NBER WORKING PAPER SERIES

YOUR MONEY AND YOUR LIFE: THE VALUE OF HEALTH AND WHAT AFFECTS IT

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Working Paper 6895
http://www.nber.org/papers/w6895

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
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January 1999

This paper was prepared for the NBER Conference on Frontiers in Health Policy Research, June 11, 1998. We are grateful to Alan Garber, Zvi Griliches, David Meltzer, and Doug Staiger for helpful comments, and to the National Institutes on Aging and the Alfred P. Sloan Foundation for research support. The views expressed here are those of the author and do not reflect those of the National Bureau of Economic Research.

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ABSTRACT

This paper examines the role of medical care in improving health and compares that value of better health produced by medical care with the costs of that care. Valuing medical care requires measuring the health of the population. We start by developing a measure of the nation's *health capital* -- the dollar value of health a person will have over the course of their remaining life. We estimate health capital empirically using data on the length of life, the prevalence of adverse conditions for those alive, and the quality of life conditional on having an adverse condition. For a newborn in 1990, we estimate health capital at about $3 million, while for the elderly, health capital is nearly $1 million. Health capital has increased greatly over time -- by roughly $40,000 to $50,000 per decade. Comparing the change in health capital with the increase in medical spending, we estimate that, for most plausible assumptions, increased medical technology has been worth its cost. In our preferred specification, only about 30 percent of the improvement in health capital in the past 40 years would need to result from medical care advances for the improvement of medical technology to justify its cost. While we find that on average value of medical technology is high, we discuss other evidence that substantial amounts of medical care is provided in situations where its value is low. We thus suggest a fundamental repositioning of the public debate about medical spending. Traditionally, the question that has been posed in the public sector is: how can society (or the government) limit medical costs so that we can afford medical care in the future on our budget today? Our results suggest that a more appropriate question is: how can we get more of the spending that is valuable but avoid the spending that is not valuable?

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Does the United States spend too much on medical care? Most policy makers believe that it does. Medical costs have been increasing more rapidly than national income for several decades, and medical spending in the United States vastly exceeds levels in other countries -- even countries with substantially better health outcomes. "Cost containment" is a permanent fixture on the policy agenda.

At the same time, we like what medical spending buys us. For example, we can now transplant livers, kidneys, hearts and lungs, all of which we were unable to do a few decades ago; if this is what medical spending buys us, do we want to give it up?

The heart of this issue is perhaps the most fundamental question in health economics: how much is medical care worth, and how much should we be willing to pay for it? Or, to put the question in a more common vernacular, would you rather have more money or more life? This question is the subject of our paper.[1]

As our examples above suggest, there is no clear consensus on this question. Indeed, even at a gross level people have seemingly contradictory views about this issue. Consider a simple quiz:

1) Which medical care system would you rather have: (a) the medical system today with the medical technology that is currently available; or (b) the medical system that was available in 1968, with only the medical technology available at that time, but at its lower cost?

2) Do you believe that the medical care system is (a) efficient; or (b) relatively inefficient?

Our anecdotal evidence is that most people answer (b) and (a). But these answers seem contradictory. Are people urging us to cut back, as in question (2), or to spend more, as in question (1)?

The key to all of these questions is valuing the health outcomes that result from medical treatments. Without a value of health, we cannot make rational public policy about spending on medical care. The primary goal of our paper is thus to measure the value of health. Following Grossman (1972), we develop a measure of *health capital* – the dollar value of health a person will have over the course of their remaining life. Health capital is integral to evaluating the worth of the medical system. Society should have more medical technology if that technology increases health capital by more than it costs and less if the opposite is true.

We measure health capital empirically using data on the length of life, the prevalence of adverse conditions for those alive, and the quality of life conditional on having an adverse condition. Health capital is large. For a newborn in 1990, we estimate health capital is about $3 million, while for the elderly health capital is nearly $1 million.

Comparing the change in health capital over time with the increase in medical spending, we estimate that, for most plausible assumptions, increased medical technology over the past half century has almost certainly been worth its cost. We thus conclude that the *average* value of medical technology changes is high. Our results do not imply that *all* of medical spending is worth it, however. We discuss evidence that substantial amounts of medical care are provided in situations where its value is low.

The combination of a high average value of medical care and a low marginal value suggests a fundamental repositioning of the public debate. The question that has been posed in the public sector is: how can society (or the government) limit medical costs so that we can afford medical care in the future on our budget today? Our results suggest that a more appropriate question is: how can we get more of the spending that is valuable but avoid the spending that is not valuable? Answering this latter question, and not necessarily the former, has the potential to yield lasting improvements to our nation's fiscal and physical health.

In the first section of the paper, we document trends in medical spending and health. The second and third sections estimate health capital and compare changes in health capital with changes in medical spending. The fourth section illustrates our results in the case of two specific diseases: cardiovascular disease and cancer. The fifth section then moves from asking whether medical care is worth it in total to asking whether all of medical care is worth it. The final section draws out the implications of these findings for public policy.

X.1 Trends in Medical Spending and Health

Medical spending has increased dramatically over time in the United States, as it has in most of the developed world. In 1950, the United States spent about 5 percent of GDP on health; by 1990, medical spending was over 12 percent of GDP. Some of this increased spending is because the United States population was older in 1990 than in 1950 and older people spend more on medical care than younger people. But even age-specific medical spending has increased rapidly, as technological change has affected the type of medical care that can be provided.

We summarize the increase in medical spending over time by the present value of future medical consumption. Consider some year t. In that year, there is an age-specific pattern of medical spending, denoted

$m_t(s)$ for people of age s. If there is no technological change in medicine, no change in the incidence of disease, and no change in the price of given medical services, people alive k years in the future can expect to spend on average $m_t(s+k)$ on medical care. Similarly, the probability that a person of age s will live an additional k years, using cross-section survivor rates, is denoted $Pr_t\ [Alive\ at\ s+k\ |\ s]$. With no changes in medical technology, behavioral, or environmental factors, this probability would continue into the future as well. Expected medical spending k years in the future is the product of spending conditional on being alive times the share of people expected to be alive: $Pr_t\ [Alive\ at\ s+k\ |\ s] \cdot m_t(s+k)$. Expected medical spending over the person's remaining life is then the discounted value of this amount:

$$\textbf{(1)} \qquad Medical\ Spending_t(s) = \sum_{k=0}^{\infty} \frac{Pr_t[Alive\ at\ s+k|s] \cdot m_t(s+k)}{(1+r)^k}.$$

where r is the real discount rate.

Table X.1 shows expected medical spending for infants and people age 65 over time. The first row uses a 3 percent real discount rate, our baseline value (as discussed below). In 1950, a newborn could expect to spending nearly $8,000 over his or her lifetime on medical care; that amount increased to $20,000 in 1970 and $45,000 in 1990. The values are much greater with a zero percent discount rate (over $180,000 in 1990) and much smaller with a 6 percent discount rate, reflecting the heavy concentration of medical spending at advanced ages.

For the elderly, there was a similar increase in medical spending. The average person reaching age 65 could expect to spend $4,000 on medical care in 1950, and nearly $59,000 in 1990. Since the public sector pays for about three-quarters of medical spending for the elderly, this increase in spending reflects a tremendous increase in the public sector burden.

At the same time as medical sending has increased, so has the length of life. Figure X.1 shows life expectancy at birth and at age 65 over the 20^{th} century. Increases in longevity have been impressive.

Life expectancy at birth increased by 27.4 years over this period, and life expectancy at age 65 increased by 5.5 years.

A comparison of figures X.1 (a) and (b) shows that the nature of mortality improvement has changed fundamentally over the twentieth century. In the first four decades of the century, mortality reductions were concentrated at younger ages. Life expectancy at birth increased by 15.9 years between 1900 and 1940, while life expectancy at age 65 was virtually unchanged. Indeed, only four percent of the increased life expectancy at birth was a result of increased life expectancy at age 65. Increased longevity for the non-elderly population, especially infants, was achieved through better sanitation, pasteurized milk, increased nutrition, less crowded housing, and other economic and public health factors.

Between 1940 and 1960, mortality reductions were prominent for both the young and the old. In those two decades, life expectancy at birth increased by 6.3 years, and life expectancy at age 65 increased by 1.9

years. About 20 percent of the increased life expectancy at birth was a result of increased longevity at age 65. These mortality reductions were primarily the result of reduced death from infectious disease, resulting from the discovery of penicillin and other antibiotics.

Since 1960, mortality reductions at older ages have dominated the survival picture. Between 1960 and 1990, life expectancy at birth increased by 5.2 years, while life expectancy at age 65 increased by 2.6 years. About 37 percent of the increase in longevity at birth is a result of increased survival at age 65.

Figure X.2 shows more information about the sources of mortality reduction in the post-1950 period. In 1950, as is true today, the two leading causes of death were cardiovascular disease (heart disease and stroke) and cancer. Both of these diseases strike the elderly more than the non-elderly. In the past 40 years, there has been dramatic progress in the battle against cardiovascular disease. Cardiovascular disease mortality has fallen by 3 percent per year since 1968.

In contrast, mortality from cancer has been unchanged or if anything has increased slightly.

Consider the following question: if you had a newborn (or a grandchild) today, would you be willing to pay $35,000 so that the child would have 1990 medical technology instead of 1950 medical technology? If the medical technology led to the increase in longevity, we suspect most people would answer yes. Indeed, we suspect the answer would be yes if medical spending accounted for only one-quarter of the increase in longevity. This calculation is an approximation to a cost-benefit analysis for medical care. In the next section, we show how to make this calculation more complete.

X.2 Cost-Benefit Analysis for Medical Care

To measure the value of the medical system, we need to value the additional health it provides. "Health" is a difficult concept to measure, however, since it has many dimensions. Part of health is physical -- Is the person alive? Can they care for themself, work, and engage in other normal activities of living? There is a mental component as well; indeed, many physical ailments (such as partial paralysis from a stroke) will have important mental consequences. Finally, health depends on social factors, for example whether the environment permits a disabled person to get around and work. We need to combine these dimensions of health into a useful index.

We compress these different dimensions into one scale by thinking of them as attributes of a single quality of life. Suppose we scale a person's health on a 0 to 1 basis, where 0 is death and 1 is perfect health. Living with a given disease, or with the simple impairments of advanced age, falls between 0 and 1. We denote the health of a person of age s in year t as $H_t(s)$. If a person is dead, their quality of life is zero. Thus, we can also express average health at any age as $H_t(s) = Pr[alive\ at\ s] \cdot Q_t(s)$, where $Q_t(s)$ is the average quality of life among those who are alive.

Being in better health makes people happier than being in worse health. We denote the value of a year in perfect health as *V*. The value of health in any year is therefore $V \cdot H_t(s)$. We assume that *V* is constant over time and across people. This is probably not the case. If health is a normal good, the value of a given amount of health will rise as people's income increases. But in the time period we look at, this change is unlikely to be very large. Society may also value years lived at some ages more than others. Society has invested more in some people than in others, and some contribute more back to society than others. Or society may care more about people with dependents than about people who are independent (Murray and Lopez, 1996).[2] Because there is no obvious way to rank different years, however, we assume all years have the same value.

Following Grossman (1972), we define *health capital* as the present value of a person's lifetime health:

$$\text{(2)} \qquad Health\ Capital_t(s) = V \cdot \left[\sum_{k=0}^{\infty} \frac{H_t(s+k)}{(1+r)^k} \right].$$

The term in [.] in equation (2) -- the discounted value of the expected number of quality-adjusted lifeyears a person has remaining -- is frequently termed the number of "Quality-Adjusted LifeYears" a person has left, or QALYs (Zeckhauser and Shepard, 1976).

Note that health capital is defined using the current age pattern of expected quality of life, analogous to our measure of medical spending. For example, health capital assumes that infants today will have the same quality-adjusted life at age 60 as current 60 year-olds do, just as our medical spending calculation assumed they would spend the same amount. This is clearly not a forecast of quality-adjusted life or medical spending for an infant born today. But this measure summarizes the current state of health and medical spending in the population.

Our notion of health capital is related to the idea of human capital, a familiar term in labor economics. Having more education allows one to earn more. The present value of income a person can earn from their education is termed their human capital.

Having more health allows one to be happier (and possibly to earn more). The present value of the health the person has is their health capital.

The measures of health capital and expected medical spending can be used to evaluate the net benefits of changes in the medical system. Consider two time periods, t_0 and t_1. For a person of age s, the increased cost of their lifetime medical spending between those time periods is $\Delta Medical\ Spending_{t0,t1}(s) = Medical\ Spending_{t1}(s) - Medical\ Spending_{t0}(s)$. Similarly, the increase in health capital over this time period is $\Delta Health\ Capital_{t0,t1}(s) = Health\ Capital_{t1}(s) - Health\ Capital_{t0}(s)$. Thus, one might measure the net benefits of medical technology as:

$$(3)\quad \begin{pmatrix} Net\ Benefits\ of \\ Medical\ Technology \end{pmatrix}_{t_0,t_1}(s) = \Delta Health\ Capital_{t_0,t_1}(s) - \Delta Medical\ Spending_{t_0,t_1}(s).$$

The difficulty with this measure is that factors beyond medical technology will affect health capital and medical spending. If people eat better or exercise more over time, health capital will improve and medical spending is likely to fall. The spread of AIDS reduces health capital and increases medical spending.

We thus need to filter out medical technology changes from other factors affecting these measures. In the case of medical spending, research shows clearly that essentially all of long-term growth of medical costs is a result of technological changes in medical treatments (Aaron, 1991; Newhouse, 1992; Cutler and McClellan, 1996; Fuchs, 1996). We thus make the assumption that all of medical spending increases over time results from changes in medical technology. We are unwilling to make a similar assumption about health capital, however. Many analyses show that behavioral and environmental changes have had a large impact on population health over time. We therefore need to parcel out these effects from the effects of changes in medical technology. Conceptually, we suppose that a share β of changes in health capital result from changes in medical technology. The net benefit of changes in medical technology is therefore:

$$(4) \quad \begin{pmatrix} \textit{Net Benefits of} \\ \textit{Medical Technology} \end{pmatrix}_{t_0,t_1}(s) \;=\; \beta \cdot \Delta \textit{Health Capital}_{t_0,t_1}(s) \;-\; \Delta \textit{Medical Spending}_{t_0,t_1}(s).$$

If we could estimate β, we could evaluate this equation exactly. But we do not have an estimate of β. Instead, we follow a different approach. Given the increase in health capital that we observe, we ask the question: what share of the improvement in health capital would have to result from medical technology to make the technology worth it? We define this share as the *effectiveness ratio*:

$$(5) \qquad \textit{Effectiveness Ratio}(s) \;=\; \left(\frac{\Delta \textit{Medical Spending}_{t_0,t_1}(s)}{\Delta \textit{Health Capital}_{t_0,t_1}(s)} \right)$$

If the effectiveness ratio is sufficiently small, then medical technology will likely be worth its cost; if the effectiveness ratio is large technology is probably not worth it. After calculating the effectiveness ratio, we (and the readers of this paper) can make our own judgment about whether medical technology has been worth it.

X.3 Measuring Health Capital

We start by measuring health capital over time. Measuring health capital empirically requires evaluating health at each age, estimating the value of a year in perfect health, and assuming a real discount rate.

X.3.1 Measuring Health

The simplest approach to measuring health is the *Years of Life (YOL)* approach. In this approach, we assume that there are only two values of health: alive, with a value of $H=1$; and dead, with a value of $H=0$. This assumption is justified if death is so bad that being alive in any condition is essentially perfect health relative to death. We forecast length of life using Social Security life tables, the same data used in constructing expected medical spending.

The second approach is the *Quality-Adjusted LifeYears (QALY)* approach, where we attach quality weights to living with each of a range of particular conditions. Adding up the probability of each condition times the quality weight of that condition gives the value of health. We measure the prevalence of adverse medical conditions using data from the annual National Health Interview Survey (NHIS). The NHIS asks about a number of acute and chronic conditions. The difficulty is that disease prevalences are not reliably reported over time. In many cases, the reported prevalence of disease increases as more treatments become available, diagnostic capabilities improve, or awareness of the disease rises. For example, as drugs for hypertension have improved and social awareness of the disease has increased, more people will be diagnosed with hypertension and report they are hypertensive. But there may be no actual change in hypertension in the population; indeed, if people are watching their salt intake, exercising regularly, and taking anti-hypertensive medication, the true prevalence of hypertension may actually decline.

After examining the NHIS documentation and other sources of data, we identified nine conditions that we believe are consistently reported between 1970 and 1990: amputation, arthritis, blindness, other vision problems, cardiovascular disease, diabetes, hearing problems, orthopedic problems, and paralysis. Not surprisingly, these conditions are very severe; for more minor conditions, reporting changes make time-series comparisons unreliable.

The NHIS does not reliably report on cancer prevalence. To remedy this, we obtained data from the National Cancer Institute's Surveillance, Epidemiology and End Results (SEER) database. The SEER tracks incidence and survival rates for cancer. Since the recurrence rate for cancer is very low after 5 years, we define the prevalence of cancer as the share of people alive who have been diagnosed with cancer within the past 5 years. Cancer data suffer from measurement issues similar to those noted above for hypertension. Better imaging techniques (for example, from CT scanners and MRIs) have increased the early detection of cancer. Further, survival is naturally greater for cancers detected early. These two factors together imply that reported prevalence of cancer will increase, when that may not be the case. We have no way to adjust for this, however, so we accept an upward-biased estimate of cancer prevalence. Our resulting health improvements are thus likely to be too small.

The prevalence of each of these conditions in 1970 and 1990 (adjusted for the changing age and sex mix of the population) is shown in the first columns of Table X.2. The prevalence of most conditions is increasing over time. Between 1970 and 1990, for example, the four most common conditions -- orthopedic problems, arthritis, cardiovascular disease, and hearing problems - all increased in prevalence, by up to 50 percent. Independent data -- for example, from the Framingham Heart Study – confirm these trends; people are living longer after having had cardiovascular disease than they did in the past, implying that the prevalence of cardiovascular disease survivors is increasing.

We also need the quality of life weight for each condition. Estimating disease-specific quality of life is quite difficult. The most common method for estimating quality weights is through surveys (Torrance, 1986). For example, people might be asked how many years of perfect health they would trade off for a given number of years with a particular condition (termed the "time-tradeoff" method). The answer to this question gives an implicit quality adjustment for the disease. In practice, however, there is no consensus in the literature about the disutility associated with various conditions or the change in these disutilities over time.

We therefore follow an alternative approach to quality measurement. The Health Interview Survey asks people to rate their health as either excellent, very good, good, fair, or poor.[3] We assume that a person's underlying health, h^*_I, is related to their demographics and health conditions (X_i) as:

$$h_i^* = X_i\beta + \epsilon_i \tag{6}$$

If we assume that peoples' self-reported health reflects their underlying health state, we can estimate the β coefficients using the self-report data. In particular, if ϵ is normally distributed, equation (6) can be estimated as an ordered probit model for self-reported health. The β's then give the reduction in quality of life associated with each condition.[4]

In addition to including the health conditions in Table X.2 into the equation, we also include other health conditions that the NHIS asks about. Including these conditions will allow us to isolate the effect of the conditions we are interested in on health separate from other health problems they are correlated with. Because some conditions often occur together, we include a number of interaction terms. One set of interaction terms is for conditions that are common in the elderly: arthritis, cardiovascular disease, and diabetes. A second set of interaction terms is for orthopedic problems and paralysis.

Finally, we include basic demographic measures: age and age squared, and the interaction of the age variables with sex. The age coefficients are of particular interest; they indicate the extent to which, independent of disease, health declines over time.

The last two columns of Table X.3 show our regression estimates from the 1989-91 NHIS. Each of the diseases has a negative and statistically significant effect on self-reported health, as we would expect. The interaction terms are generally positive, also as we expect. It is less bad to have both diabetes and cardiovascular disease than one would think given the independent effect of diabetes on health and cardiovascular disease on health. Finally, the age terms show that health declines with increasing age, even independent of medical conditions.

To determine how QALY weights have changed over time, we estimated a similar model using data from 1979 to 1981. In these years the self-reported health question consists of only four categories ("very good" is excluded); however, this does not affect our methodology.[5] The results of this regression are shown in the first two columns of Table X.3.

The last two columns of Table X.2 show the implied quality of life weight for each condition in 1980 and 1990.[6] The estimates generally accord with intuition:

quality of life is lowest for cardiovascular disease and diabetes, and highest for minor vision and hearing problems. Importantly, quality of life for each condition is improving over time. Whether because of medical care or other factors, people consistently report themselves in less worse health than they did in the past.

Unfortunately, the NHIS does not ask about self-reported health prior to 1978, so we are unable to use our methodology to obtain QALY weights for earlier periods. However, we need QALY estimates to measure changes in health beginning before 1980, so we assume that the improvements observed in the QALY weights from 1980 to 1990 are the continuation of a trend from 1970 to 1980. Thus we forecast back to 1970 to obtain the QALY weights shown in the third column of Table X.2.

To illustrate the age effects, Figure X.3 shows the implied age factors in 1990 for men and women. We show the quality of life for a person of each age without any of the 10 adverse conditions. Even independent of disease there is a pronounced decline in the quality of life as one gets older. Quality of life for a 30 year old is 90 percent as high as a newborn; by age 65 quality of life has fallen to 73 percent as high, and by age 85 quality of life is only 62 percent as high.

Our estimates of the age coefficients were not as consistent over time as those for the QALYs. The data for women in 1980 showed a strong *increase* in quality-adjusted life at very old ages that was not present in the 1990 data. This appeared to be a problem of age-norming in the responses. People may report their health relative to the health of other people their age, or to their expectations of health at that age. This would bias the age coefficients towards zero and could account for an increase in self-reported health at older ages. Since we believe that this pattern results from changes in the reference point for the question rather than actual changes in health at older ages, we assume that the 1990 age factors apply throughout the time period.

Quality of life among people alive is the sum of the quality of life for their age, and the quality of life reduction resulting from specific diseases that they have:

$$(7)\quad Q_t(s) = \left([QALY_t \textit{ for age } s] + \sum_d Pr_t[\textit{Condition } d \textit{ at age } s] \cdot [QALY_t \textit{ for } d] \right).$$

Figure X.4 shows quality of life by age in 1970 and 1990, incorporating the set of diseases and conditions described above. This graph shows only the quality of life conditional on being alive (it does not include zeros for people who have died). Quality of life has improved over time, particularly at older ages. For example, QALY at age 65 increased by about 4 percentage points between 1970 and 1990, and QALY at age 85 increased by about 8 percentage points. There are two offsetting trends that underlie this net gain in health. The first is an increasing prevalence of disease in the population, particularly for the elderly. Declining mortality, particularly the dramatic fall in cardiovascular deaths, implies that more people are surviving with cardiovascular disease as well as other chronic conditions. The effect of increased disease prevalence is shown by the lower line in Figure X.4. At the same time, however, quality of life conditional on having a disease has improved. This effect is large enough that the average person alive in 1990 was healthier than the average person alive in 1970, even though more people have a chronic condition in 1990.

X.3.2 The Value of a Year in Perfect Health (V)

After measuring years of life, we need to value them in dollars. The value of a quality-adjusted lifeyear is a subject of much debate.[7] There are two general approaches to measuring the value of life. One approach is to measure the value of life implicitly through revealed preference for risk. One can often observe market settings involving a trade-off between money and risk of death and use this information to impute the value an individual places on life. Examples of observed trade-offs include wage premia for jobs involving a risk of death (for example Moore and Viscusi, 1988), and the purchase of safety devices such as smoke detectors (for example Dardis, 1980). Alternatively, one can directly elicit the value of a life using contingent valuation. Individuals are asked how much they are willing to pay for a hypothetical reduction in risk (or willing to accept in compensation to forego the benefit), such as a particular treatment for a disease or removal of an environmental risk. There are a number of issues to be considered with contingent valuation, such as how the questions should be structured (e.g., open ended versus a series of discrete choices), whose willingness to pay should be elicited (e.g., should family members' willingness to pay be included in valuing a drug treatment), and how to incorporate the fact that willingness to pay may vary with income, age and time. However, contingent valuation is widely used in cost-benefit analysis, particularly in environmental and health related studies.

Tolley et al. (1994) synthesize the literature on valuing life and life years and conclude that a range of $70,000 to $175,000 per lifeyear is reasonable. We assume a benchmark value of $100,000 per lifeyear. One attractive feature of our analysis is that it is straightforward to change the value of a life year.

X.3.3 The Discount Rate

The final issue we need to address is what discount rate to use. This too is a venerable issue in economics (See Atkinson and Stiglitz (1980) for discussion). The appropriate discount rate is the rate that trades off utility in different years. While market interest rates are very high (as high as 7 to 8 percent in real terms), these are discount rates for dollars in different years, not utility. Market interest rates will exceed utility discount rates because of taxation, risk, and because increases in productivity over time reduce the marginal utility of consumption.

Discount rates as low as 0 percent have been used to discount future utility.[8] Others have argued for higher discount rates. It may be possible to explain why some people smoke, for example, if we assume they have discount rates of 20 percent or more (Fuchs, 1982). Rather than choose one discount rate, we use three rates, roughly spanning the literature: 0 percent, 3 percent, and 6 percent. Our benchmark assumption is a discount rate of 3 percent.

X.3.4 The Effectiveness Ratio

Figure X.5 and table X.4 report our estimate of health capital. The left columns of the table report health capital using the years of life approach; the right columns use the quality-adjusted life years approach. In the Years of Life approach, we report health capital since 1950; in the Quality of Life approach, we only have data from 1970 on. In each case, we report health capital for newborns and people turning 65.

Health capital is large. For a newborn, health capital in 1990 is $2.5 to $3 million using a 3 percent discount rate and $5 to $7.5 million using a 0 percent discount rate. This amount is substantially greater than what an infant will earn over the course of his or her lifetime. Working forty years at an annual salary of $30,000 per year is only $1.2 million of income, or $373,000 discounted at a 3 percent rate.[9] Of course, there is no guarantee that a person is able to afford the worth of their health. Indeed, if a year of life in perfect health is worth $100,000, many people do not have the savings to cover even one year. For the elderly, health capital is about $750,000 to $1 million using a 3 percent discount rate.

Table X.5 compares the change in health capital over time with the change in medical spending over time. The first row shows the change in health capital for infants, using the 3 percent discount rate. Using both the Years of Life approach and the Quality of Life approach, health capital has risen substantially, by $75,000 to $100,000 between 1970 and 1990, and another $60,000 between 1950 and 1970. This is the equivalent of an additional one-half to one year in perfect health over each two decade period.

The second row shows the increase in medical spending over this time period. Lifetime medical spending increased by $25,000 between 1970 and 1990, and by $37,000 between 1950 and 1990. Comparing rows 1 and 2 makes clear that the increases in health capital are greater than the increases in medical care spending. This is true for both time periods and for both measures of health.

The third row of the table shows the effectiveness ratio. Recall that this ratio is the cutoff number for which medical technology changes are worth it. For example, using the Quality of Life approach, if medical spending accounted for only 27 percent of the increase in health capital the benefits of medical technology ($95,000 x .27 = $25,000) would just equal their cost. The 27 percent figure is reported in the third row of the table. In [.]'s below that, we report the effectiveness ratio using a 0 percent discount rate (30 percent) and a 6 percent discount rate (28 percent).

For infants, the effectiveness ratio is consistently about 30 percent. This is true for both approaches to measuring health and for a variety of discount rates. The effectiveness ratio ranges about 20-30 percent for the elderly.

Whether medical technology accounts for at least 30 percent of the change in health capital is, of course, unknown. One would need to do detailed studies of particular conditions to learn the answer to this, as we show below. Indeed, determining the role of medical technology and other factors in improving health is quite complex. It is perhaps most common to think of medical technology in the context of disease treatment, but improvements in medical technology can affect primary prevention as well. For example, advances in pharmaceuticals to control hypertension and high cholesterol have contributed to the reduced incidence of coronary heart disease. At the same time, non-medical factors contributing to health also impact both prevention and treatment. Regular exercise when young not only reduces one's risk of getting certain diseases, it may also enable one to recover faster from surgery or improve mobility conditional on having a disease.

Although it is difficult to attribute precise changes in health to specific factors, we suspect (partly on the basis of our results below) that medical care has been responsible for at least 30 percent of the improvement in health.

X.4 A Tale of Two Diseases

To better understand changes in health capital and the role of medical technology in promoting these changes, we examine outcomes and costs for two specific diseases. Cardiovascular disease and cancer have long been the two leading causes of death in the U.S.. However, the impact of these diseases on changes in health capital over time is markedly different. Table X.6 shows the contribution of the two diseases to the increase in quality-adjusted health capital from 1970 to 1990, using our baseline discount rate of 3 percent.

For newborns, cardiovascular disease accounted for $5,000 of the increase in health capital, or about 5 percent. For the elderly, cardiovascular disease contributed $67,000 to the increase in health capital, or about 40 percent of the total. This large difference reflects the fact that cardiovascular disease tends to occur later in life. Health capital for infants is affected to a much larger extent by changes in infant survival than by changes in chronic disease mortality at advanced ages. Cancer, on the other hand, has actually had a negative effect on health over time, reducing health capital by $2,000 for newborns and $12,000 for people at age 65. This is because mortality rates for cancer have actually increased slightly over this time period.

The next three rows separate the changes in health capital attributable to these diseases into three components: changes in mortality, changes in the prevalence of the disease among the living, and quality of life conditional on having the disease. For cardiovascular disease, reductions in mortality contributed heavily to the rise in health over this period, increasing health capital by $76,000 at age 65. This was partially offset by the increased prevalence of the disease -- people are living longer with cardiovascular disease than they used to. But for those surviving with cardiovascular disease, quality of life has improved measurably, increasing health capital at age 65 by $28,000.

With cancer, incidence increased over the period and mortality changes were mixed, increasing at older ages and declining modestly at younger ages. Both elements cause a decline in health capital for the elderly. For newborns, there are small gains resulting from decreased mortality which are offset by the greater number of people with the disease. Recall that we assume a constant QALY for cancer patients due to lack of information on changes in quality of life. If quality of life for cancer patients is increasing, our calculations will underestimate the contribution of cancer to health. However, even if the gains in quality of life were sufficiently large to completely offset the negative contribution of cancer to health, it seems likely that any positive effect on health would still be considerably smaller than that of cardiovascular disease.

To determine the increase in spending on these conditions, we use data from various national surveys. A longstanding literature on the cost of illness has compiled data on national spending by disease (see, for example, Hodgson, 1997), including both acute and long-term care costs. We use data from the early 1970s and the late 1980s that has estimated the costs of cardiovascular disease and cancer. Cardiovascular disease and cancer are both a major part of medical spending. In 1987, for example, cardiovascular disease was the most expensive medical condition, accounting for one-seventh of medical spending. Cancer was the third most common diagnosis (injuries was second), accounting for nearly 10 percent of spending.

After allocating national spending by age, we add up age-specific spending to determine the present value of spending on each disease. The next rows of Table X.6

show these values. For infants, spending on both cardiovascular disease and cancer increased by $3,000 in present value between 1970 and 1990. At age 65, the increases are greater: $6,000 for cardiovascular disease and $4,000 for cancer.

The effectiveness ratios are shown in the last row of the table. For cardiovascular disease, medical care would need to account for 8 percent of the change in health capital for it to be worth it from the perspective of the elderly, but 64 percent for it to be worth it from the perspective of infants. The difference between these values for infants and the elderly is that a reasonable amount of medical spending on heart disease occurs at younger ages (for example anti-hypertensive medication), but the greatest mortality and morbidity consequences occur later in life. For cancer, the change in quality of life is negative so we estimate that medical spending has not been worth it.[10]

The question for cardiovascular disease is whether medical technology passes this test. Much work has been done examining trends in risk factors and mortality from cardiovascular disease. Many studies have documented the decline in risk factors such as smoking, hypertension, and high cholesterol that parallels the decline in cardiovascular disease incidence and mortality (McGovern et al. (1996), Sytkowski et al. (1990), Sytkowski et al. (1996), etc.). Some of these risk factor improvements are due to lifestyle changes, and others to medical technology such as hypertension drugs. Literature examining mortality trends several decades ago (Goldman and Cook, 1984) highlighted the role of lifestyle changes in reduced mortality from cardiovascular disease. But more recent literature has stressed the role of medical care in mortality reductions. McGovern et al. (1996) found that mortality from coronary heart disease (CHD) fell 25 percent between 1985 and 1990; for men the decline in in-hospital mortality was more than twice as large as the decline in out-of-hospital mortality, suggesting that medical care had a larger impact on mortality declines in the late 1980s than did primary prevention.

Hunink et al. used a simulation model for CHD to estimate the contribution of primary and secondary risk factors to the mortality decline between 1980 and 1990. They estimate that 25 percent of the decline is attributable to primary prevention (reduced incidence of CHD), 29 percent is attributable to secondary prevention (reducing the rate of additional cardiac events in patients who have CHD), and 43 percent is attributable to improvements in treatment. If we consider that many risk factor reductions result from medical technology - for example, 14 percent of the mortality reduction came from reduced blood pressure which is often achieved through anti-hypertension medication - it is not unreasonable to conclude that at least half of the reduction in mortality over the 1980s can be attributed to medical technology. Sytkowski et al. (1996) find a similar degree of contribution from risk factors, ranging from 16 to 46 percent, however, they do not address the specific contribution of medical treatments.

In fact, studies which look directly at the contribution of specific technologies to the reduction in CHD mortality confirm that medical technology has played a large role. McGovern et al. estimate that thrombolytic therapy alone reduced 28-day mortality for patients hospitalized with acute myocardial infarction between 1985 and 1990 by 20-30 percent. Doliszny et al. found that the contribution of coronary artery bypass graft surgery to the decline in CHD mortality grew from 0.2 percent to 6.6 percent between 1970 and 1984.

Of course, mortality is but one element of health capital. As Table X.6 shows, nearly half of the gain from reduced cardiovascular disease mortality is offset by the increased prevalence of the disease. By reducing mortality rates, medical technology also contributes to the greater number of people alive with the disease. At the same time, quality of life conditional on having the disease has improved. There is virtually no information on the relative roles of lifestyle changes and medical technology on functional status, emotional well being, and other factors contributing to the quality of life with cardiovascular disease. Both elements certainly contribute: less invasive surgeries lead to faster recoveries and are less debilitating, while being in better physical condition improves functional status after a cardiac event.

However, assume for the moment that none of the gain in quality of life is attributable to medical technology - certainly a conservative assumption. Medical technology therefore would need to account for about 15 percent of the remaining change in health capital due to cardiovascular disease in order to be effective for the elderly (.15 x ($76,000-$35,000) = $6,000). Given the findings above, this is likely to be the case, particularly in more recent years. At birth, prevalence increases outweigh additional years of life, so that some improvement from quality would need to be accounted for in order for the increase medical technology to be worthwhile. Thus for a large share of the population, it seems reasonable to conclude that medical spending on cardiovascular disease has been worth the cost.

X.5 The Marginal Value of Medical Care

The results in the previous sections suggest that *as a whole*, medical technology has been worth its cost. That does not imply that *all* of medical technology has been worth its cost, however. All medical care is valuable for some people but less valuable for other people. Our medical care system, however, has not found a good way to give medical care to people who value it a lot while denying it to people who will benefit from care only a little. Patients generally pay little for medical care at the time they are sick, giving them little incentive to limit the care they receive. And providers were historically paid on a fee-for-service basis, so that they earned more when they did more. The result was strong incentives to provide essentially all care with any medical benefit, independent of whether the value of the care was greater than its social cost. In such a situation, one might expect that a lot of medical spending would be found to have low value.

Empirical research has found exactly this. In a number of situations, analysis finds substantial provision of care in situations where the health benefits are small. One set of research examines the impact of being in more and less generous insurance policies on medical spending and health outcomes. The Rand Health Insurance Experiment, for example, randomized people to different insurance plans to measure medical spending and health (Newhouse et al., 1993). The HIE found that people used more medical care in more generous insurance plans, but that additional care did not produce large health improvements. Other researchers have evaluated the impact of the Prospective Payment System in Medicare on medical care costs and health outcomes (Kahn et al., 1991; Cutler, 1995; Staiger and Gaumer, 1996). These studies uniformly find that prospective payment reduced medical inputs – patients were in the hospital for less time and received less care after prospective payment. But again, here were no adverse long-term health impacts from this. Indeed, two of the studies (Cutler, and Staiger and Gaumer) find that for some patients who would have lived only a few months, life expectancy was shorter when payment rates were reduced, but for patients who would have lived as long as one year, there was no adverse health impact.

Another line of research compares medical treatments in different countries (e.g., Rouleau et al., 1993; Mark et al., 1994; McGlynn et al. 1994; Tu et al., 1997), different areas of the country (e.g., Wennberg et al., 1987), and more and less intensive hospitals (e.g., Garber, Fuchs, and Silverman, 1984) to judge the value of more intensive medical care. Uniformly, these studies find a substantial amount of wasted resources. To take just one example, the United States performs coronary bypass surgery for heart attack patients as much as 10 times more frequently as Canada does. But mortality rates in the United States are no lower than they are in Canada, even several years afterwards. While there are some suggestions that quality of life may be greater for the elderly with a heart attack in the United States, it is difficult to escape the conclusion that a substantial amount of bypass surgery that is performed in the United States does not have large medical benefits.[11] Indeed, examination of detailed patient records suggests that as much as 15 percent of bypass surgeries performed in the United States may be performed on patients for whom bypass surgery is not believed to be of any medical value (Winslow et al., 1988).

X.6 Implications

How is it possible for medical care to be worth it as a whole, but for there to be so much waste in the medical system? Consider medical care for a particular type of patient, for example bypass surgery for heart attack patients. Suppose we rank all the patients in order, from those who will benefit the most from bypass surgery to those who will benefit the least.

Figure X.6 shows the relation between the total health benefit from providing bypass surgery and the number of patients treated. The total benefits increase when more patients are treated, but they do so at a declining rate. We imagine that initially the medical care system is at point A. At this point, limiting bypass surgery by a little bit will have very few adverse health consequences, since many people benefit from the care only a small amount. But limiting bypass surgeries will save substantial resources.

Now suppose that over time, physicians get better at performing bypass surgery. Outcomes improve for similar patients. But suppose that as a result of the better outcomes, physicians decide to provide bypass surgery to more patients. We might wind up in point B. More patients are treated in total, and the health benefits are greater, but for the *marginal patient*, the health benefits are still low. In this example, the medical technology change might be worth it *in total* – the move from A to B might be good for society as a whole- but we still overprovide medical resources. If we limited the care provided at point A or point B, we would save substantial spending but only give up small health benefits.

This model has interesting implications for our quiz in the introduction. In this situation, people should want to pay for the additional medical care they can receive in 1998 compared to thirty years ago *and* they should also believe the medical sector is inefficient. There is no inherent conflict between these two views.

But the implication for public policy is less sanguine. Policy makers frequently ask the question: how can we design a health care system that we can afford in the future on our current budget? One is tempted, in such a context, to think about resource budgets, global caps, and the like.

The question presumes, however, that medical spending increases are wasteful. Our results suggest this presumption is incorrect, at least for many types of medical care. A better question for public policy would thus be: how can we design a health care system that keeps the valuable improvements in medical technology but works to reduce the amount of care provided with low value -- independent of how much such a system would cost? This type of question leads to thinking about demand-side incentives, supply-side incentives, and the incentives for new technology.

It is important for sound policy making to ask the right questions -- questions of the type we ask here. Often, policy makers ask the right questions, but the answers they give are not appropriate. When policy begins by asking the wrong question, however, it is difficult to believe that it will ever get the right answer.

References

Aaron, Henry. 1991. *Serious and Unstable Condition.* Washington, D.C.: The Brookings Institution.

Atkinson, Anthony B., and Joseph E. Stiglitz. 1980. *Lectures in Public Economics.* McGraw-Hill.

Bell, Felicitie C., Alice H. Wade and Stephen C. Gross. 1992. *Life Tables for the United States Social Security Area 1900-2080.* Actuarial Study 107. Baltimore, MD: U.S. Social Security Administration, Office of the Actuary.

Cutler, David M. 1995. The Incidence of Adverse Medical Outcomes Under Prospective Payment. *Econometrica* 63 (1): 29-50.

Cutler, David M. and Mark McClellan. 1996. Determinants of Technological Change in Heart Attack Treatment. Mimeograph.

Cutler, David M., and Elizabeth Richardson. 1997. Measuring the Health of the United States Population. *Brookings Papers on Economic Activity: Microeconomics.* 1997: 217-271.

Cutler, David M., and Elizabeth Richardson. 1998. The Value of Health, 1970-1990. *American Economic*

Review 88 (2): 97-100.

Dardis, Rachel. 1980. The Value of a Life: New Evidence from the Marketplace. *American Economic Review* 70 (5): 1077-1082.

Fuchs, Victor. 1982. Time Preference and Health: An Exploratory Study. In Victor Fuchs, ed., *Economic Aspects of Health.* Chicago: University of Chicago Press.

Fuchs, Victor. 1996. Economics, Values, and Health Care Reform. *American Economic Review* 86 (1): 1-24.

Garber, Alan, Victor Fuchs, and James Silverman. 1984. Case Mix, Costs and Outcomes. *New England Journal of Medicine* 310 (19), 1231-37.

Goldman, L. And E.F. Cook. 1984. The Decline in Ischemic Heart Disease Mortality Rates: an Analysis of the Comparative Effects of Medical Interventions and Changes in Lifestyle. *Annals of Internal Medicine* 101 (6): 825-36.

Gramlich, Edward M. 1990. *A Guide to Benefit-Cost Analysis.* 2nd edition, Englewood Cliffs, N.J.: Prentice Hall.

Grossman, Michael. 1972. *The Demand for Health: A*

Theoretical and Empirical Investigation. Columbia University Press.

Hodgson, Thomas. 1997. *Medical Care Expenditures by Diagnosis: Estimates, Data Sources, and Methodology*. National Center for Health Statistics. Mimeograph.

Kahn, Katherine L., et al. 1990. Comparing Outcomes of Care Before and After Implementation of the DRG-Based Prospective Payment System. *Journal of the American Medical Association* 264 (15): 1984-1988.

Mark, Daniel B., et al. 1994. Use of Medical Resources and Quality of Life After Acute Myocardial Infarction in Canada and the United States. *New England Journal of Medicine* 331 (17): 1130-1135.

McGlynn, Elizabeth A., et al. 1994. Comparison of the Appropriateness of Coronary Angiography and Coronary Artery Bypass Graft Surgery Between Canada and New York State. *Journal of the American Medical Association* 272 (12):934-940.

McGovern, Paul G., et al. 1996. Recent Trends in Acute Coronary Heart Disease - Mortality, Morbidity, Medical Care and Risk Factors. *New England Journal* *of Medicine* 334 (14): 884-890.

Moore, Michael J., and W. Kip Viscusi. 1988. The Quantity-Adjusted Value of Life. *Economic Inquiry* 26 (3): 369-388.

Murray, Christopher J.L., and Alan D. Lopez, eds. 1996. *The Global Burden of Disease*. Washington, D.C.: The World Health Organization.

Newhouse, Joseph P. 1992. Medical Care Costs: How Much Welfare Loss? *Journal of Economic Perspectives* 6 (3): 3-21.

Newhouse, Joseph P. 1993. *Free For All? Lessons From the Rand Health Insurance Experiment*. Cambridge: Harvard University Press.

Rouleau, Jean L. 1993. Comparison of Management Patters After Acute Myocardial Infarction in Canada and the United States. *New England Journal of Medicine* 328 (11): 779-784.

Zeckhauser, Richard J. and Donald S. Shepard. 1976. Where now for saving lives? *Law and Contemporary Problems* Autumn 1976: 5-45.

Staiger, Doug, and Gary Gaumer. 1996. The Effect of Prospective Payment on Post-Hospital Mortality.

Mimeograph.

Sytkowski, Pamela A., et al. 1990. Changes in Risk Factors and the Decline in Mortality from Cardiovascular Disease. *New England Journal of Medicine* 322 (23): 1635-1641.

Sytkowski, Pamela A., et al. 1996. Sex and Time Trends in Cardiovascular Disease Incidence and Mortality: The Framingham Heart Study, 1950-1989. *American Journal of Epidemiology* 143 (4): 338-350.

Tolley, George, Donald Kenkel, and Robert Fabian, eds. 1994. *Valuing Health for Policy: An Economic Approach.* Chicago: University of Chicago Press.

Torrance, George W. 1986. Measurement of Health State Utilities for Economic Appraisal. *Journal of Health Economics* 5: 1-30.

Tu, Jack V., et al. 1997. Use of Cardiac Procedures and Outcomes in Elderly Patients with Myocardial Infarction in the United States and Canada. *New England Journal of Medicine* 336 (21): 1500-1505.

Wennberg, John E., J.L. Freeman, and W.J. Culp. 1987. Are Hospitals Services Rationed in New Haven or Over-Utilized in Boston?. *Lancet* 1 (8543) : 1185-

1188.

Winslow, Constance M., et al. 1988. The Appropriateness of Performing Coronary Artery Bypass Surgery. *Journal of the American Medical Association* 260 (4) : 505-510.

Table X.1: Lifetime Medical Spending

Discount rate	1950	1970	1990
Age 0			
3 percent	$7,800	$19,500	$44,600
0 percent	23,900	65,000	181,700
6 percent	3,800	9,200	19,700
Age 65			
3 percent	4,000	14,100	59,200
0 percent	5,400	20,400	85,700
6 percent	3,100	10,500	43,700

Note: Spending is in 1990 dollars.

Table X.2: Disease Incidence and Quality of Life

Condition	Prevalence 1970	Prevalence 1990	QALY Weight 1970	QALY Weight 1980	QALY Weight 1990
Amputee	6.1	6.0	0.87	0.88	0.89
Arthritis[a]	111.8	127.8	0.69	0.74	0.79
Blindness	8.6	2.0	0.73	0.80	0.87
Other vision	48.0	30.2	0.84	0.88	0.93
Cancer[b]	11.1	18.7	0.70	0.70	0.70
Cardiovascular disease[a]	64.7	99.3	0.57	0.64	0.71
Diabetes[a]	45.9	54.3	0.65	0.65	0.66
Hearing	80.9	91.2	0.91	0.92	0.93
Orthopedic[a]	102.1	135.0	0.70	0.79	0.88
Paralysis[a]	7.4	7.1	0.62	0.65	0.68

Note: Prevalence is adjusted for the change in the age- and sex-mix of the population.

[a] There are also interactions for these QALY estimates which are not reported.

[b] QALY estimate is based on review of literature rather than model estimate.

Table X.3: Coefficient Estimates

Disease	1979-81 Coef.	1979-81 Std. Err.	1989-91 Coef.	1989-91 Std. Err.
Musculoskeletal				
Arthritis	-.608	(.010)	-.578	(.010)
Skin conditions	-.293	(.010)	-.315	(.009)
Endocrine				
Diabetes	-.809	(.018)	-.927	(.018)
Other endocrine	-.546	(.012)	-.518	(.009)
Diabetes * Hrt Dis	.340	(.060)	.348	(.055)
Diabetes * Stroke	.546	(.093)	.374	(.076)
Circulatory				
Hypertension	-.423	(.010)	-.375	(.010)
Ischemic heart disease	-.856	(.019)	-.814	(.018)
Stroke	-.780	(.040)	-.692	(.033)
Other circulatory	-.613	(.010)	-.541	(.010)
Respiratory				
Asthma	-.779	(.017)	-.708	(.014)
Bronchitis	-.495	(.023)	-.370	(.019)
Sinusitis	-.141	(.013)	-.192	(.012)
Other respiratory	-.461	(.012)	-.313	(.011)
Digestive	-.661	(.012)	-.656	(.011)
Impairments				
Hearing	-.192	(.015)	-.200	(.010)
Amputee	-.280	(.038)	-.301	(.023)

Table X.3 cont'd.

	1979-81		1989-91	
Disease	Coef.	Std. Err.	Coef.	Std. Err.
Paralyzed	-.825	(.034)	-.873	(.034)
Orthopedic	-.494	(.010)	-.333	(.008)
Other impairments	-.575	(.019)	-.340	(.018)
Vision Impairments				
Blind	-.474	(.038)	-.356	(.050)
Glaucoma	-.080	(.041)	-.094	(.031)
Cataract	-.026	(.030)	-.073	(.022)
Bad Eyesight	-.272	(.021)	-.201	(.020)
Age and Sex				
Age	-.018	(.0005)	-.011	(.0004)
Age^2	.0001	(.000006)	$-5x10^{-7}$	(.000005)
Sex	-.051	(.012)	-.028	(.011)
Sex*Age	.012	(.0007)	.010	(.0006)
$Sex*Age^2$	-.0002	$(8.6x10^{-6})$	-.00014	(.000007)
Break Points				
Cut 1	-2.89	(.010)	-2.98	(.010)
Cut 2	-1.92	(.009)	-2.13	(.008)
Cut 3	-.56	(.008)	-1.10	(.008)
Cut 4	---	---	-.28	(.008)
Summary Statistics				
N	312,365		333,708	
ln(Likelihood)	-292,294		-406,65	

Note: Model is estimated as an ordered probit. Model also includes a race dummy variable. In 1990, self-reported health is divided into: excellent; very good; good; fair; and poor. In 1980, there was no category for very good.

Table X.4: Health Capital

Discount Rate	Years of Life Approach (thousands of dollars) 1950	1970	1990	Quality of Life Approach (thousands of dollars) 1970	1990
Age 0					
3 percent	$2,768	$2,823	$2,900	$2,350	$2,444
0 percent	6,838	7,100	7,508	5,002	5,389
6 percent	1,564	1,586	1,613	1,426	1,464
Age 65					
3 percent	$736	$844	$1,003	$590	$759
0 percent	965	1128	1369	740	987
6 percent	585	661	773	486	608

Note: Calculations assume the value of life is $100,000 per year in perfect health.

Table X.5: The Costs and Benefits of Changes in Medical Spending

	Years of Life Approach (thousands of dollars)		Quality of Life Approach (thousands of dollars)
	1950-1990	1970-1990	1970-1990
Age 0			
Change in health capital	$132	$77	$95
Change in medical spending	37	25	25
Effectiveness ratio	29% [24%, 33%]	33% [29%, 39%]	27% [30%, 28%]
Age 65			
Change in health capital	$267	$159	$169
Change in medical spending	55	45	45
Effectiveness ratio	21% [20%, 22%]	28% [27%, 30%]	27% [26%, 27%]

Note: Calculations assume the value of a year in perfect health is $100,000 and the real discount rate is 3 percent. The effectiveness ratio is the share of the increase in health capital that needs to result from medical spending for the increase in spending to have a positive benefit-cost margin. The numbers in [.] are the effectiveness ratio assuming a 0 percent discount rate and a 6 percent discount rate.

Table X.6: Contributions of Specific Diseases to the Costs and Benefits of Changes in Medical Spending

	QALY Approach, 1970-1990 (thousands of dollars)	
	Cardiovascular Disease	Cancer
Age 0		
Change in health capital	$5	-$2
Mortality effect	9	2
Prevalence effect	-23	-4
QALY effect	18	---
Change in medical spending on disease	3	3
Effectiveness ratio	64%	--
Age 65		
Change in health capital	$69	-$12
Mortality effect	76	-2
Prevalence effect	-35	-10
QALY effect	28	---
Change in medical spending on disease	6	4
Effectiveness ratio	8%	--

Note: Change in health capital is the sum of the mortality, prevalence and QALY effects.

Calculations assume the value of a year in perfect health is $100,000 and the real discount rate is 3 percent. The effectiveness ratio is the share of the increase in health capital that needs to result from medical spending for the increase in spending to have a positive benefit-cost margin.

Notes

1. For a more detailed analysis of these issues, see our related papers (Cutler and Richardson, 1997, 1998).

2. This is based on the empirical observation that many people express a preference for saving the lives or lifeyears of middle-aged people more than the very young or very old. Murray and Lopez explicitly rule out variation by other factors such as income or the number of dependents an individual is supporting. The exclusion of these criteria in valuing people is made on *a priori* grounds.

3. Prior to 1982, very good was omitted.

4. For a more detailed discussion of this issue, see Cutler and Richardson (1997).

5. We tested the importance of this change by combining the "very good" and "good" categories in the 1989-91 model. The resulting QALY estimates were virtually identical to those shown for 1989-1990 in Table 2.

6. Since the NHIS does not ask about cancer, we use a quality of life weight from the literature (0.7) and assume it is constant over time.

7. See Viscusi (1993) and Tolley et al. (1994) for a review. Neumann and Johannesson (1994), O'Brien and Viramontes (1994) and Johansson (1996), among others, provide examples of estimating the value of life and present further discussion of the

methodology.

8. Ramsey (1928) argued for a social discount rate of 0, citing no ethical reason why future utility ought to be less than current utility.

9. Assuming 40 years of work beginning at age 22.

10. Of course, this ignores any effect of previous treatments of cancer helping with future gains in cancer quality of life.

11. Although few studies have measured quality of life differences across countries.

Figure captions:

Figure X.1 (a): Life expectancy at birth

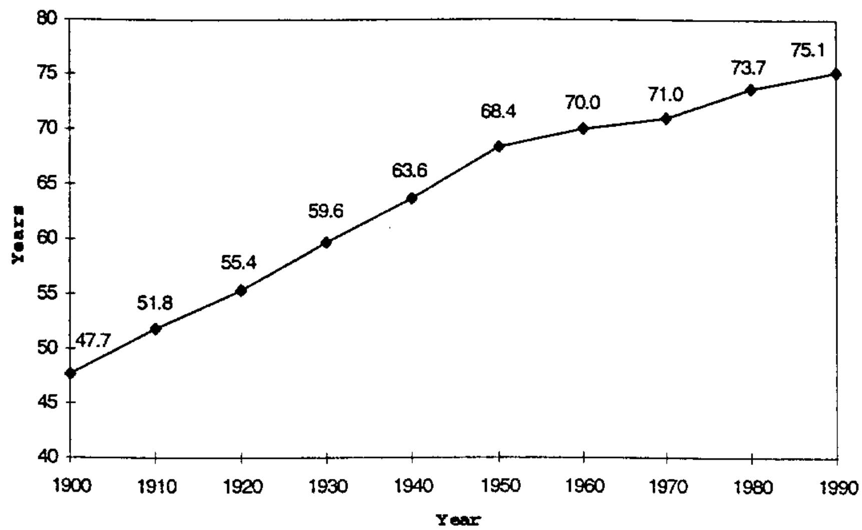
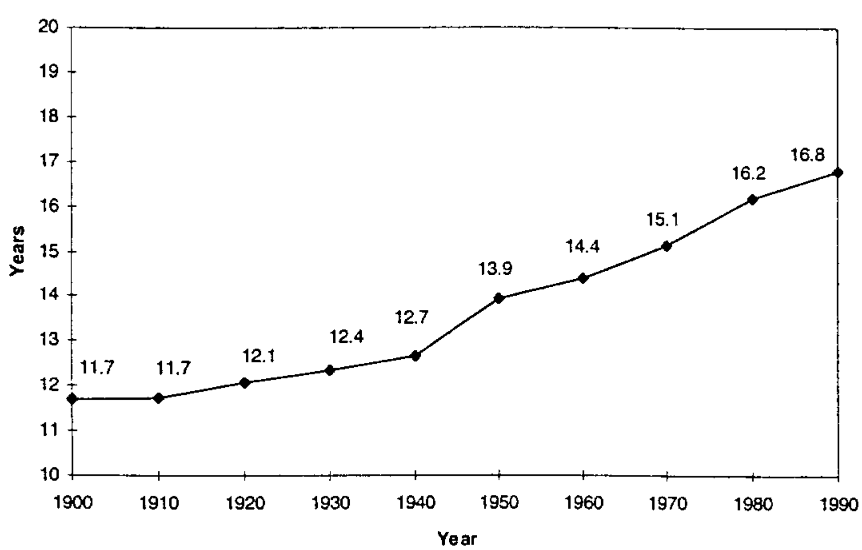
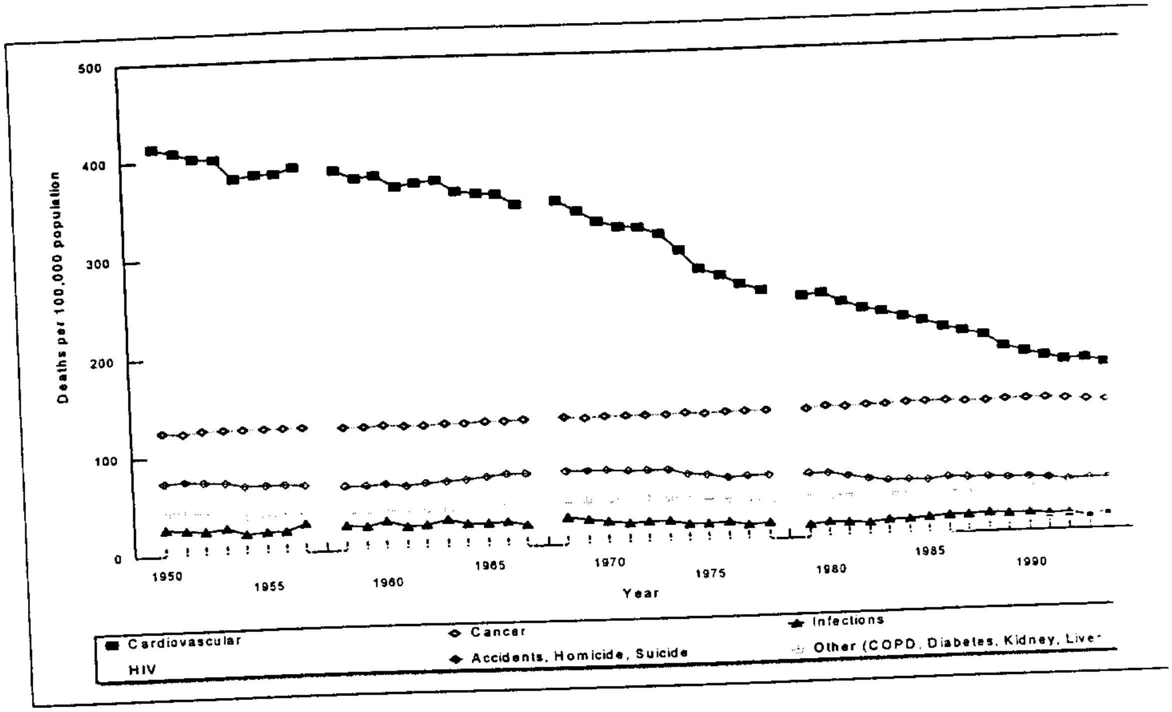


Figure X.1 (b): Life expectancy at 65



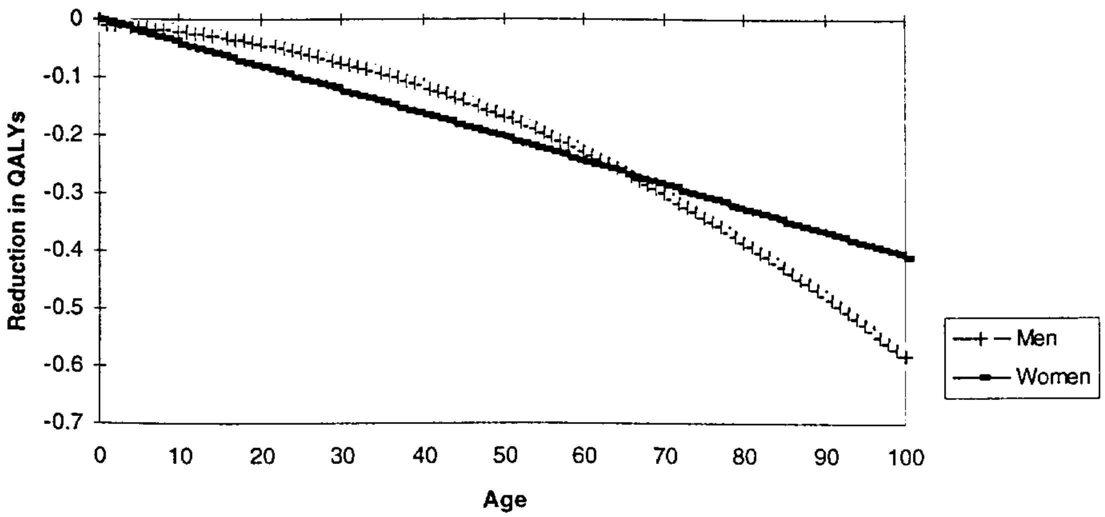
Source: Bell, Wade and Gross (1992).

Figure X.2: Mortality by cause of death, 1950-1994



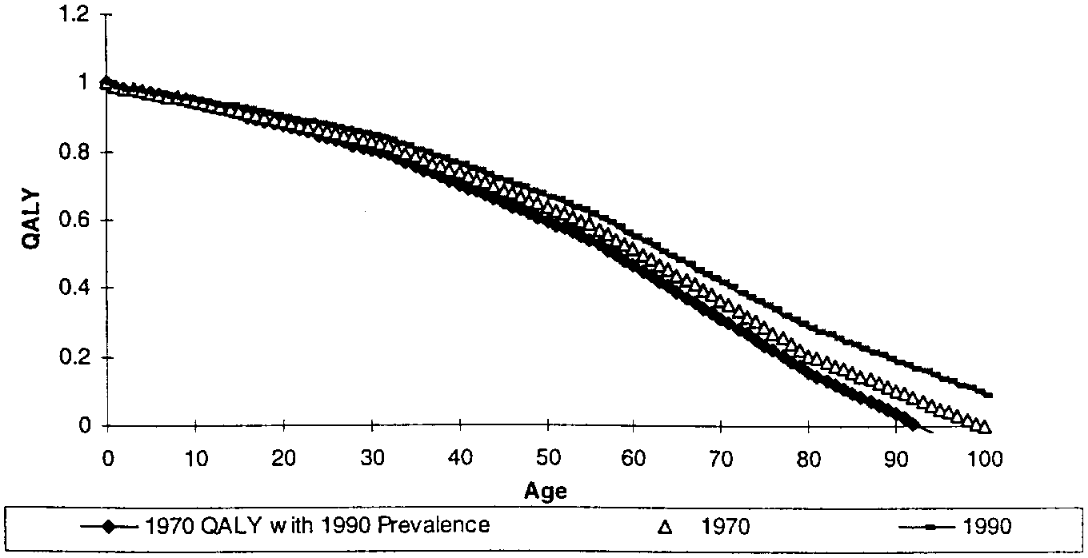
Source: National Center for Health Statistics, unpublished data

Figure X.3: Implied quality of life age factors



Source: Authors' calculations.

Figure X.4: Expected QALYs by age



Source: Authors' calculations.

Figure X.5 (a): Health capital at birth

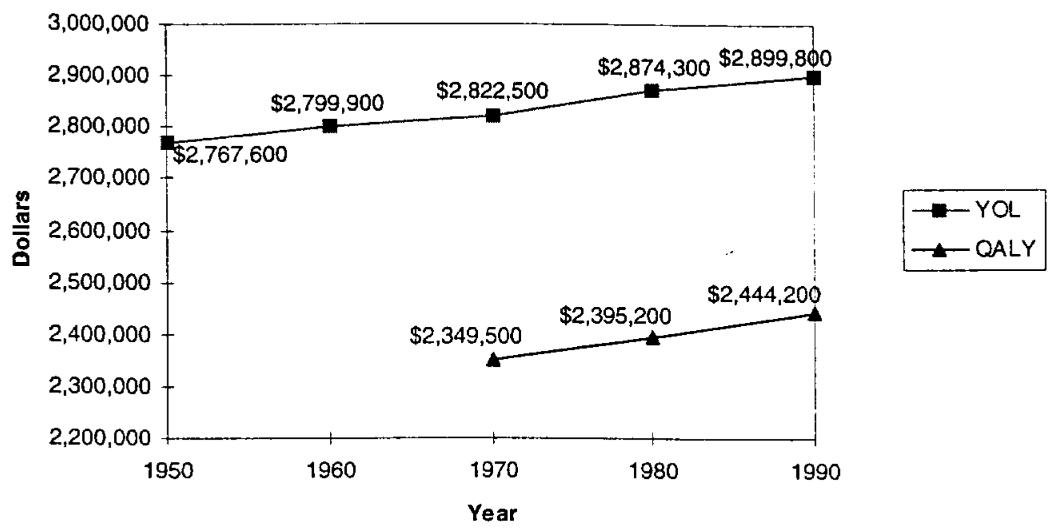
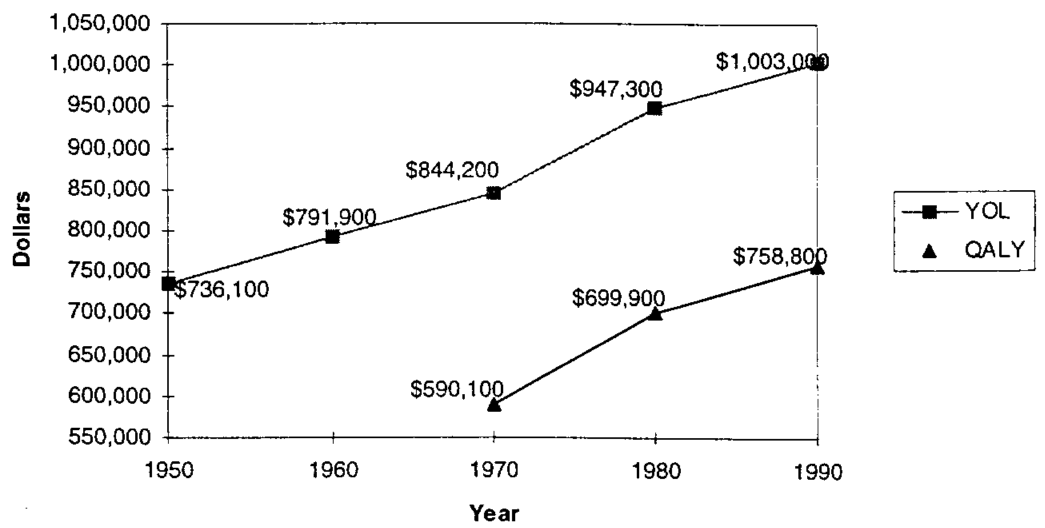


Figure X.5 (b): Health capital at 65



Note: Authors' calculations. Assumes a 3 percent discount rate.

Figure X.6: The Relation Between Medical Care and Health