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Stagnating Life Expectancies and Future Prospects in an Age of Uncertainty*

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Abstract

Objective—This article provides a timely assessment of U.S. life expectancy given recent stalls in the growth of length of life, the continuing drop in international rankings of life expectancy for the U.S., and during a period of growing social and economic insecurity.

Methods—Time series analysis is used on over 70 years of data from the Human Mortality Database to forecast future life expectancy to the year 2055.

Results—The results show limited improvements in U.S. life expectancy at birth, less than 3 years on average, for both men and women.

Conclusions—Even in uncertain times, it is important to look forward in preparing for the needs of future populations. The results presented here underscore the relevance of policy and health initiatives aimed at improving the nation's health and reveal important insight into possible limits to mortality improvement over the next five decades.

Keywords

mortality; life expectancy; health; inequality

Persons in the United States (henceforth U.S.) and other developed nations live longer and better lives than in any time throughout history. But during periods of impressive expansion in length of life, a similar expansion has occurred between more and less advantaged groups. In the U.S., the most affluent live nearly 5 years on average longer than the most deprived. And life expectancy in the U.S. continues to fall down the ladder of international rankings of length of life (United States Central Intelligence Agency 2010), despite disproportionate spending on health care (Murray and Frenk 2010). For example, the U.S. ranks 10th in per

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capita GDP worldwide but trails Jordan, a country ranked 111th in per capita GDP, in life expectancy (United States Central Intelligence Agency 2010). Programs have been developed and even successfully implemented to address resource inequalities. With worsening recent economic conditions however, the U.S. and other countries around the world face uncertain futures.

Formally, life expectancy indicates the average number of years a person can expect to live and can be measured at birth and at various points throughout the life course. But life expectancy also represents a general measure of the quality of life experienced by groups of people. Though the U.S. is one of the richest countries in the world, it has witnessed a growing gap between the wealthiest and poorest inhabitants (Pappas et al. 1993; Lantz et al. 1998). Research from Marmot (2004) highlights the troubling nature of such a gap in terms of health and length of life. A very small proportion of the population at the top displays not only better outcomes than those at the very bottom but also those in the middle. The result is a growing number of Americans represented in groups showing rising rates of obesity, a lack of health insurance, and such unhealthy behaviors as smoking cigarettes (Committee on the Consequences of Uninsurance 2002; Flegal et al. 2005; Olshansky et al. 2005; Rogers, Hummer, and Nam 2000; Pampel 2005).

The work of Wilkinson (1996) has provided a stark reality that reminds us that how countries distribute their resources is a stronger predictor of longevity than sheer wealth. While persons in the U.S. are living longer than ever before, these now lasting negative trends and falling international rankings in life expectancy suggest the real and observable consequences of inequality. For the first time in nearly 20 years, average life expectancies dropped in the U.S. (Miniño et al. 2010). Though the drop is small in stature and only time will reveal the seriousness of such a drop, it calls attention to the potential for stagnating and even declining life expectancies in future length of life in an age of economic and social uncertainty.

Historical Trends in Length of Life

In 1900, U.S. life expectancy at birth for the total population was just 47.3 years; by the year 2006, it had jumped to 77.7 years (Arias 2010). In the first half of the twentieth century these increases were uneven and were punctuated by periodic dramatic reductions in life expectancy owing to infectious diseases; for example, between 1917 and 1918, life expectancy at birth plummeted 11.8 years because of the influenza epidemic. The second half of the twentieth century witnessed gains that were slower and less variable.

The future pace of mortality decline is, of course, indeterminate. Nevertheless, researchers of aging contend the decline may slow simply as a result of biological limits. Other researchers believe technological advancements can overcome biological limits and still others contend that changes in health lifestyles could increase length of life with or without medical breakthroughs.

Optimistic researchers expect substantial gains in life expectancy, comparable to some of the histrionic gains of the past (Vaupel 2010). In fact, the dramatic pace in which life expectancies in developed nations have improved in the last 200 years (Oeppen and Vaupel

2002; Kirkwood 2008) suggests living to 100 may soon become the norm (Christensen et al. 2009).

The Epidemiologic Transition Theory argues that previous reductions in mortality have been realized through far-reaching medical breakthroughs, public health advances, and increases in quality of life, including warmer clothes, better housing, and higher overall incomes (Omran 1971; Tuljapurkar, Li, and Boe 2000). Public health advances in the nineteenth and twentieth centuries include chlorination, pasteurization, and refrigeration (Omran 1971). Major public health interventions in the 20th century – including recognizing the health risks of tobacco use; vaccinations; improved motor vehicle safety; infectious disease control; efforts to provide cleaner air, water, and land; and safer foods – have further lowered mortality (Centers for Disease Control 1999). Koch's 1882 isolation of the tubercule bacillus led to practical application of the germ theory of disease, and Fleming's 1928 discovery of penicillin led in the 1940s to the use of antibiotics (Wilmoth 1998).

Recent medical breakthroughs include improved treatment for heart disease and cancer, kidney dialysis, and organ transplants (Fogel and Costa 1997; Rogers, Hummer, and Krueger 2005). New medical technologies could further increase life expectancy and include cancer vaccines, prevention of diabetes and Alzheimer's disease, treatment of acute stroke, telomerase inhibitors, and anti-aging compounds (see Goldman et al. 2005). Gene therapy, heralded as the next major medical breakthrough, may be some years off, may affect a small proportion of the population, and may more directly affect morbidity and disability than mortality. Many of the potential life extending medical technologies can be costly (Goldman et al. 2005), which may restrict if not prohibit their application, and they may only be available to more advantaged groups who are aware of such advancements (Glieb and Lleras-Muney 2008). However, advancements in the distribution of preventative medicine hold large payoffs in future length of life (Goldman et al. 2005).

There are reasons to be guarded about future gains in life expectancy. Persistent risky behaviors, external causes of death, increasing financial costs, and the law of diminishing returns (Rogers and Hackenberg 1987; Wong-Fillipp and Haberman 2004) can temper life expectancy gains. We have witnessed previous periods of stagnation if not deterioration in life expectancy. In some ways, past progress hinders future gains (Vaupel 1986). It is much easier to reduce infectious diseases than such complex chronic and degenerative diseases as heart disease, cancer, Alzheimer's disease, and AIDS (Tuljapurkar et al. 2000). The Taeuber Paradox (Keyfitz 1977) reveals that especially at older ages diseases are interrelated, so that the elimination of one disease may not substantially reduce overall mortality (Tuljapurkar and Boe 1998). Although cancer contributes to about one-quarter of all deaths in the U.S., the large majority of these deaths occur at older ages, so its elimination might add just a little over three years to life expectancy at birth (Anderson 1999). Similarly, because survival at younger ages is already so high and cannot improve much further, future gains in life expectancy must be realized among older ages where fewer person-years are added (Bongaarts 2005). Vaupel (1986) estimates improvements in age-specific mortality at ages proximal to a population's life expectancy at birth generally translate into the greatest gains in overall life expectancy.

Some suggest that increased risky behaviors coupled with declining mortality due to other factors has ushered us into a new stage of the epidemiologic transition, where behavioral factors are leading causes of death (McGinnis and Foege 1993; Mokdad et al. 2004; Olshansky et al. 2005; Rogers and Hackenberg 1987). Individuals continue to overeat and to remain inactive even in the midst of an obesity epidemic; they continue to smoke, drink excessively, and use drugs despite cautions and even prohibitions; and they continue to engage in violence, unprotected sexual intercourse, and reckless driving even with knowledge of their potential life-shortening effects. The continued risk brought by these negative health behaviors are unfortunately clustered among more disadvantaged (Pampel, Krueger, and Denney 2010) and growing segments of the population.

Forecasting Life Expectancies

Both sexes are impacted by conditions that affect future gains or losses in length of life. However, the persistent and important differences in life expectancy for men and women call for sex-specific forecasts. The sex gap in life expectancy at birth, which was relatively low but variable in the early 1900s, widened to its highest levels in 1975 and again in 1979, at 7.8 years. Since 1979, the sex gap in life expectancy has gradually closed to 5.0 years by 2004, the narrowest level in almost 60 years, and was slightly higher, at 5.1 years, in 2006 (Arias 2010). Both males and females have enjoyed substantial long-term increases in survival. The gains for men and women differ by period. For example, females experienced substantial gains in survival between 1930 and 1950, with smaller gains between 1950 and 1970. Males, while they have lower survival than females in every period, experienced small gains between 1950 and 1970, with some of their greatest survival gains between 1970 and 1990. Thus, large survival gains for males, especially over the last three decades, contribute to converging male and female length of life (Preston 2005).

Researchers and policy makers must fully understand past and present mortality trends to accurately determine future ones. Techniques for forecasting mortality vary in accuracy and complexity: expert opinions and forecasts of age-, sex-, and sometimes cause-specific mortality rates can vary widely. More complex methods do not necessarily result in more accurate forecasts. At the same time, simple methods may be illustrative but misleading.

The Social Security Administration (SSA) regularly publishes low, intermediate, and high projected period life expectancies at birth. The 2008 report states that by 2055 life expectancy at birth will rise to 77.7 years for males and 81.5 years for females, based on low cost estimates. The intermediate and high cost estimates are slightly higher: 80.4 for males and 83.8 for females based on intermediate estimates and 83.2 for males and 86.3 for females based on the high cost estimates (Board of Trustees 2008). Social Security and other official forecasts rely heavily on subjective expert opinion, often reflect the optimistic or pessimistic climate of the times, and over the past century have generally underestimated actual life expectancy (Lee and Miller 2001).

In their seminal paper, Oeppen and Vaupel (2002) hold that although more sophisticated techniques are available, linear projections of, or “best practices”, life expectancies are reasonable and relatively accurate. Employing international data from the years 1840

through 2000, they use the highest female and male life expectancy at birth that is reported for any country in that year. Based on these record-holding countries, they present a linear relationship between the 160-year period and female life expectancy at birth. They argue that more developed countries can expect unprecedented increases in life expectancy, and that in about 60 years, life expectancies at birth could reach 100 years. Further, they assert that the linear life expectancy trend “may be the most remarkable regularity of mass endeavor ever observed” (2002: 1029).

A linear pattern in life expectancy should hold for different time periods and countries, including the U.S. But a forward linear trend based on the first half of the twentieth century for the U.S. would vastly overestimate present life expectancies. And a backward linear projection would quickly lead to severe life expectancy underestimates. Oeppen and Vaupel (2002) find a larger slope for females than for males, state that the sex gap in life expectancy has increased over time, and thus claim that the sex gap in life expectancy will constantly continue to widen over time which is contrary to the closing sex gap observed over the last several decades (Arias 2010). Thus, although Oeppen and Vaupel’s (2002) linear method is direct and instructive, it may not work for all periods and countries and does not represent current trends in the sex gap.

Olshansky et al. (2005) argue against extrapolative methods for forecasting life expectancy, stating that the past may not reflect future gains or losses. They also suggest, contrary to many demographers’ advice, that the Social Security Administration (SSA) should *not* increase their forecasts, even though it has had a tendency to underestimate in the past. However, extrapolating past trends has produced reasonable forecasts and historical extrapolation is less prone than other methods to subjective biases and common assumptions, such as the existence of a biological maximum lifespan (Preston 2005).

British actuary Benjamin Gompertz (1925) first proposed a mathematical law of mortality by modeling mortality rates for humans aged approximately 20 to 60 with a simple exponential equation. This function accurately describes age-specific mortality for humans and other species at select ages. When Gompertz developed the equation, mortality above age 80 (or age 60 or 70 for that matter) was of little concern (Olshansky and Carnes 1997). However, at older ages, mortality does not continue to increase in an exponential fashion but instead shows a deceleration in the age-specific rate of increase in the death rate and increases linearly through at least age 105 and possibly 110 (Wilmoth 1995). Heligman and Pollard (1980) and others have expanded Gompertz’s equation to fit mortality at all ages and to allow for deceleration of mortality at the older ages.

Researchers and policy makers may be interested in age-specific mortality rates, as well as aggregated measures such as life expectancy. Recently, investigators have converted age- and sex-specific mortality rates into model schedule parameters and have then used time series analysis to project the parameter estimates (for reviews, see Tuljapurkar and Boe 1998, and Wong-Fillips and Haberman 2004).

Lee and Carter (1992) developed a method for forecasting mortality based on the equation

$$\text{Ln}(m_{x,t}) = a_x + b_x * k_t + \varepsilon_{x,t} \quad (1)$$

where $m_{x,t}$ is the central death rate for age x at time t , a_x and b_x are parameters dependent only on age that represent age effects and age patterns of mortality change, respectively, k_t is a temporal factor representing level of mortality, and $\varepsilon_{x,t}$ is the error term. Lee and Carter's method is renowned for its simplicity; there is only one temporal parameter to model, and its error term is relatively easy to calculate (Lee 2000).

Lee and Miller (2001) evaluate the Lee-Carter method and find that when compared to observed data, both Lee and Carter's (1992) projections and hypothetical historical projections are reasonable. More recently, Girosi and King (2008) find that the Lee-Carter method is highly inaccurate for specific age and sex groups, leaving a quite limited utility for the technique.

Bongaarts (2005) uses a shifting logistic model to project adult mortality. He first fits mortality data to a three-parameter logistic model. Next, he fixes the slope parameter to its average value, refits the mortality data to the three-parameter logistic model, and then extrapolates the remaining two parameters. Although extrapolation is straightforward, the trends over time in at least one of the parameters is not steady, and therefore may be better captured by other nonlinear techniques (Bongaarts 2005). Bongaarts presents results for ages 25–100 and acknowledges that the model will not work for younger ages because there are too few parameters to model mortality among infants, children, and young adults during the accident peak. Although the focus on ages 25–100 is important, it does not provide a complete picture of mortality trends.

McNown and Rogers (1989) use a parameterized time series approach to forecast mortality. The McNown-Rogers method begins with the eight-parameter Heligman-Pollard (1980) mortality model:

$$q_x = A^{(x+B)^c} + D e^{(-E(\ln x - \ln F)^2)} + \frac{GH^x}{(1+GH^x)} \quad (2)$$

It then employs univariate time-series techniques to forecast the eight parameters into the future.

The Heligman-Pollard model of mortality can be decomposed into three broad age groups. Parameters A, B, and C focus on childhood mortality, D, E, and F young adult mortality, and G and H older age mortality. Despite its complexity and estimation of eight separate parameters, the model has been shown to produce consistent and accurate estimates. To address complexity in the model, some have suggested reducing the number of parameters, thereby eliminating the volatility due to infant and early childhood mortality and the so-called "accident peak" during young adult years (McNown 1992). Indeed, considering mortality only for adults over the age of 20 or 30 can reduce the Heligman-Pollard function from eight to five or even two parameters (parameters A–C and possibly D–F can be dropped). However, once again, these models are then inherently incomplete as they cannot

estimate mortality across the lifespan. Rather, we propose examining the patterns of the eight-parameter model over time for all ages. Doing so may provide insight into the fluctuations and stability of the parameters, allowing some parameters to be held at a constant value in the equation.

METHODS

Data

Comparatively little attention has been paid to the data used in various examinations and forecasts of U.S. mortality. This is, in part, because of a historical lack of consistency in the computation and sources of death rates, life expectancies, and other measures of mortality in the U.S. (see Smith and Bradshaw 2006). Indeed, it is vitally important to know the computational and organizational history of data used to investigate mortality trends, and come as close as possible to a central consistent source of mortality data for the U.S. The Human Mortality Database (HMD), a joint venture between the University of California–Berkeley and the Max Planck Institute (HMD [<http://www.mortality.org>] 2008), has gone a long way toward addressing these concerns.

We use death data compiled by HMD for the years 1933 to 2004. The year 1933 marked the completion of an initiative to admit states into a death registration system for the entire U.S. This was the beginning of an all-inclusive effort to compile deaths by year and, thus, data on U.S. deaths are considered to be complete and of acceptable quality since this time. Even so, available data on U.S. deaths since 1933 have not been consistently compiled and deserve consideration. From 1933 to 1958, for some age ranges, total numbers of deaths were assembled by 5-year age groups rather than by single years of age. For example, deaths for these years are available for individuals 80 to 84 years of age rather than age 80, age 81, and so on. To allow examinations of death by single year of age across these years, HMD interpolates deaths for the five-year age groups using a cubic spline procedure (for a complete description, see the *Methods Protocol* for the HMD 2008).

Furthermore, data on deaths for the years 1933 to 1952 include an open age range of age 100 and older. To provide some consistency with later years of death data, HMD uses the Kannisto model of old age to extrapolate deaths by single year to ages 110 and older for the years 1933 to 1952 (see the *Methods Protocol* for HMD 2008). Because our ultimate intention is to forecast death rates 50 years into the future, it would be inappropriate to use data for ages greater than 99, since age at death past age 99 is itself extrapolated. Therefore, we use ages 0 to 99 for the years 1933 to 2004 to fit the model schedule and predict mortality estimates and use that information to forecast mortality schedules 50 years into the future.

Model Fitting

We fit q_x values to the eight-parameter Heligman-Pollard model with the TableCurve 2D program (2002), which accommodates user-defined functions. We started with the first year, 1933, identified the best fit for the eight parameters, and then sequentially fit each

subsequent year. The advantage of using *TableCurve 2D* is that it provides an objective way to determine the best fit.

We identified three parameters, B, E, and F that could be held at a constant value in the equation. Parameter B addresses early life mortality, especially for the first year of life (Heligman and Pollard 1980), and fluctuated very little over the 70 years of observed data. Parameters E and F address young adult mortality. Specifically, parameter E measures the spread of the accident hump while parameter F approximates the modal age of the accident hump (Heligman and Pollard 1980). Parameter E fluctuated erratically at times over the 70-year period, introducing some unnecessary noise into the overall model. Similar to parameter B, parameter F showed very little variation over the time span. Consequently, we experimented with holding these three parameters at their mean values and re-estimated the models accordingly. The R^2 was over .987 for each year before and after holding the parameters at their constant values.

Parameter Forecasts

Adapting the strategy of McNown and Rogers (1989), we use time series methods to model the temporal patterns of the model schedule parameters to project these parameters, and hence the age patterns of adult mortality, into the future. The univariate models employed by McNown and Rogers (1989) are of limited value for forecasting because of their short memories and their inability to capture interactions among the parameters. The dynamic interdependence among the parameters can be incorporated into a multivariate time series model such as a vector autoregression (VAR). In the VAR models, each parameter is expressed as a function of its own lags and of lags on the other four time-varying parameters. VAR exploits information on the feedback among the five series to create forecasts of potentially greater accuracy than those produced by the univariate models. For both female and male VAR models, all parameters are modeled in logarithmic form to preclude the projection of implausible negative parameter values and to create models with homoscedastic errors. For both VARs, a single lag is found to be sufficient to produce models with nonautocorrelated errors.

The accuracy of the parameter forecasts is checked with predictions into a ten-year holdout sample, and with longer run retrospective forecasts. For the former, the model is estimated with data through 1994 to produce forecasts for the period 1995–2004. These forecasts of the female parameters produce mean absolute percent errors that are less than 7.5 percent. Irregularities in the patterns of the male parameters over this holdout sample period make these forecasts less accurate, with parameters C, D, and G showing mean absolute errors in excess of ten percent.

The retrospective forecasts provide information on the long run forecasting potential of the models. VAR models are estimated over the entire sample, but a fifty-year dynamic forecast, without updating, is generated for the period 1955–2004. Only forecasted values of the lagged variables in the VAR are used in these dynamic forecasts, to mimic the case for producing true out-of-sample forecasts beyond 2004. For both male and female parameters, these retrospective forecasts track the long run trends in the observed data, although VAR

forecasts cannot capture the shorter run fluctuations in the parameter histories. Mean absolute percent errors are all less than twelve percent.

These forecast evaluations indicate that the long run trends in the parameters are adequately captured by the models, providing the basis for projecting these parameter values up to fifty years into the future. Forecasting farther into the future requires greater assumptions about patterns of mortality and may be unwarranted (Olshansky et al. 2009). Of course, any such forecasting exercise must be grounded in the assumption that the historical patterns and interrelations in the data will be reflected into the future.

RESULTS

The projections of parameters from 2005 through 2055 are attached to the historical data for 1933–2004, and displayed in Figure 1. For males and females, parameter A declines rapidly during the observed and projected years, indicating a steady reduction of mortality in the first year of life. A similar reduction is observed in parameter C, measuring early childhood mortality. Parameter D, measuring the intensity of the “accident hump”, shows a marked decline in the first 20 years for females and then levels off. For males, parameter D begins to decline and then peaks during the mid to late 1940s, likely a result of increased young adult male mortality during World War II. After this peak, there is some continued fluctuation and eventual reduction, though the value stays higher for males, reflecting their increased young adult mortality.

The older age mortality parameters, G and H, suggest a continuing convergence of male and female mortality at the oldest ages. In particular, parameter G, indicating the slope of the mortality curve at the oldest ages, begins to converge around 1990 and continues to do so at a steady rate through the remaining historical years and into the projections. Parameter H acts in conjunction with parameter G, that is, as parameter G decreases, H increases. Further, parameter H denotes the deceleration of mortality at the older ages and shows male and female variations and even dispersal from the 1960s to the 1980s only to converge starting in the 1990s and leveling off through the forecasted years.

For parsimony, we present tabular results for 1940 and subsequent 20-year periods through 2055. Table 1 provides observed and projected probabilities of death by age and sex. The probability of death at age 0 declines steadily for both sexes, especially from 1940 to 1960. Males experienced a slightly larger reduction of the probability of death at age 0 during the observed period, moving from .057 to .008. Males and females benefit from a decreasing probability of death at age 0 throughout the observed period but the pace begins to slow. This slowing pace is reflected in the projections to the year 2055; it is estimated that the probability of death for males at age 0 will be .0032 compared to .0019 for females.

U.S. males and females experienced substantial reductions in mortality at ages 40 to 60 from 1940 to 1980. But after 1980, these reductions in the probability of death also began to slow. That trend carries forward in the projections. Indeed, for males and females, there are modest decreases in the probability of death during these ages. For example, in 2000, the probability of death at age 60 for males and females was .013 and .008 respectively. By

2055, it is estimated that these probabilities will reduce slightly to .011 for males and .006 for females.

At the oldest ages, the observed data show steady slight improvements in mortality. Again, looking at the observed data from 1980 to 2000, these improvements become less prominent. For example, the probability of death for 80 year-old females improves from .059 to .049. A similar, yet slightly more dramatic trend exists for males, moving from .094 to .073. Projecting to the year 2055, males and females experience similar slight reductions in death at the oldest ages. Indeed, the probability of death for males in the year 2055 at age 80 reduces to .067 from .073 in the year 2000. For 80 year-old females, the movement is from .050 in 2000 to .045 in 2055.

From our forecasted probabilities of death we calculated corresponding life expectancies (see Table 2). Contrary to gains observed between the earliest and latest observed years (compare 1940 to 2000), but consistent with slow improvements observed in the latest observed years (compare 1980 to 2000), our forecasts produce modest gains in life expectancy at all ages for males and females. In addition, our forecasts suggest life expectancies of males and females will converge to a point of equilibrium. In 2000, female life expectancies at birth were just over 5 years greater than male life expectancies at birth, the smallest gap between the sexes to date. But our forecasts suggest that male and female gains in life expectancy have slowed to a similar pace, leaving males at a continued 5-year disadvantage in life expectancy at birth by the year 2055.

From 2000 to 2055, female life expectancies at age 0 increase 2.7 years, from 79.56 to 82.25. Males see a gain of 2.2 years, from 74.28 to 76.53. By stark contrast, from 1940–2000, life expectancies at birth increased over 13 years among males and 14 years among females. Our forecasts show minimal gain at every stage of life, with slightly larger improvements for females.

Especially at the oldest ages, modest improvements in mortality displayed in Table 1 correspond with small improvements in length of life in Table 2. For example, in 2055 males and females can expect to add 1.0 to 1.3 years of life at age 60 as compared to life expectancies in the year 2000. At age 80 the gain is less than a year for both sexes.

DISCUSSION

The future health and longevity of the U.S. population, much like future economic prospects, is uncertain. In the first half of the 20th century, Americans experienced phenomenal improvements in life expectancy that generally persisted but began to slow in the second half of the century. Life expectancy research revolves around arguments that take optimistic (Oeppen and Vaupel 2002) versus pessimistic – or arguably realistic (Olshansky et al. 2005) – approaches. Our projections are consistent with “best practices” life expectancy, showing continued improvements in life expectancy for both sexes through 2055. But these improvements are quite modest, placing our results closer to the middle of the optimistic and pessimistic perspectives.

Making predictions about future life expectancy is risky business (Olshansky et al. 2009). Even the best forecasting techniques rely on assumptions about how well the past can represent the future. Nevertheless, forecasts can help us prepare for scenarios which the future may hold.

On the one hand, there are compelling reasons to expect modest rather than rapid future gains in U.S. life expectancy. Life expectancy gains could continue to slow with outbreaks of infectious diseases, environmental and human-made catastrophes, continued risky behavior, and increases in poverty and income inequality (Olshansky et al. 1997, 1998; Wilkinson 1996). Most major causes of death today are chronic, progressive, degenerative, multifactorial, and relatively resistant to intervention and treatment: heart disease, stroke, cancer, Alzheimer's disease, and AIDS (Tuljapurkar et al. 2000). A growing number of Americans live without health insurance, which reduces their ability to obtain preventive care and increases their risk of shorter lives (Hadley 2003). And the U.S. is one of many developed nations suffering the consequences of an obesity epidemic and with substantial proportions of persons who continue to engage in behaviors, such as cigarette smoking, that greatly impact longevity (Olshansky et al. 2005; Rogers, Hummer, and Nam 2000).

On the other hand, centuries of evidence reflect impressive gains in length of life (Oeppen and Vaupel 2002) and have repeatedly failed to support attempts to identify biological maximums to human longevity (Kirkwood 2008). Through innovation and creativity, societies have discovered ways to eradicate agents that shorten life and harnessed methods to extend it (Vaupel 2010). One challenge facing continuous growth in length of life will be in the distribution of healthy living resources. While medical technologies can be expensive and unevenly distributed (Glied and Lleras-Muney 2008) implementing healthy living practices and strategies to all groups does not have to be.

In times of economic and social insecurity now is the time for policy makers to consider the ramifications of various scenarios. If the pendulum swings too far in either direction creative solutions will need to be put in place. Even facing modest increases in life expectancy, we must adequately prepare for issues surrounding population aging. With the recent media attention of stagnating and even declining life expectancies in the U.S. (Reinberg 2010), more analyses will be justifiably forthcoming. This paper has built on but one (McNown and Rogers 1989) of several proven and available techniques to forecast life expectancy using an appropriate and impressive amount of historical data. Additional forecasts might find these estimates to be overly conservative, especially at the oldest ages (Bongaarts 2005). However, the models hold up to rigorous robustness checks, calculate estimates over the entire life course, and provide forecasts on a very relevant period looking forward.

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Figure 1.
Observed (1933–2004) and Projected (2005–2055) Mortality Parameter Values by Sex,
United States

Table 1
Observed (1940 to 2000) and Forecasted (2020 to 2055) Sex- and Age-Specific Mortality.

Age	Selected Years				
	Observed			Projected	
	1940	1960	1980	2000	2020 2040 2055
A. Female q_x					
0	0.044970	0.022670	0.011270	0.006420	0.003535 0.002423 0.001931
20	0.001920	0.000630	0.000610	0.000460	0.000447 0.000422 0.000407
40	0.004590	0.002440	0.001660	0.001450	0.000969 0.000827 0.000751
60	0.018200	0.013560	0.009820	0.007850	0.007057 0.006213 0.005753
80	0.101440	0.081880	0.058840	0.049730	0.051475 0.047147 0.044717
98	0.335570	0.321240	0.277080	0.280830	0.252923 0.241743 0.235244
B. Male q_x					
0	0.057410	0.029690	0.014040	0.007810	0.005428 0.003929 0.003183
20	0.002450	0.001800	0.001990	0.001340	0.001267 0.001191 0.001141
40	0.005930	0.003820	0.003050	0.002580	0.002091 0.001851 0.001710
60	0.026530	0.024940	0.018820	0.012590	0.012736 0.011624 0.010946
80	0.121960	0.109990	0.093940	0.072500	0.074109 0.069905 0.067216
98	0.355780	0.338210	0.314300	0.313580	0.292721 0.285256 0.280109

Source: Human Mortality Database, 2008.

Table 2
Observed (1940 to 2000) and Forecasted (2020 to 2055) Sex- and Age-Specific Life Expectancies.

Age	Selected Years				
	Observed		Projected		
	1940	1960	1980	2000	2020 2040 2055
A. Female e_x					
0	65.58	73.31	77.44	79.56	80.47 81.61 82.25
20	50.30	55.68	58.81	60.39	61.02 62.03 62.61
40	32.60	36.70	39.61	41.08	41.60 42.55 43.11
60	16.86	19.64	22.11	23.17	23.30 24.07 24.53
80	6.06	7.09	8.49	9.08	9.18 9.56 9.80
98	1.16	1.18	1.22	1.22	1.25 1.26 1.27
B. Male e_x					
0	61.16	66.63	69.98	74.28	74.81 75.87 76.53
20	46.78	49.64	51.77	55.36	55.67 56.57 57.14
40	29.43	31.30	33.54	36.76	36.87 37.67 38.19
60	14.86	15.84	17.36	19.87	19.76 20.34 20.73
80	5.39	6.01	6.65	7.56	7.63 7.89 8.06
98	1.14	1.16	1.19	1.19	1.21 1.22 1.22

Source: Human Mortality Database, 2008.