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Predictors of Mortality among the Elderly

Michael D. Hurd, Daniel McFadden, and
Angela Merrill

5.1 Introduction

Mortality risk is a fundamental determinant of consumption and saving in a life-cycle model. Understanding the behavioral reactions to variation in mortality risk is important from a scientific point of view and from a policy point of view. The reaction will reveal the degree of risk aversion, which is an important behavioral parameter. The economic status of the oldest old will depend on their consumption and saving choices in the years closely following retirement. Under the life-cycle model, the predicted changes in life expectancy will have an effect on national saving beyond what would be forecast from a compositional effect.

Mortality risk in the population may be adequately measured by life-tables; however, individuals are likely to have additional information about their life chances and use that information in making consumption and saving decisions. Some of that information may be related to observable characteristics such as health status and socioeconomic status (SES). Accounting for the relationship between SES and mortality (the SES gradient) is particularly important. The gradient is important because it causes difficulties in predicting the economic status of a cohort and in under-

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standing life-cycle behavior from cross-sectional variation in wealth. Besides cohort effects that would, by themselves, cause wealth to decline with age in cross-section, the mortality gradient will cause wealth to increase both in cross-section and in panel. As a cohort ages those with less wealth die, leaving survivors from the upper part of the wealth distribution. Thus, even if no couple or single person dissaves after retirement, the wealth of the cohort would increase with age. This makes it difficult to study life-cycle wealth paths based on synthetic cohorts, which will eliminate cohort differences in lifetime time resources but not differential mortality. These difficulties carry over to studies of income and consumption in synthetic cohorts.

Yet it is likely that individuals have subjective information about their own survival chances that cannot be discovered from mortality rates stratified by observable covariates such as SES. First, some personal characteristics are not easily measured, so they cannot be used as stratifying variables. Second, individuals may misperceive their survival chances, choosing consumption based on subjective yet biased life expectancy. If we are to understand consumption choices we need to have observations on the subjective variables that individuals use in making their choices. Third, even if we could stratify by many characteristics and understand average bias, there surely would remain considerable heterogeneity in subjective survival probabilities: Understanding that heterogeneity would help in the estimation of life-cycle models.

To model and use heterogeneous information about survival chances in life-cycle models is a multistep process. First, we need to find the observable correlates of mortality and measure their effects. Second, we need to measure the perceptions of individuals about their own mortality risk, and, given observable characteristics, to find if these perceptions have explanatory power for mortality. Third, we need measures of mortality risk that embody all of our knowledge about heterogeneity in models of decision making. This paper addresses the first two of these steps.

Differential mortality by SES has been observed over a wide range of data and populations: Mortality rates are high among those from lower SES groups (Kitagawa and Hauser 1973; Shorrocks 1975; Hurd 1987; Hurd and Wise 1989; Jianakoplos Menchik and Irvine 1989; Feinstein 1992). However, because of data limitations the measures of SES have typically been occupation or education. In the Health and Retirement Study (HRS) and the Asset and Health Dynamics of the Oldest Old (AHEAD) study there is scope for expanded studies of differential mortality because these are panel surveys with considerable age density and they obtain extensive data on income, wealth, and health conditions in addition to occupation and education. The AHEAD data in particular offer opportunities for increasing our knowledge of the gradient because the population (aged seventy or over at baseline) has not been studied to the extent to which younger populations have been. Furthermore, the fact that the

AHEAD population is almost completely retired means that a very strong confounding effect of health on income via work status is practically eliminated. Finally, almost the entire AHEAD population is covered by Medicare: Therefore, an important causal pathway linking SES to mortality via access to health care services is reduced and even possibly eliminated.

The HRS and AHEAD asked each respondent to give an estimate of his or her chances of surviving to a target age, which was approximately twelve years in the future. In the HRS this variable is a significant predictor of mortality between waves 1 and 2 (Hurd and McGarry forthcoming). Here we aim to find if it has predictive power for mortality in the AHEAD population both unconditionally and conditionally on observable characteristics.

In this paper we will verify that SES is related to mortality in the AHEAD data. Then we will give evidence about the validity of the subjective survival probabilities. The evidence will be of three kinds: whether the subjective survival probabilities vary in cross-section in a way that is appropriate given the variation in actual mortality; how the subjective survival probabilities change in panel in response to new information such as the onset of an illness; and whether they predict actual mortality. We will then examine whether, conditional on health status and SES, the subjective survival probabilities have explanatory power for predicting mortality.

5.2 Data

Our data come from the AHEAD study (see Soldo et al. 1997), a biennial panel survey of individuals born in 1923 or earlier and their spouses. At baseline in 1993 it surveyed 8,222 individuals representative of the community-based population except for oversamples of blacks, Hispanics, and Floridians. Wave 2 was fielded in 1995.

The main goal of AHEAD is to provide panel data from the three broad domains of economic status, health, and family connections. Our main interest in this paper is to understand the predictors of mortality between waves 1 and 2, especially education, income, wealth, and the subjective probability of survival. In wave 1, individuals and couples were asked for a complete inventory of assets and debts and about income sources. Through the use of unfolding brackets, nonresponse to asset values was reduced to levels much lower than would be found in a typical household survey such as the Survey of Income and Program Participation (SIPP).[1]

Both HRS and AHEAD have innovative questions about subjective

1. To handle nonresponse to asset and total income questions, we use a nested composite imputation procedure. We impute nonresponse to asset ownership, unfolding brackets, and asset amounts sequentially. Ownership and complete brackets are imputed using stepwise logistic regression on a number of demographic characteristics. Dollar amounts are then imputed, conditional on a complete bracket, using a nearest neighbor which makes extensive use of covariates (Hoynes, Hurd, and Chand. 1998).

probabilities, which request the subject to give the chances of future events. We will use observations on the subjective probability of survival. The form of the question is as follows:

> [Using any] number from 0 to 100 where "0" means that you think there is absolutely no chance and "100" means that you think the event is absolutely sure to happen . . . [w]hat do you think are the chances that you will live to be at least *A*?

A is the target age. *A* is 80, 85, 90, 95, or 100 if the age of the respondent was less than 70, 70–74, 75–79, 80–84, or 85–89, respectively. The question was not asked of those aged 90 or over or of proxy respondents.

AHEAD queries about a wide range of health conditions. Many are asked of the respondent in the following form: "Has a doctor ever told you that you have . . . ?" We will use information on ten conditions such as cancer, heart attack/disease, and lung disease. The respondent is queried about limitations to activities of daily living (ADL). We will use as an indicator of poor health three or more ADL limitations.

AHEAD measures cognitive status in a battery of questions which aim to test a number of domains of cognition (Herzog and Wallace 1997). Learning and memory are assessed by immediate and delayed recall from a list of ten words that were read to the subject. Reasoning, orientation, and attention are assessed from Serial 7's, counting backward by one, and the naming of public figures, dates, and objects.[2] In prior work we have found that unrealistic stated subjective survival probabilities are associated with low cognitive performance (Hurd, McFadden, and Gan 1998). Therefore we aggregated the cognitive measures in AHEAD and formed a categorical variable to indicate low cognitive performance.

AHEAD also has a battery of questions that are extracted from the Center for Epidemiologic Studies (CESD) scale, which aims to assess depressed mood. We form an indicator of depressed mood based on these questions.

5.3 Results

The baseline AHEAD sample was 8,222, of which 813 died between waves 1 and 2, and 7,364 survived; the vital status of 45 is unknown. Excluding those forty-five, the two-year mortality rate was 0.099.[3] This mortality rate cannot be compared with any lifetable rate for two reasons:

2. "Serial 7's" asks the subject to subtract 7 from 100, and then to continue subtracting 7 from each successive difference for a total of five subtractions.

3. The mortality rate including the 45 cases among the living was 0.0988. Including them among the dead, the mortality rate was 0.104. In the rest of the paper we will include them among the living for convenience, but their treatment is not consequential compared with the lack of data on the institutionalized population.

Table 5.1 Two-Year Mortality Rates (weighted)

	Male		Female	
	N	Mortality Rate	*N*	Mortality Rate
69–74	1,170	0.064	1,626	0.058
75–79	820	0.126	1,264	0.080
80–84	574	0.164	953	0.104
85–89	268	0.216	468	0.169
90+	82	0.402	221	0.262
All	2,914	0.125	4,532	0.095

Source: Authors' calculations from AHEAD waves 1 and 2.

First, the AHEAD baseline is the community-based population, so that it excludes residents of long-term care facilities who have substantially higher mortality rates than the community-based population. Lifetables include residents of long-term care facilities and of other institutions.[4] Second, the AHEAD sample includes spouses of AHEAD age-eligible respondents, but the spouses may themselves not be age eligible. The age-ineligible spouses do not make up any population whose mortality rate can be compared with a lifetable.

The mortality rate of the AHEAD age-eligible sample ($N = 7{,}446$) was 0.107; the lifetable rate interpolated to 1993 was 0.155. The difference comes from the high mortality rates among the institutionalized.

Table 5.1 shows weighted mortality rates for the age-eligible part of the AHEAD population by age and sex, and the number of observations. A few respondents were aged sixty-nine at their initial interviews but we include them in the seventy to seventy-four age band. The weights account for the oversamples at baseline. The figures show sharply increasing mortality rates with age and a considerable difference between men and women. At older ages the number of subjects diminishes rapidly due to mortality, cohort effects, and the fact that the institutionalized are not in the AHEAD baseline.

Table 5.2 presents mean wealth and income by age and marital status. Wealth is the total of housing, financial, and business and other real estate wealth, but it does not include any pension wealth. Income includes all financial income such as pension income, but no flow from owner-occupied housing. Just as in other cross-sectional data sets, wealth and income fall with age, and both are higher among couples than among singles. The table makes clear that we cannot study the relationship between mortality and economic status without effectively controlling for age.

4. Because AHEAD will follow the baseline respondents into institutions, it will eventually be representative of the entire cohort of 1923 or earlier.

Table 5.2 **Mean Wealth and Income, Weighted (thousands)**

	Age				
	70–74	75–79	80–84	85–89	90+
Wealth					
Singles	141.6	113.0	91.4	86.6	77.2
Couples	269.3	243.1	204.7	187.9	86.1
Income					
Singles	17.0	14.9	13.1	13.4	11.2
Couples	31.8	30.8	29.6	25.8	15.0

Source: Authors' calculations from AHEAD wave 1.

Note: For couples, "age" is the respondent's age, "Wealth" is the wealth of the couple, and "Income" is the income of the couple. Thus each couple enters the table twice.

5.3.1 Wealth, Income, and Education

Table 5.3 shows mean and median wealth in wave 1 by vital status in wave 2. At baseline among single males aged seventy to seventy-four who survived to wave 2, average wealth was about $216.5 thousand. Wealth was just $67.2 thousand among those who died. This is, of course, a substantial difference and indicates considerable differential mortality by wealth holdings. The difference among single females is smaller but still substantial. Among married males there is only a small difference, whereas married female survivors had almost twice the wealth on average as deceased married females. The medians also indicate considerable differential mortality by wealth.

There is diminished differential mortality by wealth among those aged seventy-five to seventy-nine. Given the amount of observation error on wealth, we judge there to be little difference in wealth holdings by mortality outcome among those married at baseline, either male or female. There is some difference among singles. The differences are smaller still among the eighty- to eighty-four-year-olds, and there are no consistent differences among the eighty-five-to eighty-nine-year-olds. The medians show somewhat more differential mortality but not as much as at the youngest age interval.

Among those aged ninety or over, sample sizes are small. For example, only thirty-nine single males and twenty married females were in the age interval at baseline. The group with the largest number of observations (single females) shows no differential mortality.

These data are summarized in figure 5.1, which shows the wealth of decedents relative to the wealth of survivors.[5] For example, single female decedents aged seventy to seventy-four had about 40 percent of the wealth of survivors. The figure shows a general trend to smaller differences in

5. Not shown when the category has fewer than 100 observations.

Table 5.3 Wealth at Baseline (thousands)

	Vital Status in Wave 2						
	All	Survived			Died		
	N	*N*	Mean	Median	*N*	Mean	Median
Ages 70–74							
Single							
Male	250	228	216.5	69.8	22	67.2	20.4
Female	828	776	128.7	51.7	52	52.9	25.6
Married							
Male	906	854	282.6	150.8	52	268.3	115.6
Female	777	737	260.3	140.6	40	138.6	100.8
Ages 75–79							
Single							
Male	204	176	176.7	68.3	28	129.9	96.0
Female	802	737	100.8	44.0	65	75.8	29.5
Married							
Male	606	531	255.3	125.2	75	225.8	103.0
Female	445	410	232.5	117.0	35	214.8	80.0
Ages 80–84							
Single							
Male	160	126	111.0	52.0	34	106.0	48.0
Female	704	624	91.4	42.4	80	60.5	25.8
Married							
Male	407	350	212.5	110.7	57	191.4	69.6
Female	244	225	201.2	113.3	19	144.6	95.5
Ages 85–89							
Single							
Male	106	84	111.9	35.8	22	75.8	11.0
Female	393	324	82.7	39.0	69	80.0	20.0
Married							
Male	161	125	178.3	74.3	36	135.0	63.2
Female	73	64	225.3	79.0	9	260.2	72.0
Ages 90+							
Single							
Male	39	23	205.2	25.9	16	65.7	26.2
Female	199	143	59.0	11.0	56	84.8	26.1
Married							
Male	43	26	97.7	66.5	17	81.9	35.0
Female	20	18	83.4	78.5	2	29.4	47.3

Source: Authors' calculations from AHEAD waves 1 and 2.

wealth at greater ages. We conclude that overall there is evidence of differential mortality by wealth: On average, those who died had about 70 percent of the wealth of those who survived. However, the difference decreases with age.

Table 5.4 has comparable results but for average education. Thus, among males aged seventy to seventy-four the average level of education

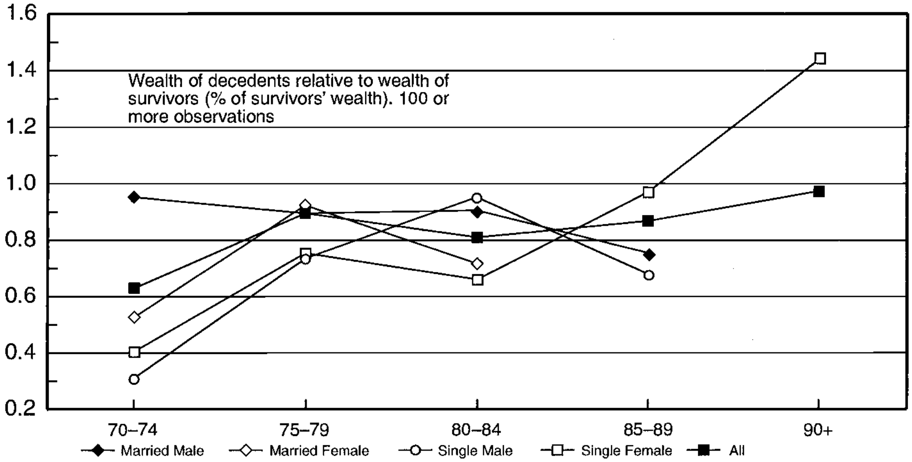

Fig. 5.1 Wealth differences by vital status

was 11.5 years among survivors and 10.4 among the deceased. In the first age band the differential is considerable and it is the same for each sex. At ages seventy-five to seventy-nine the differential decreases for men but remains about the same for women, and by ages eighty to eighty-four there is no differential among men. It is notable that in the highest age interval, the educational level of women is higher than that of men even though for these cohorts the educational level of a complete population of men would have been considerably higher. An explanation is found in the differential mortality at younger ages: Women consistently have a higher mortality gradient by education than men, causing the better-educated women to survive at a higher rate than the better-educated men.

Tables 5.5 and 5.6 show mortality rates by wealth and income quartiles, respectively. The quartiles are defined separately by marital status, but the quartile boundaries are the same over the entire age range. Because of the correlations between age and economic status, and between age and mortality, overall mortality varies strongly by wealth or income quartile as shown in the last line of each table. However, this relationship is much less clear when age is controlled for. In the first age band there is a consistent decline across the quartiles, but in the other age bands there is little consistent pattern even though mortality is generally the largest in the lowest wealth quartile. Mortality by income has a more consistent pattern and for some age intervals the effects are very strong. For example, among eighty to eighty-four-year-olds the mortality rate in the lowest income quartile is about 56 percent greater than in the highest. As with wealth, however, the differential seems to diminish with age.

These figures, particularly for wealth, suggest that differential mortality

Table 5.4 **Years of Education**

	70–74		75–79		80–84		85–89		90+	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Survived	11.5	11.5	11.3	10.9	10.4	10.4	10.0	10.7	8.6	9.2
Died	10.4	10.4	11.1	10.0	10.4	10.2	8.5	10.2	8.1	9.1
N	1,170	1,626	820	1,264	574	953	268	468	82	221

Source: Authors' calculations from AHEAD waves 1 and 2.

Table 5.5 Two-Year Mortality Rates: Wealth Quartiles

	Wealth Quartile			
	Lowest	2nd	3rd	Highest
70–74	0.09	0.06	0.06	0.04
75–79	0.12	0.09	0.10	0.09
80–84	0.15	0.13	0.10	0.11
85–89	0.23	0.18	0.16	0.16
90+	0.30	0.29	0.27	0.37
All	0.14	0.11	0.10	0.08

Source: Authors' calculations from AHEAD waves 1 and 2.

Table 5.6 Two-Year Mortality Rates: Income Quartiles

	Income Quartile			
	Lowest	2nd	3rd	Highest
70–74	0.10	0.05	0.06	0.05
75–79	0.10	0.12	0.08	0.09
80–84	0.14	0.14	0.12	0.09
85–89	0.25	0.17	0.13	0.16
90+	0.31	0.32	0.27	0.28
All	0.14	0.11	0.09	0.08

Source: Authors' calculations from AHEAD waves 1 and 2.

may decrease with age. To test that idea we estimated analysis-of-variance models in which the observations are mortality rates classified by age intervals and income and wealth quartiles. The models had complete interactions between age intervals and income quartiles and between age intervals and wealth quartiles. We tested for significance of the interactions. We could reject the null hypothesis that the interactions for couples and separately for singles are all zero at the 5 percent level, but not at the 1 percent level. Because the age interactions are not particularly strong and in the interest of simplifying the analysis, our basic model will have age effects, and income and wealth quartiles but not interactions. We will leave the exploration of the age interaction for future research.

Table 5.7 has mortality rates by education level for males. As the table shows, in the AHEAD data mortality is higher for men with nine to eleven years of education than for males of zero to eight years of education, and this is true holding age constant. We have no good reason for this result, except possibly that those with zero to eight years of education have been highly selected by the time they reach the AHEAD ages. Holding age constant, we see some pattern of differential mortality in the younger age bands, but it is less apparent at older ages.

Table 5.7 Two-Year Mortality Rates: Education (males)

	Years of Education			
Age	0–8	9–11	12	12+
70–74	0.07	0.11	0.06	0.04
75–79	0.12	0.19	0.08	0.13
80–84	0.15	0.26	0.20	0.11
85–89	0.25	0.28	0.10	0.15
90+	0.43	0.48	0.42	0.37
All	0.14	0.18	0.09	0.09

Source: Authors' calculations from AHEAD waves 1 and 2.

Table 5.8 Two-Year Mortality Rates: Education (females)

	Years of Education			
Age	0–8	9–11	12	12+
70–74	0.09	0.06	0.05	0.04
75–79	0.11	0.08	0.07	0.06
80–84	0.10	0.11	0.12	0.10
85–89	0.20	0.20	0.14	0.16
90+	0.25	0.16	0.31	0.28
All	0.13	0.10	0.08	0.08

Source: Authors' calculations from AHEAD waves 1 and 2.

Among females in their seventies there is a strong and consistent relationship between mortality and education, but at older ages there is little if any (table 5.8).

Overall we conclude that there is differential mortality by educational attainment at the younger ages in the AHEAD population, but the effects diminish with age. Particularly among females, who comprise most of the observations in the population aged eighty or over, there is little evidence for a mortality gradient by education.

5.3.2 Subjective Probabilities of Survival

The subjective probability of survival has been studied extensively in data from the HRS (Hurd and McGarry 1995, forthcoming). In cross-section it aggregates well to lifetable levels and it varies appropriately with known risk factors. Furthermore, in panel it is a significant predictor of actual mortality even after accounting for SES and a number of disease conditions. In AHEAD baseline it aggregates well to lifetable values among those aged seventy to seventy-nine, but in the older age groups the subjective survival probabilities overstate survival compared with lifetable rates (Hurd, McFadden, and Gan 1998). One cause of the excess survival prob-

Table 5.9 **Subjective Survival Probabilities: Wealth Quartiles (weighted)**

	Wealth Quartile			
	Lowest	2nd	3rd	Highest
70–74	0.500	0.470	0.509	0.534
75–79	0.382	0.369	0.385	0.403
80–84	0.310	0.310	0.326	0.306
85–89	0.287	0.256	0.317	0.320
All	0.403	0.385	0.422	0.443

Source: Authors' calculations from AHEAD wave 1.

Notes: Target ages for survival are 85 for the 70–74 age group; 90 for the 75–79 age group; 95 for the 80–84 age group; and 100 for the 85–89 age group. Survival probabilities are not asked of persons aged 90 or above.

ability is that a fairly small number of subjects give a probability of 1.0 of surviving to the target age. The propensity to give a probability of 1.0 is related to low cognitive status, and often an individual will give a probability of 1.0 to a number of unrelated subjective probability questions. Such regularities provide evidence of error in some of the responses. Nonetheless, we will take the responses as they were given by the AHEAD subjects. We imagine, however, that the predictive power of the subjective survival probabilities could be increased were some of the reporting error removed by application of a model of the error.

Table 5.9 shows the average subjective survival probability by age band and wealth quartile.[6] It is important to group by age in this manner because all the respondents in each age band were given the same target age. As would be expected the average survival probability declines with age, but unlike actual mortality there is little systematic variation in the survival probability as a function of wealth. For example, among those aged seventy to seventy-four the average subjective survival probability is about the same in the lowest and the 3rd quartiles. Only in the highest quartile is it greater. Yet the actual two-year survival rate was 5 percentage points higher in the 4th quartile than in the 1st quartile: Such a large difference in two-year survival should accumulate to a much greater difference in subjective survival to the target age.

As shown in tables 5.10 and 5.11, there is little variation in the survival probabilities as a function of either income quartiles or education bands, respectively.

A possible reason for the lack of any pattern by wealth, income, or education is the rather high rate of nonresponse to the survival probabilities.[7] A substantial number of interviews were by proxy, often because of

6. Both the wealth and income quartiles are calculated separately by marital status.

7. This low response rate in AHEAD is in contrast to the very high response rate in HRS.

Table 5.10 Subjective Survival Probabilities: Income Quartiles (weighted)

	Income Quartile			
	Lowest	2nd	3rd	Highest
70–74	0.483	0.488	0.492	0.545
75–79	0.348	0.376	0.387	0.415
80–84	0.324	0.331	0.281	0.319
85–89	0.277	0.289	0.333	0.278
All	0.382	0.404	0.410	0.451

Note: See table 5.9 for source and notes.

Table 5.11 Subjective Survival Probabilities: Education (weighted)

	Years of Education			
	0–8	9–11	12	>12
70–74	0.494	0.508	0.491	0.532
75–79	0.341	0.388	0.384	0.417
80–84	0.308	0.338	0.274	0.340
85–89	0.354	0.241	0.308	0.258
All	0.382	0.411	0.413	0.442

Note: See table 5.9 for source and notes.

the frailty of the targeted respondent. In this case it made no sense to ask a proxy about the subject's subjective survival probability. In addition, a rather large number of respondents replied "Don't know" (DK) to the query. Table 5.12 has the counts of nonresponse as a function of wealth quartile. Overall, about 25 percent of singles and 21 percent of married persons were nonrespondents (not shown). It is clear that the rate of nonresponse is greatest among those in the lowest quartiles. For example, among seventy- to seventy-four-year-olds, the rate of nonresponse was about 31 percent in the lowest quartile and 11 percent in the highest. Furthermore, because the propensity to give a proxy interview and the likelihood of a DK response are related to health status, it is probable that the responding sample is systematically selected toward those with higher survival probabilities. Therefore, the averages in the lowest quartiles are higher than the true quartile averages whereas the averages in the highest quartiles are closer to the true averages, acting to reduce any upward trend in the subjective survival probabilities as a function of wealth.

We ask whether the pattern of nonresponse could conceivably be responsible for the lack of pattern in the subjective survival probabilities, even though there is a clear pattern in actual mortality. We illustrate that it could be responsible by assigning a subjective survival probability of

Table 5.12 Subjective Survival Probabilities: Number of Nonresponses (all)

	Wealth Quartile			
	Lowest	2nd	3rd	Highest
70–74				
Don't know	107	51	52	45
Refused	16	10	11	3
Proxy	62	47	54	39
Other	1	1	1	0
75–79				
Don't know	76	57	45	40
Refused	17	13	10	15
Proxy	67	48	38	31
Other	0	0	0	1
80–84				
Don't know	75	44	46	23
Refused	22	28	12	5
Proxy	75	44	36	24
Other	1	0	0	1
85–89				
Don't know	44	18	14	17
Refused	10	7	5	5
Proxy	55	18	23	15
Other	0	0	0	0
90+	120	77	62	42
Total missing	748	463	409	306

Source: Authors' calculations from AHEAD wave 1.

zero to the nonresponders. Figure 5.2 shows the variation in the subjective survival probabilities under that assignment. The probabilities increase in wealth in each age band. These results show that differential nonresponse has a quantitatively important effect on the level and variation in the subjective survival probabilities. In future work we will explore methods for imputing missing values, but for the rest of this paper we will, as appropriate, use categorical variables to account for nonresponse.

Table 5.13 shows the estimated regressions of the subjective survival probabilities on the wealth and income quartiles, education bands, and other explanatory variables. We control for age and for the varying interval between the interview and the target age by including as a right-hand variable the lifetable survival rate to the target age from the age of the respondent. If respondents reported their subjective survival probability to be the same as the lifetable rate, the coefficient on this variable would be 1.0. The estimated coefficient shows that the age gradient in the subjective survival probability is less than the age gradient in the lifetable rate. This is partly due to the overestimation of subjective survival probabilities among the oldest compared with the lifetable values.

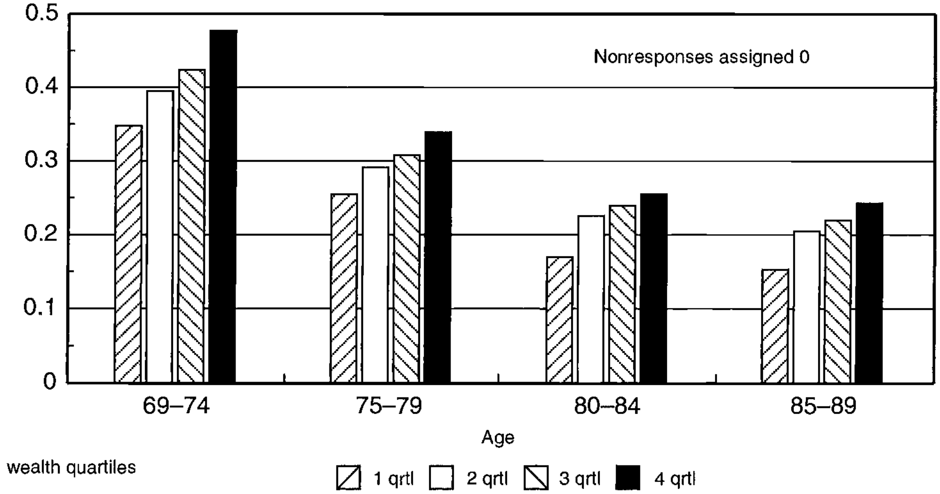

Fig. 5.2 Subjective survival probabilities (all)

The three sets of SES variables show no systematic pattern, which is the basic finding from the cross-tabulations in tables 5.9, 5.10, and 5.11. Relative to the lifetable, males overstate their survival chances by 0.07. This tendency toward over-optimism is also found in the HRS population (Hurd and McGarry 1995).

The last two columns of table 5.13 contain regressions that include controls for health condition. Most of the health conditions are asked of the respondent in the following form: "Has a doctor ever told you that you have . . . ?" The exceptions are "low cognitive score," which is a categorical variable indicating a low score on the sum of three items that were administered in the survey itself; and "Depression" (CESD8), which is based on eight items from the CESD (Wallace and Herzog 1995). A categorical variable for depression indicates a score of 5 or more on the CESD. Eight of the thirteen health variables are significant at the 0.05 level, and they are associated with a reduction in the subjective survival probabilities of 9–25 percent of the average probability. For example, having had heart disease of a heart attack prior to wave 1 is associated with a reduction in the subjective survival probability of 0.062 from a base of 0.415, or about 15 percent. Based on these results we would expect the subjective survival probabilities to predict actual mortality because of their association with the health conditions that, themselves, are associated with mortality.

5.3.3 Change in the Subjective Survival Probabilities

As individuals age the subjective survival probabilities should increase among survivors holding the target age constant. Between waves 1 and 2

Table 5.13 **Determinants of Subjective Survival Probabilities (average probability = 0.415)**

	$R^2 = 0.06$		$R^2 = 0.10$	
	Coefficient	*t*-statistic	Coefficient	*t*-statistic
Intercept	0.206	11.819	0.330	14.855
Wealth quartiles				
Lowest	—	—	—	—
2nd	−0.028	−2.029	−0.045	−3.247
3rd	−0.009	−0.617	−0.030	−2.062
Highest	−0.007	−0.465	−0.030	−1.921
Income quartiles				
Lowest	—	—	—	—
2nd	0.020	1.447	0.013	0.988
3rd	0.011	0.765	0.000	0.022
Highest	0.033	2.006	0.023	1.382
Years of education				
0–8	—	—	—	—
9–11	−0.001	−0.090	−0.006	−0.417
12	−0.019	−1.369	−0.029	−2.049
>12	0.012	0.828	0.004	0.259
Lifetime survival to target age	0.516	17.796	0.499	17.097
Male	0.072	4.330	0.070	4.253
Married	−0.006	−0.475	−0.020	−1.630
Married male	0.014	0.659	0.017	0.832
Health conditions				
Heart disease/attack			−0.062	−6.214
Cancer			−0.049	−3.748
Stroke			0.000	0.022
High blood pressure			−0.037	−4.037
Diabetes			−0.036	−2.612
Lung disease			−0.079	−5.665
Arthritis			−0.037	−3.444
Incontinence			−0.020	−1.705
Hip fracture			−0.044	−1.894
Fall requiring treatment			0.022	1.227
Low cognitive score			0.018	1.569
ADL limitation (>2)			−0.060	−3.040
Depression (CESD8 >4)			−0.103	−6.676
Missing cognition			0.019	0.571

Source: Authors' calculations from AHEAD wave 1.

Notes: Based on OLS estimation. ADL = activities of daily living; CESD8 = depression subtest of the Center for Epidemiologic Studies (CESD). Subjective survival probabilities are not asked of persons aged 90 or above. $N = 5{,}440$.

the average increase was 0.064 (16 percent) among singles and 0.051 (15 percent) among couples. Tables 5.14 and 5.15 show the levels and changes by age band and by sex. The tables show that the subjective survival probabilities are overstated relative to lifetables at older ages, particularly among men. For example, among men aged eighty-five to eighty-nine the

Table 5.14 **Change in Subjective Survival Probabilities and Lifetable Rates, Wave 1 to 2 (males)**

	Subjective Survival to Target Age			Lifetable Survival to Target Age		
	Wave 1	Wave 2	Percent Change	Wave 1	Wave 2	Percent Change
70–74	0.508	0.548	7.9	0.389	0.423	8.7
75–79	0.382	0.470	23.0	0.226	0.259	14.6
80–84	0.332	0.396	19.3	0.098	0.121	23.5
85–89	0.314	0.345	9.9	0.034	0.048	41.2

Source: Authors' calculations from AHEAD waves 1 and 2.

Notes: Target ages for survival are 85 for the 70–74 age group; 90 for the 75–79 age group; 95 for the 80–84 age group; and 100 for the 85–89 age group. Survival probabilities are not asked of persons aged 90 or above.

Table 5.15 **Change in Subjective Survival Probabilities and Lifetable Rates, Wave 1 to 2 (females)**

	Subjective Survival to Target Age			Lifetable Survival to Target Age		
	Wave 1	Wave 2	Percent Change	Wave 1	Wave 2	Percent Change
70–74	0.510	0.558	9.4	0.575	0.605	5.2
75–79	0.388	0.469	20.9	0.399	0.432	8.3
80–84	0.303	0.399	31.7	0.200	0.228	14.0
85–89	0.299	0.376	25.8	0.074	0.091	23.0

Note: See table 5.14 for source and notes.

average subjective survival probability to age 100 is 0.314, whereas the average lifetable value is 0.034. In terms of relative risk, the increases in the subjective survival probabilities from wave to wave are reasonably close to the increases in the lifetable probabilities except in the oldest age intervals. Although it is difficult to know what the appropriate standard of comparison is, it is notable that in all age bands the subjective survival probabilities increase between the waves. This increase was not found in HRS: Among survivors, the average subjective survival probability decreased slightly (Hurd and McGarry forthcoming).

Besides increases in the subjective survival probabilities that are due to the AHEAD subjects' surviving for two years, the probabilities should change in response to new information that alters survival chances. Such information would be onset of a health condition that is associated with an increased risk of death. Table 5.16 shows the incidence of new conditions between waves 1 and 2 for all respondents. Thus, for example, among singles who had not had cancer prior to the baseline interview, 5.1 percent had a cancer between the waves. Among all singles, including those with

Table 5.16 Incidence of Conditions between AHEAD Waves 1 and 2

	Singles (N = 3,410)		Married (N = 3,496)	
	N at risk	Rate	N at risk	Rate
Onset between waves 1 and 2				
Cancer	2,940	5.14	3,009	5.08
Cancer (including repeat cancer)	3,410	5.45	3,496	5.78
Stroke	3,095	4.78	3,214	4.54
Stroke (including repeat stroke)	3,410	5.81	3,496	5.49
Heart attack or disease	2,335	10.00	2,402	9.00
Heart attack or disease (including repeat attack)	3,410	13.96	3,496	12.04
High blood pressure[a]	1,430	12.03	1,693	9.27
Diabetes[a]	2,621	3.17	2,787	2.54
Lung disease	3,024	2.91	3,113	2.67
Arthritis[a]	2,113	17.13	2,460	13.74
Incontinence[a]	2,355	14.06	2,660	12.11
Hip fracture	3,190	2.70	3,379	1.10
Hip fracture (including repeat fracture)	3,410	3.05	3,496	1.37
Fall requiring treatment	3,099	12.62	3,278	9.37
Fall requiring treatment (including repeat fall)	3,410	14.81	3,496	10.76
Low cognitive score[b]	1,927	29.58	2,408	24.29
ADL limitations > 2	2,969	10.44	3,215	6.56
Depression (CESD8)[c]	2,667	6.11	2,847	4.95
Living in a nursing home wave 2	3,410	8.18	3,496	3.66
Spouse died	—	—	3,496	7.87

Source: Authors' calculations from AHEAD waves 1 and 2.

Notes: Sample includes all persons with a wave 1 and a wave 2 interview (including proxy and exit proxy interviews for the deceased).

[a] Condition not asked in exit proxy. Incidence may be underestimate, because it includes as at-risk those who died.

[b] Score of 15 or less on AHEAD cognitive battery questions.

[c] CESD8 score greater than 4; self-respondents only, N = 3,105 for singles and N = 3,096 for married.

a history of cancer prior to baseline, 5.5 percent had a new or initial cancer between the waves. Although it is not the focus of this paper, the table shows that having a prior history of cancer, stroke, heart attack/disease, hip fracture, or fall increases the risk of a new, similar event. Having a low cognitive score, which is associated with increased risk of dementia, has the greatest rate of onset.

About 8.2 percent of singles who were living in the community at wave 1 were in a nursing home at wave 2.

There is little difference in the rates of onset between singles and couples except for limitations on the activities of daily living (ADL limitations) and nursing home entry. The measure of ADL limitations is an indicator for ADL limitations greater than two, and singles had an incidence rate of

Table 5.17 Change in Subjective Survival Probabilities (average change = 0.057)

	Coefficient	*t*-statistic
Intercept	0.068	6.777
Married	−0.007	−0.483
Male	0.022	1.154
Married male	−0.030	−1.273
Incidence of health conditions		
Heart disease/attack	−0.000	−0.021
Cancer	−0.063	−2.328
Stroke	−0.025	−0.799
High blood pressure	−0.053	−2.249
Diabetes	−0.083	−2.478
Lung disease	−0.066	−1.840
Arthritis	0.016	0.965
Incontinence	−0.020	−1.133
Hip fracture	0.007	0.136
Fall requiring treatment	0.010	0.486
Low cognitive score	0.004	0.256
ADL limitations > 2	0.067	2.238
Depression	−0.061	−2.504
Spouse died	0.054	2.001
Entered nursing home	−0.017	−0.311

Source: Authors' calculations from AHEAD waves 1 and 2.

Notes: Change in the subjective survival probability is wave 2 report minus wave 1 report. Incidence of heart attack, cancer, and stroke includes new incidents among those with a prior history. Survival probabilities not asked of persons aged 90 or above. $N = 4{,}061$. $R^2 = 0.005$.

10.4 percent compared with couples of 6.6 percent. The difference likely comes from the fact that (on average) singles are older than couples, and from the ability of couples to help each other, disguising some mild cases of ADL limitations. As in the case of ADL limitations, the rate of entry into a nursing home is greater among singles because of age differences and because a spouse can provide help that will keep the other spouse in the community.

Table 5.17 shows the estimated regression of the change in the subjective survival probabilities between waves 1 and 2 on the incidence of health conditions and other events.[8] To the extent that the onset of a new condition provides new information about survival chances, onset should reduce the subjective survival probabilities. A number of the conditions have negative coefficients indicating that onset reduces the subjective survival probabilities, and cancer, high blood pressure, diabetes, and depression have negative effects that are significant at the 5 percent level. The depression indicator is somewhat different from the other health condition indicators in that it probably depends on the same or similar aspects of health as

8. For heart attack, cancer, and stroke, those with a history of the condition at baseline and who had a new incident between waves 1 and 2 are included as incident cases.

the subjective survival probabilities.[9] The death of a spouse increased the subjective survival probabilities. In the HRS, the death of a spouse *decreased* subjective survival probabilities (Hurd and McGarry forthcoming). An explanation for the difference may be that at the ages of the AHEAD respondents the death of a spouse is preceded by a period of care that reduces the optimism of the caregiver.

The onset of ADL limitations of 3 or more increased subjective survival probabilities. Because there is no obvious reason for this result, we performed some estimations with more detail. First, the increase is found in detailed regressions for singles and couples separately. Second, we defined some additional categories for change in ADL limitations and estimated their effects. The categories were (1) no baseline ADL limitation and one or more ADL limitations in wave 2; (2) one or more ADL limitations in baseline and an increase in limitations by wave 2; and (3) one or more ADL limitations in baseline and no increase by wave 2. For category (1), which is onset of any ADL limitation, the effect is to reduce the subjective survival probability by a small amount (−0.014, not significant). For category (2), the effect is to increase the subjective survival probability by 0.054 (p-value of 0.045), and for category (3) it is to increase the subjective survival probability by 0.040 (p-value of 0.109). Thus the increase in the subjective survival probability accompanying the onset of three or more ADL limitations is due to those who had existing baseline ADL limitations reporting higher probabilities in wave 2. We have no explanation for this increase.

5.3.4 Subjective Survival Probabilities and Mortality

As discussed earlier, the rate of response about subjective survival probabilities was rather low in AHEAD, and actual mortality between waves 1 and 2 was above average among the nonresponders. As shown in the last row of table 5.18, the overall mortality rate among the 7,446 age-eligible subjects in wave 1 was 10.6 percent. The other rows show mortality rates among those who did not answer the question about subjective survival probabilities. These nonrespondents are divided according to reason for nonresponse. The first row shows the mortality rate among those who were aged ninety or over at wave 1: By survey design, they were not asked the question about subjective survival, and their two-year mortality rate was about 0.30. Those who answered DK (don't know) had approximately average mortality rates, whereas those who refused to answer (RF) had somewhat elevated mortality rates. A large group (685) were interviewed by proxy in wave 1, and they had a substantially higher mortality rate than average. A main reason for interview by proxy was that the subject was

9. The depression indicator takes the value 1 if the sum of the eight items on the CESD8 is greater than 4.

Table 5.18 Two-Year Mortality Rates among Nonrespondents to Subjective Survival Question

	Mortality Rate	*N*
Reason for nonresponse		
90+	0.300	303
DK	0.109	765
RF	0.124	194
Other	0.042	24
Proxy	0.244	685
Responders and nonresponders	0.106	7,446

Source: Authors' calculations from AHEAD waves 1 and 2.

Table 5.19 Two-Year Mortality Rates

Subjective Survival Probability	Mortality Rate	*N*
0	0.13	1,254
1–10	0.10	608
11–20	0.07	218
21–30	0.05	327
31–49	0.06	148
50	0.05	1,331
51–70	0.04	224
71–80	0.05	486
81–90	0.04	222
91–99	0.07	41
100	0.05	616

Source: Authors' calculations from AHEAD waves 1 and 2.

too frail or cognitively impaired to be interviewed. This frailty is reflected in the mortality rate.

Table 5.19 has mortality rates by subjective survival probability in wave 1. The table shows that the subjective survival probabilities have considerable explanatory power for mortality, particularly in the low range. Thus, for example, the mortality rate among those who gave a zero probability of survival was about 0.13 compared with about 0.05 among those who gave a 0.50 probability of survival. The mortality rates are basically flat in the interval from 0.21 to 0.90. This is similar to the relationship found between the subjective survival probabilities and mortality in the HRS (Hurd and McGarry forthcoming). The increase in mortality at the two highest probability intervals indicates observation error that is likely related to misunderstanding or cognitive malfunctioning.

More detailed cross-tabulations of the correlates of mortality are not practical, so we turn to data-descriptive Probit estimation as a way to reduce the dimensionality of the predictors. Table 5.20 has the results from

Table 5.20 Determinants of Two-Year Mortality

	Effect	Asymptotic t	Effect	Asymptotic t	Effect	Asymptotic t
Intercept	−0.268	22.450	−0.304	22.353	−0.412	23.361
Lifetable mortality	0.566	13.014	0.645	9.979	0.577	8.486
Wealth quartiles						
Lowest	—	—	—	—	—	—
2nd	−0.014	1.351	−0.009	0.868	0.004	0.349
3rd	−0.017	1.533	−0.013	1.158	0.008	0.670
Highest	−0.026	2.031	−0.022	1.659	−0.001	0.079
Income quartiles						
Lowest	—	—	—	—	—	—
2nd	−0.014	1.367	−0.009	0.834	−0.003	0.238
3rd	−0.027	2.313	−0.022	1.873	−0.014	1.106
Highest	−0.023	1.698	−0.014	1.070	−0.003	0.203
Education level						
0–8	—	—	—	—	—	—
9–11	0.014	1.313	0.025	2.244	0.034	2.962
12	−0.005	0.468	0.003	0.235	0.020	1.753
>12	−0.017	1.405	0.000	0.006	0.017	1.356
Male	0.022	1.761	0.025	1.928	0.027	2.063
Married	−0.023	2.060	−0.028	2.451	−0.014	1.172
Married male	−0.007	0.422	−0.011	0.656	−0.017	0.978

Subjective survival				
Stated minus lifetable	−0.079	5.693	−0.053	3.693
Missing: proxy	0.114	10.118	0.085	6.782
Missing: refused	0.028	1.262	0.013	0.528
Missing: don't know	0.013	1.031	0.013	0.978
Missing: age 90+	−0.014	0.633	−0.009	0.389
Health conditions				
Heart disease/attack			0.028	3.357
Cancer			0.047	4.511
Stroke			0.045	3.695
High blood pressure			0.017	2.132
Diabetes			0.035	3.231
Lung disease			0.071	6.581
Arthritis			−0.014	1.578
Incontinence			−0.003	0.330
Hip fracture			0.038	2.413
Fall requiring treatment			0.000	0.034
Low cognitive score			0.047	5.109
ADL limitation (>2)			0.070	6.025
Depression (0,1)			0.036	3.010
Missing cognition			0.033	1.492

Source: Authors' calculations from AHEAD waves 1 and 2.

Notes: Based on probit estimation. N = 7,367. Average mortality = 0.107.

Probit estimation of the determinants of mortality. The left-hand variable takes the value of 1 if a subject died between the waves and zero otherwise. We control for age and sex by including as a right-hand variable the two-year mortality rate by age and sex from an interpolated 1993 lifetable. Thus, the other right-hand variables will show the deviation in mortality rates from the lifetable rate. The Probit coefficients have been translated into probability effects via the linear approximation

$$\frac{\partial P}{\partial x} = \beta\phi,$$

where β is the Probit coefficient on x and ϕ is the normal density evaluated at the average mortality rate of singles.[10]

The table has three sets of results depending on which variables are included. In each set the first column has the effects and the second the statistic for testing the null hypotheses that the effect is zero. Approximately, a statistic of 2.0 indicates significance at the 5 percent level.

The first entry in the table is the coefficient on two-year, age- and sex-specific mortality rates from a 1993 interpolated lifetable. The coefficient is less than 1.0, reflecting the fact that in AHEAD mortality does not increase with age as rapidly as the lifetable mortality. The difference in mortality is partly due to the increasing fraction of the population that is institutionalized at greater ages. In that this part of the population is missing from AHEAD, mortality rates in AHEAD will be progressively lower than lifetable mortality rates, which reflect the entire population. An additional factor could be that AHEAD is a more accurate measure of current mortality than the lifetables that we use.[11]

In the first column of table 5.20 mortality does systematically decrease in wealth in approximately the same way as in the cross-tabulations in table 5.5, but the coefficient on just one of the wealth quartiles is significant at the 5 percent level. Mortality is generally lower in the higher-income quartiles. The effect of education is partly obscured by the higher mortality rate in the second education band compared with the first, but moving from the second to the fourth education band reduces mortality by 0.039 (p-value of 0.054).

The mortality rate of men was about 0.022 greater than would be predicted from the lifetable.[12] Married respondents had mortality rates that

10. We will use the word "effects" when we refer to the probability coefficients. We recognize that while they describe systematic relationships in the data they do not necessarily measure causal relationships. It would require considerably more investigation to ascribe causality.

11. To test whether our single lifetable mortality rate was adequately controlling for age we also added five age intervals (not shown). None was significant and all were small. We conclude that there is no requirement for age indicators when the age- and sex-specific lifetable mortality rates are used.

12. Separate estimation of the mortality probit by sex shows that the coefficient on "lifetable" is different for male and female.

were about 0.023 lower than singles: This is a substantial reduction amounting to about 21 percent of average mortality. There was no differential effect of marital status for men compared with women. That is, marriage does not provide additional mortality protection for men relative to women.[13]

The next two columns show the effects when the subjective survival probability is added along with a set of variables to account for missing observations on the subjective survival probability. We entered the subjective survival probability as a deviation from the lifetable survival rate to the target age. We did this because of the varying time interval between the age of the subject and the target age. This formulation also automatically scales for the fact that the effect on two-year mortality of a survival probability to an age eleven to fifteen years in the future will vary with baseline age.

When the subjective survival probability is added, both the wealth and income effects are reduced and they are no longer statistically significant. The effect of education as measured by the difference between the second and fourth bands remains substantial and the difference is significant. The subjective survival probability is itself a powerful predictor of mortality: Varying the subjective survival probability from zero to 1 would reduce two-year mortality risk by 0.079, or 74 percent. The indicator variable for proxy interview predicts much higher mortality.

The last two columns have Probit results when the baseline health conditions are included. Of the thirteen health conditions, ten are significant at the 5 percent level, and each acts to increase mortality risk with the effects varying from 16 to 66 percent. Adding the health variables reduces the effect of the subjective survival probability by 33 percent, but it is still substantial. The effect of a proxy interview is reduced, as would be expected because proxy interviews are often due to poor health. Those with low cognitive score at baseline had elevated mortality rates.[14]

In additional estimations which we do not report here, we estimated separate mortality Probit models for males and for females. Our objective was to learn whether there were substantial differences in the effects of SES or health conditions on mortality. In general there were few differences: As in the pooled results, no income or wealth quartile had a sizable effect, nor was any significant. However, the education gradient between the second and fourth age bands, which we found in the pooled estimation, was found only in the results for men. The effect of marital status was somewhat greater for men than for women, reducing the mortality rate by 0.032 compared with 0.015. In terms of relative risk, the reduction in risk

13. See Lillard and Waite (1994) for the opposite finding.

14. We interacted low cognitive status with the subjective survival probability. The interaction did have a positive sign, indicating that among those with low cognitive status the subjective survival probability is less predictive of mortality, but the effect was small and not significant (not shown).

for men was 26 percent and for women it was 16 percent. The effects of health conditions were about the same for men and women.

5.4 Conclusion

We found that, as in other data, mortality is related to SES. The relationship is strong at younger ages in AHEAD and appears to weaken at older ages. Any explanation at this point would be rather speculative, but the finding is consistent with the view that the primary cause of the gradient is unobserved individual characteristics that cause bad health and therefore early death, and that cause lower earnings and therefore lower wealth and less education. Were the causality to run primarily from economic resources to health and mortality, we should see a persistent difference in mortality outcomes in very old age between those with substantial resources and those with few. We tentatively conclude that we do not see this, although we acknowledge this should be confirmed by further analysis. If the differential is due to unobserved individual differences, the mortality gradient operating at younger ages will have truncated the distribution, so that in extreme old age the variation in individual characteristics would be greatly reduced. Therefore, classifying people by SES would not produce any substantial differences in mortality.

In cross-section, the subjective survival probability is related to baseline health conditions, and there is some consistency in the relative importance of the health conditions on the subjective survival probability and in their importance in predicting actual mortality. For example, of the five largest health effects on the subjective survival probability, three are among the five largest predictors of mortality (cancer, lung disease, and ADL limitations > 2). In panel, the subjective survival probability increases among survivors, and the effects of new health conditions on the panel change in the subjective survival probabilities are similar to the cross-sectional effects of baseline health conditions. For example, of the five largest effects of the onset of health conditions on changes in the subjective survival probability, three are among the five largest cross-sectional effects (cancer, lung disease, and depression).

The subjective survival probability predicts actual mortality as in the HRS, which should increase our confidence that it can be used to construct individualized lifetables for models of life-cycle saving behavior as proposed by Hurd, McFadden, and Gan (1998). Whether such lifetables will have substantial explanatory power for saving remains to be determined as more waves of AHEAD become available.

The relationship between SES and mortality that is found in cross-tabulations (as in table 5.5) disappears when health status is controlled for (as in table 5.20). This result suggests that any differential access to health care services related to SES is small. Were that not the case, in a population with homogeneous baseline health (or with effective controls for baseline health status) those with higher SES would be more likely to receive appropriate treatment for the onset of a severe condition and, therefore, to survive. We do not find such a relationship. There could still be a role for SES, however, through modifications in the probability of the onset of health conditions, which, in turn, would affect mortality risk. To assess that path will require an additional dynamic model of health status.

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Comment Finis Welch

This paper is essentially a work-in-progress that to this point has shown no surprises. Among the elderly, those who believe they are unhealthy seem to be so, and those who have a serious condition that might be expected to increase mortality appear to be at greater risk than those without such conditions. Furthermore, as is true of all the comparisons I have seen, health and wealth seem to be positively correlated. I really have only two substantive comments and they are directed more toward work on data of this sort than to this paper specifically.

First, in using the Asset and Health Dynamics of the Oldest Old (AHEAD) survey, age and marital status cannot be treated blithely. This has several facets. Because the AHEAD survey is community based and excludes the institutionalized population, as age increases, members of the survey become progressively more healthy in comparison to the overall population of same-age and -sex individuals. Thus, one should be careful in making statements such as: "The mortality gradient, whether a function of wealth, income, or education, apparently decreases with age." Next, the age-ineligible members of AHEAD, by definition, are younger spouses of age-eligible members of the survey. As such, they are more likely than others of the same age to be healthy, and perhaps wealthy as well. Finally, marital status per se is associated with health.

The young and single, especially if never married, are less healthy. The old and formerly married, whose spouses have been deceased for a considerable period, as "survivors" may be more healthy than those whose spouses have survived. This is, of course, pure speculation, but the point is that in this sample, age and marital status—especially contemporary marital status without regard to marital history—should be handled with care.

Second, studies of mortality determinants among the elderly are likely to yield counter-intuitive results that are easily misunderstood. Consider a treatment, such as smoking, that increases mortality at relatively young ages. Since people are heterogeneous, the treatment will affect some more than others. As the effects of the treatment accrue, the most susceptible succumb and the strong survive. When observing mortality only at advanced ages, after the most susceptible have been lost to the sample, we should not be surprised to find that the treatment seems to have little or even perverse effect.

We have all heard stories about those who claimed to have lived lives from which few survived. Would we want to judge the effects of such behavior only by observing the subsequent mortality of the—perhaps few—hardy survivors?

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