



CHAPTER 3

Population Health and Economic Growth

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Improvements in health may be as important as improvements in income when thinking about development and human welfare. Although good health is a goal in its own right—independent of its relationship with income—the link between health and income 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 because cheap and easily implementable health policies 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, improved access to safe water and sanitation, and increased ability to purchase more and higher-quality health care. However, health may be not only a consequence but also a cause of high income. This can work through a number of 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 on 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 life span can increase the incentives to save for retirement, generating higher levels of savings and wealth, and a healthy workforce can increase the incentives for business investment. In addition, health care costs can compel families to sell productive assets, forcing them into long-term poverty. The fourth mechanism is the effect of health on the numbers and age structure of the population.

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, but the size of the effects is an important issue. In this chapter we examine the base of evidence that tries to estimate the magnitude of the health impact.

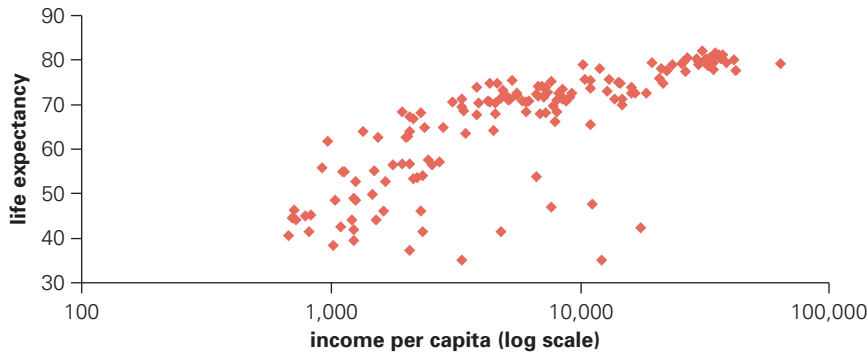
Four difficulties are apparent in assessing existing work in this area. The first is the issue of measurement. “Health” is measured differently in different studies. There is a wide variety of health measures in microeconomic studies. All of these are aimed at measuring some aspect of morbidity at the individual level. Similarly, macroeconomic studies use a variety of indicators, but these focus on measures of the mortality rate, such as life expectancy. It is difficult to compare studies that use such different notions of “health.” The second difficulty 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, which affect productivity as an adult. This implies that health effects in the macroeconomy may have long time lags, given that the average worker may have been born 40 or more years before, making the macroeconomic relationship difficult to estimate. The fourth issue is the effect of health on the economy, holding all other factors fixed, and the effect on a more general equilibrium framework, where other factors respond to improved health. Some studies measure the partial equilibrium effect, whereas 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.

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) demonstrates a positive correlation between

Figure 3.1 Income and Life Expectancy, 2005



Source: World Bank 2007. Data are for 155 countries in 2005.

Note: Income is in current international dollars, measured at purchasing power parity.

national income levels and life expectancy. Figure 3.1 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 level and health to argue for an emphasis on economic growth in poor countries as a method of improving 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 forces behind health improvements have been improvements in health technologies and public health measures that prevent the spread of infectious disease, and not higher income (Cutler, Deaton, and Lleras-Muney 2006).

Overall, Preston’s (1975) original view of the determinants of health seems to hold. If we plot the relationship between population health and national income, there 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) yields curves that are higher in later years, indicating an improvement in health over time even if income were to remain fixed. More than 75 percent of the health gains we have observed have come from upward movements of the health-income curve and less than 25 percent have come 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.

Health and Welfare

In this section 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 life span 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 improvements in welfare that have come about due to improvements in population health and those due to economic growth and higher incomes. Conceptually we can measure the monetary 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 the average life expectancy and health of Americans in 1900. The income gain they would require is a measure of the value of health and longevity in monetary 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, although income gaps between countries have been very persistent over the last 50 years, there has been large-scale convergence in life expectancy, suggesting that overall levels of world welfare have been converging (Becker, Philipson, and Soares 2005; Bourguignon and Morrisson 2002). The large monetary value of health gains gives a rationale for investing in health quite apart from its instrumental value as an input into productivity.

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 the cost of ill health is lost labor time. However, ill health may also have an effect on worker productivity. 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 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 and others 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 8 and 10 percent (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 experiments using iron supplementation to reduce iron deficiency anemia led to sizable effects on worker productivity in Indonesia (Basta, Soekirman, and Scrimshaw 1979). Quasi-experiments can be used where it is possible to treat changes in 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 after eradication had higher incomes as adults than 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 interventions 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 improve population health at low cost, suggesting that even modest income gains from health will generate very high rates of return. By comparison, treating chronic noninfectious 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.

Health, Education, and Cognitive Ability

It is widely agreed that education affects 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 life span on increasing incentives to invest in human capital. This effect increases the benefits of education for the individual

(Kalemlı-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 (Kalemlı-Ozcan 2002). Evidence for this effect is limited, although 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. Jamison and Leslie (1990) review the links between health conditions and what they see as the three main educational problems in developing countries: children who are not prepared 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. The United Nations estimates that roughly 30 million children are born in developing countries annually for whom physical development is impaired as a result of poor nutrition in utero. (United Nations Administrative Committee on Coordination, Subcommittee on Nutrition 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 and others 1994: 1739). Moreover, malnourished children are less likely to enroll in school, and those who ultimately 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 schoolchildren because most illnesses are not fatal.) When not fatal, these conditions impair children's ability to learn by contributing directly 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 2004c) and is the leading cause of preventable pediatric blindness in low-income countries (Sommer and West 1996). Impaired vision is a formidable 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 lower 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 2 billion people (WHO 2004c). Horton and Ross (2003) estimate that income forgone due to iron deficiency ranges from 2 percent of GDP in Honduras to 7.9 percent 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 to 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 percent 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 childbearing may account for the drop in the number of girls enrolled in secondary and tertiary school. A ubiquitous and disturbing pattern is that, when illness strikes a family, girls often discontinue their studies to assume responsibilities for household chores. (Overviews of the interactions between health and education appear in Bloom 2005, 2006.)

A year of education increases wages by about 10 percent in developing countries (Patrinos and Psacharopoulos 2004). In the United States a standard deviation gain in either mathematics or language test scores corresponds to 8 percent higher wages (Krueger 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).

Health and Saving

Poor health affects both the ability to save and the impetus to save. Sickness can impose large out-of-pocket medical expenses that 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 for the health system. For example, in India 83 percent of health spending comes from the private sector and 94 percent of private sector spending consists of out-of-pocket expenses (WHO 2007). Health shocks may throw families into poverty if they lack insurance and are forced to sell productive assets, such as land or animals, to pay for medical expenses (Xu and others 2003).

Because poor health tends to be associated with a short life span, 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 life span elicits greater savings for retirement. Blanchard (1985) considers the theoretical effect of a longer life span in

a macroeconomic model. Hurd, McFadden, and Gan (1998) find that expectation of increased longevity leads to greater household wealth 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, China, since the 1960s. But the effect of a longer life span need not be increased saving for retirement; people could instead choose to work longer. The behavioral response to longer life spans depends on social security arrangements and retirement incentives (Bloom and others 2007).

In a life-cycle model with a stable age structure and no population 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 a longer life span on savings is temporary and occurs when life expectancy rises. In the long run, the high saving rates of the working-age population will be offset by the dissaving of a large cohort of elderly.

Although we focus on saving, the more important mechanism for accumulating wealth may be investment. In many poor societies, the household is the focus of production and consumption activities. Household savings can take the form of investments in assets that directly affect productivity, such as land, animals, machinery, or seeds. In more advanced economies, savings may be held as investments abroad and do not automatically add to national productive capital. However, in most countries there is a close connection between domestic saving and investment, since international capital markets are not perfect. 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 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).

Health and Demography

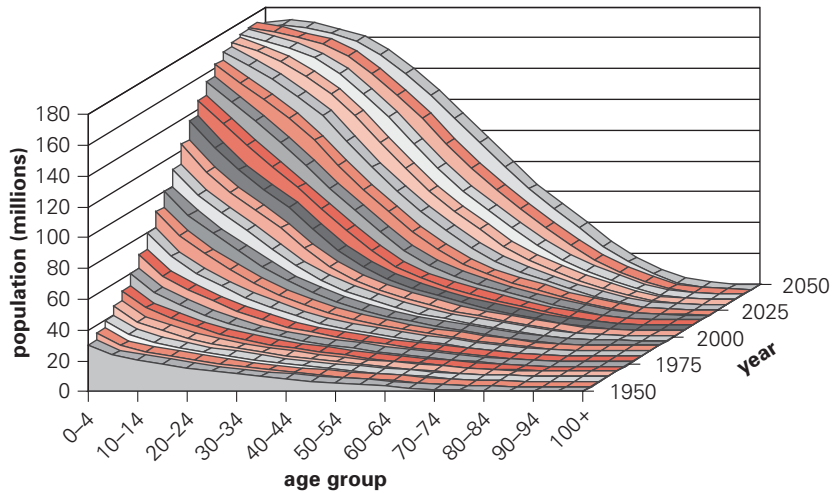
The global population explosion of the nineteenth and twentieth centuries was caused not by a rise in fertility but by a fall in mortality. Lower mortality and improved survival rates not only increased population numbers, but also led to significant increases in the number of young people because the largest improvements in mortality were initially in infant mortality. 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 catalyze 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 twentieth century is attributable to improving health and falling death rates. In developing countries, health advances tend to lower infant and child mortality, leading initially to a surge in the number of children. Reduced infant mortality, larger 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 to match more closely their desired and realized fertility.

This process creates a “baby boom” generation that is larger than both preceding and succeeding cohorts. Subsequent health improvements tend to primarily affect the elderly, reducing old-age mortality and lengthening life spans. 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, declines in population spur economic growth in per capita terms. For example, the very high death rates and decline in population due to the Black Death in fourteenth-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 twentieth century saw both a population explosion and substantial rises in income levels. Recent evidence from growth models suggests that high population density in coastal areas is conducive to economic growth, implying that scale and specialization effects can outweigh the negative impacts of large populations.

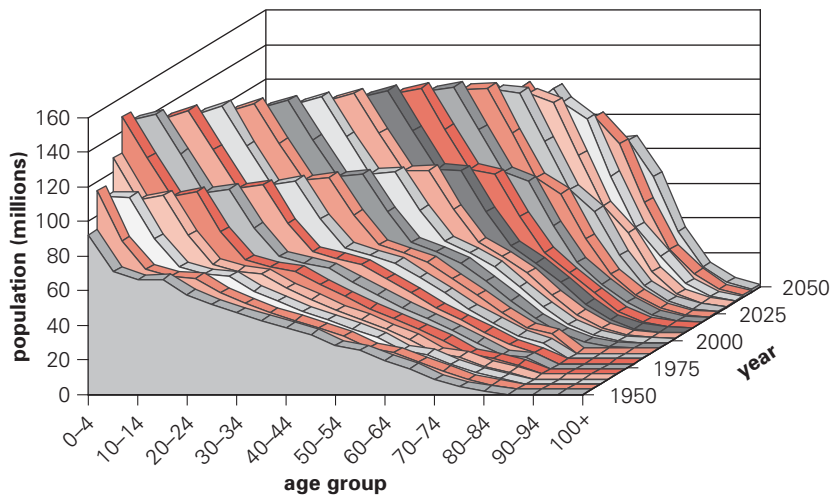
Although it is difficult to find significant effects of overall population growth on economic growth, it is possible to consider the components of population growth separately. High birth and low death rates both generate population growth, but they seem to have quite different effects on economic growth (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. As long as 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. Figure 3.2 shows how the decline in infant mortality rates is leading to a population explosion and high youth dependency rates in Africa. Figure 3.3 shows a similar pattern in East Asia, but in this case falling fertility led to a decline in the number of births after 1970 and current low levels of youth dependency. However, the aging of the large baby boom cohort in East Asia will create high old-age dependency rates in the near future. Bloom, Canning, and Sevilla (2004) find that the demographic dividend

Figure 3.2 Population in Sub-Saharan Africa, by Age, 1960–2040



Source: United Nations 2007.

Figure 3.3 Population in East Asia, by Age, 1950–2060



Source: United Nations 2007.

increases the potential labor supply but that 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 life spans, however, we are seeing a compression of morbidity; the period of sickness toward the end of life is falling as a proportion of overall life span (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.

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. Although 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 requires age-specific mortality rates that are not available for many developing countries, and published figures for life expectancy from the World Bank and United Nations are often constructed from quite incomplete raw data (Bos, Vu, and Stephens 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 link 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 and microeconomic relationships difficult.

The effect of health on individual productivity implies a relationship between population health and aggregate output. Shastri 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 making roughly equal contributions to differences in income levels. These factors explain a little more than half of the cross-country income gap; the remainder of the gap is ascribed to differences in total factor productivity.

¹ The World Health Organization data are available at <http://www.who.int/healthinfo/bod/en/index.html>.

The argument that health is unidimensional 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 height is not related to health and that a population's average height is not a good indicator of its health status. However, changes in population height over time still may reflect changes in health status. Crimmins and Finch (2006) show that the cohorts that underwent substantial improvements in infant mortality in developed countries in the late nineteenth century were the same cohorts that experienced gains in adult height and improvements in adult mortality. However, Akachi and Canning (2007a, 2007b) 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 cohorts' eventual adult height are strongly related. In Sub-Saharan Africa, however, cohort average height has stagnated over the last 50 years, while infant mortality has declined rapidly. This indicates that health gains in Sub-Saharan Africa may be more dependent on life-saving medical interventions and less on broad-based improvements in nutrition and the absence of disease that would reduce morbidity.

Table 3.1 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 1,000 births each year. However, while the consumption of both protein and calories has been increasing significantly elsewhere, within Sub-Saharan Africa it has 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 than the cohort born in 1961. In the rest of the developing world, the height of adult women rose approximately 1.6 centimeters on average during this 24-year period.

Another approach is to estimate directly the effect of population health on economic growth. Estimating the effect of the current level of population

Table 3.1 Regional Time Trends in Adult Height, Infant Mortality, and Nutrition, 1961–85

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)

Source: Akachi and Canning 2007a.

Note: These results are based on regressions with country fixed effects and regional time trends. Coefficients give the average annual change of the variable in the region; standard errors are in parentheses. Height trends are estimated with weighted least squares, weighted by the number of individuals used to calculate the cohort average height.

***Significant at 1 percent.

Table 3.2 Annual Growth Rate of Per Capita Income, by Income per Capita and Infant Mortality Rate (1960), 1960–2000

% growth

Initial income, 1960 (constant 2000 US\$, purchasing power parity)	Initial infant mortality rate			
	≤50	51–100	101–150	151+
≤\$1,000	—	3.9 (1)	2.0 (11)	0.8 (9)
\$1,001–\$2,000	—	4.8 (3)	1.5 (7)	0.5 (7)
\$2,001–\$3,500	—	1.6 (6)	1.7 (6)	1.0 (4)
\$3,501–\$7,000	3.5 (6)	2.1 (9)	0.7 (2)	1.0 (1)
\$7,001+	2.5 (17)	0.9 (1)	—	—

Source: Alsan and others 2007.

— Not available.

Note: The number reported is the average growth rate of countries in that income and infant mortality rate interval. The numbers in parentheses represent the number of countries in the interval that are used in constructing the average.

health on current level of income 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 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 and others (2001) argue that the effect of health on economic growth is larger in developing countries than in developed countries. Table 3.2, taken from Alsan and others (2007), gives economic growth rates over the period 1960–2000 for countries grouped by initial income and life expectancy. This table illustrates 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.

Although measures of population health 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 differences in health 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. 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 carries with the inclusion of other variables in the growth regression that may account for potential omitted variables. Sala-i-Martin, Doppelhofer, and Miller (2004) test 67 potential variables that might affect economic growth. They start by putting an equal probability of 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 posterior probability of each variable being included. If the model has only five explanatory variables, then 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 nine explanatory variables adds life expectancy, malaria prevalence, the fraction of the population that is Confucian, and the population density in coastal areas. This indicates that the predictive power of health for economic growth (as measured by life expectancy and malaria prevalence) is robust to the specification of the growth regression.

Acemoglu and Johnson (2007; also in this volume) raise a second objection to the argument that health affects economic growth. They instrument health using the initial disease burden and worldwide 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 way into productivity improvements. However, the major innovation in their paper is the argument that health improvements increase longevity and spur population growth and that this population growth puts a strain on other factors, causing income per capita to fall.

As we note 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 takes time, and it seems likely that the initial effects of rising child survival (which is where mortality health gains tend to be concentrated in developing countries) on income per capita are negative. Acemoglu and Johnson's work certainly points toward the need for a better understanding of the demographic consequences of health improvements. Given the importance of the effect of a reduction in mortality on fertility behavior for understanding the effects of health improvements, the base of evidence is rather weak. Cleland (2001) argues for a strong effect on fertility based on evidence regarding the timing of the fertility, although he emphasizes that 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) find that the major effect appears to be

community-level expectations of infant mortality, whereas 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 improve population health without first having a high income level. However, the number of such interventions that can be implemented is large (Commission on Macroeconomics and Health 2001).

Disease-Specific Issues

Economists and public health specialists have carried out considerable research on the manner and extent to which specific diseases have economic implications. We discuss below some findings on tropical diseases, malaria, and HIV/AIDS.

Tropical Diseases and Malaria

Sub-Saharan Africa suffers from poor health due to the widespread presence of tropical disease. Many tropical diseases may have a small effect on mortality but a high morbidity burden. Diseases such as malaria, schistosomiasis, and intestinal worms can cause anemia and reduced energy levels and productivity as well as result in 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 DDT campaigns are used to eliminate malaria. Bleakley (2006) examines the effect of childhood exposure to malaria in Brazil, Colombia, Mexico, and the United States on income level 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 then compares this with the change in earnings in nonmalarial areas over the same period. He finds very large effects with a removal of childhood malaria, increasing adult earnings by around 50 percent. Cutler and others (2007) undertake a similar study of the DDT 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 malaria on adults. Focusing just on working days lost as a result of bouts of illness, Babu and others (2002) note that in malaria-endemic areas adults can expect about two bouts of malarial fever a year, with each bout leading to the loss of

Table 3.3 Prevalence of Preventable Neglected Diseases, by Region*% of the population*

Region	Trichuriasis	Ascariasis	Hookworm	Schistosomiasis
Latin America and Caribbean	19	16	10	4
Sub-Saharan 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

Source: De Silva and others 2003.

— Not available.

between five and 10 working days. This amounts to a reduction in labor supply of about 5 percent. Although this effect on working days lost 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 effects on health and worker productivity (Ramaiah and others 2000). About 120 million people are infected worldwide, mainly in Asia and the Americas. Efforts to attack malaria transmission through targeting the transmission vector are likely to reduce the burden of this disease as well.

Parasitic worm diseases have high rates of prevalence in developing countries (see table 3.3). Iron deficiency anemia, which can result from the parasitic diseases, has insidious effects, lowering energy levels, worker productivity, and wages (Thomas and Frankenberg 2002). Parasitic worm diseases are most common in children, where they affect school attendance, literacy, and physical development (Bleakley 2003; Miguel and Kremer 2004), although the potential for effects on cognitive development are less clear (Dickson and others 2000).

The low costs of interventions that can substantially reduce or eliminate the burden of these parasitic diseases should make such interventions a high priority even in the poorest countries. Annual population- and school-based administration of drugs is safe and effective and costs very little (Molyneux 2004; 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 their low mortality burden 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 diseases has a very low weight in estimates of the total burden of disease (Murray and Lopez 1996), even though their effects on worker productivity may be large. There is a strong case for focusing on these “neglected” diseases for economic, if not for health, reasons (Canning 2006b).

HIV/AIDS

Approximately 33 million people are infected with HIV (UNAIDS 2008), and 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 affects economies and is associated with lower economic growth. 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 significantly reduces fertility 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 shorter expected life span, which reduce the returns to education. The high level of stigma associated with HIV/AIDS can lower 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 life span, 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 policies to combat HIV/AIDS, various prevention options are highly cost-effective and could have a large impact on the course of the epidemic. The high cost of antiretroviral treatment (ART) relative to other interventions that can improve health makes it difficult to justify in very poor countries (Canning 2006a). However, recent evidence suggests that patients on ART are well enough to return to work and that this economic payoff may strengthen the case for treatment (Thirumurthy, Graff Zivin, and Goldstein 2005).

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