CHAPTER 1

Life Expectancy and Income among the First Countries to Begin Health Transitions

Life Expectancy

Within the last two centuries every country around the globe has experienced sustained periods of progress in survival, with health transitions beginning as early as the 1770s and as recently as the 1970s.[1] Around 1800, when some countries were beginning their transitions, life expectancy at birth was as low as 22.5 years in the indigenous populations of Oceania and as high as 34.8 years in some parts of the Americas. The global average was about 28.5 years. (Life expectancy at birth measures the current probability of surviving at each age for the year in question, rather than the actual survival prospects of a person born that year. Thus it gives the best assessment available of population survival that year.)

Working with countries of the world as they were identified in 2000 rather than with the much more ambiguous boundaries and identities of 1800, and considering survival in the decades just before each country began its health transition, the lowest pre-transition life expectancy was perhaps 20.1 years (Pakistan) and the highest 40 to 42 years (Scotland, Switzerland, the United States).[2] The overall average across countries in the periods when they began health transitions was 33.1 years.[3] Both that and the 1800 average were higher than the life expectancy of 20–25 years at the transition from Paleolithic to Neolithic populations, around the domestication of plants and animals, but only by a few years.[4] Thus, a true revolution in survival has occurred since 1800, with most of the gains having come since 1920.

Such estimates of life expectancy average across long periods for pre-

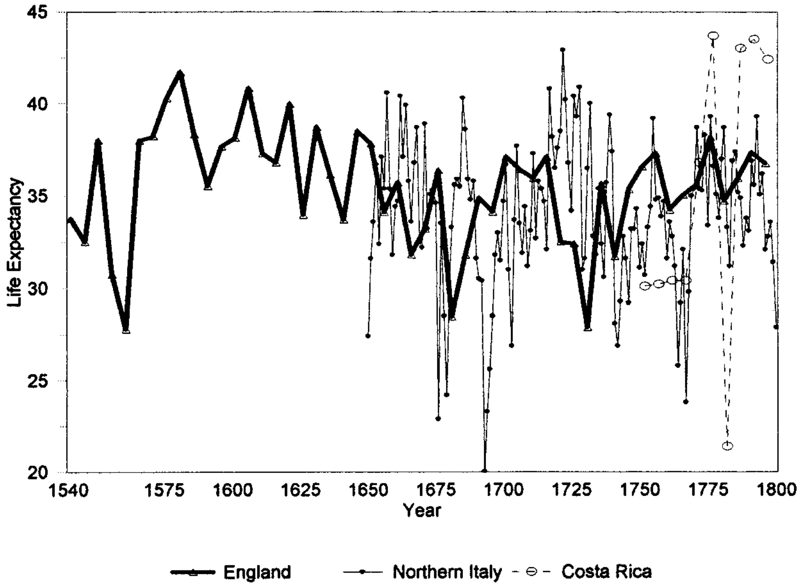


FIGURE 2. Life expectancy in England, northern Italy and Costa Rica, 1540–1800. (Wars, epidemics, and famines all may cause sudden and severe declines in survival.)
Sources: Patrick R. Galloway, "A Reconstruction of the Population of North Italy from 1650 to 1881 Using Annual Inverse Projection with Comparison to England, France and Sweden," *European Journal of Population* 10 (1994): 223–74; Héctor Pérez Brignoli, *El crecimiento demográfico de America Latina en los siglos XIX y XX: Problemas, metodos y perspectives* (San Jose: Centro de Investigaciones Historicas, Universidad de Costa Rica, 1989), p. 12; and E. A. Wrigley and R. S. Schofield, *The Population History of England, 1541–1871: A Reconstruction* (Cambridge: Cambridge University Press, 1989), pp. 528–29.

transition levels, going back as far, in the case of England, as the 1540s and, for northern Italy, the 1650s. Although early year-to-year and period-to-period estimates for three regions (England, northern Italy and Costa Rica; figure 2) do show waves of rising and falling survival prospects, there was still no strong indication of a long-run trend in that early period.

—period.
[FIGURE]
[Figure 2 about here]

Nonetheless, some countries had made significant gains in survival, and by 1800 the world was divided between higher and lower survival regions. The countries in northwestern Europe, from the United Kingdom to Norway, Sweden, and Iceland, belonged to a high survival region, as did also Japan and Costa Rica. But France, British India, and the slave populations of the British Caribbean faced lower survival prospects.[5] It is not yet pos-

sible to say much about when or under what circumstances the early shifts toward higher survival occurred. And it remains possible that some of the higher survival areas had enjoyed that status back to Paleolithic times.

For the moment the most important inference to be drawn is that life expectancy was variable but not trended in the pre-transition era, varying usually within the range from 25 to 35 years.[6] There is no indication of progressively improving human management of mortality risks, although there are many ways in which humans in 1800 were better at controlling the disease and injury risks in their environment than their counterparts had been around the time of the Neolithic Revolution. The problem was that many of the things people did in building their civilizations also aggravated those risks. On the positive side, societies across the world collected knowledge about herbal treatments for disease and injury, and educated a body of health care providers in the accumulated and collective wisdom of their cultures about how to prevent and treat disease and injury. Some of the concoctions they used and some of the things they knew appear, in retrospect, to have been useful, though others seem to have been largely beside the point and some even harmful. Also, in some countries people deferred marriage and thereby reduced fertility along with infant and child mortality.

On the negative side, most human communities traded with their neighbors, allowed people to move from place to place, and formed urban concentrations of population, all of which had adverse effects. Trade and migration carried communicable diseases from place to place and contributed to a microbial unification of the globe in which people would be exposed to unfamiliar diseases brought from afar. Towns and cities meant that people lived closer together, transmitting airborne diseases more efficiently. The provisions they had made for the disposal of human waste and refuse in sparsely settled rural areas were not sufficient to protect them from disease in the urban setting. Many towns or cities sought to control disease, but few had found anything approaching effective measures, judged in the light of today's understanding of disease transmission. The net effect was higher mortality in towns and cities than in rural areas. For example, Stockholm's life expectation in the 1890s, 43.0 years, was about ten years less than the expectation in rural areas.[7] In general in the same period rural farm laborers, who did not own land and worked irregularly, lived longer than any occupational group living in cities.

Only a few countries managed to initiate health transitions before the 1870s. One of these can be used to illustrate the longer history of survivorship. Figure 3 shows the reconstructed life expectancy history of, suc-

FIGURE 3. Life expectancy in England, England and Wales, and the United Kingdom, 1540s to 2000.
Sources: (England) E. A. Wrigley et al., *English Population History from Family Reconstitution, 1580–1837* (Cambridge: Cambridge University Press, 1997), pp. 614–15 (E. A. Wrigley and R. S. Schofield, *The Population History of England, 1541–1871: A Reconstruction* [Cambridge: Cambridge University Press, 1989], pp. 528–29, indicate similar levels and a similar path of life expectancy for England in the overlapping period); (England and Wales) Human Mortality Database, www.mortality.org, accessed various dates in 2004; (United Kingdom) World Bank, *World Development Indicators 2004 on CD-ROM* (Washington: World Bank, 2004).

cessively, England, England and Wales, and the United Kingdom from the 1540s to 2000. Gains in survival began in the first decade of the nineteenth century, but were meager until the period 1900–1950. The urban penalty persisted in England until the last years of the nineteenth century. During the nineteenth century it slowed the pace of life expectancy gains even though survival prospects were improving in both cities and rural areas, taken separately. But the main point made with figure 3 is the deliberate pace of progress among the pioneers. They began early, and they all achieved high life expectancy, but for the most part they moved toward a life expectancy at birth above 75 years much more slowly than would be the case for countries that began health transitions later.

—later.
[FIGURE]
[Figure 3 about here]

Gains in Material Prosperity

In the material circumstances of life, in contrast, many human communities had by 1800 made noteworthy progress since the ancient domestication of plants and animals, and some had made substantial progress. While this is easy enough to assert with confidence, it is more difficult to suggest values for the level of material comfort or the standard of living. The standard of comparison used today is most often the gross domestic product per capita (GDPpc) expressed in values adjusted for price change.

Two important factors, however, wealth and the things that people produce for themselves, are rarely considered as part of GDP. First, the accumulated stock the community has in housing; improvements to infrastructure, such as roads, ships, farms, and workshops; human learning; and all the other things that constitute resources for growth, must of course be counted as wealth rather than as product. It is usually quite difficult to gauge the sum of this accumulated wealth for a single country, much less to make comparisons among countries or across time. If the main goal is to estimate economic growth, then GDP and each year's addition to GDP may give a rough idea about the scale of wealth. That is, like the interest on a treasury note, the annual yield gives a way to estimate the size of the capital behind that yield. But the goal here is to understand gains in survival, which are related to a society's wealth but not directly products of it. For both the level of life expectancy and the prospect of improving it, some forms of wealth are more important than others, and returns on wealth do not adequately capture the difference. This can be illustrated by an aside dealing with smallpox vaccination.

Smallpox was the leading cause of death in northwestern Europe in the eighteenth century and probably a leading cause of death in most global regions in the same period. In regions where the disease was endemic, children around age 1 were most susceptible. Where smallpox was unfamiliar, people of all ages were susceptible. Edward Jenner introduced vaccination against smallpox in England in 1796 and not long thereafter speculated that this technique could make it possible to eradicate smallpox everywhere.

Vaccination was first used effectively, as a mass population technique to reduce mortality, in the Nordic lands in the early years of the nineteenth century. Those countries had quite significantly lower income levels than England or than most other countries neighboring England, but they were better prepared to take advantage of smallpox vaccination. What mattered,

as Peter Sköld has shown, was not just the invention of vaccination but also the capacity to deploy it widely enough to curtail smallpox mortality. Sweden moved to control smallpox faster and earlier than most other countries in Europe by "constructing a system of health related laws" and deploying leadership from the center via an effective administrative system that was able to assemble a large enough number of vaccinators, most of them neither medical practitioners nor government officials and including many members of the clergy. The Swedish people accepted vaccination much more readily than they had accepted the earlier practice of inoculation, which tried to protect against the dangers of smallpox by inducing a mild case. In contrast, vaccination protected by using the much less dangerous cowpox material to deceive the immune system into building antibodies against smallpox. In Sweden a compulsory vaccination law was adopted in 1816, with a fine to punish parents who did not get their children vaccinated. Mortality from smallpox had already dropped sharply from 1810, however, showing that it was not compulsion but other characteristics of Sweden's vaccination program that mattered the most. Other countries adopted laws compelling vaccination but did not succeed in getting such a large share of the population vaccinated so quickly and often did not succeed in enforcing their laws on compulsory vaccination.[8]

The institutions that made vaccination an early success in Sweden existed ahead of time, rather than being created for the moment. The two novelties were vaccination itself and its general acceptance by the people. That acceptance was, in Sköld's telling of this history, a product of the successful outcome of early practice with vaccination, from 1802. People were prepared to adopt a new public health practice where it was shown to be successful and where community leaders supported it. Continued acceptance was assisted also by the government's openness in publishing statistics about vaccinations and the successful outcome of the early vaccinations.

The history of smallpox vaccination in Sweden suggests that social organization and social habits, trustworthy leadership, and openness in communicating information mattered more than per capita income and economic resources in determining whether children would be protected against smallpox. Thus the important point is that Sweden's social organization was well suited to the conquest of smallpox, but not so well suited to generating a high level of, or large annual gains in, GDP. Social organization constitutes a form of wealth that played the key role in protecting Swedish children against smallpox, but is not an asset of the type that is ordinarily counted as wealth.

The second group of items that GDP estimates typically exclude are the things people produce for themselves that do not pass through markets. The food people grow for themselves; the houses they build and improve; the learning that occurs outside of formal schooling, such as acquiring the skills associated with farming or with a trade, and learning from parents; the services provided within a household or between households without any exchange of cash; and many other products, services, and behaviors therefore go unmeasured. New information may also be a form of income when it enhances the standard of living. Learning about how to avoid or manage a disease may, like learning a skill, add to well-being. These unmeasured goods differ in scale from time to time and from country to country, so that making comparisons across time and space is difficult. Yet the differences are hugely important for comparisons across broad swaths of time and for comparing poor and rich countries at the same dates.

Phyllis Deane developed the approach usually taken in trying to account for transactions outside the cash economy in a study of social accounting in colonial Nyasaland and Northern Rhodesia in the early 1950s. Her case study draws attention to the disparities between the cash economy, in which the Europeans living there operated most of the time, and the non-cash economy, where Africans operated much of the time in "inter-village trade" and "goods and services produced for home consumption." That parallel made it easy enough to discover the cash value of many products and services exchanged in the non-cash economy, so that Deane was able to give a plausible estimate of the 1945 subsistence and barter incomes of Africans in Northern Rhodesia. According to her estimate, the Africans' subsistence and barter activity nearly matched their cash incomes. But Deane did not try to measure all types of activity in the informal economy, omitting, among other items, illegal activity and the labor of dependents within a household, and she did not draw a contrast between the accumulated wealth of most Europeans, which made it easier for them to generate incomes, and that of Africans, which was meager and less productive of income or survival. It was clear enough that Europeans were much better off than Africans: Deane estimated European income at about £600 per earner versus about £27 per adult male African.[9]

It is more difficult to produce plausible estimates of income for people living in subsistence economies without parallel cash economies, as is true for most historical communities and for the informal sectors of modern economies. The term *informal economy* describes the parts of an economy in which transactions are hidden, whether because they occur by barter,

in illegal or quasi-legal activity, or in unreported cash transactions. In the informal economy people deliberately obfuscate income and consumption in order to avoid taxation, conceal illegal activities, or obtain eligibility for social services for which they would not otherwise qualify. Rough estimates of the size of the informal economy in Jamaica place it at 39 percent of formal economy activity in 1989.[10] Janet MacGaffey argues that actual economic activity around 1990 in Zaire (Democratic Republic of the Congo) may have been three times greater than the official GDP, amidst rapid growth in the informal sector.[11] Thus the unobserved part of income may be quite substantial, and it may be significant even in a developed economy. Estimates of the scale of black market activity in England in the 1970s range from a low of 2 to a high of 15 percent, but were probably closer to the lower figure.[12]

Scholars who have tried to assess levels of output broadly across time and space have sometimes adopted a simplifying device, which is to assign a minimum level of GDPpc to poor and primitive economies. Angus Maddison appears to have had such a device in mind in assigning the value of 400 international (or purchasing power parity) dollars of 1990 to GDPpc in Australia for 1500–1700 and New Zealand for 1500–1840, before the arrival of Europeans and in a period when there was no cash economy. But Maddison later deviates from this approach by assigning lower values to a number of countries in Africa for various parts of the period 1950–2001, including Botswana in the 1950s and Chad in the 1980s. For Zaire in 2001 he estimates GDPpc at only 202 international dollars of 1990. Thus Maddison suggests that per capita income in the Maori population of New Zealand in 1800 was about twice as high as it was in Zaire in 2001.[13] Presumably he means to estimate output as money transactions in the formal economy, excluding smuggling, an important activity in Congo in 2001, and many other things that added to the material standard of living there. (Since so many of the amounts that will be referenced below will be given in international dollars of 1990, it is convenient to adopt an abbreviation of I$. Unless otherwise indicated, in this book the symbol I$ always refers to 1990 values. Using U.S. experience with price change as a rough guide, I$ 100 in 1990 was equal to about I$ 150 in 2005.)[14]

What is implied by the I$ 400 floor (or any other floor) is that people living within the market sector could supply themselves with their basic needs for that sum. In truth the sum of I$ 400 is much too low a value to assign to the output of the average person living in a primitive economy in the past or a low-income country in the modern world. The idea behind this number is that, on average, the people in a primitive or poor community live at a subsistence level, just meeting their basic needs in

food, housing, fuel and heat, apparel, and so forth. But it is difficult to imagine how those needs could be met with a money equivalent of I$ 400. What level should be preferred is little more than guesswork, but may be as much as several times higher. It is not possible actually to correct Maddison's estimates to incorporate economic activity outside the formal and cash sectors because scaling up the floor of GDPpc estimates also involves scaling up all lower-range estimates.

Since many low-income countries have a larger share of economic activity outside the cash and formal economies than do most high-income countries, underestimation of income from these activities will understate actual levels of GDPpc in low-income countries more than in high-income countries. Thus Maddison's approach tends, by understating income in poor countries, to exaggerate the difference between poor and rich countries.

The GDPpc approach also tends to overstate income in rich lands by counting all forms of economic activity on the same footing. The rich lands produce many items that are far removed from food, housing, clothing, and other necessities for survival, and those items, such as a second house and a car for each adult, add to income levels. In a way, then, the rich lands appear to be better off than they actually are, judged by the standards that prevail in poor lands. Since the outcome in judging economic growth is the sum of GDP, any activity that generates income appears to have equivalent merit, per unit of income. GDPpc estimates therefore mask elements of income in rich lands that are more superficial than substantial. Nonetheless, although both factors—economic activity in the informal or invisible sector and the practice of counting all visible economic activity on the same footing—tend to exaggerate the difference in actual income levels between rich and poor lands, there is no question but that the low-income lands are poor.

Despite these important shortcomings in measuring and comparing income, it is useful to consider how far differences in life expectancy may be related to differences in national income. As the next section will show, most of this consideration can rely at least initially on Western countries, for which estimates of GDP back to 1820 or even earlier have a much stronger foundation than do the estimates made for other parts of the world in the eighteenth and nineteenth century.

Life Expectancy and Income: An Evolving Relationship

Maddison estimates GDPpc values across the globe in 1820 for thirty-eight countries in I$. (Again, all I$ values continue to be given in terms of con-

TABLE 1. Gross Domestic Product per Capita (GDPpc) in 1990 International Dollars (I$) and Life Expectancy circa 1820 in 14 Countries

	GDPpc (1990 I$)	Life Expectancy
Belgium	1,319	32.3 years
Canada	904	39.0
China	600	35.5
Denmark	1,274	44.4
England, Wales, and Scotland	2,121	39.0
Finland	781	37.1
France	1,135	38.2
Germany	1,077	40.3
Greece	641	29.0
Ireland	877	38.3
Italy	1,117	34.9
Norway	1,104	47.8
Spain	1,008	26.8
Sweden	1,198	39.7

SOURCES: *For GDPpc estimates*: Angus Maddison, *The World Economy: Historical Statistics* (Paris: Development Center of the Organization for Economic Cooperation and Development, 2003), pp. 58–59, 87, 100, 142, 146, 180–81; *for England, Wales, and Scotland:* Angus Maddison, *The World Economy: A Millennial Perspective* (Paris: Development Center of the Organization for Economic Cooperation and Development, 2001), p. 247. *For life expectancy estimates: Belgium,* averaging three closely-spaced estimates for 1827, 1829, and 1832, J.-M.-J Leclerc, "Tables de mortalité ou de survie et table de population pour la Belgique, dressées au moyen des statistiques officielles de 1880 à 1890," *Bulletin de la commis-*

stant 1990 dollars.) These show sharp differences in the material standard among these countries, ranging from a low of I$ 400 in New Zealand to a high of I$ 2,121 in England, Wales, and Scotland.[15] Life expectancy estimates are available for fourteen of these thirty-eight countries, and those are given together with Maddison's GDPpc estimates in table 1. This is just enough cases to allow analysis of the statistical association between GDPpc and life expectancy. The result is a very small association (adjusted R-square of −0.003) lacking statistical significance.[16] Among these countries, then, with most of them on the eve or in the early stages of health transitions but after significant periods of economic progress, higher average incomes around 1820 did not coincide with elevated survival prospects.

—prospects. [TABLE] [Table 1 about here]

Thirty-one countries initiated health transitions between the 1770s and the 1890s. Table 2 shows the period when sustained gains began plus the life expectancy level and Maddison's estimates of GDPpc for the twenty-four countries for which both are available at that point. (Appendix 1 gives

sion centrale de statistique 17 (1890–96): 65, and A. Quetelet, "Nouvelles tables de mortalité pour la Belgique," *Bulletin de la commission centrale de statistique* 4 (1851): 18–19. *Canada,* Robert Bourbeau and Jacques Légaré, *Evolution de la mortalité au Canada et au Québec, 1831–1931: Essai de mesure par génération* (Montreal: Presses de l'Université de Montréal, 1982), their estimate centered on 1831. *China,* the mid-point of the estimate for 1800–1850 from William Lavely and R. Bin Wong, "Revising the Malthusian Narrative: The Comparative Study of Population Dynamics in Late Imperial China," *Journal of Asian Studies* 57 (1998): 714–48. *Denmark,* averaging estimates for 1817 and 1822 from Otto Andersen, "Denmark," in *European Demography and Economic Growth,* ed. W. R. Lee (London: Croom Helm, 1979), p. 111. *England, Wales, and Scotland,* the average of estimates for England for 1816–26 from E. A. Wrigley and R. S. Schofield, *The Population History of England, 1541–1871: A Reconstruction* (Cambridge: Cambridge University Press, 1989), p. 529. *Finland,* averaging estimates for 1815 and 1825 from Väinö Kannisto, Mauri Nieminen, and Oiva Turpeinen, "Finnish Life Tables since 1751," *Demographic Research* 1 (1999), at www.demographic-research.org/Volumes/Vol1/1. *France,* the average of estimates for each year 1818–22, from France Meslé and Jacques Vallin, "Reconstitution de tables annuelles de mortalité pour la France au XIXe siècle," *Population* 44 (1989): 1121–58. *Germany,* the average of estimates centered on 1810 and 1820 from Arthur E. Imhof, ed., *Lebenserwartungen in Deutschland, Norwegen und Schweden im 19. und 20. Jahrhundert* (Berlin: Akademie Verlag, 1994), p. 464. *Greece,* the estimate for 1850 from George Siampos, *Mortality Decline and Longevity in Greece* [in Greek] (Athens: Anotate Schole Oikonomikon kai Emporikon Epistemon, 1989), p. 416. *Ireland,* the estimate for 1821–41 from Phelim P. Boyle and Cormac Ó Gráda, "Fertility Trends, Excess Mortality, and the Great Irish Famine," *Demography* 23 (1986): 543–62. *Italy,* the average of estimates for North Italy for 1818–22 from Patrick R. Galloway, "A Reconstruction of the Population of North Italy from 1650 to 1881 Using Annual Inverse Projection with Comparison to England, France and Sweden," *European Journal of Population* 10 (1994): 223–74. *Norway,* the average of estimates centered on 1818 and 1823 from Helge Brunborg, "The Inverse Projection Method Applied to Norway, 1735–1974," unpublished typescript, July 1976. *Spain,* the estimate for the second half of the eighteenth century from Fausto Dopico and Robert Rowland, "Demografía del censo de Floridablanca: Una aproximación," *Revista de historia económica* 8 (1990): 591–618. *Sweden,* the average of the estimates for 1818–22 from the Human Mortality Database at www.mortality.org.

a complete schedule for the beginning periods of health transitions in 167 countries, the 166 with 2004 populations of at least 400,000 plus Iceland.) With the exception of Canada, the twenty-eight countries for which GDPpc levels can be estimated were above I$ 1,000 at the initiation of health transitions.[17] And most had significantly higher levels still, with an average of I$ 1,831. In terms of GPDpc in constant dollars, the countries listed in table 2 had a noteworthy advantage over the lowest income and survival countries of the nineteenth century or even of the period 1950–2000, many of which neither attained income levels as high as these nor managed to inaugurate sustained economic growth.

—growth, [TABLE] [Table 2 about here]

According to Maddison's GDPpc estimates, a few countries achieved levels above I$ 1,000 but did not begin health transitions until later. All of these countries—Bulgaria, Chile, Greece, Portugal, Romania, Sri Lanka, and Uruguay—initiated health transitions by the 1920s. Among them only Chile, with a 1900 GDPpc of I$ 1,949, and Uruguay with I$

TABLE 2. Life Expectancy and Gross Domestic Product per Capita (GDPpc) at the Beginning of Health Transition in 24 Countries

Period When Health Transition Began	Country	Life Expectancy around Initiation of Health Transition	GDPpc around Initiation of Health Transition (1990 international dollars)
1770s	Denmark	c. 33	1,039 in 1700; 1,274 in 1820
1790s	France	28.1	910 in 1700; 1,135 in 1820
	Sweden	35.3	977 in 1700; 1,198 in 1820
1800s	England and Wales	36.3 (England only)	2,006 in 1801
1810s	Norway	38.3	1,104 in 1820
1820s or 1830s	Canada	39.0	904 in 1820
1840s	Belgium	38.3	1,694 in 1846
1820s to 1890s	Ireland	38.3	1,775 in 1870
1860s or 1870s	Australia	48.0	3,273 in 1870
	Netherlands	37.3	2,757 in 1870
	New Zealand	51.8–53.1	3,100 in 1870
1860s to 1900s	Mexico	24–29	1,011 in 1890; 1,366 in 1900
1870s	Finland	32.1	1,211 in 1875
	Germany	36.7–38.4	2,112 in 1875
	Switzerland	40.3–40.7	2,645 in 1875

2,219, seem to be cases where the level of economic development markedly outran development of the factors capable of supporting survival gains.

Most other countries had lower levels of income in the nineteenth century. A GDPpc of roughly I$ 1,000 would appear to have been a threshold for initiating gains in survival. But most of these countries reached higher levels before beginning health transitions. Argentina, the Netherlands, Switzerland, and the United States stand out as countries that might, if GDPpc mattered particularly in the initiation of survival gains in the nineteenth century, have begun transitions earlier than they appear to have done.[18]

Figure 4 shows the relationship between GDPpc in 1990 I$ and life

TABLE 2. (*continued*)

Period When Health Transition Began	Country	Life Expectancy around Initiation of Health Transition	GDPpc around Initiation of Health Transition (1990 international dollars)
1870s or 1880s	Italy	35.4	1,581 in 1880
1870s to 1890s	Japan	36.6	1,012 in 1890
	United States	39.4	3,106 in 1885
1880s or 1890s	Austria	31.7	2,443 in 1890
1890s	Czech Republic	35	1,505 in 1890
	Spain	29.5	1,689 in 1895
1890s or 1900s	Argentina	33.3	2,756 in 1900
	Russia	31	1,237 in 1900
1890s to 1920s	Costa Rica	30.5	1,624 in 1920

SOURCES: Angus Maddison, *The World Economy: Historical Statistics* (Paris: Development Center of the Organization for Economic Cooperation and Development, 2003), pp. 58–59, 87, 100, 142, 146, 180–81; Maddison, *The World Economy: A Millennial Perspective* (Paris: Development Center of the Organization for Economic Cooperation and Development, 2001), p. 247; James C. Riley, "Bibliography of Works Providing Estimates of Life Expectancy at Birth and of the Beginning Period of Health Transitions in Countries with a Population in 2000 of at least 400,000" at www.lifetable.de/RileyBib.htm.

expectancy periodically from 1820 to 2001. And table 3 shows results from linear regression analysis of associations between the two factors. Among the countries for which both estimates are available at each comparison date, the relationship between per capita income and life expectancy at birth has evolved over time. For 1820, figure 4(a) shows a cluster without any statistical association. By 1870, in a larger group of countries with more dissimilar histories in income and life expectancy, the association was linear, and by 1913 it was at its most robust. For 1950, 1973, and 2001 the association was curvilinear, with or without the outliers, which are oil-rich states (Kuwait in 1950, and Kuwait, Qatar, and the United Arab Emirates in 1973). Judging by the adjusted R-square value, the linear association developed between 1820 and 1870 among the mostly Western countries represented by the analysis.[19] That association reached a peak around 1913 and then weakened.[20]

—weakend.
[FIGURE]
[Figures 4a—4f about here]
[TABLE]
[Table 3 about here]

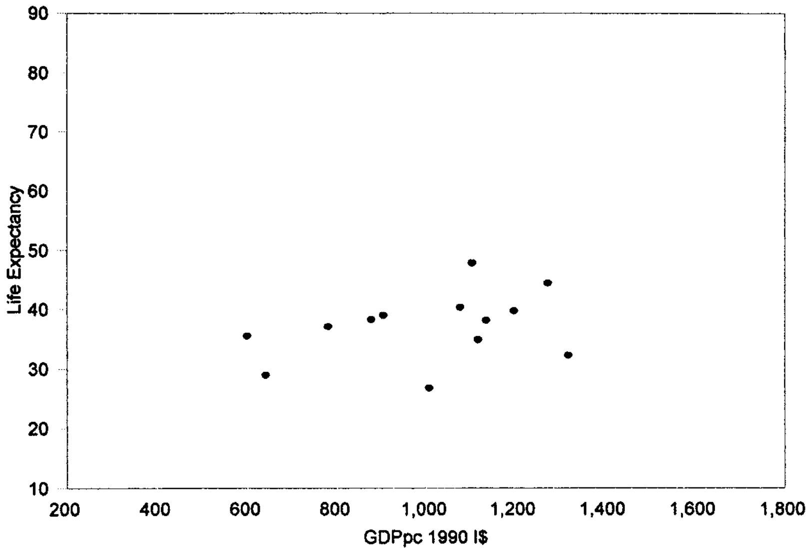
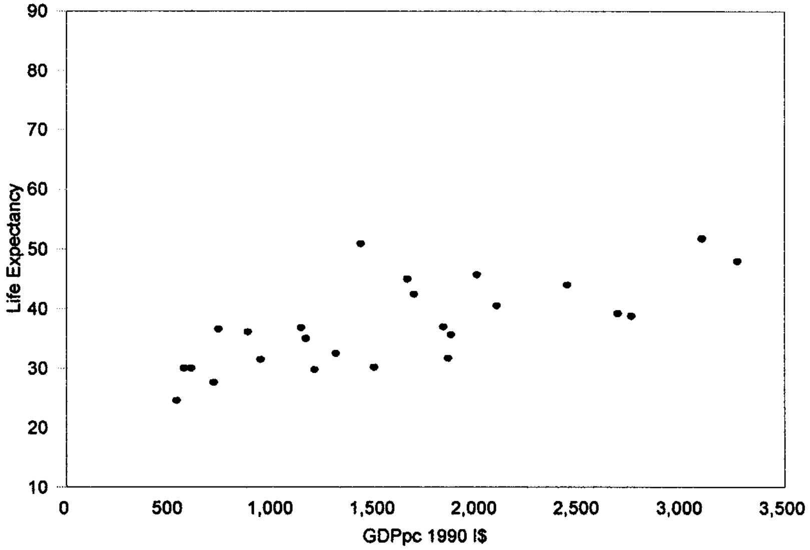
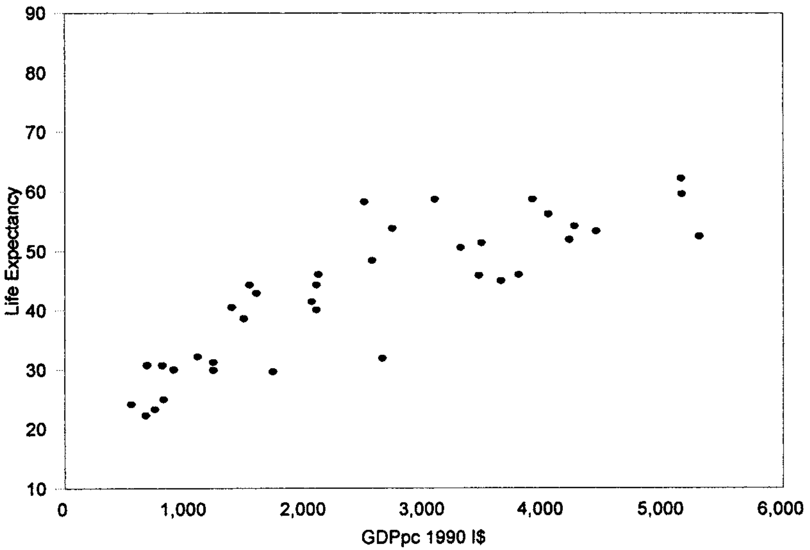


FIGURE 4. Gross domestic product per capita (GDPpc) in 1990 international dollars (I$) and life expectancy, in 1820, 1870, 1913, 1950, 1973, and 2001. (Please take note of changes in the horizontal axis across time.)
Sources: Angus Maddison, *The World Economy: Historical Statistics* (Paris: Development Center of the Organization for Economic Cooperation and Development, 2003), pp. 58–69, 87–89, 100–101, 142–48, 180–87, 218–23; and James C. Riley, "Bibliography of Works Providing Estimates of Life Expectancy at Birth and of the Beginning Period of Health Transitions in Countries with a Population in 2000 of at least 400,000" at www.lifetable.de/RileyBib.htm, with comments on sources preferred for certain estimates. (a) 1820: 13 countries; (b) 1870: 25 countries; (c) 1913: 37 countries; (d) 1950: 126 countries; (e) 1973: 132 countries; (f) 2001: 132 countries

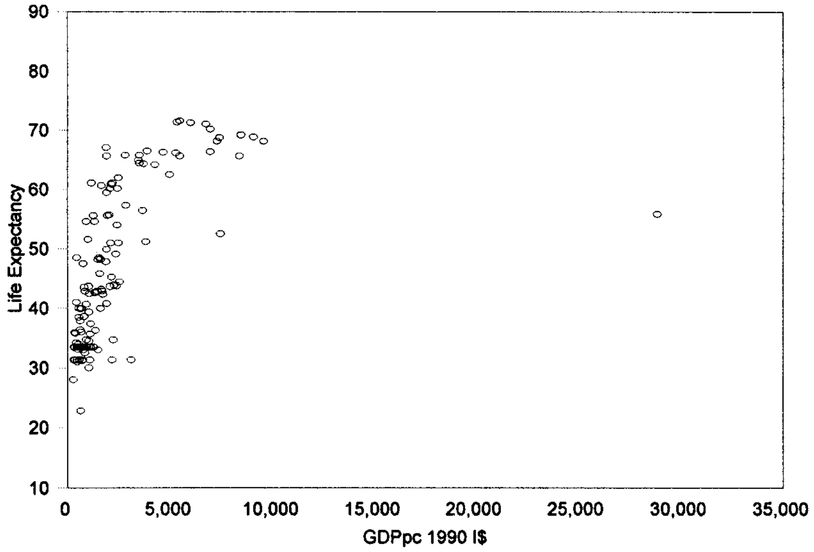
If the assumption is made that cause runs more strongly from income to life expectancy than from life expectancy to income, then one implication of this analysis is that a higher income level was most effective in promoting higher life expectancy between 1870 and 1913. That was the beginning period of investments by the richer lands in water filtration and chlorination and in sewage treatment and disposal, which controlled many water-borne diseases, and of investments in education, mostly in primary schooling, which armed the general population with ways to inform themselves about disease risks. Considering the possibility of an association running from superior health to superior income, however, it may also be true that gains in survival in that period had a positive effect on labor productivity.[21]





The association between income per capita and life expectancy remained strong in 2001, intensified by the rising number of African countries with low income and low life expectancy. But it had less strength then than it had had at any earlier year back to 1820.

Table 4 shows results from the linear analysis of income change and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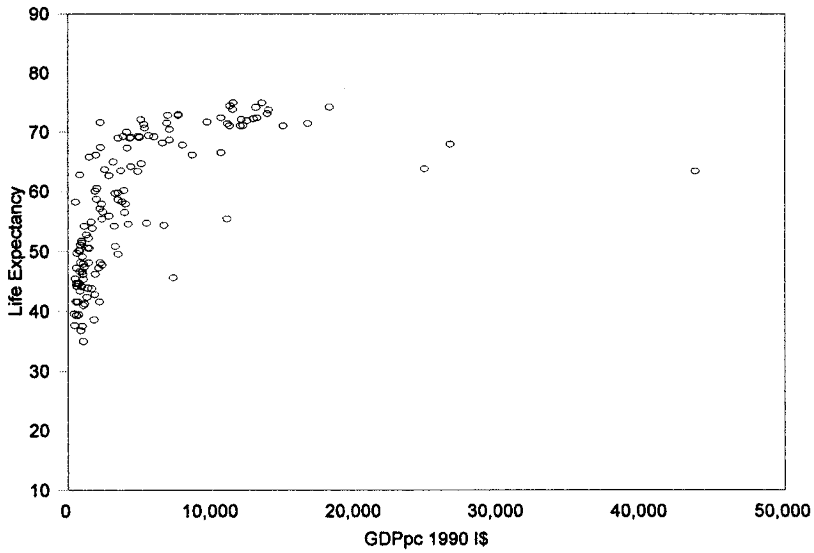
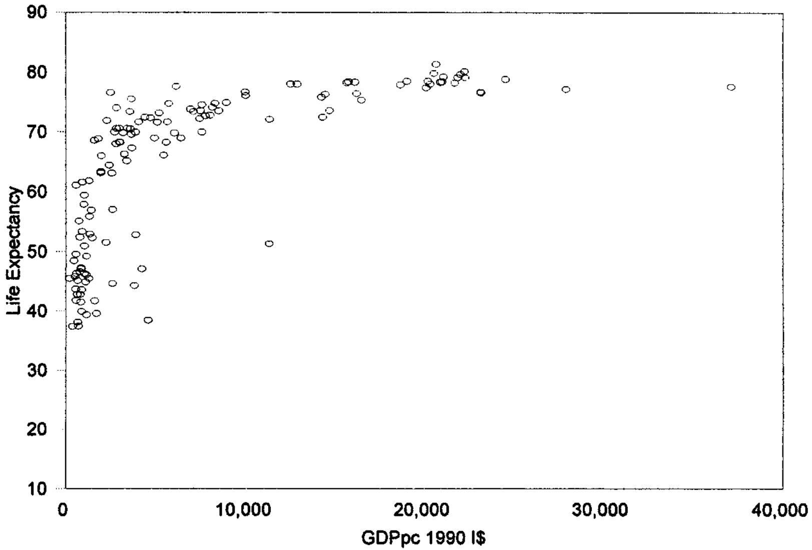
Life Expectancy
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
GDPpc 1990 I$


90
80
70
60
50
40
30
20
10
Life Expectancy
0
10,000
20,000
30,000
40,000
50,000
GDPpc 1990 I$



life expectancy change *between* each pair of dates. Two comparisons—1870 to 1913 and 1950 to 1973—stand out, showing a positive association between the *pace* (percentage) of income growth and of life expectancy gains and between the *amount* of income growth and life expectancy gains, though in both cases only the latter association is statistically significant. In the 1820 to 1870 comparison, which includes only eleven cases, ten of them from Europe, income gains coincided with life expectancy losses often enough to produce a negative association. For 1913 to 1950 neither the pace nor the amount of income change was positively associated with life expectancy gains often enough to show up as statistically significant. The association present from 1950 to 1973 broke down in the succeeding comparison, between 1973 and 2001, a period when many countries lost life expectancy and also when life expectancy gains coincided with losses in income in some countries.

—countries.
[TABLE]
[Table 4 about here]

Of course income, by itself, does not produce higher survival odds or better health. Countries and families with higher incomes have the advantage that they can elect to spend more on health or seek out health-favoring investments, such as the water filtration and piping systems that European cities began to build in the late nineteenth century, which counterbalance some health-disfavoring factors, such as larger cities with denser populations, crowded housing, and a greater potential for contamination of water with human waste.

TABLE 3. Statistical Relationship between Income per Capita and Life Expectancy for 6 Periods (1820–2001) Shown in Figure 4

	Number of Countries	Adjusted R-square	Without Outliers
1820	13	−.003	—
1870	25	.477***	—
1913	37	.720***	—
1950	126	.300***	.586***
1973	132	.335***	.557***
2001	132	.460***	—

SOURCES: Angus Maddison, *The World Economy: Historical Statistics* (Paris: Development Center of the Organization for Economic Cooperation and Development, 2003), pp. 33, 58–69, 87–89, 100–101, 111, 142–44, 147–48, 180–87, 218–24; James C. Riley, "Bibliography of Works Providing Estimates of Life Expectancy at Birth and of the Beginning Period of Health Transitions in Countries with a Population in 2000 of at least 400,000" at www.lifetable.de/RileyBib.htm.

*** significant at $p < .001$

Any discussion of the association between income and health thus requires two prior discussions. One of those deals with how much the people who make spending decisions, in the household or in the public sector, know about factors that favor health, how accurate their knowledge is, and how effectively they assess the efficiency of differing options in safeguarding or enhancing health. The other deals with the decisions actually made about spending, which are certain to be influenced by many other things than just the health-favoring qualities of one item that may be acquired compared to another. Thus, for example, visiting a doctor may be the most effective thing a householder can do for the recovery of a sick child, but the decision to visit may depend on many unrelated things: the doctor's proximity, whether there is still enough money left from the last paycheck to pay the doctor, the parents' judgment about how serious the sickness is, the implicit value the parents assign to that child, and many more.

This is not the place to attempt to construct a theory or a history of spending choices. Nevertheless the point being made can be buttressed by examining the association between UN estimates of per capita spending on health in 174 countries in 2001 and life expectancy in those countries, which appears in figure 5. This figure shows two distributions. Along

TABLE 4. Change in Income and in Life Expectancy, 1820–2001, Using Data from Table 3

	Number of Countries	Adjusted R-square, Percentage Income Change and Life Expectancy Change	Adjusted R-square, Amount of Income Change and Life Expectancy Change
1820–70	11	–.100	–.099
1870–1913	25	.090	.323**
1913–50	37	–.025	.009
1950–73	127	.001	.127***
1973–2001	133	.008	–.007

SOURCES: Angus Maddison, *The World Economy: Historical Statistics* (Paris: Development Center of the Organization for Economic Cooperation and Development, 2003), pp. 33, 58–69, 87–89, 100–101, 111, 142–44, 147–48, 180–87, 218–24; James C. Riley, "Bibliography of Works Providing Estimates of Life Expectancy at Birth and of the Beginning Period of Health Transitions in Countries with a Population in 2000 of at least 400,000" at www.lifetable.de/RileyBib.htm.

NOTE: Because the data are incomplete and the analyses consider differing time comparisons, the number of countries considered in this table differs slightly from the number in Table 3.

** significant at $p < .01$; *** significant at $p < .001$

the vertical axis many countries in 2001 spent less on health than U.S.$ (of 2001) 500 per capita, combining public and private spending, amid radically different life expectancy levels, ranging from less than 35 years to more than 75. And along the horizontal axis life expectancies clustered in the area about 70 years and above, even though per capita spending varied from less than $500 to nearly $5,000 (in the United States). Clearly in some countries, such as the United States, people and policymakers appear to have made massively ineffectual decisions about how to spend money on health services. And, at the other extreme, countries varied little in their spending per capita, but widely in the life expectancy level. Even though a statistical analysis suggests an association between health spending and life expectancy level, nearly all of the association will have to be explained by other factors.[22]

—factors. [FIGURE] [Figure 5 about here]

It is also evident, from the comparative study of national histories, that different countries have typically followed different paths in elevating life expectancies. Those paths were determined by the options available when one country's health transition began, by what the people in a country and its public sector could afford to do, and most especially by which of the many opportunities for action were seized. In a well-known exam-

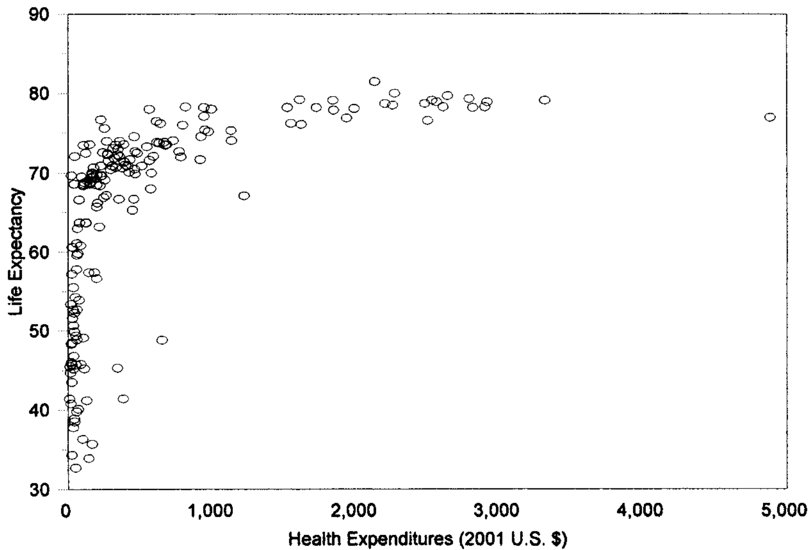


FIGURE 5. Life expectancy and per capita spending on health in 174 countries in 2001.
Source: United Nations, Human Development Report 2004, at http://hdr.undp.org/statistics/data/indic/indic_52_1_1.html, accessed July 8, 2005.

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ple, Japan, which invested little in sanitary improvements, did not follow the same path as Britain, which invested heavily in sanitary improvements.[23] The same thing is true in nearly every comparison, and it is this variety in paths followed and opportunities seized that motivated the research behind this book.

All the countries considered in this study, the twelve given extended treatment and the others discussed briefly, share the characteristic of getting a bigger survival pay-off for what consumers and the public sector spent on health and health-related items than did the United States or other high-income countries. But it may be more important to look not so much at how they spent their money as at other things that were largely independent of income. In the case studies that begin with chapter 3 the issue of income will regularly be raised. But most of the discussion in those case studies deals with actions taken in lieu of spending, for the main point is that in these countries people were too poor simply to spend their way into better health.

Conclusion

Sustained economic growth began before sustained gains in survival. All the countries that initiated health transitions before 1900 began the process of elevating life expectancy when they were low-income lands, judged by the standards of the period 1950–present: that is, they were all poor by today's standards (although they were already richer than many of the low-income countries of the years 1950–present). The evidence reviewed in this chapter suggests that it has been difficult for countries to initiate and sustain gains in survival from GDPpc levels below I$ 1,000 in 1990 values, a threshold that seems to distinguish the health transition pioneers from other countries and regions. (In international dollars of 2005, the threshold would be roughly 1,500.) Above that threshold, however, income levels in the nineteenth century did not determine either the level of life expectancy or the period when gains in survival might begin.

Among countries with per capita incomes above I$ 1,000, income itself seems to have held little importance in 1820. The average income level began to matter in life expectancy gains between 1820 and 1870, and in 1913 the association between income and life expectancy levels peaked. Yet some countries attained higher incomes for that period, well above I$ 1,000, before they managed to begin health transitions.

To this point scholarly investigations of life expectancy gains in nineteenth-century Europe have focused on improvements in nutrition and public health. Sköld's work on the virtual eradication of smallpox in Sweden early in the nineteenth century suggests that additional factors may also be important. For Sweden's control of smallpox, social organization and political will mattered more than income, and it may be that this explanation offers a clue for understanding why the pioneer countries in general were able to elevate life expectancy.

In other respects, however, the experience of the pioneers offers less promise of providing answers to the question of how some low-income lands were able to begin their own health transitions and sustain those transitions to the point that they matched the rich countries in life expectancy. The threshold of I$ 1,000 in 1990 values may be important and will be considered in the case studies that follow. But the point at which income growth was initiated and the changing association between income and life expectancy levels will not matter, at least for the low-income countries that remained poor. More especially, the investments that Western countries made, such as in urban public health improvements,

will not matter because none of the countries to be considered in this study could afford to follow that path.

Moreover, spending on health appears to be weakly related to life expectancy, at least around 2001. Some countries do an ineffectual job in their spending and some countries an excellent job of it, assessed by survival and therefore by the proportion of people at each age in their populations living through that year of life. The most interesting cases are those doing an exceptionally good job of it.