Population Health and Economic Growth

David Bloom and David Canning
Harvard School of Public Health

December 2007
Revised April 2008

Paper presented to the Commission on Economic Growth meeting Washington D.C. on October 16, 2007.

1. Introduction

Improvements in health may be as important as improvements in income in thinking about development and human welfare. Good health can be thought of as a goal in its own right independently of its relationship with income. However, there is a link between health and income that is important for policy purposes. To the extent that health follows income, income growth should be the priority for developing countries. To the extent that income is a consequence of health, investments in health, even in the poorest developing countries may be a priority. This argument for health as an investment good is particularly relevant since there are cheap and easily implementable health policies that can improve health dramatically even in the poorest countries.

Empirically, high levels of population health go hand in hand with high levels of national income. This is not unexpected. Higher incomes promote better health through improved nutrition, better access to safe water and sanitation, and increased ability to purchase more and better quality health care. However, health may be not only a consequence but also a cause of a high level of income. This can work through several mechanisms (Bloom and Canning, 2000). The first is the role of health in labor productivity. Healthy workers lose less time from work due to ill health and are more productive when working. The second is the effect of health on education. Childhood health can have a direct effect on cognitive development and the ability to learn as well as school attendance. In addition, because adult mortality and morbidity (sickness) can lower the prospective returns to investments in schooling, improving adult health can raise the incentives to invest in education. The third is the effect of health on savings. A longer prospective lifespan can increase the incentive to save for retirement, generating higher levels of saving and wealth, and a healthy workforce can increase the incentives for business investment. In addition, health care costs can force families to sell productive assets forcing them into long term poverty. The fourth is the effect of population health on population numbers and age structure.

The economic effects of population health can be seen both at the individual and macroeconomic levels. There is no real dispute about the presence of these effects on economic development. However the size of the effects is an important issue. We examine the evidence base that tries to estimate the magnitude of the health impact.

Four difficulties are apparent in assessing existing work in this area. The first is the issue of measurement. "Heath" is measured differently in different studies. There are a wide variety of heath measures in microeconomic studies. All of these are aimed at measuring some aspect of morbidity, or sickness, at the individual level. In macroeconomic studies a variety of measures are used. However these focus on morality rates measures such as life expectancy. It is difficult to compare studies that use such different notions of "health". The second issue is causality. Given that income affects health, and health affects income, we have to disentangle the two directions of causality. The third issue is one of timing. There is growing evidence of long term effects of early childhood health on cognitive and physical development that affects productivity as an adult. This implies that health effects in the macro economy may have long time lags, given the average worker may have been born 40 or more years before, making the macro economic relationship difficult to estimate. The fourth issue is the differing effect of health on the economy, holding all other in factors fixed, and the effect in a more general equilibrium framework where other factors respond to the improved health. Some studies measure the partial equilibrium effect while others attempt to capture the induced changes in other factors and the general equilibrium impact.

The issue of population health and economic outcomes is particularly acute in sub-Saharan Africa. This region has a high burden of tropical infectious disease, such as malaria, tuberculosis, and intestinal worms, and it also suffers from the HIV/AIDS pandemic. We examine the impact of this disease burden on the prospects for economic development in sub-Saharan Africa.

2. Determinants of Health

Although we focus on the economic implications of population health, there is clearly two-way causality as health is partly a consequence of income levels. Preston (1975) demonstrated a positive correlation between national income levels and life expectancy. Figure 1 shows such a "Preston Curve" for recent data. One reason for this link is that higher income levels allow greater access to inputs that improve health, such as food, clean water and sanitation, education, and medical care. Fogel (2004) emphasizes the role of access to food while Deaton (2006) puts more weight on public health measures such as clean water and sanitation (see Cutler and Miller, 2005). Cutler and McClellan (2001) examine the increasing contribution of medical care to

health outcomes. Pritchett and Summers (1996) use the relationship between income levels and health to argue for an emphasis on economic growth in poor countries as a method of increasing population health. However, the findings of Easterly (1999) weaken this argument. Easterly finds that, although income levels and population health are closely related, the effect of changes in income on population health over reasonable time spans appears to be quite weak. By contrast, relatively inexpensive public health interventions and policies can have remarkable impacts on population health even in very poor countries. In practice, the major force behind health improvements has been improvements in health technologies and public health measures that prevent the spread of infectious disease, and not higher incomes (Cutler, Deaton and Lleras-Muney, 2006).

Overall, Preston's (1975) original view of the determinants on health seems to hold. If we plot the relationship between population health and national income these is definitely an upward slope, particularly at low income levels. However plotting the same curve at different points in time (Preston used 1900,1930,and 1960) give different curve and in each period curve health is higher at each level of income than previously. Over 75% of the health gains we have observed have come from upward movements of the health-income curve and less than 25% from movements along the curve as countries get richer. This reinforces the idea that health interventions can improve population health, without the need for prior improvements in income.

3. Health and Welfare

We examine the role of health as an instrument to generate economic well being. However, any reasonable view of the contribution of health to human welfare would also include the direct welfare benefits of a long lifespan and good health. Estimates of the monetary value of life (as measured by the willingness to pay to avoid a small risk of death) are often very large (Viscusi and Aldy, 2003). We can use these estimates of the value of life to compare the welfare improvements that have come about due to improvements in population health and the improvements due to economic growth and higher incomes. Conceptually we can measure the money value of health gains by the amount of money people would be willing to pay to forgo these gains (the equivalent variation). For example we can ask someone living with today's income, health and life expectancy in the United States what level of income would be required for them to accept living with average life expectancy and health of Americans 1900. The

income gain they would require is a measure of value of health and longevity in money units, and can be very large. Such comparisons suggest that in many countries the value of health gains has been comparable to, or has even surpassed, the value of income gains (Nordhaus, 2003). In addition, while incomes gaps between countries have been very persistent over the last fifty years there has been large scale convergence in life expectancy suggesting that overall world welfare levels have been converging (Bourguignon and Morrisson, 2002, Becker, Philipson and Soares, 2005). The large monetary value of health gains gives a rational for investing in health quite apart from its instrumental value as a input into productivity.

4. Health as Human Capital

The idea of health as a form of human capital has a long history (for example, see Mushkin, 1962). Grossman (1972) develops a model in which illness prevents work so that the cost of ill health is lost labor time. However, there may also be an effect of ill health on worker productivity in employment. A major difficulty in measuring the economic effect of health is the two-way causality between wealth and health (Smith, 1999). Another difficulty is the lack of consensus on what is meant by health. Different studies use different health measures: self-assessments of health, biomarkers, medical records, limitations on physical functioning, and anthropometric measurements have all been used as health indicators. Each of these approaches may fail to provide a complete picture of an individual's health status, giving rise to a problem of measurement error. In addition, it is necessary to separate out the effect of investments in health from the effect of natural or genetic variation in health (Schultz, 2005).

One solution to these problems in measuring the effect of health on worker productivity is to establish the causal paths in panel data through the use of timing of health shocks and income or wealth responses (for example, Adams et al., 2003). Case, Fertig and Paxson (2005), controlling for parental influences and education, find that childhood health has a significant impact on adult health and earnings. Yet another approach to establishing causality is to use instrumental variables. For example, Schultz (2002) instruments adult height with childhood health and nutrition to argue that each centimeter gain in height due to improved inputs as a child in Ghana and Brazil leads to a wage increase of between eight and ten per cent (Strauss and Thomas, 1998, provide a survey of studies in this area).

Thomas and Frankenberg (2002) caution against drawing inferences from observational studies and instead advocate an experimental approach. Two randomized experiment using iron supplementation to reduce iron deficiency anemia led to sizeable effects on worker productivity in Indonesia (Basta, Soekirman and Scrimshaw, 1979). Quasi-experiments can be used where it is possible to treat changes to health as if such changes were randomly generated. Bleakley (2003) considers the effects of the eradication of hookworm and malaria in the United States in the 1910s and 1920s. These diseases were pandemic in many counties of the American South prior to eradication. Bleakley, controlling for normal wage gains in areas that were not infected, shows that children not exposed to these diseases due to their eradication had improved incomes as adults relative to those born before eradication. This body of research on health and human capital generally supports the idea that health affects worker productivity. However, it lacks a good appreciation of which types of health intervention are most important and what rate of return can be achieved by investing in health as a form of human capital. In many developing countries, relatively inexpensive activities designed to prevent the spread of infectious disease (for example, vaccination) can increase population health at low cost, suggesting that even modest income gains from health will generate very high rates of return. By comparison, treating chronic non-infectious disease in developed countries is often costly. There is evidence that susceptibility to chronic disease in later life is determined by health and nutrition as a fetus and in infancy (Barker, 1992; Behrman and Rosenzweig, 2004), suggesting that early health investments are crucial for adult productivity.

5. Health, Education and Cognitive Ability

Education is widely agreed to affect economic outcomes, and health affects education through two mechanisms. The first is the effect of better child health on school attendance, cognitive ability, and learning. Bleakley (2003) finds that deworming of children in the American South had an effect on their educational achievements while in school. Miguel and Kremer (2004) find that deworming of children in Kenya increased school attendance. The second mechanism is the effect of lower mortality and a longer prospective lifespan on increasing incentives to invest in human capital. This effect occurs for the individual for whom the benefits of education are now greater (Kalemli-Ozcan, Ryder and Weil, 2000). In addition, lower infant mortality may encourage parents to invest more resources in fewer children, leading to low fertility but high

levels of human capital investment in each child (Kalemli-Ozcan, 2002). Evidence for this effect is limited, though Bils and Klenow (2000) do find an effect of life expectancy on investments in education at the national level.

There are several paths from impaired health to the inadequate education of children. Leslie and Jamison (1990) review the links between health conditions and what they see as the three main educational problems in developing countries: children who are unprepared to attend school, the failure of many students to learn in school, and the unequal participation of girls in schooling.

Children's readiness for school may be hindered by cognitive and physical impairments. These problems may begin *in utero* due to inadequate nutrition and poor health of the mother. An estimated 30 million infants are born each year in developing countries with impaired growth due to poor nutrition during fetal life (UN 2000). For example, cretinism, which can be avoided if iodized salt is provided to the mother, is the most common preventable cause of mental retardation worldwide (Cao *et al.* 1994: 1739). Moreover, malnourished children are less likely to enroll in school; those who do enroll do so at a later age (UN 2004).

The failure of children in developing countries to learn in school is often attributable to illness. The most important causes of morbidity among school-age children include helminthic infections, micronutrient deficiencies, and chronic protein malnutrition. (Estimates of mortality may be inadequate in assessing the burden of disease among school children because most illnesses are non-fatal.) When not fatal, these conditions impair children's ability to learn by directly contributing to disease, absenteeism, and inattention among children. Micronutrient deficiencies have a variety of adverse health effects. Vitamin A deficiency contributes to measles mortality and diarrheal illness (WHO 2004a) and is the leading cause of preventable pediatric blindness in low-income countries (Sommer and West 1996: 649ff). Impaired vision is a huge barrier to receiving an education, particularly in resource-poor settings. Globally, 4.4 million children and 6.2 million women of childbearing age manifest varying degrees of vision impairment from vitamin A deficiency (UN 2004). Iron deficiency is a well-documented cause of impaired cognitive development and lowered school achievement, and has a high economic cost (Grantham-McGregor and Ani 2001). It is also one of the most prevalent nutrient deficiencies in the world, affecting an estimated two billion people (WHO 2004a). Horton and Ross (2003) estimate that income forgone due to iron deficiency ranges from 2 per cent of GDP

in Honduras to 7.9 per cent in Bangladesh. The higher estimates are associated with severe iron deficiency and higher returns to educational attainment in the labor market for a given country.

Biological and cultural forces affect the health of girls and can impede their educational attainment. Attending to remediable medical problems could help keep girls in school. Menstruation exacerbates iron-deficiency anemia and at around the same developmental stage, iodine deficiency disorders also begin to affect more girls. Pregnancy increases nutrient demands and the risk of morbidity and mortality from a multitude of associated causes. An estimated 15 per cent of women develop potentially life-threatening complications associated with pregnancy, such as hemorrhage, infection, unsafe abortion, eclampsia, and obstructed labor (WHO 2004b). Early marriage and child-bearing may account for the drop-off in number of girls enrolled in secondary and tertiary school. A ubiquitous and disturbing pattern is that when illness strikes a family, girls often discontinue studies to assume responsibilities for household chores. Overviews of the interaction between health and education appear in Bloom (2005, 2006).

A year of education increases wages by about 10 per cent in developing countries. (Psacharopoulos and Patrinos 2004). In the United States a standard deviation gains in mathematics and language test scores each correspond to 8% higher wages (Kruger, 2003) and there is evidence that in developing countries the effects may be even higher. this suggests that the effects of childhood health on educational outcomes and cognitive development may be even more substantial (Glewwe, 1996, Moll 1998). However wage studies such as these should be interpreted with caution given how much of production in developing countries is carried out by subsistence farming where productivity estimates are more difficult to construct (Glewwe, 2002)

6. Health and Saving

Poor health affects both the ability to save and the impetus to save. Sickness can have a large effect on out-of-pocket medical expenses, which can reduce current and accumulated household savings. This occurs in developed countries (Smith, 1999) but is of particular concern in developing countries. In many developing countries the weakness of public and private insurance systems means that out of pocket spending by households is the main source of financing of the health system. For example, in India 83% of health spending comes from the private sector and 94% of the private sector spending is out of pocket expenses (World Health Organization, 2007). Health shocks mean that families may be thrown into poverty if there is a lack of insurance and

productive assets such as land or animals must be sold to pay for medical expenses (Xu et al. 2003).

Because poor health tends to be associated with a short lifespan, increasing population health and expected longevity will have an effect on the planning horizon and will influence life-cycle behavior. With a fixed retirement age, a longer lifespan elicits greater savings for retirement. Blanchard (1985) considers the theoretical effect of a longer lifespan in a macroeconomic model. Hurd, McFadden, and Gan (1998) find that increased expectation of longevity leads to greater wealth-holding at the household level in the United States. Bloom, Canning, and Graham (2003) find an effect of life expectancy on national savings, using cross-country data. Lee, Mason, and Miller (2000) argue that rising life expectancy can account for the boom in savings in Taiwan since the 1960s. But the effect of a longer lifespan need not be increased saving for retirement; people could instead choose to work longer. The behavioral response to longer lifespans depends on social security arrangements and retirement incentives (Bloom, Canning, Moore and Mansfield, 2007).

In a life-cycle model with a stable age structure and no population growth or economic growth, the dissaving of the old will exactly match the saving of the young at any level of life expectancy. This suggests that the aggregate effect of longer lifespans on savings is temporary and occurs when life expectancy rises. In the long run, the high savings rates of the working age population will be off set by the dissaving of a large cohort of elderly.

While we focus on saving the more important mechanism may be via investment. I n many poor societies, the household is the focus on production as well as consumption activities. Household saving can take the form of investments in productive assets, such as land, animals, machinery, or seeds that directly affect productivity. Even in more advanced economies where saving is in the form of financial assets, an effect on saving may lead to higher investment if capital markets are not perfectly open. In addition, a healthy population and workforce may increase productivity and encourage foreign direct investment (Alsan, Bloom, and Canning, 2006) while infectious disease can lower productivity and deter investment. These empirical results are supported by historical evidence. The best known example is that of the building of the Panama Canal. Yellow fever and communicable diseases claimed the lives of 10,000 to 20,000 workers between 1882 and 1888, forcing Ferdinand de Lesseps and the French to abandon the construction project (Jones 1990).

7. Health and Demography

The global population explosion of the 19th and 20th centuries was caused not by a rise in fertility but by a fall in mortality. Lower mortality and improved survival rates increased population numbers, but also led to significant increases in the number of young people since the largest improvements in mortality are initially in infant mortality rates. In the long run, reductions in infant mortality lead to a fall in desired fertility, creating a one-time baby-boom cohort. As this large cohort ages, the resultant changes in population age structure can have significant economic implications.

Improvements in health and decreases in mortality rates can catalyse a transition from high to low rates of fertility and mortality – the 'demographic transition' (Lee, 2003). Population growth is the difference between birth and death rates (ignoring migration) and the global population explosion in the 20th century is attributable to improvements in health and falling death rates. In developing countries, health advances tend to lower infant and child mortality rates, leading initially to a surge in the number of children. Reduced infant mortality, increased numbers of surviving children, and rising wages for women can lower desired fertility (see Schultz, 1997) leading to smaller cohorts of children in future generations. Better access to family planning can also help couples achieve match more closely their fertility desires and realizations.

This process creates a 'baby boom' generation that is larger than both preceding and succeeding cohorts. Subsequent health improvements tend primarily to affect the elderly, reducing old-age mortality and lengthening the lifespan. In many theoretical models a population explosion reduces income per capita by putting pressure on scarce resources and by diluting the capital– labor ratio. In these models population declines spur economic growth in per capita terms. For example, the very high death rates, and decline in population, due to the Black Death in 14th century Europe appear to have caused a shortage of labor, leading to a rise in wages and the breakdown of the feudal labor system (Herlihy, 1997). However, in modern populations there appears to be little connection between overall population growth and economic growth; indeed the 20th century saw both a population explosion and substantial rises in income levels. recent evidence from growth models (see below) suggests that high population density in coastal

areas is conducive to economic growth suggesting that scale and specialization effects can outweigh the negative impacts of large populations.

Although it is difficult to find significant effects of overall population growth on economic growth, it is possible to consider the components of population growth separately. High birth and low death rates both generate population growth, but seem to have quite different effects on economic growth (Bloom and Freeman, 1988; Kelley and Schmidt, 1995). This may be because, while both forces increase population numbers, they affect the age structure quite differently. The effect of changing age structure due to a baby boom has large effects as the baby boomers enter the workforce and then as they eventually retire. While the baby boomers are of working age, economic growth may be spurred by a 'demographic dividend' if the baby boom generation can be productively employed. Bloom, Canning and Sevilla (2004) find that the demographic dividend increases the potential labor supply but its effect on economic growth depends on the policy environment. There is a worry that health improvements and population aging will lead to high dependency rates and a slowdown in economic growth. In addition to longer lifespans, however, we are seeing a compression of morbidity; the period of sickness towards the end of life is falling as a proportion of overall lifespan (Fries, 1980; 2003). The idea that old-age dependency starts at 65 is essentially a result of social security retirement arrangements (Gruber and Wise, 1998) and healthy aging means that physical dependency now often occurs at much later ages.

8. Health and Economic Growth

There are two approaches to estimating the effect of health on economic growth. the first is to take estimates of the effect of health from microeconomic studies and use these to calibrate the size of the effects at the aggregate level. The second is to estimate the aggregate relationship directly using macroeconomic data. We begin by considering the calibration approach.

An immediate difficulty is that in macroeconomic models, population health is usually taken to be life expectancy, or some other mortality measure, as opposed to the morbidity measures used at the individual level. While the world Health Organization's Global Burden of Disease project now gives estimates of disability rates due to ill health, as well as mortality rates, such data are available only for recent years[1]. In addition, even calculating life expectancy

[1] The World Bank data is available at http://www.who.int/healthinfo/bod/en/index.html

requires age-specific mortality rates that are unavailable for many developing countries and published life-expectancy figures from the World Bank and United Nations are often constructed from quite incomplete raw data (Bos et al., 1992). In particular, we often only have reasonable estimates of infant mortality in developing countries and mortality rates at older ages are imputed using standard life tables. There is a need to improve our measures of population health and to expand them to measures that correspond to morbidity and not just mortality.

Even with a mortality measure such as life expectancy it is difficult to assess how this can be related to evidence from microeconomic studies on the lick between morbidity and productivity. This disjunction can be bridged by assuming a one-to one relationship between mortality and morbidity rates in a population; however it is not clear that such a relationship holds, making comparison of the macroeconomic relationship and microeconomic relationships difficult.

The effect of health on individual productivity implies a relationship between population health and aggregate output. Shastry and Weil (2003) calibrate a production function model of aggregate output using microeconomic estimates of the return to health. They assume a stable relationship between average height and adult survival rates so that when adult survival rates improve we can infer a rise in population heights. Using estimates of the effect of height on worker productivity and wages from microeconomic studies they calibrate what health improvements in the form of lower adult survival rates should mean for aggregate output. They find that cross-country gaps in income levels can be explained in part by differential levels of physical capital, education, and health, with these three factors being roughly equal in terms of their contribution to differences in income levels. A little over half of cross-country income gaps are explained by these factors; the remainder of the gap is ascribed to differences in total factor productivity.

The argument that health is uni-dimensional so that health indicators can be used interchangeably is useful for analysis but it is not clear that it is true. In terms of mortality and height indicators. Deaton (2007) makes the point that most of the cross country variation in heights is not related to health and that a population's average height is not a good indicator of its health status. However, it may still be the case that changes in population height over time reflect changes health status. Crimmins and Finch (2006) show that the cohorts that underwent substantial improvements in infant mortality in developed countries in the late 19th century were

the same cohorts that experienced gains in adult height and improvements in adult mortality. However, Akachi and Canning (2007a,b) argue that this relationship appears to hold today in most developing countries, but not in Sub-Saharan Africa. In most developing countries gains in infant mortality rates and the cohorts eventual adult height are strongly related. In Sub-Saharan Africa however cohort average height has been declining slightly over the last fifty years while infant mortality has declined rapidly. The health gains in Sub-Saharan Africa are more dependent of life saving medial interventions and less on than usual on broad based improvements in nutrition and the prevalence of disease that would reduce morbidity.

Table 1 shows time trends of height infant mortality and nutrition. In terms of infant mortality, we find very similar rates of decline in Sub-Saharan Africa and developing countries in other regions: a decrease of about 2.1 versus 2.4 deaths per thousand births each year. On the other hand, while both protein and calorie consumption have been increasing significantly elsewhere, within Sub-Saharan Africa protein and calorie consumption remained virtually unchanged over the whole period. The trends in height are also quite distinct. In Sub-Saharan Africa heights overall have been decreasing; the cohort born in 1985 is about 0.5 centimeters shorter that the cohort born in 1961. On the other hand, in the rest of the developing world the height of adult women has risen by approximately 1.6 centimeters on average during this twenty four year period.

Another approach is to estimate the effect of population health on economic growth directly. Estimating the effect of the current level of population health on current income levels is subject to the problem of reverse causality; income also affects health. One way around this problem is to look at the effect of population health on subsequent economic growth, arguing that the timing can determine the direction of causality. This requires the absence of reverse causality through an expectation effect (so that current health is not caused by expected future economic growth).

Growth regressions show that the initial levels of population health are a significant predictor of future economic growth (Bloom, Canning and Sevilla, 2004, provide a survey of this literature). Bhargava et al. (2001) argue that the effect of health on economic growth is larger in developing countries than in developed countries. Table 2, taken from Alsan et al. (2007) gives rates economic growth over the period 1960-2000 for groups of countries where grouping is by initial income and life expectancy. This table shows why studies tend to find health to be a

significant predictor of economic growth. At each level of income there is a tendency for the countries with higher initial levels of life expectancy to experience more rapid economic growth.

While population health measures are highly predictive of future economic growth, there is a debate about how to interpret the link. The health effect could be interpreted as the macroeconomic counterpart of the worker productivity effect found in individuals. However, Acemoglu, Johnson and Robinson (2003) argue that health differences are not large enough to account for much of the cross-country difference in incomes, and that the variations in political, economic and social institutions are more central factors. They argue that health does not have a direct effect on growth, but serves in growth regressions as a proxy for the pattern of European settlement, which was more successful in countries with a low burden of infectious disease.

One way to address the issue is to see how the effect of health caries with the inclusion of other variables in the growth regression that may account for potential omitted variables. Sala-i-Martin, Doppelhofer and Miller (2004) conduct test 67 potential variables that might affect economic growth. They start by putting an equal probability of being affecting growth on each variable. They then run possible models of a particular size (for example, 5, 7, 9 and 11 explanatory variables) and perform Bayesian updating on the results to find the find the posterior probability of each variable being included. If the model has only five explanatory variables they select the East Asia dummy, primary schooling, price of investment goods, initial income and fractional tropical area as the most likely explanations of economic growth. However extending the model to include 9 explanatory variables adds life expectancy and malaria prevalence (as well as the fraction of the population Confucian and the population density in coastal areas). This indicates that the predictive power of health for economic (as measured by life expectancy and malaria prevalence) is robust to the specification of the growth regression.

Acemoglu and Johnson (2006) raise a second objection to the argument that health affects economic growth. The instrument health using the initial disease burden and world wide technological progress in disease specific interventions. They find that instrumented health does not predict the level of income. This result is subject to the criticism of lag times; it may take time for health technologies to be implemented and time for the health improvements in children to work their wt into productivity improvements. However, the major innovation in the paper is the argument that health improvements increase longevity and spur population growth and this population growth puts a stain on other factors, causing income per capita to fall.

As we have already noted in the section on demography, the resultant population growth is usually short lived. Falling infant mortality usually leads to a fall in fertility, which stabilizes population numbers and generates a demographic dividend through a very low level of youth dependency. However this effect does take time and it seems likely that the initial effects of rising child survival (which is where mortality health gains tends to be concentrated in developing countries) on income per capita are negative. Acemoglu and Johnson's work certainly points towards a need for a better understanding of the demographic consequences of health improvements. Given the importance of the effect of mortality reduction on fertility behavior for our understanding of the effects of health improvements the evidence base is rather weak. Cleland (2001) argues for a strong effect on fertility based on the evidence on the timing of the fertility, though he emphasizes the effect may be delayed. However, at the individual level the replacement effect of a child's death on the mother's fertility is fairly small (Palloni and Rafalimanana, 1999). They find that the major effect appears to be community level expectations of infant mortality, while Bongaarts and Watkins (1996) emphasize the role of diffusion of social norms in fertility behavior, making the effects of infant mortality on fertility difficult to estimate from household data.

Even if a causal interpretation of the effect of health on individual productivity and economic growth is accepted, the argument for using health as an input depends on there being low-cost health interventions that can increase population health without first having a high income level. There are, however, a large number of such interventions that can be implanted (Commission on Macroeconomics and Health, 2001).

9. Disease Specific Issues

(i) Tropical Diseases and Malaria

Sub-Saharan Africa suffers from poor health due to the widespread presence of tropical disease. A particular issue with many tropical diseases is that they may have a high morbidity burden but a small effect on mortality. Diseases such as malaria, schistosomiasis and intestinal worms can cause anemia and reduced energy levels and productivity as well as having significant long term developmental effects if acquired by children.

Gallup and Sachs (2001) find that countries heavily burdened with malaria experienced significantly lower growth between 1965 and 1990 even after allowing for the effect of life expectancy in each country. New evidence is pointing to large long term effects on education and productivity outcomes for children who avoid being infected when DTT campaigns are used to eliminate Malaria. Bleakley (2007) examines the effect of childhood exposure to Malaria in the USA, Mexico Colombia and Brazil on income levle as an adult. He identifies the effect by looking at the earnings of children born after the DDT intervention in previously malarial areas with those born before the intervention, and comparing this with the change in earnings in non-malaria area over the same period. He finds very large effects with a removal of childhood malaria increasing adult earnings by around 50%. Cutler et al. (2007) undertake a similar study of the DTT eradication program in India in the 1960s and find significant effects on the educational outcomes of children who avoided exposure to malaria due to the program.

There is abundant evidence of the large effects of the malaria on adults. Focusing just on working days lost as a result of bouts of illness Babu et al (2002). In malaria endemic areas adults can expect about two bouts of malarial fever a year bout with each leading to the loss of between 5 and 10 working days. This amounts to a reduction in labor supply of about 5%. While this effect on working days loss is substantial, the effect of early exposure on children's cognitive development and eventual earnings may be much greater.

Lymphatic filariasis is also transmitted by mosquitoes and has large health (about 120 million eople are infected worldwide, mainly in Asia and the Americas) and worker productivity effects (Ramaiah et al (2000)). Efforts to attack malaria transmission through targeting the transmission vector are likely to reduce the burden of this disease as well.

The parasitic worm diseases have high rates of prevalence in developing countries (see Table 3). Iron deficiency anemia, which can result from the parasitic diseases, has insidious effects lowering energy levels, worker productivity and wages (Thomas and Frankenberg (2002)). The parasitic worm diseases are most common in children where they have effects on school attendance, literacy and physical development (Bleakley (2003), Miguel and Kremer (2004), though the potential for effects on cognitive development are less clear (Dickson et al. (2000)).

The low costs of interventions that can substantially reduce, or eliminate, the burden of these parasitic diseases should make these a high priority even in the poorest countries. Annual

population and school based drug administration is safe and effective and costs very little (Molyneux (2004) and Molyneux, Hotez, and Fenwick (2005)). It promises large benefits, both in terms of reduced morbidity burden and economic gains. These tropical diseases (other than malaria) are now often grouped under the heading of "neglected" diseases. This is because of their low mortality burden which makes them less of a health priority than high mortality diseases. In addition the ill health they cause is not acute and rarely results in patients reporting to medical facilities for treatment. The morbidity associated with these disease has a very low weight in estimates of the total burden of disease (Murray and Lopez, 1996), even though their effects on worker productivity many be large. There is a strong case for focusing on these "neglected" diseases for economic if not health reasons (Canning, 2006).

(ii) HIV/AIDS

It is estimated that approximately 39 million people are infected with HIV (UNAIDS 2006), and that AIDS is now the world's leading killer of adults ages 15–59 (WHO 2003). Co-infections of HIV and malaria or tuberculosis can exacerbate an already dire health situation. A high prevalence of some diseases negatively impacts economies and is associated with lower economic growth rates. Although HIV/AIDS has increased mortality rates dramatically, its impact on income per capita is unclear. HIV/AIDS is associated with high mortality but the period of sickness before death is relatively short. This mutes the worker productivity effects of the disease. Bloom and Mahal (1997) find that HIV/AIDS does not seem to lower the growth rate of income per capita; lower output is matched by lower population numbers due to high death rates. Young (2005) goes further and argues that AIDS mortality reduces fertility significantly, and that this, together with the deaths of large numbers of people, will lower population pressure and increase the income per capita of the survivors of the pandemic in South Africa.

Many authors, however, argue that AIDS mortality has significant indirect effects that will reduce economic growth in the long term. Deaths from HIV/AIDS are concentrated among young adult men and women, leading to a higher dependency ratio. Bell, Devarajan, and Gersbach (2004) argue that the creation of a generation of AIDS orphans may lead to lack of care and education for children and to low productivity in the future. This effect may be compounded by fatalism induced by high AIDS mortality and shortened expected lifespan,

which reduce the return to education. The high level of stigma associated with HIV/AIDS can reduce trust in the community, while high mortality and the strains imposed by extreme ill health before death can weaken families, community groups, firms, and government agencies, with long-term consequences for social capital (Haacker, 2004).

It is important to remember that income per capita is not a complete measure of welfare. Resources devoted to preventing and treating HIV/AIDS are part of measured income but reduce consumption of other goods, reducing welfare even as measured GDP per capita may remain steady. A more comprehensive welfare measure that included the welfare gain derived from a long lifespan, as well as annual income, would show a large welfare reduction due to HIV/AIDS (Crafts and Haacker, 2004). The main welfare effect of HIV/AIDS is the sickness and death of its victims and the impact of these on the victims' families; the effect on the average income level of the survivors is decidedly secondary.

In terms of policy to combat HIV/AIDS there are a number of prevention options that are highly cost effective and could make a large impact on the course of the epidemic. However in terms of health gains, the high cost of anti-retroviral treatment (ART) relative to other interventions that can improve health make it difficult to justify in very poor countries (Canning, 2006). However recent evidence has suggested that patients on ART are well enough to return to work and this economic payoff may strengthen the case for treatment (Thirumurthy, Zivin, and Goldstein, 2005).

Bibliography

Adams, P., Hurd, M.D., McFadden, D.L., Merrill, A. and Ribeiro, T. 2003. Healthy, wealthy, and wise? Tests for direct causal paths between health and socioeconomic status. Journal of Econometrics 112, 3–56.

Acemoglu, D., Johnson, S. and Robinson, J. 2003. Disease and development in historical perspective. Journal of the European Economic Association, Papers and Proceedings 1, 397–405.

Akachi Y, Canning D. 2007a, The Height of Women in Sub-Saharan Africa: the Role of Health, Nutrition, and Income in Childhood. Annals of Human Biology;34(4):397-410.

Akachi Y, Canning D. 2007b, Health Capital in Sub-Saharan Africa: Evidence from Adult Heights, Program on the Global Demography of Aging, Harvard University.

Alsan, M., Bloom, D.E. and Canning, D. 2006. The effect of population health on foreign direct investment inflows to low- and middle-income countries. World Development 34, 613–30.

Alsan, Marcellea, David E. Bloom, David Canning and Dean Jamison, " The Consequences of Population Health for Economic Performance," in *Health, Economic Development and Household Poverty,* edited by Sara Mills, Lucy Gibson and Anne Mills, Routledge, Oxford, 2007, pp 21-39.

Barker, D.J.P. 1992. The Fetal and Infant Origins of Adult Disease. London: BMJ Books.

Basta, S., Soekirman, K. and Scrimshaw, N. 1979. Iron deficiency anemia and productivity of adult males in Indonesia. American Journal of Clinical Nutrition 32, 916–25.

Becker, G.S., Philipson, T.J. and Soares, R.R. 2005. The quantity of life and the evolution of world inequality. American Economic Review 95, 277–91.

Behrman, J.R. and Rosenzweig, M.R. 2004. The returns to birthweight. Review of Economics and Statistics 86, 586–601.

Bell, C., Devarajan, S. and Gersbach, H. 2004. Thinking about the long-run economic costs of AIDS. In The Macroeconomics of HIV/AIDS, ed. M. Haacker. Washington, DC: International Monetary Fund.

Bhargava, A., Jamison, D., Lau, L. and Murray, C. 2001. Modeling the effects of health on economic growth. Journal of Health Economics 20, 423–40.

Bils, M. and Klenow, P.J. 2000. Does schooling cause growth? American Economic Review 90, 1160–83.

Blanchard, O.J. 1985. Debt, deficits, and finite horizons. Journal of Political Economy 93, 223–47.

Bleakley, H. 2003. Disease and development: evidence from the American south. Journal of the European Economic Association 1, 376–86.

Bloom, D.E. and Canning, D. 2000. The health and wealth of nations. Science 287, 1207–8.

Bloom, D.E., Canning, D. and Graham, B. 2003. Longevity and life-cycle savings. Scandinavian Journal of Economics 105, 319–38.

Bloom, D.E., Canning, D. and Sevilla, J. 2004. The effect of health on economic growth: a production function approach. World Development 32, 1–13.

Bloom, D.E. and Freeman, R.B. 1988. Economic development and the timing and components of population growth. Journal of Policy Modeling 10(1), 57–82.

Bloom, D.E. and Mahal, A.S. 1997. Does the AIDS epidemic threaten economic growth? Journal of Econometrics 77, 105–24.

Bloom, D.E. and Sachs, J. 1998. Geography, demography, and economic growth in Africa. Brookings Papers on Economic Activity 1998(2), 207–73.

Bongaarts J. and S.C. Watkins (1996). Social Interactions and Contemporary Fertility Transitions. *Population and Development Review*, 22(4): 639-682.

Bos, E., Vu, M.T., Stephens, P.W. and Patience, W. 1992. Sources of World Bank estimates of current mortality rates. Policy Research Working Paper Series 851. Washington, DC: World Bank.

Francois Bourguignon, Christian Morrisson, 2002, Inequality among World Citizens: 1820-1992**,** *The American Economic Review*, Vol. 92, No. 4, pp. 727-744.

Canning, David, "The Economics of HIV/AIDS in Low-Income Countries: The Case for Prevention", *Journal of Economic Perspectives*, 2006, Vol. 20(3), pp 121-142.

Canning, David, "Priority Setting and the 'Neglected' Tropical Diseases," *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 2006, Vol. 100(6), pp 499-504.

Case, A., Fertig, A. and Paxson, C. 2005. The lasting impact of childhood health and circumstance. Journal of Health Economics 24, 365–89.

Cleland J. (2001). *The* Effect of Improved Survival on Fertility: A Reassessment. *Population and Development Review*, 27: 60-92

Commission on Macroeconomics and Health. 2001. Macroeconomics and Health: Investing in Health for Economic Development. Geneva: World Health Organization.

Crafts, N. and Haacker, M. 2004. Welfare implications of HIV/AIDS. In The Macroeconomics of HIV/AIDS, ed. M. Haacker. Washington, DC: International Monetary Fund.

Crimmins E, Finch C. 2006, Infection, inflammation, height, and longevity. Proceedings of the National Academy of Sciences;103(2):498-503.

Cutler, D.M., Deaton, A.S. and Lleras-Muney, A. 2006. The determinants of mortality. Journal of Economic Perspectives 20(3), 71–96.

Cutler, D.M. and McClellan, M. 2001. Productivity change in health care. American Economic Review 91, 281–86.

Cutler, D.M. and Miller, G. 2005. The role of public health improvements in health advances: the twentieth-century United States. Demography 42, 1–22.

Cutler, David Cutler & Winnie Fung & Michael Kremer & Monica Singhal, 2007. "Mosquitoes: The Long-term Effects of Malaria Eradication in India," NBER Working Papers 13539.

Deaton, A. 2006. The great escape: a review essay on Fogel's The Escape from Hunger and Premature Death, 1700–2100. Journal of Economic Literature 44, 106–14.

Deaton A. 2007. Height, health, and development. Proceedings of the National Academy of Sciences of the United States of America. 8 August.

De Silva NR, Brooker S, Hotez PJ, Montresor A, Engels D, et al. Soil-transmitted helminth infections: Updating the global picture. *Trends Parasitol*. 2003;19:547–551.

Easterly, W. 1999. Life during growth. Journal of Economic Growth 4, 239–76.

Fogel, R.W. 2004. The Escape from Hunger and Premature Death, 1700– 2100: Europe, America, and the Third World. Cambridge: Cambridge University Press.

Fries, J.F. 1980. Aging, natural death, and the compression of morbidity. New England Journal of Medicine 303, 130–5.
Fries, J.F. 2003. Measuring and monitoring success in compressing morbidity. Annals of Internal Medicine 139, 455–9.

Gallup, J.L. and Sachs, J.D. 2001. The economic burden of malaria. American Journal of Tropical Medicine and Hygiene 64(1, 2 Supplement), 85–96.

Glewwe P. The relevance of standard estimates of rates of return to schooling for education policy: a critical assessment. *Journal of Development Economics* 1996; 51: 267-290.

Glewwe P. Schools and skills in developing countries: education policies and socioeconomic outcomes. *Journal of Economic Literature* 2002; 40: 436-482.

Grossman, M. 1972. On the concept of health capital and the demand for health. Journal of Political Economy 80, 223–55.

Gruber, J. and Wise, D. 1998. Social security and retirement: an international comparison. American Economic Review 88(2), 158–63.

Haacker, M. 2004. HIV/AIDS: the impact on the social fabric and the economy. In The Macroeconomics of HIV/AIDS, ed. M. Haacker. Washington, DC: International Monetary Fund.

Herlihy, D. 1997. The Black Death and the Transformation of the West. Cambridge, MA: Harvard University Press.

Hurd, M., McFadden, D. and Gan, L. 1998. Subjective survival curves and life-cycle behavior. In Inquiries in the Economics of Aging, ed. D. Wise. Chicago: University of Chicago Press.
Jones, T. (1990). *The Panama Canal: A brief history.*

Kalemli-Ozcan, S. 2002. Does mortality decline promote economic growth? Journal of Economic Growth 7, 411–39.

Kalemli-Ozcan, S., Ryder, H.E. and Weil, D.N. 2000. Mortality decline, human capital investment, and economic growth. Journal of Development Economics 62, 1–23.

Kelley, A.C. and Schmidt, R.M. 1995. Aggregate population and economic growth correlations: the role of the components of demographic change. Demography 32, 543–55.

Krueger Alan B., 2003. "Economic Considerations and Class Size," *Economic Journal*, 113: F34-63.

Lee, R. 2003. The demographic transition: three centuries of fundamental change. Journal of Economic Perspectives 17(4), 167–90.

Lee, R., Mason, A. and Miller, T. 2000. Life cycle saving and the demographic transition: the case of Taiwan. Population and Development Review 26(Supplement), 194–219.

Miguel, E. and Kremer, M. 2004. Worms: identifying impacts on education and health in the presence of treatment externalities. Econometrica 72, 159–217.

Moll PG. Primary schooling, cognitive skills and wages in South Africa. *Economica* 1998; 65: 263-84.

Murray, Christopher J. L. and Alan D. Lopez, editors, 1996, Global Burden of Disease, Harvard University Press.

Mushkin, S.J. 1962. Health as an investment. Journal of Political Economy 70(5), 129–57.

Nordhaus, W. 2003. The health of nations: the contribution of improved health to living standards. In Measuring the Gains from Medical Research: An Economic Approach, ed. K.H. Murphy and R.H. Topel. Chicago: University of Chicago Press.

Preston, S. 1975. The changing relation between mortality and level of economic development. Population Studies 29, 231–48.

Palloni A. and H. Rafalimanana (1999). The Effect of Infant Mortality on Fertility Revisited: New Evidence from Latin America, *Demography* 36(1): pp. 41-58.

Pritchett, L. and Summers, L. 1996. Wealthier is healthier. Journal of Human Resources 31, 841–68.

Sala-i-Martin, X., Doppelhofer, G. and Miller, R.I. 2004. Determinants of long-term growth: a Bayesian averaging of classical estimates (BACE) approach. American Economic Review 94, 813–35.

Schultz, T.P. 1997. The demand for children in low income countries. In Handbook of Population and Family Economics, vol. 1A, ed. M.R. Rosenzweig and O. Stark. Amsterdam: North-Holland.

Schultz, T.P. 2002. Wage gains associated with height as a form of human capital. American Economic Review, Papers and Proceedings 92, 349–53.

Schultz, T.P. 2005. Productive benefits of health: evidence from low income countries. In Health and Economic Growth: Findings and Policy Implications, ed. G. Lopez-Casasnovas, B. Riveras and L. Currais. Cambridge, MA: MIT Press.

Shastry, G.K. and Weil, D.N. 2003. How much of cross-country income variation is explained by health? Journal of the European Economic Association 1, 387–96.

Smith, J.P. 1999. Healthy bodies and thick wallets: the dual relation between health and economic status. Journal of Economic Perspectives 13(2), 145–66.

Strauss, J. and Thomas, D. 1998. Health, nutrition and economic development. Journal of Economic Literature 36, 766–817.

Thirumurthy, Harsha, Zivin, Joshua Graff and Goldstein, Markus P., 2005, "The Economic Impact of AIDS Treatment: Labor Supply in Western Kenya". NBER Working Paper No. W11871.

Thomas, D. and Frankenberg, E. 2002. Health, nutrition and prosperity: a microeconomic perspective. Bulletin of the World Health Organization 80(2), 106–13.

United Nations, 2007, World Population Prospects: the 20o6 Revision, Department of Economic and Social Affairs, Population Division.

Viscusi, W.K. and Aldy, J.E. 2003. The value of a statistical life: a critical review of market estimates from around the world. Journal of Risk and Uncertainty 27, 5–76.

Young, A. 2005. The gift of the dying: the tragedy of AIDS and the welfare of future African generations. Quarterly Journal of Economics 120, 243–66.

World Bank, 2007, World Development Indicators 2007, Washington D.C..
World Health Organization, 2007, World Health Statistics, Geneva, WHO.

Xu, K., D. Evans, K. Kawabata, R. Zeramdini, J. Klavus, and C. Murray, 2003, Household catastrophic health expenditure: a multicountry analysis**.** The Lancet, Volume 362, Pages 111-117.

Table 1
Regional Time Trends in Adult Height, Infant Mortality, and Nutrition, 1961- 1985

Region	Adult Height	Infant Mortality Rate	Calories per capita per day	Protein grams per capita per day
Sub-Saharan Africa	-0.021*** (0.003)	-2.120*** (0.052)	0.394 (0.820)	-0.019 (0.025)
Other Developing Countries	0.066*** (0.003)	-2.359*** (0 037)	16.488*** (0.795)	0.333*** (0.022)

Coefficient reported on common regional time trend with country fixed effects. Coefficients represent per annum change, standard errors in parentheses, significance level indicated as *(10%), **(5%), ***(1%). Height trends estimated with weighted least squares; weighted by the number of individuals used to calculate the cohort average height.
Source: Akachi and Canning (2007b).

Table 2
Annual Growth Rate of Per Capita Income, 1960–2000
(by income per capita and infant mortality rate, 1960)

Initial Infant Mortality Rate, 1960	**IMR ≤ 50**	**50 < IMR ≤ 100**	**100 < IMR ≤ 150**	**IMR > 150**
Initial Income, 1960 (Constant 2000 US$, PPP)				
GDP ≤ $1000	–	3.9 (1)	2.0 (11)	0.8 (9)
$1,000 < GDP ≤ $2,000	–	4.8 (3)	1.5 (7)	0.5 (7)
$2,000 < GDP < $3,500	–	1.6 (6)	1.7 (6)	1.0 (4)
$3,500 < GDP ≤ $7,000	3.5 (6)	2.1 (9)	0.7 (2)	1.0 (1)
GDP > $7,000	2.5 (17)	0.9 (1)	–	–

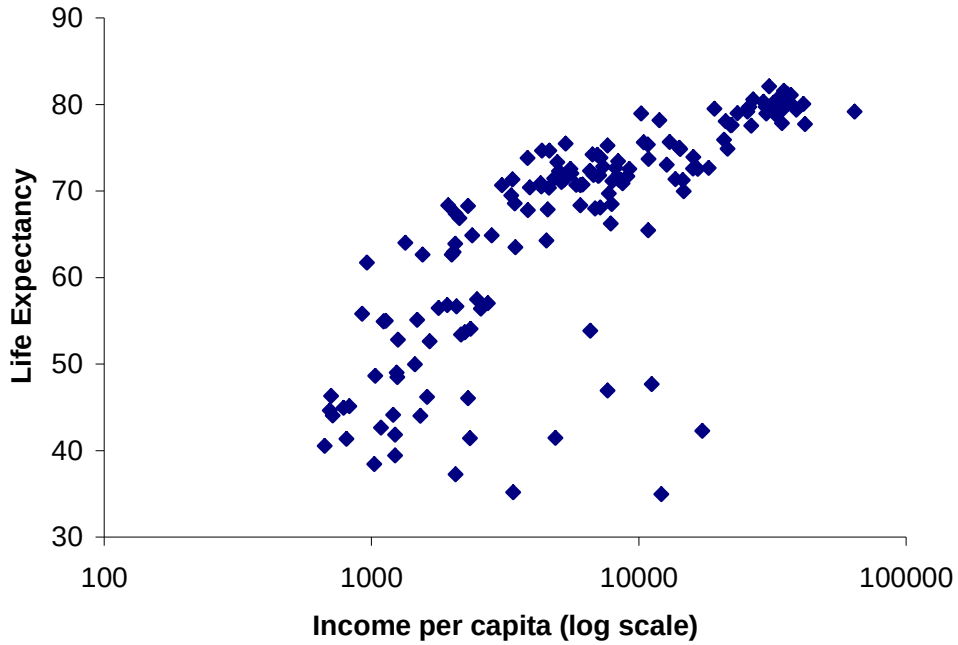
Source: Alsan, Bloom, Canning and Jamison (2007).

Table 3
Preventable Neglected Diseases
Prevalence

Region	Trichuriasis	Ascariasis	Hookworm	Schistosomiasis
Latin America and Caribean	19%	16%	10%	4%
Sub Sharan Africa	24%	25%	29%	29%
Middle East and North Africa	2%	7%	3%	7%
South Asia	20%	27%	16%	
India	7%	14%	7%	
East Asia and the Pacific	28%	36%	26%	
China	17%	39%	16%	0.10%

Data Source: De Silva et al. (2003).

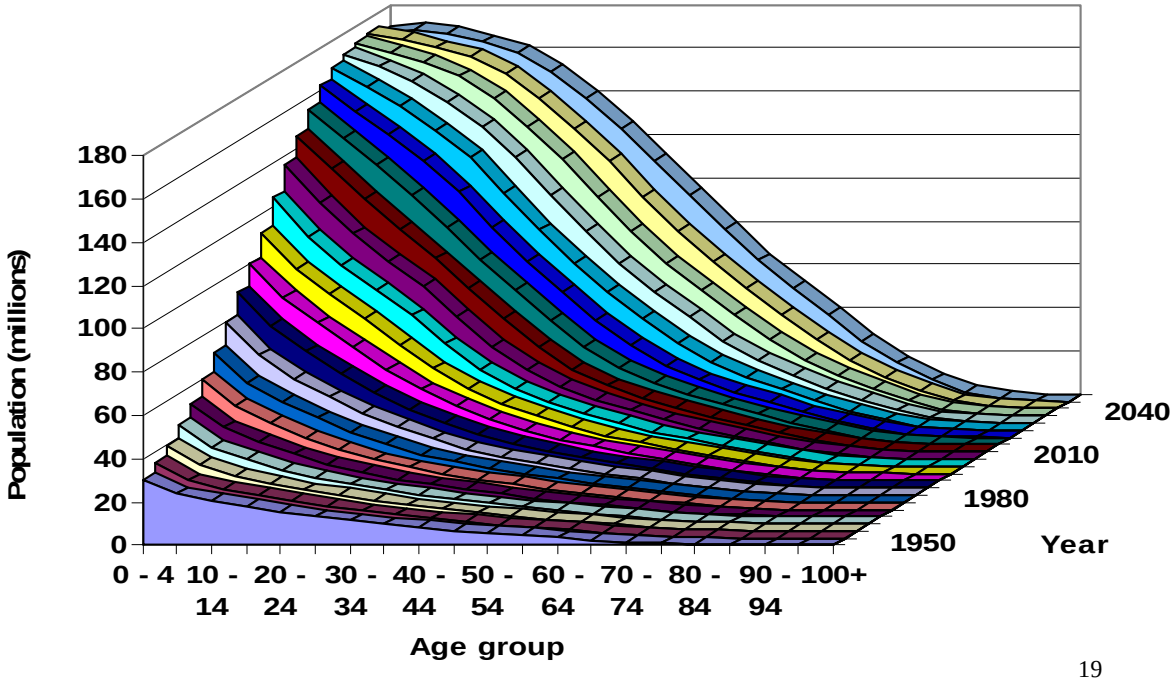
Figure 1
Income and Life Expectancy 2005



Data Source: World Bank (2007). Data are for 155 countries in 2005.
Income is in current international dollars, measured at purchasing power parity.

Figure 2

Sub-Saharan Africa's population

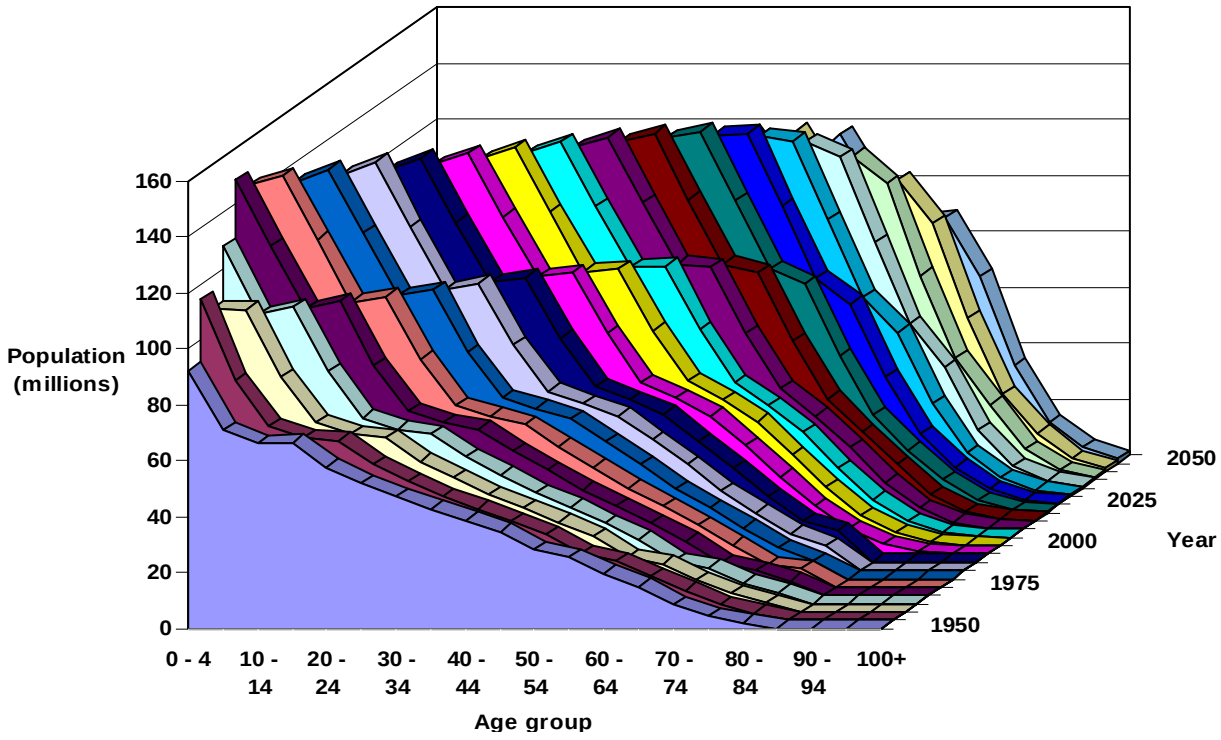


19

Data Source: United Nations (2007).

Figure 3

East Asia's Population



20

Data Source: United Nations (2007).