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MARKET EVIDENCE OF MISPERCEIVED MORTALITY RISK *

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Abstract

We construct and implement a test of rational consumer behavior in a high-stakes financial market. In particular, we test whether consumers make systematic mistakes in perceiving their mortality risks. We implement this test using data from secondary life insurance markets where consumers with a life-threatening illness sell their life insurance policies to firms in return for an up-front payment. We compare predictions from two models: one with consumers who correctly perceive their mortality risk, and one with consumers who are misguided about their life expectancy, and find that our data are most consistent with the predictions made by the second model.

Keywords

life insurance; mortality; rational; expectations

1 Introduction

Making insurance decisions is difficult. Traditional economic models of insurance decisions assume, at a minimum, that consumers can accurately assess the risks they face. But is this assumption reasonable? Extensive evidence from the psychology literature shows that people make systematic mistakes in assessing their mortality risks. For example, Lichtenstein et al. (1978) and others have shown that people underestimate mortality risks from likely causes of death and overestimate mortality risks from unlikely causes of death. In related research, studies have found that people overestimate highly publicized risks.¹

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Evidence from the Health and Retirement Survey (HRS) suggests that people tend to be optimistic about their longevity, with optimism greatest for people with the shortest life expectancies. Conversely, the HRS evidence suggests the healthiest people tend to be pessimistic about their longevity, especially after a recent diagnosis of a chronic disease.² However, little of this survey evidence is directly on point because consumers face no immediate costs for holding incorrect perceptions. Do consumers' misperceptions persist when such mistakes are costly?

In this paper, we develop a market-based test of whether consumers make systematic mistakes in assessing their own mortality risks when making high stakes financial decisions. Our test relies on nationally representative data from secondary life insurance markets, where terminally ill HIV+ consumers bequeath their life insurance policies to firms in return for an up-front payment. These markets are good candidates for such a test because in the secondary life insurance market, incorrect perceptions of mortality risk can result in substantial foregone financial losses for consumers.

To set up this test, we describe a model of the secondary life insurance market in which consumers correctly perceive their risk of death. In this model, an increase in mortality risk increases a consumer's wealth by increasing the market value of the consumer's life insurance policy. The consumer can sell some or all of his life insurance policy on the secondary insurance market to capitalize on the rise in market value. We also develop a second model, which is the same in every aspect except that consumers systematically misperceive their mortality risks.

Both models predict a positive correlation between mortality risk and the propensity to sell life insurance. However, the models produce contrasting predictions about the correlation between asset holdings and the decision to sell life insurance. The model with correctly perceived mortality risk predicts a positive correlation. By contrast, the model with incorrect mortality perceptions predicts that: (1) among sicker patients, those with significant non-liquid assets should be *more* likely to sell life insurance; (2) among healthier patients, those with significant non-liquid assets *may* be less likely to sell life insurance. We test predictions from these models using nationally representative data on life insurance sales by HIV+ individuals.

2 The Secondary Life Insurance Market: A Model

A secondary life insurance transaction (also called a viatical settlement) is the sale of an existing life insurance policy to a third party for immediate cash payment at a discount to face value. When a consumer sells his existing contract, the buyer (typically a firm) becomes the sole beneficiary of the policy and collects the face value when the seller dies. Before any sale is made, buyers require the seller to undergo an extensive medical examination by a doctor chosen by the buyer so that the buyer can independently establish the life expectancy of the seller.

The secondary life insurance industry emerged in the 1980s in response to the advent of AIDS, which at that time was almost always fatal. The initial focus of the viatical settlement market on HIV+ consumers was due to the unique demographics of the HIV+ population. HIV+ patients tend to be younger (and therefore less likely to have dependents) and predominantly gay (and hence more likely to have lost their significant other to death from HIV). These demographics implied that HIV+ consumers were more likely than other

¹Moore and Zhu (2000) find that people systematically overestimate the effects of passive smoking on their health.

²Please see Hurd et al. (1999) and Schoenbaum (1997) for evidence on these points. We provide a discussion on these topics in Section 4.

comparably ill patients to sell their life insurance policies (which might have been acquired as a fringe benefit of employment). The industry has grown rapidly since then; there were \$500 million in policies sold by 1995 and \$1 billion in policies by 1998 (National Viatical Association, 1999). The discovery of effective medication for HIV infection appears not to have deterred growth. Companies are expanding their business and some have started marketing settlements to the elderly and patients with other terminal illnesses (American Council of Life Insurance, 1999).

There is a good reason why this market attracts only consumers who have suffered adverse health events. Life insurance premiums are set at the time of purchase based upon the mortality profile of the consumer *at the time of purchase*. When a consumer suffers an adverse health event (worse than average for his age), suddenly he is more likely to collect his life insurance earlier than originally thought at the time of purchase. Indeed, his premiums would be much higher were he to buy the policy after the event. In effect, the adverse health event creates equity in the consumer's existing life insurance policy. It is this equity, which is a real asset for the consumer, that is sold on the secondary life insurance settlements market.

Consider a consumer who is endowed with a life insurance policy that was purchased prior to the development of the illness with face value $\bar{F}$, as well as non-liquid assets (such as a house) with value NL . The consumer can sell all or part of his life insurance policy in the viatical settlement market, and he can sell or borrow against his non-liquid assets in a market for capital. The value of these endowments is determined by prices in the viatical settlement and capital markets, both of which we assume to be competitive.

There are two periods: consumers survive the first period with certainty, die at the beginning of the second period with probability π , and if they survive, die with certainty at the end of the second period. Let θ be the consumer's perceived mortality risk, which may be accurate ($\theta = \pi$), overly optimistic ($\theta < \pi$), or overly pessimistic ($\theta > \pi$). The only uncertainty in this simple model comes from the timing of death. By transacting in the secondary life insurance and capital markets, the consumer can move resources from the present to the future, as well as between different uncertain states of the world.

The consumer maximizes the expected net present value of a utility stream that depends on consumption in each period when he is alive and upon the level of bequests left to his dependents when he dies. At the beginning of the first period the consumer earns income y_1 , sells an amount f of his life insurance policy at the actuarially fair price, p , consumes an amount c_1 and borrows or lends his remaining liquid assets. At the end of the first period the uncertainty about the length of the consumer's life is resolved—he knows then whether he will survive to the second period. If the consumer dies he leaves assets b_d as bequests in the beginning of period two, consisting of the net value of the consumer's house, proceeds of his remaining life insurance policy, and the portfolio of his bonds and interest payments.

$$b_d = (y_1 + pf - c_1)(1+r) + NL + \bar{F} - f \quad (1)$$

The first term in the parenthesis reflects the consumer's net lending or borrowing. If the consumer survives, then at the beginning of the second period, he earns income y_2 and consumes an amount c_2 . Since all uncertainty is resolved by the beginning of the second period, we assume that the consumer bequeaths b_s to his heirs and to the buyer of his life insurance policy *at the beginning* of the second period rather than when he dies at the end of the second period. An heir who prefers to receive the bequest at the end of the second period can simply buy a bond of one-year maturity with his bequests. Under these conditions,

second period bequests will include savings from the first period, life insurance that has not been cashed out, non-liquid assets, and unspent earnings from the second period:

$$b_s = (y_1 + pf - c_1)(1+r) + \frac{NL + \bar{F} - f}{1+r} + y_2 - c_2 \quad (2)$$

We assume that the market for used life insurance is competitive.³ Thus, p is the perfectly competitive market price a viatical settlement company is willing to pay per unit face value of a policyholder with mortality risk π . Let r be the market rate of interest at which the firms can borrow funds. Then,

$$p = \frac{\pi}{1+r} + \frac{1-\pi}{(1+r)^2}. \quad (3)$$

The consumer's problem is to choose the optimal value of consumption and the financing of the consumption through sale of life insurance to maximize expected utility from consumption and bequests:

$$\max_{c_1, c_2, f} \ln(c_1) + \frac{\theta \kappa \ln(b_d)}{1+r} + \frac{(1-\theta) \ln(c_2)}{1+r} + \frac{(1-\theta) \kappa \ln(b_s)}{1+r} \quad (4)$$

where $\kappa \in (0, 1]$ mediates the strength of the bequest motive. We make functional form assumptions on the per-period utility functions to simplify the algebra.⁴ Consumers maximize utility relative to the information set they have, so the expectation is taken over the distribution of perceived mortality risk, rather than actual mortality risk. Of course, actual mortality risk enters through p , which in part determines b_s and b_d . The first order conditions for the problem are:

$$\frac{1}{c_1} = \frac{\theta \kappa}{b_d} + \frac{(1-\theta) \kappa}{b_s} \quad (5)$$

$$\frac{1}{c_2} = \frac{\kappa}{b_s} \quad (6)$$

$$\frac{\theta(1-\pi)}{b_d} = \frac{\pi(1-\theta)}{b_s} \quad (7)$$

Equation (5) shows that consumers set the marginal utility of consumption in the first period equal to their expected marginal utility of bequests, where the expectation is taken with

³In Bhattacharya et al. (2005), we develop evidence that secondary life insurance markets are competitively priced. In particular, we find that calculations of the expected net present value of viatical settlements for people with different life expectancies match (suitably transformed) transaction prices in that market.

⁴In the version of the model where consumers correctly perceive their mortality risk ($\theta = \pi$), the comparative static results we report hold for all per-period utility functions that meet standard monotonicity and concavity conditions. Please see Bhattacharya et al.

(2003) for a proof. In the version of the model where mortality risk is incorrectly perceived ($\theta \neq \pi$), we can prove that $\frac{\partial f}{\partial \pi} > 0$ (that is, that mortality risk and the optimal level of life insurance sales are positively correlated) for all per-period utility functions that meet

standard monotonicity and concavity conditions. We conjecture, but are unable to prove, that the comparative static results for $\frac{\partial f}{\partial NL}$ in the $\theta \neq \pi$ model hold for the general utility function case as long as standard assumptions about monotonicity and concavity hold.

respect to their perceived mortality risk. Similarly, equation (6) shows that once the uncertainty about death is resolved, the marginal utility of consumption in the second period equals the marginal utility of bequests in the second period.

Equation (7) shows that selling life insurance helps consumers reduce the riskiness of their bequest portfolio. In other words, selling life insurance gives consumers a way to increase long-term bequests at the cost of decreasing near-term bequests. This happens because the *ex post* cost of obtaining funds from a viatical settlement (relative to borrowing) depends on the timing of the consumer's death—if consumers die at the end of the second period then a viatical settlement will have lower costs than borrowing, but if consumers die at the end of the first period then viatical settlement will be more expensive than borrowing. Borrowing does not affect the riskiness of the bequest portfolio since the repayment of secured loans taken in prior periods is not contingent on the mortality of the consumer. Of course, the expected *ex ante* cost of financing an extra dollar of consumption through borrowing and selling life insurance will be the same.

3 Comparative Statics Results

We focus in this paper on two comparative statics results that have direct empirical analogs

that we can test with our data: $\frac{\partial f}{\partial \pi}$ and $\frac{\partial f}{\partial NL}$. Here, we describe the main results and the intuition behind them (we leave the algebra for the appendix). First, an increase in mortality risk increases the magnitude of life insurance sales.

$$\frac{\partial f}{\partial \pi} > 0 \quad (8)$$

The intuition for this result is as follows. An increase in mortality risk increases the consumer's wealth by increasing equity in the consumer's life insurance policy. In response to this increase in wealth, the consumer will demand both increased consumption and bequests, which are both assumed to be normal goods. Thus the consumer will sell some or all of the life insurance policy and use some of the proceeds for current consumption and invest the remaining proceeds for future consumption or bequests. This comparative static prediction holds regardless of whether people correctly or incorrectly perceive their mortality risk.

Second, the effect of an increase in non-liquid assets on life insurance sales depends on the relative values of π and θ . For a consumer who correctly perceives mortality risk ($\theta = \pi$), an increase in non-liquid assets leads to an increase in life insurance sales:

$$\frac{\partial f}{\partial NL} > 0 \quad (9)$$

The intuition for this result is as follows. Trivially, an increase in the value of the non-liquid assets (such as a house) increases the consumer's wealth. This increase in wealth would mechanically increase the size of near-term bequests, b_d , were the consumer to die at the end of the first period. To maximize utility under these changed circumstances and equate the marginal utility of bequests and consumption, the consumer will want to liquidate some of his life insurance holdings, effectively moving funds between from the early death state (which is overly funded because of the nature of the increased wealth) to the current time period. Therefore, the consumer will increase life insurance sales and use some of his

wealth to increase consumption and late term bequests, at the expense of the originally increased near term bequests.

For consumers who do not correctly perceive mortality risk, however, the comparative static result is more complicated (though it simplifies to the same expression as in the correctly perceived mortality risk case when $\theta = \pi$):

$$\frac{\partial f}{\partial NL} = \frac{\kappa(\pi - \theta) + \pi((1 - \pi)(1 + r)r + (1 - \theta)(1 + r + \kappa r))}{\pi(1 - \pi)(2 + \kappa + r - \theta)r}, \quad (10)$$

The intuition for this result is as follows. The marginal effect of an increase in non-liquid assets on the sale of life insurance can be broken into two effects: a wealth effect and a misperceived mortality risk effect. The wealth effect (which corresponds to the second term in the numerator of equation 10) operates as we describe above in the $\theta = \pi$ case and tends

to lead to $\frac{\partial f}{\partial NL} > 0$. The sign of the misperceived mortality risk effect (the first term in the numerator of equation 10) depends upon the sign of $\pi - \theta$. When a consumer overestimates his mortality risk ($\pi < \theta$), he will find the price of life insurance in the secondary market to be disappointing; since he believes he will die sooner than the market does, he expects a higher price for his policy than the market can provide. He will thus believe that borrowing money to finance consumption is a better deal than selling life insurance. An increase in NL will allow him to borrow more (since he has more collateral) and sell less life insurance. By contrast, when a consumer underestimates her mortality risk ($\pi > \theta$), she will be pleasantly surprised by the market price of life insurance. The effect of increasing NL will thus have the opposite effect on life insurance sales than it has on the pessimistic consumer.

We show in the appendix that there exists $\theta^*(\pi) > \pi$ such that for all $\theta > \theta^*(\pi)$,

$$\frac{\partial F}{\partial NL} < 0; \quad (11)$$

for $\theta = \theta^*(\pi)$

$$\frac{\partial F}{\partial NL} = 0; \quad (12)$$

and for all $\theta < \theta^*(\pi)$,

$$\frac{\partial F}{\partial NL} > 0. \quad (13)$$

Figure 1 graphically demonstrates the comparative static results for $\kappa = 0.8$ and $r = 0.5$. The

upward sloping solid curve is the set of (θ, π) pairs where $\frac{\partial f}{\partial NL} = 0$. At points above that curve, including the set of points where $\theta = \pi$ (the 45 degree line where people correctly perceive their mortality risk), have $\frac{\partial f}{\partial NL} > 0$. At points below that curve, $\frac{\partial f}{\partial NL} < 0$.

The horizontal line represents an arbitrary mortality probability (health status), say $\bar{\pi}$. Above $\bar{\pi}$, we will call patients “sick” and below $\bar{\pi}$, we will call patients “healthy”, though it should be understood all the people we are analyzing have a serious and life-threatening disease and hence have higher mortality hazards than similar people without the disease. The 45° degree line and the $\pi = \bar{\pi}$ lines divide the (π, θ) space into four regions: in the northeast region,

people are “sick” and excessively pessimistic about their mortality risk; in the north region, people are “sick” and overly optimistic; in the south region, people are “healthy” and overly pessimistic; and in the southwest region, people are “health” and overly optimistic.

4 Comparing Model Predictions

In this section, we translate the comparative static results of the last section into predictions that we should observe in the data if each theory is true. We reserve a full discussion of the data available to us to Section 5.1. The key point to know for this section is that the data permit us a good measure of π (actual mortality risk), serviceable measures of f and NL , but no measure whatsoever of θ (perceived mortality risk). Our goal is to determine whether the data on viatical settlement sales are more consistent with a model of correctly perceived mortality risks or incorrectly perceived mortality risk. The obvious empirical strategy is to divide the universe of HIV patients with life insurance into groups based upon their objective health status and their level of optimism relative to that objective standard, and then to measure the relationship between viatical settlement sales and non-liquid asset holdings in those groups (since our model predicts different things about that relationship depending on the mortality perceptions of consumers). Without some further hypothesis about how people set their expectations about mortality, our model imposes no testable

implications about the sign of $\frac{\partial f}{\partial NL}$.

To see this last point, consider Figure 1 again. In HCSUS, we have a good measure of π but no measure whatsoever of θ . People, for instance, above the $\pi = \bar{\pi}$ line are all observationally equivalent in HCSUS. In fact, for any $\bar{\pi}$, both the region above the $\pi = \bar{\pi}$

line and the region below that line include a mix of people where $\frac{\partial f}{\partial NL} < 0$, $\frac{\partial f}{\partial NL} = 0$, and $\frac{\partial f}{\partial NL} > 0$.

Conversely, with a strong enough assumption about how mortality expectations are set, our

model does produce some unambiguous predictions about the sign of $\frac{\partial f}{\partial NL}$. Most obviously, if we assume that people correctly perceive their mortality risk ($\theta = \pi$), then everyone is on

the 45° line where $\frac{\partial f}{\partial NL} > 0$.

For the misperceived mortality model, we will need a similar, though less drastic structural assumption, to generate an unambiguous prediction. Recent studies using data on subjective survival expectations from the Health Retirement Study (HRS) and the Asset and Health Dynamics Among the Oldest Old (AHEAD) find that people tend to be optimistic about their longevity, with of optimism greatest for people with the shortest life expectancies. Schoenbaum (1997), using data from the HRS, shows that current heavy smokers tend to be overly optimistic about their probability of surviving to age 75; that is, heavy smokers' subjective assessment of their own survival probabilities are higher than those obtained from actuarial models. By contrast, light smokers' subjective assessment of their probability of surviving to age 75 is marginally lower than the actuarial prediction.

Hurd et al. (1999) report a very similar pattern among older populations using data from the AHEAD. For example, 85–89 year-old female respondents' subjective probability of surviving to age 100 years is 0.30, while the life table value is merely 0.07. By contrast, presumably healthier 70–74 year-old female respondents are more pessimistic about their survival chances than is warranted—their subjective probability of surviving to age 85 years is 0.51, while the life table value is 0.58.

The data from these studies show that peoples' perceptions of their own mortality risks are systematically biased. In particular, people with relatively low life expectancy tend to *underestimate* their mortality risks and people with relatively high life expectancy tend to marginally *overestimate* their mortality risks. Another interpretation of these data is that patients perceive their mortality risks to be the same as the average mortality risks for their group, but do not know whether their own risks lie above or below the average. For example, heavy smokers perceive their mortality risks to be the same as those of the "average smoker," and therefore underestimate their own mortality risks. Similarly, HIV+ consumers might perceive their mortality risks to be the same as the average mortality risks for HIV+ persons and therefore those with advanced disease (AIDS) are likely to underestimate their mortality risks.

Formally, given an arbitrary $\bar{\pi} \in (0, 1)$, we assume that HIV+ individuals fall into one of two sets. Either they are early in the course of their disease ("healthy") and pessimistic about their survival probability ($\pi < \bar{\pi}$ and $\pi < \theta$), or they are later in the course of their disease ("sick") and optimistic ($\pi > \bar{\pi}$ and $\pi > \theta$). For the latter group, our model unambiguously

predicts $\frac{\partial f}{\partial NL} > 0$, while for the former group, our model has an ambiguous prediction for the sign of $\frac{\partial f}{\partial NL}$.

We exclude the possibility that there are optimistic HIV+ patients early in the course of their disease ($\pi < \bar{\pi}$ and $\theta < \pi$). We also exclude the possibility that there are HIV+ patients late in the course of their disease who are pessimistic ($\pi > \bar{\pi}$ and $\theta > \pi$). Our misperceived mortality risk model consists of the model we describe in Section 3 plus this set of formal assumptions about the distribution of (π, θ) pairs in the population. Analogously, our accurately perceived mortality risk model (hereafter "standard model") consists of the same model in Section 3 plus the assumption that $\theta = \pi$.

With the model of Section 3 augmented by these assumptions about the setting of mortality expectations, both the standard model and the misperceived mortality risk model make several sharp predictions regarding the behavior of consumers in the viatical settlement and credit markets. The following prediction is common to both the standard model and the misperceived mortality risk model:

Prediction 1[S][M]: *Mortality risk is positively correlated with the decision to sell back life insurance.*

An empirical finding of a negative correlation between mortality risk and the probability of selling back life insurance would contradict both models. The next prediction is also common to both models:

Prediction 2[S][M]: *For the sickest consumers, the decision to sell back life insurance is positively correlated with non-liquid asset holdings.*

As with Prediction 1, a finding of a negative or zero relationship between non-liquid asset holdings and life insurance sales among the sickest consumers would contradict both models. By contrast, the two models have distinct predictions for the relationship between non-liquid asset holdings and life insurance sales among healthier consumers. The standard model predicts the following:

Prediction 3[S]: *For the healthiest consumers, the decision to sell back life insurance is positively correlated with non-liquid asset holdings.*

The misperceived mortality risk model has a weaker prediction for healthier consumers:

Prediction 3[M]: *For the healthiest consumers, the decision to sell back life insurance may be positively, negatively, or not correlated with non-liquid asset holdings.*

The key difference between the two models is in the predicted relationship between asset holdings and life insurance sales among the healthiest consumers. A positive correlation in the data for this subset of consumers would support both the standard and misperceived mortality risk model. A zero or negative correlation would contradict the standard model, but not the misperceived mortality risk model. A finding of a negative correlation would be particularly strong evidence against the standard model. It would suggest that among HIV patients, those earliest in the course of their disease (and hence healthiest) are particularly pessimistic about their survival chances.

5 Empirical Test of the Models

5.1 Data

To test the predictions of these models, we use data from a nationally representative study of HIV+ patients in care – the HIV Costs and Services Utilization Survey (HCSUS). The HCSUS employed a multi-stage national probability sample design to identify HIV+ patients over 18 years old, who made at least one visit for regular care in the contiguous United States in January or February of 1996. It does not include HIV+ patients whose only contact with the health care system was through military, prison, or emergency department facilities, or who have not made contact with the health care system for their HIV. HCSUS collected data between March 1996 and January 1998 with three waves of interviews, which we refer to as “Baseline,” “Follow-Up 1,” and “Follow-Up 2.” HCSUS represents approximately 231,400 HIV+ adults and our analytic sample represents an estimated 123,200 of these HIV+ adults who owned life insurance (Bozzette et al., 1998).

This dataset is appropriate for our analysis because it contains extensive information on a sample of terminally ill patients who constitute a large share of the viatical settlements market (National Viatical Association, 1999).⁵ The dataset has information on the respondents’ demographics, income and assets, health status, life insurance, and participation in the viatical settlements market. Though HCSUS does not contain information about transaction prices and quantities in the viatical settlements market, we do not need them to conduct the tests we describe in Section 4.

Questions about life insurance holdings and sales were asked in the first follow-up (FU1) survey in 1997 and the second follow-up (FU2) survey in 1998. Of the 2,466 respondents in FU1, 1,353 (54.7%) reported life insurance holdings. These 1,353 respondents are our analytic sample as they are the only patients at risk to sell back life insurance. We exclude 344 respondents with missing values for at least one of the key variables—diagnosis date, health status, liquid assets, or non-liquid assets. These excluded respondents were similar to the sample with complete data when compared by their observed covariates. We also exclude 123 respondents who resided in states with minimum price regulation of viatical settlements as these regulations distort the viatical settlements market by restricting settlements by relatively healthy consumers (see Bhattacharya et al., 2005). In our remaining analytic sample of 886 respondents, 146 (16%) respondents had sold their life insurance by the FU1 or FU2 interview dates.

Table 1 compares summary statistics from the baseline interview of respondents who sold their life insurance at some point in time with those who never did.⁶

⁵We obtained data from detailed annual statements filed with the Texas department of insurance by each viatical settlement company licensed to trade viatical settlements in Texas. These data show that in the years 1995 to 1998, 98% of the policies sold in the viatical market in Texas were by consumers with a diagnosis of HIV or AIDS.

Viators (people who have sold back life insurance) are more likely than never-viators to be male, white, college-educated and older. They are also richer and are more likely to own a house. They are also less likely to be married or have any children alive. Finally, viators are typically in poorer health than never-viators, with lower CD4 T-cell levels at the baseline survey and more progressive HIV disease.

HCSUS respondents report whether they sold their life insurance by the first or second follow-up interview. Given these responses, we estimate a logit model of the decision to sell back life insurance. Since we do not observe the exact date of sale we include years at risk as an additional covariate.⁷ Years at risk are measured starting from the year of diagnosis with HIV, or the viatical settlement inception date–1988–whichever is earlier to the date of sale or last interview. All other covariates including health status and asset ownership are measured at time of the baseline interview.

5.2 Measuring Health, Income, and Assets

We include demographics, health status, income, and a full set of interactions between non-liquid assets and health status as covariates in our empirical model. We also include marital status, living alone, and whether the respondent has at least one living child as proxies for the strength of the bequest motive.

When HCSUS was conducted, the two most important health status measures for HIV patients were CD4+ T-lymphocyte cell count and the Center for Disease Control (CDC) definition of clinical stage. CD4+ T-cell count measures the function of a patient's immune system; depletion correlates strongly with worsening HIV disease and increasing risk of opportunistic infections (Fauci et al., 1998). While healthy patients have CD4 cell counts above 500 cells per ml., declines into lower clinically recognized ranges correlate with worsening disease. These ranges are: between 200 and 500 cells per ml., between 50 and 200 cells per ml., and below 50 cells per ml. There are three categories in the CDC definition of clinical stage: asymptomatic, symptomatic, and AIDS (Centers for Disease Control and Prevention, 1993). Patients have AIDS if they manifest conditions such as Kaposi's sarcoma, toxoplasmosis, or the other life-threatening conditions on the CDC list. Symptomatic HIV+ patients manifest signs of to their infection, but not one of the CDC's listed conditions.

We construct a one-dimensional indicator of objective mortality risk by regressing two-year mortality after the baseline survey on the two clinical health measures. This probit regression is shown in Table 2. Of our sample of 886 respondents 4.4% died within 2 years of the survey. Not surprisingly, respondents with lower CD4 T-cell levels or with more advanced disease are more likely to die. Using these results, we predict two-year mortality rates for each respondent.

We use the predicted mortality estimates to compute the average mortality risks for HIV+ persons and divide our sample into respondents with above average mortality risks and respondents with low mortality risk. Based upon this division we create two linearly dependent dummy variables, *Unhealthy* and *Healthy*, which are our main health status indicators. Respondents with CD4+ cell counts less than 50 or those whose disease has progressed to AIDS are classified as *Unhealthy* and the remaining as *Healthy*. 13% of the

⁶Including the 344 respondents who had at least one missing value has no appreciable effect on the summary statistics that we report in Table 1.

⁷We also test the sensitivity of the results by estimating a discrete-time hazard model of the decision to sell back life insurance that more formally accounts for the time at risk and allows for time varying covariates. The results from the hazard model are similar to those reported in this paper and are available by request to the authors.

Unhealthy respondents died within 2 years of interview and in contrast 1% of the *Healthy* died within 2 years of interview.

We experiment with an alternate definition for *Unhealthy* and *Healthy* to test the robustness of our results. In the alternate specification, we define health status on the basis of stage of disease alone and not on the basis of CD4 levels. Those with AIDS will be classified as *Unhealthy* and we assume that these respondents underestimate mortality risks. On the other hand, respondents with asymptomatic or symptomatic stage of disease will be classified as *Healthy* and we assume that these respondents overestimate mortality risks.

Finally, we measure health of the respondents when the survey was conducted and not at the time when the policy was sold back. However, we argue that current health (i.e. when the survey was conducted) is a good proxy for past health (i.e. when the policy was sold back). For example, the correlation between CD4 cell counts measured at baseline survey and the first follow-up survey (the first follow-up survey was conducted about 15 months after the baseline survey) is 0.81. Also, since effective treatment for HIV was not widely available during these survey years current health can be viewed as a lower bound on health of the respondent when the policy was sold back. For example, of the respondents with CD4 cell count below 50 at the time of the baseline interview, less than 5% experienced a rebound in CD4 cell counts above 50. Similarly, respondents who were diagnosed with AIDS at baseline, all the respondents remained diagnosed with AIDS at the first follow-up survey.

The baseline (HCSUS) survey asked respondents about the value of real estate, vehicles, and farm or business, stocks, CDs and other financial assets less any debt on these assets. Unfortunately, these comprehensive questions on assets and debts have missing values for a significant proportion of the respondents 10%. In a different section of the survey, respondents were asked, “do you live in a house or apartment which you or your spouse own.” In contrast to the data on assets and debt data on house ownership did not have missing values. There was a significant positive correlation between networth (assets less debts) and house ownership among respondents who report data on both assets and house ownership. For example, the median networth of respondents who did not own a house was zero and the median networth of house owners was \$23,000. Similarly, the mean networth of house owners was nearly three times the mean networth of respondents who did not own a house (\$80,595 vs. \$27,498). Given the small sample size of the HCSUS survey, the significant missing values for detailed asset ownership questions, and the high correlation between networth and house ownership in our sample we use indicators for house ownership and non-ownership as our measure of non-liquid assets in our empirical models. We designate the indicators for house ownership and non-ownership as *House* and *No-House*, respectively. The results were qualitatively similar but less precise (given the sharp reduction in sample size) when we used data from the detailed asset and debt questions instead of house ownership in our empirical models.⁸

We use income, which was asked in each interview, as a measure of liquid assets. Because many HCSUS respondents only report their income within ranges, we enter income in our models as a series of indicator variables: $1(\text{Income} < \$500 \text{ per month})$, $1(\$501 \leq \text{Income} < \$2,000)$, and $1(\text{Income} \geq \$2,000)$.

⁸HCSUS does not contain information on home equity loans or bank loans. As highlighted above it only contains information on the stock of housing and financial assets net of debts on those assets. To test the predictions related to borrowing and credit markets we would need information on borrowing and loans undertaken after the respondent became HIV+. However, such information is not present in the data. Therefore we rely on viatical settlement transactions data only to test the predictions from our models.

5.3 Results

Table 3 reports the mean marginal effects for four different specifications of the empirical model.⁹ Table 4 maps the predictions from the standard and misperceived mortality risk models into empirical hypotheses and reports results from chi-squared tests of each hypothesis.

Model 1 in Table 3 and Table 4 report the results for the simplest empirical model needed to test the models' predictions. Healthy consumers with houses have the lowest probability of selling back life insurance. Healthy consumers without houses are more likely to sell back life insurance than healthy house owners ($p < 0.05$). In contrast, unhealthy consumers without houses are less likely to sell back life insurance than unhealthy consumers who own a house ($p < 0.05$). The results clearly demonstrate an ordering of the probability of selling back insurance that is consistent with prediction 3[M] of the misperceived mortality risk model, but not with prediction 3[S] of the standard model. These results are also consistent with Prediction 1[M][S] from both the economic and misperceived mortality risk model. Regardless of home ownership, unhealthy consumers are significantly more likely to sell back life insurance ($p < 0.01$).

Model 2 in Table 3 and Table 4 adds demographic, education and bequest motive variables to Model 1. Whites have significantly higher probability of selling back life insurance than do Blacks, Hispanics, and respondents of other races. Older respondents are significantly more likely to sell back life insurance. There are no statistically significant differences between high school dropouts, high school graduates and college educated respondents in the probability of selling back life insurance, though the point estimates indicate college graduates and those with some college education are more likely to sell back life insurance. As was the case with Model 1, the results of this model are also consistent with misperceived mortality risk model, but not the standard model.

In Model 3, we check the robustness of our results to a change in the definition of health status. In that model, respondents with AIDS are classified as *Unhealthy* and those with less advanced disease (Asymptomatic and Symptomatic) are classified as *Healthy*. We also include separate controls for other measures of health status— CD4 T-cell level indicators (higher levels indicate better immune function). Except for these changes, the specifications of Models 2 and 3 are identical. As with Models 1 and 2, the estimates from Model 3 are also consistent with the misperceived mortality risk model.

All of these specifications yield essentially the same outcome: among sicker HIV patients, home ownership is positively correlated the propensity to sell back insurance; among healthier HIV patients, home ownership is negatively correlated with the propensity to sell back insurance.

6 Alternate Theories

The evidence presented here is consistent with the misperceived mortality risk model rather than the standard model. Here, we consider four alternate explanations that could, under certain conditions, give rise to similar findings.

One important factor that we did not explicitly model is means-tested programs such as Medicaid. In most states, proceeds from viatical settlements are counted as assets for the purposes of means-testing, but life insurance policies themselves are excluded. Clearly, this

⁹We average the marginal effects for each covariate across all individuals in the sample as they depend not only on the regression coefficient associated with the covariate but also on the values of the other covariates.

might reduce incentives to sell back life insurance for individuals who would otherwise be eligible for these programs. However, the bias here goes the wrong way. Such program rules make the unhealthy *less* likely to sell insurance—and contrary to what the data show—since they tend to be more indigent and thus more likely to be eligible for Medicaid or other public programs.

A related alternative explanation concerns the tax treatment of viatical settlements. The 1996 Health Insurance Portability and Accountability Act, which came into effect in January 1997, exempts proceeds derived from a viatical settlement from federal taxes as long as the seller is certified by a physician to have a life expectancy of 24 months or less or to be chronically ill. Several large states, such as California and New York, have also passed similar provisions exempting viatical settlement transactions from state taxes (Sutherland and Drivanos, 1999). Although these laws might lead to a negative correlation between health and the probability of selling insurance after 1997, the vast majority of our data refer to the period before the HIPAA implementation. Most respondents in our study reported that they sold their life insurance before the first quarter of 1997 – thus there is only a 2–3 month overlap in the time when these laws were effective and the period of life insurance sales in the HCSUS sample.

As in any insurance market, asymmetric information (patients know more than firms about their mortality risks) could be an important determinant of market outcomes in the viatical settlements market. As Akerlof (1970), Wilson (1977), and Rothschild and Stiglitz (1976) demonstrate, asymmetric information might lead to adverse selection in insurance markets; that is, high-risk individuals are more likely to participate and low risks are driven out of the market. Since, consumers are sellers in this market, adverse selection in these markets leads to the opposite of the typical “lemons” problems; it is unobservably sick patients rather than healthier patients who are driven out of the market.

The institutional details of this industry argue against the importance of adverse selection in these markets. In particular, there are good reasons to believe that viatical settlement companies have accurate information on patient’s mortality risks. Unlike other insurance markets, viatical settlement firms often use the services of independent physicians and actuaries to determine the life expectancy of the seller National Viatical Association (1999). Furthermore, companies scrutinize patient medical records before making an offer to buy, and they have access to the mortality experience of a large pool of patients. Of course, even these efforts may not completely eliminate asymmetric information—patients may still have private information about their health status.

If private information is a concern then we would expect that those who sold were less likely to die in the period after the sale. To check this we estimate a probit model with two-year mortality as the dependent variable and the decision to sell life insurance and our clinical indicators—CD4 levels and stage of disease—as the explanatory variables. This test is similar in spirit to the test that Cawley and Philipson (1999) use to look for the presence of adverse selection in life insurance markets. In this model, the coefficient on whether a person sold his life insurance was insignificant and had the wrong sign (positive), which suggests that adverse selection is not an important concern in this market.¹⁰

Finally, it is worth considering the role of transaction costs. Transaction costs in credit markets might be systematically different for healthy and unhealthy consumers; in particular, unhealthy consumers might face a higher cost of borrowing against their house as compared with healthy consumers. For example, lenders might charge higher prices to

¹⁰Results from this model are available upon request from the authors.

unhealthy consumers if they expect to incur significant costs in collecting loan repayments from the estates of unhealthy consumers and but do not expect such costs for healthy consumers (as they might be more likely to repay their loans before they die). In this case, it would be likely that unhealthy consumers would prefer the viatical settlement market, while healthy consumers would prefer the credit market to finance their consumption needs. However, this explanation is based on two assertions that are unlikely to be true. First, this explanation assumes that lenders know the health status or life expectancy of borrowers. This is unlikely since credit applications do not usually require borrowers to disclose their health status. Second, this explanation assumes that transaction costs in the viatical settlement market do not systematically depend on the life expectancy of the sellers. However, it seems likely that unhealthy consumers, who have little time left alive, might view the sometimes lengthy process of searching and negotiating with viatical firms in this relatively new market as particularly onerous, relative to healthier consumers. Therefore, it seems unlikely that our results are driven by differences in transaction costs in credit markets for healthy and unhealthy consumers, although we cannot rule out this explanation.

7 Discussion and Conclusions

Our empirical findings are that, among healthier HIV+ consumers, homeowners are less likely to sell their life insurance than are non-home owners. In contrast, among healthier HIV+ consumers, homeowners are more likely to sell their life insurance policies. These empirical findings cannot be reconciled with a standard model in which consumers correctly perceive their mortality risk. Instead, these findings are consistent with the hypothesis that HIV+ consumers substantially underestimate their life expectancy early in the course of their disease and overestimate their life expectancy later in the course of their disease.

This conclusion raises the following question: can such consumer mistakes persist in the long run? The standard argument against persistence of consumer mistakes is that they lead to mispriced or imperfect markets that in turn create arbitrage opportunities. However, Barberis and Thaler (2002), in their review of the literature on consumer mistakes in financial markets, argue persuasively that while the statement “prices are right” implies “no free lunch,” the converse does not necessarily hold. They argue that mispricing does not always lead to arbitrage opportunities, as strategies designed to take advantage of mispricing—especially in financial markets—can be costly or risky. Our results add a new dimension to this debate; we find that “prices are right” does not imply “no mistakes.” Our results show that despite consumer mistakes, there is no real mispricing in this market—the only mistakes are in consumer perceptions not in market prices. Thus, since prices are actuarially fair (firms make zero profits), such mistakes are likely to persist.

The above discussion leads naturally to a simple set of policy implications to reduce consumer mistakes: requiring buyers to provide more forthright disclosures of mortality risks and to “decode” prices for sellers in a way that is more easily understandable. Such regulations have recently been implemented in other mortality contingent claims markets such as the reverse mortgage market.¹¹ Recognizing that consumers typically find it difficult to compare the costs of a reverse mortgage with other credit instruments, the Home Owner Equity Protection Act (HOEPA, 1994) subjects all reverse mortgages to a Truth-in-Lending disclosure. This provision requires lenders to project and disclose the total annual average cost of these loans if they were repaid after two years, at the borrower’s life expectancy and

¹¹Reverse mortgage markets allow consumers to take loans against equity in their homes. However, unlike normal loans, reverse mortgages limit the loan repayment to the value of the house and require no repayment for as long as the borrower is alive. Thus, just like viatical settlement markets, the loan amount available from a reverse mortgage will depend on the life expectancy of the borrower.

40% beyond the borrower's life expectancy. Our findings suggest that similar regulations might be beneficial for consumers in secondary life insurance markets.

References

- Akerlof GA. The market for 'lemons': Quality uncertainty and the market mechanism. *Quarterly Journal of Economics*. 1970; 84:488–500.
- American Council of Life Insurance. Accelerated death benefits popularity doubles, new acli-limra survey shows. Washington, D.C.: LIMRA International News Release; 1999 Apr 5.
- Barberis, N.; Thaler, R. A survey of behavioral finance; Working Paper 9222, National Bureau of Economic Research; 2002.
- Bhattacharya, J.; Goldman, DP.; Sood, N. What accounts for the variation in retirement wealth among us households?; Working Paper 9863, National Bureau of Economic Research; 2003.
- Bhattacharya J, Goldman DP, Sood N. Price regulation in secondary insurance markets. *Journal of Risk and Insurance*. 2005; 72:61–75.
- Bozzette SA, Berry SH, Duan N, Frankel M, Leibowitz AA, Lefkowitz D, Emmons C, Senterfitt J, Berk M, Morton SC. The care of hiv-infected adults in the united states. hiv cost and services utilization study consortium. *New England Journal of Medicine*. 1998; 339:1897–904. [PubMed: 9862946]
- Cawley J, Philipson T. An empirical examination of information barriers to trade in insurance. *American Economic Review*. 1999; 89:827–846.
- Centers for Disease Control and Prevention. 1993 revised classification system for hiv infection and expanded surveillance case definition for aids among adolescents and adults. *JAMA*. 1993; 269:729–730. [PubMed: 8093740]
- Fauci, AS.; Braunwald, E.; Isselbacher, KJ.; Wilson, JD.; Martin, JB.; Kasper, DL.; Hauser, SL.; Longo, DL., editors. *Harrison's Principles of Internal Medicine*. 14th Edition. New York, NY: McGraw-Hill Inc.; 1998.
- HOEPA. The Home Owner Equity Protection Act of 1994. 1994 15 U.S.C. §1639.
- Hurd, M.; McFadden, D.; Merrill, A. Predictors of mortality among the elderly; Working Paper 7440, National Bureau of Economic Research; 1999.
- Kimball, M. Precautionary saving and the marginal propensity to consume; Working Paper 3403, National Bureau of Economic Research; 1990a.
- Kimball M. Precautionary saving in the small and in the large. *Econometrica*. 1990b; 58:53–73.
- Lichtenstein S, Slovic P, Fischhoff B, Layman M, Combs B. Judged frequency of lethal events. *Journal of Experimental Psychology: Human Learning and Memory*. 1978; 4:551–578.
- Moore MJ, Zhu CW. Passive smoking and health care: Health perceptions myth vs. health care reality. *Journal of Risk and Uncertainty*. 2000; 21:283–310.
- National Viatlcal Association. Nva information booklet. Washington, DC: NVA; 1999.
- Rothschild M, Stiglitz JE. Equilibrium in competitive insurance markets: An essay on the economics of imperfect information. *Quarterly Journal of Economics*. 1976; 90:630–649.
- Schoenbaum M. Do smokers understand the mortality effects of smoking? evidence from the health and retirement survey. *American Journal of Public Health*. 1997; 87:755–759. [PubMed: 9184501]
- Sutherland W, Drivanos P. Viatlcal settlements: Life insurance as a liquid asset for the seriously ill. *Journal of Financial Planning*. 1999;12.
- Wilson C. A model of insurance markets with incomplete information. *Journal of Economic Theory*. 1977; 16:167–207.

Appendix

Consider a consumer whose initial wealth includes a house with a market value of NL dollars (net of any outstanding loans against the house) and a life insurance policy with face value $\bar{F}$ dollars. In our simple model, there are two periods. In period one, consumers earn income y_1 , sell an amount f of their life insurance policy at the actuarially fair price p ,

consume c_1 and lend or borrow their remaining assets. Consumers survive period 1 with certainty but die before the beginning of period 2 with probability π . If they die at the end of period 1 they leave bequests b_d which includes their house, remaining life insurance policy and bonds/debts.

$$b_d \equiv (y_1 + pf - c_1)(1+r) + NL + \bar{F} - f \quad (\text{A-1})$$

The actuarially fair price of the life insurance policy is:

$$p \equiv \frac{\pi}{1+r} + \frac{(1-\pi)}{(1+r)^2} \quad (\text{A-2})$$

Since all uncertainty is resolved at the end of period 1, we assume that if the consumer survives through period 2 (with probability $1-\pi$), he bequeaths his belongings at the beginning of period 2 rather than when he dies at the end of period 2. An heir who prefers to receive the bequest at the end of the second period can simply buy a bond of one-year maturity with his bequests. Under these conditions, bequests at the end of the second period (b_s) include savings from the first period, life insurance that has not been cashed out, housing assets, and unspent earnings from the second period.

$$b_s \equiv (y_1 + pf - c_1)(1+r) + \frac{NL}{1+r} + \frac{\bar{F} - f}{1+r} + y_2 - c_2 \quad (\text{A-3})$$

Finally, even though the true probability of dying at the end of period 1 is π , consumer perceives this probability to be θ . This subjective mortality risk can be equal to, less than, or greater than the true mortality risk.

The consumer's problem is to maximize expected present value of utility from consumption and bequests:

$$\max_{c_1, c_2, f} u(c_1) + \frac{\theta \kappa u(b_d)}{1+r} + \frac{(1-\theta)u(c_2)}{1+r} + \frac{(1-\theta)\kappa u(b_s)}{1+r}. \quad (\text{A-4})$$

We assume per-period utility is monotone and concave: $u' > 0$ and $u'' < 0$. We also assume that $0 < \kappa < 1$, which guarantees that the per-period utility return from bequests is lower than the per-period utility return from direct consumption. Substituting equations (A-1) and (A-2), and then differentiating (A-4) with respect to c_1 , c_2 , and f yields the following first order conditions:

$$u'(c_1) - \theta \kappa u'(b_d) - (1-\theta)\kappa u'(b_s) = 0 \quad (\text{A-5})$$

$$u'(c_2) - \kappa u'(b_s) = 0 \quad (\text{A-6})$$

$$-\theta(1-\pi)u'(b_d) + (1-\theta)\pi u'(b_s) = 0 \quad (\text{A-7})$$

(A-5) implies that the marginal utility of consumption in period 1 should equal the expected marginal utility from bequests; (A-6) implies that the marginal utility of consumption in period 2 should equal the marginal utility from far-term bequests; and (A-7) implies that the

ratio of the marginal utility of near and far-term bequests should equals the ratio of odds of true over perceived mortality risk. In (A-7), the odds ratio depends on the extent and direction of self-deception about mortality risks. If mortality risk is correctly observed, then the odds ratio is one and near- and far-term bequests are equal at the optimum. If $\theta > \pi$ (which indicates excessive pessimism), then (A-7) implies $u'(b_d) < u'(b_s)$ and hence near-term bequests will optimally exceed far-term bequests. Conversely, if $\theta < \pi$ (which indicates excessive optimism), far-term bequests will optimally exceed near-term bequests.

We will first compute the comparative statics of a change in the true mortality risk on

optimal life insurance sales ($\frac{\partial f}{\partial \pi}$). Rewriting the first order conditions and some simple algebraic manipulation yields:

$$\begin{aligned}\pi u'(c_1) - \theta \kappa u'(b_d) &= 0 \\ u'(c_2) - \kappa u'(b_s) &= 0 \\ (1 - \theta)u'(c_2) - (1 - \pi)u'(c_1) &= 0\end{aligned}$$

The second order conditions for the problem implies that the determinant of the following matrix is negative:

$$D = \begin{bmatrix} \pi u''(c_1) + (1+r)\theta \kappa u''(b_d) & 0 & (1-\pi)\theta \kappa u''(b_d) \frac{r}{1+r} \\ (1+r)^2 \kappa u''(b_s) & u''(c_2) + \kappa(1+r)u''(b_s) & -\kappa \pi r u''(b_s) \\ -(1-\pi)u''(c_1) & (1-\theta)u''(c_2) & 0 \end{bmatrix},$$

Let

$$dx = [dc_1 \quad dc_2 \quad df],$$

and

$$w = [\kappa u'(b_d) \quad 0 \quad u'(c_2)].$$

We totally differentiate the first order equations and among the exogenous variables, permit only mortality risk (π) to change. This yields the following system of equations:

$$Hdx' = w'd\pi \quad (\text{A-8})$$

Solving equation (A-8), it is easy to show that the sign of $\frac{\partial f}{\partial \pi}$ will be the same as the sign of the following expression:

$$- \left[(\pi u''(c_1) + (1+r)\theta \kappa u''(b_d))(u''(c_2) + \kappa(1+r)u''(b_s))u'(c_2) + \kappa^2(1+r)^2(1-\theta)u''(b_s)u''(c_2)u'(b_d) + \kappa(1-\pi)(u''(c_2) + \kappa(1+r)u''(b_s))u''(c_1)u'(b_s) \right]$$

Since we assume $u'' < 0$ and $u' > 0$, this implies our first comparative static result:

$$\frac{\partial f}{\partial \pi} > 0 \quad (\text{A-9})$$

We turn next to the sign of $\frac{\partial f}{\partial NL}$. Define

$$z = [\theta\kappa(1+r)u''(b_d) \quad \kappa(1+r)^2u''(b_s) \quad 0].$$

We totally differentiate the first order equations and among the exogenous variables, permit only housing asset holdings (NL) to change. This yields the following system of equations:

$$Hdx' = z'dNL \quad (A-10)$$

This system implies:

$$\frac{df}{dNL} = \frac{\begin{vmatrix} \pi u''(c_1) + (1+r)\theta\kappa u''(b_d) & 0 & \theta\kappa(1+r)u''(b_d) \\ (1+r)^2\kappa u''(b_s) & u''(c_2) + \kappa(1+r)u''(b_s) & \kappa(1+r)^2u''(b_s) \\ -(1-\pi)u''(c_1) & (1-\theta)u''(c_2) & 0 \end{vmatrix}}{\begin{vmatrix} \pi u''(c_1) + (1+r)\theta\kappa u''(b_d) & 0 & (1-\pi)\theta\kappa u''(b_d)\frac{r}{1+r} \\ (1+r)^2\kappa u''(b_s) & u''(c_2) + \kappa(1+r)u''(b_s) & -\kappa\pi r u''(b_s) \\ -(1-\pi)u''(c_1) & (1-\theta)u''(c_2) & 0 \end{vmatrix}} \quad (A-11)$$

We are unable to sign (A-11) for a general utility function with the properties that we have assumed up to here in the appendix.¹² Instead, we assume a particular utility function: $u(x) = \ln x$. With this utility function, (A-11) reduces to (10) from the main paper:

$$\frac{\partial f}{\partial NL} = \frac{\kappa(\pi - \theta) + \pi((1-\pi)(1+r)r + (1-\theta)(1+r+\kappa r))}{\pi(1-\pi)(2+\kappa+r-\theta)r}. \quad (A-12)$$

For given values of r and κ , the set of points (π^*, θ^*) where $\frac{\partial f}{\partial NL} = 0$ is traced out by the following function:

$$\theta^*(\pi^*) = \frac{\pi^*(1+r)(2+\kappa-\pi^*)}{\pi^*(1+r+\kappa r) + \kappa} \quad (A-13)$$

Next, we show that for all $\pi \in (0, 1)$, $\theta^*(\pi) > \pi$. We adopt a proof by contradiction. Suppose our statement is not true. Then equation (A-13) implies,

$$\frac{\pi(1+r)(2+\kappa-\pi)}{\pi(1+r+\kappa r) + \kappa} \leq \pi.$$

Some algebraic manipulation shows that this is equivalent to:

¹²Based on our work with this expression, we conjecture that the results that we report in the main text of the paper about $\frac{\partial f}{\partial NL}$ hold for general utility functions that also display a positive prudence property (Kimball, 1990a,b) that is decreasing in consumption. In our context, this assumption is equivalent to $u'''(x) > 0$ and $u''''(x) < 0$, however, we are unable to obtain a proof of our conjecture even with these additional assumptions.

$$\pi \geq \frac{2+2r+\kappa r+\kappa}{2+2r+\kappa r} > 1$$

which is impossible.

Finally, we show that for fixed values of $\pi^* \in (0, 1)$, κ , and r , we have that $\frac{\partial f}{\partial NL} > 0$ for all $\theta < \theta^*(\pi^*)$ and that $\frac{\partial f}{\partial NL} < 0$ for all $\theta > \theta^*(\pi^*)$. The sign of $\frac{\partial f}{\partial NL} > 0$ depends only on the numerator of (A-12), since the denominator is always positive in the relevant range. Rearranging terms in the numerator yields the following function of θ :

$$g(\theta) = \kappa\pi^* + \pi^*(1 - \pi^*)(1+r)r + (1+r+\kappa r) - \theta(1+r)(1+\kappa)$$

By the definition of θ^* , $g(\theta^*) = 0$. Also, g decreases linearly with θ , which proves our assertions about the sign of $\frac{\partial f}{\partial NL}$ for the various values of θ .

Figure 1.
Comparative Statics: df/dNL

Table 1

Weighted Descriptive Statistics at Baseline

Variables	Never sold life insurance (N=740)	Ever sold life insurance (N=146)	Entire sample (N = 886)
<u>CD4 T-cell levels:</u>			
< 50 cells per ml	9.36%	12.08%	9.83%
50 – 200 cells per ml	21.68%	40.00%	24.84%
201 – 500 cells per ml	43.32%	31.40%	41.26%
> 500 cells per ml	25.64%	16.52%	24.07%
<u>Disease Stage:</u>			
Asymptomatic	10.93%	11.85%	11.09%
Symptomatic	54.37%	38.61%	51.64%
AIDS	34.70%	49.54%	37.26%
<u>Income and Assets:</u>			
House ownership	29.38%	33.57%	30.11%
Monthly Income			
< \$500	15.81%	13.57%	15.42%
\$501 – \$2000	39.85%	38.73%	39.66%
> \$2000	44.34%	47.70%	44.92%
<u>Bequest Motives:</u>			
Any Children Alive	37.82%	29.18%	36.32%
Married	16.01%	12.30%	15.37%
Separated, Divorced, Widowed	25.55%	28.06%	25.98%
Never Married	58.44%	59.64%	58.64%
<u>Demographics:</u>			
Age	34.88 years	38.01 years	35.42 years
Male	84.19%	89.35%	85.08%
Black	25.41%	17.32%	24.01%
Hispanic	13.61%	4.18%	11.98%
White	56.68%	75.97%	60.01%
Other race	4.30%	2.53%	3.99%
Have college degree	24.52%	36.38%	26.57%

Note: We compute these statistics from weighted means in the 1997–98 HIV Cost and Services Utilization Survey.

Table 2

Two-Year Mortality Probit Regression

Variable	Coefficient	Standard Error
CD4 T-cell < 50	1.78	0.46
CD4 T-cell 51–200	1.09	0.45
CD4 T-cell 201–500	0.54	0.46
CD4 T-cell 500+	-	
Asymptomatic	−0.47	0.47
Symptomatic	−0.25	0.2
AIDS	-	
Intercept	−2.57	0.45

Note: “CD4 T-cell 500+” and “AIDS” are reference categories.

Table 3**Empirical Models of the Probability of Selling Back Life Insurance**

Variables	Model (1)	Model (2)	Model (3)
<u>Income</u>			
Income(500,2000]	0.009 [0.039]	−0.013 [0.038]	−0.012 [0.038]
Income > 2000	0.037 [0.040]	−0.014 [0.041]	−0.014 [0.041]
<u>Health and House Ownership</u>			
Unhealthy*House	0.357 [0.076] **	0.320 [0.072] **	0.142 [0.063] **
Unhealthy*NoHouse	0.147 [0.057] **	0.156 [0.055] **	0.062 [0.050]
Healthy*NoHouse	0.062 [0.037] *	0.078 [0.036] **	0.092 [0.042] **
<u>Bequest Motives</u>			
Married		0.003 [0.044]	0.012 [0.045]
Separated		0.007 [0.035]	0.017 [0.036]
Child alive		−0.051 [0.034]	−0.06 [0.034] *
Living Alone		0.007 [0.027]	0.002 [0.026]
<u>Demographics</u>			
Black		−0.068 [0.030] **	−0.066 [0.030] **
Hispanic		−0.129 [0.027] **	−0.132 [0.026] **
Other race		−0.093 [0.042] **	−0.094 [0.042] **
Male		0.001 [0.041]	0.003 [0.041]
Age		0.007 [0.002] **	0.007 [0.002] **
High school		−0.048 [0.046]	−0.04 [0.047]
Some College		0.053 [0.050]	0.072 [0.051]
College		0.065 [0.057]	0.081 [0.058]
<u>CD4</u>			
CD4 < 50			0.111 [0.065] *
CD4 [50,200)			0.167 [0.049] **
CD4[200, 500)			0.028 [0.036]
Years at risk	−0.000 [0.005]	−0.000 [0.005]	−0.001 [0.005]
Observations	886	886	886

Notes: Coefficients are mean marginal effects. Standard errors in brackets.

* significant at 10%;

** significant at 5%.

Reference Categories are Income < 500; Healthy*House; Never Married; White; Less than high school; Asymptomatic; CD4 > 500

Table 4

Chi-squared Tests of Model Predictions

Model Predictions ^a	p-value: ^b		
	Model 1	Model 2	Model 3
Misperceived Mortality Risk Model			
Prediction 1[M]: Positive correlation between objective mortality risk and the decision to sell life insurance. $H_A: [Pr(Unhealthy, Assets) > Pr(Healthy, Assets)] \& [Pr(Unhealthy, No Assets) > Pr(Healthy, No Assets)]$	Accept H_A p<0.01	Accept H_A p<0.01	Accept H_A p=0.018
Prediction 2[M]: Among unhealthy consumers, a positive correlation between the decision to sell life insurance and the amount of non-liquid assets. $H_A: Pr(Unhealthy, Assets) > Pr(Unhealthy, No Assets)$	Accept H_A p<0.01	Accept H_A p<0.01	Accept H_A p=0.053
Prediction 3[M]: Among healthy consumers, positive, negative, or no correlation between the decision to sell life insurance and the amount of non-liquid assets. $H_A: Pr(Healthy, Assets) ? Pr(Healthy, No Assets)$	No prediction	No prediction	No prediction
Standard Model			
Prediction 1[S]: Positive correlation between objective mortality risk and the decision to sell life insurance. $H_A: [Pr(Unhealthy, Assets) > Pr(Healthy, Assets)] \& [Pr(Unhealthy, No Assets) > Pr(Healthy, No Assets)]$	Accept H_A p<0.01	Accept H_A p<0.01	Accept H_A p=0.018
Prediction 2[S]: Among unhealthy consumers, a positive correlation between the decision to sell life insurance and the amount of non-liquid assets. $H_A: Pr(Unhealthy, Assets) > Pr(Unhealthy, No Assets)$	Accept H_A p<0.01	Accept H_A p<0.01	Accept H_A p=0.053
Prediction 3[S]: Among healthy consumers, positive correlation between the decision to sell life insurance and the amount of non-liquid assets. $H_A: Pr(Healthy, Assets) > Pr(Healthy, No Assets)$	Reject H_A p=0.954	Reject H_A p=0.985	Reject H_A p=0.986

Notes:

^aPr(X, Y) is the probability of selling life insurance for consumers in both groups X and Y

^b p-values are reported for chi-squared tests. Each model prediction compares the probability of selling life insurance for consumers in different groups and predicts which group of consumers will have a higher (or lower) probability of selling life insurance. For each statistical test the null hypothesis (H_0) is that probability of selling life insurance for consumers in the different groups is equal. The alternate hypothesis (H_A) is that the model prediction is true. For example, for prediction 1 H_0 is that the unhealthy and the healthy have an equal probability of selling life insurance. H_A is that the unhealthy have a higher probability of selling life insurance.