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# Perceptions of Mortality: Individual Assessment of Longevity Risk

Kathleen McGarry



The published version of this working paper may be found in the 2022 publication: *New Models for Managing Longevity Risk: Public-Private Partnerships.*

## Perceptions of Mortality: Individual Assessment of Longevity Risk


### Abstract

Financially successful retirement depends in large part on managing longevity risk: individuals need to save during their working lives to cover expenses in retirement, and then they must spend down those savings carefully so as not to outlive their assets. Despite the centrality of individuals' expectations regarding life expectancy, little is known about how longevity expectations are formed and how they evolve as individuals age. This paper assesses the evolution of subjective survival probabilities, defined as the probabilities that people believe they will live to at least 75 or 85 years of age. I examine the correlates of these reported probabilities when initially measured, how they change over time, and in particular, how they change with major life course events like the death of a parent, in-law, spouse, or sibling. I also examine how the subjective probabilities change in response to health shocks such as a heart attack or diagnosis of diabetes.



### Keywords

Life expectancy, subjective survival, mortality probabilities, longevity, health

### Disciplines

Economics

### Comments

The published version of this working paper may be found in the 2022 publication: *New Models for Managing Longevity Risk: Public-Private Partnerships.*

# New Models for Managing Longevity Risk

## Public-Private Partnerships

Edited by

Olivia S. Mitchell

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# Contents

*List of Figures* ix
*List of Tables* xii
*Notes on Contributors* xiv

1. Introduction: New Models for Managing Longevity Risk: Public-Private Partnerships 1
   *Olivia S. Mitchell*

**Part I. Understanding Longevity Risk**

2. Perceptions of Mortality: Individual Assessment of Longevity Risk 11
   *Kathleen McGarry*

3. Disability-free Life Trends at Older Ages: Implications for Longevity Risk Management 34
   *Douglas A. Wolf*

4. Does Working Longer Enhance Old Age? 57
   *Maria D. Fitzpatrick*

5. Working Longer Solves (*Almost*) Everything: The Correlation Between Employment, Social Engagement, and Longevity 70
   *Tim Driver and Amanda Henshon*

**Part II. Public-Private Partnerships to Help Fill the Gaps**

6. Aging in Place: The Role of Public-Private Partnerships 91
   *Nancy A. Hodgson*

7. Public-Private Partnerships Extend Community-based Organization's Longevity 105
   *Dozene Guishard and William J. Dionne*

8. Innovative Strategies to Finance and Deliver Long-term Care 122
*Nora Super, Arielle Burstein, Jason Davis, and Caroline Servat*

9. Building on Hope or Tackling Fear? Policy Responses to the Growing Costs of Alzheimer's Disease and Other Dementias 150
*Adelina Comas-Herrera*

**Part III. Implications for the Financial Sector and Policymakers**

10. State-sponsored Pensions for Private-Sector Workers: The Case for Pooled Annuities and Tontines 171
*Richard K. Fullmer and Jonathan Barry Forman*

11. New Financial Instruments for Managing Longevity Risk 207
*John Kiff*

12. Property Tax Deferral: Can a Public-Private Partnership Help Provide Lifetime Income? 231
*Alicia H. Munnell, Wenliang Hou, and Abigail N. Walters*

13. The Market for Reverse Mortgages among Older Americans 258
*Christopher Mayer and Stephanie Moulton*

*The Pension Research Council* 301
*Index* 305

# Chapter 2

# **Perceptions of Mortality**

## Individual Assessment of Longevity Risk

*Kathleen McGarry*

A financially successful retirement depends, in large part, on how people manage their longevity risk. Individuals need to save during their working lives to cover expenses in retirement, and then spend down those savings over the remainder of their lives to finance their consumption. This is the behavior predicted by the standard life cycle model in economics. The longer an individual expects to live, the longer he or she must work and/or save to finance consumption in retirement. Underestimating one's longevity could lead one to consume assets 'too quickly,' exhausting resources while one is still very much alive. In contrast, overestimating life expectancy would lead to a loss of utility, as savings would, in some sense, be wasted by not being consumed.[1]

The appeal of financial instruments such as life insurance and annuities also depends on peoples' estimates of their longevity. For instance, annuities are more valuable to those with longer life expectancies, while those anticipating shorter lifespans would find life insurance more appealing, along with estate planning. Despite the centrality of individuals' expectations regarding life expectancy, we know little about how these expectations are formed initially or how they evolve as an individual ages. Though a relatively recent strand of the economics literature has begun to explore subjective probabilities, much of the focus to date has been on the statistical properties of these distributions, and there is a great deal more to learn.

This chapter examines the evolution and validity of subjective survival probabilities, specifically the probability that an individual anticipates living to a target age. I examine the correlates of these reported probabilities when initially measured, how they change over time, and in particular, how they change with major life course events like the onset of a medical condition or the death of a close relative. Finally, I explore briefly their validity with respect to actual survival to that age.

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As was true in past work, we confirm that subjective expectations of survival vary with known risk factors such as smoking status, sex, and health. I also find strong evidence that measures of individual expectations contain important information—information that goes beyond that gleaned from life tables, and thus has the potential to help researchers better understand individual financial decisions. Furthermore, individuals appear to incorporate new information regarding their health status as it becomes available; the diagnosis of a medical condition significantly affects one's projection of survival probabilities.

This chapter is organized as follows. First, I discuss the recent literature most relevant to this study, particularly drawing on research that uses the survey data and subjective probability question employed here. Next, I discuss the data in more detail, followed by a focus on the subjective probability measures themselves, particularly their validity and evolution over time. A final section concludes and provides some discussion of how these expectations might be informative with regard to financial outcomes.

## Prior Research

Subjective probabilities figure prominently in economic models of behavior, and much research examining the validity and usefulness of subjective probabilities has focused on survival probabilities.[2] These studies have shown that subjective survival probabilities are, on average, close to actual survival probabilities, though there is substantial variation among groups. For example, men seem to overestimate their survival probabilities on average, while women underestimate them (Hurd and McGarry 1995, 2002). Similarly, subjective survival probabilities vary with known risk factors such as smoking status and schooling level, and they are also predictive of actual outcomes. For instance, Bassett and Lumsdaine (2001) examined subjective probability reports for a number of outcomes and concluded that these subjective measures varied with observable characteristics in expected ways (e.g. married women reported lower probabilities of working at later ages than did single women). The survival probabilities examined here and elsewhere have been used to study decision-making in several contexts including social security claiming, saving behavior, and retirement (Hurd et al. 2004; Bloom et al. 2006).

Despite these successes, there are reasons to question how useful such probabilities are in economic models. One of the most notable issues is the propensity of individuals to provide 'focal responses,' particularly probabilities of zero, one, or 0.50, since the actual probabilities for the chance of surviving to a given age cannot truly take a value of zero or 100 percent. Therefore, such reports can be problematic when included in economic models. For instance, a reported value of 50 percent could be the individual's true belief, or instead it could be a value close to 50 percent but rounded to a focal number. Alternatively, 50 percent could indicate a substantial amount of uncertainty, or even an unwillingness to think about the issue. Bruine de Bruin et al. (2000) examined what they termed the '50 blip' in probability questions, noting that individuals use wording such as a 50–50 chance, or 50 percent probability, to indicate that they were uncertain about the outcome, rather than intending to imply a specific probability. Additionally, that paper suggested that people might respond with '50 percent' to avoid thinking about 'negative and uncontrollable events' (p.127). Clearly, asking respondents about their chances of survival prompts them to consider their own mortality risk, for many a negative (and unpleasant) thought. Nevertheless, by contrast, Bissonnette et al. (2017: e294) concluded that there was 'little support for the idea that 50 percent-point answers are used to avoid answering questions.'

Despite the obvious statistical issues regarding such misreporting, most evidence indicates that these self-assessment survival reports contain some useful information that cannot be obtained elsewhere, and that they ought not to be completely dismissed. An individual reporting a 100 percent chance of surviving to age 75 likely intends to convey that he or she feels healthy and very much expects to live to that age and beyond. While analysts would be more comfortable were he or she to report a probability of, say, 90 percent, the person's report is nonetheless likely to be useful in understanding retirement and savings decisions. Furthermore, as van Santen et al. (2012) noted, excluding respondents who give focal responses not only leads to a smaller sample but also one that is likely to be biased. In particular, a researcher who excludes focal responses is likely to omit proportionately less-educated individuals.

For the analyst who needs to incorporate probabilities with focal responses into models, Kleinjans and van Soest (2014) have proposed a method of adjusting these responses. Their method, and similar techniques, have been successfully employed elsewhere, particularly with respect to survival probabilities (Hurd et al. 2004; Bloom et al. 2006; Bissonnette et al. 2017.

Another issue in the realm of reporting error relates to the magnitudes of the probability of related events. When comparing probabilities of two (or more) scenarios, such as the probabilities of working to ages 62 and 65, or the probabilities of living to ages 75 and 85, a small fraction of respondents in the HRS report a larger probability for the *latter* scenarios, for example a greater probability of living to age 85 than to age 75. This behavior clearly indicates a misunderstanding of probabilities, and such results are typically impossible to employ in economic models of behavior or, in the case of survival probabilities, used in deriving survival curves.

The usefulness of the information contained in an individual's subjective expectation report will also depend on how well self-reports compare with known population averages or actuarial predictions. In the case of survival probabilities, this standard of comparison would be with survival probabilities obtained from life tables. It may be that the individual's own report is more informative or contains information supplemental to life tables. For instance, Elder (2013) found that life table probabilities had far greater explanatory power in models of survival than did subjective expectations, in a subsample of respondents for whom mortality status was known. Nevertheless, his results also showed that the subjective expectations were positively and significantly linked to surviving to the target age, even when controlling for the life table probability. This result strongly suggests that there is important information contained in subjective survival measures. Moreover, when analyzing behavior, what an individual believes with regard to various measures is crucial, regardless of actuarial probabilities.

## Data

The data set used in this analysis comes from the Health and Retirement Study (HRS), a panel survey of the US population age 51 or older.[3] These surveys collect extremely detailed information on respondents' health, financial resources, family, and personal characteristics; and they also ask respondents about the likelihood of various events, including the probability of surviving to a particular age, working to a given age, entering a nursing home, and leaving an inheritance. The database has also been linked with administrative records, most notably the National Death Index, Social Security Administration data, and Medicare records, providing researchers with the opportunity to merge data not typically associated with nationally representative surveys. The initial cohort of sample members was first interviewed in 1992 and consisted of those born between 1931 and 1941 and their spouses or partners. Additional cohorts of both older and younger individuals were added in 1998 to create a sample that, when appropriately weighted, is approximately nationally representative of the population over the age of 50. New cohorts have since been added every six years to fill in the lower end of the relevant age distribution. HRS respondents are interviewed biennially until their deaths (or until they attrite from the survey for other reasons),[4] with the most recent available data collected in 2016.[5]

The exceptionally long panel available for the original cohort, stretching from 1992 to 2016, means that respondents in the original HRS cohort who have not died or attrited from the survey have been interviewed 13 times over 24 years. It is thus possible to observe these individuals throughout much of their remaining lives, providing a near-complete picture of the various shocks people have faced as they have aged. Of particular note is that, by 2016, the youngest members of this cohort had (or could have) attained age 75. This is important because the primary subjective survival probability question, delineated below, asks respondents to report their chances of living to age 75. I can thus assess the predictive power of individual reports of survival probabilities for nearly the entire sample. To my knowledge, this is the first research study to do just that.

The question of interest (and its preface) in the initial HRS survey wave is:

> Next I would like to ask you about the chances that various events will happen in the future. Using any number from zero to 10, where zero equals absolutely no chance and 10 equals absolutely certain . . . What do you think are the chances that you will live to be 75 or more?

Later waves broadened the scale to range from zero to 100. For consistency, the responses in this first wave are multiplied by 10 in this analysis.[6]

There are similar questions about living to age 85 (in waves 1–4) and about the probability of living approximately 10 more years. Here I limit my analysis to the age 75 question, because it is the only one that is consistent across waves and that also allows me to observe the true outcome for the original respondents.

The analysis focuses on individuals in the initial HRS cohort; I exclude persons born after 1941 and who were thus too young to provide measures of mortality up to age 75. I also exclude proxy respondents because they were not asked the subjective probability questions. This leaves me with an analysis sample of 8,529 individuals.[7] Note that, over time, as individuals died or were lost to follow-up, the number of respondent interviews in each wave declines. In addition, because the primary variable in the analysis, the subjective probability of surviving to age 75, was not asked of respondents over the age of 65 for most of the survey (in all waves other than the first), the number of responses regarding survival probabilities declines as respondents 'aged out' of the question. Importantly, however, those individuals continue to contribute information regarding their longevity throughout the 13 waves of data, regardless of age, and thus they provide the important information regarding the accuracy of subjective expectations.

Descriptive statistics for a number of economic and demographic characteristics in the HRS analysis sample are reported in Table 2.1. Here I show the means and standard errors for the entire sample in the first two columns, and then I repeat these statistics separately for those respondents who survived to age 75 and those who did not. The values for the variables listed on the left hand side of the table are measured as of the first observation.

Table 2.1 Summary statistics (weighted)

| | ALL (n = 8,529*) | | Decedent (n = 2,210) | | Survivor (n = 5,070) | |
|---|---|---|---|---|---|---|
| | Mean | SE | Mean | SE | Mean | SE |
| *Demographic characteristics:* | | | | | | |
| Prob live to age 75 | 64.42*** | 0.318 | 56.45 | 0.691 | 67.29 | 0.389 |
| Prob live to age 85 | 42.52*** | 0.347 | 44.88 | 0.440 | 35.97 | 0.701 |
| Age | 56.26*** | 0.031 | 56.15 | 0.062 | 56.47 | 0.040 |
| Male | 0.47*** | 0.005 | 0.57 | 0.100 | 0.43 | 0.007 |
| Married 0/1 | 0.77*** | 0.004 | 0.70 | 0.009 | 0.79 | 0.005 |
| Years of schooling | 12.35*** | 0.031 | 11.73 | 0.064 | 12.59 | 0.039 |
| Number of children | 3.22 | 0.021 | 3.30 | 0.045 | 3.26 | 0.027 |
| Nonwhite/Non-Hispanic 0/1 | 0.13*** | 0.003 | 0.17 | 0.008 | 0.12 | 0.004 |
| Hispanic 0/1 | 0.06 | 0.002 | 0.06 | 0.005 | 0.06 | 0.003 |
| *Health status/ conditions* | | | | | | |
| Excellent health | 0.24*** | 0.004 | 0.12 | 0.007 | 0.27 | 0.006 |
| Very good | 0.30*** | 0.005 | 0.21 | 0.008 | 0.33 | 0.006 |
| Good | 0.27** | 0.005 | 0.29 | 0.009 | 0.26 | 0.006 |
| Fair | 0.13*** | 0.003 | 0.21 | 0.008 | 0.10 | 0.004 |
| Poor | 0.07*** | 0.003 | 0.16 | 0.007 | 0.04 | 0.003 |
| Underweight | 0.01*** | 0.001 | 0.02 | 0.003 | 0.01 | 0.001 |
| Obese | 0.23*** | 0.004 | 0.27 | 0.009 | 0.22 | 0.005 |
| Ever smoked | 0.38*** | 0.005 | 0.79 | 0.008 | 0.59 | 0.006 |
| Current smoke | 0.26*** | 0.005 | 0.44 | 0.010 | 0.21 | 0.005 |
| Active 3+ times/week | 0.21*** | 0.004 | 0.18 | 0.008 | 0.22 | 0.006 |
| *Family:* | | | | | | |
| Mother alive | 0.41*** | 0.005 | 0.37 | 0.010 | 0.42 | 0.007 |
| Father alive | 0.16** | 0.004 | 0.13 | 0.007 | 0.16 | 0.005 |
| Number of siblings | 2.85** | 0.025 | 2.73 | 0.050 | 2.88 | 0.032 |
| *Household financial characteristics:* | | | | | | |
| Working | 0.68*** | 0.005 | 0.58 | 0.010 | 0.71 | 0.006 |
| Household income | 85,161*** | 972 | 66,682 | 1,630 | 91,000 | 1,282 |
| Household total wealth | 257,146*** | 5,647 | 153,032 | 7,285 | 292,143 | 7,720 |

*Note*: Values are measured at the first interview. Dollar values are in 2018 dollars. Stars indicate if the difference between the survivors and decedents is significant at the ***1 or **5 percent levels. The two rightmost columns do not sum to the total, because a third category, those who attrit from the survey prior to age 75 and for whom the mortality outcome is unknown, are excluded from the breakdown by outcome.

*Source*: Author's calculations from the Health and Retirement Study.

The average age of respondents was 56, slightly fewer than half of these respondents were male, and over three-quarters were married at baseline. Respondents' health was good at the outset: using the self-assessed health measure, where respondents could report being in excellent, very good, good, fair, or poor health, only seven percent said they were in poor health. Sadly, rates of obesity and smoking were high: 23 percent reported values for their height and weight such that the respondent was classified as obese,[8] and 26 percent smoked (in 1992). Only 21 percent reported engaging in vigorous activity three or more times a week. Given the typical age difference between husbands and wives, and the shorter life expectancy for men, the probability that the respondent had a living mother was 41 percent compared to just 16 percent for a father.

Unsurprisingly, there are large differences in the means of these variables between those who survived to age 75 and those who did not, all significantly different from zero except for the number of children and the probability of being of Hispanic ethnicity (both of which are similar across groups).[9] Perhaps most interesting for the present study are the large differences across the two groups in subjective survival probabilities. The average reported probability of surviving to age 75 for those who did not survive is 56 percent, while the average for those who did survive was 67 percent. Similarly large differences are found for the probability of living to ages 85–45 versus 36 percent. The well-known differences in life expectancy by sex are apparent, with 57 percent of decedents being male compared to just 43 percent of survivors.

With respect to other measures, survivors were advantaged in every way. They had more schooling, were less likely to be nonwhite, and reported being in better health. Only four percent of survivors reported being in poor health, compared to 16 percent of decedents. Thus subjective health, like subjective survival probabilities, appears consistent, at least on average, with actual outcomes. Survivors were approximately half as likely to be smokers, less likely to be obese, and more likely to engage in vigorous activity than decedents. They also had a higher income and greater wealth.

In what follows, I examine how the subjective assessments by individuals of their likelihood of surviving to age 75 relate to actual mortality, to known risk factors for mortality, and how these expectations were updated over time with the arrival of new information.

## Survival Probabilities

### Cross-sectional properties

Table 2.2 provides statistics regarding the issue of focal responses, namely responses of zero, 50, or 100 percent. I report the distribution of focal responses in both the first wave and for all of the survey waves stacked

Table 2.2 Probability of focal response

| Type of response | Percent of sample | | |
|---|---|---|---|
| | All | Decedents | Survivors |
| *First wave (n = 8,202)* | | | |
| Non-focal response | 50.5 | 47.5 | 50.8 |
| Subjective probability = 0 | 6.5 | 12.0 | 4.8 |
| Subjective probability = 50 | 21.7 | 22.4 | 22.7 |
| Subjective probability = 100 | 21.3 | 18.1 | 21.8 |
| Total | *100* | *100* | *100* |
| *All waves (n = 35,463)* | | | |
| Non-focal response | 49.1 | 44.3 | 51.0 |
| Subjective probability = 0 | 5.24 | 11.2 | 3.6 |
| Subjective probability = 50 | 25.17 | 27.0 | 24.3 |
| Subjective probability = 100 | 20.38 | 17.5 | 21.2 |
| Total | *100* | *100* | *100* |

*Source*: Author's calculations from the Health and Retirement Study.

together. The latter makes full use of the available data, but by construction those who live longer contribute more observations than shorter lived respondents. This can lead to potentially biased assessments of the properties of subjective probabilities if the two groups have different likelihoods of reporting focal values in general, or of probabilities of zero, 50, or 100 percent in particular. Here and in Table 2.3, I therefore present statistics for both the single wave and for the aggregate sample.

As others have reported, Table 2.2 shows a substantial heaping of respondents at 50 percent and 100 percent (just over 20% of the sample reported each of these values), but there is a much lower mass at zero percent. Clearly, from a probability standpoint, values of zero and 100 are inappropriate: a person saying zero or 100 percent where not trained in statistics could indicate that he or she felt certain of the outcome, whether low or high, and simply rounded to a convenient number. While some analysts have called into question the value of reported probabilities of 50 percent, as noted earlier, excluding those giving focal responses likely leads to biased results. Unsurprisingly, the bias is greater for less educated individuals who were less clear about probabilities, where the tendency to report zero, 50, or 100 percent was greatest.

There are also differences between decedents and survivors in the prevalence of focal responses, as one would expect, with more reported values of zero and fewer reports of 100 percent among those who did die before age 75, but with a similar percentage reporting a probability of 50 percent. Interestingly, nearly 20 percent of those who died before age 75 reported a 100 percent chance of surviving to that age.

The second panel illustrates similar patterns for the stacked sample including observations in all waves. This combined sample is weighted

TABLE 2.3 Regression of survival probability on individual characteristics

| Variable | Coefficient | (Standard error) |
|---|---|---|
| *Personal Characteristics:* | | |
| Male | −3.30*** | (0.50) |
| Age | 0.44*** | (0.06) |
| Schooling | 0.50*** | (0.13) |
| Nonwhite | 5.30*** | (0.71) |
| Hispanic | −3.57** | (1.04) |
| Married | 0.95 | (2.05) |
| *Health:* | | |
| Excellent | 11.59*** | (0.03) |
| Very good | 5.42*** | (0.53) |
| Good (omitted) | – | – |
| Fair | −8.66*** | (0.76) |
| Poor | −20.56*** | (1.20) |
| *Existing Medical Condition:* | | |
| High blood pressure | −1.07** | (0.48) |
| Stroke | −1.33 | (1.22) |
| Diabetes | −1.60** | (0.78) |
| Cancer | −2.90*** | (0.84) |
| Lung problems | −3.92*** | (1.05) |
| Heart problems | −4.09*** | (0.72) |
| Arthritis | −0.24 | (0.45) |
| *Behaviors:* | | |
| Physically active | 0.83*** | (0.18) |
| Smokes now | −4.07*** | (0.62) |
| Smoked ever | 1.05** | (0.52) |
| *Family:* | | |
| Mom alive | 9.53 | (5.54) |
| Mom's age | 0.02 | (0.07) |
| Mom's age at death | 0.11*** | (0.02) |
| Dad alive | 8.80 | (8.26) |
| Dad's age | 0.02 | (0.09) |
| Dad's age at death | 0.11*** | (0.02) |
| Mean of dependent variable | 65.12 | |
| Number of observations | 31,711 | |
| Number of respondents | 7,834 | |

*Note*: Stars indicate if the coefficient estimates are significantly different from zero at the ***1 or **5 percent levels.
*Source*: Author's calculations from the Health and Retirement Study.

toward those who were the longest lived, and thus likely younger at the outset. Interestingly, the patterns are similar to those identified before, though differences between survivors and decedents are slightly more pronounced. Approximately one-half of the observations were non-focal responses; there

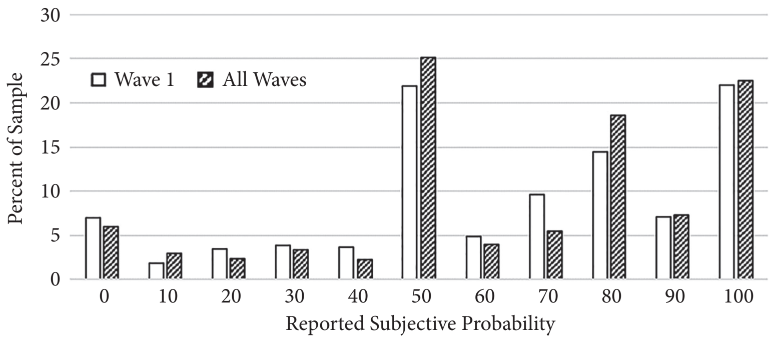


**Figure 2.1** Distribution of HRS survival probabilities: wave 1 and all waves

*Source*: Author's calculations from the Health and Retirement Study.

were a large number of observations at probabilities of 50 percent and 100 percent, and fewer at zero.

Figure 2.1 shows the entire distribution of reports as a percentage of the sample for each of the 11 possible probabilities.[10] The lighter bars are for the first wave and the darker bars for the stacked waves (which again, skew right). The spikes in the percentage reporting 50 and 100 percent are clearly visible. Nonetheless, one can also see the distribution of non-focal responses which span the full probability range. Of note, the average life table probability for this sample was 69.3, so the distribution and the means in Table 2.1 compare well with this value. Additional differences are explored in more detail below.

## Regression estimates

While Table 2.1 illustrated the strong correlation between numerous individual characteristics and actual survival, many of these factors are also correlated with subjective survival probabilities, suggesting that the individuals may be consciously or unconsciously incorporating known risk factors into the assessments of their own survival probabilities. Table 2.3 explores some of these correlations in a multivariate regression of the subjective survival probability on characteristics such as sex, health, smoking status, etc., all of which are likely to factor into actual survival probabilities and thus into respondents' assessment of their survival probabilities. Here I stack all observations for an individual and correct the standard errors for these multiple measures.[11] Because these estimates are similar to those reported elsewhere (Hurd and McGarry 1995), I discuss them only briefly and use a parsimonious specification to convey the main points although here we have more observations.

Consistent with known differences in life expectancies, men report a significantly lower survival probability, 3.3 percentage points lower, than do women. (The average difference in life table values is approximately twice that.) Probabilities rise with age, as they should given the shorter time until age 75 for older respondents, and they rise as well with schooling. All else constant, nonwhite respondents forecast a substantially greater chance of survival, and Hispanic respondents, less.[12]

A key factor in assessing one's probability of surviving is one's health status. The HRS offers several ways to measure health: a first is self-reported health, on a scale of one through five, ranging from excellent to poor. It also asked people to assess their current medical conditions, taking the form:

> Has a doctor ever told you that you had a heart attack, coronary heart disease, angina, congestive heart failure, or other heart problems?

A similar question was asked about high blood pressure, stroke, diabetes, cancer, lung problems, and arthritis. Finally, I include measures of peoples' health behaviors: physical activity, smoking status (current and former), and measures of obesity or being underweight.

Unsurprisingly, these health measures are strong predictors of individuals' survival probabilities. For the general measure of overall health, differences in outcomes between the various states of health are large. Moving from excellent to poor health results in a predicted decline of 32 percentage points in the probability of survival or approximately 50 percent.

Each of the medical conditions captured by the HRS has a negative effect on expectations, and all but stroke and arthritis have effects that are significantly different from zero, typically at the one percent level. Behaviors such as being physically active and smoking have the expected effects, and they are similarly highly significantly different from zero. There is a large negative relationship between smoking currently and subjective survival probabilities, with smokers reporting a lower probability by approximately four percentage points or six percent. This result holds, despite prior work finding that smokers underestimate their risk, indicating that the true difference could be even greater (Khwaja et al. 2007; Bissonnette et al. 2017).

Finally, in examining the relationship between survival probabilities and the mortality experience of family members, there is a positive and significant relationship between the age at death of a parent and the respondent's own expectations.

## Comparison of subjective expectations

As noted above, the time span of the data allows me to follow the original HRS respondents (approximately age 51–61 in 1992) for 24 years, until the

Table 2.4 Survival probabilities

| | All | Women | Men |
|---|---|---|---|
| *Wave 1* | | | |
| Actual survival probability | 70.9 | 76.2 | 64.7 |
| Subjective survival probability | 64.1 | 65.8 | 62.0 |
| Life table value | 69.4 | 75.8 | 61.9 |
| Ratio subjective/life table | 0.93 | 0.87 | 1.00 |
| Number | 7000 | 3820 | 3180 |

*Note*: Sample is limited to those who report a value for the subjective survival probability and for whom actual survivor status is known.
*Source*: Author's calculations from the Health and Retirement Study.

youngest reached age 75. With these data, I can compare the subjective survival probabilities reported at younger ages with actual outcomes. Similarly, I can compare the predictive power of subjective assessments with objective assessments from life tables which depend here only on age and sex.

The first column of Table 2.4 shows that life table estimates are a more accurate assessment, on average of survival than subjective reports, with a mean self-reported probability of surviving to age 75 of 69.4, compared to the actual survival probability of 70.9. The average of the subjective reports was just 64.1, indicating that, on average, respondents underestimated their survival probabilities. This underestimate could be a potential liability with respect to adequate savings for retirement and financial well-being later in life. Much of the difference between the subjective assessments and actual outcomes or life table values stems from the substantial underreporting by women, a result that is consistent with the poor financial outcomes for women at older ages relative to men. (In 2018, 11.1% of women age 65+ were poor, compared to 8.1% of men in the same age range; US Bureau of the Census 2020).[13]

Figure 2.2 further examines the validity of these reported survival probabilities. Here I assign respondents to a subjective probability bin based on their first reported probability of living to age 75, and then I calculate the actual survival probability to age 75 for individuals in that bin. There is a positive, nearly monotonic, relationship between reported survival probabilities and actual survival. The non-monotonicity at the endpoints, zero and 100, points to measurement error for these responses. Those reporting zero have a very low subjective probability, similar to those reporting 10 percent, suggesting that these respondents may have simply been 'rounding down' to zero. At the other end of the distribution, those reporting living to

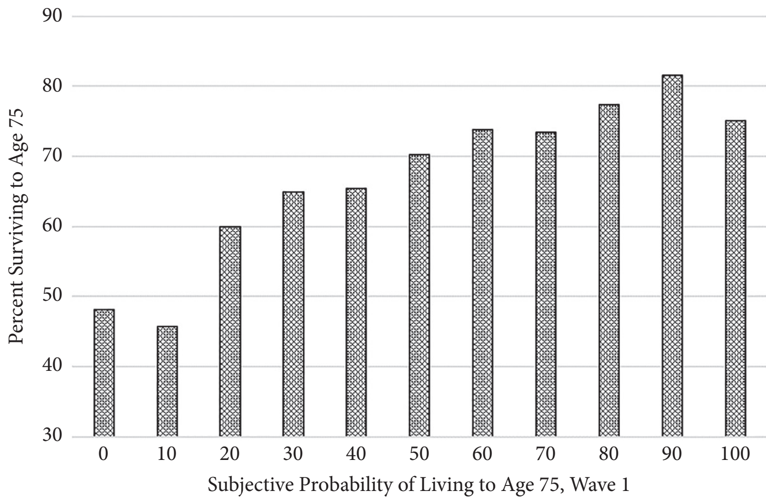


**Figure 2.2** Percentage surviving to age 75 by subjective probability, HRS
*Source*: Author's calculations using the Health and Retirement Study.

age 75 with certainty, did have a high survival probability but less than that for those reporting a 90 or even an 80 percent chance, again suggesting strong rounding.

In other words, while I conclude that the subjective survival measures are not perfect, they do seem to correlate well with actual mortality experience and with known correlates of mortality risk.

## Updating of survival probabilities

Of particular interest is how people update or change their expectations over time in response to new information.[14] Table 2.5 illustrates the change in subjective survival probabilities associated with a change in self-reported health status. It extends Hurd and McGarry (2002) with many more waves of data than the two waves used in that study. Relying on the additional years of information available here, I follow respondents to older ages and thus observe more transitions into fair or poor health status than in earlier work. It is in these worsening health categories that one might expect survival probabilities to be most impacted, as opposed to movements from excellent to very good health that would be expected earlier in the life course.

The rows of Table 2.5 correspond to the five health status categories in a given wave (wave T)—excellent, very good, good, fair, or poor—and the columns denote health status in the subsequent wave (T+1). The top panel of the table illustrates the number of individuals in each cell, corresponding

Table 2.5 Changes in subjective health and survival

| Wave T | Wave T+1 Excellent | Very good | Good | Fair | Poor |
|---|---|---|---|---|---|
| | *Numbers Transitioning* | | | | |
| Excellent | 2654 | 1169 | 346 | 66 | 19 |
| Very good | 1623 | 4402 | 1815 | 260 | 37 |
| Good | 541 | 2099 | 3933 | 1048 | 137 |
| Fair | 114 | 381 | 1234 | 1907 | 544 |
| Poor | 26 | 66 | 213 | 5391 | 897 |
| | *Change in Survival Probabilities* | | | | |
| Excellent | −0.36 | −3.01 | 1.11 | −14.43 | −3.77 |
| Very good | 0.99 | −0.43 | −1.22 | −5.27 | −3.34 |
| Good | 0.50 | 2.22 | −0.53 | −2.56 | −6.33 |
| Fair | 6.99 | 6.97 | 1.61 | −0.03 | −4.95 |
| Poor | 17.58 | 11.34 | 15.41 | 5.50 | −0.56 |

*Source*: Author's calculations from the Health and Retirement Study.

to the reporting of a particular transition between two health states. The bottom panel shows the average change in the reported values for the subjective probability of surviving to age 75 between the two waves. For instance, 66 respondents reported excellent health in one wave and fair health in the next. Among this group, the average decline in the probability of surviving to age 75 was 14.43 percentage points (or 22% based on the sample-wide average of 65).

As is apparent, respondents revised down their subjective survival probabilities as their perception of their health status declined. There is only one cell in the table which did not exhibit this pattern—the transition from excellent to good health—and the change in average survival probabilities for those in that cell was relatively small—just a 1.11 percentage point increase in survival probability. Interestingly, all diagonal values of the table (i.e. the changes in subjective probabilities for those who report being in the same broad health category in each of the two waves) were negative. For example, for the 3,933 respondents who reported being in good health in both waves, the average change in subjective probability of survival was −0.53. This pattern indicates a slight decline in expected survival with age, despite no change in their subjective health reports in terms of the five-point excellent to poor scale. This result suggests that the 100-point scale used in the probability question offers a more finely defined gradient for measuring health than general measures of overall health.

A more formal measure of health related to questions about the onset of medical conditions diagnosed by a doctor. To the extent that the onset of various medical conditions such as a heart attack or cancer was unexpected, their onset would likely be associated with a reduction in the subjective survival probability. These questions regarding new medical conditions parallel those asked initially:

> Since WAVE X MONTH/YEAR, has your doctor told you that you had a heart attack, coronary heart disease, angina, congestive heart failure, or other heart problems?

Again, the questions covered high blood pressure, stroke, diabetes, cancer, lung problems, and arthritis, in addition to the heart problems in the question above.

This measure is imperfect, in that while a heart attack or stroke is unlikely to be missed, the incidence of high blood pressure will depend on whether an individual had seen a doctor. In employing the onset of disease as a measure of the change in health, we could also miss a more gradual degradation of health not attributable to one of these factors. With these caveats in mind, Table 2.6 examines the change in probabilities for those reporting the onset of a new medical condition. I divide the sample into those who had an onset of the particular condition ('Developed condition') and those who did not ('No condition'), and I note the average subjective probabilities both 'Before' and 'After' for each group, as well as the change between the two waves.

Perhaps unsurprisingly, the largest changes in the subjective survival probabilities were among those who had a diagnosis of cancer, followed by that of a stroke, then of heart disease, and finally of lung problems. Conditions such as high blood pressure, diabetes, and arthritis had only small effects on expected survival chances. This result is consistent with the medical literature, and it suggests that people do update their probabilities with the arrival of new information. Furthermore, these changes across time for those determined to have a health condition were larger than changes for those not so diagnosed, for all but high blood pressure and arthritis. Nearly all of the differences are significant at a one percent level.

Some of the changes associated with a given condition could be seen as relatively small relative to the expected increase in mortality risk, note that the 'Before' expectations ought to include all information known to the respondent at the time of the survey. Someone with a higher risk of heart attack, perhaps based on family history, smoking status, or obesity, might have already incorporated much of this risk into his or her expectation. In such a case, the onset/event itself would be unlikely to convey entirely new information. Given our data, we cannot assess how much new information the event conveys.

In addition to medical and health information, new information about a respondent's own mortality risk could arise from the death of a close family member. This could include data about a genetic risk via the death of a

TABLE 2.6 Onset of medical conditions and family mortality

| | Subjective survival probabilities | | | | | |
|---|---|---|---|---|---|---|
| | Developed condition | | | No condition | | |
| Event | Before | After | Change | Before | After | Change |
| *Health conditions*: | | | | | | |
| High blood pressure | 65.41 | 64.14 | −1.27 | 65.68 | 65.73 | 0.05 |
| Stroke | 54.80 | 50.88 | −3.93 | 65.76 | 65.78 | 0.03** |
| Diabetes | 60.47 | 59.78 | −0.70 | 65.77 | 65.78 | 0.02*** |
| Cancer | 63.89 | 56.47 | −7.43 | 65.72 | 65.84 | 0.12*** |
| Lung problems | 56.15 | 53.00 | −3.14 | 65.78 | 65.81 | 0.04** |
| Heart problems | 61.30 | 57.97 | −3.33 | 65.77 | 65.86 | 0.08*** |
| Arthritis | 65.41 | 64.53 | −0.88 | 65.78 | 65.73 | −0.17 |
| Any condition | 63.14 | 61.10 | −2.04 | 66.14 | 66.53 | 0.39*** |
| *Deaths in the family* | | | | | | |
| Parent died | 68.35 | 68.81 | 0.46 | 65.43 | 65.39 | −0.04 |
| Mother died | 68.05 | 68.49 | 0.44 | 65.49 | 65.47 | −0.01 |
| Father died | 69.43 | 69.64 | 0.21 | 65.60 | 65.58 | −0.02 |
| Sibling died | 63.66 | 64.95 | 1.28 | 65.94 | 65.87 | −0.07 |
| Spouse died | 61.61 | 62.53 | 0.91 | 65.73 | 65.73 | −0.01 |
| Parent-in-law died | 66.85 | 66.37 | −0.48 | 65.59 | 6.60 | 0.01 |
| Mother-in-law died | 66.28 | 66.71 | 0.43 | 65.60 | 65.57 | −0.04 |
| Father-in-law died | 67.50 | 65.42 | −2.08 | 65.63 | 65.42 | 0.03 |
| Sibling-in-law died | 64.49 | 63.86 | −0.63 | 65.87 | 65.90 | 0.02 |

*Note*: Stars indicate if the changes in the subjective survival probabilities for those who experience the onset of a condition and those who do not are significantly different at the ***1 percent or **5 percent levels.
*Source*: Author's calculations from the Health and Retirement Study.

blood relative, or simply about mortality risk in general, say from the death of a spouse or in-law. The lower portion of Table 2.6 assesses the potential impact of the death of different relatives on reported survival probabilities. Despite the intuition, there is little evidence that respondents update their expectations in light of the death of a parent, sibling, spouse, or in-law. In results not reported here in detail, these conclusions remain unchanged if I allow for separate effects for men and women—testing to see if perhaps the death of a same-sex parent resonates more than the death of an opposite-sex parent. The lack of a response could stem from the age of the respondents. Because they were already in their 50s at the study's baseline, their parents were likely already rather old; the mean age for mothers in the sample at the initial interview was 80, and for fathers, 82. New information stemming from a parent (or parent-in-law) death at these later ages might not provide much information about the respondent's own probability of surviving to age 75. Thus, while the age at which a parent died was a significant predictor of the survival probability as show in Table 2.3, the actual death of a parent at these ages did not significantly alter the assessment.

TABLE 2.7 Regression of change in subjective probability

| Variable | Coeff | (std err) |
|---|---|---|
| *Health:* | | |
| Much better | 2.07** | (0.87) |
| Somewhat better | 1.49** | (0.65) |
| Same (omitted) | – | – |
| Somewhat worse | −1.98*** | (0.50) |
| Much worse | −8.78*** | (1.25) |
| *Onset of condition:* | | |
| High blood pressure | −0.66 | (0.96) |
| Stroke | −3.01 | (2.46) |
| Diabetes | 0.66 | (1.41) |
| Cancer | −5.01*** | (1.48) |
| Lung problems | −1.53 | (1.96) |
| Heart problems | −2.18 | (1.27) |
| Arthritis | −1.08 | (0.87) |
| *Family:* | | |
| Mom died btw waves | 0.57 | (0.78) |
| Mom's age at death | 0.005 | (0.003) |
| Dad died btw waves | 0.82 | (1.03) |
| Dad's age at death | −0.006 | (0.005) |
| Mean of dependent var | −0.056 | |
| Number of observations | 24,294 | |
| Number of respondents | 7,341 | |

*Note*: Stars indicate if the coefficient estimates are significantly different from zero at the *** 1 or **5 percent levels.
*Source*: Author's calculations from the Health and Retirement Study.

Finally, in Table 2.7, I examine the relationship between changes in self-reported health, changes in medical conditions, changes in the status of close relatives, and changes in survival probabilities in a single regression to assess their relative importance in a more formal manner. The measure of the change in self-assessed health used here is drawn directly from a question asking respondents to report how their health changed from the previous wave, rather than by comparing two independent reports of current health across waves. Specifically, the question reads:

> Compared with your health (2 years ago / [in the prior wave]), would you say that your health is much better now, somewhat better now, about the same, somewhat worse, or much worse than it was then?

A total of 10.5 percent of respondents reported that their health was much better or somewhat better, two-thirds said their health was about the same, and 23 percent reported somewhat or much worse health.

As seen in Table 2.5, changes in self-assessed health are strongly correlated with changes in survival probabilities. The coefficients for all four categories are significantly different from zero and relatively large. Someone who reported his or her health as 'much better' than in the prior wave had an expected increase in his or her probability of surviving of 2.07 percentage points. With a mean change between waves of close to zero, this is a large amount. The largest change in the table was for those whose health became 'much worse.'

For the onset of conditions, the relationships are all negative with the exception of the diagnosis of diabetes, although few coefficients are significantly different from zero. The strongest effect is for the diagnosis of cancer, which results in a decline of five percentage points. The coefficient for heart problems is also significantly different from zero and larger in magnitude than all but the 'much worse' health change. The advent of a stroke has a large effect in terms of magnitude but was not significantly different from zero because of the large standard error.

Once again, we confirm that the death of family members has no statistically significant effect on respondents' subjective survival probabilities.

## The validity of survival probabilities

Tables 2.6 and 2.7 provide clear evidence that individuals adjust their expectations with the arrival of new information (recognizing that what is 'new' information to the researcher may not be entirely new to the respondent). Next, I ask whether and to what extent these updates in survival probabilities improve the predictive validity of the subjective expectations questions. In so doing, I compare subjective probabilities with life table values and then with eventual survivorship status at age 75. To see more clearly how the subjective probabilities evolve over time, I limit my sample to those who survived and remained in the survey through at least wave six, and I then examine the trends in reported probabilities across those six waves.

Table 2.8 shows the average of the self-reported survival probability in each survey wave (SSP), the average life table values (LT), and the average of the ratio of the two probabilities (Ratio). The first triplet of columns (All) pertains to the full sample. The next two sets of columns pertain to survivors and decedents, respectively. There are several patterns contained in these data that are worth noting. First, the subjective survival probabilities are relatively constant across years. For the full sample, the average in the first wave was 68, while in the sixth wave (equivalent to 10 years of time), the average was 67.5—a minor change. Values for intervening years are similar. Second, the life table probabilities show a monotonic increase as probability theory implies. The conditional probability of surviving to age 75, having survived an additional year, is greater than the original probability. With these two trends, the ratio of the subjective to life table probability values steadily declines.

TABLE 2.8 Ratio of subjective survival probability to life table value

| | All (n = 1825) | | | Survivors (n = 1468) | | | Decedents (n = 357) | | |
|---|---|---|---|---|---|---|---|---|---|
| | SSP | LT | Ratio | SSP | LT | Ratio | SSP | LT | Ratio |
| Wave 1 | 68.0 | 68.4 | 1.0 | 70.0 | 68.8 | 1.02 | 59.8 | 66.9 | 0.90 |
| Wave 2 | 66.4 | 69.4 | 0.96 | 68.3 | 69.7 | 0.99 | 58.4 | 67.9 | 0.86 |
| Wave 3 | 67.9 | 70.9 | 0.96 | 70.1 | 71.2 | 0.99 | 58.9 | 69.5 | 0.85 |
| Wave 4 | 67.2 | 72.7 | 0.93 | 69.6 | 73.1 | 0.96 | 57.6 | 71.4 | 0.81 |
| Wave 5 | 68.0 | 74.8 | 0.91 | 70.5 | 75.1 | 0.94 | 57.7 | 73.6 | 0.79 |
| Wave 6 | 67.5 | 77.6 | 0.87 | 70.3 | 77.9 | 0.91 | 56.3 | 76.5 | 0.74 |

*Note*: Sample is those individuals for whom survivorship status at age 75 is known and who were interviewed through at least wave 6 with reported values for the probability of living to age 75 at each interview. The sample is thus balanced. SSP is the subjective survival probability, LT is the life table probability, and Ratio is the ratio of SSP to LT.
*Source*: Author's calculations from the Health and Retirement Study.

When comparing the figures across the survivors and decedents, we see that the subjective probabilities for survivors are uniformly higher than those for decedents. In fact, these differences are surprisingly large, given that the decedents in this sample, by construction, must survive for at least six waves or 10 years beyond the first report. They are thus the longest lived/healthiest of the decedents, with ages in wave 6 ranging from approximately ages 61–71. The differences in life table reports are far smaller than those for self-reports, because they rely solely on age and sex, factors that do not differ sizably for the two groups. There is no measure of underlying health or other individual-specific measures used in constructing the life table values. For both survivors and decedents, the life table values rise monotonically, and thus the ratios for self-reported to life table probabilities decline. For survivors, these ratios remain close to one, indicating relatively accurate reporting in terms of actuarial values, although one might expect a value greater than one because these individuals do survive. In contrast, self-reports for decedents are (accurately) well below the actuarial predictions. This result for decedents indicates that individual reports contain additional information missed in population averages: they predict a lower survival probability, on average, than actuarial tables, and they are correct in the sense that, *ex-post*, they did not survive.

To compare more directly both the subjective reports and the life table values with observed outcomes, Table 2.9 presents the correlations between each of these probabilities and actual survival to age 75. Again, the comparisons are carried out by wave. The correlations for both sets of probabilities are all positive and significantly different from zero, but they are substantially higher for the subjective probabilities than for the life table values. In Table 2.6 we saw that the self-reported probabilities for women were closer to life table values than those for men, and thus in this table, the correlations between subjective probabilities for men and actual survival are

TABLE 2.9 Correlation between subjective and life table probabilities and outcomes

| | All | | Women | | Men | |
|---|---|---|---|---|---|---|
| Wave | Subjective | Life table | Subjective | Life table | Subjective | Life table |
| Wave 1 | 0.145 | 0.106 | 0.105 | 0.091 | 0.167 | 0.117 |
| Wave 2 | 0.147 | 0.108 | 0.108 | 0.085 | 0.176 | 0.127 |
| Wave 3 | 0.161 | 0.110 | 0.143 | 0.082 | 0.171 | 0.115 |
| Wave 4 | 0.174 | 0.114 | 0.173 | 0.094 | 0.165 | 0.117 |
| Wave 5 | 0.193 | 0.121 | 0.164 | 0.099 | 0.220 | 0.131 |
| Wave 6 | 0.207 | 0.124 | 0.189 | 0.085 | 0.220 | 0.127 |

*Source*: Author's calculations from the Health and Retirement Study.

also greater than those for women. Also, note that as the respondent ages and gets closer to the target age of 75, there is less uncertainty regarding survival and the correlations increase.

## Discussion and Conclusion

The advent of 'big data' has proved to be a boon to researchers in a variety of fields. Yet as important as these data are to scientific research, survey information is still needed to address many of the most important questions. The data discussed and analyzed in this chapter, namely information on subjective probabilities, provide a prime example of the value of collecting information directly from individuals. In many ways, the HRS has managed to take the best from both worlds, with links to administrative data sets such as Medicare and Social Security Administrative data. The HRS allows researchers to access enormous amounts of high quality information on respondent behavior. In addition, however, the survey data collected from individual interviews allow for insight into the motivation behind observed behavior.

Here my focus has been on a relatively different and important type of question, namely older peoples' subjective probability of living to age 75. Despite evidence of measurement error, the subjective probabilities do reveal information beyond that gleaned from life tables, notwithstanding the prevalence of rounding to focal responses. Furthermore, as new information arises, particularly that related to the respondent's health, the respondent updates those probabilities and these updates too contain useful information beyond the life tables. As work continues in this area, we can anticipate refinements in questioning and in statistical methods that will allow researchers to make the most of these data and to improve the accuracy of our economic models.

## Notes

1. Some life cycle models allow for a bequest motive in which individuals receive utility from leaving bequests to their heirs (cf. Dynan et al. 2002).
2. Other studies have analyzed expectations regarding stock market returns (Dominitz and Manski 2011b; Lumsdaine and Potter van Loom 2017), returns to schooling (Dominitz and Manski 1996), and income (Dominitz and Manski 2011a).
3. Specifically, I use data from the RAND version of the HRS.
4. Although the original samples are drawn from the non-institutionalized population, respondents are followed into nursing homes. Individuals who are unable to answer the survey questions are interviewed via a proxy. Additionally, non-respondents are retained in the survey and attempts are made to recontact them in subsequent waves. Attrition from the survey has been exceptionally low; see HRS (2017) for detailed information on response rates.
5. Data for the 2018 interview were not available at the time of this writing.
6. Perozek (2008) noted that the change in scale did not seem to affect the likelihood of 'rounded' responses, and there is little evidence to suggest that this change would alter the conclusions of her study or other similar efforts.
7. Because I use population weights in the analysis, also excluded from the sample are those with zero weight.
8. This level likely contains substantial bias such that the body mass index (BMI) is underreported (e.g. Keith et al. 2011).
9. The number of observations for the full sample is larger than the sum of survivors and decedents, because the mortality status for some who left the survey is unknown.
10. Recall that respondents were asked to report a value between zero and 10 inclusive. These reports were scaled to represent probabilities of zero to 100.
11. Despite having multiple observations per respondent, I do not estimate this regression as a fixed effects model because variables of primary interest such as schooling, race, and sex do not vary over time in the data and are thus not identified. Other variables such as smoking status also show little variation. The estimated effects for health-related variables are substantially unchanged in a fixed effects framework, and I explore the effect of changes in these variables below.
12. Hispanics can be of any race.
13. Perozek (2008) estimated survival probabilities using subjective reports from the HRS. She similarly found survival probabilities based on reports from women were lower than those from the life tables used by social security. In contrast the subjective survival probabilities for men were higher than life table values. Interestingly, the Social Security Administration later raised their estimate of male life expectancy and lowered the estimate female life expectancy. Her results thus suggest that the subjective responses in the HRS are valuable, and reflect more than a simple reading of actuarial values.
14. Bissonnette et al. (2017) found in panel data that respondents seemed update their assessment of near-term mortality risk as they aged.

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