide. However, there can be some possible scenarios that may invalidate this assumption. For example, adult children may view parents as having greater needs of care that would best be served by living in the same household. Therefore, he/she may change living decision (move to the same household) to facilitate care arrangements. Because this scenario can be theoretically possible, it is important to validate the assumption for empirical estimation, otherwise there may be a bias in the estimated effect of living arrangement variable

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[40] For spouse caregivers living arrangement most likely is not a decision.

on the provision of informal care. In other words, we need to examine the validity of this assumption (i.e. living arrangement, is exogenous or not).

There are essentially two important issues that need to be examined: *first*, the validity of the exogeneity assumption of the living arrangement variable and *second,* the validity of the orthogonality assumption of the instruments[41] used in testing the exogeneity of the living arrangement variable. Instruments should be correlated with living arrangement variable but uncorrelated with the error term. To address the *first issue* the Hausman (1978) test was performed. This is a regression based test suggested by Hausman (1978, 1983). The null hypothesis of this test is that the living arrangement variable is exogenous. Then the test was performed by regressing potential endogenous variable (living arrangement) on all other exogenous variables and the instruments and in the second step informal care hour was regressed on the vector of other exogenous variables including the endogenous variable and the residual from the first stage regression. Testing the significance of the residual indicates the rejection or failing to rejection of the null hypothesis. Based on the test result (F=0.34 with a p-value of 0.63), we don't have sufficient evidence to conclusively reject the possibility that the living arrangement variable is exogenous. This could be due to lack of the power of the test.

To address the *second issue* whether instruments (mentioned above) are orthogonal to the error term we performed the Over-identification test (OID) as the validity of the Hausman test depends on the maintained assumption about the instrument's orthogonality. The OID test can be performed when the number of excluded instruments exceeds the number of included endogenous variables in the model. Here the OID test is performed using two instruments for

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[41] The instrument used for 'living' together variable is 'things that a caregiver does prevent patients from getting worse'. This has found to be highly correlated with the endogenous variable, but not correlated to the outcome variable. For the OID test I used patients' education in addition to this instrument.

this single potential endogenous variable. The null hypothesis of the OID test is that instruments are orthogonal to the error term. The test statistic is known as Sargan's statistic and has an nR^2 form (Wooldridge, 2002, page 123). The test statistic can be easily calculated by regressing IV equation's residual on all instruments, both the included exogenous variables and instruments (those don't appear in the structural equation) and get the R^2 value (Baum and Schaffer, 2003). Under the null hypothesis the test statistic has χ^2 distribution with K-1 degrees of freedom, where K is the number of instruments used. The test generated a $\chi^2(1)$ statistic of 0.05 implying that the null hypothesis of orthogonality of instruments could not be rejected at any conventional level of significance. Failing to rejection of the null hypothesis indicates that there is not enough evidence to reject that the instruments are uncorrelated to the error term while used in the Hausman test. However, the OID test can lead to a substantial over-rejection of the null hypothesis (Hahn & Hausman, 2005), if the correlation between instruments and the potential endogenous variable is weak. This may inflate the actual size of the test compared to the nominal size.

The usefulness of the Hausman test is that if we fail to reject the null we can have some confidence on the instruments used given that the instruments satisfy the orthogonality assumption. Although the Hausman (1978) test is widely used to test the endogeneity of explanatory variables in a regression, the test statistic may be undefined (or can have negative value) in small sample.

There are other *enabling* factors that are unique to patients and caregivers- for example, a caregiver's education level can be a proxy for knowledge of services, whereas a patient's education level influences formal service use. In the empirical analysis only a caregiver's

education level is considered as an *enabling* factor, as she/he is responsible for making the decision on both types of care.

The final set of *enabling* factors include the price of formal care, family wealth and caregiver's income level that affect the access to formal care services. We use the availability of Medicaid as a proxy for price (Kemper, 1992), although this is a poor proxy for formal home care because Medicaid covers little of that type of cost. We believe that formal care is a normal good, hence higher family wealth is expected to increase the use of more formal care as is a caregiver with higher income.

At the patient level, the *need* factors are severity of illness or impairment (ADL, IADL). It is reasonable to expect that the amount of care required is positively correlated with the severity of a patient's impairments, including the patient's judgment-making capacity and impulsive behavior which are usually impaired in a person with dementia. In the empirical model these latter impairments are captured by the variable indicating 'need for supervision'. Caregiver *need* factors include physical and emotional stress or strain associated with caregiving, a change in perceived health status[42] resulting directly from the caregiving. The stressful effects of caregiving are exacerbated when the elder person is cognitively impaired, emotionally disturbed, incontinent and immobile and has multiple and severe functional limitations (Noelkar 1984). Moreover, these negative effects may influence (directly or indirectly) the need for formal health care services.

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[42] This is measured by whether a caregiver reported a reduced level of physical exercise, getting less sleep or rest and having less time to visit a doctor.

5 Empirical Method and Specification

The theoretical model has laid the foundation for the empirical specification and the estimation method. Both informal and formal cares are jointly determined based on a single optimizing decision by the caregiver. When the optimization problem is not separable[43] in terms of the objective functions and constraints, then the reduced form equations for those choice variables share the same set of exogenous variables. In our case the optimization problem is nonseparable in the choice of informal and formal care because of the budget constraint and therefore the reduced-form equations of both informal and formal care share the same set of regressors[44]. In the empirical model two linear reduced form equations (one for informal care equation 12) and the other for formal care equation 13) are estimated given patients and caregivers characteristics and other exogenous factors (e.g. Contoyannis & Jones, 2004, Alves &Belluzzo, 2004, Rosenzweig &Schultz, 1983). These two reduced form equations are estimated as a system of equations using the Seemingly Unrelated Regression (SUR) method.

A simple demand-supply simultaneous equation problem helps to understand the specific empirical technique used to estimate the above system of equations. In a simple demand-supply model simultaneity problem is arising since the two decision makers are choosing the quantity demanded (Q_d) and quantity supplied (Q_s) based on the decision of the other. Let's consider the following simple system of demand and supply model:

$$Q_d = \alpha_1 P + \alpha_2 y + \varepsilon_d \qquad (14)$$

$$Q_s = \beta_1 P + \varepsilon_s \qquad (15)$$

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[43] The optimization problem is called separable when both the objective function and constraints are separable. In this model constraints are not separable in terms of t_{ic} and F. Therefore, at the optimum, values of t_{ic} and F will depend on same exogenous variables and other parameters in the model.

[44] Two regression models are estimated for formal care use: formal home health care and institutional care(combined use of nursing home care and hospital care).

At the equilibrium demand and supply jointly determine the equilibrium price (p) and quantity (q). In this case because p and q are determined based on the decision of the other, they would be econometrically endogenous to each other. This simultaneity problem is solved by recovering the structural parameters in terms of information contained in the reduced form parameters. This in turn depends on the identification of the structural equations. The identification of the structural equations is performed by exclusion restrictions (i.e. comparing the number of excluded exogenous variables from the equation with the number of included endogenous variables in that equation) and the estimation is performed based on the nature of identification. For example, if an equation is overidentified, instrumental variable method using two-stage least square (2SLS) technique can be performed to obtain consistent estimates. The 2SLS technique is implemented by using proper instruments where instruments for endogenous variables that must be uncorrelated with the error term but strongly correlated with the endogenous variable.

In our model, both t_{ic} and F are jointly determined based on a single optimization decision thus SUR is an appropriate estimation technique (because both are the choice variables of a single optimization problem, they are not econometrically endogenous). We are trying to explain what determines the (joint) choice of t_{ic} and F and it depends on all the exogenous factors and other parameter in the model. Therefore it is clear from the above discussion how our problem is different from the linear simultaneous equation problem. Also since the optimization problem is not separable in the choice of t_{ic} and F, both equations (12) and (13) share the same set of regressors which indicates that there is no excluded variable from these equations (Fevang et. al., 2008).

5.1 Dependent Variables

Our outcome variables of interests are the amounts of informal care hours provided in each month and the number of units of different types of formal care services used monthly during the twelve months preceding the survey.

Caregivers provide informal care because of functional limitations in daily living activities due to cognitive impairments. Additional care is provided for supervision and transportation due to behavioral problems associated with dementia (Langa et al.; 2001) and ensuring patient safety. We consider informal care as the total time spent on active care, supervision and transportation per month.[45] To reduce skewness we used the log of total informal care hours provided per month[46] as the dependent variable. On an average 195 hours of informal care was provided per month for active care, supervision, and transportation. Because some caregivers answered one but not both of the questions, a bracketed variable is created for those missing cases (10) based on assumptions about the intensity of care-giving per day for dementia and impaired persons (Langa et al.; 2001). Based on national estimates of quantity of informal care for individuals with dementia, 27 hours per week or 4 hours per day was assigned for those 10 cases (Langa et al.; 2001). The analysis was re-run without those 10 cases and no significant change was found.[47] Formal care utilization is measured by two separate variables;- (1) the natural log of nights in a nursing home or hospital[48], and (2) the number of formal home

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[45] The survey questions were phrased as follows: "how many days in the last month did you provide active care, supervision and transportation?" and "days that you provide care, how many hours per day?"

[46] We Considered log of (1+ informal care hours per month), and same for formal care utilizations which is consistent with the existing literature (Bolin et al.; 2008, Van Houtven &Norton; 2004, Sasso& Johnson; 2002).

[47] Informal care hours are missing for 5% of the cases. The Heckman (1979) model is used to examine sample selection bias and no evidence of sample selection bias is found due to missing observations of informal care hours.

[48] The use of nursing home care and hospital care is essentially the same for dementia patients except one is for short term care and the other is for long term, we combined these two formal care utilization levels by combining the number of nights a patient spent in nursing home or in hospital during the twelve months preceding the survey and labeled it as 'institutional care'. To reduce skewness, we used log of the total number of nights spent in nursing

health care services used (as described above in the discussion of ADL and IADL needs). On an average, respondents spent 72 nights in a nursing home or hospital and used 1.35 specific formal home health care services.

5.2 Independent variables

The patient level demographics include patient age, gender, education, ethnic background and marital status. The average age of a typical patient is 85 years and has less than a high school education. Twenty-eight percent of the patients are married and 63% are female, 69% are Caucasians, 20% are African American, and 11% are Hispanic.

About 75 % of the sample members needed assistance with ADL and 90% needed help with IADL.[49] Seventy-one percent needed both type of help. Health insurance characteristics reflect the universal coverage by Medicare with 96 % of patients receiving Medicare and about 27% received Medicaid. About 25% received both Medicare and Medicaid. Only 5% of the patients had long term care insurance.

Caregivers averaged 61 years of age and had more than a high school education. About 73% were female. Over one-half of the caregivers were adult children (51%), 22% were spouses and 27% were friends and other family members. About 40% of the caregivers worked for pay and average earning per year is $10,008.[50] The caregiver's racial composition includes 70% Caucasians, 30% African American or others and 12% Hispanic. About 50% of the caregivers live with the patient in same household. On an average caregiver reported having good health

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home or in hospital during the same period. Therefore, institutional care=log of (1+number of nights spent in nursing home +number of nights spent in hospital).

[49] ADL and IADL are measured by the number of distinct activities for which assistance is needed. The typical patient needing help with ADL needed help with 3.5 specific activities. For IADL this number averaged 4.2 specific activities.

[50] This number represents average income of all caregivers including those didn't work due to the caregiving responsibility. Such a low average earning indicates indirect cost (productivity loss) associated with dementia. The average earnings of those only worked last year is $24, 450.

status, although 58% reported emotional stress in the caregiving process, and 57% reported reduced level of physical exercise due to their caregiving responsibility. We present means, standard deviations, and ranges of all demographic, socioeconomic and health data of our study sample in Table1.

6. Results and Discussion

Since equations (12) and (13) share the same set of regressors there is no gain in efficiency by estimating equations as a system as opposed to estimating equations separately using ordinary least squares. We estimate three equations – one for informal care and two for different types of formal care, home health and institutional care, which includes both nursing home and hospital care.[51] Results are given in Table 2. Overall the model fit is quite good for cross-section data on individuals, with R^2 values of 41%, 44%, and 53% respectively. The F-tests indicate that the independent variables are jointly significant with extremely low p-values.

6.1 Predictive factors of Informal care[52]

Although the independent variables are jointly significant with a very low p-value, only 6 variables individually are significant with a p-value of .1 or better. The result shows that married patients receive a higher level of informal support than single, never married, separated or widowed patients. Living with a caregiver increases the amount of informal care hours provided per month. This result is in agreement with the findings that Pezzin et al. (1995) observed among the disabled elderly from the Channeling experiment study in the U.S. The need for supervision shows a positive impact on informal care hour provided per month. This supports

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[51] Preliminary analysis which separated nursing home and hospital care produced the same qualitative results and similar quantitative results. Hence, they were combined into a single regression for further analysis.
[52] Because the focus of the paper is on altruism, the discussion of that variable for all three equations is left for a separate section. We first discuss the other variables in the models.

one of the recommendations that the Advisory Panel (Advisory Panel on Alzheimer's disease, 1991) offered in order to extend the LTC needs for people with dementia in this country. Finally, informal care provision is significantly higher among patients having bladder incontinence. These findings are similar to Bonsang (2008) who observed that the level of disability of the elderly person was a significant predictor of informal care use.

Whites provide significantly less informal care compared to non-Whites. Roff et al. (2004), however, attributed more informal care among African Americans to a stronger commitment to their religions. However, our findings show that whites give less care than all other racial groups so this explanation may not apply here.

Caregivers' physical stress is associated with the higher level of informal care help. This result is a bit counterintuitive, as one would expect that having physical stress in the caregiving would reduce the amount of informal care provided. However, a strong collinearity between female and physical stress may confound this effect, as female caregivers generally report more stress compared to male caregivers. But this is not the case here as these two variables do not appear to be strongly correlated. The correlation coefficient between these two variables is found to be 0.09, which is fairly low for variables considered collinear to each other. This may be a potential problem of reverse causality that means the direction of causation could be happening from physical stress to informal care or vice-versa. This is hard to solve using the cross section data like the ADAMS, because of the difficulty of finding valid instrument for this variable. Only panel data would offer potential solution to this problem because of repeated observations for each individual in the sample. However, we include caregivers' stress because our aim is to examine the impact of caregiving burden (measured by a caregiver's physical and emotional stress) on the use of formal health care services.

6.2 Paid home health care

The estimation for Home Health care explains about 44 percent of the variable between patients, and is significant with a 0.01 p-value. Several of the variables were highly significant. The Patients' Age has a positive impact on the use of paid home health care help. This agrees with what Bonsang (2008) observed among the disabled elderly in Europe. Non-White patients rely significantly less on formal paid health care help than Whites. This is consistent with the result that Kemper (1992) found among the disabled elderly using the Channeling experiment survey data in the U.S. Among the *enabling* factors, patients sharing households with caregivers use less number of paid domestic care services. This is also in agreement with what Bonsang (2008) found in Europe.

There is also a positive and significant relationship between the need for supervision and the number of paid domestic help. This result supports one of the Panel's recommendations that the LTC eligibility criteria should be based on measures of impaired functioning that are characteristics of people with dementia. One such measure is the need for supervision where the degree of cognitive impairments interferes with patients' independent functioning. The use of paid home care services is significantly less among patients with good health status.

Female caregivers' use less paid home care services than do male caregivers. Spouses and adult children (shown by the variable Relation) significantly use less formal home care services than other family members or friends. Finally, if a caregiver feels emotional stress there is a statistically significantly increase in the use of paid home health care services.

6.3 Institutional Care

Among the predisposing characteristics, non-White patients use significantly less institutional care than Whites. Several *enabling* factors are found statistically significant in the

equation explaining the use of institutional care among dementia patients. First, wealthier patients use more institutional care. Moreover, the use of institutional care is higher among patients with Medicare. Finally, sharing a household with a caregiver appears to have a negative effect on the quantity of institutional care. This finding agrees with what Greene (1983) found among the elderly in a community based study in the U.S. There are some important *needs* factors that also significantly influence the use of institutional care. The higher number of ADL limitations has a positive impact on the level of institutional care and the need for supervision also increases the utilization of institutional care. Patients with good health status received less institutional care, but a patient's current smoking status has a significant positive impact on the level of institutional care. Caregivers' age significantly increases the use of institutional care.

6.4 Effect of Altruism

Finally, we explain the role of altruistic motivation in predicting the use of informal and formal health care services. A caregiver's altruistic attitude towards providing care has a positive impact on both informal care and domestic paid help care. This result is also consistent with our theory where we assume γ is positive or zero in providing informal care. Because the data on this variable was completely focused on caregivers' feelings about providing informal care, one should definitely expect a positive coefficient on this altruism variable. This means that if a caregiver feels good about providing care, may provide more of it. Moreover, if a caregiver derives specific pleasure from providing care, he/she could delay the institutional care by substituting formal paid care services, if that improves patient's health. The negative coefficient found for this parameter in the equation for institutional care tells us that altruistic caregivers were less likely to institutionalize patients. Schulz et. al.(2004) found a similar result among dementia caregivers in the U.S.

Finally, we can determine (from the estimation results) the optimal amounts of informal and various types of formal care services used by a typical patient given a set of individual characteristics of patients and their caregivers. These are important information that can be used to predict, for example, Medicare cost in the future for hospital and home health care use.

7. *Implications, limitations, and conclusions*

We examined *predisposing*, *enabling* and *need* factors that determine jointly the level of informal care and different types of formal health care services utilized by people with dementia. Our findings indicate a variety of patient and caregiver characteristics are important for predicting the appropriate mix of informal care, utilizations of formal home care and institutional care. We found that patients who lived with caregivers use less formal care services but receive more informal help. This indicates that living arrangement decision is an important factor in estimating future long-term care expenditures attributable to dementia. We also identified how caregivers respond to patients' needs of care, how they perceive the personal impact of the care, how they influence formal care services and finally, how caregiver's overall feelings about providing care influence informal care and patients' use of formal care services. From a policy perspective it is important to know the collective impacts of these individual factors on the utilization of health care services in order to ensure the well-being of both caregivers and care recipients.

This study has limitations that merit discussion. First, because of the cross-sectional nature of the ADAMS data, we are not able to unequivocally establish causal effects; this would require a longitudinal dataset that is currently unavailable in the U.S. Our results are subject to this potential limitation. However, this study provides some important insights to policy makers those who face the challenges in restructuring long-term care policies for dementia patients and

their family caregivers in the U.S. For example, our findings provide strong evidence that the newly proposed caregiver legislation bills[53] need to be passed in order to enhance the well-being of family caregivers and patients in the future years. Second, the estimation of linear demand functions for informal and formal care requires a well-behaved utility function that generates the demand functions in the neighborhood of some points in the interior of the domain of the demand system. However, the assumption that the linearity is preserved *only locally* is the most common and acceptable in the empirical estimation of linear demand functions. This is typical of almost all functional forms. In fact, few of the existing functional forms that have been used to study demand behavior are well-behaved globally. Since this study is the first that provides a comprehensive analysis of factors influencing the use of these both types of care by dementia patients, simple structural relationship would help policy makers, individuals and families in understanding impacts of patients and caregivers characteristics to predict the use of health care services in the future years for better health care planning and policy making. Future study can extend this analysis by estimating a flexible demand system that does not require such restrictive assumptions of the underlying preference.

Future caregiving research can be extended to a dynamic framework of care needs, caregiving roles and outcomes. Specifically, tone issue needing to be examined is how the disease progression interacts with caregiving responsibilities, care needs and the use of formal care services. Moreover, measuring caregivers' outcomes is important to understand caregiving responsibilities and impact of interventions to ameliorate the burden of dementia caregiving.

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[53] Several bills are pending in Congress (March 2009) related to family caregiving in the areas of respite, tax bills, Social security/Medicare/Medicaid enhancements, family leave enhancements and other legislations (http://www.thefamilycaregiver.org/pdfs/updates2009)

From a policy perspective, the issue of eligibility criteria for assessing the long-term care needs is important due to a dramatic increase in dementia prevalence rate in the U.S. This study has important implications for policy makers who want to address that eligibility issue. The strong relationship between the supervision help, a patient's need characteristic, and formal care use (both paid home care and institutional care) confirms that the present eligibility criteria[54] chosen for LTC needs doesn't capture the unique nature of the care needs for people with dementia. This also indicates that the eligibility criteria should focus on the 'supervision need' where the degree of cognitive impairment interferes with a person's judgment in decision making capacity, impulsive behavior and ability to complete ADLs or IADLs without substantial supervision. This supports the *Empowered at Home Act of 2009* that aims to improve state plan options for extending home health care and community based services under the Medicaid program. This would also promote the purchase of "meaningful private long-term care insurance" through the proposed tax breaks for family caregivers.

The above Home Act policy would also expect to lower the economic value of unpaid care (as mentioned in the introduction) as well as indirect business costs due to loss of employment. The hours spent on informal care can be spent on alternative activities, either paid employment or leisure, if the extension of home health and community services helps families to get alternative care. Moreover, as the disease progresses patients require increasing levels of supervision and personal care and caregivers continue to experience high level of stresses that adversely affects caregivers' health. The extension of the Home Act policy perhaps would lower some of these negative health impacts and it would also indirectly lower Medicare expenditures for dementia caregivers (as one third dementia caregivers are also Medicare beneficiaries).

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[54] For both publicly and privately (i.e. third party payer) funded services, eligibility criteria is typically based on functional disability in the specified ADLs (Schulz, 2000).

This study provides strong evidence that supports the development of intervention policies and programs to promote the well being of family caregivers. We indentified some important characteristics of family caregivers that significantly influence patients' use of formal health care services and long-term care decisions. First, we find evidence that a caregiver's emotional stress, an important need characteristic, is positively associated with the higher use of formal paid home care services. This result supports that the new bill, *Elder Caregiver Support and Information Enhancement Act of 2009*[55] regarding additional appropriations for the family caregiver support program under the Older American Act of 1965 needs to be passed in order to provide better support services that family caregivers need. Specifically, *Alzheimer's Family Assistance Act of 2009*[56] would certainly help family caregivers to compensate a part of long-term costs for paid home care services those are not covered by public programs and private insurance. Second, living arrangement choice, an important enabling factor, also advocates for greater social support networks for reducing the stress of family caregivers. Because caregivers those who live with patients experience greater burden and restrictions and the perception of the presence of a strong social support perhaps provides substantial relief of stress that can ultimately reduce caregivers' negative health effects.

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[55] On January 14, 2009, Representative Steve Israel (D-NY) introduced a bill (H.R. 519) to authorize $250 million in funding for the National Family Caregiver Support Program (NFCSP) for each of the Fiscal Years (FY) 2010, 2011, and 2012.

[56] This Act allows (1) a phased-in tax credit ($2000 in 2009, increasing by $500 each year until allowing $3500 in 2012 and thereafter) for family caregivers of spouses and dependents who have long-term care needs; (2) a tax deduction for long-term care insurance premiums; and (3) apply certain consumer protection standards to long-term care insurance contracts.

Table 1. Variables and descriptive of the sample (N=270).

Variable	Description	Mean	SD	Min.	Max.
Independent variables					
Caregiver					
Age	years	61.00	13.79	21	93
Marital status	1, if married	0.70	0.45	0	1
Gender	1, if female	0.73	0.44	0	1
Education	1, if has some college	0.51	0.50	0	1
Race	1, if White	0.70	0.45	0	1
Hispanic	1, if yes	0.12	0.33	0	1
Self-reported health	1, if excellent/very good/ good	0.73	0.45	0	1
Income	income last year	10,008 .00	19,299.00	0	100,000
Relationship	1, if spouse or adult children	0.72	0.45	0	1
Living status	1, if sharing a household with patient	0.50	0.50	0	1
Work status	working for pay	0.40	0.49	0	1
Physical activity	1, if reduced	0.57	0.49	0	1
Feel good	1, if feel good	0.87	0.33	0	1
Physical stress		0.46	0.49	0	1
Emotional stress		0.58	0.49	0	1
Perceived health	1, if change	0.63	0.48	0	1
Patient					
Age	years	85.00	6.75	70	110
Gender	1, if female	0.63	0.48	0	1
Marital status	1, if married	0.28	0.44	0	1
Education	in years	9.10	4.42	0	17
Race	1, if white	0.69	0.46	0	1
Hispanic	1, Hispanic	0.11	0.31	0	1
Self-reported health	1, if excellent/very good/ good	0.44	0.49	0	1
ADL[1]	# of ADL limitations	2.78	2.27	0	6
IADL[2]	# of IADL limitations	3.36	1.80	0	5
ADL-help	Needed help	0.75	0.43	0	1
IADL-help	Needed help	0.90	0.30	0	1
Both	Needed both	0.71	0.45	0	1
Supervision		0.69	0.43	0	1

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[1] Activity of Daily Livings: (6 categories were considered): problems with bathing, eating, dressing, toileting, getting out of bed, getting across the room.
[2] Instrumental Activity of Daily livings (5 categories were considered): problems with preparing meals, grocery/shopping, making telephone calls, taking medications and managing money.

Continued

Variable	Description	Mean	SD	Min.	Max.
Chronic	# of chronic conditions	3.00	1.5	0	6
Medicaid	1, if has Medicaid	0.25	0.43	0	1
Medicare	1, if has Medicare	0.96	0.19	0	1
Long-term	1, if long-term insurance	0.05	0.23	0	1
Wealth	per 10,000 dollar	150.00	276	7	2160
ependent Variables					
Informal care	hours per month	195	204	0	646
Paid home care	number of areas	1.35	1.46	0	6
Institutional care	number of nights				
	during 12 months period	72	130	0	372

Table 2. Factors influence informal care and various types of formal care utilizations (N=270).

Patient's Characteristics

Variables	**IC**	**Home health**	**Institutional care**
	(# of hrs)	(# of areas)	(# of days)
PREDISPOSING			
Age	0.02	0.04***	0.02
Female	0.14	-0.19	-0.29
Non-White	-1.04	-1.02***	-1.04*
Hispanic	-1.19	-1.40	-1.03
ENABLING			
Wealth	0.00	0.00	0.002**
Living	1.44***	-0.67***	-1.80***
Medicare	-0.21	0.46	1.16*
Medicaid	0.01	-0.05	0.36
Married	1.74*	0.29	-0.59
NEED			
ADL	0.07	0.07	0.31***
IADL	0.02	0.08	0.02
Supervision	1.80***	0.52**	0.54*
Health Status	0.49	-0.47**	-0.46*
Incontinence	0.72**	0.32*	0.33
Chronic	0.02	0.03	-0.06
Current			
Smoking	-0.02	-0.13	0.42*
Moderate			
Drinking	-0.64	-0.07	-0.48

***significant at 1%, ** significant at 5%, * significant at 10%

Continued

Caregiver's characteristics

Variables	__IC__	__Home health__	__Institutional care__
	(# of hrs)	(# of areas)	(# of days)
PREDISPOSING			
Age	0.00	0.00	0.03**
Female	0.07	-0.56***	-0.42
White	-1.32**	-0.59	-0.56
Married	0.03	-0.16	-0.19
Relation	-0.16	-0.42*	-0.05
ENABLING			
Education	-0.23	0.07	0.04
Income	0.29	0.11	-0.02
NEED			
Physical stress	1.31***	0.28	-0.23
Emotional stress	0.46	0.51***	-0.14
Health	-0.38	-0.12	0.26
Slowdown	-0.39	0.17	0.35
ALTRUISM			
Feel good	0.80*	0.45*	-0.52
R^2	0.41	0.44	0.53
Adj R^2	0.31	0.34	0.45
F-value	4.02***	4.59***	6.63***

***significant at 1%, ** significant at 5%, * significant at 10%

Appendix.

Cross partial derivates of health production function:

From the first order condition with respect to formal care, F we have

$$L_F = (\frac{\partial U^{ic}}{\partial h^p} \frac{\partial h^p}{\partial F}) + \lambda p_f = 0 \qquad\qquad A_1$$

Rewriting equation A_1,

$$\frac{(\partial U^{ic}(h^p(IC,F)))}{\partial h^p} * \frac{\partial h^p}{\partial F} + \lambda p_f = 0 \qquad\qquad A_2$$

Partially differentiating A_2, with respect to IC gives

$$(\frac{\partial U_h^{ic}}{\partial h^p} \frac{\partial h^p}{\partial IC}) \frac{\partial h^p}{\partial F} + U_h^{ic} \frac{\partial^2 h^p}{\partial F \partial IC} = 0 \qquad\qquad A_3$$

Finally, rearranging A_3 gives the change in the marginal product of formal care with respect to informal care as

$$\frac{\partial^2 h^p}{\partial F \partial IC} = -\frac{\overset{<0}{U_{hh}^{ic}} \overset{>0}{h_{ic}^p h_F^p}}{\underset{>0}{U_h^{ic}}} = \frac{\partial^2 h^p}{\partial IC \partial F} > 0 \qquad\qquad A_4$$

The sign of the cross partial derivate is positive. Utility is assumed to be concave. That is, utility increases at a decreasing rate with health. The marginal benefit of health with respect to informal and formal care is positive. The change in the marginal benefit of formal care with respect to informal care is positive.

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