The Insurance, Health, and Savings Decisions

of Elderly Women Living Alone

Morris A. Davis[1]

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I estimate the parameters of a new dynamic model of the health insurance, health care, and savings decisions to elderly women living alone. In this model, the elderly purchase health care services to learn their current state of health, and, if not healthy, receive treatment that increases their probability of survival. The elderly also completely control their out-of-pocket health care costs through their choices on the use of health care services, the purchase of supplemental Medicare insurance, and, via the Medicaid program, their savings decisions. Simulations of the model suggest that significant changes to the Medicare or Medicaid programs will not reduce the life-expectancy of the elderly: The elderly adjust their assets and insurance in response to Medicare and Medicaid changes, but do not alter their use of health care services.

[1]The author thanks Ken Wolpin for many years of help and encouragement. The author also thanks Teran Martin for assistance. This is a revised version of my dissertation, "The Health and Financial Decisions of the Elderly." The opinions expressed here are those of the authors and not necessarily those of the Board of Governors of the Federal Reserve System or its staff. Please address correspondence to Morris Davis, Federal Reserve Board, mail stop 97, 20th and C Streets NW, Washington DC 20551, USA. Tel: 202 452-3628. Fax: 202 728-5889. Email: *Morris.A.Davis@frb.gov*.

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I estimate the parameters of a new dynamic model of the health insurance, health care, and savings decisions to elderly women living alone. In this model, the elderly purchase health care services to learn their current state of health, and, if not healthy, receive treatment that increases their probability of survival. The elderly also completely control their out-of-pocket health care costs through their choices on the use of health care services, the purchase of supplemental Medicare insurance, and, via the Medicaid program, their savings decisions. Simulations of the model suggest that significant changes to the Medicare or Medicaid programs will not reduce the life-expectancy of the elderly: The elderly adjust their assets and insurance in response to Medicare and Medicaid changes, but do not alter their use of health care services.

1 Introduction

In this paper, I predict how the assets, private health insurance holdings, use of doctor services, and use of nursing homes of the current generation of elderly women living alone will change if the Medicare and Medicaid programs significantly change.

My predictions are based on simulations of a multi-period dynamic model of behavior for this group of elderly women. In this model, each period elderly women living alone choose whether or not to buy supplemental Medicare insurance; decide whether or not to see a doctor to obtain a diagnosis of their current state of health, receiving treatment that increases their survival probability if diagnosed as ill; and, choose whether or not to enter a nursing home for a long-term spell if diagnosed as functionally disabled. They also choose consumption, which along with the cost of their insurance and health care choices, determines their future assets. The elderly receive per-period random utility from consumption and their insurance, doctor, and nursing home choices. Each period, these elderly make the set of decisions that maximize the appropriately discounted expected value of lifetime utility.

The structural parameters of this model are estimated using the AHEAD data set. The estimation procedure allows for unobservable heterogeneity in preferences, survival probabilities, and costs, and thus the sequence of optimal decisions. In the last section of this paper, simulations of the model are performed at counterfactual Medicare and Medicaid policies to predict how the life-expectancy of the elderly will respond if the Medicare and Medicaid programs were to significantly change.

Results. The model is able to fit many features of the insurance, health use, and asset decisions in the data. The ability of the model to fit some aspects of the data relies on unobserved heterogeneity in parameters in the population. Analysis of the parameter estimates also suggest that Medigap purchasers are not adversely selected: The expected cost of care of Medigap purchasers is not higher than the expected cost of care of those insured with only Medicare.

Finally, two simulations of counterfactual Medicare and Medicaid policies suggest that sizable changes to the Medicare and Medicaid programs will not impact the life-expectancy of the elderly. In the first simulation, Medicare and Medicaid cost-sharing is substantially increased but non-price rationing of services is not imposed; in the second, out-of-pocket prices do not change but non-price rationing of the use of health care is imposed for those applying for Medicaid nursing homes or those insured by only Medicare. The largest decline in the life expectancy of the current cohort of 70-year old women living alone from both simulations of different Medicare and Medicaid policies is from 13.43 to 13.40 years.

Previous Literature. A large literature has emerged in the past ten years that studies optimal wealth accumulation and depletion decisions, retirement decisions, and health expenses and outcomes using a dynamic forward-looking framework. A few (but not all) important papers in this literature include Hubbard, Skinner, and Zeldes (1995), Rust and Phelan (1997), Palumbo (1999), French and Jones (2003), Blau and Gilleskie (2005), French (2005), van der Klaauw and Wolpin (2005). The model of this paper is the first that I know of where, in a discrete-choice dynamic forward-looking framework, the elderly can completely control their health expenses: They can spend down their assets so their health care is free (as in Hubbard, Skinner, and Zeldes 1995), they can purchase Medigap insurance to reduce out-of-pocket expenditures, or, they can choose not to use any health care.[2] This is a contribution because it may be important to allow, as a choice, the elderly to consume no health care and incur no health related costs in order to understand the impact of current Medicare and

[2] In the other papers, for example Hubbard, Skinner, and Zeldes (1995), health expenses are stochastic and are drawn from a distribution each period. Khwaja (2005) also has a paper where the elderly can control their health behaviors and costs, but the model does not allow for savings.

Medicaid policies on the health and savings decisions and outcomes observed in the data.

Because elderly women living alone are the focus of this study, the results of this paper may not apply to the entire population of elderly. For theoretical reasons, I focus on these elderly in order to ignore different mortality and health-related probabilities of men and women, bequest motives to surviving spouses (Hong and Rios-Rull 2004), and informal care for a functionally disabled spouse. And, like any model, my model also omits "real world" details that may be important to understand: I do not allow for non-market care of the functionally disabled elderly by a child (Byrne et. al. 2004); I assume the elderly do not have bequest motives to children (DeNardi 2004); and, I assume that the elderly do not consider their housing assets as part of their wealth. Still, the model of this paper is complex, and in many ways, realistic. For example, Medicaid spend-down and reimbursement rules are carefully specified to match current laws. In the next section, the model is detailed. The data are discussed in the third section. The last few sections of the paper discuss the parameter estimates, model fit, policy simulations, and conclusions.

2 Model

Overview. While alive, the elderly make four choices each period. They choose their health insurance coverage, whether or not to see a doctor to learn the state of their health and get treatment if ill, whether or not to enter a nursing home if functionally disabled, and consumption. The elderly receive utility from consumption and random non-pecuniary utility from the choices themselves and maximize the net present value of discounted utility subject to a per-period budget constraint. Due to Medicaid rules, the budget constraint these elderly face each period is a complicated function of their current income and assets, their insurance choice, and their health care choices. The elderly die probabilistically between periods. The probability of survival depends on the state of health, whether treatment was administered if ill, and in the case of nursing homes, if the treatment was administered in a nursing home subsidized by Medicaid.

The elderly in this model are all retired and are assumed to have no outside employment options. They control their assets by consuming either more or less than their fixed real retirement income, subject to a borrowing constraint. The elderly also directly control their health care expenses and, to a lesser extent, their probability of survival. Unlike other models that study consumption behavior at the end of the life-cycle, [3] health expenses are not treated as an exogenous random draw from a distribution. Rather, the elderly can choose not to use any health care, or, they can reduce their out-of-pocket expenses on health services through the choice of their health insurance program as well as through their savings decisions: If their non-housing financial resources are low enough, they may be eligible for Medicaid which provides free health services. Although health states are assumed to transition over time exogenously,[4] the elderly somewhat control their probability of survival by purchasing health care services that increase survival probabilities in certain health states.

The model is complicated and the notation tricky for two reasons. First, the institutional details of the Medicare and Medicaid programs as well as health insurance programs are complicated. These details significantly alter the choice set and payoffs to choices of the elderly, and therefore it may be important to model them accurately. Second, the model is designed with an eye toward estimation. The model must not only be able to reproduce, on average, the choices observed in the estimation sample, but in order to generate a likelihood

[3] See Palumbo (1999) for example.

[4] This is unlike Khwaja (2005), where the elderly can control their health through smoking and other decisions.

it must have the ability to replicate the sequence of choices observed for each elderly person in the sample.

This model will punt on a few important issues. To begin, the elderly in this model have no bequest motives. In estimation, I restrict the sample to elderly women living alone, and therefore do not have to worry about bequests to a surviving spouse (Hong and Rios-Rull 2004). This of course does not rule out bequest motives to children, which could act as insurance against mortality risk (Hurd 1989 and Domeij and Johanneson 2004). I do not include bequests for two reasons. First, if bequests to children are included, then perhaps inter-vivo transfers from parents to children and children to parents should also be included, and the relative weight that parents and children place on each other's utility will have to be specified and estimated (DeNardi 2004). The model will lose much of its current focus on health. Second, I do not have data on the assets of the children of these elderly, and it seems plausible that the marginal utility of the bequeathed amount depends on the wealth of the children.

Also, in this model, the marginal utility of consumption is assumed to be independent of the current state of health. Certainly, previous research (Viscusi and Evans 1990 and Gilleskie 1998) suggests that the marginal utility of consumption is health dependent. The model, as specified, does not allow health to affect the marginal utility of consumption: By assumption, many elderly in the model do not know the exact state of their health unless they go to a doctor for diagnosis. If health is assumed to affect the marginal utility of consumption, and the elderly know their marginal utility, then the elderly would know their health without going to the doctor. It seemed important to model a doctor as a provider of information as well as treatment, and this latter scenario has been ruled out.

Finally, we completely omit housing wealth from the model. Obviously, this may be an important omission since, for many elderly households, housing wealth accounts for the majority of their net worth (Li and Yao 2005). We omit housing wealth for practical reasons, namely that households do not have to sell their house to be eligible for Medicaid: The Medicaid eligibility rules only apply to non-housing assets. For housing wealth to be meaningfully included in the model, it would need to be treated as a separate state variable, and the computational burden of the project would increase exponentially.[5]

Details. In each period the elderly first choose a health insurance plan. There are three types of health insurance plans in the model, indexed by the variable i. All elderly are insured with Medicare, $i = 1$. Some have the option of purchasing Medicare supplemental insurance, called Medigap, $i = 2$; others have Medigap provided to them for free by an ex-employer, $i = 3$, called "free Medigap" throughout the paper. Define $d_t^{1,i}$ as a dummy variable that indicates the type of health insurance the elderly are covered with in period t. $d_t^{1,i} = 1$ if the elderly purchase or are covered by health-insurance plan i, 0 otherwise.

After choosing a health insurance plan, in the same period the elderly choose whether or not to go to a doctor for a diagnosis of their current state of health and treatment if they are not diagnosed as healthy. Denote the period t decisions on whether the elderly go to a doctor as the dummy variable d_t^2: If the elderly go to a doctor, $d_t^2 = 1$, 0 if they do not go.

After deciding whether or not to go to a doctor for a diagnosis, the elderly decide on their consumption and, if diagnosed as functionally disabled, decide whether to enter a nursing home for the duration of the period. Denote the period t consumption decision as C_t and the period t decision on whether or not to enter a nursing home as d_t^3. When the elderly enter a

[5]Even if housing wealth were included in the model, the elderly would have incentives to juggle their portfolio of housing and non-housing assets, depending on whether or not they wanted Medicaid to fund their health expenses. This would introduce another choice to the model (the value of housing assets), further increasing the computational burden.

nursing home $d_t^3 = 1$, 0 otherwise. Note that the elderly can choose to enter a nursing home only if they go to a doctor and are diagnosed as functionally disabled.

The total current period utility the elderly receive in any period after having made all choices is

$$\frac{\epsilon_t^c C_t^{1-\sigma}}{1-\sigma} + b_t^{ins} d_t^{1,2} + b_t^{doc} d_t^2 + b_t^{nh} d_t^3 \tag{1}$$

In the above equation, the utility from the consumption choice is $\epsilon_t^c C_t^{1-\sigma} / (1-\sigma)$, where ϵ_t^c is a random shock to the marginal utility of consumption. ϵ_t^c is drawn from a lognormal distribution with time-invariant mean $\bar{b}^c$ and standard deviation sd^c. The elderly also receive additive utility or disutility from their purchase of Medigap insurance, from seeing a doctor, and from residing in a nursing home, denoted respectively b_t^{ins}, b_t^{doc}, and b_t^{nh}. These are random variables that are Normally distributed, and are independently distributed with respect to time, each other, and ϵ_t^c. They have known and constant means of $\bar{b}^{ins}$, $\bar{b}^{doc}$, and $\bar{b}^{nh}$, and standard deviations of sd^{ins}, sd^{doc}, and sd^{nh}. Sometimes, b_t^{ins}, b_t^{doc}, and b_t^{nh} are referred to as the insurance, doctor visit, and nursing home "shocks."

The decisions the elderly make in any period occur sequentially, and can be thought of as occurring in three stages, without any discounting between stages. In the first stage, the elderly choose a health insurance plan. Some elderly have Medigap provided to them for free by an ex-employer. These elderly make no insurance choice per-se. Other elderly are institutionally constrained from purchasing Medigap, to be explained later, and these elderly are insured with only Medicare. All others can choose to purchase Medigap or remain insured only by Medicare. Before the insurance decision is made, the elderly know the value of the random variable that affects their payoff if they purchase Medigap, b_t^{ins}. They do not know the exact values of their random payoffs to their remaining decisions. This specification allows for selection of Medigap purchasers based on $\bar{b}^{doc}$, $\bar{b}^{nh}$, and $\bar{b}^c$, but not on any particular (future within-period) draw of the doctor, nursing home, and consumption shocks.

In the second stage of the period, b_t^{doc} is realized and the elderly choose whether or not to see a doctor. Visiting a doctor results in a diagnosis of their current health state. There are four states of health in the model and they are indexed by the variable h. The elderly are either diagnosed as healthy ($h = 1$), as having a chronic condition called "CR" ($h = 2$), as sick with the chronic condition and a functional impairment "CR+ADL" ($h = 3$), or afflicted with only the functional impairment "ADL" ($h = 4$). Health states are fixed throughout a period but probabilistically evolve between periods according to a known, age-dependent Markov process. Even if the elderly get a diagnosis of their health state in period $t-1$, they may not know their health state in period t unless they go to a doctor for a diagnosis.

The value of a doctor's visit has three components in addition to its direct (dis)utility. As mentioned, the doctor identifies the state of health. The doctor also automatically provides treatment to those elderly that are not in the healthy state and treatment increases the probability of survival to the next period. Finally, those that are diagnosed as functionally impaired ($h = 3$ or 4) receive the option of residing in a nursing home. Nursing homes are modeled as increasing the probability of survival to the next period for functionally disabled elderly. In this second stage, the elderly do not know the exact values of b^{nh} and b^c, but, as mentioned, they do know $\bar{b}^{nh}$ and $\bar{b}^c$.

In the third and final stage of a period the consumption and nursing home shocks are revealed. The elderly choose consumption and those elderly that go to a doctor and are diagnosed in health state CR+ADL or ADL also choose whether or not to enter a nursing home for the remainder of the period. After the consumption and nursing home decisions are made, the elderly wait to the end of a period, at which point some of them die. The health state of survivors then evolves, and the elderly start the next period. Death is certain by period $T + 1$.

To explain how the elderly in this model make their choices, and how their costs and survival probabilities are determined, it is easiest to start with the terminal period and work backward through time, much in the way a computer algorithm would solve a dynamic programming problem. In the terminal period T, the elderly consume all assets A_T and time-invariant pension and social security income W and then die with certainty. Given ϵ_T^c, the value of having assets A_T is

$$V_T(S_T) = \frac{\epsilon_T^c C_T^{1-\sigma}}{1-\sigma}, \tag{2}$$

where $C_T = A_T + W$. S_T denotes the state variables in the terminal period: Non-housing assets A_T and the utility shock ϵ_T^c.

Next, consider the optimal consumption and nursing home decisions of period $T-1$. Denote the state variables of the third stage of $T-1$ as S_{T-1}^3. These state variables include $T-1$ assets, all period $T-1$ utility shocks, the outcome of the period $T-1$ insurance and doctor decisions, and the variables L_{T-1} and H_{T-1} that will be discussed later. The optimal consumption and nursing home choices solve

$$\begin{aligned} V_{T-1}^3\left(S_{T-1}^3\right) &= \max_{d_{T-1}^3, C_{T-1}} \{\tfrac{\epsilon_{T-1}^c C_{T-1}^{1-\sigma}}{1-\sigma} + b_{T-1}^{nh} d_{T-1}^3 + \beta \pi_{T-1}^s E\left[V_T(S_T) | S_{T-1}^3\right]\} \\ s.t.\ A_T &= (1+r)(A_{T-1} + W - oop_{T-1} - C_{T-1}) \\ A_T &>= 0. \end{aligned} \tag{3}$$

In (3), β is the discount factor and r is the one period risk-free rate of return on all financial assets. The out-of-pocket expenses the elderly pay for their health insurance, doctor, and nursing home choices is denoted oop_{T-1} and the subjective probability the elderly form of living to period T given they are alive at $T-1$ is denoted π_{T-1}^s. The value of the optimal consumption and nursing home decisions given state variables S_{T-1}^3 is denoted $V_{T-1}^3\left(S_{T-1}^3\right)$.

The out-of-pocket expenses the elderly pay on their health care, exclusive of any health insurance they purchase, depends on their current assets and income due to the rules of Medicaid's spend-down program. In the absence of Medicaid benefits, the elderly would pay the following amount out-of-pocket for their health insurance and health care

$$n^i_{T-1} + d^2_{T-1} doc^{i,h}_{T-1} + d^3_{T-1} m^{i,h}_{T-1}, \tag{4}$$

where n^i_{T-1} is the premium cost of health insurance plan i, $doc^{i,h}_{T-1}$ is the out-of-pocket cost of a doctor visit and treatment, if applicable, for those elderly in health state h and insured with health insurance i, and $m^{i,h}_{T-1}$ is the out-of-pocket cost of a one period stay in a nursing home with health insurance i when in health state h. The Medicaid program covers any costs after the elderly have spent-down their assets and income to pre-specified levels, denoted $\bar{A}$ and $\bar{W}$ respectively. For those elderly insured with just Medicare insurance ($i = 1$), the maximum amount they will pay out-of-pocket on their health expenses is

$$\max\{\left(A_{T-1} - \bar{A}\right), 0\} + \max\{\left(W - \bar{W}\right), 0\}. \tag{5}$$

For those purchasing private Medigap insurance, equation (5) changes slightly. The Medicaid rules specify that Medicaid will not subsidize private insurance premiums, but money spent on these premiums counts toward the spend-down criteria. For these elderly, the maximum amount they will pay out-of-pocket prior to Medicaid subsidization is

$$n^i_{T-1} + \max\left[\left(\max\{\left(A_{T-1} - \bar{A}\right), 0\} + \max\{\left(W - \bar{W}\right), 0\} - n^i_{T-1}\right), 0\right], \tag{6}$$

where $i = 2, 3$. I assume the elderly apply for Medicaid benefits as soon as they are eligible, and the variable oop_{T-1} is set to the minimum of (4) and (5) or (6), depending on which insurance program the elderly have chosen.

For those elderly that go to a doctor in the period, they know their health state and their true probability of survival to period T, denoted π^h_{T-1}. π^h_{T-1} is a function of the health state h and the health choices of the elderly: Whether or not they went to a doctor, entered a nursing home, and had any of their care subsidized by Medicaid. In estimation, I will allow nursing home care that is subsidized by Medicaid to be of different quality than care that is entirely privately funded. If Medicaid subsidizes any health care costs, the model variable $mcaid$ (which will show up later) will be set to 1, 0 otherwise.

Those elderly that do not go to a doctor may not know their true state of health and thus the subjective probability of survival may not be the same as the actual probability. Let q_{T-1}^h denote the elderly's subjective probability that they are in state h. Then π_{T-1}^s is calculated as

$$\pi_{T-1}^s = \sum_{h=1}^{4} q_{T-1}^h \pi_{T-1}^h \left(d_{T-1}^2 = 0, d_{T-1}^3 = 0\right). \tag{7}$$

The notation $\pi_{T-1}^h \left(d_{T-1}^2 = 0, d_{T-1}^3 = 0\right)$ makes explicit that the subjective probability of survival conditions on the fact that the elderly know they did not go to a doctor or enter a nursing home.

Define the age-specific probability of transitioning from h' in $T-2$ to h in $T-1$ given a $T-2$ health state of h' as $\gamma_{T-2}^{h,h'}$. Now define the variable L_{T-1} as the number of periods since the elderly last went to a doctor and H_{T-1} as the last diagnosed health state. Suppose $L_{T-1} = 1$, meaning the last doctor diagnosis occurred one period ago, and the last diagnosed health state was $H_{T-1} = h'$. In this case q_{T-1}^h in equation (7) is simply equal to $\gamma_{T-2}^{h,h'}$.

Now consider $L_{T-1} = 2$, meaning the last diagnosis occurred two periods ago; and, denote the last diagnosed health state as $H_{T-1} = h''$. q_{T-1}^h is calculated using Bayes rule, conditioning on the fact that the elderly have survived 2 periods since the last doctor's diagnosis of their health state. In period $T-2$, the subjective probability of being in health state h' was equal to $\gamma_{T-3}^{h',h''}$. Call this set of subjective probabilities $q_{T-2}^{h'}$ for $h' = 1, \ldots, 4$. Now, the probability of being in health state h at period $T-1$, conditional on survival to $T-1$, is

$$q_{T-1}^h = \sum_{h'=1}^{4} \gamma_{T-2}^{h,h'} \left[\frac{q_{T-2}^{h'} \pi_{T-2}^{h'} \left(d_{T-1}^2 = 0, d_{T-1}^3 = 0\right)}{\sum_{\tilde{h}=1}^{4} q_{T-2}^{\tilde{h}} \pi_{T-2}^{\tilde{h}} \left(d_{T-1}^2 = 0, d_{T-1}^3 = 0\right)} \right]. \tag{8}$$

The expression in brackets updates the subjective probabilities over health states formed in period $T-2$ with the information that the elderly lived to period $T-1$, given the elderly did not go to the doctor in $T-2$.

Moving back to the second stage of period $T-1$, the elderly decide whether or not to go to the doctor. Denote all variables that are known at this stage as S^2_{T-1}. This state space is identical to the state space at stage three except that the consumption shock, nursing home shock, and doctor's diagnosis are not known and the number of periods since last going to the doctor (L_{T-1}) and last diagnosed health state (H_{T-1}) may change, discussed below. Given the structure of the problem, the payoff from going to a doctor ($d^2_{T-1}=1$), denoted $V^2_{T-1}\left(S^2_{T-1}|d^2_{T-1}=1\right)$, is

$$V^2_{T-1}\left(S^2_{T-1}|d^2_{T-1}=1\right)=E\left[V^3_{T-1}\left(S^3_{T-1}\right)|S^2_{T-1},d^2_{T-1}=1\right]+b^{doc}_{T-1}. \tag{9}$$

Analogously, the payoff from not going to the doctor is

$$V^2_{T-1}\left(S^2_{T-1}|d^2_{T-1}=0\right)=E\left[V^3_{T-1}\left(S^3_{T-1}\right)|S^2_{T-1},d^2_{T-1}=0\right]. \tag{10}$$

The elderly make the decision that maximizes their payoff, denoted $V^2_{T-1}\left(S^2_{T-1}\right)$:

$$\begin{aligned} &V^2_{T-1}\left(S^2_{T-1}\right)= \\ &\max\{V^2_{T-1}\left(S^2_{T-1}|d^2_{T-1}=1\right),V^2_{T-1}\left(S^2_{T-1}|d^2_{T-1}=0\right)\}\end{aligned} \tag{11}$$

If the elderly go to a doctor, the number of periods since last seeing the doctor L_{T-1} is updated, and depending on the diagnosis, the last diagnosed health state H_{T-1} may change. For computational reasons, I specify that the elderly can not wait more than 3 periods before seeing a doctor.

Finally, moving back to the first stage of the period, the elderly make their health insurance choice. The elderly that have Medigap provided for free make no insurance choice. With some exogenous probability p_{T-1}, the elderly that had free Medigap in period $T-2$ lose their free Medigap before the start of the period. The elderly that lose their free Medigap coverage can choose to be insured with just Medicare or pay for Medigap.[6] Of the elderly that did not start the period with free Medigap, some may not be able to purchase Medigap. If the elderly have financial resources less than the cost of health insurance premiums ($A_{T-1}+W < n^2_{T-1}$), they can not buy Medigap because Medicaid will not subsidize the cost of Medigap health insurance premiums. Or, the elderly who had Medicare health insurance in period $T-2$ and have a "pre-existing condition" are also not allowed to buy Medigap. The elderly are defined as having a pre-existing condition if their last doctor's diagnosis, H_{T-1}, is not the healthy state. However, Medigap plans are renewable by law, and so the elderly with Medigap insurance in period $T-2$ can buy Medigap in period $T-1$ regardless of their last diagnosis as long as they have the financial resources. The fact that health care insurers do not have to sell insurance to elderly in sick health states but cannot turn away previous customers means that Medigap plans have an option value for future decisions.[7]

For those elderly that are not institutionally or financially prohibited from purchasing Medigap, the health insurance decision solves the following problem:

$$\begin{aligned}(12)\quad & V^1_{T-1}\left(S^1_{T-1}\right) = \\ & \max\{\left(E\left[V^2_{T-1}\left(S^2_{T-1}\right)|S^1_{T-1}, d^{1,2}_{T-1}=1\right] + b^{ins}_{T-1}\right), E\left[V^2_{T-1}\left(S^2_{T-1}\right)|S^1_{T-1}, d^{1,1}_{T-1}=1\right]\}\end{aligned}$$

The first term of the maximization operator in (12) is the value of purchasing Medigap, while the second term is the value of being insured with only Medicare; the maximal value of the insurance decision is denoted $V^1_{T-1}\left(S^1_{T-1}\right)$. The state variables at the first stage, S^1_{T-1}

[6]These elderly are not subject to the pre-existing conditions clauses but must have resources to purchase the Medigap plan themselves. This is discussed later in this section.

[7]This is not particularly relevant to the Medigap decision in period $T-1$ since death occurs after period T, but does affect the value of Medigap prior to period $T-1$.

are the same as the state variables in the second stage except that the value of the random utility shock from seeing the doctor (ϵ^{doc}_{T-1}) is not known.

At this point, I have outlined all the payoffs, constraints, and decision variables in $T-1$. Going back to the third stage of decision period $T-2$, the problem of the elderly is analogous to the problem in the third stage of period $T-1$. The optimal consumption and nursing home decisions in the third stage of period $T-2$ satisfy

$$
\begin{aligned}
V^3_{T-2}\left(S^3_{T-2}\right) &= \max_{d^3_{T-2}, C_{T-2}} \left\{ \frac{\epsilon^c_{T-2} C^{1-\sigma}_{T-2}}{1-\sigma} + b^{nh}_{T-2} d^3_{T-2} + \beta \pi^s_{T-2} E\left[V_{T-1}\left(S^1_{T-1}\right) | S^3_{T-2}\right] \right\} \\
s.t.\ \ A_{T-1} &= (1+r)\left(A_{T-2} + W - oop_{T-2} - C_{T-2}\right) \\
A_{T-1} &>= 0
\end{aligned}
\tag{13}
$$

The expectation in the above equation is with respect to the random component of S^1_{T-1}, the utility shock associated with purchasing Medigap in period $T-1$, ϵ^{ins}_{T-1}.[8]

In a fashion identical to that described for period $T-1$, the optimal decisions at each stage of period $T-2$ can be derived and then we can "move backward" to period $T-3$. Continuing recursively in this way, all the optimal decision at each stage of each period at all periods can be calculated at any set of state variables. The computational procedure to solve for the decision rules of this model basically follows the exposition in this section and is detailed in the computational appendix.

3 Data

The parameters of the model are estimated using the AHEAD (Asset and Health Dynamics of the Oldest Old) data set. The AHEAD data set obtains information from a sample of older

[8]For those insured with ex-employer provided Medigap in period $T-2$, the expectation is also over the shock that determines whether or not they keep this insurance in period $T-1$.

Americans on non-housing and housing assets, income, health insurance, health utilization, and health care costs at every interview. I use the first two waves of AHEAD data (1993 and 1995) in estimation. The period length of the model is two years, the length of time between interviews. The primary AHEAD respondents are elderly age 65 and older, and are drawn from a nationally representative sample, with the exception that African-Americans and the elderly living in Florida are oversampled. The initial wave of AHEAD respondents are also drawn only from a non-institutionalized population; however, those respondents that enter nursing homes over time are kept in the AHEAD sample.

For reasons discussed in the introduction, the estimation sample includes only elderly women living alone. Of the 5,000 elderly women interviewed by the AHEAD survey in Wave 1, approximately 40% live alone. After imposing other sample restrictions, 741 people remain in the working sample in Wave 1.[9] Of these 741 people, 651 survive to the Wave 2 interview. The two waves yield information on one decision period of the model: Respondents' answers to Wave 1 questions provide data on the state variables and respondents' answers to Wave 2 questions provide data on the choice variables of this period.

[9]The elderly are also excluded from the sample if (1) they are missing information that is used to determine choices or states; (2) they have non-housing assets larger than $150,000 or yearly income larger than $37,500; (3) they do not have Medicare insurance or do have long-term care insurance; and, (4) they have cancer or ever had cancer. The cutoff value of yearly income in restriction (2) seems low, but due to the assets restriction only 20 people otherwise eligible to be in the sample earn yearly income between $37,500 and $75,000. The elderly without Medicare or with long-term care insurance (in Wave 1 or Wave 2) are excluded because the prices they face for health care are different than the prices the rest of the sample faces for health care. Finally, those that report they "ever had cancer" in Wave 1 or report getting a cancer from Wave 1 to Wave 2 are excluded from the sample for reasons that will be discussed later.

Choice Variables: Table 1 reports the unconditional choice distribution for the elderly in the remaining sample by 5 year age intervals, from age 67 to age 90.[10] If respondents visited a medical doctor about their health at least once between Wave 1 and Wave 2, stayed overnight in a hospital as a patient between Wave 1 and Wave 2, or stayed overnight in a long-term health care facility at least once between Wave 1 and Wave 2, then they are classified as having chosen to see a doctor, $d_t^2 = 1$. Between 93 and 98 percent of all elderly women living alone went to a doctor at least once in this two year period.

If, in Wave 2, the elderly respond that their primary residence is a nursing home facility, d_t^3 is set to 1, otherwise it is 0.[11] Shown in this table, between 2 and 6 percent of the sample of elderly entered a nursing home and declared it their primary residence between the first two waves of the AHEAD data.

Respondents are classified as having chosen Medigap insurance if they report that they have privately provided (non Medicaid) insurance that supplements Medicare.[12] If the reported cost of this insurance was $0 in Wave 1 and Wave 2, these respondents are classified as having ex-employer provided Medigap, $d_t^{1,3} = 1$. If the cost of this supplemental insurance was non-zero in Wave 1 or Wave 2, $d_t^{1,2}$ is set to 1. The remaining elderly are classified as having only Medicare insurance, $d_t^{1,1} = 1$. With the exception of the youngest cohort in the estimation sample, approximately one-half of the sample choose to purchase Medigap, and

[10]The listed age in Table 1 is the age of the respondent at the Wave 2 interview date. Also note that assets are reported in the AHEAD and not consumption, and so in this table assets as the choice.

[11]A nursing home is defined as a facility that provides 24 hour nursing assistance and supervision, provides room and meals, and dispenses medication.

[12]I do not classify the elderly with only non-Medicare government health insurance programs, like CHAMPUS, as insured by Medigap.

this proportion does not vary much by age for those older than age 73.

Finally, although consumption is not directly observable, in Wave 2 respondents report non-housing assets and out-of-pocket expenses on health care and health insurance. Given income, initial (Wave 1) non-housing assets, and out-of-pocket insurance and health-care expenses, the consumption choice C_t can be imputed.

State Variables: Table 2 lists the distribution of initial state variables by five year age intervals: income (W),[13] non-housing assets (A_t), number of periods since last seeing the doctor (L_t), last diagnosed health state (H_t), and last type of health insurance ($d_{t-1}^{1,i}$). Approximately half the elderly in the working sample have initial non-housing assets and per-period income low enough to qualify for Medicaid at the beginning of a period. The assets ($\bar{A}$) and income ($\bar{W}$) eligibility levels that determine Medicaid eligibility are specified by the "Qualified Medicare Beneficiary" (QMB) criteria. For the elderly to be QMB recipients of Medicaid assistance, they must have non-housing assets no greater than twice the allowable amount for SSI eligibility and yearly income no greater than the federal poverty line, although these rules vary by state (see the 1994 Green Book for details). I set $\bar{A} = \$12,000$ and $0.5 * \bar{W} = \$7,890$ (the 1997 federal income poverty line for people living alone).

Approximately 93% of the elderly went to the doctor at least once in a twelve month period prior to the Wave 1 interview;[14] these elderly have L_t set equal to one period. The remaining elderly (about 7%) have L_t set to two periods.

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[13] Given each model period is two years, per-period income is two times the yearly income reported in Wave 1.

[14] The AHEAD Wave 1 questionnaire asks if the elderly consulted with a doctor, entered a hospital overnight, or entered a long-term care facility at least once in a twelve month (not twenty four month) period prior to the Wave 1 interview.

If the elderly have privately provided supplemental Medicare insurance in Wave 1 and they list the Wave 1 cost of this supplemental insurance as \$0, then $d_{t-1}^{1,3} = 1$. If the elderly have supplemental Medicare insurance and pay for it, $d_{t-1}^{1,2} = 1$; the remaining elderly are defined as having only Medicare, $d_{t-1}^{1,1} = 1$. Between 50% and 60% of the elderly have privately provided supplemental Medicare insurance in Wave 1, and that this proportion increases with age.

Both the doctor choice and the insurance choice are persistent between waves. This is not shown in Tables 1 and 2. Of the elderly that saw a doctor within 12 months of the Wave 1 interview, only 2% (12 out of 609) choose not to go to a doctor by the Wave 2 interview. However, of the elderly that did not see a doctor within 12 months of the Wave 1 interview, 21% (9 out of 42) choose not to go to a doctor by the Wave 2 interview. Similarly, of the 237 people insured with only Medicare in Wave 1, 219 are insured with only Medicare in Wave 2 (92%), while of the 366 people insured with (privately purchased) Medigap in Wave 1, 299 are insured with privately purchased Medigap in Wave 2 (82%).[15]

The elderly are defined as having last been diagnosed in the chronic condition CR if they report in Wave 1 that they have ever been diagnosed with diabetes, lung disease, or heart disease, or some combination of these diseases. These conditions are assumed to be permanent; the Wave 2 AHEAD interview implicitly assumes that anyone reporting they had ever been diagnosed with diabetes, lung disease, or heart disease in Wave 1 automatically has the same condition in Wave 2. These conditions were chosen for the model state CR because they represent most major causes of death in national statistics: diabetes, lung disease, and heart disease combined account for between 50% and 60% of all listed causes of death of

[15] Of the 48 people insured with ex-employer provided Medigap in Wave 1, 28 are insured with the same insurance in Wave 2 (58%).

the elderly (Death and Death Rates ..., 1992). Those elderly that report they ever had cancer as of Wave 1, or developed cancer between Wave 1 and Wave 2, were excluded from the working sample. Even though cancer accounts for approximately another 20% of the listed causes of death of the elderly (Death and Death Rates ..., 1992), cancer is not in the model–and those that ever had cancer are excluded from the sample–because cancer would have to be modeled as an additional health state. The probability of dying with undiagnosed cancer may be different than diabetes or heart disease, and more importantly, it is possible to recover from cancer with treatment.

In this model, functional disability is defined to be a "nursing home disease." If the elderly have this nursing home disease, they can seek treatment, which is residence in a nursing home; if the elderly do not have the nursing home disease they cannot get the treatment. It is not obvious how to combine observable conditions to identify those elderly that would increase their survival probability if they were to enter a nursing home. Here, the elderly are defined as having the functional disability if they have difficulty bathing.

This was chosen based on a subjective determination of the relationship between responses to Wave 2 Activities of Daily Living (ADL) questions and entrance into a nursing home in Wave 2.[16] Of all ADL questions (among all possible sets or combinations of Activities of Daily Living questions), the best predictor of nursing home use is the bathing question: 64% of those in nursing homes (16 out of 25) had trouble bathing, while only 17% of those not in nursing homes (108 out of 625) had trouble bathing. This is consistent with previous research (Headen 1993) showing that the inability to bathe oneself is the most important health-condition correlate of nursing home entry.[17]

Probabilities: Table 3 shows transitions among health states as well as the unconditional

[16]The Wave 1 population of the AHEAD is non-institutionalized, so only Wave 2 questions are considered.

[17]Headen (1993) also shows that senility is an important predictor of nursing home entry. Unfortunately,

probability of dying by Wave 1 health state for those elderly that went to the doctor in Wave 1. In the model, health states transition exogenously. According to Table 3, healthiness is a persistent state; 75% of those diagnosed as healthy in Wave 1 are diagnosed as healthy again in Wave 2. As noted earlier, the CR condition is assumed to be an absorbing state because of the way the Wave 2 questions are asked. However, unlike the healthy state and the CR state, the ADL condition is not very persistent: Most elderly diagnosed with a functional disability in Wave 1 were not diagnosed as having this disability in Wave 2. Unfortunately, some of the observed transitions out of the ADL state may be attributable to the fact that the Wave 2 bathing question is concerned with a less serious functional impairment than the Wave 1 bathing question. But, I assume that the change in the bathing question between waves does not affect the observed transitions in to and out of the ADL state.

Costs: Both the total cost of a doctor's visit (conditional on a diagnosis) and the out-of-pocket cost of a doctor's visit, conditional on health insurance and a diagnosis, are shown in Table 4.[18] These data suggest that Medicare subsidizes somewhere between 80% and 95% of the cost of a doctor's diagnosis. Although the out-of-pocket cost of a two year nursing home stay is not reported, the total cost of a two year stay in a nursing home and a doctor's diagnosis is reported (not shown in Table 4). The median reported total cost of care for those the elderly with primary residence in a nursing home $\$65,000$ for both those in the ADL and CR+ADL states.

The fact that Medigap supplements Medicare suggests that, all else equal, the out-of-pocket costs of the elderly insured with Medigap should be less than the the costs of the

all of the Wave 2 respondents in nursing homes that were capable of bathing themselves were not asked the cognition questions.

[18]Total cost includes both what the insurers pay and what the elderly pay out-of-pocket.

elderly insured only with Medicare. However, as Table 4 indicates, the median reported out-of-pocket expense for the elderly that are healthy (or are in the ADL state), go to a doctor, and are insured with Medicare is lower than the median out-of-pocket expense for the elderly with the same health states but have Medigap insurance.[19] One explanation for this, other than sampling error, is that perhaps Medigap purchasers are adversely selected. To account for this possibility, the estimation procedure, detailed in the next section, allows for unobserved heterogeneity.

4 Estimation

Likelihood: Suppose that an individual j's insurance choice, doctor choice, nursing home choice, consumption choice, and all state variables are directly observable. Label these choices as $d_t^{1,j}$, $d_t^{2,j}$, $d_t^{3,j}$, and C_t^j and the relevant set of state variables (given the 3-stage structure) as $S_t^{1,j}$, $S_t^{2,j}$, and $S_t^{3,j}$. Suppose, however, that there are two types of people in the estimation sample, labeled τ^1 and τ^2, and types differ in costs, probabilities, and preferences. If a person's type is not directly observable, given the independence of the shocks and sequential nature of the choices, the probability that individual j's observed set of choices occurs is:

$$(14) \qquad \sum_{k=1}^{2} Pr\left(\tau^k|S_t^{1,j}\right) Pr\left(d_t^{1,j}|S_t^{1,j},\tau^k\right) Pr\left(d_t^{2,j}|S_t^{2,j},\tau^k\right) Pr\left(d_t^{3,j},C_t^j|S_t^{3,j},\tau^k\right).$$

(14) allows that the first set of observed state variables, $S_t^{1,j}$, can be (and should be) correlated with a household's type.

[19] The out-of-pocket expenses of the elderly that use Medicaid are not included in the calculation of the median out-of-pocket expense.

Given the setup of the model, $Pr\left(d_t^{1,j}|S_t^{1,j},\tau^k\right)$ and $Pr\left(d_t^{2,j}|S_t^{2,j},\tau^k\right)$ are one dimensional integrals in ϵ_t^{ins} and ϵ_t^{doc} respectively.[20] For example, the probability that person j goes to the doctor given state variables $S_t^{2,j}$ and type τ^k is given directly from (11). Similarly, the probabilities over the insurance choice are given by (12).

The joint nursing home and consumption probability, $Pr\left(d_t^{3,j},C_t^j|S_t^{3,j},\tau^k\right)$, is evaluated using a Monte-Carlo method with some smoothing. This probability is smoothed in order to generate standard errors using feasible number of draws of the consumption and nursing home shocks. To explain the smoothing, consider the case of an elderly person that can decide whether or not to enter a nursing home. For this person, denote the value at a particular consumption shock and nursing home shock from nursing home choice $d_t^{3,j}$ and discrete consumption choice C_t^j as $V\left(d_t^{3,j},C_t^j\right)$. Given there are only two possible nursing home choices and say C feasible consumption choices for each nursing home choice,[21] the smoothed simulated probability of the particular nursing home choice $d_t^{3,j}$ and discrete consumption choice C_t^j is calculated via Monte-Carlo integration, and is set equal to the average value of

$$\frac{\exp\left(\frac{V\left(d_t^{3,j},C_t^j\right)-\max\limits_{d_t^3,C_t^c}\left[V\left(d_t^3,C_t^c\right)\right]}{\lambda}\right)}{\sum\limits_{j'=0}^{1}\sum\limits_{c'=1}^{C}\exp\left(\frac{V\left(d_t^3=j',C_t^{c'}\right)-\max\limits_{d_t^3,C_t^c}\left[V\left(d_t^3,C_t^c\right)\right]}{\lambda}\right)} \tag{15}$$

[20] As noted, some elderly are given Medigap for free, while others are not allowed to purchase Medigap. These people make no insurance choice per-se.

[21] Remember from the model solution section that consumption can only adopt one of a discrete number (denoted C) of values. Although C is the same for both nursing home choices, the set of feasible consumption points may differ with the nursing home choice (because the nursing home may be costly). See the computational appendix for details.

over multiple nursing home and consumption shocks.[22,23]

(14) is not directly implementable without additional modifications. First, observed consumption will, in general, not equal one of the discretized consumption values for which a smoothed simulated probability is calculated. To accommodate this feature of the data, i.i.d. measurement error is incorporated in the likelihood. If an exact value of period t consumption can be inferred from reported asset data,[24] the likelihood over period t consumption is calculated as the sum, over all discrete consumption values for which there is a smoothed probability, of the smoothed probability of that discrete consumption choice times the density of the distance between reported consumption (assumed to be measured with error) and the discrete value of consumption.[25]

Similarly, i.i.d. measurement error is also incorporated in the likelihood function for reported out-of-pocket expenses. Measurement error in reported out-of-pocket expenses is included because, given a household's type, assets, income, and insurance, doctor, and nursing home choices, out-of-pocket expenses are exactly determined by the model.

Finally, the likelihood incorporates measurement error in income and Wave 1 assets. Income is assumed to be measured with error because the model is only solved for a discrete

[22]For those that do not make a nursing home choice $d_t^3 = 0$ always, and the summation in the denominator of (15) is only over consumption.

[23]In (15), λ is the smoothing parameter; for the joint consumption and nursing home probability estimate to be consistent, λ must approach 0 as the sample size gets large. I set λ to 0.1.

[24]Given out-of-pocket expenses, which are determined by the three discrete choices of the period and Wave 1 income and assets, consumption can be imputed as long as Wave 2 assets are exactly reported.

[25]If consumption can only be identified as occurring in a range of possible values, a CDF (rather than a density) over the range of possible measurement error draws is included in the likelihood.

set of income values. Related, Wave 1 assets are assumed to be measured with error because the exact decision rules of the model are solved for a discrete set of asset values at each point in the backwards recursion of the computation.[26] Denote the likelihood (14) for person j at particular asset level A_t^l and particular income level W^m as $l^j\left(A_t^l, W^m\right)$, where A_t^l and W^m denote values of the assets and income state variables for which an exact decision rule in Wave 1 has been calculated. If person j has reported Wave 1 assets of A_t^j and income W^j, then the likelihood for person j is set equal to:

$$\sum_l \sum_m f\left(A_t^j, A_t^l\right) f\left(W^j, W^m\right) l^j\left(A_t^l, W^m\right). \tag{16}$$

The summations over l and m are summations over the set of all discretized assets A_t^l and discretized income W^m for which the model is solved and likelihood is calculated. $f\left(A_t^j, A_t^l\right)$ is the density of measurement error in reported assets A_t^j given assets A_t^l for which the likelihood is calculated, and $f\left(W^j, W^m\right)$ is the density of measurement error in reported income W^j given income W^m at which the likelihood is calculated.[27] For all individuals in the data set, the assets state variable A^l (comprising $S_t^{1,j}$) at which the likelihood is calculated are \$3,000, \$10,000, \$20,000, \$45,000, and \$90,000, while the one-period (two year) income W^m (comprising $S_t^{1,j}$) at which the likelihood is calculated are \$15,000, \$25,000, and \$50,000.

Finally, note that $S_t^{1,j}$, $S_t^{2,j}$, and $S_t^{3,j}$ include year of birth as a state variable, distinct from age. The costs and efficacy of health care of the current generation of ninety year olds is likely very different from the costs and efficacy of health care that the current generation of seventy year olds will face when they are ninety. For computational reasons, respondents

[26] See the computational appendix for details.

[27] As with consumption, some elderly can only report a range of values where their assets and income lie. For these elderly, $f(.)$ is the cumulative density of measurement error in equation (16).

are grouped together into four different cohorts based on their Wave 2 age. Respondents that are 67-72 are labeled as 70 years old (birth year 1925); 73-78 are labeled as 76 years old (birth year 1919); 79-84 are labeled as 82 years old (birth year 1913); and 85-90 are labeled age 88 (birth year 1907).

5 Functional Forms, Parameter Estimates, and Fit

Survival Probabilities. Survival probabilities are modeled for each health state as logistic functions of age and type.[28] For those in the CR, CR+ADL, and ADL states, survival probabilities are also a function of whether or not the elderly went to a doctor. Finally, entrance into a nursing home (and whether or not the nursing home was partially or fully subsidized by Medicaid) affects survival probabilities for those in the CR+ADL and ADL states. For all health states h, the probability of dying (given doctor choice d_t^2, nursing home choice d_t^3, and type of nursing home $mcaid$ (= 1 if subsidized at all by Medicaid, 0 if funded entirely privately), is the following:

$$1 - \pi_t^h = \frac{\exp(z)}{1 + \exp(z)}. \tag{17}$$

For those in the healthy state ($h = 1$),

$$z = \alpha_l^h \tau^1 + \alpha_2^h \tau^2 + \alpha_3^h age_t, \tag{18}$$

[28]Year of birth does not enter survival probabilities distinctly from age because only one wave of deaths is observed, so no age/cohort variation in deaths is observed. This implies (among other things) that there is no systematic variation in cohorts in inherent healthiness, and, that health care technology (as captured by the reduction in mortality probabilities from seeing the doctor when ill) does not change over time.

where age_t is defined as the respondent's age minus 70 years and τ^k is a dummy variable that equals one if the person is type k and zero otherwise. For those in the CR state ($h = 2$),

$$z = \alpha_l^h \tau^1 + \alpha_2^h \tau^2 + \alpha_3^h age_t + \alpha_4^h \left(1 - d_t^2\right), \tag{19}$$

and for those in the CR+ADL ($h = 3$) and ADL states ($h = 4$),

$$z = \alpha_l^h \tau^1 + \alpha_2^h \tau^2 + \alpha_3^h age_t + \alpha_4^h \left(1 - d_t^2\right) + \left(\alpha_5^h + \alpha_6^h mcaid\right) d_t^3. \tag{20}$$

α_5^h and $\alpha_5^h + \alpha_6^h$ are forced to be less than zero to ensure that nursing homes decrease the probability of dying. Given these restrictions, the parameter estimates and associated standard errors are listed in Table 5. Note that in all the parameter tables in the sections that follow, parameters in shaded boxes have been fixed outside the estimation procedure.

Unfortunately, the standard errors on many parameters is quite high. The conclusions I draw are based on the point estimates. These estimates suggest the following: The doctor decreases mortality probabilities in the CR, CR+ADL, and ADL health states; Medicaid nursing homes are ineffective at increasing survival probabilities; and, private nursing homes decrease mortality probabilities for the functionally disabled. With respect to unobserved heterogeneity, type twos are estimated to have lower mortality probabilities than type ones in all health states except ADL.

Health Transition Probabilities. Transition probabilities among health states are modeled as multinomial logistic functions of age. For the elderly that were healthy or in the ADL state ($h' = 1$ or 4) at period $t - 1$, the probability that they are in health state h (for $h = 2$, 3, or 4) at period t is:

$$\gamma_t^{h,h'} = \frac{\exp\left(\omega_1^{h,h'} + \omega_2^{h,h'} age_t\right)}{1 + \sum_{h''=2}^{4} \exp\left(\omega_1^{h,h''} + \omega_2^{h,h''} age_t\right)} \tag{21}$$

For $h = 1$,

$$\gamma_t^{h,h'} = \frac{1}{1 + \sum_{h''=2}^{4} \exp\left(\omega_1^{h,h''} + \omega_2^{h,h''} age_t\right)} \tag{22}$$

For those elderly in the CR or ADL+CR state ($h' = 2$ or 3) at time $t-1$, (21) and (22) are in general applicable except that h cannot equal 1 or 4 (healthy or ADL), so $\gamma_t^{1,h'} = \gamma_t^{4,h'} = 0$ for $h' = 2, 3$. The transition probability parameter estimates are listed in table 6.

Utility Function. As noted, the utility from consumption is

$$u\left(C_t; \epsilon_t^c\right) = \frac{\epsilon_t^c C_t^{1-\sigma}}{1-\sigma} \tag{23}$$

The two-year discount factor β is fixed at 0.9606. All of the utility shocks in the model ϵ_t^{ins}, ϵ_t^{doc}, ϵ_t^{nh}, and ϵ_t^c are all drawn independently of each other and over time. ϵ_t^{ins}, ϵ_t^{doc}, and ϵ_t^{nh} are drawn from the normal distribution with mean zero and standard deviations sd^{ins}, sd^{doc}, and sd^{nh}. $\log\left(\epsilon_t^c\right)$ is drawn from the normal distribution with type-specific mean $\bar{b}^c$ and standard deviation sd^c, fixed at 1.0 for both types.

Shown in table 7, I estimate σ to be 3.3, in the same ballpark as previous studies (French 2005). I also find that both types of elderly enjoy non-pecuniary utility from visiting the doctor and disutility from entering nursing homes. I estimate that type twos like going to a doctor less and dislike nursing homes more than type ones. Type twos also like purchasing Medigap less than type ones.

Unobserved Heterogeneity. Given a set of Wave 1 state variables, the probability individual j is type τ^1 is specified as:

$$Pr\left(\tau^1\right) = \frac{\exp(z)}{1 + \exp(z)}, \tag{24}$$

where

$$\begin{aligned} z = {} & \xi_1 + \xi_2 I\left(L_t = 2\right) + \xi_3 I\left(H_t = 2\right) + \xi_4 I\left(H_t = 3\right) + \xi_5 I\left(H_t = 4\right) \\ & + \xi_6 I\left(d_{t-1}^{1,1} = 1\right) + \xi_7 A_t + \xi_8 W + \xi_9 age_t. \end{aligned} \tag{25}$$

In the above expression, $I(.)$ is the indicator function: $I(.)$ equals one if the expression in parentheses is true, zero otherwise. Estimates of the set of ξ are listed in table 8. Certain Wave 1 characteristics are a clear signal of type: Those that did not go to the doctor in Wave 1 and were last diagnosed as healthy are almost certainly type twos and those that were last diagnosed as CR+ADL or ADL within one period are almost certainly type ones. Given that type twos have lower mortality probabilities than type ones, a-priori I expected that the probability of being type two increases with age, but I do not estimate this to be the case.[29] Finally, those that last had Medicare insurance are estimated to be more likely to be type twos. This is consistent with simulations of the model at the estimated parameters that suggest that type twos are less likely to buy Medigap than type ones.

Costs: The estimated costs of insurance, and the costs of seeing the doctor and entering a nursing home conditional on insurance are listed in tables 9 and 10. For both types, the cost of Medicare insurance (and the cost of ex-employer provided Medigap) is fixed at $\$1,106$, 24 times the 1995 published Medigap Part B monthly premium of $46.08. The cost of Medigap is fixed at $\$3,241$, which is the cost of Medicare plus the median reported price of Medicare supplemental health insurance (for those that purchased Medicare supplemental health insurance). Notice that even though the out-of-pocket costs of doctor services differ by type, the estimation procedure, which for each type forces Medigap costs to be lower than Medicare costs, has difficulty estimating the costs of those insured with Medigap. The data suggests that Medigap does not reduce the cost of doctor services. The Medigap reduction in nursing home costs reported in Table 10 is imposed on the data: Nursing home residents only report their total costs of health care and their out-of-pocket cost of health care is

[29] Given there is no age/cohort variation, both the age and the cohort correlation with type are captured by ξ_9.

not observed. The out-of-pocket cost for nursing homes for those insured with Medigap is set to be $\$10,000$ less than the out-of-pocket cost for nursing homes for those insured with Medicare. The $\$10,000$ reduction is imposed because all Medigap plans pay the $100 Medicare deductible on the first 100 days of a nursing home stay and it is assumed that Medigap does not subsidize any other nursing home costs (see Waid, 1997 for details).

Miscellaneous. All costs are assumed to grow at a constant real rate of η percent a year. We estimate η to be 7%, shown in Table 11. The probability that the elderly lose ex-employer provided Medigap is estimated to be $p = 0.41$ per period for all elderly. The real rate of return on assets is assumed to be two percent per-year.[30] Finally, measurement error in assets, income, and out-of-pocket expenses is drawn from a distribution whose variance varies with "true" assets, income, and out-of-pocket expenses, that is, if y_t^r is the true but unreported value of assets, income, or out-of-pocket expenses and y_t^o is the observed (reported) value, $y_t^o = y_t^r + e_t$, where e_t is Normally distributed with 0 mean and standard deviation of $\nu_1 + \nu_2 y_t^r$. This allows the reported variable to vary when y_t^r is close to zero ($\nu_1 \neq 0$) but also allows the range of error to grow with y_t^r ($\nu_2 \neq 0$). I estimate ν_1 and ν_2 to be 1.00 and 0.78 respectively.

Fit. This section reports the fit of the choice distributions by age. The log-likelihood value at the estimated parameters is $-9,315.064$.

Tables 12 through 15 compare the model's predicted distribution of insurance, doctor, and nursing home choices, by age, with the data. These predictions are generated by simulating the choices of an artificial sample of people that have the same initial characteristics as the data. This simulated sample of people is generated by simulating the outcomes of 100

[30]The overall rate of consumer price inflation is assumed to be two percent per-year between Waves 1 and 2.

sub-people for each of the 741 people alive in Wave 1 of the data set. These simulations are performed in the following way. First, each of these 100 sub-people are assigned the same initial number of periods since last doctor's visit, last diagnosed health state, last type of health insurance coverage, and age (which is constrained to be either 70, 76, 82, or 88)[31] as the particular person in the data on which they are based. Then, each of these 100 simulated sub-people draw measurement error on income and assets, and these draws, in conjunction with reported assets and income for the original person on which the sub-person's characteristics are based, determine each sub-person's initial income (which is constrained to be either $\$15,000$, $\$25,000$, or $\$50,000$) and assets (which is constrained to be either $\$3,000$, $\$10,000$, $\$20,000$, $\$45,000$, or $\$90,000$). Once income, assets, last diagnosed health state, number of periods since last diagnosis, and age have been determined for each subperson, probabilities over types are known, and a sub-person's type is randomly drawn. Given type, last diagnosed health state, and number of periods since last diagnosis, the probability of death is determined, and each sub-person draws a shock that determines whether or not they survive. Then, for all sub-people that survive, an insurance shock is drawn and they make an insurance choice, a doctor shock is drawn and they make a doctor choice, and finally consumption and nursing home shocks are drawn and they make consumption and (if applicable) nursing home choices. These choices are recorded, and the entire process is repeated for all 741 people in the working data set.

Tables 12 and Table 13 report the unconditional distribution of insurance and doctor choices among survivors (both observed and predicted) by age. These tables suggest that

[31] As with the likelihood calculations, those elderly with reported Wave 2 age of 67-72 are listed as having age of 70. Similarly, the elderly with reported age of 73-78 are listed as age 76, 79-84 as age 80, and 85-90 as age 88.

the model closely matches the observed distribution of the insurance choice and the doctor choice by age. A possible exception is for those aged seventy: The model predicts that seventy year olds have Medigap and go to the doctor with higher probability than observed.

Tables 14 and 15 at the end of this section show two different methods used to evaluate the model's fit of the nursing home choice. Table 14 displays the unconditional distribution of the nursing home choice among survivors, observed and predicted, by age. By this account, the model predicts nursing home use fairly accurately, except at the oldest age, at which the model over-predicts nursing home use. Table 15 shows the distribution of the nursing home choice by age, conditional on being eligible to enter a nursing home, that is conditional on going to the doctor and getting a diagnosis of CR+ADL or ADL. From this perspective, the model over-predicts nursing home use at all ages by about ten percent.

Finally, Table 16 shows the unconditional distribution of the assets (consumption) choice among survivors by age, when observed assets are lumped into four discrete bins.[32] Based on this table, it appears the model does an OK predicting assets; the model under-predicts assets in the lowest and highest bins. Note that the number of bins in this table was chosen arbitrarily.[33] Also, for some people, I can only determine the upper and lower bound on their level of assets. For these people, the midpoint of the bound is used to sort their reported assets into the appropriate bin.

[32]Not everyone in the working sample reports assets, explaining why the number of observations in this table is less than in the other tables evaluating model fit.

[33]The bounds on each bin were determined by dividing observed assets (as a choice) unconditional on age into quartiles.

6 Analysis and Policy Simulations

Selection of Medigap Purchasers. The simulation procedure detailed in the last section can also be used to determine the extent (if any) of the adverse selection of Medigap purchasers in 1995 (the year for which simulations of the model apply). Two alternate definitions of adverse selection in the market for Medigap are studied. In the first, the elderly women that live alone and purchase Medigap are defined as adversely selected if their expected total cost of their care (including insurers' costs and out-of-pocket costs of the insured), *conditional on going to the doctor*, is higher than the expected total cost of care of Medicare purchasers that go to the doctor.[34] In the second definition, Medigap purchasers are defined as adversely selected if their unconditional expected total cost of care is larger than the unconditional expected total cost of care of those insured with only Medicare. Although this latter definition of adverse selection combines the classic notions of moral hazard and adverse selection, it provides a useful way to summarize expected cost differences of those elderly that purchase Medigap and those that choose to remain insured only with Medicare.

The simulated type proportions by insurance and health service rendered are listed on Table 17. Simulations show that those insured with Medigap go to the doctor with about the same probability as those insured with only Medicare.[35] Since doctor visits marginally vary by insurance, the extent of adverse selection (if any) of Medigap purchasers will be similar according to both definitions. However, also shown in Table 17, doctor diagnoses vary by

[34]Since Medicaid is a payer of last resort, Medicaid only pays the out-of-pocket expenses that the elderly can not pay themselves. As a result, the total cost of care for those using Medicaid equals the out-of-pocket costs the elderly have to pay (some, if not all, paid for by Medicaid) plus the insurers' cost.

[35]It also appears that those insured with Medigap are slightly less likely enter a nursing home than those insured with Medicare.

insurance: Those insured with Medigap are less likely to be diagnosed with the chronic condition than those insured with Medicare. As it turns out, this is important because the chronic condition is the most costly condition to treat.

Table 18 shows the total cost of health services by type under two different assumptions. AHEAD respondents are asked questions that bound the total cost of their health care, but the width of the bounds varies with the lower bound, and, some people can not report an upper bound to the total cost of their care (so an upper bound is imposed for them). Under total cost "Assumption #1," the type specific average of the midpoint of these bounds is reported by health service, and under total cost "Assumption #2" the type specific median of the midpoint of these bounds is reported. Although the magnitude of total costs varies by assumption, type specific differences in total costs do not differ much except for those diagnosed with CR and possibly those diagnosed with CR+ADL.

From Table 17 and Table 18 it is possible to calculate the total expected cost of care, conditional on going to the doctor, and the unconditional total expected cost of care by health insurance. Under both definitions of adverse selection and both total cost assumptions, there is no evidence that Medigap purchasers, among this sample of elderly, are adversely selected. Under total cost Assumption #1, the expected total cost of health care of Medigap purchasers that go to a doctor is $\$21,017$, $\$1,861$ less than the expected total cost of health care of Medicare purchasers that go to a doctor; the unconditional expected total cost of health care of those insured with Medicare purchasers is $\$22,184$, $\$1,653$ larger than the unconditional expected total cost of health care of Medigap purchasers. Qualitatively similar results are obtained using total cost Assumption #2.

The reasons that those insured with Medicare have higher expected total costs of care than those that purchase Medigap are straightforward. First, as mentioned, conditioning on doctor use does not affect any selection results. Then, given the structure of the model, there are only two ways by which Medigap and Medicare purchasers can have different expected total costs of care: Either Medigap purchasers, on average, receive different diagnoses than those insured with Medicare, or, there is variation in (a) the type-specific total cost of a diagnosis and (b) the distribution of types by diagnosis and health insurance. The data suggest that (a) and (b) are not the case. Rather, the elderly insured with Medicare are more likely to be diagnosed with the chronic condition, and diagnosis and treatment of the chronic condition is more costly than diagnosis and treatment of any other health state.[36]

Finally, note that Table 17, Table 18, and Table 9 suggest that Medigap is actuarially unfair: Medigap insurers only expect to pay \$592 for each person enrolled, while they charge \$2,135 for enrollment. Table 9, which reports the estimated out-of-pocket doctor costs by type of person and insurance, shows that I estimate that Medigap does not reduce the out-of-pocket doctor costs of type twos at all and only slightly reduces the out-of-pocket doctor costs of type ones. Therefore, Medigap insurers' biggest expense is the \$10,000 they must pay when an elderly person chooses to enter a nursing home. Entrance into a nursing home is sufficiently rare such we find that Medigap insurance is profitable for insurers.

Public Policy Simulations. Table 19 reports the simulated remaining lifetime health insurance, doctor visits, nursing home entrance, and assets of a typical cohort of seventy year olds at current Medicare and Medicaid policies. This artificial cohort was constructed by simulating 125 sub-people for each of the 47 people age 67-72 in the sample.[37] Each of the

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[36]It can be argued that the appropriate statistic for adverse selection in Medigap is the total cost of doctor services, not the total cost of health care, since Medicare does not pay for long term nursing homes. In all cases, the total expected cost of doctor services is approximately \$3,000 less than the total cost of all health care and the conclusions are identical.

[37]This procedure explains why the age seventy simulated sample size is 5,875.

125 sub-people have the same number of periods since the last doctor's visit, last diagnosed health state, and last type of health insurance coverage as the particular person in the data on which they are based, however, age 70 assets, income, and then type are randomly drawn using a procedure identical to that described in the last section.[38] Once all of the age seventy state variables are established, the elderly in the simulations make their decisions according to the structure of the model until death. Shown at the bottom of this table, the predicted life-expectancy of this cohort is 13.43 years.

These simulations suggest that the elderly will reduce their purchase of Medigap steadily throughout their lifetime, keep their doctor visits constant at approximately 96%, and increase their use of nursing homes until, at age 98, nearly 20% will be enrolled in a nursing home. The average assets of this sample are also predicted to increase until age 76, then steadily decline until age 100. Average assets increase until age 76 because some elderly save quite a lot in case they wish to enter a private nursing home; after age 76 the cost of this saving outweighs the increase in life-expectancy from entrance in a private nursing if functionally disabled. If the model is simulated assuming that neither private nor Medicaid-subsidized nursing homes increase the survival probabilities of the functionally disabled, the elderly are predicted to steadily deplete their assets.

Note also that the predicted age 85-90 distribution of assets and Medigap choices of the simulated seventy year olds is very different from the distribution of assets and Medigap behavior of current elderly age 85-90, for two reasons. First, all health insurance and health care costs are estimated to be increasing at the real rate of seven percent a period while the real rate of return on savings is assumed to be only four percent each period. So, the

[38] In the tables that follow, and unlike the tables used to evaluate model fit, assets are reported without any measurement error draws.

incentives to save and incentives to purchase Medigap change with respect to calendar year. Second, the estimated percentage of type twos of the 85-90 year olds in the first two waves of AHEAD data (11%) is very different from the simulated age 85-90 percentage of type twos of the current generation of seventy year olds (38%). Shown in the estimation section, the different types receive different benefits from savings and Medigap purchase.

In the first counterfactual simulation used to understand how changes to Medicare and Medicaid would affect outcomes of these elderly, substantially more cost-sharing is imposed. The type-specific out-of-pocket costs of doctor services, by type of insurance, in this counterfactual simulation are reported in Table 20. Summarizing the changes, (1) the Medicare premium does not change, but out-of-pocket costs of doctor services of those insured with only Medicare are specified to be 50% higher than current levels; (2) Medigap out-of-pocket costs do not change but the cost of Medigap insurance is increased by 50%, so the total cost of Medigap becomes $\$4,308.50$; and, (3) nursing home costs do not change, but Medicaid eligibility criteria are fixed at 50% of their current levels ($\bar{W} = \$7,890$ and $\bar{A} = \$6,000$).

The outcomes of this simulation are reported in Table 21. The elderly basically do not change their predicted use of health services relative to current policies and therefore the simulated life-expectancy of the cohort nudges down just .02 years. The elderly do not purchase more Medigap, but save more. Interestingly, the elderly pay more for their health care and yet save more than at the baseline set of Medicare and Medicaid policies. This result is driven by incentives to enter private nursing homes. At this counterfactual set of Medicare and Medicaid policies, the elderly must spend more to become eligible for Medicaid; given that they must spend more to become eligible for Medicaid, some choose to save more to afford a private nursing home, and this extra saving increases predicted mean assets. Table 22 shows different asset profiles when both Medicare and Medicaid impose increased cost sharing, when only Medicare imposes increased cost sharing, and when only Medicaid eligibility changes. Shown in this table, the change in Medicaid is causing the change in savings: If Medicare changes but Medicaid does not, predicted assets decrease relative to the baseline of no policy change until age 90.

In the second policy experiment, Medicare and Medicaid ration the use of doctor visits and nursing homes. In these simulations, those elderly that apply to enter a Medicaid nursing home are refused entrance with 25% probability. This is akin to specifying that the elderly must join a "waiting list" for entrance into Medicaid nursing homes, where only a certain fraction on the list are admitted each period. Also, the elderly that are (a) insured with only Medicare and (b) last diagnosed as healthy one period ago are not allowed to visit a doctor with 25% probability. This restriction does not apply to elderly insured with Medigap. This rationing scenario was constructed to mimic a more subtle rationing that Medicare may impose. Explaining, in the model if an elderly person goes to the doctor in a period, they go once, and at this one visit they learn about their health and get treatment if sick. In the data, twenty five percent of the elderly women living alone insured with Medicare and last diagnosed as healthy go to the doctor 22 times or more in a two-year period. Suppose Medicare limits the number of checkups in a two-year period to 24 for these elderly, but those purchasing Medigap are not subject to this restriction. From the data we cannot tell the precise visit at which the elderly learn the current state of their health and get treatment if ill. If twenty five percent of the elderly learn about changes to their health and get treatment if ill after 24 visits to the doctor in a two-year period, then the rationing of the counterfactual simulation may look like a rule that limits the number of doctor visits for the elderly that were last diagnosed as healthy.

Table 23 reports the simulation results. With rationing, the elderly save slightly more and purchase more Medigap. By purchasing Medigap, these elderly circumvent the Medicare rationing of doctor visits, and so the percentage of elderly that visit the doctor falls by less than one percent compared to the baseline Medicare and Medicaid policies. The elderly do not choose to save enough, however, to pay for their own nursing homes, and the use of nursing homes drops. However, the predicted life expectancy of the sample falls by only only .03 years relative to baseline Medicare and Medicaid policies. The decline in life-expectancy is not greater because doctor visits do not change by very much, and although nursing home use declines, Medicaid-subsidized nursing homes only slightly increase the survival probabilities of the functionally disabled.

7 Conclusions

Four conclusions can be drawn from this research. First, the elderly receive non-pecuniary utility and disutility from the use of health care services, and these non-pecuniary benefits and costs are important determinants of many of the decisions observed in the data. Second, doctor services increase survival probabilities for those elderly that are not healthy, and private nursing homes increase survival probabilities (but Medicaid-subsidized nursing homes do not increase survival probabilities) for the elderly that are functionally disabled. Third, conditional on type, Medigap only marginally lowers the out-of-pocket costs of doctor services. As an aside, it is unclear why the elderly purchase Medigap, other than from any direct utility they receive from the purchase itself. Finally, heterogeneity in cost, preference, and technology parameters in the sample may be important in explaining some of the key features of the data.

The model appears to fit the insurance, doctor, and nursing home choices by age well. There is room for disagreement as to whether or not the model can fit the observed distribution of non-housing assets. Simulations of the model illustrate that Medigap purchasers do not appear to be adversely selected, at least not in 1995. For those insured with Medigap, the total expected cost of care (conditional on going to the doctor) and the unconditional total expected cost of care were less than those for the elderly insured with only Medicare.

Finally, simulations of the model at counterfactual Medicare and Medicaid policies suggest that if Medicare and Medicaid were to impose increased cost-sharing, the elderly adjust their assets, but not their insurance, nursing home, or doctor choices. Simulations also show that if Medicare and Medicaid ration care, the elderly would purchase more Medigap to avoid the rationing of doctor visits, but would not save enough to enter private nursing homes and overall entrance into nursing homes would decline. In both of these counterfactual simulations, the life-expectancy of the elderly is predicted to be the same as with current Medicare and Medicaid policy.

Appendix

In this Appendix, I describe how I solve for the decision rules of the model. Note that for any individual, income in real terms is fixed, so the model solution for any individual conditions on income.[39]

First, the value of consumption at the terminal period is calculated at all values of the state space elements. To make these calculations, feasible assets are discretized and the expected value $V_T(S_T)$ at these different discrete asset values is evaluated via Monte-Carlo integration. The value of optimal consumption is then calculated for each of a set of randomly drawn consumption shocks (from the appropriate distribution) and for each discrete element of the state space. The average value of $V_T(S_T)$ at each discretized state space element is set equal to the expected value, $E[V_T(S_T)]$, which is needed for the calculation of the stage 3 period $T-1$ value function. A cubic spline that preserves monotonicity is passed through the calculated expected values as a function of assets; this cubic spline is then considered the true expected value function for any feasible assets in period T.

At this point, the optimal consumption and nursing home decisions in period $T-1$ are calculated for all possible state variables S^3_{T-1} at the third stage of period $T-1$. As before, assets in S^3_{T-1} are discretized. Given a value of the consumption shock ϵ^c_{T-1} and nursing home shock ϵ^{nh}_{T-1} and the values of the other state variables, the value of optimal consumption is calculated first without and then with nursing home entry (for those that can enter nursing homes). Optimal consumption (both with and the without nursing home entry) is calculated by forcing feasible consumption to be one of a discrete number of points on a grid and then performing a grid search to find the feasible consumption point that

[39] In order to generate a likelihood, I solve the model for multiple values of income. Further, I solve the model for a discrete set of birth cohorts for reasons discussed in the Estimation section.

yields the highest value. The feasible consumption grid consists of evenly spaced points bounded by 0 and the financial resources that remain after the out-of-pocket expenses on the insurance, doctor, and nursing home choices have been paid. These bounds enforce the no-borrowing constraint on consumption and they also let the points of the consumption grid change with the nursing home choice (since out-of-pocket expenses may differ with the different nursing home choices).[40] The optimal value for the third stage at a particular value of the consumption shock and nursing home shock is the maximum of the value of optimal consumption with entrance in a nursing home (if applicable) and the value of optimal consumption without entrance in a nursing home. Given the procedure for finding the optimal value for the third stage at a particular value of the consumption shock and nursing home shock, $E\left[V_{T-1}^3\left(S_{T-1}^3\right)\right]$ is calculated by Monte Carlo integration over the set of consumption and nursing home shocks at all discretized S_{T-1}^3.

At this point, the expected value over the second stage (the doctor choice) at all discretized S_{T-1}^2 is evaluated using Gaussian Quadrature.[41] This evaluates the following expectation from equation (11):

$$\begin{aligned} &E\left[V_{T-1}^2\left(S_{T-1}^2\right)\right] = \\ &E\left[max\{\left(E\left[V_{T-1}^3\left(S_{T-1}^3\right)|S_{T-1}^2, d_{T-1}^2 = 1\right] + b_{T-1}^{doc}\right), E\left[V_{T-1}^3\left(S_{T-1}^3\right)|S_{T-1}^2, d_{T-1}^2 = 0\right]\}\right] \end{aligned} \tag{26}$$

where the outside expectation in the above equation is over the doctor shock.

Similarly, the expectation over the first stage (the insurance choice) at all discretized S_{T-1}^1 of period $T-1$ is calculated using Gaussian Quadrature (if a one-dimensional integral

[40]The cubic spline through the expected value of assets in the terminal period allows evaluation of the value of consumption points in period $T-1$ that do not necessarily correspond to the discretization of assets for which the expected value in the terminal period is calculated.

[41]The set of discrete asset points in S_{T-1}^3 is the same as that in S_{T-1}^2 and S_{T-1}^1.

needs to be evaluated). For those that are eligible to purchase Medigap, this expectation over the insurance shock is derived from (12) and equals:

$$\begin{aligned} & E\left[V_{T-1}^{1}\left(S_{T-1}^{1}\right)\right] = \\ (27) \quad & E\left[max\{\left(E\left[V_{T-1}^{2}\left(S_{T-1}^{2}\right)|S_{T-1}^{1}, d_{T-1}^{1,2}=1\right]+b_{T-1}^{ins}\right), E\left[V_{T-1}^{2}\left(S_{T-1}^{2}\right)|S_{T-1}^{1}, d_{T-1}^{1,1}=1\right]\}\right] \end{aligned}$$

For those that are not allowed to purchase Medigap (see the model section), the expectation over the first stage of period $T-1$ is simply:

$$(28) \qquad E\left[V_{T-1}^{2}\left(S_{T-1}^{2}\right)|S_{T-1}^{1}, d_{T-1}^{1,1}=1\right]$$

The expectation over the first stage is more complicated for those with ex-employer provided Medigap, since with probability p_{T-1} these elderly lose their ex-employer provided Medigap and then must choose to purchase Medigap or be insured with only Medicare. Even though these elderly are not subject to pre-existing conditions clauses, they must have enough resources on hand to purchase the Medigap premium. If this is the case, the expectation over the first stage equals p_{T-1} times (27) plus $(1-p_{T-1})\, E\left[V_{T-1}^{2}\left(S_{T-1}^{2}\right)|S_{T-1}^{1}, d_{T-1}^{1,3}=1\right]$. For those that can not afford Medigap if they lose their ex-employer provided Medigap, the expectation over the first stage equals $(1-p_{T-1})\, E\left[V_{T-1}^{2}\left(S_{T-1}^{2}\right)|S_{T-1}^{1}, d_{T-1}^{1,3}=1\right]$ plus p_{T-1} times (28).

Once the expectation over the first stage, $E\left[V_{T-1}^{1}\left(S_{T-1}^{1}\right)\right]$, has been calculated at all discretized S_{T-1}^{1}, a cubic spline that preserves monotonicity is passed through $E\left[V_{T-1}^{1}\left(S_{T-1}^{1}\right)\right]$ at the discretized set of assets and treated as the true expected value function over continuous assets. At this point, the period $T-2$ optimal consumption and nursing home decision at all discretized S_{T-2}^{3} can be calculated. This entire process is repeated recursively from period $T-2$ to period 1 to yield the full set of decision rules implied by the model.

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Table 1 Distribution of Choices by 5 Year Age Intervals

	Age (# of observations)	67-72 (47)	73-78 (246)	79-84 (231)	85-90 (127)
$d_t^{1,i}$	% Medicare	61.7	45.9	42.4	44.1
	% Self-Purchased Medigap	36.2	50.4	52.4	51.2
	% Ex-Employer Medigap	2.1	3.7	5.2	4.7
d_t^2	% Do not go to Doctor	6.4	2.4	3.9	2.4
	% Go to Doctor	93.6	97.6	96.1	97.6
d_t^3	% Do Not Enter Nursing Home	97.9	97.6	95.2	93.7
	% Enter Nursing Home	2.1	2.4	4.8	6.3
$\frac{A_{t+1}}{1+r}$	Median Non-Housing Assets	\$800	\$1,550	\$2,000	\$5,000

Table 2 Distribution of States by 5 Year Age Intervals

	Age (# of observations)	67-72 (47)	73-78 (246)	79-84 (231)	85-90 (127)
$d_t^{1,i}$	% Medicare	46.8	32.2	34.6	32.3
	% Self-Purchased Medigap	48.9	54.4	58.4	58.3
	% Ex-Employer Medigap	4.3	7.3	6.9	9.4
L_t	% 1 pd. Since Doctor Visit	91.5	94.3	93.5	92.9
	% 2 pds. Since Doctor Visit	8.5	5.7	6.5	7.1
H_t	% Last diagnosed as Healthy	42.5	50.4	52.8	48.8
	% Last Diagnosed as CR	51.1	38.6	38.1	39.4
	% Last Diagnosed as CR+ADL	6.4	9.4	5.2	5.5
	% Last Diagnosed ADL	0	1.6	3.9	6.3
W	Median Yearly Income	$7,968	$9,000	$8,450	$8,725
A_t	Median Non-Housing Assets	$300	$1,000	$850	$1,000
	% Eligible for Medicaid (at start of period)	61.7	44.7	48.5	50.4

Table 3 Health State Transitions

			Wave 2[1]			
		%Died	%Healthy	%CR	%CR+ADL	%ADL
Wave 1	Healthy (330 obs.)	11.2	74.5	11.0	1.4	13.1
	CR (290 obs.)	13.1	0	80.5	19.5	0
	CR+ADL (55 obs.)	18.2	0	40.0	60.0	0
	ADL (20 obs.)	5.0	47.4	5.3	10.5	36.8

Table 4 Doctor's Visit by Diagnosis

Health State	Median Reported total cost[2]	Median out-of-pocket cost (Medicare)[3]	Median out-of-pocket cost (Medigap)
Healthy	$3,000.00	$836.00	$1,100.00
CR	$15,000.00	$2,164.00	$1,720.00
CR+ADL	$15,000.00	$3,640.00	$2,885.00
ADL	$15,000.00	$680.00	$1,980.00

[1] The health transition percentages condition on survival to Wave 2.
[2] Respondents do not directly report the total cost of their health care; they are asked questions that bound the total cost of health care. The median of the midpoint of these bounds is reported in this column.
[3] The median reported out-of-pocket costs do not include costs of the elderly that have had costs subsidized by Medicaid.

Table 5 Survival Probability Parameter Estimates

	Healthy (h=1)	CR (h=2)	CR+ADL (h=3)	ADL (h=4)
α_1^h	-2.8059	-1.9294	-0.8346	-1.7965
	(0.4523)	(0.3140)	(0.5598)	(2.6685)
α_2^h	-3.9466	-4.4294	-2.8648	-0.5426
	(2.7721)		(10.9128)	(4.0038)
α_3^h	.0825	.0359	-.0043	.0755
	(0.0358)	(0.0286)	(0.0558)	(0.1793)
α_4^h		1.199	.06267	0.8823
		(5.5934)	(27.4374)	(5.3803)
α_5^h			-3.8098	-2.7183
			(1.2878)	
α_6^h			3.8096	2.3504

Estimated standard errors are in parentheses

Table 6 Transition Probability Parameter Estimates

Period t Health State		Period t-1 Health State: Healthy (h=1)	CR (h=2)	CR+ADL (h=3)	ADL (h=4)
CR (h=2)	$\varpi_1^{h,h'}$	-1.8286		0.9207	-4.5347
		(0.3556)		(0.5771)	(49.4008)
	$\varpi_2^{h,h'}$	-0.0372		-0.1674	0.1585
		(0.0404)		(0.0723)	(3.0846)
CR+ADL (h=3)	$\varpi_1^{h,h'}$	-5.5197	-2.1895		-2.3640
		(1.0129)	(0.3306)		(3.1857)
	$\varpi_2^{h,h'}$	0.1395	0.0702		0.1241
		(0.0920)	(0.0315)		(0.2328)
ADL (h=4)	$\varpi_1^{h,h'}$	-3.3310			-02379
		(0.5092)			(1.3243)
	$\varpi_2^{h,h'}$	0.1526			-0.0116
		(0.0435)			(0.1173)

Estimated standard errors are in parentheses

Table 7 Utility Parameter Estimates

CR	Type τ^1	Type τ^2
σ	3.2982	3.2982
	(1.6146)	
$\bar{b}^{ins}$	0.2600	-0.0034
	(0.2732)	(0.2332)
$\bar{b}^{doc}$	9.1160	2.4551
	(0.0017)	(3.1951)
$\bar{b}^{nh}$	-20.9573	-28.1994
	(18.8678)	(35.9438)
$\bar{b}^{c}$	5.5885	6.1407
	(4.3132)	(5.0652)
sd^{ins}	1.1833	1.1833
	(0.7819)	
sd^{doc}	4.7793	4.7793
	(5.7280)	
sd^{nh}	34.2162	34.2162
	(40.2973)	

Estimated standard errors are in parentheses

Table 8 Type Parameter Estimates

ξ_1	-1.7752
	(8.8125)
ξ_2	-9.4432
	(17.3068)
ξ_3	2.9626
	(2.5269)
ξ_4	8.5735
	(31.0903)
ξ_5	8.5735
	(34.1957)
ξ_6	-1.2959
	(1.8097)
ξ_7	-0.0232
	(0.0231)
ξ_8	0.2401
	(0.4994)
ξ_9	0.0276
	(0.2145)

Estimated standard errors are in parentheses

Table 9 1995 Out-of-Pocket Cost of a Doctor Visit

		Type τ^1	Type τ^2
Medicare	Healthy (*h*=1)	$1,574	$696
		($698)	($805)
	CR (*h*=2)	$2,277	$2,434
		($121)	($623)
	CR+ADL (*h*=3)	$2,759	$6,979
		($598)	($56,201)
	ADL (*h*=4)	$1,944	$43
		($2,033)	($1,855)
Costly Medigap and Ex-Employer Medigap	Healthy (*h*=1)	$1,574	$696
	CR (*h*=2)	$2,019	$2,434
		($114)	
	CR+ADL (*h*=3)	$2,584	$6,979
		($357)	
	ADL (*h*=4)	$1,944	$43

Estimated standard errors are in parentheses

Table 10 1995 Out-of-Pocket Cost of a One-period (2 Year) Nursing Home Stay

	Medicare	Medigap[4] Ex-Employer Medigap
CR+ADL (*h*=3)	$62,114	$52,114
	($1,551)	
ADL (*h*=4)	$57,658	$47,658
	($7,811)	

Estimated standard errors are in parentheses

[4] The two types are restricted to have the same total cost.

Table 11 Miscellaneous Parameters

η	1.0718
	(0.0324)
P	0.4143
	(0.0758)
υ_1	1.0050
	(0.0554)
υ_2	0.7789
	(0.0101)

Estimated standard errors are in parentheses

Table 12 Health Insurance Probabilities (Observed and Predicted) by Age

	observed age	67-72	73-78	79-84	85-90
	(# observations)	(47)	(246)	(231)	(127)
	model age	70	76	82	88
Medicare	observed	.6170	.4593	.4242	.4406
	predicted	.5449	.4440	.4029	.4411
Medigap[5]	observed	.3830	.5407	.5758	.5591
	predicted	.4551	.5560	.5971	.5589
chi-squared statistic (p value)	d.f.=1	0.9852	0.2333	0.4357	0.0000
		(0.3209)	(0.6291)	(0.5092)	(0.9964)

[5] This includes both the elderly that pay for their own Medigap and the elderly that have Medigap provided for free. These choices are combined because of the low number of observations of elderly with Medigap provided for free.

Table 13 Doctor Probabilities (Observed and Predicted) by Age

	observed age	67-72	73-78	79-84	85-90
	(# observations)	(47)	(246)	(231)	(127)
	model age	70	76	82	88
Go to	observed	.9362	.9756	.9610	.9764
Doctor	predicted	.9658	.9698	.9744	.9846
Do Not Go To	observed	.0638	.0244	.0390	.0236
Doctor	predicted	.0342	.0302	.0256	.0154
chi-squared	d.f.=1	1.2467	0.2826	1.6628	0.5632
Statistic		(0.2642)	(0.5950)	(0.1972)	(0.4530)
(p value)					

Table 14 Nursing Home Probabilities #1 (Observed and Predicted) by Age

	observed age (# observations) model age	67-72 (47) 70	73-78 (246) 76	79-84 (231) 82	85-90 (127) 88
Enter Nursing Home	observed predicted	.0213 .0168	.0244 .0335	.0476 .0531	.0630 .0871
Do Not Enter Nursing Home	observed predicted	.9787 .9832	.9756 .9665	.9524 .9469	.9370 .9129
chi-squared statistic (p value)	d.f.=1	0.0576 (0.8103)	0.6292 (0.4277)	0.1390 (0.7093)	0.9277 (0.3355)

Table 15 Nursing Home Probabilities #2 (Observed and Predicted) by Age

	observed age	67-78[6]	79-84	85-90
	(# observations)	(39)	(55)	(38)
	model age	70, 76	82	88
Enter	observed	.1795	.2000	.2105
Nursing Home	predicted	.2802	.2708	.2795
Do Not Enter	observed	.8205	.8000	.7895
Nursing Home	predicted	.7198	.7292	.7205
chi-squared	d.f.=1	1.9608	1.3962	0.8939
statistic		(0.1614)	(0.2374)	(0.3432)
(p value)				

[6] Ages 67-72 and 73-78 are combined because there are only 5 observations of ederly age 67-72.

Table 16 Asset Choice Probabilities (Observed and Predicted) by Age

	observed age (# observations) model age	67-78[7] (159) 70, 76	79-84 (122) 82	85-90 (60) 88
$A_{t+1} \leq \$1,000$	observed	.3333	.2869	.2000
	predicted	.1819	.2015	.2292
$\$1,000 \leq A_{t+1} \leq \$10,000$	observed	.2201	.1393	.1167
	predicted	.3159	.3202	.2974
$\$10,000 \leq A_{t+1} \leq \$50,000$	observed	.2264	.3443	.3833
	predicted	.3247	.3241	.2994
$\$50,000 \leq A_{t+1}$	observed	.2201	.2295	.3000
	predicted	.1775	.1542	.1740
chi-squared statistic (p value)	d.f.=3	31.0206 (0.0000)	21.5239 (0.0001)	13.6959 (0.0033)

[7] Ages 67-72 and 73-78 are combined because there are only 20 elderly capable of reporting Wave 2 assets age 67-72.

Table 17 Use of Health service, Insurance, and Type

	Medicare		Medigap	
Choice	Percent Choose	Percent Type τ^1 [8]	Percent Choose	Percent Type τ^1
$d_t^2 = 0$	3.03%	7.92%	2.31%	15.84%
$d_t^2 = 1$, Healthy	35.17%	77.20%	42.39%	85.46%
$d_t^2 = 1$, CR	42.98%	94.17%	38.14%	95.52%
$d_t^2 = 1$, CR+ADL , $d_t^3 = 0$	9.19%	95.97%	7.35%	96.01%
$d_t^2 = 1$, CR+ADL, $d_t^3 = 1$	3.38%	97.21%	2.82%	97.51%
$d_t^2 = 1$, ADL, $d_t^3 = 0$	4.53%	80.06%	5.00%	93.29%
$d_t^2 = 1$, ADL, $d_t^3 = 1$	1.72%	86.74%	1.99%	90.21%
Total	100.00%		100.00%	

[8] The percent of purchasers that are type 2 is 100 minus the percent that are type 1.

Table 18 Total Cost of Health Service, by Service, Assumption and Type

	Assumption #1		Assumption #2	
Choice	Total Cost, Type τ^1	Total Cost, Type τ^2	Total Cost, Type τ^1	Total Cost, Type τ^2
$d_t^2 = 0$	\$0	\$0	\$0	\$0
$d_t^2 = 1$, Healthy	\$8,316	\$7,235	\$3,000	\$3,000
$d_t^2 = 1$, CR	\$21,845	\$7,706	\$15,000	\$3,000
$d_t^2 = 1$, CR+ADL , $d_t^3 = 0$	\$51,718	\$35,650	\$15,000	\$15,000
$d_t^2 = 1$, CR+ADL, $d_t^3 = 1$	\$113,832[9]	\$97,764	\$77,114	\$77,114
$d_t^2 = 1$, ADL, $d_t^3 = 0$	\$12,247	\$14,787	\$15,000	\$15,000
$d_t^2 = 1$, ADL, $d_t^3 = 1$	\$69,905	\$72,445	\$72,658	\$72,658

[9] This includes the total cost of a diagnosis for those type 1 in the CR+ADL state plus the out-of-pocket expense of a two year stay in a nursing home for those diagnosed in the CR+ADL state (assuming Medicare does not pay any nursing home costs).

Table 19 Base Care Predicted Outcomes of Elderly age 70 in 1995

Age	Alive	Mean Initial Assets	% Buy Medigap	% Go to Doctor	% Enter Nursing home
70	5875	$20,737	44.87%	96.61%	1.79%
72	5258	$23,587	40.74%	96.18%	2.42%
74	4662	$25,625	36.89%	95.67%	3.07%
76	4116	$26,666	33.02%	96.26%	4.01%
78	3596	$24,412	28.75%	95.69%	4.48%
80	3103	$20,146	24.59%	96.10%	5.83%
82	2649	$15,352	19.78%	96.04%	7.02%
84	2237	$11,786	16.00%	95.75%	8.81%
86	1881	$9,255	14.19%	95.00%	9.46%
88	1543	$7,480	9.79%	96.44%	11.73%
90	1267	$5,817	7.26%	95.66%	12.47%
92	1036	$4,778	4.25%	95.85%	13.71%
94	852	$3,695	2.23%	94.48%	16.31%
96	729	$3,146	1.37%	94.38%	18.11%
98	639	$2,070	0.78%	93.11%	19.09%

Life Expectancy of sample at age 70: 13.43 years

Table 20 Alternative Policy #1 1995 Out-of-Pocket Cost of a Doctor Visit

		Type τ^1	Type τ^2
Medicare	Healthy (h=1)	$2,361	$1,044
	CR (h=2)	$3,416	$3,651
	CR+ADL (h=3)	$4,139	$10,469
	ADL (h=4)	$2,916	$64.5
Costly Medigap and Ex-Employer Medigap	Healthy (h=1)	$1,574	$696
	CR (h=2)	$2,019	$2,434
	CR+ADL (h=3)	$2,584	$6,979
	ADL (h=4)	$1,944	$43

Table 21 Alternative Policy #1 Predicted Outcomes of Elderly age 70 in 1995

Age	Alive	Mean Initial Assets	% Buy Medigap	% Go to Doctor	% Enter Nursing home
70	5875	$20,737	43.90%	96.48%	1.79%
72	5258	$24,670	40.30%	95.85%	2.38%
74	4665	$27,499	37.15%	95.31%	3.00%
76	4120	$29,282	33.88%	95.56%	3.98%
78	3598	$29,318	30.04%	94.89%	4.45%
80	3108	$25,896	23.58%	95.43%	5.95%
82	2652	$21,289	18.10%	95.25%	7.01%
84	2238	$15,691	12.47%	94.15%	8.40%
86	1878	$11,903	10.97%	93.50%	9.48%
88	1536	$8,825	8.20%	94.92%	11.46%
90	1257	$5,505	6.36%	94.11%	12.41%
92	1024	$3,657	3.52%	94.53%	13.28%
94	839	$1,843	1.55%	93.56%	16.33%
96	717	$1,151	0.84%	93.17%	17.57%
98	627	$704	0.48%	92.66%	18.66%

Life Expectancy of sample at age 70: 13.41 years

Table 22 Mean Assets by Age, Alternative Policy #1 and Variants

	Mean Assets			
Age	Baseline	Medicare, Medicaid change	only Medicaid change	only Medicaid change
70	$20,737	$20,737	$20,737	$20,737
72	$23,587	$24,670	$23,019	$24,983
74	$25,625	$27,499	$24,502	$28,252
76	$26,666	$29,282	$25,279	$30,517
78	$24,412	$29,318	$23,001	$30,971
80	$20,146	$25,896	$19,033	$27,349
82	$15,352	$21,289	$14,549	$22,361
84	$11,786	$15,691	$11,404	$16,438
86	$9,255	$11,903	$9,134	$12,788
88	$7,480	$8,825	$7,430	$9,794
90	$5,817	$5,505	$5,698	$6,446
92	$4,778	$3,657	$4,617	$4,486
94	$3,695	$1,843	$3,624	$2,363
96	$3,146	$1,151	$3,046	$1,406
98	$2,070	$704	$2,014	$749

Table 23 Alternative Policy #2 Predicted Outcomes of Elderly age 70 in 1995

Age	Alive	Mean Initial Assets	% Buy Medigap	% Go to Doctor	% Enter Nursing home
70	5875	$20,037	57.24%	95.90%	1.24%
72	5257	$24,146	54.06%	95.43%	1.85%
74	4662	$26,674	49.96%	94.92%	2.64%
76	4116	$28,041	45.21%	95.14%	3.11%
78	3595	$26,256	40.50%	94.74%	3.42%
80	3101	$21,360	35.28%	95.07%	4.13%
82	2651	$16,536	30.93%	94.95%	5.17%
84	2237	$12,784	25.57%	94.05%	6.21%
86	1880	$10,131	21.91%	93.19%	6.91%
88	1541	$8,104	15.25%	94.35%	8.44%
90	1260	$6,309	10.79%	93.33%	9.68%
92	1022	$5,084	6.75%	94.42%	9.98%
94	836	$4,067	4.90%	93.18%	11.24%
96	714	$3,298	2.66%	92.44%	12.75%
98	626	$2,258	1.44%	90.73%	13.10%

Life Expectancy of sample at age 70: 13.40 years