

November 15, 2000

# **Increasing Longevity and Medicare Expenditures**

Tim Miller

Center for the Economics and Demography of Aging  
University of California at Berkeley  
2232 Piedmont Avenue  
Berkeley, CA 94720  
tmiller@demog.berkeley.edu  
<http://www.demog.berkeley.edu/~tmiller>

Research for this paper was funded by a grant from the NIA, AG11761. An earlier version of this paper was presented at the 1998 Annual Meetings of the Population Association of America. Helpful suggestions were given by Ronald Lee, James Lubitz, reviewers at this journal, and participants at the PAA and at UC Berkeley's Demography Brownbag Series. The model and data presented in this paper are available at: <http://www.demog.berkeley.edu/~tmiller>.

**ABSTRACT**

Official Medicare projections forecast the elderly population to be less healthy and more costly over the next century. This stems from their use of *age* as an indicator of health status. Increases in longevity are assumed to increase demand for health care as individuals survive to older and higher use ages. This paper suggests an alternative approach in which *time-until-death* replaces *age* as the demographic indicator of health status. Increases in longevity are assumed to postpone the higher Medicare use and costs associated with the final decade of life. The two approaches are contrasted using mortality forecasts consistent with recent projections from the US Census Bureau and the Social Security Administration. The Time-until-death Method yields significantly lower cost forecasts. However, the hypothetical cost-savings from improved health are small relative to the size of the Medicare solvency problem brought about by population aging.

## INTRODUCTION

Over the next few decades, the United States will undergo a large demographic transformation ushered in by the retirement of the baby boomers and the possibility of dramatic increases in their longevity. How will this impact the future of Medicare, the federal government's health insurance program for the elderly?

The Medicare Trustees<sup>1</sup> are given the difficult task of assessing the future finances of Medicare – both in the next few years and out to 2075. Such long-run forecasting may seem a futile exercise – since we are uncertain about the number of Medicare enrollees, their use of health care, the cost of such care, and the technologies available near the end of this century. But, these kinds of modeling exercises help us to distinguish between probable and improbable scenarios among an infinite number of imaginable futures. Modeling also forces us to examine our fundamental assumptions. In this paper, I focus on one such assumption: the relationship between increases in longevity and future health care cost.

In official Medicare forecasts, the baby boom is a major force behind exploding program costs. The retirement of baby boomers during the next few decades will lead to very large increases in the number of Medicare enrollees. In addition, enrollees are increasingly likely to live to advanced ages. Typically, older Medicare enrollees use more health care and are more expensive than younger enrollees. Therefore, increasing longevity is viewed as increasing Medicare costs.

To forecast the health costs of the Medicare population, one needs to predict both the number of enrollees and their health status as reflected in average costs. Defining, much less predicting, health status is a daunting task. One could define health status by indicators of disability or specific disease conditions. The Trustees chose a simple demographic indicator: *age*. This parsimony is an important feature of their model that is worth preserving. However, *age* is not an adequate indicator of the health status of an elderly population and it is a poor basis for predicting the future.

Consistent with the arguments of Lubitz and Prihoba (1984), Fuchs (1984), and Lee (1994), I suggest an alternative demographic indicator of health status: *time-until-death*. Average medical costs rise both with age and with time-until-death. In fact, the main reason that Medicare costs rise with age is that older individuals as a group are closer to death than younger individuals. From a cohort perspective, increases in longevity may be expected to lead to postponement of these costs of the final decade and final year of life. From a period perspective, declines in age-specific mortality may be expected to lead to declines in age-specific costs – because declining mortality reduces the proportion of high cost users (those near death).

---

<sup>1</sup> The Health Care Financing Administration (HCFA) is the federal agency that administers Medicare. The Office of the Actuary in HCFA under the direction of the Board of Trustees prepares the annual forecasts of Medicare. Throughout the paper, I refer to methods and decisions as those of the Medicare Trustees, although they are actually of HCFA and the Office of the Actuary.

This paper compares these 2 approaches to forecasting Medicare costs: one based on a fixed age schedule of costs (similar to the Trustees current methodology) and the other based on a fixed time-until-death schedule of costs. These accounting models implicitly assume quite different views about the future health status of the elderly. Alternative projections of Medicare expenditures and taxes are reported. The time-until-death model yields significantly lower cost forecasts than the Trustees current methodology, especially in the face of more rapid gains in longevity such as those in the recent Census Bureau projection. However, the hypothetical cost-savings from improved health (declining death rates) is small relative to the size of the Medicare solvency problem brought about by population aging.

## FINANCING MEDICARE

The Medicare program reimburses Medicare enrollees for health care expenditures mainly related to hospital stays (the Hospital Insurance or HI program) and physician charges (the Supplementary Medical Insurance or SMI program). In 1999, reimbursements totaled \$213 billion dollars or 12% of the Federal budget, making Medicare one of the largest federal government programs. It is also one of the fastest growing Federal programs, averaging 5% real annual growth over the last decade (U.S. Office of Management and the Budget, 2000). The Trustees forecast that by mid-century the Medicare payments received by the elderly will be almost as much as their social security retirement benefits with the Medicare program projected to be 4.8% of GDP and the social security retirement program (OASI) at 5.7% of GDP (Board of Trustees, 2000).

Since Medicare, like Social Security, is financed as a pay-as-you-go system, it is convenient to construct period measures of the annual finances. Let  $T$  represent aggregate taxes collected and  $H$  represent aggregate expenditures. We can express these aggregates in terms of average earnings and health costs.

$$T = W * y * z$$

Where  $W$  is the working-age population,  $y$  is per-capita earnings, and  $z$  is the Medicare tax rate. For ease of exposition, I assume all revenue derives from payroll taxes.<sup>2</sup>

$$H = E * h$$

$E$  is the number of enrollees and  $h$  is the average Medicare cost per enrollee.

We can solve for the Medicare tax rate by assuming that aggregate expenditures equal aggregate taxes:

$$z = [E/W] * [h/y].$$

We can use this simple formula to understand the broad outlines of the future financial difficulties of Medicare. In 1999, there was about 1 Medicare enrollee for every

---

<sup>2</sup>In 1999, 57% of Medicare revenue was derived from payroll taxes. Other sources included general federal revenue (25%), premiums from enrollees (8%), taxes on Social Security benefits (3%), and interest and other sources (7%). (Board of Trustees, 2000).

4 workers, and annual expenditures per enrollee (\$5,400) were about 18% of the average annual wage (\$30,200). Thus, in a balanced system, Medicare taxes would stand at about 4.5% of payroll, [ $0.045 = 0.25 * 0.18$ ]. In 2075, Medicare taxes would be 12.5%, nearly triple that of 1999. This is due mainly to the effect of population aging: projections show about 1 enrollee for every 2 workers in 2075 – twice its 1999 level. In addition, costs per enrollee are projected to be about 24% of the average annual wage -- 1.33 times its 1999 level. (Board of Trustees, 2000).

The rapid increase in health costs per enrollee is due to forecasted increases in both the price and use of medical technology. During the initial 25 years of the Trustees' projection, the cost per unit of medical care is assumed to be rising much faster than workers' wages. Future cost containment policies are assumed to reign in this growth. During the last 50 years of the Trustees' projection, costs per unit of care are projected to increase at the rate of productivity growth in the case of HI (Medicare reimbursement to hospitals) and GDP growth in the case of SMI (Medicare reimbursement to physicians) (Board of Trustees, 2000). So, changes in demography are assumed to be the only forces affecting Medicare costs beyond 25 years.

In addition to rising prices, the Trustees predict increasing Medicare HI usage per enrollee. As noted in the introduction, the Trustees implicitly estimate the future health status of the Medicare population based upon age. The aging of the Medicare population leads to a forecasted increase in Medicare usage – at least in terms of HI. SMI does not appear to be forecast based on age. (White, 1999). In addition, a growing proportion of Medicare users are enrolled in HMOs for which Medicare reimbursement is set in part by age.

#### **HEALTH STATUS AS MEASURED BY TIME-UNTIL-DEATH**

As a basis for projecting costs, we must estimate how Medicare expenditures vary by health status. Lubitz, Beebe, and Baker (1995) provide one set of estimates. The data are drawn from the Continuous Medicare History Sample which contains Medicare administrative data on a 5% random sample of Medicare enrollees. From this sample, they selected all persons 65 and older who died in 1989 or 1990. They excluded persons with End Stage Renal Disease, persons enrolled in HMOs, disabled persons below age 65, and persons not continuously covered by Medicare Hospital Insurance (HI) and Supplementary Medical Insurance (SMI). The sample is comprised of 129,166 persons who died in 1989 or 1990. For each person, the administrative data contain payment claims submitted to Medicare by physicians, hospitals, and other providers. The administrative records in the sample only date back to 1974. Therefore, complete lifetime cost histories are only available for those who died between the ages of 65 and 81. Those dying at older ages are missing cost data for the earlier years. However, as discussed below, Medicare costs are quite low for beneficiaries who are many years away from death and therefore this missing data is not vital for our estimation.

Medicare costs<sup>3</sup> were classified by two measures of health status: age and time-until-death. Figure 1 presents average Medicare costs by age and time-until-death. For example, we see that annual Medicare costs for 70 year-olds who were 15 years away from death (that is, who would die at age 85 ) were about \$1,600. This amount does not change much across age. We see that 80 year-olds who were 15 years away from death have similar annual costs (about \$1,800). However, costs rise in the final decade of life and especially in the last years. For 70 year-olds who were 5 years away from death, annual costs were \$3,300 and for those in the final year of life, annual costs were \$14,400. Generally, Medicare costs were very strongly associated with time-until-death and weakly associated with age. Using data on the age-distribution of decedants in 1990, I have summarized the cost data by time-until-death. These results are presented in Table 1 below.

**Table 1. Annual Medicare costs per enrollee by years before death.**

<b>Years before death</b>	<b>Costs</b>	<b>Relative Costs</b>
<b>1</b>	\$11,100	6.94
<b>2</b>	\$7,000	4.38
<b>3</b>	\$4,500	2.81
<b>4</b>	\$3,800	2.38
<b>5</b>	\$3,400	2.13
<b>6</b>	\$3,100	1.94
<b>7</b>	\$2,800	1.75
<b>8</b>	\$2,500	1.56
<b>9</b>	\$2,300	1.44
<b>10</b>	\$2,200	1.38
<b>11-17</b>	\$1,600	1.00

Source: Author's calculation based on data from Lubitz, Beebe, and Baker (1995).

The correlation between *age* and Medicare costs appears to be largely explained by *time-until-death*. Therefore, *age* is a poor measure of health status and cannot be reliably used as a basis for forecasting. The alternative forecasts I present use *time-until-death* as a measure of health status and hence increases in longevity delay both death and the high costs associated with the final decade of life and especially the final years of life.

---

<sup>3</sup>The administrative records for beneficiaries report Medicare reimbursements in current dollars for each year. Between 1974 and 1980, both inflation and increases in the real volume of Medicare services led to large increases in Medicare spending. Therefore, the retrospective cost histories would show dramatic increases in costs in the final years of life. These could be attributed to period effects such as inflation and expansion of the Medicare program. In an attempt to remove these effects, Lubitz, Beebe, and Baker (1995) converted current dollar costs in year x to 1990 dollars using the rate of growth in per beneficiary Medicare costs between year x and 1990. In other words, an individual's retrospective Medicare costs are measured relative to the average cost of beneficiaries in that year. These relative costs are then converted to 1990 dollars by multiplying by the average cost of beneficiaries in 1990. Cost in 1990 dollars = cost in year x \* (per capita cost in 1990 / per capita cost in year x).

It is also evident in Figure 1 that the costs of the final year of life seems to decline with age. For example, those dying at age 70 incurred costs of \$14,400; while those dying at age 90 incurred costs of \$8,900. Declines in the costs of the final year of life at advanced ages are due either to age-based health care rationing (older patients treated less aggressively than younger patients) or to frailty. Neither is likely to persist at their current levels in the future. For this reason, a forecasting model using both *age* and *time-until-death* would likely understate future costs.

The Time-until-death model will use a fixed time-until-death schedule of health costs for its projection. There is some evidence that this schedule has been stable over time. Lubitz and Riley (1993) provide empirical evidence that Medicare costs of decedents relative to survivors remained constant over their study period (1976-1988). Garber, MaCurdy, and McClellan (1998) using Medicare data from 1988-1995 find that relative spending on decedants did not change over that period. However, there were shifts in the composition of spending on decedants -- with declines in acute care offset by increases in hospice and home health care. These two studies are encouraging. Despite changes over the last two decades in medical technology, in the Medicare program itself, and in the characteristics of Medicare enrollees (age and disability), *time-until-death* has remained a consistent indicator of costs.

## **DELAY IN MORBIDITY**

The time-until-death model projects using a fixed time-until-death schedule of health costs. It assumes that increases in longevity will postpone the period of high health costs and, by implication, of morbidity which have characterized the final decade of life. This delay in morbidity assumption stands in contrast to the compression of morbidity hypothesis proposed by Fries (1980, 1984). Considering the possibility of continued medical advances in the face of a fixed life span, Fries proposed that "the period of infirmity may be compressed into a shorter period toward the end of life" (Fries, 1984, p. 354). A more pessimistic vision holds that medical advances might have greater success at prolonging life rather than in postponing morbidity -- leading to an expansion of morbidity (Olshansky, et al., 1991). The time-until-death model with its assumption of a delay in morbidity represents a middle path between potentially large cost increases due to an expansion of morbidity (implied by the Trustees Model) and potentially large cost savings due to a compression of morbidity.

Research on trends in active or disability-free life expectancy provides mixed evidence on the delay in morbidity assumption. Crimmins, Saito, and Ingegneri (1997) examine trends in the United States from 1970-1990. The decade of the 1970s showed an expansion of morbidity: the expected number of years disabled after age 65 increased by 1 year for both men and women. By contrast, the evidence from the 1980s lends support to the delay in morbidity hypothesis -- with very slight changes in the expected years disabled in the community (an increase of 0.2 years for males and a decrease of 0.1 years for females) and no change in the expected number of years spent institutionalized. Evidence on changes in active life expectancy in France during the 1980s shows no expansion of morbidity. On balance, the evidence tends to be more supportive of the

compression of morbidity hypothesis. Robine, Mormiche, and Sermet (1998) find a large (2.5 year) increase in life expectancy at birth from 1981 to 1991. There was no change in the expected years with a severe disability for women but men showed a 0.3 year decline (from 1.5 years to 1.2 years). The expected number of years with moderate disability declined slightly over the period (by 0.1 years for women and 0.2 years from men).

Singer and Manton (1998) suggest an alternative to these demographic measures of health status: disability rates. Manton, Corder, and Stallard (1997) have documented a rapid decline in disability rates among the elderly. Assuming that Medicare costs are strongly correlated with disability, these declines imply substantial cost savings. If the rates declines documented for the period 1982-1994 were to persist into the future, Singer and Manton predict that the disability-adjusted support ratio in 2070 would be unchanged from its 1994 level. The large cost increases generated by population aging would be entirely offset by cost-savings brought about by disability decline. By contrast, the Time-until-death model links costs with mortality rather than disability and therefore costs can be postponed but never eliminated.

Further research into multiple measures of health status which include age, time-until-death, disability status, and specific disease conditions is certainly warranted. A recent analysis by Cutler and Meara (1999) shows that disability and time-until-death have independent effects on costs and together explain most of the variation by age. Consideration of other population characteristics would lead to richer, more descriptive models which may also lead to more accurate forecasts of health costs. However, there is considerable uncertainty in forecasting both the size and health costs of numerous classification groups well into the 21<sup>st</sup> century when the disease frontier will have shifted to a host of new diseases and new definitions of disabilities. In comparison, demographic indicators like *age* and *time-until-death* are easily identifiable and reliably predicted. In the sections that follow, I will contrast two forecast models: one which uses a fixed age schedule of costs implying an expansion of morbidity and the other which uses a fixed time-until-death schedule of costs implying a delay in morbidity.

## PROJECTIONS USING COSTS BY AGE

As the Trustees forecasting model is not publicly available, I present a simple Age Model which highlights a central feature of their methodology. It is an approximation to the more complex methodology employed by the Trustees. The distinctive age patterns of Medicare taxes and benefits are shown in Figure 2. In the Age Model, aggregate taxes and benefits in any future year are estimated by multiplying the age profiles shown in Figure 2 by population forecasts.

The Age Model projects aggregate taxes for  $t$  years in the future as:

$$T(t) = z(t) * e^{vt} * \sum_{\alpha=20}^{64} y(\alpha) * K(\alpha, t)$$

Where  $z(t)$  is the Medicare tax rate,  $v$  is the rate of productivity growth in the economy,  $y(a)$  is the average wage of those aged  $a$  in 1997,  $K(a, t)$  is the population aged  $a$  in year  $1997+t$ .

Aggregate costs are projected as:

$$H(t) = e^{i^*t} * \sum_{\alpha=65}^{120} h(\alpha) * K(\alpha, t)$$

Where  $i$  is the rate of medical care inflation in the economy,  $h(a)$  is the average Medicare cost of those aged  $a$  in 1997,  $K(a, t)$  is the population aged  $a$  in year  $1997+t$ .

For  $a \geq 65$ , let  $K(a, t) = E(t) * k(a, t)$ , where  $E(t)$  is the number of enrollees (defined here as the population over age 65), and  $k(a, t)$  is the proportional age distribution of enrollees in year  $1997+t$ . Then, we can express aggregate benefit payments as:

$$H(t) = e^{it} * E(t) * \sum_{\alpha=65}^{120} h(\alpha) * k(\alpha, t)$$

Here, we see that total Medicare expenditures are decomposed into 3 multiplicative factors: a general price level factor, the number of enrollees, and the average cost per enrollee. This average cost is the sum of the product of the age-profiles of health care usage and the age distribution of the enrollees. The impact of the baby boomers on average costs is evident in Figure 3. The top panel shows the average age of Medicare enrollees. The bottom panel shows the average costs per enrollee based on the Age Model outlined above, with the rate of medical care inflation in the economy equal to zero. When the baby boomers begin to retire, they enter the Medicare system as relatively inexpensive enrollees and drive average costs downward. As they age, they become more expensive (traveling along the  $h(a)$  curve of Figure 2) and cause average costs per enrollee to rise.

Note that for ease of exposition, I have not modeled changes in productivity nor in the price of medical care. I have assumed that  $v$  and  $i$  in the Age Model are both zero over the entire projection period. Hence, in these simulations, increases in average costs of enrollees will stem only from demographic causes throughout the 75-year projection period (as they do in the last 50 years of the Trustees' model).

How well has the simple Age Model captured the essence of the Trustees' methodology? The Age Model uses inputs similar to those used by the Trustees in their 1997 report: mortality forecasts with life expectancy at birth increasing by nearly 5 years to 80.85 years in 2070 (based on life tables constructed by the Office of Actuary of the Social Security Administration), immigration forecasts (900,000 net annual immigrants), fertility forecasts (falling from a current level of 2.02 to a long-run average of 1.9), and an age-profile of Medicare costs based on the age factors used by Medicare for cost reimbursements of HMOs based on their patient population. The latter profile (see Table 2) is meant to approximate the use of age in the Trustees' estimate of future costs of HI.

I have also used the age-profile of hospital discharges from 1995 and the resulting cost patterns are quite similar.

**Table 2. Medicare costs by age.**

Age	Risk adjuster (sexes combined)	Relative Costs
65-69	0.49	1.00
70-74	0.64	1.30
75-79	0.81	1.65
80-84	0.98	1.98
85-89	1.15	2.33
90-94	1.22	2.47
95+	1.18	2.38

Source: Health Care Financing Administration, Risk Factor Tables, Announcement of Calendar Year 2000 Medicare+Choice Payment Rates, March 1, 1999.

The estimates from the Age Model are quite similar to those of the Trustees as seen in Figure 4. Panel A contrasts predictions of the annual growth rate in Medicare costs. Panel B contrasts predictions of the growth rate in the number of enrollees. Panel C contrasts predictions of the growth rate in the costs per enrollee. In the initial decades, the Age Model consistently underestimates the growth rates in enrollees and average costs as forecast by the Trustees. Presumably, this is due to short-term effects not captured by the Age Model. Beyond 2020, the Age Model generally tracks the Trustees forecast.

## PROJECTIONS USING COSTS BY TIME-UNTIL-DEATH

In the Age Model, the future health status of the Medicare population is judged solely on the basis of age. In this section, the Time-until-death Model is presented which measures health status on the basis of time-until-death.

Of course, the date of death of any individual cannot be known with any certainty. But, demographers can predict the distribution of time-until-death in a population. The cohort life table value of  $e_{\alpha}$  is the mean time-until-death for a group of individuals aged  $\alpha$ . The value of  $l_{q\alpha}$  is the proportion of individuals at age  $\alpha$  that will die this year. The entire distribution of time-until-death  $\{\Omega=0 \text{ to } \Omega=\infty\}$  is given by the distribution of deaths  $\Omega$  years in the future to those currently aged  $\alpha$ . In life table notation, the time-until-death distribution for individuals aged  $\alpha$  is

$$\frac{l(\alpha + \Omega) \cdot \mu(\alpha + \Omega)}{l(\alpha)} \quad \text{For } \Omega = 0, \dots, \infty$$

where  $l(x)$  is the proportion of a cohort surviving to exact age  $x$  and  $u(x)$  is the force of mortality at exact age  $x$ .

The time series of the time-until-death distribution is estimated based on forecasts of future US mortality rates. The forecast is taken from the Office of the Actuary, Social Security Administration. This mortality forecast was used in the 1995 Trustees Reports in forecasting the finances of the Medicare system<sup>4</sup>.

Figure 5 shows the effect of increasing longevity on the time-until-death distribution for those aged 65 in 1937, 1997, and 2057. The distribution is shifting outward over time due to mortality decline (historical and forecast). In 1937, the expectation of life at age 65 was 12.5 years; by 1997 it had risen to 17.5 years; and by 2057 it is forecast to reach 19.9 years. This improvement in health status means that average Medicare usage by 65 year-olds will be declining over time.

The aggregate cost estimate from a Time-until-death Model would be:

$$H(t) = \sum_{\Omega} e^{i^*t} * h(\Omega) * K(\Omega, t) = [E(t)] * [e^{i^*t}] * \left[ \sum_{\Omega} k(\Omega, t) * h(\Omega) \right]$$

where  $i$  is the rate of medical care inflation in the economy,  $h(\bullet)$  is the average Medicare costs of those  $\bullet$  years before death in the baseline year,  $K(\bullet, t)$  is the population  $\bullet$  years before death  $t$  years in the future.,  $E(t)$  is the number of enrollees, and  $k(\bullet, t)$  is the percent distribution of the enrollee population by time-until-death in  $t$  years in the future.

The Time-until-death Model implies a very different time-path of average costs per enrollee than the Age Model. Panel A of Figure 6 shows the average time-until-death of Medicare enrollees over the projection period. In 1997 the average Medicare enrollee was expected to live another 11.5 years (Berkeley Mortality Database). Over time, the Medicare population moves further away from death – and from the costs associated with being close to death. Panel B shows the decline in average costs per enrollee implied by shifts in the time-until-death distribution. This distribution is changing due to both increasing longevity and the aging of the baby boomers.

## COMPARISON OF COST PROJECTIONS

Figure 7 contrasts aggregate Medicare costs estimated by the Age Model and Time-until-death Model. Both models use the conservative longevity forecast by the Trustees – an increase in life expectancy to 80.9 years in 2070. Cost projections of the Age Model are 14% higher in 2070 than costs projected by the Time-until-death Model. Even at the relatively modest gains in life expectancy forecast by the Trustees, there are significant differences in cost estimates between these models.

---

<sup>4</sup> The data were obtained online from the Berkeley Mortality Database. <http://demog.berkeley.edu/wilmoth/mortality>. These data are not corrected for possible age misreporting.

To recognize that the cost-savings from declines in age-specific mortality rates can be in the range of 14% as indicated by the simulations, consider the following analytic approximation. Between 1997 and 2070, the life expectancy of 65 year olds is expected to increase by 3 years from 17.65 to 20.65 (Berkeley Mortality Database). To the Trustees, the 3 years gained in life expectancy are viewed as quite costly – coming in the 80+ age range where costs are typically 40% higher than the average enrollee. In the alternative view, the 3 years gained in life expectancy are viewed as quite inexpensive – coming in the relatively low cost years well before the end of life where costs are typically 70% lower than the average enrollee. Using these rough estimates, we can see that Medicare Trustees would overstate costs by about 17% [ $1.17 = (17.65 + 3 * 1.40) / (17.65 + 3 * 0.30)$ ]

In order to assess the impact of increasing longevity on Medicare financing, I ran 3 simulations of alternative mortality forecasts using the Age Model and the Time-until-death Model. Lee and Carter (1992) develop a method for modeling and forecasting mortality rates based on a single, time-varying parameter – the general mortality level index. I use Lee-Carter methods to derive alternative time series of this index which yield mortality rates and the time-until-death distributions. The baseline forecast uses Lee-Carter's original forecast of the mortality level index based on their estimate of the historical trend in this index. Life expectancy at birth is forecast to reach 86.6 in 2070. This is quite similar to the middle forecast of the most recent Census Bureau projections (Hollmann, Mulder, and Kallan 2000). The second forecast assumes that mortality falls half as fast as Lee and Carter (1992) predict which roughly approximates the middle forecast from the Trustees, with  $e(0)$  reaching 82.0 in 2070. The third forecast assumes that mortality falls twice as fast as Lee-Carter's original forecast (that is, the general mortality level index falls twice as fast as originally forecast) with  $e(0)$  reaching 93.5 in 2070.<sup>5</sup>

The results of the 3 simulations are presented in Figure 8, which shows changes in Medicare taxes as a percentage of payroll. Rising Medicare costs will greatly outstrip revenues from taxes and premiums and I express this shortfall in terms of changes in the tax rate. This is just a convenience, since future shortfalls could also be met by increasing premiums or reducing benefits. Premiums are assumed to equal 25% of SMI (physician reimbursements) as established by the Balanced Budget Act of 1997. Recall that for ease of exposition, all simulations assume that medical care inflation and productivity growth rate are zero.

---

<sup>5</sup>The estimate of a life expectancy of 93.5 in 2070 may strike some as implausibly high. Such an increase implies annual declines in age-specific mortality of 2.3% per year for ages 80-84, 2.0% for 85-89, and 1.7% for those aged 90-94. These rates of decline are certainly rapid but they are not unprecedented. Kannisto et al. (1994) examine evidence on the rates of decline in age-specific mortality for the elderly populations in 27 countries. Observed rates of decline from the 1960s to 1980s in female age-specific mortality in Japan [80-84,85-89,90-94], Finland [80-84,85-89, 90-94], and Iceland [85-89,90-94] all exceed these forecasted rates of decline.

This graph is the central result of the paper and reveals 3 key findings. First, note that Medicare tax rates do not change much over the next 15 years. In these simulations, medical prices are assumed to be rising at the rate of general inflation so that only changes in demography are affecting Medicare. These results indicate that the current short-term financial crisis facing Medicare does not stem from demography. The effects of the retirement of the baby boomers are seen in the steady rise of tax rates beginning in 2015 or so.

Second, note the large variation in tax rates predicted by the Age Model for the 3 longevity forecasts. Tax rates in 2070 vary from a low of 12% assuming a moderate increase in longevity [ $e(0)=82.0$ ] to a high of 19% assuming a more rapid increase in longevity [ $e(0)=93.5$ ]. By contrast, the Time-until-death Model shows relatively moderate differences in tax rates: 10 to 12%. Under the moderate increases in longevity forecast by the Trustees, cost projections based on age would exceed those based on time-until-death by about 15%. Under more rapid increases in longevity, cost projections based on age greatly exceed those based on time-until-death: by 32% with  $e(0)$  of 86.6 in 2075 and 57% with  $e(0)$  of 93.5.

To see that the modest tax increases forecast by the Time-until-death Model are consistent with rapid increases in longevity, we can return to the simplified analytical calculations (considered on the previous page). Currently, the average 65 year old can expect to live another 17.6 years. According to official estimates, by the year 2070 the average 65 year old can expect to live 20.6 years. This gain of 3 years, or 16% increase in the average life span over 65, would raise lifetime costs by a modest 5.6%, assuming that costs of those more than 10 years away from death are about 1/3 of the costs of the average enrollee [ $5\% = 3 * 0.33 / 17.65$ ]. Even a dramatic doubling of the life span over 65 would raise lifetime costs by only about a third.

In addition to comparing the tax estimates for 2070, we can also summarize the tax differences over the entire 75 year projection period by taking the net present value of taxes paid. I discount by 2 percentage points over the rate of productivity growth (which is assumed to be zero). Using the Age Model, the Trustees would project a \$3.8 trillion shortfall in taxes over the next 75 years if longevity increased very rapidly ( $e_0$  reaching 93.5 in 2070). By contrast, the Time-until-death Model shows a shortfall of \$740 billion or roughly 1/5 the size of the deficit the Trustees would have forecast.

Finally, we see an interesting transitional effect of increasing longevity in the Time-until-death Model simulation. In the short-run, the more rapid the increase in longevity, the lower the health care costs. It is obvious from comparative steady state analysis that low mortality populations will have higher health costs. Living longer is more expensive. However, there are important transitional effects between steady states. When mortality falls the cost-savings from declines in age-specific costs occur before the cost increases from the growth in numbers of elderly. This is because the number of elderly at any age is the result of the cumulative product of past survivorship rates. So, it takes some time for the elderly population to increase as a result of the new survivorship rates. To understand this phenomenon in its starkest terms, imagine that mortality were suddenly and completely eliminated. Medicare decedants who had previously accounted

for nearly 30% of Medicare costs would now become survivors with significantly lower costs. Hence, total costs would drop by about 25% in the first year of this zero-mortality regime. Over time, Medicare costs would steadily rise as the number of Medicare enrollees rose to an infinite or very large finite number.

## **CONCLUSION**

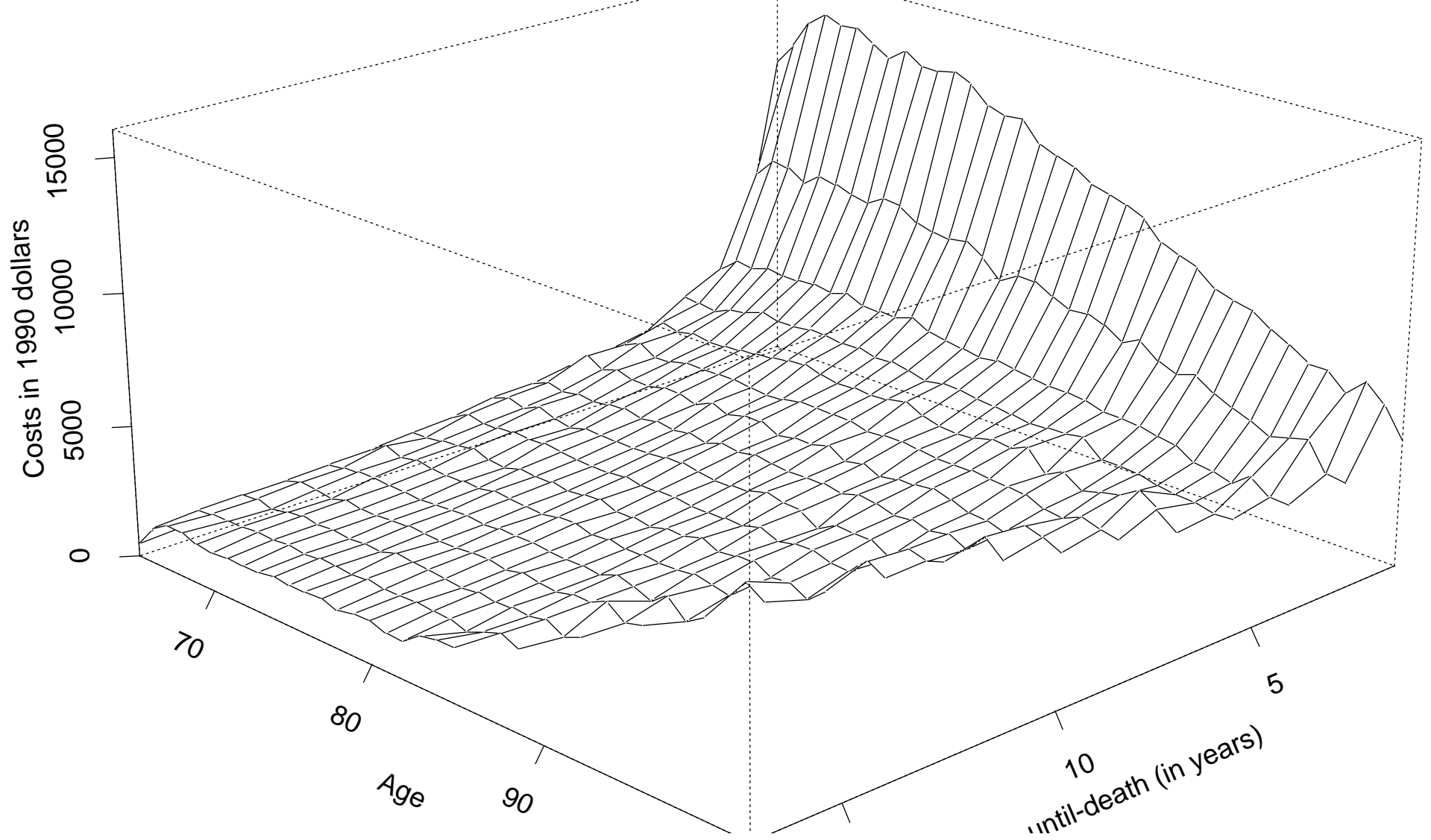
The Medicare Trustees by relying on a fixed age schedule of Medicare costs implicitly forecast an expansion of morbidity as longevity increases. Their cost projections are quite sensitive to increases in longevity. I presented an alternative forecast relying on a fixed time-until-death schedule of Medicare costs. Administrative data have shown that Medicare costs rises dramatically during the final decade of life. My forecast assumes that the future is characterized by neither an expansion nor a compression but rather a postponement of this period of high costs and, by implication, of morbidity to later in life. Hypothetical cost savings from delay in morbidity are not large enough to offset the financial strains projected in Medicare owing to population aging.

**REFERENCES**

- Berkeley Mortality Database. [www.demog.berkeley.edu](http://www.demog.berkeley.edu)
- Board of Trustees, Federal Hospital Insurance Trust Fund. 2000. 2000 Annual Report of the Board of Trustees of the Federal Hospital Insurance Trust Fund. Washington, DC: U.S. Government Printing Office.
- Board of Trustees, Federal Supplementary Medical Insurance Trust Fund. 2000. 2000 Annual Report of the Board of Trustees of the Federal Supplementary Medical Insurance Trust Fund. Washington, DC: U.S. Government Printing Office.
- Crimmins, Eileen M.; Saito, Yasuhiko; and Ingegneri. 1997. "Trends in Disability-Free Life Expectancy in the United States, 1970-90." *Population and Development Review*, Vol. 23, No. 3, pp. 555-572.
- Cutler, David M. and Meara, Ellen. 1999. "The Concentration of Medical Spending: An Update." NBER Working Paper Series. National Bureau of Economic Research.
- Fries, James F. 1980. "Aging, natural death, and the compression of morbidity." *New England Journal of Medicine*. Vol 303, pp. 130-135.
- Fries, James F. 1984. "The compression of morbidity: Miscellaneous comments about a theme." *The Gerontologist*. Vol. 24, pp. 354 - 359.
- Fuchs, V.R. 1984. "Though much is taken: reflections on aging, health, and medical care." *Milbank Memorial Fund Quarterly* 62:143-166.
- Garber, Alan M., MaCurdy, Thomas E., and McClellan, Mark L. 1998. "Medical Care at the End of Life: Diseases, Treatment Patterns, and Costs." NBER Working Paper Series, No. 6748. National Bureau of Economic Research.
- Hollmann, Frederick W., Mulder, Tammany J., and Kallan, Jeffrey E. 2000. "Methodology and Assumptions for the Population Projections of the United States: 1999 to 2100." Population Division Working Paper No. 38. Population Projections Branch, Population Division, Bureau of the Census, U.S. Department of Commerce, Washington, DC.
- Kannisto, V.; J. Lauritsen; A. R. Thatcher; and J. W. Vaupel. 1994. "Reductions in Mortality at Advanced Ages: Several Decades of Evidence from 27 Countries." *Population and Development Review* 20:793-810.
- Lee, R. D. and L. Carter. 1992. "Modeling and Forecasting U.S. Mortality." *Journal of the American Statistical Association* 87:659-671.
- Lee, R.D. 1994. "Fertility, Mortality, and Intergenerational Transfers: Comparisons Across Steady States." Pp. 135-157 in *The Family, The Market, and The State in*

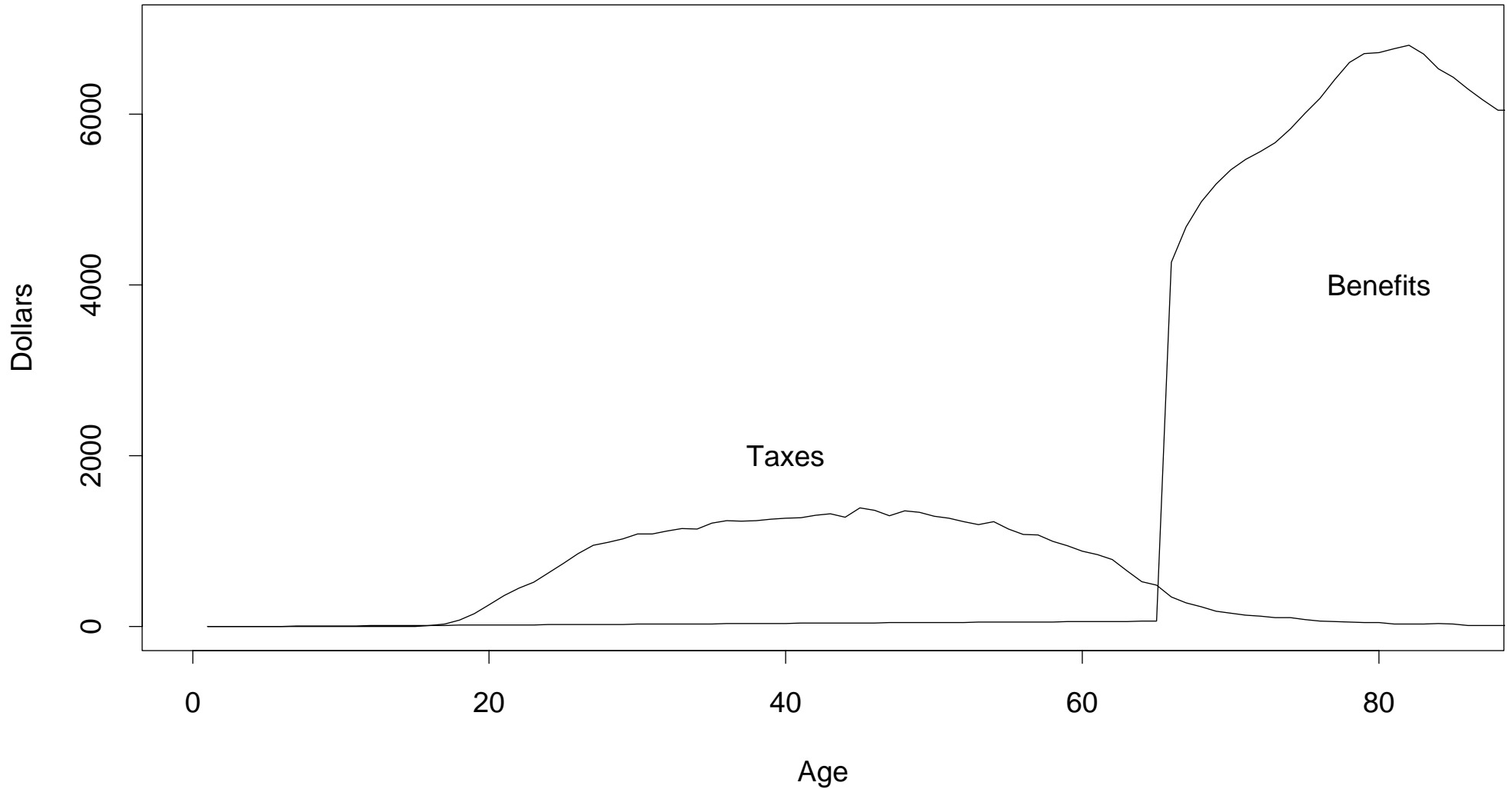
- Ageing Societies*, edited by J. Ermisch and N. Ogawa. Oxford: Oxford University Press.
- Lubitz, J.; J. Beebe; and C. Baker. 1995. "Longevity and Medicare Expenses." *New England Journal of Medicine* 332: 999-1003.
- Lubitz, J. and R. Prihoba. 1984. "The Use of Medicare Services in the Last Two Years of Life." *Health Care Financing Review* 5:117-131.
- Lubitz, J. and G. Riley. 1993. "Trends in Medicare Payments in the Last Year of Life." *New England Journal of Medicine* 238:1092-1096.
- Manton, K.; L. Corder; and E. Stallard. 1997. "Chronic disability trends in elderly United States populations: 1982-1994." *Proceedings of the National Academy of Science* 94:2593-2598.
- Olshansky, S. Jay; Rudberg, Mark A.; Cassel, Christine K.; and Brody, Jacob A. 1991. "Trading Off Longer Life for Worsening Health: The Expansion of Morbidity Hypothesis." *Journal of Aging and Health*, Vol. 3, No. 2, pp. 194-216.
- Robine, Jean-Marie; Mormiche, Pierre; and Sermet, Catherine. 1998. "Examination of the Causes and Mechanisms of the Increase in Disability-Free Life Expectancy." *Journal of Aging and Health*, Vol. 10, No. 2, pp. 171-191.
- Singer, Burton H. and Manton, Kenneth G. 1998. "The effects of health changes on projections of health service needs for the elderly population of the United States." *Proceedings of the National Academy of Sciences*, Vol. 95, pp. 15618-15622.
- United States, Office of Management and the Budget. 1999. *Historical Tables, Budget of the United States Government, Fiscal Year 2000*. Washington, DC: U.S. Government Printing Office.
- White, Joseph. 1999. "Uses and abuses of long-term Medicare cost estimates." *Health Affairs*, Vol. 18, No. 1, pp. 63-79.

Figure 1: Medicare Costs per Enrollee  
by Age and Time-until-death



Source: Lubitz, Beebe, and Baker (1995), based on retrospective Medicare costs of 1990/91 decedants.

Figure 2: Average Medicare Taxes and Benefits by Age in 1997



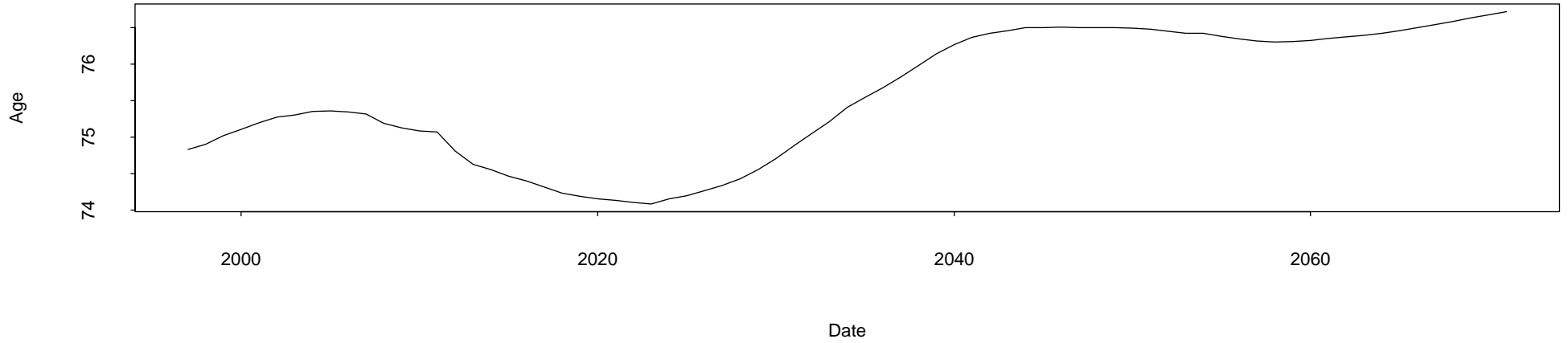
Premium contributions are not shown.

Sources: Taxes estimated from Current Population Survey.

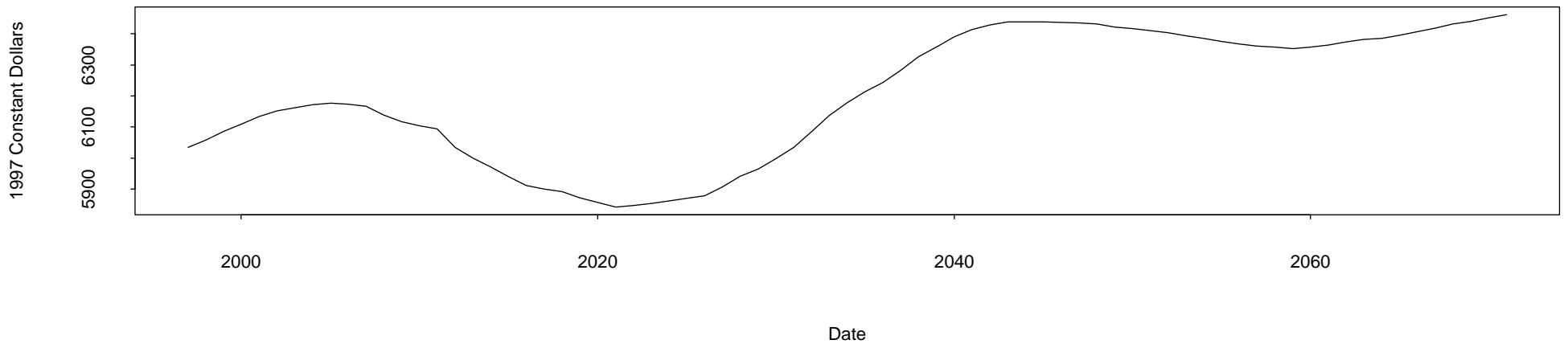
Benefits estimated from Medicare's New Beneficiary Follow-up Survey.

Figure 3

Panel A: Average Age of Medicare Enrollees



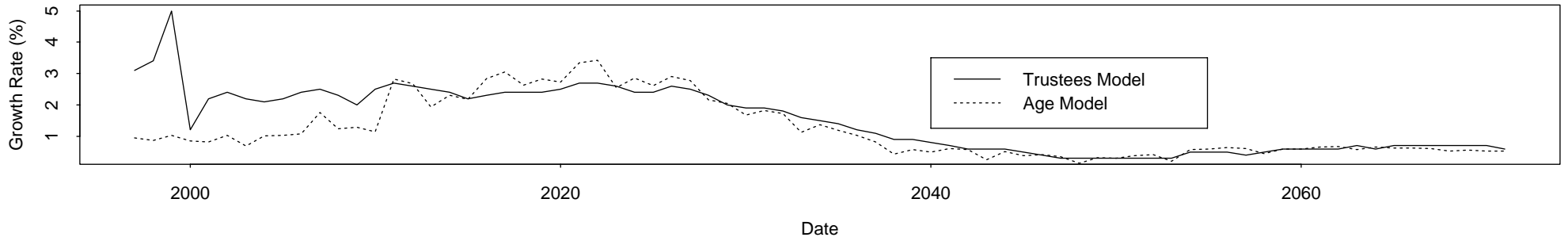
Panel B: Average Cost Per Enrollee Predicted by Age Model



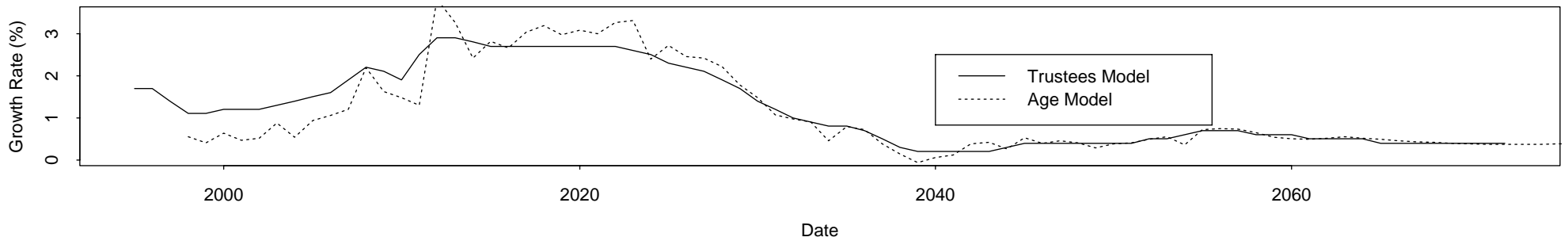
Model is run assuming medical prices rise at the rate of general inflation.

# Figure 4

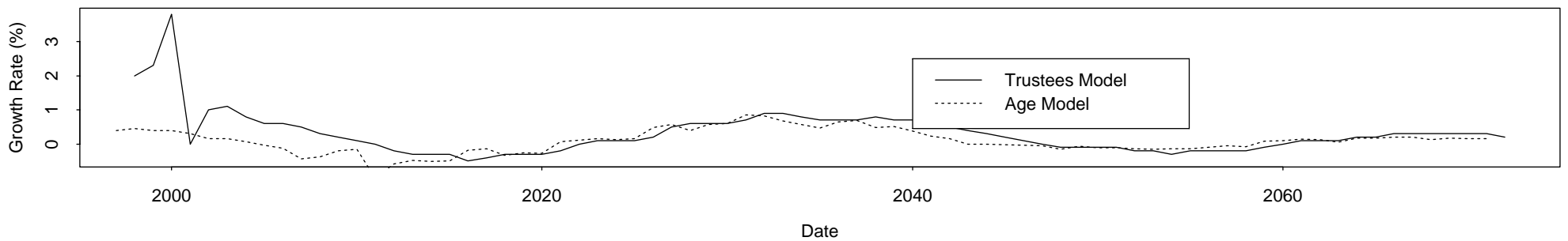
## Panel A: Annual rate of increase in Medicare costs



## Panel B. Rate of increase in enrollees



## Panel C: Rate of increase in average cost per enrollee due to age/sex composition of enrollees



Model is run assuming medical prices rise at the rate of general inflation.

Figure 5: Time-until-death Distribution for 65 year olds: 1937,1997,2057

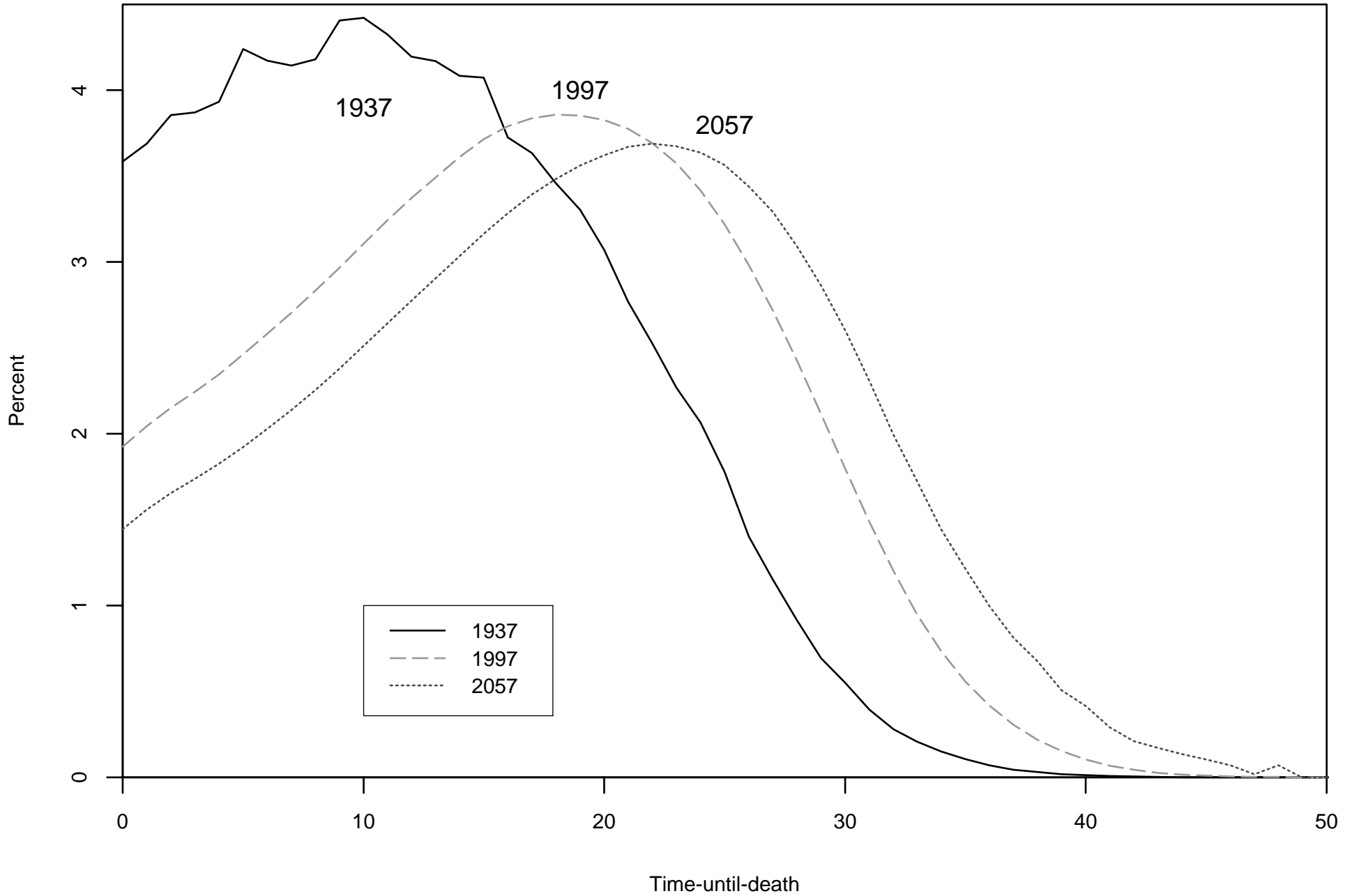
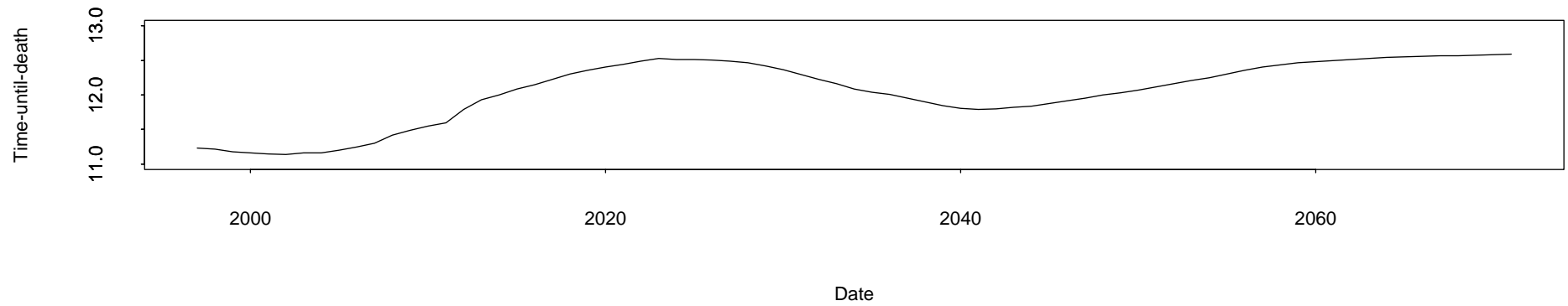
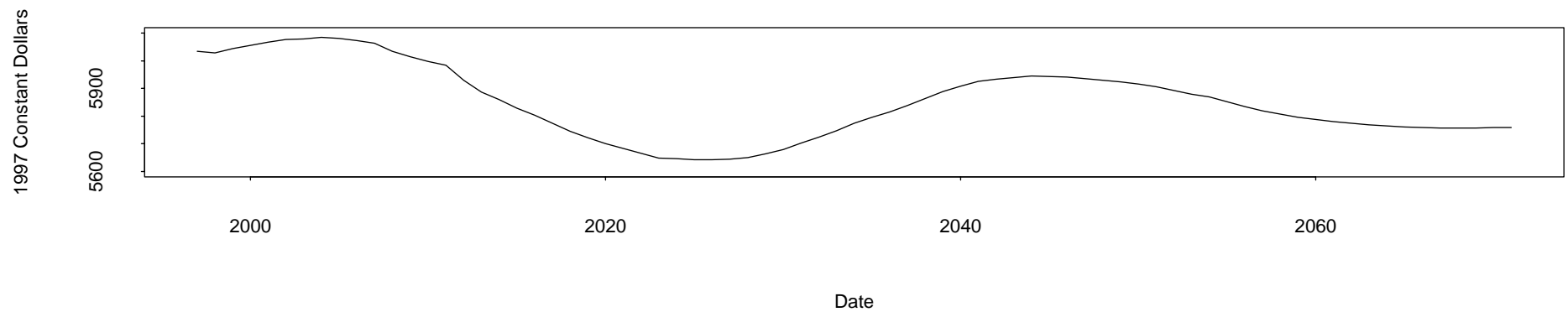


Figure 6

Panel A: Average Time-until-death of Medicare Enrollees

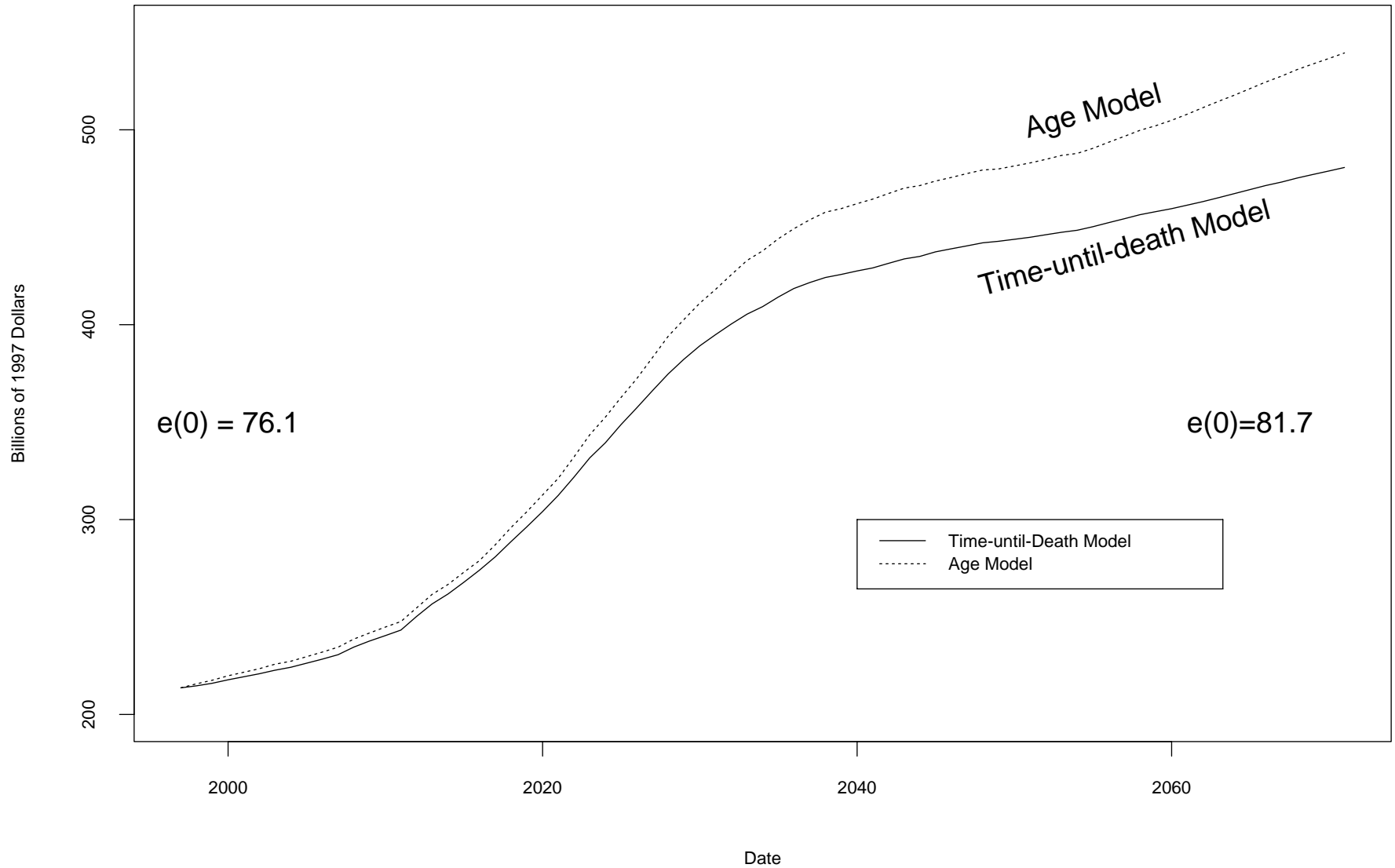


Panel B: Average Cost Per Enrollee Predicted by Time-until-death Model



Model is run assuming medical prices rise at the rate of general inflation.

Figure 7: Estimate of Aggregate Medicare Costs in Age and Time-until-death Models



Model is run assuming medical prices rise at the rate of general inflation.  
Model is run using Trustees' Mortality Forecast.

Figure 8. Effect of Increasing Longevity on Medicare Tax Rates

