DO HEALTH AND LONGEVITY CREATE WEALTH?

By

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Preface

"Health is the greatest wealth."

Virgil (70 - 19 B.C.)

Health, of course, is vital for productivity and quality of life, and it is understood that as society accumulates more wealth it can provide better health benefits for its people. But health as a driver of the economy is a relatively new concept within scholarly and economics circles. In recent years, many of the foremost schools of economic thought—among them the Rand Corporation and the Universities of Chicago, Belfast, Harvard, and Yale—have come to recognize health as a critical driver of the economy.

During his tenure as an economist at the International Longevity Center-USA, Anthony Webb undertook an intensive exploration of the existent scholarly literature on the connection between health and wealth. The resulting report is a thoughtful and carefully nuanced examination of the subject. Dr. Webb discusses trends in disparities in health and longevity, and the evidence regarding whether health and longevity do indeed create wealth. Consideration is given to the impact of improvements in health and increases in longevity on the level of investment in both human and physical capital, as well as the impacts, both direct and indirect, of health on labor productivity and wealth accumulation.

The International Longevity Centers of Great Britain, France, and the United States developed the Alliance for Health & the Future to focus upon issues that relate to Europe. We believe the concept "health creates wealth" counters the widely held notion that longevity and population aging are economic threats that put a drain on society. Furthermore, we believe it is time to recognize that health results in productive engagement throughout life. The growing industries that serve older people, such as health care, pharmaceuticals, living arrangements, and financial services, offer a very different way of thinking about our future.

As Robert Fogel, 1993 Nobel laureate in economics, noted, "The railroad was the economic driver in the nineteenth century, the automobile [and oil] in the twentieth, and health care innovation will be in the twenty-first."

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INTRODUCTION

Historical background

The past 200 years have seen enormous increases in life expectancy at birth. These increases began in Northwestern Europe and have become worldwide, so that with the exception of sub-Saharan countries affected by AIDS, tuberculosis, and malaria, life expectancy at birth in almost all countries today is at least double that achieved in Northwestern Europe in the eighteenth century. Although there have been recent declines in life expectancy in sub-Saharan Africa and the former Soviet Union, many demographers believe that life expectancy will continue to increase in coming decades, even in those societies with the greatest longevity. Longer term, there is disagreement as to the potential for increases in human longevity.

Increases in longevity need not be associated with improvements in the average health of the population. It is possible that they could be associated with a decrease in the average level of health if people who would otherwise have died now survive in poor health. It is not a straightforward matter to determine whether average health is improving or declining. Whereas measuring past trends in mortality merely requires accurate records of births and deaths, measuring trends in health requires not only the application of medical diagnostic skills that may have improved over time, but also that account be taken of the changing pattern and effects of disease and changes in the age structure of the population. Diseases that were once debilitating or fatal may now be curable or at least manageable so that statistics on the incidence of a particular disease, even if they are reliable and even when adjusted for changes in the age structure of the population, may give a misleading indication of the burden of that disease on that population.

It is well known that there have been dramatic reductions in the incidence of many acute infectious diseases. The evidence that I will present shows that there have also been dramatic reductions in the incidence, increases in the average age of onset, and progress in the treatment of many of the chronic diseases of old age.

Why study the relationship between health, wealth, and longevity?

There is good reason to anticipate that improvements in health and increases in longevity will have profound economic consequences, affecting health care costs, labour-force participation rates, worker productivity, and the financing of both funded and pay-as-you-go pension systems, to name just a few of the most obvious.

Countries are at widely differing stages of the "demographic transition," the transition from high birthrates and short life expectancy to low birthrates and much greater life expectancy. One of the earliest life tables that I have seen is based on data collected in Northampton, England, in the year 1793, and it shows an infant mortality rate, the probability that a child will die before its first birthday, of 26 percent.[1] Fogel (1994) tells us that, in the

eighteenth century, life expectancy and general health were even worse in countries such as France. No country today has an infant mortality rate even approaching that level, and all countries are at least along the path to low mortality and low fertility.[2] However, no country has yet reached a steady state in which both fertility and mortality rates have stabilised, and in which the effects of past changes are no longer significantly affecting the age distribution or the rate of growth of the population.[3] An understanding of the economic consequences of demographic changes can therefore help all countries predict and plan for the future.

Improvements in health and longevity have been associated with dramatic increases in health care expenditure, not only in dollar terms but also as a percentage of gross national product. But this does not necessarily mean that the improvements in health and longevity are causing the increase in medical expenditures. As societies become richer, they will naturally choose to spend part of their increased income on additional medical care. In economic parlance the "income elasticity of demand" for health care, the percentage increase in health care expenditures divided by the percentage increase in income, is greater than zero.

Improvements in medical technology may also shift the demand curve, although economic theory is ambiguous about whether this will lead to an increase or a decrease in health care expenditure. Improvements in medical technology may lower the cost of a medical procedure. People will respond to the reduction in price by demanding more of the procedure and possibly substituting that procedure for other similar procedures. If the "price elasticity of demand" for the procedure, the percentage increase in the quantity consumed divided by the percentage reduction in the price, is greater than one, then total expenditure will increase. If it is less than one, total expenditure will decrease.

New medical interventions may also enhance the range of treatment possibilities. To the extent that previously unavailable treatments are undertaken, then health costs will rise, but new medical technology may also substitute for older and less effective or more expensive technologies.

Average medical expenditures increase with age, so one might conclude that increased longevity will result in an increased demand for medical care. But average medical expenditures may, in fact, be more closely related to proximity to death than to age. Furthermore, improvements in age-specific levels of health may shift any residual relationship between age and medical expenses so that, over time, people of any given age need less health care. Although we observe increases in both longevity and health care expenditure in time series data, this correlation does not imply causality, and a proper analysis needs to take account of all the factors referred to above.

These health care expenditures have an "opportunity cost," the other desirable goods and services on which the money could alternatively have been spent. It is therefore reasonable to ask whether the health and longevity benefits have exceeded the costs and whether we spent too much or too little on health care.

But why do we pose these questions in relation to health care and not, with the same force, in relation to other categories of expenditure? Health care differs from many other goods and services in that the amount an individual pays for health care depends only to a very limited extent on the quantity of care he or she consumes. There are many reasons why this is so. Considerations of equity between the sick and the healthy may influence government policy toward the financing of health care, as might concerns about the efficiency of private health insurance markets. Also there are very likely substantial positive externalities associated with health care.

For example, vaccination programs not only reduce the probability that an individual becomes infected with a disease, but also may confer "herd immunity," a reduction in the incidence of the disease among the whole population, the benefit of which does not accrue exclusively to the individual who is vaccinated. A healthy individual may earn more than someone who is unhealthy, and the government may capture part of the additional earnings through the tax system. These externalities may result in the individual investing less than the socially optimal amount in his health care and suggest a role for government in subsidising its provision. More recent evidence, discussed in this paper, suggests the existence of a potentially even more important positive externality, namely that good health can also substantially enhance a country's rate of economic growth.

But all expenditures have an opportunity cost: the other desirable goods and services on which the money could have been spent. It is therefore legitimate to ask whether the "right" amount is being spent on health care, inclusive of administrative, billing, and marketing costs, and whether, at the margin, health care benefits, evaluated in terms of improved health, increased longevity, and more rapid economic growth, exceed expenditures.[4]

Organisation of the paper

The remainder of this paper is organised as follows. In Section 2, I define health, wealth, and longevity. In Section 3, I discuss trends in longevity, health, and wealth over the past 200 years. I focus not only on averages but also on trends in disparities in health and longevity. In Section 4, I consider the evidence as to whether health and longevity do indeed create wealth. I review the literature on the relationship between health, longevity, and health care expenditures and examine the claim that increases in health expenditures are the result, as well as the cause, of increased longevity. I then consider the direct and indirect impacts of health on labour productivity and wealth accumulation. Concerns are often expressed about the impact of increased longevity on the dependency ratio, the ratio of those aged 18 to 64 to those aged under 18 and over 64. I consider whether these concerns are justified.

I also consider the literature that attempts to put a value on the outputs of health care expenditures—the improvements in health and additional years of life that the expenditures buy and whether the returns justify the costs. I then consider the impact of improvements in health and increases in longevity on the level of investment in both human and physical capital and the economic consequences of the "demographic dividend," the temporary reduction in the dependency ratio that is a demographic consequence of the transition from high to low mortality and fertility. Finally, I say a few words about the impact of population aging on the structure of the economy.

Section 5 concludes. I argue that concerns about projected increases in the dependency ratio are largely mistaken. I also argue that although we are right to be concerned about inefficiencies and misallocations of resources in the health care system, on average, we get a good return on our investment. I argue that, on average, but not necessarily at the margin, health care expenditures offer a handsome return in terms of increased wealth, to say nothing of the enormous value that, under any plausible method of accounting, one might place on the additional years of health and life.

2. DEFINING AND MEASURING LONGEVITY, HEALTH, AND WEALTH

Defining and measuring longevity

In advanced industrial countries, reliable mortality records go back almost 200 years. For example, the United Kingdom established a national system of registration of births and deaths in 1837.

Demographers usually measure longevity in terms of life expectancy at birth, either of a population alive at a particular time or of a population born in a particular year, the former being recorded in a period life table and the latter in a cohort life table. We don't actually know the average longevity of a particular birth cohort until the last member of that cohort has died. Calculations of the life expectancies of more and more recent birth cohorts therefore increasingly depend on forecasts of trends in mortality rates.

Societies with similar life expectancies at birth can have quite different mortality profiles with quite different economic consequences. The death of an infant is a personal tragedy for the family, but its economic consequences are much less than those that result from the death of a prime-age worker. Infant mortality rates were extremely high in the nineteenth century, so that remaining life expectancy at 1 year of age was actually greater than life expectancy at birth. Individuals surviving early childhood had a good chance of surviving to late middle age. Social Security Administration cohort life tables show that an American male born in 1850 stood a 14.6 percent chance of dying before his first birthday, but that having attained age 20 (in 1870), he could expect to live to 61.9 years of age. Mortality rates at all ages were far higher among the poor than among the better off. In contrast, sub-Saharan Africa achieves similar life expectancy with lower infant mortality rates, but higher mortality rates among prime-age workers, together with a reversal of the usual inverse relationship between adult mortality and socioeconomic status.[5]

Defining and measuring health

Defining health is much more difficult. One might define it in terms of the presence or absence of particular diseases. But if we are to make a comparison between countries or over time, we must take account of changes in the pattern of disease. Furthermore, the consequences of diseases have changed dramatically, with improvements in disease management and in the services available to the infirm. A person who has a particular disease may justifiably regard himself as being in good health if the disease is not life threatening, if its symptoms can be controlled, and if it has no effect on his ability to perform activities of daily living (ADLs).

An alternative measure of the burden of disease is the effect of ill health on individuals' abilities to perform ADLs or to pursue their chosen occupation. But the consequences of many disabilities depend on the support available to the individual and on the consequences for the individual of being unable to perform particular ADLs. For example, the consequences of being unable to climb stairs very much depend on whether one's building has an elevator. The consequences of many disabilities may be less serious today as a result of the reduction in the proportion of occupations requiring manual labour and the proliferation of labour-saving devices.

There are also particular problems when comparing countries and time periods. Some diseases may be asymptomatic and will remain undiagnosed in the absence of a medical examination. But the likelihood of an individual receiving a medical examination may vary across countries, and with age, birth cohort, gender, socioeconomic status, and the individual's assessment of the affordability and efficacy of any possible treatment. Techniques of medical diagnosis have improved over time and will vary across countries. Social surveys rarely have the resources to conduct medical examinations of their participants and must rely on self-reported health data. Data that includes medical records will, with rare exceptions, identify only the presence of illness in those who have chosen to seek medical advice.

A particular problem is the interaction of longevity with disease. An intervention that prolongs the life of an individual will reduce the average health of the whole population if that individual's health status following treatment is worse than that of the remainder of the population. We cannot assume that improvements in health care will improve average health. For example, improvements in postnatal care may improve the average health of infants who would have survived anyway but may also result in the survival of infants in very poor health who would otherwise have died. The extent to which one effect dominates the other will be determined both by the available technology and also by the choices that are made as to the circumstances in which that technology should be applied. Expenditure on health care may be having substantial beneficial effects on mortality and on the health of people who would have survived anyway, even at a time when the average health of the surviving population appears to be declining.

The World Health Organization (WHO) measures "health-adjusted life expectancy" (HALE), defined as the number of years or the percentage of life that the average individual in various countries can expect to survive in full health given current mortality and disability rates. Their data suggests that, at least on a between-country comparison, increased longevity is resulting in a compression of morbidity in both relative and absolute terms. With some exceptions, people in long-lived societies not only spend a dramatically smaller proportion of their lives in ill health but also spend fewer years in ill health. For example, WHO data show that men in Japan and France can expect to live to 73.6 and 71.3 years, respectively, yet will spend only 8.3 and 8.7 percent of their lives in ill health, or 6.6 and 6.5 years, respectively. In contrast, men in Brazil can expect to spend 13 percent of their lives, or 9.8 years, in ill health. The main exception to the rule that low mortality is associated with fewer years in ill health is in sub-Saharan Africa, where, due to the AIDS epidemic and until recently the absence of effective treatment, people typically spend an extremely small proportion of their short lives in ill health.

In addition to focusing on changes in the average health of a population, one may also wish to examine changes in health disparities, for example between men and women, between people of different socioeconomic classes, and in the evolution of health status throughout the life course. A significant problem here is that people in poorer health and in lower socioeconomic classes experience higher mortality. Differential mortality can result in biased estimates of the relationship between health status and socioeconomic class.

Defining and measuring wealth

Wealth can be regarded as either a stock, the capital value of all the net assets owned by the individual or society; or a flow, the annual income that those assets produce. A comprehensive measure of wealth might include human capital, the aggregation of personal attributes and investments in education and on-the-job training that enhance an individual's productivity. Grossman (1972) introduced the concept of health capital, a component of human capital, the collection of skills and attributes that enhance an individual's productivity.[6] Individuals can be thought of as being endowed at birth with an initial amount of health capital. They and their family can maintain or enhance this initial capital through investment in "health preventive activities," activities that maintain or enhance their health status, or they can deplete initial capital through activities that are deleterious to their health.

Health capital not only enhances an individual's productivity but also has an intrinsic value, and

a proper accounting of the costs and benefits of improvements in health and increases in longevity should take account of that value.

Calculating an individual's or a society's stock of wealth is not a straightforward matter. The capital values of some assets, for example human and health capital, are not readily observable because the relevant markets are limited or nonexistent. But the absence of a market doesn't mean that the asset has no value or should be disregarded in an accounting of costs and benefits. We can infer the values that people place on such nontraded assets from the decisions that they make over such matters as occupational choice. I return later to discuss the appropriateness of the methodologies customarily used.

The capital values of other assets will depend not only on the income or cash flow they currently produce, but also on expectations about future increases in income and on the interest rate at which one discounts the anticipated cash flow or income. Some assets, for example domestically held government bonds, may represent assets of some members of society but have zero net value to society as a whole. Accounting for Social Security and other pay-as-you-go pension entitlements is particularly difficult.[7] The expected present value of a household's current or future entitlement to Social Security is a financial asset, even though the household can neither sell it nor borrow against it. However, prior to retirement, households also hold a liability, in the form of the expected present value of their future contributions, and even after retirement the value that a household places on its Social Security entitlement may be reduced by the net burden, if any, that Social Security places on their children.

In view of these issues, it may sometimes be easier to measure the wealth of an individual or society in terms of the income flow that the stock of wealth produces. One commonly used measure of the flow of income in a country is per capita gross national product (GNP), the sum of the market value of all the goods and services produced in the country in a given year, divided by population. Some assets are not income producing, and although statisticians impute income for some such assets, for example owner-occupied housing, they do not do so for others, for example public infrastructure. The equivalent measure of a particular household's flow of wealth is simply that household's income, again after inputting income from owner-occupied assets.

The major disadvantage of these flow-based measures of income is that they tell us little about the sustainability of the income, either at a national level, where revenues from the extraction of nonrenewable resources are counted as income, or at a household level, where individuals may be approaching ages at which they may be either unable or unwilling to continue working.

Each measure has its particular strengths and weaknesses and may be more appropriate for particular analyses. For example, per capita GNP is possibly the most appropriate yardstick of the financial wealth of a society, although it takes account of health capital only to the extent that it is reflected in the value of output. Broad-based measures of wealth, including the financial assets, housing, and the present value of employer pensions and Social Security, are probably the best measure of the wealth of individual households entering or already in retirement.

In addition to per capita GNP, one may wish to consider the distribution of income and how changes in health disparities might affect the distribution of income and wealth.

3. TRENDS IN LONGEVITY, HEALTH, AND WEALTH

Trends in longevity

In Northwestern Europe and the United States, reliable mortality records date back to the early nineteenth century, and in some countries, for example Sweden, even earlier. In the United States, the average life expectancy at birth of men and women was around 33 years in the eighteenth century. According to Social Security Administration data and forecasts, male and female life expectancy was 46.6 and 49.4 years, respectively, for the 1850 birth cohort, 51.5 and 58.3 years for the 1900 birth cohort, and is projected to be 72.2 and 78.6 years for the 1950 birth cohort and 79.9 and 84.4 years for the 2000 birth cohort. Although mortality rates increased in both Britain and the United States in the middle of the nineteenth century, the pattern otherwise is one of continuing reductions in mortality.[8] The earlier improvements resulted from reductions in mortality at younger ages, particularly infant mortality, and more recent improvements resulted primarily from reductions in mortality at more advanced ages. To illustrate, Cutler and Meara (2001) calculate that in the first four decades of the last century 80 percent of life expectancy improvements resulted from reduced mortality for those below age 45, with the bulk of this for infants and children. In the last four decades, about two-thirds of the improvements resulted from reductions in mortality among those over age 45.

There is a debate between mathematical and biological demographers as to whether we are approaching some natural limit to human longevity. Biological demographers argue that there are biological limits to human longevity and that we are approaching those limits and should expect a deceleration in the rate of increase of average longevity. Mathematical demographers, while conceding the existence of biological limits to longevity, often argue that, at least for short- and medium-term projections, the best forecasts are those derived from an analysis of the pattern and determinants of past increases in longevity. Thus Wilmoth (2000) argues that there is a highly stable trend toward increasing longevity and that the best forecast of life expectancy in the middle of the twenty-first century is obtained by an extrapolation of past trends, whereas Olshansky, Carnes, and Cassel (1990) postulate that we are approaching biologically fixed limits to human longevity. Olshansky believes that average life expectancy will not attain 100 years anytime soon, if indeed it ever does. Although similar claims have proved to be incorrect in the past, this does not mean that Olshansky's current forecast will likewise transpire to be mistaken. Olshansky has famously made a $500 million wager, payable in 2150, with biologist Stephen Austad that someone already born will live to be 150 by 2150.

Analysis of Social Security Administration period life tables suggests that mortality improvements among older women in the United States have stabilised and possibly even been reversed over the past 20 years. My analysis of these tables shows that in 1900, a woman who was lucky enough to survive to age 80 stood a 14 percent chance of dying before her 81st birthday. By 1950, 1980, and 1990, the probabilities had dropped to 8.7, 6.2, and 5.6 percent, respectively, but by 2000 the death rate had crept up to 5.7 percent. More significant than the magnitude of the increase is the bend in the trend, the fact that an apparently steady pattern of mortality reductions has come to an end.

What is puzzling is that the pattern of mortality reductions has come to an end during a period in which there has been substantial progress in the treatment of coronary heart disease, which is a

major cause of premature death. Some commentators attribute the cessation of mortality reductions to increasing obesity. More speculatively, it is possible that reductions in the mortality risk associated with risky behaviours, such as eating too much or indulging in unsafe sex, encourage those behaviours, with people choosing to take part of the benefit of medical progress not in the form of lower mortality but in the form of the adoption of riskier and preferred lifestyles.

Trends in health

I have already referred to the difficulties involved in calculating the extent of improvements in health. Using Union Army veteran records, Fogel (2004) shows that, among males of any given age, there have been dramatic declines in the incidence of chronic disease and that there have also been increases in the average age of onset.[9] Costa (2000) compared the incidence of five functional limitations among men aged 50 to 74 in 1988 to 1994 with their incidence among Union Army veterans of the same age a century earlier. She found that the incidence of these functional limitations had declined by around 40 percent over the twentieth century. She attributed 37 percent of the decline to reductions in the incidence of chronic ill health, and 24 percent to reductions in the effects of such ill health. Keppel et al. (2002) find that further reductions in many health disparities were achieved over the period 1990 to 1998.

Cutler and Meara (1999) document significant declines during the period 1984 to 1994 in the proportion of elderly men that is severely disabled. Among those 65–69, the proportion that was severely disabled (defined as having three or more ADLs or being institutionalised) dropped from 10.4 to 9.5 percent. But among those aged 80–84, it dropped from 37.6 to 30.3 percent, and among those aged 85-plus, it dropped from 63.7 to 57.1 percent.

Trends in wealth

Over the course of the twentieth century, per capita GDP in the United States has increased somewhat more than fivefold, the increase in the United Kingdom being somewhat less. Percentage increases in per capita GDP in Japan and most of Western Europe have been even greater. According to Maddison (1995) and IMF staff estimates, at constant 2000 prices per capita GDP in the United States rose from $4,096 in 1900 to $27,272 in 2000. In Japan, it rose from $1,135 to $20,616, and in the United Kingdom from $4,593 to $19,704. In the United States and the United Kingdom, these increases followed a century of less rapid GDP growth. Over the course of the nineteenth century, per capita GDP in the United Kingdom grew at an average rate of about 1.2 percent, so per capita GDP in the United Kingdom at the start of the Industrial Revolution probably amounted to about $1,360 in 2000 dollars, somewhere near where it is today, in purchasing power parity terms, in much of sub-Saharan Africa.

With some notable exceptions, there had been a decline in the relative incomes of those countries that were already poor in 1900. Although economists have, for many years, constructed within-country income distributions, it is only recently that a similar calculation has been attempted on a global basis. Sala-i-Martin (2002) calculates that, over the period 1980 to 1998, global inequality has actually declined due largely, but not solely, to rising real incomes in China.

However, the above calculations of growth in per capita GDP do not take into account reductions in mortality and cross-country convergence in mortality rates. In 1900, life expectancy at birth in the United States was 51.5 years for men and 58.3 years for women. In 2000, the only non–sub-Saharan African countries that had not attained this level of life expectancy were

Afghanistan, Haiti, Bhutan, and Laos, yet many countries had yet to attain the level of per capita income that the United States had achieved in 1900. As I will show later, if one includes in GDP the value of mortality improvements, then there has, in fact, been a substantial reduction in global income inequality over the course of the last century.

Trends in within-country disparities in longevity, health, and wealth

Socioeconomic and racial differences in mortality have been substantially reduced, but not eliminated, over the course of the twentieth century. Fogel (2004) calculates that the disparity between the highest and lowest infant mortality rates among 120 wards in six U.S. cities declined by 83 percent over the first half of the twentieth century. He also reports similar reductions in disparities in British life expectancies at birth.

Fogel argues persuasively that adult height is a good indicator of health status and that relative height is a good measure of relative health status. Using army records, Steckel (2001) documents the changes in average adult height that have occurred over the past millennium. As is well known, average height has increased considerably over the last 200 years. For example, in Sweden, the average height of army conscripts increased from 167 to 179 centimetres (65.7 to 70.4 inches) over the period 1820 to 1965. But socioeconomic disparities in height have also decreased. The rich are still, on average, taller than the poor, but the height differential is much less than 200 years ago.

There is also a considerable literature documenting the long-term trend toward greater equality in earnings in the United States and other advanced industrial countries, a trend that, at least in the United States, came to an end in the 1970s. Improvements in the relative health and nutrition of the poor undoubtedly contributed to a reduction in income inequality, particularly over the longer term. Fogel (1994) has shown that in France in the eighteenth century, some 10 percent of the population was so malnourished that it lacked the energy for any work and that another 10 percent had only sufficient energy for three hours of light work a day.

4. THE RELATIONSHIP BETWEEN HEALTH, LONGEVITY, AND WEALTH

The relationship between health, longevity, and health care expenditures

It is not clear a priori what effect medical interventions may have on average lifetime health care costs. Medical interventions may increase average lifetime health care costs if people who would otherwise have died survive in poor health and go on to have higher-than-average lifetime health care costs. On the other hand, those who previously survived in poor health may now survive in better health and go on to have lower lifetime health care costs than they would have incurred in the absence of the intervention.

Consider the case of low–birth-weight infants, referred to in the literature as "marginal" infants. As explained previously, improvements in postnatal care may improve the average health of the population by enabling those who would have survived anyway to survive in better health, but it may also decrease it by enabling those who would otherwise have died to survive but with disabilities and in poor health.

Cutler and McClellan (2001) suspect that the share of marginal infants with medical and developmental problems is much the same now as it was in 1950. If, as a result of improvements in medical technology, a greater number of marginal infants are now surviving, then medical interventions to save marginal infants may have increased average lifetime health costs, even excluding the cost of the initial intervention.

We can obtain a more complete picture from the tables in Cutler and Meara (2000), who report changes at ten-year intervals in survival probabilities for babies of various birth weights over the period 1950 to 1990, and the change over the period 1960 to 1990 in the percentages of survivors in each birth-weight category with developmental problems. Among babies weighing 1,000 to 1,499 grams, the survival rate almost exactly doubled, from 47.8 to 94.3 percent, during the period 1960 to 1990. But the percentage of survivors with health problems fell more than proportionately, from 68 to 28 percent, implying that the proportion of babies born in that weight range who survived with health problems fell by 19 percent.

However, as mentioned previously, it is important to note that the medical choices that doctors, parents, and governments make will influence the relative magnitude of the two effects. At one extreme, one might choose to withhold care from those babies that one expected would die in the absence of care but to survive in poor health if provided with care. At the other extreme, one could choose to provide all treatment that increased survival probabilities, regardless of the anticipated quality of life or anticipated lifetime medical costs.

The direct and indirect impacts of health on labour productivity

The most direct and obvious way in which health can affect wealth is by limiting an individual's ability to perform his chosen occupation. Healthy workers are likely to be more productive than the sick in fairly obvious ways. They will take fewer days' sick leave and will have greater physical strength. Particularly at older ages, some individuals may be in such poor health as to be incapable of work.

One does, in fact, observe strong cross-section and time-series relationships between health and wage earnings in both individual level and aggregate data. The problem is one of establishing causality. Better health may make workers more productive. On the other hand, higher earnings may make health care more affordable, although it is noteworthy that there is a strong relationship between health and labour-market earnings even in those countries in which health care is free at the point of consumption. Other explanations for the observed relationship between health and earnings include the possibility that there is a positive correlation between the inherited components of health and intelligence, or that some third factor, for example education, increases earnings and also leads to the adoption of behaviours that improve health.

There is evidence that earnings inequalities that appear to be unrelated to health may in fact have a health-related component. For example, Edwards and Grossman (1977) found that an individual's health in childhood can affect his ability to benefit from education and thus indirectly affect his subsequent earnings. There is even the possibility of multiple feedbacks, with education affecting adult health (see Wilson 2001 and Berger and Leigh 1988) and adult health in turn affecting adult earnings.

There is a substantial literature that examines the relationship between health and productivity in Third World countries (Ram and Schultz 1979; Bhargava 1997; Strauss 1986; Thomas and Strauss 1997; Strauss and Thomas 1998; and Basta et. al. 1979). Basta examined the effect of giving iron supplements to a sample of Indonesian rubber tappers, many of whom suffered from anemia. A control group received placebos. The treatment group achieved substantial increases in productivity relative to the controls.

The findings of these studies may have only limited applicability to advanced industrial economies where a much smaller proportion of the population works in agriculture and in other physically

demanding occupations and the average level of health is much better. But even in advanced economies, a nonnegligible proportion of older persons suffers from incapacities that either prevent these people from working or limit the kinds of work they can perform. In some cases, these limitations are institutionalised, for example in coal mining, where workers transfer from higher paid but physically demanding underground work to lower paid but less demanding surface work as their health declines.

Studies indicate a strong relationship between health status and labour market outcomes, even in advanced industrial economies. Uccello (1998) analyzes data from the 1990 panel of the Survey of Income and Program Participation and the 1994 wave of the Health and Retirement Study. She finds that significant proportions of older workers have health conditions that limit their ability to work or prevent them from working altogether, that individuals in physically demanding occupations are more likely to retire early, and that the earlier an individual leaves the labour force the more likely it is that he has health problems that prevent him from working. Boaz and Muller (1990) find that individuals are not using poor health as a socially acceptable excuse to justify early retirement, and that those who retire early subsequently consume more medical care and suffer higher mortality than those who remain in the labour force.

However, Smith (1999) finds evidence that episodes of even serious ill health result in relatively modest out-of-pocket medical expenses and losses of labour income. He nonetheless found that ill health led to substantial wealth reductions, suggesting that out-of-pocket medical costs and losses of labour income may understate the total financial costs of ill health. He speculated about what these out-of-pocket costs might be, for example transportation, reconfiguration of home-care environments, and so on, but the data set contains insufficient detail on consumer expenditure to permit further investigation. An alternative explanation for the observed relationship might be that individuals suffering ill health reassess their longevity and increase the rate at which they decumulate their wealth.

An alternative to using household-level microdata is to make a cross-country comparison of aggregate data. Bloom et al. (2001) examined data on 104 countries for the periods 1970 to 1980 and 1980 to 1990. They modelled growth in output over each of these periods as a function of changes in total factor productivity, physical capital, the size of the labour force, and three components of human capital—schooling, work experience, and a measure of health status. As there are no internationally comparable measures of health status covering such a large number of countries, they used increases in life expectancy at birth as a proxy for improvements in health status. Although the paper does not indicate whether they used period or cohort life expectancies, they do in fact correctly use period tables.[10] They obtain a strong result, finding that a one-year increase in life expectancy raises worker productivity by 4 percent. Meltzer (1992) found that mortality reductions, particularly reductions at younger ages, increased economic growth by increasing the average duration of payback to investments in education and therefore the optimal amount to invest.

Models of this type can be used to estimate the impact on economic growth of health and mortality shocks, such as the AIDS-related increase in mortality in sub-Saharan Africa and the mortality crisis in the former Soviet Union. Bloom and Malaney (1998) conclude that increases in mortality have been "at most a small contributor to Russia's poor macroeconomic performance," reducing the rate of economic growth or, more correctly, increasing the rate of economic decline,

by one-third of 1 percent a year over the period 1990 to 1995.

However, it is by no means certain that changes in the life expectancy of the whole population are a good proxy for contemporaneous changes in the health of people of working age. Changes in life expectancy are only imperfectly related to changes in mortality among the working-age population, which is in turn imperfectly related to changes in the health of that population. In particular, if one regards health as a stock, then current-period mortality may reflect not only current but also past health. Current-period mortality reductions may likewise reflect not only current but also past improvements in health, so that current-period health improvements may be incorrectly estimated from contemporaneous reductions in mortality. Nonetheless, the strong results may be difficult to attribute to non–health-related causes.

The impact of health on household wealth accumulation

Health status may directly affect wealth accumulation by limiting an individual's capacity to work. It may also affect it indirectly because a shorter life span, a reduced ability to work, and possibly a reduction in the ability to absorb education will reduce the return an individual can obtain from his and his family's investment in his education and, thus, the amount that an individual and his family choose to invest in his education.

However, childhood health may also be correlated with other factors that affect subsequent earnings, for example the socioeconomic status of the child's family. To identify the direct effects of health on wealth accumulation ideally requires a completely unanticipated health shock occurring after the age at which most people finish education. The American Civil War provides just such a natural experiment. It exposed individuals to an environment in which disease was rampant. Lee (2003) analyzed the health records of Union Army recruits. At an individual level, a correlation between ill health during service and subsequent wealth accumulation may reflect differences in personal characteristics, so Lee used the casualty rate of the company in which the individual served as a proxy for the severity of the health shock. He found that health while in service had a strong effect on subsequent wealth accumulation. For example, men who fought in companies that lost at least 5 percent of their men due to injuries accumulated 46 percent less wealth by 1870 than men who served in companies that suffered zero losses.

The impact of increased longevity on the dependency ratio

The dependency ratio is the ratio of economically inactive persons to labour force participants. It is sometimes adjusted to reflect the fact that needs, particularly health care needs, vary over the life course. It is primarily determined by mortality, fertility, and labour force participation rates.[11] Mortality reductions among prime-age workers may initially decrease the dependency ratio. However, mortality reductions at ages when workers have retired must, as a matter of arithmetic, increase the dependency ratio unless the average age of retirement increases. If the country's per capita capital stock does not increase, an increase in the dependency ratio will result in a decline in per capita consumption.[12]

Although dependency ratios are projected to increase in almost all countries, a substantial part of the increase is the result of changes in fertility rates that are only an indirect consequence of increased longevity, if at all. In the United States, the current relatively low dependency ratio reflects a fortuitous combination of events. During the interwar period, the fertility rate declined dramatically. Almost all the babies born during that period have now retired, and the low fertility rate during

the interwar period had the effect of reducing the number of individuals who are currently retired. During the postwar period, there was a baby boom. These babies are now, of course, of working age, and the high birth rate during the postwar period has had the effect of decreasing the current dependency ratio. Subsequently, there was a decline in the birth rate, reducing the number of dependent children. Had the 1930s baby bust and the 1950s baby boom not occurred, the current dependency ratio would be substantially higher.

The impact on the dependency ratio of reductions in mortality depends crucially on the effect that these mortality reductions and associated improvements in health have on the labour force participation rates of older workers. Models that ignore these interactions are likely to produce seriously misleading forecasts. Börsch-Supan (2003) examines the case of Germany and makes a variety of assumptions about increases in longevity and labour force participation, trends in fertility and unemployment rates, and the average age of retirement. He considers a number of alternative scenarios—for example, in his most optimistic scenario average retirement age increases by five years, whereas in his most pessimistic it increases not at all.

Under his most optimistic labour force participation assumptions, he projects that the dependency ratio will increase from its current 55 percent to 77 percent by 2050, holding all other assumptions constant. However, under his most pessimistic labour force participation assumptions, he projects that the dependency ratio will increase to 120 percent.

Many of the most pessimistic projections of dependency ratio increases assume no increase in the age of retirement, and one obtains quite different forecasts if one makes different but plausible assumptions. For example, Toder and Solanki (1999) calculate that if in the United States, which admittedly has a higher fertility rate than Germany, people were to delay retirement so as to maintain a constant number of years in retirement as longevity increased, the 2040 dependency ratio would be no less than that in 1997.

So what factors might affect the labour force participation rate of older workers? Burtless (2003) provides an analytical framework for considering this question. Individuals face a tradeoff between leisure and consumption. They can retire young and enjoy low per-period consumption or retire later and enjoy higher per-period consumption. If longevity increases, the individual can enjoy preferred combinations of consumption and leisure. Assuming a constant real wage, an individual could, for example, spend the same number of years in retirement but enjoy greater per-period consumption because a greater proportion of his adult life will be spent working. Although we would normally expect both lifetime consumption and lifetime leisure to increase in response to an increase in longevity, it is perfectly conceivable that an individual might choose to reduce either his lifetime consumption or his lifetime leisure.

An important implication of the analysis is that increased longevity makes people better off, even if they choose not to increase lifetime consumption, because they get to enjoy additional leisure, which presumably has at least some value.

The cost of additional leisure is the consumption foregone. If individuals can earn very little in the labour market beyond current retirement ages, then taking additional leisure will involve relatively small consumption losses, and an increase in longevity might result in only a small increase in the average age of retirement.[13] But if the improvements in health that are associated with increased longevity increase the productivity of older workers and shift the terms of the tradeoff between labour

and leisure, then one might expect a more substantial increase in the age of retirement.

The reward to continued employment is not merely the net wage, but also the part of the increase in the expected present value of the employee's pension entitlements that results from continued labour force participation. In a defined benefit (DB) pension plan, the monthly pension to which the individual will be entitled upon retirement may increase very little once he has attained the early or normal retirement age specified in the plan.[14] On the other hand, delaying retirement involves forfeiting a year's pension income. At advanced ages, the pension reward to working an additional year can be small or even negative, with the present value of the increase in the monthly pension being insufficient to compensate for the fact that it will be now be paid for one year less.

Several studies have shown that the age-related incentives in Social Security and employer pensions have a powerful effect on retirement patterns. Friedberg and Webb (2003) calculate that the age-related incentives in DB pension plans cause employees to retire two years earlier than in the absence of those incentives. An international study by Gruber and Wise (2004) found strong evidence of a relationship between retirement patterns and pension incentives.

DB pension plans are gradually being displaced by defined-contribution plans, which lack these age-related incentives, while steps have been taken to reduce similar age-related incentives in Social Security. It is difficult to forecast what effect these reforms might have on labour force participation rates among older persons. Although over the last 50 to 100 years declines in the average age of retirement have been associated with an increase in the prevalence of DB pension plans and in the generosity of Social Security, we cannot be certain to what extent these changes caused the decline in the age of retirement. Real incomes were also increasing over this period, and it is quite plausible that, as incomes rose, individuals chose to enjoy longer periods of leisure at the end of their lives, irrespective of the economic incentives. It is possible that some older workers have very strong preferences for leisure and that labour market participation rates will not increase much, regardless of what happens to potential earnings. Fogel (2003) argues that societies have become so rich that people are becoming saturated with goods formerly thought of as luxuries and that as a result they will increasingly choose additional leisure at older ages in preference to additional consumption. I find the hypothesis unconvincing. It is far from obvious to me that the material wants of most of the population are close to being satiated, while if people were increasingly choosing leisure over additional consumption, one might expect the additional leisure to be consumed over the individual's lifetime rather than in old age. I believe that health shocks and the pension-related disincentives to labour supply by older workers documented by Gruber and Wise (2004) are the principal causes of early retirement.

Health undoubtedly plays a major part in the retirement decisions of many workers, and we really need to better understand how increased longevity will affect the health of older workers and how health improvements might affect potential earnings if we are to forecast labour force participation rates of older workers.

Some older persons are in such poor health as to be physically incapable of work. However, the research of Steuerle et al. (1999) provides evidence that the majority of workers are physically capable of working beyond current retirement ages. There is also evidence of a continuing improvement in the health of older persons, although some authors, for example Lakdawalla et al. (2003), fear

that increasing obesity may lead to a reversal of this trend. An unwillingness to acquire new skills on the part of some older workers and a lack of training opportunities may be more significant deterrents to the labour force participation by older persons in a knowledge-based economy in which a decreasing proportion of jobs requires strength and stamina.[15] However, Friedberg (2003) shows, in relation to computer use, that it is not age but impending retirement that acts as a deterrent to the acquisition of new skills.

We can dismiss one possible reason for believing that the labour force participation rates might not increase, or indeed should not increase, as a result of increased longevity, namely the "lump of labour" fallacy: the notion that there is a fixed number of jobs available in the economy and that a job given to one person is a job taken away from someone else, leaving the dependency ratio unchanged. This idea is entirely fallacious, and there is every reason to believe that the labour market would equilibrate supply and demand for labour in response to an increase in labour supply by older workers, just as it has accommodated increases in the labour supply of women, particularly married women.

Of course, per capita GNP excludes not only the value of leisure but also nonmarket outputs, for example family caregiving. The effect of improvements in health on the quantity of such nonmarket outputs is ambiguous. Health improvements will make it possible for a greater proportion of older persons to undertake such activities, but the same health improvements may encourage some to postpone retirement and reduce their supply of nonmarket services. Improvements in the health of the very old may reduce the demand for such services if those improvements are of sufficient magnitude to outweigh the increase in the number of older persons.

Placing a value on improvements in health and longevity

National income accounts include the cost of health care inputs, the cost of doctors' and nurses' salaries, and so on, whereas what people value is not health care inputs but health care outputs, reductions in mortality, and improvements in health. So there is a strong case for restating those accounts to include the outputs and exclude the inputs.

There is a substantial literature that infers the value that individuals place on mortality reductions from the wages paid in occupations with differing levels of mortality risk. It is not altogether clear that the valuations obtained from an analysis of the decisions of prime-age males working in manual occupations can, or should, be extrapolated to other types of individuals, and a lot might depend on the precise purposes for which the valuations were to be used. For example, a calculation of the economic losses of the September 11 terrorist attack would take into account the very high earnings of some of the victims, but we might, for reasons of public policy, wish to limit the amounts of compensation paid to those victims from public funds.

Particular problems arise in relation to the valuation of the lives of infants. The philosopher Peter Singer controversially argues that infants have not yet acquired a consciousness of their identity, and that the death of an infant imposes no loss beyond the pain and suffering their parents might experience plus the cost to the parents (lost earnings, medical expenses, and so on) of "replacing" the lost infant. A "Singerian" approach to the valuation of reductions in infant mortality might produce much smaller amounts than those obtained from using valuations from the occupational choices of prime-age males. As development of identity is a major process of childhood, one might wish to adjust one's estimate of the

value of each remaining year of life or the discount rate applied, according to the age at which the probability of death is reduced.

On the other hand, estimates based on occupational risk premia may understate the value of human life because many high earners never engage in risky occupations and never feature in the calculations. Although many people would feel very uncomfortable with the idea that, when deciding how to spend public money, one should attach substantially greater weight to mortality reductions among the rich, one might wish to incorporate the high earners' valuations of their mortality reductions in calculations of the value to society of new medical discoveries. It is also possible that less risk-averse people self-select into risky occupations, and that more risk-averse people in other occupations would demand higher premia, or that people who enter risky occupations systematically underestimate the risks involved or their ability to limit those risks. Some people may have little choice in the occupations they pursue, and lack of alternative work, for example in a mining community, may depress the level of earnings in the risky occupation.

Nordhaus (2002) uses values obtained from research on prime-age males to calculate the value that people place on improvements in life expectancy over the twentieth century, scaling back earlier years' values in line with the growth in consumption.[16] He calculated that the value people place on the mortality reductions that occurred over the period 1900 to 1995 was equivalent to the value they would place on an annual increase in consumption of between 2.2 and 3.0 percent, depending on the computational assumptions. Consumption growth over that period averaged 2.1 percent, so mortality reductions contributed more to improvements in well-being than did increases in the consumption of goods and services.

Nordhaus considers the possibility that the prime-age males typically studied in the calculations of the value of human life may place a higher value on mortality reductions than the older persons who are the primary beneficiaries of recent mortality reductions.[17] The results were only slightly affected when he incorporated plausible age-related variations in the value of a statistical life.

There is a number of potential biases in Nordhaus's calculations. First, the calculations of the value of a statistical life refer to prime-age males who are likely to be in good health. People who survive in poor health may place much lower values on reductions in mortality. But, on average, health status has greatly improved over the last century, and an accounting that included health status would almost certainly result in larger benefits than those referred to above.

Second, calculations of the value of a statistical life typically take as their starting point the risk premium that people require in order to work in a particular occupation. As mentioned above, these calculations may not be representative of the average value placed on a statistical life by the population as a whole.

Third, the greatest reductions in mortality have been among the poor, who, if only because of their lesser financial resources, may place a lower dollar value on mortality reductions than the rich. The use of population average valuations of a statistical life will therefore tend to overstate the average valuation placed on mortality reductions because the greatest reductions have occurred among those with the lowest valuations.

Fourth, one can apply precisely the same arguments that Nordhaus uses to justify substituting the value of health outputs for the cost of health inputs to the valuation of the many new goods and services made available during the twentieth century. The

prices at which these goods are sold are very often only a small fraction of the market value of the quantities of existing goods and services that the individual would be willing to sacrifice in order to be able to consume the new good. As Nordhaus concedes, calculations of growth in per capita GNP almost certainly understate the value that individuals place on these new goods and services.

However, whatever adjustments one proposes, the fact remains that the value of health improvements is enormous. Nordhaus shows that over the period 1980 to 1990 the value of mortality reductions was approximately twice the increase in health care expenditures, some of which will have been spent on procedures that enhanced the quality rather than the quantity of life. If the health care expenditures were the sole cause of the mortality reductions, then society has benefited from the health care expenditures, ignoring the economic distortions of the taxes required to pay for them. But, as Nordhaus concedes, factors other than health care expenditures, for example improvements in diet and housing, have very likely contributed to the reductions in mortality. Furthermore, to the extent that mortality reductions are the result of health care expenditures, they will be the result not only of current expenditures but also of expenditures of a different magnitude and character incurred over the lifetimes of the individuals concerned. Even if we accept that the overall return from health care expenditures has been in excess of the amount expended, we still do not know whether, at various margins, health care expenditures have been cost-effective. Some treatments may, on average, pass the cost-effectiveness test, others may not, and the cost-effectiveness of any particular treatment will also vary from patient to patient, depending on the patient's age and state of health.

An alternative approach is to examine the relationship between increases in total medical expenditure and overall reductions in mortality. Lichtenberg (2002) estimated the contribution of medical expenditures and innovations to increased longevity, innovations being measured in terms of new molecular entities approved by the FDA. A significant problem in analyses of this type is reverse causality. We observe that medical expenditures, the range of available drugs, and longevity are all increasing over time. In relation to medical expenditures, we need to distinguish between the hypothesis that the expenditures are causing the reduction in mortality and the alternative hypothesis that reductions in mortality are causing the increase in expenditures, for example because older people require more medical care. Lichtenberg addresses this problem by substituting lagged health expenditures for current health expenditures in an econometric model in which mortality reduction is the dependent variable and by testing whether there is a relationship. He claims that this year's medical expenditure is not going to cause last year's reduction in mortality.[18]

He rejects the reverse causality hypothesis and shows that drug releases and medical expenditures have significant effects on mortality. He estimates the medical expenditure costs of a life year saved at only $11,053 in 1982–84 dollars. Most studies have put a lower bound of around $100,000 on the value of a life year, so, even allowing for inflation, this suggests a very substantial return on the expenditure.

Yet another approach is to focus on the costs and benefits of treatment of particular diseases. Cardiovascular disease is the leading cause of death in the United States. Cutler et al. (1999) show that the increase in expenditure on treating heart attacks reflects an increase in the intensity of treatment. They calculate that additional expenditure of $4,000 per patient has increased average life span by eight months. This represents a good return under almost any assumptions regarding the value of life and the quality of life

that these survivors enjoy. However, the analysis does not distinguish between average and marginal effects.

An important conclusion of this line of research is that, given plausible assumptions regarding the value of human life, even small mortality reductions produce returns that greatly exceed the related medical expenditures. For example, Murphy and Topel (1999) calculate that the economic value of cures for cancer and heart disease amounts to $95 trillion. This figure is for the United States alone. One would have to double it at least to include the benefits to individuals living in other advanced industrial economies. Even a 1 percent reduction in cancer mortality would be worth $500 billion. By comparison, the United States spent only $35 billion on all kinds of medical research in 1995, so that even quite small reductions in mortality would be cost-effective.

The impact of health and longevity on investments in human and physical capital

There are several plausible transmission mechanisms from health to investments in human capital and also some possible feedbacks from investments in human capital back to health. A first transmission mechanism is simply that a healthy child may be better able to absorb knowledge and less likely to miss school. For example, Lozoff et al. (2000) show that iron deficiency has a long-term impact on educational attainment. Case et al. (2003) and Case et al. (2002) find evidence that childhood health can have a lasting impact on educational attainment and adult health and earnings even in advanced countries. Macrolevel studies, for example Bloom et al. (2001), reach similar conclusions.

A second transmission mechanism is that increased longevity increases the payback to investment in education by increasing the expected present value of a lifetime's additional wages. Kalemli-Ozcan et al. (2000) review the literature and go on to predict significant effects in a calibrated overlapping generations model, an economic model containing households at all stages of the life cycle.

A third transmission mechanism is that reductions in infant mortality may lead parents to desire fewer children. Researchers disagree as to the extent to which the decline in fertility is attributable to the decline in child mortality (for a review, see Kalemli-Ozcan 2002). With imperfect capital markets, parents may be either unwilling or unable to make the optimal level of investment in their children's K–12 education. A reduction in fertility may enable parents to more closely approach their desired level of investment, thus providing an additional channel through which a reduction in mortality may increase investment in human capital.

A number of papers (Berger and Leigh 1988; Lleras-Muney 2002; and Arkes 2003), find evidence that education can in turn result in improved health so that societies may enter a virtuous circle of improvements in both health and education.

An important point made by Bloom and Canning (2003) is that increased longevity increases the average level of experience of the workforce. Studies have shown that the effect of experience on labour productivity can be as large as the effect of education. Of course, if levels of education are increasing over time, then this effect will be offset by the fact that these older workers will have, on average, fewer years of schooling than younger cohorts.

An interesting study is that of Alsan et al. (2004), who claim that health positively affects inflows of foreign direct investments in low- and middle-income countries. As previously mentioned, it is difficult to obtain internationally comparable measures of health status, so they follow previous

work by using life expectancy at birth as a proxy for health status. They control for a variety of factors that might influence a country's attractiveness to foreign investors. A possible concern is that there might be some unobservable factor that could influence both life expectancy and the country's attractiveness to investors. One obvious such factor is the quality of the country's institutions, which they control for through measures of bureaucratic quality and governmental corruption, but there may possibly be others that the authors are failing to capture. But on the face of it, the results are compelling.

The demographic dividend

One of the indirect effects of improvements in health and increases in longevity on capital formation is through the so-called demographic dividend. In preindustrial times, human societies were characterised by high fertility and a relatively short life expectancy. The dependents were mainly children, as relatively few people survived to old age. The demographic revolution of increased longevity and low fertility will eventually lead to a new equilibrium in which there will be proportionately fewer dependent children and proportionately many more dependent old people. During the transition, the dependency ratio falls, as the proportion of the population that is elderly is not yet at its new equilibrium level. The transition increases per capita income directly because there are fewer dependents among whom each worker's product has to be shared, and possibly indirectly if the process results in an increase in the capital stock and therefore per capita income.

Many authors claim that the increase in savings rates in East Asian countries can be attributed to increased longevity. They postulate two mechanisms. First, if, as a result of increased longevity living to retirement is now a realistic prospect, then increased longevity will stimulate life-cycle savings. Second, the country will experience a temporary increase in the proportion of prime-age workers, who are life-cycle savers, relative to older persons, who are life-cycle "dissavers."

Bloom et al. (2004), and indeed many other authors, suggest that increased longevity may stimulate saving for retirement. These authors correctly point out that saving for retirement will occur only when mortality rates have fallen low enough for retirement to be a realistic prospect. But, in the absence of the age-related incentives provided by employer pensions and Social Security, one might plausibly regard people as planning to retire not at some fixed age regardless of health but at an age when declines in health have increased the disutility of work and decreased the returns to work by sufficient amounts. If increasing longevity is associated with a compression in morbidity, one might expect the duration of retirement to decrease, not increase, with increases in longevity and for retirement savings to fall. The truth, I suspect, is more complex, and that retirement is a luxury good that individuals wish to consume substantially more of as their incomes increase. So increasing longevity makes a lengthy retirement possible, increasing incomes make it desirable, and the combined effect increases household savings.

Bloom and Canning (2003) make the point that the demographic dividend will increase savings only if saving is attractive. It is no surprise that Latin America, with a history of inflation, economic instability, and generous pay-as-you-go pension systems, has not enjoyed an East Asian-style savings boom. Households clearly have less need to make life-cycle savings if their retirement consumption is to be met by a pay-as you-go pension system. However, Bloom and Canning may be overgeneralising when they say that "in East Asia workers have had to rely on their private savings or on government schemes that are funded by forced

saving and asset accumulation." Although this statement is undoubtedly true of some countries, Singapore (which is not, of course, in East Asia) being the most famous example, it is not true of Japan, which has a not ungenerous pay-as-you-go pension system, the sustainability of which is now a matter of intense debate.

Economists still have only a limited understanding of the determinants of household savings. It varies considerably from year to year, and in the United States has declined considerably since the 1960s. The life-cycle model of savings behaviour postulates that households save during their working lives and dissave in retirement. Yet many households save little, and the evidence for postretirement dissaving is mixed. Nonetheless, savings rates, measured as increases in net financial assets, expressed as a percentage of household income, are highest among those aged 40 to 60, and some of this is undoubtedly life-cycle related. In a pay-as-you-go pension system with a high replacement rate, workers have little or no need to make life-cycle savings for their old age. In a funded system, workers will accumulate wealth and the retired will decumulate. In equilibrium, the savings of workers will be matched by the asset decumulation of older persons.[19] During the transition, the savings of the workers will exceed the decumulations of older persons, and the country's capital stock will increase. Once the country attains a new equilibrium, the capital-output ratio will no longer increase but will nonetheless be permanently higher than before. Using simulation techniques and, crucially, assuming a fixed retirement age, Auerbach and Kotlikoff (1992) show that in the United States increased longevity may initially increase the savings rate although eventually the dissaving of older persons will also increase. Lee et al. (2000) simulate the effect of population aging in Taiwan and show that the demographic transition can account for the extremely high savings rates observed in that economy.

In advanced industrial countries, most retirement savings are invested in stocks and bonds.[20] Although the rates of return obtained by individual households may be affected by their particular investment choices, management charges, and design features of DB plans, the average rate of return is very largely determined by average stock and bond market returns. In developing countries, capital markets may be less developed. In countries where households lack access to the credit market, or where there is a history of war, inflation, or government expropriation, much retirement savings may be in the form of land, real estate, gold, and cattle. These assets may yield low, zero, or even negative real rates of return. For example, the marginal return to additional investment in cattle may be negative if the additional cattle result in overgrazing, and gold, which provides no income, carries insurance and storage costs. The ability of a society to profit from the demographic dividend may well depend on the quality of its government and the efficiency of its financial markets.

It is clear that a society will be poorer if its institutions do not permit savings to be allocated to the most profitable uses. However, economic theory is ambiguous as to the effect of the rate of return on the amount a household will save for retirement. An increase in the rate of return may have both income and substitution effects. An increase in the rate of return makes it possible for the household to enjoy greater consumption in all periods, and this will decrease the amount saved. It also increases the amount of consumption that can be enjoyed in the future, per dollar of current consumption foregone, providing an incentive to additional saving. The very high savings rates in East Asia took place in an environment of low inflation and were associated with the establishment of institutions

designed to facilitate the channelling of household savings to productive uses. This does not necessarily demonstrate causality, as the institutions may have been created in response to an initially strong taste for savings on the part of households.

The impact of population aging on the structure of the economy

Börsch-Supan (2003) highlights the impact that population aging is likely to have on the pattern of demand for goods and services and thus on the pattern of demand for labour. These changes are likely to happen quite slowly, giving labour and capital markets time to reallocate resources away from areas of declining demand to areas of increasing demand. Labour and capital markets may adjust more slowly in Europe than in the United States, whose labour and capital markets are often regarded as being more flexible and responsive. Although certain categories of expenditure, such as medical care, may increase at the expense of reductions elsewhere, and the demand for some skills, for example those held by health care professionals, may increase, there seems no a-priori reason to expect that changes in patterns of demand will have a significant effect on the rate of economic growth or the distribution of income. Many categories of expenditure are common to people of all ages. More fundamentally, to demonstrate that changes in patterns of demand will affect the growth or distribution of income, it is necessary to show that the goods and services consumed by older people differ systematically in the average skill requirement of the labour inputs or the capital intensity or rate of technical progress of their production. But, at first glance, it is difficult to discern any systematic relationship, and I suspect that capital and labour markets will smoothly respond to changes in the pattern of demand, in just the same way as they have adapted to many other changes in the pattern of demand, without any significant changes in factor prices.

5. SUMMARY AND CONCLUSIONS

Increased longevity and the dependency ratio

There is a widely held view that increased longevity will increase the proportion of frail dependents in society and condemn us to reduced real incomes. I believe there are many reasons to reject this view. First, the increase in the dependency ratio is not only a result of increased longevity but also is in large part the result of declines in the birth rate. It seems strange that rather than regarding the stabilisation of the world's population as a great achievement we should now regard it as a curse.

Second, the evidence clearly shows that increases in longevity are associated with improvements in the average level of health, particularly among older persons. Pessimistic forecasts of the increase in the dependency ratio invariably assume either no increase or only a small increase in labour force participation rates among older persons. The fact that labour force participation rates by older persons are so low in advanced industrial economies probably says less about the ability or willingness of older persons to work than about the financial incentives to greater labour force participation. The reform of employment legislation and pension and Social Security systems so as to provide appropriate incentives and opportunities for continued employment, while safeguarding those who are no longer capable of work, is essentially a political problem that does not seem to me to be insoluble.

Third, even if labour force participation rates among older persons do not increase, for example because older persons have a strong taste for leisure, the economic consequences are likely to be a modest reduction in the rate of growth in per capita income to which we have become accustomed rather than actual declines in per capita income.

Increased longevity and health care costs

Health care consumes an ever increasing percentage of national income. It would be incorrect to attribute all, or even most, of the increase in health care spending to increased longevity. Medical expenditure is determined to a large extent by increasing incomes and new technology. Richer societies understandably choose to spend some part of the additional resources now available to them on purchasing better health in the same way as they also choose better houses and better cars. It is also understandable that new medical technology, which expands the range of treatment possibilities, should increase demand for health care.

When health care is free at the point of consumption, people will demand it regardless of the cost provided it offers some benefit however small. This is not a cause for concern if we place an infinite value on reductions in mortality and in the alleviation of pain and suffering. In reality, we demonstrate through the choices that we make in our day-to-day lives that we do not, in fact, place an infinite value on such mortality reductions. So, does medical expenditure represent value for money given the valuations that we appear to place on our lives?

The evidence of research into the relationship between medical expenditures and overall mortality reductions and between specific classes of expenditure and the mortality reductions associated with those expenditures is that, on average, medical expenditures offer a positive net return. In fact, for plausible valuations of human life, the returns greatly exceed the expenditures incurred. Of course, this is not to say that, at the margin, some classes of expenditure offer negative returns, but there is no evidence that such negative returns are systematic. So if we define wealth as including the value that individuals place on their health, health care expenditures have almost certainly led to a net increase in wealth.

But does health actually increase wealth, narrowly defined?

The emerging evidence is that health is really fundamental to worker productivity and stimulates the investments in physical and human capital that are essential to economic growth. This evidence is derived not only from microlevel studies of household behaviour but also from macrolevel intercountry comparisons. We are justifiably concerned about rising health care expenditures, but we should also be concerned about the risks of not making the expenditures. Suppose that Bloom and Canning are correct, and that good health boosts economic growth by 0.3 to 0.5 percent a year.[21] Compound this over 50 years and you arrive at numbers that dwarf health care expenditures. In order to determine how the lessons of the past may apply to the future, we call for further research to deepen our understanding of this vital issue.

References

1. Edmund Halley (of comet fame) created the first modern life table in 1693, based on data from the city of Breslau in what is now Poland.

2. In 2004, the highest infant mortality rate, 19.3 percent, was in Angola, but most developing countries had rates around 5 percent. For example, India was 5.8 percent, one-fifth of the rate in eighteenth-century England.

3. We will never attain a perfectly steady state, even in the absence of fresh perturbations, as the effects of past perturbations echo across the generations. For example, holding fertility levels constant we can expect an echo of the baby boom as the boomers' children in turn have children. Furthermore, a steady state does not necessarily imply a stable population. If, as seems likely, average completed family size after the demographic transition is going to be less than the replacement rate, then a steady state might result in a decreasing population.

4. If we place an infinite value on life or the alleviation of pain and suffering, then all health treatments are justified, regardless of cost, provided the treatment offers some reduction in mortality risk or in the burden of pain and suffering, net of any pain and suffering that the treatment might itself involve. In practice, people are not willing to pay an infinite amount to reduce their risk of dying, and economists have developed techniques to calculate the value of a statistical life, using, for example, data on the wage premia required for risky occupations.

5. In South Africa in 2004, life expectancy at birth was 44.19 years, and the infant mortality rate 62.18 per 1,000 live births. In the U.S. in 1900, life expectancy at birth was 54.9 years, but the infant mortality rate was 133 per 1,000 (CIA's *World Factbook* https://www.cia.gov/cia/publications/factbook/index.html). Apart from being a human tragedy, the pattern of "shortgevity" in sub-Saharan Africa may be particularly economically harmful. Cogneau and Grimm (2002) show that in Côte d'Ivoire, mortality among prime-age workers is highest among those with higher earnings and the most human capital.

6. Research into human capital was pioneered by Gary Becker, the Nobel laureate. For an overview, see Becker, *Human Capital: An Empirical and Theoretical Analysis, With Special Reference to Education* (Chicago: University of Chicago Press, 1994).

7. Pensions can be either "funded" or financed on a pay-as-you-go basis. In a pay-as-you-go system, each period's pension contributions are used to pay that period's pension payments. In contrast, in a funded pension, contributions are invested in real or financial assets. Other things being equal, a country with a funded system will have more capital than one with a pay-as-you-go system. The U.S. Social Security system is almost entirely unfunded, the assets of the Social Security trust fund being negligible in relation to the present value of the pension liabilities.

8. Researchers have attributed this increase to public health problems associated with urbanisation. In the latter decades of the twentieth century, there has been an even more rapid increase in the percentage of Third World populations living in cities without a corresponding rise in mortality. Indeed, during the last 50 years, the most rapid reductions in mortality have occurred in the Third World.

9. Union Army veterans were 0.18 inches taller than the general population and therefore probably a little healthier, so Fogel's result, if anything, overstates the health of the nineteenth-century population and understates the subsequent decline. The data is, however, representative of those who enlisted. By 1900, 90 percent of the veterans had applied for a pension, and of these, 90 percent had received a

medical examination. Of course, only men were liable for military service, but it seems reasonable to assume that women have enjoyed similar reductions in the incidence of chronic disease.

10. A period table shows the mortality risk of people alive in a particular year. A cohort table shows the mortality risk of people born in a particular year. Changes in period table mortality from time t to time t+1 will reflect changes in mortality during that period. A comparison of the mortality predicted by the cohort table for those born at time t with that predicted by the table for those born at time t+1 reflects differences in past and projected mortality improvements over a whole lifetime.

11. In most countries and time periods, net immigration has had a much smaller impact.

12. The decline should be placed in context. Börsch-Supan (2003) studied Germany, a country with extremely low fertility. Even under his most pessimistic scenario, half of the projected annual increase in labor productivity over the period 2000 to 2050 would be eaten up by the increase in the dependency ratio, which still leaves the other half available to finance increased consumption. Germans will continue to increase their consumption but not quite as rapidly as in the past.

13. Burtless (2003) shows that average male earnings in the U.S. peak around age 45. The subsequent decline is only partly explained by reductions in hours. It is possible that there is a selection effect with higher-earning workers better able to afford retirement. Membership in defined-benefit (DB) pension plans has been shown to lead to early retirement, and DB-plan members tend to have higher earnings than the population as a whole.

14. A DB pension plan is one in which the pension payable is some function of average or final salary and years of service. In contrast, in a defined-contribution pension plan, the pension is a function of investment performance.

15. Actual or perceived age discrimination may play a part. In the United States, age discrimination in employment has been illegal since 1986. Johnson and Neumark (1997) offer evidence that age discrimination adversely affected the employment prospects of older workers, but his data go back to 1966 to 1980. Garen et al. (1996) show that DB pension schemes can reduce the probability of an older person being hired for an entry-level position because the cost to an employer of providing a DB pension is much greater for an older hire.

16. Costa and Kahn (2002) calculate the value of life over the period 1940 to 1980 and conclude that the value of life has increased faster than the rate of growth of per capita GNP. Using Costa and Kahn's figures would produce somewhat larger valuations of mortality improvements than those obtained under an assumption of a fixed relationship between per capita GNP and the value of life.

17. The value of life may be affected by whether one's spouse, friends, and family are also still alive. DeLeire and Levy (2001) show the values women (who are more likely than men to avoid risky occupations) place on their own lives may be higher, possibly because of differences in attitudes toward family responsibilities, with women believing they are literally irreplaceable.

18. It is not quite as absurd as it first appears to claim that this year's mortality reduction might cause next year's medical expenditure increase. Mortality reductions may have the effect of causing people to survive in ill health and to incur large medical expenditures the following year.

19. The young may save more if real incomes are rising, and aggregate saving may be lower if the population size is declining.

20. The big exception is housing equity. It used to be thought that little housing equity was consumed in old age. More recent research, for example by Walker (2004), shows that housing wealth is often liquidated in old age. Sale of a house often coincides with a precipitating shock, such as the death of a spouse or entry into long-term care. It is as yet unclear whether the sale proceeds are used to pay medical and nursing home bills or whether they are used for general consumption or some other purpose.

21. See Bloom, David E., and David Canning, 2000, The health and wealth of nations, *Science* 287:1207.

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