Cognitive and Happy Life Expectancy in the US

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Short Abstract

Research over the last several decades has attempted to establish whether gains in life expectancy have been accompanied by better quality of those additional years by examining years remaining to be lived in good physical health. Although such research has established that elders are living longer and physically healthier lives than ever before, cognitive impairment potentially has a greater effect on quality of life. In this paper, we investigate years to be lived with and without cognitive impairment and with high self-assessed quality of life (i.e., happiness). Our key question is whether happy life expectancy exceeds cognitive life expectancy. Put another way: is lack of cognitive impairment a necessary condition for happiness? To address this question we use Bayesian multistate life table methods applied to panel data from eight waves of the Health and Retirement Study.

Extended Abstract

The well-being of older adults is a major concern in the US, as evidenced by extant policies put in place over fifty-years ago to promote at least a basic quality of life among the aged population (e.g., Social Security and Medicare). Quality of life, by many measures, has improved for older Americans. For example, longevity has increased and physical disability has been postponed to the latest years of life (Feedman & Spillman, 2016). However, as physical morbidity has been compressed into fewer years at the end of the life course, cognitive health has emerged as a major concern in recent years. In fact, estimates suggest that approximately a quarter of Americans aged 71 years or older have cognitive impairment even without dementia (Plassman et al., 2008), thus presenting new challenges to the well-being of older adults.

While there have been numerous advances in treating chronic diseases such as heart disease and some cancers, there have been far fewer advances in treating diseases that produce cognitive impairment. Limited evidence shows that there has been a compression of cognitive morbidity, similar to trends in physical morbidity (Crimmins, Saito, & Kim, 2016). However, in light of population aging and the sheer size of the Baby Boom cohort, the incidence of cognitive impairment is likely to increase. Given that cognitive vitality is a major component of the successful aging paradigm (Rowe & Kahn, 1997) and is commonly considered essential for quality of life in old age (Gerstorf et al., 2015), research is needed to understand the role cognitive impairment plays in reducing the quality of life of elders.

Quality versus Quantity of Life in an Aging Society

Research since the 1980s has attempted to confirm the compression of morbidity hypothesis in an effort to establish that our gains in years of life have been accompanied by better quality of those additional years (Robine et al., 2003). This notion of quality versus quantity is well-reflected in the World Health Organization's (1997) statement that "increased longevity without quality of life is an empty prize." In other words, the concern is whether we are simply adding years to life versus adding life to those years.

One common strategy for answering this question is to estimate the number of years an average person in a given population can expect to live in good health (e.g., healthy life expectancy). Specifically, total life expectancy is commonly divided into healthy vs. unhealthy years, and if healthy years exceed unhealthy years, quality of life is understood to be relatively good. A well-established literature has shown that older adults can generally expect to live more years in good health than in poor health, which is often taken to imply that quality of life is relatively good (see Stiefel, Perla, & Zell, 2010). However, this understanding is almost exclusively based on measures of physical health (e.g., self-rated health, and functional limitations). Therefore, it is relatively unknown whether additional years of life that have been gained over the last several decades are spent with some level of cognitive impairment (e.g., cognitive life expectancy)[1].

Cognitive Life Expectancy

Cognitive status is generally measured using instruments like the Mini-Mental State Examination (MMSE), and cognitive life expectancy is computed by dividing total life expectancy into the number of years an individual lives with and without impairment. Recent reports of cognitive life expectancy show that at age 65 average life expectancy with good cognitive functioning, cognitive impairment without dementia, and cognitive impairment with dementia is approximately 13, 4, and 2 years, respectively—with some small gender differences that favor women (Crimmins, Saito, & Kim, 2016). Additionally, emerging evidence shows that cognitive life expectancy differs by race/ethnicity, such that whites generally live more years with good cognitive functioning and fewer years with cognitive impairment compared to blacks and Hispanics in both relative and absolute terms (Garcia et al., 2017). However, cognitively healthy years do outnumber cognitively unhealthy years across gender and racial/ethnic divides, at least until the latest years of life. Thus, while social inequalities do exist, quality of life appears to be relatively high across the older population.

Happy Life Expectancy

Although cognitive and physical health are important components of life quality, it is increasingly recognized that they not the only, or even most important, components. Research over the last decade has focused increasingly on happiness (and life satisfaction) as one of the key markers of life quality (George, 2010). In short, if we want to know how good someone's quality of life is, why not simply as him/her whether s/he is happy? An individual's perceived level of happiness or life satisfaction is arguably a better measure of his or her quality of life than a researcher's imposed view of quality based on health measures (Layard, 2010).

In contrast to physical and cognitive health, happiness generally increases across the life course, at least until one's mid-to-late-sixties when it begins to slowly decline (Bardo, Lynch, Land, 2017)[2]. This pattern suggests that good physical health and cognitive functioning may not be necessary components for happiness. In fact, research on happiness has found that gains in happy life expectancy (i.e., the number of years an average person can expect to live with high levels of perceived happiness) have outpaced gains in disability-free life expectancy (Yang, 2008). However, thus far, these two areas of research have been separate, and samples vary substantially across literatures. Thus, we do not have definitive answers to basic questions, such as: Can people have a high quality of life despite having some cognitive impairment? And, how many years can a person expect to live happy but with cognitive impairment? We address these questions in this paper.

Data and Methods

Data for this study are from the Health and Retirement Study (HRS), a panel study of persons over age 50 (and their spouses) that began in 1990. In the mid-1990s, the HRS merged with the AHEAD study, a study of persons over age 70. Measurement inconsistencies between the two studies and within the studies over time make it difficult to use health data prior to 1998. Thus, we use study data from 1998 forward (to 2012). Data have been collected every two years, and new cohorts are periodically added to the HRS; nonetheless, we restrict our analyses to persons who were age 50 in 1998 and present in the 1998 wave. We further limit the sample to one person per household.

Measures

Estimates of cognitive and happy life expectancy require information on cognitive function, happiness, age, and mortality. Cognitive function is assessed in the HRS with the use of an adapted version of the MMSE, which includes six tasks that respectively measure memory, working memory, speed of mental processing, knowledge and language, and orientation. Scores from each of these measures were combined to form a scale that ranges from 0 to 35. There is no definitive threshold to distinguish between people with and without cognitive impairment. Given that we examine cognitive and happy life expectancy using panel data that spans a relatively long period of time (i.e., 1998-2012), and that cognitive impairment is not necessarily an absorbing state (i.e., cognitive functioning can improve and worsen over time), we use a liberal threshold—the 25th percentile MMSE score—that has also been used in previous studies that utilized this scale (Blaum, Ofstedal, & Liang, 2002).

The happiness measure was taken from the HRS's set of depressive symptom measures; the question asks whether a respondent was happy (1) all/most of the time or (0) some/none of the time in the past week. This measure is similar to other measures in social survey data designed to capture overall evaluations of happiness (e.g., the happiness measure in the General Social Survey), except the temporal bounds are generally more limited in the HRS measure (e.g., "the past week" versus "these days"). Nonetheless, this measure arguably captures an appraisal of one's overall happiness that is distinct from experienced well-being (e.g., positive and negative emotions) that is relatively more sensitive to personality traits and momentary circumstances (Freedman, Carr, Cornman, & Lucas, 2017).

Age is measured in years (see Lynch and Brown, 2005). Additionally, socioeconomic and demographic characteristics that are known to be associated with cognitive functioning, happiness, and mortality are also included in the analyses (i.e., sex, race, region of residence, education, and marital status).

Analytic Approach

Multistate life table methods are an important tool for producing easily understood measures that simultaneously reflect both quality and quantity of life. Most contemporary uses of these methods involve sample data, thus requiring techniques for capturing uncertainty in estimates. Over the last two decades, several methods have been developed that do so. However, both the development and application of multistate methods have been limited to estimating years to be spent in only two states, such as years to be lived “healthy” vs. “unhealthy.” However, we are interested in a more complex state space that includes both cognitive function and happiness. Therefore, we utilize a recently extended version of a Bayesian approach that previously allowed for only two living states (i.e., Lynch and Brown, 2005).

First, the data are structured in person-spells, with each spell reflecting the transition an individual experienced between time t and t+2. Given eight waves in the HRS, each person may contribute up to seven spells to the data set. Persons who die prior to 2012 contribute fewer spells. Next, using these data, we compute interval estimates for happy and cognitive life expectancy using multistate life table methods. This involves (1) using Markov chain Monte Carlo (MCMC) methods to sample parameters from the posterior distribution defined by a multinomial logit model predicting transitions between un/happy and cognitively un/impaired states as a function of covariates, (2) generating sets of age-specific transition probability matrices for each of the parameter samples obtained via MCMC combined with a desired covariate profile, and (3) computing multistate life tables for each set of age-specific transition probability matrices. The output is a collection of multistate life tables, the results of which can be summarized, including via interval estimates.

The state space we are interested in is shown in Figure 1. As the figure shows, there are four living states, including (1) happy and cognitively unimpaired, (2) happy and cognitively impaired, (3) unhappy and cognitively unimpaired, and (4) unhappy and cognitively impaired. Individuals may transition between any of these living states across time, they may remain in a state, or they may transition from any state to death, as represented by the arrows and transition probabilities shown in the figure. Thus, at each age, the state space can be represented by a 5-by-

5 matrix of transition probabilities, where each row in the matrix represents the state a respondent is in at time t, and each column represents the state a respondent is in at time t+2 (the time between HRS interview waves is two years). Because death is an absorbing state, there are a total of 20 possible transitions.

We model transitions between waves using a multinomial logit model with nineteen outcomes to capture transitions, with remaining in the happy and unimpaired state as the reference state, and with age and other covariates as predictors of transitions. Unlike the usual Maximum Likelihood approach to estimation of this model, which yields a single point estimate for the effects of covariates on the logit of transitions and their standard errors, Markov chain Monte Carlo methods sample from the posterior distribution of the parameters for the model. Details of MCMC methods in general can be found elsewhere (e.g., Lynch, 2007). In brief, MCMC methods yield collections of parameter values much like bootstrapping. With uniform prior distributions for all parameters in the model, the mode of the collection of parameters samples obtained via MCMC is equal to the ML estimate, and the standard deviations of these estimates is equivalent to the ML-estimated standard errors (although differing in interpretation).

Let β^g be the matrix of parameters for the g^{th} sample obtained via MCMC ($g=1\ldots G$), and let X represent a covariate vector in which all covariates but age are fixed to some desired value. Let X_a be this covariate vector in which age is set to a ($a=0\ldots\Omega$). We can obtain the age-specific transition probability matrix P_a^g as $P_a^g = f(X_a\beta^g)$, for all a, where $f()$ is the usual inverse transform to obtain probabilities from multinomial logit coefficients. This yields G sets of Ω age-specific 5-by-5 transition probability matrices.

Each of the G sets of age-specific transition probability matrices can then be used to produce a life table for the fixed covariate profile using standard multistate life table methods.

Specifically, let l_x be a 1-by-5 vector indicating the number of survivors in each state at age x. l_{x+2} can then be calculated as $l_x P_a$, where, again P_a is a transition probability matrix representing transitions between age a and $a+2$. Given a complete set of l_x across the age range, person-years lived in each state are calculated using the linear method: $L_x=.5(l_x+l_{x+2})$. These can be summed from each age forward to obtain T_x, and a vector of state expectancies at each age (e_x) can be computed by dividing each component of T_x by l_x. The end result is a collection of four state expectancies indicating how long individuals can be expected to live happy and cognitively unimpaired, happy and cognitively impaired, unhappy and cognitively unimpaired, and unhappy and cognitively impaired. These state expectancies can be summed to produce total life expectancy, overall life expectancy to be spent happy vs. unhappy, and overall life expectancy to be spent cognitively intact vs. impaired.

Repeating these multistate calculations for each of the G sets of transition probability matrices yields distributions of state expectancies that can be sorted to produce empirical interval estimates, by taking the 2.5th and 97.5th percentile values. This entire process can be repeated for different covariate profiles so that specific social and demographic groups may be statistically compared in terms of their relative expectancies. For example, whites and nonwhites can be compared, with sex, education, etc. controlled, by generating G sets of transition probabilities with sex and education set to identical values for whites and nonwhites, while “toggling” race to indicate white in one set of computations and nonwhite in another. Then, given two collections of life tables (one for each race), the probability, say, that white cognitively unimpaired life expectancy exceeds that for nonwhites can be computed by conducting repeated sampling from the distributions of cognitively unimpaired life expectancy for both racial groups and computing the proportion of times the random draw for whites is larger than that for nonwhites.

Sensitivity Analyses

Given that there is no definitive threshold for cognitive impairment, there are many different possible ways that the cognitive functioning scale could be partitioned. Thus, we will test various thresholds, similar to the work that has been done with functional limitation scales in estimates of active life expectancy (e.g., Lynch & Brown, 2003). One common partition that we will utilize is the Herzog and Wallace (1997) approach, which suggests that scores of 11 or above are considered to be within the range of normal cognitive functioning, scores between 8 and 10 reflect mild cognitive impairment, and those with scores less than 8 are considered to have moderate/severe cognitive impairment. We will also consider adjusting for test-retest bias, and cohort differences in educational attainment (see Lagana et al., 2008).

Another issue with using this measure of cognitive functioning is that respondents with cognitive impairment often do not complete all of the tasks (e.g., Serial 7s), and often in cases of severe cognitive impairment proxies will complete the survey for respondents. Various imputation techniques will be used to deal with incomplete tests (see Suthers et al, 2003). However, information for both the MMSE score and the happiness measure is missing when proxies complete the survey. In this case, there are some memory and dementia-related questions asked of proxies that can be used to determine respondents' cognitive status (Crimmins et al., 2016). Additionally, given that we hypothesize happy life expectancy to be longer than cognitive life expectancy, respondents with cognitive impairments who used a proxy can be assigned as "unhappy" to produce conservative estimates.

Results

Currently the extended Bayesian multistate life table methods are being finalized. Therefore, our results are forthcoming. We will have results within the next couple of weeks and a complete paper will follow shortly thereafter. However, below we report some descriptive statistics to show how people move in and out of cognitive impairment and happiness states.

Table 1 shows the observed transitions for moving in and out of un/happy and cognitively un/impaired states with cognitive impairment set at the 25th percentile threshold (e.g., MMSE scores equal to or less than 18). Three features of this table are worth noting. First, all cells are populated. Thus, there is indeed communication between un/happy and cognitively un/impaired states. Second, a substantial number of deaths occur over the study period. These two features are particularly important for multistate life table modeling, especially with the use of a complex state space. Third, the most common state is to remain happy and cognitively unimpaired, which makes this an ideal reference group for the multinomial logit models.

Table 2 shows the observed transitions for moving in and out of un/happy and cognitively un/impaired states with cognitive impairment set at the Herzog and Wallace mild/moderate threshold (i.e., MMSE scores equal to or less than 10). Here, similar features as shown in Table 1 can be seen, with one major difference being that relatively fewer people are recognized as having a cognitive impairment. Nonetheless, all cells are populated. Thus, the extended multistate life table methods should be effective for examining various cognitive impairment thresholds.

Notes

1. A search for “healthy life expectancy” yields approximately 13,700 results on Google Scholar, whereas “cognitive life expectancy” yields only 6 results (date of search: 09/20/2017).

2. It is generally understood that happiness does not follow a biologically set age pattern, rather age patterns in happiness are largely dependent on cultural contexts. For example, American’s happiness increases at a decreasing rate across age until about one’s mid-to-late sixties when it begins to slowly decline. Whereas European’s happiness tends to be U-shaped with a minimum between the mid-thirties and forties (see Bardo, 2017).

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Table 1. Observed transitions: cognitive impairment 25th percentile threshold (MMSE $\leq$ 18)

	HU	UU	HI	UI	D
HU	20,149	1,566	2482	326	1695
UU	1458	874	218	187	339
HI	1279	137	3147	385	1236
UI	133	91	382	252	295
D	0	0	0	0	ALL

Note: HU = happy-unimpaired, UU = unhappy-unimpaired, HI = happy-impaired,
UI = unhappy-impaired, D = dead

Table 2. Observed transitions: cognitive impairment Herzog Wallace (MMSE $\leq$ 10)

	HU	UU	HI	UI	D
HU	25,829	2,257	690	95	2575
UU	2045	1316	75	45	579
HI	190	26	348	36	356
UI	30	15	41	28	55
D	0	0	0	0	ALL

Note: HU = happy-unimpaired, UU = unhappy-unimpaired, HI = happy-impaired,
UI = unhappy-impaired, D = dead

Figure 1. State space used in multistate life table modeling.