How Beneficent is the Market?
A Look at the Modern History of Mortality

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Sweepings from butchers' stalls, dung, guts, and blood,
Drowned puppies, stinking sprats, all drenched in mud,
Dead cats, and turnip tops, come tumbling down the flood.
Jonathan Swift, A Description of a City Shower

The concept of human development has recently emerged to rival economic development as a worldwide objective of public policy.[1] In assessing human welfare, advocates of this concept would, at a minimum, place indicators of social conditions, notably life expectancy and educational achievement, on equal footing with traditional economic measures like GDP per capita and a poverty index; some would go further and include indicators of political and civil liberties. In this paper, I focus on only one of the proposed new measures, life expectancy at birth (referred to subsequently simply as life expectancy).

I think it is fair to say that, so far as life expectancy is concerned, the common reaction among economists and economic historians is skepticism of the broader measure of human development. This is because improved life expectancy is typically viewed as a natural by-product of economic development or of the institutional conditions that foster economic development. Thus, elevating life expectancy to the status of a social goal commensurate with economic growth raises no issues that economists are not already dealing with in focussing on economic growth and its determinants.

It is this view to which the present article is addressed. Specifically, the questions of concern here are: (1) is life expectancy largely or wholly a function of economic growth? (2) if

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[1] See Anand and Sen 1994; United Nations Development Program 1990; and the session on Human Development in the American Economic Review Papers and Proceedings (1994) with contributions by P. Streeten, T.N. Srinivasan, and H. Aturupane, P. Glewwe, and P. Isenman. A comparable development in economic history is traced by Steckel and Floud (1997).

not, are the conditions commonly taken to foster economic growth, namely, free markets, private property, and freedom of contract, also responsible for promoting the advance of life expectancy? As a basis for forming tentative answers to these questions, this article examines the historical experience of mortality in both developed and developing countries. A significant part of the work drawn on here has been done by scholars outside of economics; hence this article serves in part as an introduction to mortality research in other social sciences. A recent World Bank Development Report (1993), Investing in Health, presents a broad position paper on the issues of principal interest here, though it is confined to today's developing countries. As is usual with such reports, a number of valuable background papers were generated, and some of these are drawn on subsequently.

There is an extensive literature on the economics of health. Initially this work focussed chiefly on current problems of developed countries, and especially conditions in the United States.[2] More recently attention has expanded to developing countries, and has typically involved the application of a household-decision-making model to microlevel data at a point-of-time.[3]

This article is addressed to economists and economic historians broadly concerned with the problem of human development, and the institutions and policies that such development requires. The substantive concerns of the article are more narrowly focussed than the economics of health -- on the factors specifically responsible for the historical improvement in life expectancy. Empirically the scope encompasses the experience of both developed and developing countries over the past two centuries. Although the experiences of the two sets of countries are almost always treated separately, I see them as a continuum, because in both, all or most of the improvement of life expectancy is due to the great reduction -- indeed, virtual

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[2] Cf. Fuchs 1987, 1996; Phelps 1992.

[3] See the overview in Behrman and Deolalikar 1988, updated in part in Strauss and Thomas 1995; cf. also Bhargava 1997.

elimination -- of the major infectious diseases. The experience since the 1950s of today's developed countries is not included, because of the shift in the disease environment from primarily infectious to noninfectious diseases.

The analysis starts out with a brief conceptual section that helps highlight the main issues and most influential recent studies of historical experience of interest here. It then turns in section II to the historical evidence on life expectancy and economic development in several developed and developing countries with relatively good data to assess in preliminary fashion the time series association between the two. The conclusion is that neither the facts nor a priori considerations support the view that improved living levels brought about by economic growth have been the prime mover behind advancing life expectancy. Rather, as developed in section III, new techniques of disease control based on new knowledge of disease, have been the proximate sources of improved life expectancy. Section IV then considers whether the free market institutions commonly considered to be responsible for economic growth are also chiefly responsible for adopting the new techniques of disease control. History says, no, that public intervention has been crucial for implementing the new methods. Nor do free market institutions appear to have generated the new technology of disease control. The conclusion -- that public intervention has been essential to the control of infectious disease -- raises the question considered in section V, whether economic growth has been necessary for improving life expectancy via another route, by providing the resources needed to fund public spending on the new technology, either directly or through international aid, or to fund the research responsible for the advance in knowledge. The conclusion is that, while economic growth may be helpful, it has not been necessary for funding public health programs, whether directly or indirectly. Nor has it been required to finance the advance in knowledge that brought infectious disease under control.

The bottom line is that experience indicates that improved life expectancy cannot be taken to be simply a by-product of economic growth or the free market conditions that foster it. Rather, public policy initiatives have been essential to the improvement of life expectancy, and these can be, and, in fact, have been, undertaken in the absence of economic growth. Life expectancy is an objective to be pursued in its own right by the institutions and policies it requires. In what follows, economic development is taken in Kuznets' (1966) sense of modern economic growth, and is proxied, as usual, by real GDP per capita. Evidence on income distribution, although desirable, is not available in the historical and geographical detail needed, and hence distributional issues are not included here. Life expectancy is measured by life expectancy at birth. Because this measure is less sensitive to improvements in mortality at older than younger ages, one might prefer a measure such as the age-standardized death rate, but again the requisite data are not available.[4] Nor are data available for more ambitious measures such as value of life, active life expectancy, or for the recently developed measure of "disability-adjusted-life-years."[5] But life expectancy at birth has the advantage that it is, in practice, the measure actually included in the human development index (United Nations Development Program 1996, p. 106).

I.

A useful point of departure is a widely-cited article by demographer Samuel Preston (1975, cf. also Preston 1980). Preston suggested that the improvement in life expectancy can be viewed as due to either of two components: (1) that arising from a movement along what economists would call a "health production function," relating life expectancy to real GDP per capita, and (2) that due to an upward shift in the function caused by "technological change," the ability to use given resources more productively to control disease and lengthen life (Figure I-1).

Economists and economic historians will quickly note the parallel with Solow's (1957) seminal analysis of the sources of economic growth in terms of movements along and shifts in

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[4] Feachem et al. (1992) stress that adult mortality trends do not always parallel those in infant and child mortality.

[5] See Phelps 1992, ch. 15 appendix; Viscusi 1993; Crimmins, Saito, and Ingegneri, 1997; Murray and Lopez 1994; Preston 1993, Prost and Jancloes 1993.

the aggregate production function (though Preston himself was not aware of Solow's work). The difference is chiefly in the nature of the technology -- in the case of life expectancy it is methods of controlling major infectious disease that are relevant, not methods of production. Moreover, like Solow, Preston concluded that a shift in the function was the overriding source of improvement.

In explicitly separating economic development from other sources of life expectancy improvement, Preston's analytical scheme seemingly highlights nicely the issue of economic development as the source of the advance of life expectancy. To those who see development as the prime mover, it is a movement along the function that is chiefly responsible for improved life expectancy.

It is implicitly such a movement along the function that is seen as the cause of life expectancy improvement in what is widely recognized as the most influential book on historical mortality in recent decades, Thomas McKeown's The Modern Rise of Population (1976), published almost contemporaneously with Preston's article. Reasoning chiefly from cause-of-death data for England and Wales from the mid-nineteenth century onward, McKeown argues that medical advances cannot explain the observed mortality decline. He concludes that economic growth, and, in particular, improved nutrition, must be responsible for the reduction observed, although, as he admits and critics have repeated, no direct evidence on the nutrition of individuals is presented.[6] One important result of McKeown's work has been to revive research on historical mortality.[7]

A recent article by anthropologist S. Ryan Johansson sees McKeown's work as importantly influencing the views of today's neoclassical economists by apparently "providing

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[6] Cf. McKeown 1976, p. 130, and critiques by Mercer 1990 and Szreter 1988. A recent study by Curtin (1989) points out that among British troops stationed in the United Kingdom, even though "diet changed very little in the middle decades of the nineteenth century," mortality fell rapidly (pp. 41-42).

[7] See, e.g., Bengtsson, Fridlizius, and Ohlsson 1984; Rotberg and Rabb, 1983; Schofield, Reher, and Bideau, 1991; and Woods and Woodward, 1984.

scientific evidence that market forces solved health and mortality problems in the past" (Johansson 1994, p. 108). Johansson charges economic historians generally, and especially Nobel laureate Robert W. Fogel in his project on human stature, with fostering this view. In fairness to Fogel, his discussion of the secular mortality decline specifically mentions factors that would shift the health production function.[8] But his portmanteau use of the terms nutrition and nutritional status, plus the fact that his substantive discussion is almost entirely about diet, calorie consumption, and food supply might lead some readers to suppose that he is only talking about movements along the health production function.[9]

In discussing the evolution of health economics, Fuchs (1996, p. 5) observes that "[t]he economist's distinction between movement along a function and a shift in the function is a very useful one." A Preston-type framework has often been employed in the economics literature in macro analyses of mortality; indeed, formulation of an aggregate health production function antedates Preston's work (Auster, Levenson, and Sarachek 1969). One of the most recent macro-analysis examples is an econometric study by Pritchett and Summers (1996) of cross-sectional and time series data for around fifty developing countries in the period 1960-1990. The thrust of their results is McKeown-like -- that the movement along the function is an important cause of mortality reduction, although the mechanisms by which per capita GDP affects mortality are left open.[10] The authors acknowledge at several points that an exogenous shift in

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[8] Cf., e.g., Fogel 1986, 443-446; 1991, 60; 1994, 388.

[9] Fogel 1986, 447, Goldin 1995, 205, Lindert, 1986, 531-533, and Perrenoud 1991, 20-21. The conceptual problem -- of which Fogel himself is fully aware (1986, 446-7; 1991, 40; 1994, 371, 375) -- is that nutritional status is affected not only by nutritional intake, but also claims against it, especially those due to disease. The reduction or elimination of disease can improve nutritional status and increase stature with no change in intake. Hence, trends in stature cannot be taken as a proxy for trends in per capita income or real wages, as Fogel and his collaborators initially suggested (Fogel et al., 1983, pp. 247-248; for recent critiques on this score, see Gallman 1996, Mokyr and O'Gráda 1996, Preston 1996a, 2-4). One prominent economic historian, Joel Mokyr, in several important recent papers has clearly separated himself from the idea that economic development/nutrition is the prime mover behind life expectancy (Mokyr, 1993, 1996; Mokyr and Stein 1997; cf. also Brown 1995, Preston and Haines 1991).

[10] The principal dependent variable is infant mortality, but life expectancy and child mortality

the function may also be important, and even state that “investments specific to child health improvements are expected to be more ‘cost effective’ in producing health gains than economic growth” (p. 865). But the analysis itself concentrates entirely on identifying the causal effect of per capita GDP, and a hasty reader may come away with little more than the title, “Wealthier is Healthier,” and conclude that economic development solves the problem of mortality reduction.

The separability of movements along the function from shifts in the function is not as simple as it seems, as has been increasingly recognized in the economic growth literature since Richard Nelson’s (1973) critique of growth accounting. I shall argue in sections II and III below that not only the level, but the slope of the function relating life expectancy to economic growth depends on the technology of disease control. Throughout much of the nineteenth century the slope was not much different from zero, because the mortality-raising agglomeration effects of economic growth largely offset any beneficial effects arising from improved living levels. New techniques of controlling major infectious disease, that started to be used in the latter part of the nineteenth century, increased both the slope and the level of the function.

Historically, the advances in technology underlying economic growth have been in large part the result of decisions by individual firms. In the case of infectious disease control the decision-making units are much more diffuse. Firms -- in the sense of private medical practitioners of all types -- may employ better methods of treating disease. But, as shall be seen, much of the improvement of life expectancy has been due especially to preventive rather than therapeutic measures. The contribution of firms to preventive measures has been small, though not negligible (e.g., safety precautions of coal mines and textile mills, and, more importantly, medical practitioners dispensing hygienic advice). The most important decision making units, however, have been households and governments -- households, because such a wide array of decisions relating to household operation and the household environment are crucial to preventing disease, and governments, because the new methods of disease control typically

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are examined too, with similar conclusions.

necessitated government action. Indeed, government decisions were more fundamental than household, because the adoption of new household methods required health education programs that were largely promoted by governmental agencies. Thus, thinking of the aggregate life expectancy production function in terms of its micro-level counterparts, the subsequent analysis suggests that the advance of knowledge shifted the production function of governments, households, medical practitioners, and non-medical firms, but that the pivotal player bringing about the shifts was the government.

The next section presents some facts on the historical patterns of life expectancy and economic growth, and considers the pre-modern slope of the function relating the two. Section III turns to the nature of technological change in infectious disease control world-wide, and its impact on the slope and level of the function. Section IV considers the role of market forces in promoting the adoption or development of the new techniques of disease control. Section V takes up possible indirect ways that economic growth may have generated the advance in life expectancy -- by funding public policies domestically or via international aid, or by funding the advance of knowledge underlying the new techniques of infectious disease control.

II. Life Expectancy and Economic Growth: A First Look

This section addresses the presumption that the historical improvement in life expectancy is due to the favorable effect of economic growth on living levels.[11] It first presents evidence that the long term trends in life expectancy and economic growth are not closely related, drawing on the record of six countries with relatively good data. It then considers why the relationship between the two has been quite weak in the historical past.

<u>The historical record</u> -- The first point of note is that life expectancy is marked by a sharp

[11] Negative as well as positive living level effects of economic growth -- e.g., via tobacco and alcohol consumption -- are usually recognized, but the positive effects are typically assumed to predominate until fairly high income levels are reached (cf. Auster, Levenson, and Sarachek, 1969, 134-136).

increase in the rate of improvement, starting in the late nineteenth century. Borrowing from Rostow (1959), I shall call this a "take-off" to signify a substantial shift from a lower to higher rate of change. As in the case of economic growth, the precise dating of this take-off is somewhat arbitrary and varies from one country to another.

In England and Wales -- for whom the historical record of life expectancy is longest, dating from 1541 -- the take-off occurs around 1871. Prior to this there is a slow improvement in life expectancy that starts in the first half of the eighteenth century, but this does little more than return life expectancy by 1871 to the level that prevailed in Elizabethan times (Figure II-1). In Sweden, another country for which the historical record is well-researched, the take-off occurs around 1875 (Figure II-2). As in England, there is a preceding period of mild improvement dating from the late eighteenth century, which was apparently also preceded by a period of worsening mortality.

The pattern of mild followed by rapid improvement occurs in four other countries included here (Figures II-3 through II-6). In France a take-off occurs around 1893; in Japan, 1923; and in the Third World countries of Brazil and India, around 1940 and 1945, respectively. Taking all six countries together, the rate of improvement in life expectancy in the half century after take-off is from three to six times greater than in the half century before (Table II-1, cols. 3 and 4).

If the McKeown hypothesis is correct, then the take-off dates for life expectancy should conform closely to those for economic growth. But the two do not fit closely at all (Table II-2). The contrast between Sweden and England and Wales is striking. Their take-offs in life expectancy are almost identical, but those in economic growth differ by about three-fourths of a century.

Taken as a whole, the evidence for the six countries suggests that the rapid improvement in life expectancy started later than modern economic growth, but spread more rapidly. In none of the six countries did rapid improvement in life expectancy start before the 1870s, whereas economic growth was underway in two, perhaps three, countries by that time. But the time span of the take-off dates for life expectancy is much shorter than that for the take-offs in modern economic growth -- about seven decades compared with seventeen. Also, in the four countries in which life expectancy takes off before 1940 there is little evidence of any impact on life expectancy of the substantial retardation in economic growth between World Wars I and II.

What of the mild improvement in life expectancy observed in all six countries prior to take-off -- could this be due to economic growth? Neither India nor Sweden provide much support for the hypothesis -- there is little or no increase in per capita income in India in the first half of the twentieth century or in Sweden prior to 1850.[12] An alternative explanation is that in all six of the countries included here the phase of mild improvement in life expectancy is associated with a reduction in smallpox mortality as vaccination was introduced (Fenner et al., 1988). Not only was smallpox itself a major cause of death and thus lowered mortality directly, but its reduction may also have lowered mortality from other diseases by reducing the proportion in the population of persons whose immune systems had been seriously damaged by smallpox (Mercer 1990, Sundin 1995).

<u>The agglomeration effects of economic growth</u> -- Some analysts have pointed out that in the middle of the nineteenth century there is an apparent flattening of the trend in life expectancy both in England and Wales and France, despite rising income levels.[13] They suggest that the positive effect of economic growth on life expectancy due to better living conditions was countered by another effect of economic growth -- the redistribution of population to high-mortality urban centers (Figure II-7). Before its take-off, life expectancy in urban areas was about ten years less than in rural, reflecting the more rapid spread of disease where population density is high and also under the crowded conditions of factory production as modern economic growth took hold (Figure II-8; see also the estimates for early dates in Figure III-1 below). As the population became more concentrated in low-life-expectancy urban areas, there was a

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[12] Bengtsson 1997; Fridlizius 1984; Maddison 1995, pp. 196, 204.

[13] Cf. Fogel 1994; Schofield, Reher, and Bideau 1991, ch. 1; Szreter 1988; Vallin 1991.

negative effect of economic growth on life expectancy. In England and Wales, for example, between 1831 and 1861 the proportion of population in urban areas rose from about one-third to one-half, and this redistribution would, ceteris paribus, have reduced life expectancy by two years, from 40 to 38 years (Table II-3, panels 2 and 3). In fact, life expectancy rose by one year between 1831 and 1861, as improvements within the rural and urban sectors slightly outweighed the effect of population redistribution (panels 2 and 4). These within-sector increases could be due to economic growth, the reduction of smallpox, or other factors.

The implication of the agglomeration effects of economic growth for the mid-nineteenth century slope of the function relating life expectancy to economic growth is noteworthy. The positive slope commonly taken to characterize the relation between life expectancy and per capita income is sharply reduced, because higher income brings with it higher urbanization, and thus greater exposure to infectious disease. Indeed, some scholars argue that the slope of the relationship in a pre-modern mortality regime may have been negative (Mosk and Johansson 1986). This inference regarding the pre-modern slope of the function implies that the great historical improvement in life expectancy had to be due to a shift in the function, because movements along the function would have had very little positive effect. But if the function shifted, then there ought to be evidence of "technological change," that is, of new methods of preventing or curing disease. The next section turns, therefore, to the historical evidence of technological change in disease control.

III. Technological Change and Life Expectancy

The starting point for any history of disease control technology must be recognition of the appallingly low state of knowledge of disease in the first part of the nineteenth century. At that time there was no correct knowledge of the causes of disease, very little of the mode of transmission, and almost none of how to treat disease. This is not to say that there were no beliefs on these matters -- quite the contrary, there was a firmly established body of doctrine on the nature, causes, and treatment of disease. But these beliefs were as likely to be counter-productive as productive, centering, as they did, on treatment by means of emetics, cathartics, diuretics, and bleeding (Rosenberg 1979, p. 13). Even to the present day withholding water from infants suffering from diarrhea is a common practice in many parts of the world. Note the contrast with the state of knowledge regarding methods of production. When modern economic growth got started, people already knew how to grow food and manufacture goods -- the technology of economic growth increased the ability to do better what people were already doing successfully. However, with regard to controlling disease, the fact is that there was very little useful knowledge before the mid-nineteenth century. Consider the example of a Philadelphia tallow chandler in the fall of 1826 who "complained of chills, pains in the head and back, weakness in the joints and nausea ... [B]efore seeing a regular physician, he

> was bled till symptoms of fainting came on. Took an emetic, which operated well. For several days after, kept his bowels moved with Sulph. Soda, Senna tea etc. He then employed a Physician who prescribed another Emetic, which operated violently and whose action was kept up by drinking bitter tea.[14]

[14] Rosenberg 1979, p. 13; cf. also Starr 1982, pp. 32-37, Warner 1986.

Elsewhere, the author of this passage, in a masterpiece of understatement, observes: "[i]t is difficult to recapture the medical world of 1800 ... a world of thought structured about assumptions alien to a twentieth-century medical understanding" (Rosenberg 1987, p. 71). A similar gap in medical knowledge existed in the mid-twentieth century between developing and developed countries, and persists to some extent even to the present time. For example, a survey of hygienic awareness in Matlab, Bangladesh in 1986 found that less than 30 percent of mothers believed that contaminated food or water might be responsible for diarrhea, and only 2 percent, for dysentery (Bhuiya, Streatfield, and Meyer 1990, p. 466).[15] None of this is to say that before the nineteenth century there had been no improvement whatsoever in knowledge relevant to the control of disease, but given the long history of humanity, the advances that had occurred were surprisingly recent and had yet to have much practical effect.[16] The most important practical advances had been the use of quarantine and cordons sanitaires in the fourteenth century to prevent the spread of plague, and the development in the latter part of the eighteenth century of innoculation and then vaccination against smallpox.

The major breakthroughs that were eventually to bring infectious disease under control took three principal forms:

1. new methods of preventing the transmission of disease, including education of the public, starting in the mid-nineteenth century,
2. new vaccines to prevent certain diseases, starting in the 1890s, and
3. new drugs to cure infectious disease (antimicrobials), starting in the late 1930s.

The first major step in preventing the transmission of infectious disease came with what has come to be called the "sanitation revolution." Starting in the 1840s, this was a movement aimed at cleaning up the cities through purer water supplies, better sewage disposal, paving

[15] Study of developing countries' knowledge and beliefs about health has been an important concern of medical anthropology (Caldwell et al. 1990; Landy 1977; Paul 1955; for recent work in other fields, see Pebley, Hurtado, and Goldman 1996; Weiss 1988). A brief historical overview is given in Roemer, 1993, pp. 3ff.

[16] For concise surveys, see Ackernecht 1968; Dixon 1978, ch. 2; and Hall 1967.

streets, education in personal hygiene, and the like. Though based on a misguided theory of disease transmission -- the miasmatic theory, which linked disease to bad smells and vapors -- its emphasis on cleaning up public places and homes led to a gradual reduction in the transmission of waterborne and airborne diseases. The sanitation revolution is usually dated from Edwin Chadwick's landmark 1842 Report on the Sanitary Condition of the Laboring Population of Great Britain. This report, and similar studies elsewhere (e.g. Griscom 1845, Shattuck et al., 1850, Citizens' Association of New York 1866) assembled demographic data and the testimony of medical experts to document the association between filth and high mortality. The domestic household counterpart of the sanitation revolution was a new emphasis on cleanliness.[17]

Next came a series of discoveries establishing how certain diseases were specifically transmitted (Table III-1, Panel A). Two critical breakthroughs were the mid-nineteenth century discoveries of Snow and Budd that identified impure water as a vehicle for the transmission of two highly-feared killers, cholera and typhoid. The specific identification of impure water as a carrier of disease helped strengthen the case for the reforms being urged by the sanitationists. Also, in 1867 Joseph Lister, influenced by Pasteur's research on the bacteriological origins of disease, introduced antiseptic surgery, starting a trend toward sharply diminished mortality in surgical procedures by reducing the transmission of infection during surgery (Biraben 1991, Gariepy 1994).

By the last quarter of the nineteenth century the discoveries of Pasteur, Koch and others, and the laboratory techniques and methodology that had been developed, had laid the foundation for the new science of bacteriology, and essentially validated the germ theory of disease. For the first time the causal agents in a number of major diseases were identified (Table III-1, Panel B). Further breakthroughs also occurred in identifying the mode of transmission of specific diseases, most notably, of malaria and yellow fever (Panel A). A basis was laid for the systematic

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[17] "If sanitary engineering associated with Chadwick represents the public face of the public health movement, the less well-known private aspect is represented in the efforts of the voluntary health visitors and sanitary workers who, entering the homes of the poor, tried to scour the inhabitants as well as their flats" (Wohl 1983, 66; cf. also Tomes 1990).

development of immunology, and a new approach opened for the prevention of disease by the development of vaccines.[18] The conquest of diphtheria by von Behring in 1892 was the first in a series of developments that brought a number of major infectious diseases under control via immunization (Table III-2, Panel A). These developments gave increased impetus to educational measures regarding home hygiene, infant and childrearing, care of the sick, and the like (Mokyr and Stein 1997).

The developments summarized so far were techniques that reduced mortality through the prevention of disease, but the ability to cure disease remained elusive, and, as in the past, physicians could do little to help those who were seriously ill (Thomas 1983, chs. 3-5). The successful development of antimicrobials that could attack the newly identified causes of disease without harmful side effects was the next major step in bringing infectious disease under control, but it did not come until almost a half century after the causes of a number of diseases had been found. The most important breakthrough was the development of penicillin in 1941, and the long list of other antibiotics to which it subsequently gave rise (Table III-2, Panel B; Baldry 1976; Böttcher 1964).[19]

Thus, in little more than a century the ability to control infectious disease was totally transformed -- first by techniques that prevented the spread of certain major infectious diseases, then by vaccines that protected people from contracting some of these diseases, and, finally, by the development of cures. The evidence of major advances in the knowledge and technology of disease control from the mid-nineteenth century onward, such as those listed in Tables III-1 and III-2, seems indisputable. But since any such enumeration of discoveries and technological breakthroughs is somewhat subjective, it may be helpful to quote a summary assessment of the

[18] Cf. Parish 1965, Plotkin and Mortimer 1988.

[19] For a striking demonstration of the advance in medical therapy after the 1930s, compare the recommended treatments of major infectious diseases in Winslow (1931) with those in Beeson (1980). The development of antimicrobials is, of course, not necessarily the last step in the control of infectious disease. It is possible, for example, that antibiotics will eventually be replaced by bacteriotherapy -- the use of genetically modified strains of nonpathogenic microorganisms to compete against virulent pathogens (Wainwright 1990, 188).

progress of knowledge given in 1983 by one historian of the subject: “In a single century the understanding of disease increased more than in the previous forty centuries combined. The two crucial developments in this regard were the rise of technology and the application of the basic biological sciences to medicine, using new rules of experimentation and new criteria of proof” (Hudson 1983, p. 121).

The epidemiological transition in developed countries -- As these new techniques of disease control were introduced, mortality rates plunged, life expectancy took off, and noninfectious gradually replaced infectious diseases as the leading causes of death. This development, known as the “epidemiologic transition” or “health transition,”[20] is illustrated by cause-of-death data for England and Wales (Table III-3). The fact that a large share of the mortality decline there took place before 1940 makes clear that much of the control of infectious disease was accomplished by preventive measures, before the introduction of antimicrobials.

One would expect that the new techniques of disease control would improve life expectancy more rapidly in urban than rural areas, and that the gap between the two areas would consequently narrow. This is because the sanitation revolution was first and foremost a drive to clean up the cities. Moreover, efforts to educate the public on the importance of personal hygiene were directed especially at, and more easily reached, the highly concentrated urban than widely dispersed rural population. And, in fact, the historical shortfall of urban compared with rural life expectancy was steadily eliminated (Figure III-1).[21] The initial differential and subsequent trend in rural versus urban life expectancy is the opposite of what one would expect based on per capita income. Although per capita income was initially lower in rural areas (Williamson 1981, 1982), life expectancy was higher. And while rural income grew more

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[20] Bobadilla et al., 1993; Caldwell et al., 1990; Omran 1971.

[21] Some pioneering historical studies exploring the effect on mortality of urban environmental improvements are Brown, n.d.; Cain and Rotella 1990; Condran and Crimmins-Gardner 1978; Condran, Williams, and Cheney, 1984; Higgs 1979; Johansson and Mosk 1987; Meeker 1970; Mosk and Johansson 1986; Preston and van de Walle 1978; Wells 1995.

rapidly, converging toward urban levels, life expectancy grew more slowly.[22]

The point was previously made that under the mortality regime prevailing in the first half of the nineteenth century -- before the onset of sustained advance in the knowledge and technology of disease control -- the positive relation between life expectancy and income that would be expected on the basis of improved living levels was undercut by the positive association between urbanization and per capita income. The differential trend between rural and urban mortality significantly altered this relationship. As unfavorable urban conditions were removed by the new techniques of disease control, and excess urban mortality eliminated, the adverse effect of urbanization on life expectancy evaporated, leaving only the positive effect of per capita income via higher living levels. Thus the new technology of disease control had the effect of increasing the slope of the functional relationship between life expectancy and per capita income, as well as shifting that relationship upward (cf. Mosk and Johansson 1986, p. 420).

Associated with the epidemiological transition there was also a take-off in stature much like that in life expectancy. Recent work by economic historians has increasingly recognized that stature is a function of disease as well as diet, because disease seriously affects the capacity of the body to retain nutrients.[23] A microlevel illustration is the carefully documented growth history of a Gambian infant in Figure III-2 which reveals that lapses from a normal growth trajectory are primarily associated with periods of infection, especially diarrheal disease. Because the epidemiological transition especially reduced mortality and illness of the young, among whom the incidence of infectious disease is highest, one would expect the transition to have beneficial effects on stature. That this is so is indicated by the valuable times series assembled by Fogel and his collaborators. In the six European countries for which historical estimates are available, the average improvement in male stature in the century prior to the third quarter of the nineteenth century was 1.1 centimeters. In the subsequent century -- the period of

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[22] Preston, Haines, and Pamuk 1981; Preston and van de Walle 1978, p. 279; Sawyer 1981.

[23] Engerman 1997, Steckel 1995, Steckel and Floud 1997.

the epidemiological transition -- it was 7.7 centimeters (Table III-4). In every one of the six countries the rate of improvement in stature was considerably higher in the most recent century than in the earlier. As was noted above regarding life expectancy, the pre-take-off improvement in stature may also partly reflect a reduced incidence of infectious disease, in this case as smallpox vaccination spread.

Advances in infectious disease control in today's developing countries-- Since World War II there has been a sustained improvement in life expectancy in every one of the four major developing regions -- Latin America, Asia, sub-Saharan Africa, and the Middle East plus North Africa -- at a rate ranging from 3.4 to 6.6 years per decade (Figure III-2).[24] The contrast with trends in real GDP per capita is noteworthy (Figure III-3). In three of the four regions GDP per capita turns downward in 1985-95, but life expectancy continues to rise at the same pace as in the prior interval, a disparity between life expectancy and economic growth reminiscent of those noted above in the longer historical time series.

This improvement in life expectancy in developing countries has been accompanied by the introduction of essentially the same techniques of infectious disease control as were used in the developed countries.[25] For the early post-World War II period, analysts give prominent attention to efforts to bring malaria, smallpox, and other epidemic diseases under control, illustrated here by the diffusion of smallpox immunization (Figure III-4).[26] Since 1965 when

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[24] The averages in Figures III-2, III-3, and III-5 are for 80 or more developing countries, depending on availability of data, with 1990 populations greater than 900,000 -- about 14 in Asia, 21 in Latin America and the Caribbean, 13 in the Middle East/North Africa, and 40 in sub-Saharan Africa. Pritchett and Summers (1996, pp. 848-849), whose sources for the life expectancy and GDP data are the same as those used here, offer some pertinent cautions on the reliability of the life expectancy data, although no corresponding warnings are given regarding the GDP estimates.

[25] Cf. Arriaga and Davis 1969; Chen, Kleinman, and Ware 1994; Gribble and Preston 1993; Mosley and Chen 1984; United Nations 1982, 1985, 1991, 1992. Modifications have, of course, also occurred; cf. Cairncross 1989, Commission on Health Research for Development 1990, p. 15.

[26] United Nations 1952, 1957, 1961, 1963, 1973; cf. also Bulatao 1993; Gray 1974; Haines, Avery, and Strong, 1983; Preston 1980, pp. 293-301.

data first become more plentiful, access to pure water supply has improved markedly (Figure III-5, Panel A). So too has female education, an approximate indicator of improved control of transmission, especially in the home.[27] Progress in regard to immunization of children is evidenced by the the sharp rise in DTP immunization over the last three decades (Panel C). Closely associated with this has been the spread of other immunization measures and oral rehydration therapy (World Health Organization 1992). Although trend data relating directly to the supply of drugs are not available, a proxy, doctors per 10,000 population, also improves considerably (Panel D).[28] These indicators of technological change, though by no means comprehensive, signify advance on a number of fronts in the control of infectious disease in developing countries like those in developed countries, an advance consistent with the rapid rise in life expectancy.[29]

The indicators in Figure III-5 underscore the similarity between the developed and developing countries in the techniques used to control infectious disease. However, among the leaders in the take-off of life expectancy, the timing of the various innovations in control of contagious disease was quite different from that in the recent experience of today's developing countries. This is because the leading countries in life expectancy, as with economic growth, experienced sequentially technological advances that occurred more nearly simultaneously

[27] In Figure III-5, Panel B, data on primary school enrollment of school-age females are shifted forward a decade to approximate the trend in years of schooling of young homemakers.

[28] Various studies relate one or more of these indicators to mortality. See, e.g., on water, Esrey et al. 1991; female education, Caldwell et al. 1990, chs. 19-23; Chen, Kleinman, and Ware 1994, chs. 11-13; Cleland and van Ginnekin 1988; Hobcraft 1993; Jejeebhoy 1995, ch. 6; Sandiford et al. 1995; Ware 1984; immunization, Boerma and Stroh 1993; doctors, Doan 1974, Gilliand and Galland 1977.

[29] Data on public health spending are not available for the period covered here, but they are likely to be less meaningful than the specific indicators shown. This is because a fair proportion of public health spending in developing countries appears to be devoted to the benefit chiefly of middle and upper income classes, e.g., expenditures on urban hospitals, highly specialized equipment and drugs, and the like. Moreover, some measures that have been effective in reducing mortality, such as improved water supply and sewage disposal, may not be included in health spending.

among a large number of followers in the last half of the twentieth century. The increased options available to today's developing countries no doubt helps account for their more rapid rate of improvement of life expectancy than in the developed countries.

IV. Life Expectancy and the Market

To recapitulate the argument to this point, in the state of knowledge regarding health and mortality prevailing in the early nineteenth century, economic growth had at best only a small positive effect on life expectancy. This is because the positive effect of economic growth via improved living levels was substantially offset by a growing exposure to disease as the population became more urbanized. Only as advances in knowledge led to the development and use of new methods of controlling infectious disease did rapid improvement in life expectancy occur.

But even if economic growth via its effect on living levels was not directly responsible for the great improvement in life expectancy, isn't it possible that the institutions that fostered economic growth were also encouraging the development and use of the new methods of controlling infectious disease? Rodrik (1996) has noted the current broad professional consensus that economic growth is fostered by free markets, private property, and enforcement of contracts (cf. also North 1990). Weren't these same institutions at work on the problem of infectious disease? Incomes were rising and infectious disease was an important concern; wasn't it profitable for firms to attack the problem?

It is this question -- the role of the market in the great improvement of life expectancy -- to which this section is addressed. By the "market" I mean supply and demand conditions operating within the institutions of private property and free contract to allocate resources via the incentive of private profit to the satisfaction of human wants -- in this case wants with regard to the elimination of disease and reduction of mortality.

It is possible to form a tentative judgment on this question by looking at the history of the specific techniques that reduced infectious disease so dramatically -- control of the mode of transmission, immunization, and antimicrobials -- and consider the extent to which the market allocated resources to each. The answer, as shall be seen, is that the market appears to have functioned poorly. Infectious disease is a subject replete with all the classic sources of market failure -- information failures, externalities, public goods, principal-agent, and free rider problems (Stiglitz 1988). Moreover, the market registers imperfectly the needs of those most vulnerable to disease -- infants and children, the poor, and the elderly.

There is also the question whether the market might be responsible for developing the new methods of disease control. The answer to this also appears to be negative. The sequence of innovation suggests that it was not the returns to innovation but the changing feasibility of innovation that was responsible for technological progress, and feasibility depended chiefly on the internal evolution of scientific knowledge and technique in the biomedical field, not external market forces.

In what follows, I take up first the principal ways in which infectious disease was tamed, noting the new public institutions that were required to allocate resources appropriately, and then turn to the determinants of the innovations in disease control.

<u>Control of the mode of transmission of disease</u> -- For the present purpose, it is helpful to classify the techniques under this head into those requiring a change in the contaminating behavior of individuals, firms, and other agents, and those calling for correction of environmental conditions.

The contaminating behaviors of individuals encompass such things as coughing, sneezing, spitting, and nose-blowing; toilet habits; behavior in regard to personal washing and bathing; practices regarding the sources and handling of drinking water and milk; methods of food handling and preparation; customs regarding the care and feeding of infants and children; practices relating to care of the sick; and attitudes toward rodents and insects. In the nineteenth century everyday behavior in all of these respects generated significant negative externalities with regard to infectious disease. A few examples: spitting on the floor at home and in public places was often an accepted behavior; the fly, rather than being regarded as a carrier of disease, was thought of affectionately as the “friendly fly.” Writing of the habits of the poor in

Wakefield, England in 1869, Sir John Simon reports, "people are seen easing their bowels into the beck [stream] which afterwards supplied them with drinking water."[30]

At the firm level, worker and management practices fostering the spread of disease (often unwittingly) were also common. The following is an example from a statement by Stephen Smith, a physician, on the results of a sanitation survey in New York City in 1865:

> I hold in my hand a list of cases of smallpox found existing under circumstances which show how widespread is this disease. Bedding of a fatal case of smallpox was sold to a rag-man; case in a room where candy and daily papers were sold; case on a ferry-boat; woman was attending bar and acting as nurse to her husband who had smallpox; girl was making cigars while scabs were falling from her skin; seamstress was making shirts for a Broadway store, one of which was thrown over the cradle of a child sick of smallpox; tailors making soldiers' clothing, have their children, from whom the scabs were falling, wrapped in the garments; a woman selling vegetables had the scabs falling from her face, among the vegetables, etc. etc. (Smith 1911, pp. 108-109).

A description of mid-nineteenth century London's "town dairies" -- "half-underground dens and cellars in which the cows were kept for the greater part of the year, standing knee-deep in filth" -- states that "it was difficult to find a sample of London milk which would fail to show the presence of blood or pus when examined under the microscope" (Drummond and Wilbraham, 1939, pp. 299-300).

Such behaviors and practices, of central significance for the transmission of disease, are not a simple function of income and prices. They are rooted in the established norms of society, and its customs and beliefs. Each generation as it is raised internalizes various health beliefs and learns what is socially acceptable behavior. Historically, the market, by crowding people more closely together in towns, cities, and factories, magnified the negative externalities of disease-transmitting behaviors and practices. Writing in 1842 on The Condition of the Working Classes in England, Friedrich Engels observed: "Dirty habits ... do no great harm in the countryside where the population is scattered. On the other hand, the dangerous situation which

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[30] The quotation of Simon is from Wohl, 1983, p. 94. On the "friendly fly," see Rogers 1989.

develops when such habits are practiced among the crowded population of big cities, must arouse feelings of apprehension and disgust" (as quoted in Wohl 1983, p. 4).

Nor can this set of behaviors be corrected by the simple assignment of property rights. In the absence of knowledge of the mechanisms of disease causation and transmission, such assignment is not even conceivable. But given such knowledge, enforcement is not possible because of the overwhelming magnitude of transaction costs. As Phelps (1992, p. 418) points out: "If you had to sue everybody who sneezed in your vicinity, you would have no time remaining for any other activity. ... [S]ocial customs and 'manners' create society's best control mechanism." But appropriate customs and manners do not arise spontaneously. They result chiefly from increasing awareness among the public of the consequences of one's actions for the spread of disease -- awareness that depends on appropriate knowledge of disease.

The second principal source for preventing the transmission of infectious disease has been correction of environmental conditions that expose population to disease. Here too the contribution of market forces has been dubious. Some environmental techniques for controlling contagious disease, such as insect or rodent control, are quite clearly public goods. The individual may take defensive measures -- the use of screens, mosquito netting, rat traps, etc. -- but in situations of dense habitation these are likely to be ineffective in the absence of community action. What is needed are measures that go beyond the individual's resources, such as the spraying of insecticides on the breeding grounds of insects (Musgrove 1996, p. 11).

Some environmental conditions important for the control of infectious disease do involve goods that are or have been provided by the market to some extent. This is notably true with regard to those conditions that were the initial target of the sanitation revolution -- improved water supply and waste disposal. Didn't rising income generate a growing demand for these goods, and their resulting supply work to remove this source of infectious disease?

To answer this, it is helpful to start by recalling that in the mid-nineteenth century the flush toilet was a rarity -- in cities the most common facility was a vault privy, modeled on its country cousin, the out-house, but in poor neighborhoods, even these were rare.[31] The result was burgeoning accumulations of human excrement as city size rocketed. In some areas, these accumulations, because of their potential use as manure, had value as an economic good -- there was a saying that the "chamber pot is a penny savings bank" (Drummond and Wilbraham 1939).[32] But the resulting market only aggravated the problem of infectious disease, because of accompanying negative externalities. It is worth repeating an oft-quoted and apt passage from Chadwick describing conditions in British towns around 1840:

> In the parts of some towns adjacent to the rural districts the cesspools are emptied gratuitously for the sake of the manure; but they only do this when there is a considerable accumulation . . . . For the saving of cartage, as well as the convenience of use, accumulations of refuse are frequently allowed to remain and decompose and dry amidst the habitations of the poorer classes. *Dr. Laurie* in his report on the sanitary condition of Greenock, furnishes an example. He says, --
>
> The first question I generally put when a new case of fever is admitted, is as to their locality. I was struck with the number of admissions from Market-street; most of the cases coming from that locality became quickly typhoid, and made slow recoveries. This is a narrow back street . . . .

[31] "[I]n mid-century Darlington: 'In 1 yard 66 persons are obligated to use 1 privy; in another 65, and in a third 63, in a fourth 54, in a fifth 45, in a sixth 41, in a seventh 35 and so on'" (Wohl 1983, 87; cf. also Winslow 1943, 244-245).

[32] "Dogs'-dung ... called 'Pure' from its cleansing and purifying properties" was also valued, and collected by specialized workers. See the description of "Pure-finders' in Mayhew 1851, pp. 306ff.

> In one part of the street there is a dunghill, -- yet it is too large to be called a dunghill. I do not mistate its size when I say it contains a hundred cubic yards of impure filth, collected from all parts of the town. It is never removed; it is the stock-in-trade of a person who deals in dung; he retails it by cartfuls. To please his customers, he always keeps a nucleus, as the older the filth is the higher is the price. The proprietor has an extensive privy attached to the concern. This collection is fronting the public street; it is enclosed in front by a wall; the height of the wall is about 12 feet, and the dung overtops it; the malarious moisture oozes through the wall, and runs over the pavement. The effluvia all round about this place in summer is horrible. There is a land of houses adjoining, four stories in height, and in the summer each house swarms with myriads of flies; every article of food and drink must be covered, otherwise, if left exposed for a minute, the flies immediately attack it, and it is rendered unfit for use, from the strong taste of the dunghill left by the flies. (Chadwick 1842, p. 119)[33]

It may be thought that such conditions are peculiar to the mid-nineteenth century. An excerpt from an article in the New York Times of January 9,1997 on current conditions in some parts of the Third World may serve as a corrective:

> On the Bassac River just outside Phnom Penh is one of the most wretched slums in the world, a putrid slope of mud and excrement that is home to tens of thousands of people packed in rickety shacks on the bank of the river.
>
> There are latrines of a sort, for entrepreneurs have set up little platforms over the water. These are open toilets where men and women squat behind half-barrels. . . . [T]he toilet owners make money by raising fish on the sewage in fenced-off waters below the toilet platform.
>
> The fish may not sound appetizing, but the worst problem is that the slow river is used by the slum not only as its toilet, but also as its source of drinking water. . . . [T]he only water available for washing hands is the black liquid taken from between the toilets in the river.

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[33] Conditions in American cities were much like those reported in the Chadwick Report. See, for example, the reports by Griscom [1845] 1970, Shattuck [1850] 1948, Smith (1911).

The market was at work too in the mid-nineteenth century with regard to the provision of water, in the form of piped water supplied by private water companies, from containers sold by private vendors, or from sales at a local street pump or tap (Hohenberg and Lees 1985). Privately provided piped water was allocated almost wholly to meet the demands of the middle and upper income groups, while those in crowded urban slums might have to walk a quarter of a mile to the one water tap in the neighborhood.[34] In these circumstances, it is not surprising that working class families in mid-nineteenth century Burton-on-Trent "purchased an average of nine buckets of water a week for a family of five or more for <u>all</u> purposes" (Wohl 1983, 63, emphasis in original). Note that this statistic relates to working class families -- the poor would have fared even worse. In developing countries today according to a World Bank study "tens of millions of women and children spend as much as three or more hours daily fetching polluted water (Roth 1987, 231).

But water supply involves much more than a problem of unequal distribution. As cities grew, and the cost of transportation of human waste to rural areas became prohibitive, carters turned for disposal to the closest stream, pond or river. Water courses in and around large cities were transformed into enormous cesspools. William Budd's contemporary description of the "Great Stench" arising from the accumulation of sewage in the Thames River in the summer of 1858 is indicative:

> For the first time in the history of man, the sewage of nearly three millions of people had been brought to seethe and ferment under a burning sun, in one vast open cloaca [sewer] lying in their midst. . . . Stench so foul, we may well believe, had never before ascended to pollute this lower air. . . . For many weeks, the atmosphere of Parliamentary Committee-rooms was only rendered barely tolerable by the suspension before every window, of blinds saturated with chloride of lime, and by the lavish use of this and other disinfectants. More than once, in spite of similar precautions, the law-courts were suddenly broken up by an insupportable invasion of the noxious vapour. The river steamers lost their accustomed traffic, and travellers, pressed for time, often made a circuit of many miles rather than cross one of the city bridges. (As quoted in Winslow 1943, p. 288)

[34] Briggs 1985, 134-135, Goubert 1989, Wohl 1983, 61-63.

Sewage disposal thus led increasingly to contaminated water supply.[35] The problem was aggravated by industrial wastes from factories (Cain 1977, 375-6). Since pathogenic organisms can exist in water which to the naked eye is pure, not even the wealthy -- despite their ability to pay -- were assured of protection from this source of infectious disease.

All of this boils down to a simple point -- under the conditions of agglomeration arising from nineteenth century economic growth, the market could not be counted on for the provision of pure water in adequate amounts or for the proper disposal of sewage. Rather, market forces were tending to increase exposure to infectious disease. It has been suggested that economists "need to do a lot more work on the extent to which economic activity produces ill health as well as goods and services for people to buy"(Williams 1987, 1068). The problem of water supply and sewage disposal in rapidly growing cities seems like a useful place to start.

Immunization - On the face of it one might suppose that a newly available vaccine would find a ready market. But this assumes a belief in the efficacy of modern medicine that may not exist -- in sub-Saharan Africa in the 1960s, for example, babies were sometimes hidden from the national or international teams dispensing smallpox vaccinations.[36] In addition, those who have appropriate knowledge may be priced out of the market. There is also a free rider problem -- the incentive for vaccination diminishes as others become immunized. And in the case of the immunization of infants and children, there is a principal-agent issue. The child must rely on the parents' decision to immunize. But parents may be negligent, or simply not have the time needed for a round, say, of three innoculations of DTP or polio vaccine in a year.

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[35] Attempts by cities to go further upstream for water did not necessarily solve the problem of contamination. In the United States after impure water came to be recognized as a source of disease, it took about half a century before the belief that water purified itself after traveling six miles was replaced by the view that "no river is long enough to purify itself" (Marcus 1979, p. 192). For an excellent analysis of the interdependent problem of urban sanitation and water supply in the United States, see Cain 1977.

[36] Fenner et al 1988; cf. also Hanlon et al 1988, Cutts et al 1989. Resistance to modern therapies for reasons other than monetary cost has been common; see Caldwell, Reddy, and Caldwell, 1983; Caldwell et al., 1990; Dixon 1978; Landy 1977; Paul 1955.

Immunization also involves a problem like that which arises with hygiene education. One person may opt for the new practice or knowledge, but the failure of others to do so may leave that person at risk. Mention was made earlier of the synergistic relation between smallpox and other diseases. The vaccination of one person may protect her against smallpox, but if those who fail to get vaccinated suffer from damage to their immune systems caused by smallpox, they may expose the person who was vaccinated to greater risk from other diseases such as typhoid or tuberculosis.

All of these considerations add up to a questionable case for reliance on the market to foster the spread of immunization. A recent publication of the World Bank puts it more strongly: “Had it been left to private markets during the last few decades, it is inconceivable that today some 80 percent of the world’s children would be immunized against the six major-vaccine-preventable childhood diseases”(Musgrove, 1996, p. 14).

Antimicrobials -- Here, at last, one might suppose is an area that can be conceded to the market. To be sure, regarding antimicrobials as well as vaccines, there are issues of quality control and of monitoring claims for effectiveness by private producers. But can’t one rely, generally speaking, on the market as a vehicle for distributing drugs?

The answer appears to be no. There are significant externalities associated with the private distribution of drugs; most importantly, the market fails to take adequate account of the fact that the excessive use of antibiotics fosters the growth of drug-resistant bacteria. This problem quickly came to the fore in developed countries shortly after antimicrobials were introduced, and seriously undercut the high hopes originally held for these drugs (Lappé 1982). But the problem is most serious in the developing countries, where an uncontrolled free market is typically the primary vehicle of drug distribution. A quotation from a World Bank study is particularly telling, because it comes from a book explicitly devoted to a search for free market solutions:

> The proliferation of modern pharmaceuticals in developing countries can have harmful effects. . . . . [I]n many developing countries medical practitioners do not exercise any control over the use of modern prescription drugs such as antibiotics, as do practitioners in the developed countries. Throughout Latin America, for example,

prescription medications, usually manufactured by multinational pharmaceutical firms, can often be purchased over the counter in pharmacies or shops or from medicine vendors. The link between healer and healing resource is not always present, and the products are frequently available in the absence of physicians or other trained practitioners . . . .

[I]n some regions of India, indigenous practitioners supply modern medicines on a large scale. In Mysore and the Punjab 80 percent of the medicines are modern, and 50 percent of the patients receive penicillin injections, generally from unqualified practitioners supplied by pharmacists. ... [T]he greatest source of hazard [is] the tendency of "pseudo-indigenous practitioners" to use the most powerful drugs possible, such as chloramphenicol, to obtain quick results. Similar systems of "pharmaceutical medicine" have been reported in Ethiopia. (Roth 1987, p. 137, citations in original deleted.)[37]

Some have suggested that pharmaceutical companies have little motivation to waste money on this problem, since the development of drug-resistant bacteria fosters the development and sale of newer drugs (Muller 1982, p. 115). Moreover, consumers who are ill are likely to demand what they view as the most powerful drugs, without regard to their longer-term effects. In 1990 an international nongovernmental Commission on Health Research for Development (1990, p. 42), after stating that "there are few factors that affect the cost-effectiveness of health services more than fostering the appropriate use and controlling and reducing the misuse of drugs" went on to say that "[b]ehavioral research is urgently needed to improve the way pharmaceuticals are prescribed, dispensed, and used."

<u>Institutional innovations in the control of contagious disease</u> -- The foregoing suggests that free market institutions have functioned poorly to control major infectious disease. In what is widely regarded as one of the early classics in health economics,

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[37] Dixon (1978, 205-13) cites other examples of the drug promotion in developing countries by multinational pharmaceutical companies leading to their misuse. Cf. also Lappé 1982, chs. 10, 15; Chetley 1990.

Arrow (1963, p. 947) observed: "[W]hen the market fails to achieve an optimal state, society will, to some extent at least, recognize the gap, and nonmarket social institutions will arise attempting to bridge it." The history of infectious disease bears testimony to the accuracy of this generalization.

I take "institutions" here in North's (1990) sense of both formal and informal arrangements. And, indeed, both types have been required -- informal arrangements in the form of a change in social norms relating to responsibility for disease, and, also, formal establishment of an apparatus for state intervention. These are taken up in succession below.

One of the effects of the sanitation revolution was a gradual transformation in attitudes toward responsibility for disease.[38] Previously, disease had been attributed to "acts of God" or individual failings, such as sinfulness, lack of moral character, and the like. However, the growth of knowledge regarding modes of transmission of disease made it increasingly clear that the individual might be the victim of forces beyond his or her control, and that these forces were within the purview of social action. As awareness of this possibility grew, so too did support for state intervention in the interest of "public" health (Briggs 1985, II, 150).

What was lacking, however, was an effective mechanism for intervention. It was in the solution of this problem that the sanitation revolution probably made its greatest contribution. The key institutional innovation was the establishment of a network of local boards of health under the supervision of a central authority (usually a national health agency, although in the United States this function was performed by state health boards), armed with the weapon of inspection.[39] In both England and the

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[38] Institute of Medicine, 1988, chapter 3; Duffy 1992, p. 128; Flinn 1965, p. 59; Griscom [1845] 1970; Hanlon, Rogers, and Rosen 1960, p. 446; Rosenkranz 1972; United Nations 1952, p. 24.

[39] The novelty of the institutional innovation of the public health system is recognized by both contemporaries and historians. In 1890, looking back on the evolution of the public health apparatus, Sir John Simon, "the greatest of the Victorian medical

United States the last half of the nineteenth century saw the gradual emergence of this new public health apparatus.[40]

Initially the focus was on sanitation -- establishing pure water supplies, sewage disposal, paving streets, and the like. But the functions of the public health organization changed over time as knowledge and technology advanced. As the germ theory increased in acceptance a bacteriological view of public health tended to reinforce "sanitary science," and expand the functions of health departments. Bacteriological laboratories became part of the new municipal health departments, and research and diagnosis of pathogens became significant functions. Regulation of food and milk supply developed as the role of food handling in the transmission of disease became recognized. Recognition grew of the need for housing standards, building regulations, and appropriate enforcement authorities. The production and distribution of vaccines became important. And gradually some of the original activities of health departments were spun off to other municipal agencies, such as responsibility for water supply, waste removal, and "nuisances," although oversight and regulation functions continued.[41]

For households, the domestic hygiene counterpart of the new sanitary science

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officers" (Wohl 1983, 8), was to observe that "on the new foundations of Science, a new political superstructure has taken form" (Simon 1890, p. 463). Writing in the mid-twentieth century, George Rosen, author of the classic history of public health, cites Edwin Chadwick's chief contribution as his recognition that "what was needed was an administrative organ to undertake a preventive program by applying engineering knowledge and techniques in a consistent manner" (Rosen 1968, v. 13, 167).

[40] Rosen 1958, Duffy 1992, Kearns 1988, Marcus 1979, Briggs 1985, Wohl 1983.

[41] The association between the growth of knowledge regarding disease and the expansion of government regulatory and educational activities from the latter part of the nineteenth century onward is apparent in a number of articles written from the comparatively recent perspective of the early 1930s in the Encyclopaedia of the Social Sciences. See, e.g., the articles on food and drug regulations, building regulations, inspection, health education, sanitation, water supply, milk supply, housing, and slums.

centered initially on ventilation, disinfection, plumbing, water purification, isolation of the sick, and general cleanliness. Since the new knowledge was not proprietary, the market could not be relied on to disseminate it. Nor were there competitive profit-making pressures on households analogous to those fostering the adoption of new production techniques by profit-making firms. At first, the new knowledge was promoted especially by women reformers through voluntary organizations. But public health agencies gradually assumed an increasing role, and voluntary domestic hygiene was supplemented by compulsory quarantine and disinfection. As knowledge grew, education expanded to encompass food handling and infant and child care, and health programs were introduced into the schools. Because women were principally responsible for household care and childrearing, these educational efforts were especially directed towards women. Thus, in contrast to economic growth, female, rather than male, education has played a central role in the improvement of life expectancy (see note 28 above).[42]

In a recent article, Barr (1992) points out the critical importance of the little-discussed topic of "information failures" as a justification for state intervention. One could hardly find a better case than infectious disease. Throughout much of the history of the world both producers and consumers have been ignorant of the causes of disease and of the consequences of their actions for the spread of disease. Under these circumstances education of the public, based on the growth of knowledge regarding disease, has been fundamental in the control of disease, and this educational function has devolved primarily on the public health system and the schools. Regulatory

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[42] One indication of the success of these educational efforts in shifting the household's health production function are changing patterns of consumer demand. Mokyr and Stein (1997) point out that in England soap consumption rose sharply in the late nineteenth century, despite a rising price (cf. also Wohl 1983, p. 71). In regard to the late nineteenth century United States, Tomes (1990, 531) reasons that "the rush to develop and to patent sewer traps, toilet designs, window ventilators and water filtration systems ... suggests that entrepreneurs found a lucrative market among householders anxious to safeguard their families against infection."

actions enforced by the police power of the state have reinforced education.

The institutional impact of advancing biomedical knowledge went well beyond the official public health system. Voluntary associations arose, usually dedicated to a specific purpose, such as education in regard to infant care, or the diffusion of knowledge about tuberculosis. These voluntary organizations served a useful purpose in supplementing the governmental system and sometimes pointed to new possibilities or needs for action. But, as with hygiene education, the voluntary agencies were for the most part relatively short-lived, and it was the governmental system that formed the backbone of the new institutional structure dedicated to the promotion of public health.

As the germ theory became accepted it revolutionized the training of doctors and nurses, and gave birth to what we know as the modern hospital.[43] As awareness grew of "community" medicine, there arose professional associations (the American Public Health Association was founded in 1872), schools of public health (the first American school, Johns Hopkins, was established in 1918), and a specialized professional literature.[44] The history of public health is filled with "public entrepreneurs" who led in the formation of new institutions or the revamping of old to implement the new goals and knowledge (Rosen 1958, 507-15).

From its inception in the sanitation revolution, the public health movement encountered serious opposition because of the necessary expansion of the government's role in the economy. The sanitation revolution was, in effect, mirrored in a clash of ideologies between advocates of laissez-faire and proponents of state intervention, though some public sector proponents such as Chadwick sought to assimilate proposals for intervention to the prevailing laissez-faire philosophy and

[43] Abel-Smith 1960, 1964; Haines 1933; Rosen 1958, 374-82; Rosenberg 1987; Vogel 1980.

[44] Duffy 1992, 253; Rosen 1958, pp. 516-525.

Benthamite utilitarianism.[45] Specific proposals were fiercely debated in the local and national political arenas. The backbone of the opposition were those whose vested interests were threatened -- landlords, water companies, proprietors of refuse heaps and dung hills, burial concerns, slaughterhouses, and the like.[46] The opposition appealed to the preservation of civil liberties, and sought to debunk the new knowledge cited by the public health advocates, a strategy reminiscent of the current response of the tobacco industry to evidence of adverse health effects of smoking.[47]

Although more study is needed, current mortality trends in transition economies also seem to suggest that the institutional conditions fostering improved life expectancy are not the same as those believed to promote economic growth. In these countries the public sector is everywhere in retreat, and the expansion of the market and related institutional conditions deemed essential for economic growth are occurring rapidly. But adverse life expectancy developments have provoked the startling question, "Is transition a killer?" (World Bank 1996, p. 128). Particularly relevant is China's experience. Although income grew at a staggering rate, "mortality rates for children under age five, tailed off sometime in the early 1980s. By the late

[45] Briggs 1985, II, ch. 7, Flinn 1965, Kearns 1988.

[46] Briggs 1985, II, ch. 7; for the United States, cf. Wells 1995; for Germany, Evans 1987, ch. 2.

[47] Despite the documented success of smallpox vaccination, a strong antivaccinationist movement existed in Great Britain well into the late nineteenth century (Fenner et al, p. 270).

1980s China had actually fallen behind countries at similar income levels" (ibid., p. 127). The commentary on the underlying reasons clearly puts the onus on privatization:

> In rural China a share of communal production used to be set aside to finance collective needs, including primary health care, vaccination, birth control, and maternal health care. The downturn in China's health performance relative to its income level coincided with agricultural reforms that reduced the ability of the village to tax peasants. A system of cost recovery rapidly replaced tax funding, creating general problems of access. (ibid.)[48]

[48] Privatization is likely to exacerbate the serious adverse health effects of the growth of smoking in China. See Commission on Health Research for Development, 1990, p. 14. Williams (1987, p. 1067) describes smoking as "an area of public policy where the 'market failure' and 'public choice' literatures fuse into a most excruciating scenario of conflicting ideologies and interest groups, with the economics of public health caught up in the difficulty of not knowing quite how much weight to give to the pleasure of smoking in such a tangled situation."

Sources of technological change in disease control -- Economic explanations of invention have typically focussed on demand conditions as the source of technological change. With regard to advances in the control of infectious disease, demand may similarly be invoked as the main causal factor. As has been seen, in mid-nineteenth century England the prior slow century-long advance in life expectancy had come largely to a halt as a result of rapid urbanization and industrialization. Health conditions among the poor in urban centers were increasingly recognized as appalling, and epidemic outbreaks of cholera and typhoid aroused concerns generally.[49] These problems contributed to a growing search for solutions.

But while demand increased in the nineteenth century, such demand was not new -- sickness and death have been the eternal bane of humanity. As Nathan Rosenberg points out:

> Many important categories of human wants have long gone either unsatisfied or very badly catered for in spite of a well-established demand. It is certainly true that the progress made in techniques of navigation in the sixteenth and seventeenth centuries owed much to the great demand for such techniques in those centuries, as many authors have pointed out. But it is also true that a great potential demand existed in the same period for improvements in the healing arts generally, but that no such improvements were forthcoming (Rosenberg 1976, pp. 267-268).

That study of the "healing arts" was far from neglected in the sixteenth and seventeenth centuries is suggested by the fact that at Europe's leading universities at that time there were more salaried chairs in medicine than in science (Ben-David, 1984, p. 52).

Rather than demand, the actual sequence of the solutions that were found suggests that it was supply-side developments that governed advances in the control of infectious disease, specifically, changes in the feasibility of invention due to the advance of knowledge. Obviously, the most intense demand comes from those who are sick and is for the cure of disease. As has been seen, however, in the actual sequence of technological developments in the control of infectious disease, the development of cures came last, not first. The first major breakthrough came with regard to the transmission of disease, and reflects the lesser difficulty with which knowledge of transmission can be obtained vis-a-vis developing a cure. Typically, the mode of transmission of a disease is more amenable to observation than its causes, and the development

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[49] Brown 1988, Cain and Rotella 1994, Flinn 1965, Mercer 1990.

of a cure must wait upon identification of the pathogen and physiological mechanisms responsible for a particular disease. This is evidenced today in experience with the newest major infectious disease, HIV, where the modes of transmission were quickly identified and led to measures directed toward control well before effective therapies started to appear. As has been seen, before the nineteenth century, the only major advances in control of fatal infectious diseases were methods of preventing transmission.

Two major developments underlying the early growth of knowledge were the development of vital statistics, dating from the work of Petty and Graunt in the seventeenth century, and new statistical techniques, pioneered by analysts such as William Farr and Adolphe Quetelet in the first half of the nineteenth century.[50] These, together with the slow growth of medical knowledge, laid the basis for epidemiological studies of the type done by Chadwick, Snow, Budd, Villermé, Shattuck, and other analysts of health conditions in the early industrializing countries.[51]

Knowledge of the causes and mechanisms of disease, and their application to the development of systematic immunization and chemotherapy had to wait upon the emergence of microbiology. This, in turn, depended on advances in instrumentation (especially the microscope), development of laboratory research techniques, and the growth of related disciplines such as chemistry, anatomy, and physiology. The sequence in the advance of knowledge -- from epidemiological studies to identification of causes and mechanisms -- is apparent in recent experience, with regard to both HIV and the health effects of smoking. It is this sequence in the development of basic knowledge that principally explains the chronology of advances in the control of major infectious disease, not demand conditions.

V. Economic Growth and Life Expectancy Revisited

This section returns to the causal role of economic growth in life expectancy

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[50] Porter 1986, ch. 1; Briggs 1985, I, ch. 3; Wohl 1983, 144.

[51] Rosen (1958), p. 210 states that "Chadwick saw clearly that accurate statistical information could be exceedingly important in disease prevention."

improvement to consider some additional arguments. (1) Was economic growth necessary to finance public spending on the new technology of disease control, either directly in a given country or indirectly via international aid? (2) Was economic growth needed to finance the research responsible for the advance in knowledge underlying the new techniques of disease control?

Cost requirements of life expectancy improvement -- New government activities of the type required for public health are not costless. Even if economic growth does not foster rapid improvement in life expectancy via its direct effect on living levels, isn't it essential for financing the expanded functions of government? Implementing the new technology of disease control might necessitate an increase in the share of government spending in GDP, much as the technology of economic growth requires a rise in the proportion of GDP devoted to new investment, and economic growth might be necessary to generate the additional tax revenue needed for such spending. Economic growth may not be a sufficient condition for rapid advance in life expectancy, but isn't it a necessary condition?

In considering this proposition, let me immediately concede the obvious. Economic growth makes the expansion of public health programs easier by relaxing the public budget constraint; economic stagnation or decline may lead to the curtailment of already established public health programs, as happened in some Third World countries in the 1980s -- though with smaller adverse effects than one might expect.[52]

But this concession does not make economic growth a necessary condition for life expectancy improvement. The counter-argument -- that it is not -- is based on two considerations.

First, since at least the mid-1950s the cost requirements of major improvement in life expectancy have probably been no more than 2 percent of GDP, even in the poorest countries. This contrasts with the roughly 15 to 20 percent of GDP needed for the capital requirements of

[52] A National Research Council (1993) study found that economic reversals in the 1980s had an impact on child mortality in only two of seven sub-Saharan countries studied.

economic growth. The cost figure for life expectancy here is derived from estimates by public health specialists of the cost of a set of health programs considerably more ambitious than those needed to raise life expectancy per se.[53] The low cost of life expectancy improvement is illustrated dramatically by the experience of China which raised life expectancy from around 40 years in the early 1950s to 60 years by the late 1960s. At the end of this period, China's income level was about three-fourths of the 1820 level in Western Europe, where life expectancy averaged under 40 years.[54]

Second, there are a number of cases of significant improvement in life expectancy in the

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[53] In the early 1990s the cost to a poor country of "a minimum package of public health and clinical interventions, which are highly cost-effective and deal with major sources of disease burden," amounts to about 1.5 percent of the GDP of sub-Saharan Africa in 1992 (Bobadilla et al., 1994, p. 171; Maddison 1995, pp. 116, 192, 221). A 1951 estimate suggests that about the same order of magnitude of expenditure requirements for public health have prevailed since the middle of the twentieth century (Winslow 1951, p. 68). Leading demographic scholars in the late 1950s were impressed with how much could be done in poor countries to reduce mortality at quite low cost (Taeuber 1962, p. 4; Thompson, 1959, p. 28).

[54] According to Drèze and Sen (1989, p. 251), China was allocating an estimated 2 percent of GDP to health spending during this period of rapid improvement in life expectancy.

absence of marked economic growth. In sub-Saharan Africa, despite an epidemic outbreak of AIDS, life expectancy increased from 46 to 53 years between 1970-75 and 1990-95, while per capita income declined on the order of ten percent (Figures III-3 and III-4; cf. also Sen 1994). In the first half of the twentieth century several colonial powers introduced public health programs in some of their colonies that significantly improved life expectancy generally, even though there was little income growth among the bulk of the population.[55]

> These considerations suggest that economic growth is not a necessary condition for improved life expectancy -- that public programs can achieve substantial improvements in life expectancy at very low income levels and in the absence of economic growth. A recent World Bank publication, entitled <u>Public and Private Roles in Health</u>, says as much: There is a small but extremely important collection of health-related activities <u>which must be financed by the state</u> if they are to be provided at all, or provided at the socially optimum level of consumption. These interventions appear to account for much of the impact of health spending on health improvements. They probably explain why public health expenditure is somewhat more effective than private expenditure in extending life expectancy (Musgrove 1996, p. 2, emphasis added; cf. also World Health Organization 1991).

After comparing recent experience in developing countries with regard to mortality reduction and economic growth, Sen (1994, p. 315) concludes that “economic growth can certainly help reduce mortality ..., but that help is not invariably utilized, and it is not the only possible route.”

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[55] Cf. Barclay 1954 on Taiwan; Diaz-Briquets 1981, 1983 on Cuba; Kimura 1993 on Korea; Mandle 1970,1973 on Guyana; and Meegama 1981 on Sri Lanka. Other frequently cited cases of sizeable life expectancy improvement with little or no economic growth are Costa Rica from 1920 to 1950, Chile between 1960-65 and 1980-85, and the post World War II experience of the Indian state of Kerala (Mata and Rosero, 1988; Behm and Soto 1991; Castaneda 1985, 1992, ch. 3). The experience of a number of these places is reviewed in the proceedings of a 1985 conference on “good health at low cost” sponsored by the Rockefeller Foundation (Halstead, Walsh, and Warren 1985; see also Caldwell 1986).

Put somewhat differently, income growth without appropriate public policies does not substantially reduce mortality, while appropriate public policies without income growth, can.

Economic growth and international aid -- Is it possible that economic growth in the developed world played a key role in financing the health expenditures of the Third World via international aid, and that by this route economic growth lay behind the improvement in life expectancy? The answer is that most less developed countries (LDC's) have very substantially funded their own health expenditures. A study published in 1980 concluded that "total external health aid received by LDC's is less than 3% of their total health expenditures (Preston 1980, p. 315). A corresponding estimate for 1990 put health aid at less than 2 percent of health expenditures (Michaud and Murray 1994, table 10). While the flow of technical know-how to the Third World was essential, the material resource requirements for such a flow were small and for most countries did not rest on economic growth either at home or abroad.[56] Indeed, a sizeable share of public health spending in most developing countries has been on things like new high-cost hospital technologies that would have had relatively little impact on overall life expectancy.[57]

Economic growth and the advance of biomedical knowledge -- Scientific research requires resources. Was economic growth needed to finance the discoveries that lay behind the technological breakthroughs in the control of infectious disease? Certainly the location and timing of these discoveries -- in northwestern Europe starting in the mid-nineteenth century -- are generally consistent with the idea that economic growth was necessary.

Yet, if one thinks of the first great discoveries of modern science -- in astronomy and

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[56] External aid in 1990 was most important in sub-Saharan Africa, amounting overall to an estimated 10 percent of health spending; for 20 of 45 countries, external aid was more than 30 percent of health spending (Michaud and Murray 1994, table 15).

[57] Cf. Piachaud (1979) who suggests that there has been a serious misallocation of public health spending in the developing world. Roth (1987, 128) estimates that at most 30 percent of health spending in developing countries is for the preventive measures that have been so important in reducing infectious disease (cf. also Drèze and Sen 1989, p. 251; Musgrove 1996, p. 44; De Ferranti 1985, p. 61).

mechanics, "the Newtonian Revolution" -- these clearly antedated the period of modern economic growth and did not require the enormous resources generated by such growth. The roots of these discoveries go back to earlier intellectual undertakings that were supported by the societies of the Middle Ages (Lindberg 1992). That medical inquiry was not neglected is evidenced by the statistic cited earlier -- in the sixteenth and seventeenth centuries the number of university chairs in medicine exceeded those in science.

Indeed, prior to the last half century the resources required for funding science have been small. In 1929 research and development spending in the United States -- the country that was undoubtedly the leader at that time -- was 0.2 percent of GDP (OECD 1968). This includes spending by profit and nonprofit organizations for <u>both</u> basic and applied research and development in <u>all</u> fields of science. Clearly biomedical research would be a much smaller fraction. When one looks at the rudimentary laboratories of scientists like Pasteur, Koch, and Fleming, it is hard to believe they involved requirements that much exceeded those of their predecessors two centuries earlier. What was different was the knowledge that they could bring to bear -- that of optics embodied in the microscope; of chemistry, reflected in the methods and materials with which they worked; of prior epidemiological research based on new statistical data and techniques; and of new knowledge in subjects such as physiology and anatomy. The history of science suggests that it was primarily the internal evolution of knowledge, not the resources provided by economic growth, that was responsible for the great discoveries leading to the control of infectious disease.[58]

VI. Conclusions

Let me summarize some of the impressions from this look at the modern history of mortality. The improvement of life expectancy, like economic growth, has been based on a new

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[58] Dependence of biomedical research on the resources generated by economic growth may have increased since the mid-twentieth century in the developed countries with the shift in the disease environment to noninfectious diseases. A similar shift as regards the production technology underlying economic growth is suggested by Rosenberg 1997.

technology involving new institutional, capital, and labor requirements. But for life expectancy, the nature of the new technology and associated requirements is quite different from those for economic growth. The technology comprises new methods of controlling major infectious disease. The institutional requirements center on the establishment of a public health system. The capital requirements involve new public expenditures, and the labor requirements are for the bearers of the new technology -- specialized personnel in the fields of public health and medicine, and homemakers educated in personal hygiene and household sanitation.

The point of departure for understanding the vast worldwide improvement in life expectancy in the last century and a half must be the abysmal state of knowledge that prevailed throughout the world at the start of this period, and still exists today in many places. The causes of the major infectious diseases were not known, and almost nothing was known about the way in which these diseases are transmitted. In the absence of valid knowledge of the "health production function," resources allocated to the prevention or cure of disease were probably totally ineffective. These differences in knowledge persist to the present day, both among and within developing countries, and obviously call into question cross-sectional analyses that assume a uniform state of knowledge everywhere.

The phenomenon of modern economic growth burst on the world scene at the end of the eighteenth century. Because of its favorable impact on living levels, one might have expected resistance to disease to have grown and life expectancy to have been raised in the areas undergoing economic growth, even though health knowledge remained negligible and health practices of questionable value. But this reasoning regarding the effect of economic growth on life expectancy is incomplete, for it fails to take account of the agglomeration requirements of the new methods of production on which economic growth was based. The rapidly rising concentration of population in urban centers sharply increased exposure to disease, and largely vitiated any effect of increased resistance.

Only with the growth, first, of epidemiological and, then, bacterial knowledge did effective techniques emerge for controlling infectious disease. These techniques focussed primarily on the prevention of the spread of disease -- first via controlling the mode of transmission, and subsequently via immunization. It is these methods of prevention that have been chiefly responsible for the great improvement in life expectancy throughout the world. In the last half century the advance of knowledge has also added methods of curing disease to the arsenal available to fight infectious disease, particularly with the development of antibiotics, but the great bulk of the reduction in infectious disease has been accomplished largely by preventive methods.

As is recognized in the health literature, the control of infectious disease involves serious issues of market failure -- information failures, externalities, public goods, principal-agent problems, and so forth. The market cannot be counted on for such things as the provision of pure water and milk, the proper disposal of sewage, control of pests such as mosquitos and rats, the supply of uncontaminated food and other manufactured products, immunization of children and adults against major infectious diseases, and the dissemination of new knowledge regarding personal hygiene, infant and child care, food handling and preparation, care of the sick, and the like. Moreover, those most vulnerable to infectious disease -- the poor, children, and elderly -- have typically had a disproportionately small voice in market decisions. There is also a serious market failure problem with regard to the distribution of antimicrobials because of externalities associated with the development of disease-resistant bacteria.

The title of this article posed the question, how beneficient is the market? The ubiquity of market failure in the control of major infectious disease supplies the answer: if improvement of life expectancy is one's concern, the market cannot do the job. Because of market failure, public intervention has been essential to achieve a major reduction of mortality of the type experienced in the last century.

Implementation of the new techniques of disease control has required the development of new institutions, centering on the public health system. The functions of this system have included in varying degrees health education, regulation, compulsion, and the financing or direct provision of services. The establishment of a public health system has required acceptance of social responsibility for the control of major infectious disease. This shift in norms came about as the advance of biomedical knowledge increasingly pointed to factors beyond individual control as the primary source of disease, in much the same way that progress in economics in the twentieth century has led to increased acceptance of social responsibility for unemployment. In time, intervention in the interest of public health came to be seen as positive and necessary, not simply as a residual function, doing "what the market can't or won't do" (Institute of Medicine, 1988, p. 46).

The cost requirements of the new technology of disease control are much less than those of economic growth -- in the last half century, probably less than two percent of GDP in poor countries. Absent a public health system to implement the new technology of disease control, income growth associated with economic development probably has at best a small positive impact on life expectancy. Given a public health system, life expectancy can be raised substantially without economic growth. Economic growth can make the improvement of life expectancy more feasible by facilitating the financing of public interventions, but to suggest that economic growth will raise life expectancy without reference to the critical role of public sector intervention is seriously misleading. There is an essential set of governmental decisions that are not mechanically triggered by rising per capita income. Caldwell (1986, p. 210) makes the point quite simply: "[L]ow mortality for all will not come as an unplanned spinoff from economic growth."

Nor does it seem that economic growth has been indirectly responsible for life expectancy improvement by providing financing for public spending via international aid to developing countries. Such aid has been a small proportion of public health spending in developing countries, and, in fact, a sizeable share of such spending in these countries has gone to relatively low productivity expenditures on urban hospitals using developed countries' technology. It is doubtful, too, that economic growth was needed to fund the advances in biomedical knowledge underlying the breakthroughs in controlling infectious disease. The resource requirements for the research underlying the discoveries leading to the control of fatal infectious disease were small -- perhaps not much more than those invested in inquiries into the "healing arts" prior to the era of modern economic growth.

None of this is to say that the situation with regard to public sector intervention for the control of infectious disease has been, or is, optimal. Mention has just been made of the low productivity nature of much public health spending in developing countries (which is why correlations of total public health spending with mortality are frequently poor). The fact that life expectancy has been raised so much almost everywhere is testimony to the fact that a relatively few low cost interventions have been highly productive. But the solution to inefficiency in the public sector is not necessarily to turn things over to the market. What is needed is careful assessment of the cost-effectiveness of different policy interventions and attention to their political feasibility and compatability with existing health knowledge and beliefs.[59] In such work the market may be found to have a contributing role. But the assumption that the market, in solving the problem of economic growth, will solve that of human development is belied by the lessons of experience. Rather than a story of the success of free market institutions, the history of mortality is testimony to the critical need for collective action.

[59] Cost effectiveness concerns are prominent in the research of public health specialists on developing countries. Cf. Chen, Kleinman, and Ware, 1994; Feachem, Graham, and Timaeus, 1989; Feachem and Jamison 1991; Jamison, Mosley, Measham, and Bobadilla, 1993. On political aspects, see Nathanson 1996, Reuschemeyer and Skocpol 1996, Szreter 1997; on cultural beliefs, see note 15 above.

References and Bibliography

Abel-Smith, Brian, 1960. A History of the Nursing Profession. London: Heinemann.

Abel-Smith, Brian, 1964. The Hospitals, 1880-1948: A Study in Social Administration in England and Wales. Cambridge, MA: Harvard University Press.

Ackerknecht, Erwin H., 1968. A Short History of Medicine. New York: The Ronald Press Company, revised printing, 1955.

American Economic Review, 1994. Session on Human Development, 84:2 (May), 232-249.

Anand, Sudhir and Amartya Sen, 1994. "Sustainable Human Development: Concepts and Priorities," Occasional Paper No. 8. New York: United Nations Development Program, Human Development Report Office.

Arriaga, Eduardo E. and Kingsley Davis, 1969. "The Pattern of Mortality Change in Latin America," Demography 6:3 (August), 223-242.

Arrow, Kenneth J., 1963. "Uncertainty and the Welfare Economics of Medical Care," The American Economic Review, LIII:5 (December), 941-973.

Auster, Richard, Irving Leveson, and Deborah Sarachek, 1969. "The Production of Health, An Exploratory Study," The Journal of Human Resources, IV:4 (Fall), 411-436.

Baldry, Peter, 1976. The Battle Against Bacteria, Cambridge: Cambridge University Press.

Barclay, George W., 1954. Colonial Development and Population in Taiwan, Princeton, NJ: Princeton University Press.

Barr, Nicholas, 1992. "Economic Theory and the Welfare State: A Survey and Interpretation," Journal of Economic Literature, XXX (June), 741-803.

Beeson, Paul B., 1980. "Changes in Medical Therapy During the Past Half Century," Medicine, 59:2, 79-99.

Behm, Hugo and Arodys Robles Soto, 1991. "Costa Rica" in United Nations, Child Mortality in Developing Countries. New York: United Nations.

Behrman, Jere R. and Anil B. Deolalikar, 1988. "Health and Nutrition," in H. Chenery and T.N. Srinivasan (eds.), Handbook of Development Economics Vol. I, Elsevier Science Publishers, 633-711.

Ben-David, Joseph, 1984. The Scientist's Role in Society, Chicago: University of Chicago Press.

Bengtsson, Tommy, 1997. "Economic Insecurity and Adult Mortality in Rural Sweden 1760-1895," paper prepared for the pre-conference of the A theme Population and the Economy: >From Hunger to Modern Economic Growth at the 12th Intern. Economic History Congress Seville (Spain) in 1998, held in Toyonaka City, Japan, January 7-10.

Bengtsson, Tommy, Gunnar Fridlizius, and Rolf Ohlsson (eds.), 1984. Pre-Industrial Population Change. Stockholm, Sweden: Almquist and Wiksell International.

Bhargava, Alok (ed.), 1997. "Analysis of Data on Health," Journal of Econometrics, special issue, 77:1, 1-296.

Bhuyia, Abbas, Kim Streatfield, and Paul Meyer, 1990. "Mother's Hygienic Awareness, Behavior, and Knowledge of Major Diseases in Matlab, Bangladesh," in Caldwell, John, Sally Findley, Pat Caldwell, Gigi Santow, Wendy Cosford, Jennifer Braid and Daphne Broers-Freeman (eds.). What We Know About the HealthTransition: The Cultural, Social, and Behavioral Determinants of Health, Proceedings of an International Workshop, Canberra, Australia May 1989. Canberra, Australia: Health Transition Centre, Australian National

University, vol. 1, 462-477.

Biraben, J.N., 1991. “Pasteur, Pasteurization, and Medicine,” in R. Schofield, D. Reher, and A. Bideau (eds.), The Decline of Mortality in Europe, Oxford: Clarendon Press.

Bobadilla, José Luis, Julio Frenk, Rafael Lozano, Tomas Frejka, and Claudio Stern, 1993. “The Epidemiologic Transition and Health Priorities,” in Jamison, Dean T., W. Henry Mosley, Anthony R. Measham, and José Luis Bobadilla (eds.), Disease Control Priorities in Developing Countries, Oxford: Oxford University Press, 51-63.

Bobadilla, J.-L., P. Cowley, P. Musgrove, and H. Saxenian, 1994. “Design, Content and Financing of an Essential National Package of Health Services,” Bulletin of the World Health Organization, 72:4, 653-662.

Boerma, J. Ties and George Stroh, 1993. “Using Survey Data to Assess Neonetal Tetanus Mortality Levels and Trends in Developing Countries,” Demography 30:3 (August), 459-475.

Böttcher, Helmuth, 1964. Wonder Drugs: A History of Antibiotics. Philadelphia: J.B. Lippincott Company.

Briggs, Asa, 1985. The Collected Essays of Asa Briggs 2 vols. Urbana and Chicago: The University of Illinois Press.

Brown, John C., 1988. “Coping with Crisis? The Diffusion of Waterworks in Late Nineteenth-Century German Towns,” The Journal of Economic History XLVIII:2 (June), 307-318.

Brown, John C., 1995. “Private Demands for Public Health: Household Choice and Mortality Decline ca. 1900,” Working Paper #95-4, Department of Economics, Clark University, Worcester, MA.

Brown, John C., n.d. “Public Health Reform and the Decline in Urban Mortality: The Case of Germany, 1876-1912,” unpublished paper.

Brumfitt, W. and J.M.T. Hamilton-Miller, 1988. “The Changing Face of Chemotherapy,” Postgraduate Medical Journal 64, 552-558.

Bulatao, Rodolfo A., 1993. “Mortality by Cause, 1970 to 2015,” in James N.Gribble and Samuel H. Preston (eds.), The Epidemiological Transition, Washington, D.C.: National Academy Press.

Cain, Louis P., 1977. “An Economic History of Urban Location and Sanitation,” Research in Economic History 2, 337-389.

Cain, Louis P. and Elyce J. Rotella, 1990. “Urbanization, Sanitation, and Mortality in the Progressive Era, 1899-1929,” Chicago: Loyola University.

Cain, Louis P. and Elyce J. Rotella, 1994. “Death and Spending: Did Urban Mortality Shocks Lead to Municipal Expenditure Increases?” Presented at the Eleventh International Economic History Conference, Universita Bocconi, Milan, Italy.

Cairncross, Sandy, 1989. “Water Supply and Sanitation: An Agenda for Research,” Journal of Tropical Medicine and Hygiene 92, 301-314.

Caldwell, John C., 1986. “Routes to Low Mortality in Poor Countries,” Population and Development Review 12:2 (June), 171-220.

Caldwell, John, Sally Findley, Pat Caldwell, Gigi Santow, Wendy Cosford, Jennifer Braid and Daphne Broers-Freeman (eds.), 1990. What We Know About the HealthTransition: The Cultural, Social, and Behavioral Determinants of Health, 2 vols., Proceedings of an International Workshop, Canberra, Australia May 1989. Canberra, Australia: Health Transition Centre, Australian National University.

Castañeda, Tarsicio, 1985. “Determinantes del Descenso de la Mortalidad Infantil en Chile: 1975-1982,” Cuadernos de Economía 22:66 (Agosto), 195-214.

Castañeda, Tarsicio, 1992. Combating Poverty, San Francisco: ICS Press.

Chadwick, Edwin, 1842 (1965). The Sanitary Condition of the Labouring Population of Gt. Britain, edited by M.W. Flinn. Edinburgh: Edinburgh University Press.

Chain, Ernst B., 1963. "Academic and Industrial Contributions to Drug Research," Nature Supplement, 200:4905, 441-451.

Chen, Lincoln C., Arthur Kleinman, and Norma C. Ware (eds.), 1994. Health and Social Change in International Perspective, Cambridge, MA: Harvard University Press.

Chetley, Andrew, 1990. A Healthy Business? World Health and the Pharmaceutical Industry. London: Zed Books Ltd.

Citizens' Association of New York, 1866. Report of the Council of Hygiene and Public Health of the Citizens' Association of New York, Upon the Sanitary Condition of the City, 2nd ed., New York: D. Appleton and Company.

Cleland, J.G. and J.K. van Ginneken, 1988. "Maternal Education and Child Survival in Developing Countries: The Search for Pathways of Influence," Soc. Sci.Med., 27, 1357-1368.

Commission on Health Research for Development, 1990. Health Research, Essential Link to Equity in Development, Oxford: Oxford University Press.

Condran, Gretchen A. and Eileen M. Crimmins-Gardner, 1978. "Public Health Measures and Mortality in U.S. Cities in the Late Nineteenth Century," Human Ecology, 6 (March), 27-54.

Condran, Gretchen A., Henry Williams and Rose A. Cheney, 1984. "The Decline in Mortality in Philadelphia from 1870 to 1930: The Role of Municipal Services," The Pennsylvania Magazine of History and Biography, Medical Philadelphia Issue, Philadelphia: Historical Society of Pennsylvania, 108, 153-177.

Crimmins, Eileen M., Yasuhiko Saito, and Dominique Ingegneri, 1997. "Trends in Disability-Free Life Expectancy in the United States, 1970-90," Population and Development Review 23:3 (September), 555-572.

Curtin, Philip D., 1989. Death by Migration: Europe's Encounter with the Tropical World in the Nineteenth Century. Cambridge: Cambridge University Press.

Cutts, F.T., L.C. Rodrigues, S. Colombo, and S. Bennett, 1989. "Evaluation of Factors Influencing Vaccine Uptake in Mozambique," International Journal of Epidemiology, 18:2, 427-433.

De Ferranti, David, 1985. Paying for Health Services in Developing Countries: An Overview. World Bank Staff Working Paper 721, Washington, D.C.

Diaz-Briquets, Sergio, 1981. "Determinants of Mortality Transition in Developing Countries Before and After the Second World War: Some Evidence from Cuba," Population Studies 35:3 (November), 399-411.

Diaz-Briquets, Sergio, 1983. The Health Revolution in Cuba, Austin: University of Texas Press.

Dixon, Bernard, 1978. Beyond the Magic Bullet, New York: Harper & Row.

Doan, Bui-Dang-Ha, 1974. "World Trends in Medical Manpower, 1950-1970," in World Health Organization, World Health Statistics Report 27:2, 84-108.

Drèze, Jean and Amartya Sen, 1989. Hunger and Public Action, Oxford: Clarendon Press.

Drummond, J.C. and Anne Wilbraham, 1939. The Englishman's Food, London: Jonathan Cape.

Duffy, John, 1992. The Sanitarians, Urbana and Chicago: University of Illinois Press.

Engerman, Stanley L., 1997. "The Standard of Living Debate in International Perspective: Measures and Indicators," in Steckel, Richard H. and Roderick Floud (eds.), Health and Welfare During Industrialization. Chicago: University of Chicago Press, 17-45.

Esrey, S.A., J.B. Potash, L.Roberts, and C. Shiff, 1991. "Effects of Improved Water Supply and Sanitation on Ascariasis, Diarrhoea, Dracunculiasis, Hookworm Infection, Schistosomiasis, and Trachoma," Bulletinof the World Health Organization 69:5, 609-621.

Evans, Richard J., 1987. Death in Hamburg, Oxford: Clarendon Press.

Feachem, Richard G. and Dean T. Jamison, 1991. Disease and Mortality in Sub-Saharan Africa. New York: Oxford University Press.

Feachem, Richard G., Wendy J. Graham and Ian M. Timæus, 1989. "Identifying Health Problems and Health Research Priorities in Developing Countries," Journal of Tropical Medicine and Hygiene 92, 133-191.

Feachem, Richard G.A., Tord Kjellstrom, Christopher J.L. Murray, Mead Over, and Margaret A. Phillips (eds.), 1992. The Health of Adults in the Developing World. Oxford: Oxford University Press for the World Bank.

Fenner, F., D.A. Henderson, and I. Arita, 1988. Smallpox and Its Eradication. Geneva: World Health Organization.

Flinn, M.W., 1965. "Introduction," in E.M. Chadwick, Report on the Sanitary Condition of the Labouring Population of Great Britain. Edinburgh: Edinburgh University Press.

Fogel, Robert William, 1986. "Nutrition and the Decline in Mortality since 1700: Some Preliminary Findings," in Stanley L. Engerman and Robert E. Gallman (eds.), Long-Term Factors in American Economic Growth, Chicago: University of Chicago Press.

Fogel, Robert W., 1991. "The Conquest of High Mortality and Hunger in Europe and America: Timing and Mechanisms," in Patrice Higonnet, David S. Landes, and Henry Rosovsky (eds.), Favorites of Fortune, Technology, Growth, and Economic Development since the Industrial Revolution, Cambridge: Harvard University Press.

Fogel, Robert W., 1993. "New Sources and New Techniques for the Study of Secular Trends in Nutritional Status, Health, Mortality, and the Process of Aging." Historical Methods 26:1 (Winter), 5-43.

Fogel, Robert W., 1994. "Economic Growth, Population Theory, and Physiology: The Bearing of Long-Term Processes on the Making of Economic Policy," American Economic Review 84:3 (June), 369-395.

Fogel, Robert W., et al., 1983. "Secular Changes in American and British Stature and Nutrition," in Robert I. Rotberg and Theodore K. Rabb (eds.), Hunger and History, Cambridge: Cambridge University Press, 247-283.

Fridlizius, Gunnar, 1984. "The Mortality Decline in the First Phase of the Demographic Transition: Swedish Experiences," in Bengtsson, Tommy, Gunnar Fridlizius, and Rolf Ohlsson (eds.), Pre-Industrial Population Change. Stockholm, Sweden: Almquist and Wiksell International.

Fuchs, Victor, 1987. "Health Economics," in Eatwell, John, Murray Milgate, and Peter Newman (eds.), The New Palgrave: A Dictionary of Economics, New York: The Stockton Press, 2, 614-618.

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

Gallman, Robert E., 1996. "Dietary Change in Antebellum America," The Journal of Economic History 56:1 (March), 193-201.

Gariepy, Thomas P., 1994. "The Introduction and Acceptance of Listerian Antisepsis in the United States," The Journal of the History of Medicine and Allied Sciences, 49, 167-206.

Gilliand, Pierre and René Galland, 1977. "Outline on International Comparison of Public Health, Based on Data Collected by the World Health Organization," World Health Statistics Report 30:2, 227-242.

Goldin, Claudia, 1995. "Cliometrics and the Nobel," Journal of Economic Perspectives, 9:2 (Spring), 191-208.

Goubert, Jean-Pierre, 1989. The Conquest of Water. Translated by Andrew Wilson. Cambridge: Polity Press.

Gray, R.H., 1974. "The Decline of Mortality in Ceylon and the Demographic Effects of Malaria Control," Population Studies 28:2 (July), 205-229.

Gribble, James N. and Samuel H. Preston, (eds.), 1993. The Epidemiological Transition, Washington, D.C.: National Academy Press.

Griscom, John H., 1845 (1970). The Sanitary Condition of the Laboring Class of New York, NY: Arno & The New York Times. Originally published 1845, New York: Harper & Brothers.

Haines, Anna J., 1933. "Nursing," in Edwin R.A. Seligman (ed.), Encyclopaedia of the Social Sciences.Vol. 11, New York: Macmillan Co.

Haines, Michael R., Roger C. Avery, and Michael A. Strong, 1983. "Differentials in Infant and Child Mortality and Their Change Over Time: Guatemala, 1959-1973," Demography 20:4 (November), 607-621.

Hall, A. Rupert, 1967. "Scientific Method and the Progress of Techniques," in Rich, E.E. and C.H. Wilson, The Cambridge Economic History of Europe Vol. IV, Cambridge: Cambridge University Press, 96-154.

Halstead, Scott B., Julia A. Walsh and Kenneth S. Warren, 1985. Good Health at Low Cost, Proceedings of conference held at Bellagio Conference Center, Bellagio, Italy. New York: The Rockeller Foundation..

Hanlon, John J., Fred B. Rogers, and George Rosen, 1960. "A Bookshelf on the History and Philosophy of Public Health," Journal of Public Health 50:4 (April), 445-458.

Hanlon, P. P. Byass, M. Yamuah, R. Hayes, S. Bennett and B.H. M'Boge, 1988. "Factors Influencing Vaccination Compliance in Peri-Urban Gambian Children," Journal of Tropical Medicine and Hygiene, 91, 29-33.

Higgs, Robert, 1979. "Cycles and Trends of Mortality in 18 Large American Cities, 1871-1900," Explorations in Economic History 16, 381-408.

Hobcraft, John, 1993. "Women's Education, Child Welfare and Child Survival: A Review of the Evidence," Health Transition Review 3:2, 159-175..

Hohenberg, Paul M. and Lynn Hollen Lees, 1985. The Making of Urban Europe 1000-1950, Cambridge: Harvard University Press.

Hudson, Robert P., 1983. Disease and Its Control. Westport, CT: Greenwood Press.

Institute of Medicine, Division of Health Care Services, Committee for the Study of the Future of Public Health, 1988. The Future of Public Health, Washington, D.C.: National Academy Press.

Jamison, Dean T., W. Henry Mosley, Anthony R. Measham, and José-Luis Bobadilla (eds.), 1993. Disease Control Priorities in Developing Countries. New York: Oxford University Press.

Jannetta, Ann Bowman and Samuel H. Preston, 1991. "Two Centuries of Mortality Change in Central Japan: The Evidence from a Temple Death Register," Population Studies 45, 417-436.

Jejeebhoy, Shireen J., 1995. Women's Education, Autonomy, and Reproductive Behaviour: Experience from Developing Countries. Oxford: Clarendon Press.

Johansson, S. Ryan, 1994. "Food for Thought, Rhetoric and Reality in Modern Mortality History," Historical Methods 27:3 (Summer), 101-125.

Johansson, S. Ryan and Carl Mosk, 1987. "Exposure, Resistance and Life Expectancy:

Disease and Death During the Economic Development of Japan, 1900-1960," Population Studies 41, 207-235.

Kearns, Gerry, 1988. "Private Property and Public Health Reform in England 1830-70," Soc. Sci. Med., 26, 187-199.

Keyfitz, N. and W. Flieger, 1968. World Population. Chicago: University of Chicago Press.

Kimura, M., 1993. "Standards of Living in Colonial Korea: Did the Masses Become Worse Off or Better Off Under Japanese Rule?" Journal of Economic History 53, 629-652.

Kuznets, Simon, 1966. Modern Economic Growth: Rate, Structure, and Spread. New Haven: Yale University Press.

Landy, David (ed.), 1977. Culture, Disease, and Healing. New York: Macmillan Publishing Co. Inc.

Lappé, Marc, 1982. Germs That Won't Die: Medical Consequences of the Misuse of Antibiotics, New York: Anchor Press/Doubleday.

Lindberg, David C., 1992. The Beginnings of Western Science. Chicago: University of Chicago Press.

Lindert, Peter H., 1986. "Comment on Robert William Fogel, 'Nutrition and the Decline in Mortality since 1700: Some Preliminary Findings,'" in Stanley L. Engerman and Robert E. Gallman (eds.), Long-Term Factors in American Economic Growth, Chicago: University of Chicago Press.

Lunn, Peter G., 1991. "Nutrition, Immunity, and Infection," in Schofield, R. and D. Reher, The Decline of Mortality in Europe, Oxford: Clarendon Press, 131-145.

Maddison, Angus, 1995. Monitoring the World Economy 1820-1992, Paris: Development Centre of the Organisation for Economic Co-operation and Development.

Mandle, Jay R., 1973. The Plantation Economy. Philadelphia: Temple University Press.

Marcus, Alan I., 1979. "Disease Prevention in America: From a Local to a National Outlook, 1880-1910," Bulletin of the History of Medicine, 53:2 (Summer).

Mata, Leonardo and Luis Rosero, 1988. National Health and Social Development in Costa Rica: A Case Study of Intersectoral Action, Technical Paper No. 13, Washington, D.C.: World Health Organization, Pan American Health Organization.

Mayhew, Henry, 1851 (1958). Mayhew's London. London: Spring Books.

McKeown, T., 1976. The Modern Rise of Population, London.

Meegama, Srinivasa A., 1981. "The Decline in Mortality in Sri Lanka in Historical Perspective," in International Union for the Scientific Study of Population, International Population Conference, Manila, 1981, Liege, Belgium: IUSSP.

Meeker, E., 1970. "The Economics of Improving Health, 1850-1915," Ph.D. dissertation, University of Washington.

Mercer, Alex, 1990. Disease, Mortality and Population in Transition, Leicester: Leicester University Press.

Michaud, Catherine and Christopher JL Murray, 1994. Aid Flows to the Health Sector in Developing Countries. Background Paper No. 11. Washington, D.C.: The World Bank.

Mokyr, Joel, 1993. "Mortality, Technology, and Economic Growth, 1750-1914: A Suggested Reinterpretation." Northwestern University, Evanston, Ill. Unpublished.

Mokyr, Joel, 1996. "Technological Selection, Information, and Changing Household Behavior, 1850-1914." Northwestern University, Evanston, Ill. Unpublished.

Mokyr, Joel and Cormac Ó Gráda, 1996. "Height and Health in the United Kingdom 1815-1860: Evidence from theEast India Company Army," Explorations in Economic History 33, 141-168.

Mokyr, Joel and Rebecca Stein, 1997. "Science, Health, and Household Technology: The Effect of the Pasteur Revolution on Consumer Demand," in Timothy F. Bresnahan and Robert J. Gordon (eds.), The Economics of New Goods. Chicago: University of Chicago Press, 143-200.

Mosk, Carl and S. Ryan Johansson, 1986. "Income and Mortality: Evidence from Modern Japan," Population and Development Review 12:3, 415-440.

Mosley, W. Henry and Lincoln C. Chen (eds.), 1984. "Child Survival: Strategies for Research," Population and Development Review 10, Special Supplement.

Muller, Mike, 1982. The Health of Nations. London: Faber and Faber.

Murray, Christopher J.L. and Alan D. Lopez, 1994. "The Global Burden of Disease in 1990," Background Paper Number 12 for the World Development Report1993: Investing in Health, (February), The World Bank.

Musgrove, Philip, 1996. Public and Private Roles in Health, World Bank Discussion Paper No. 339. Washington, D.C.: The World Bank.

Nathanson, Constance A., 1996. "Disease Prevention as Social Change: Toward a Theory of Public Health," Population and Development Review 22:4 (December), 609-637.

National Research Council, 1993. Demographic Effects of Economic Reversals in sub-Saharan Africa. Washington, D.C.: National Research Council, Committee on Population.

Nelson, Richard R., 1973. "Recent Exercises in Growth Accounting: New Understanding or Dead End?" American Economic Review, 63 (June), 462-468.

North, Douglass C., 1990. Institutions, Institutional Change and Economic Performance, Cambridge: Cambridge University Press.

Organization for Economic Co-operation and Development, 1968. Reviews of National Science Policy, United States, Paris: Organization for Economic Co-operation and Development.

Omran, Abdel R., 1971. "The Epidemiologic Transition: A Theory of the Epidemiology of Population Change," The Milbank Memorial Fund Quarterly, XLIX:4 Part 1 (October), 509-538.

Parish, H.J., 1965. A History of Immunization, Edinburgh: E. & S. Livingstone.

Paul, Benjamin D. (ed.), 1955. Health, Culture and Community. New York: Russell Sage Foundation.

Pebley, Anne, Elena Hurtado, and Noreen Goldman, 1996. "Beliefs About Children's Illness Among Rural Guatemalan Women," Labor and Population Program, Working Paper Series 96-11, Santa Monica, CA: Rand Corporation.

Perrenoud, A., 1991. "The Attenuation of Mortality Crises and the Decline of Mortality," in R. Schofield, D. Reher, and A. Bideau (eds.), The Decline of Mortality in Europe, 18-37. Oxford: Clarendon Press.

Phelps, Charles E., 1992. Health Economics. New York: Harper Collins.

Piachaud, David, 1979. "The Diffusion of Medical Techniques to Less Developed Countries," International Journal of Health Services 9:4, 629-643.

Plotkin, Stanley A. and Edward A. Mortimer Jr., 1988. Vaccines. Philadelphia: W.B. Saunders Company.

Porter, Theodore M., 1986. The Rise of Statistical Thinking 1820-1900. Princeton: Princeton University Press.

Preston, Samuel H., 1975. "The Changing Relation Between Mortality and Level of Economic Development," Population Studies 29, 213-248.

Preston, Samuel H., 1980. "Causes and Consequences of Mortality Declines in Less Developed Countries in the Twentieth Century," in R.A. Easterlin (ed.), Population and Economic Change in Developing Countries, Chicago: University of Chicago Press, 289-341.

Preston, Samuel H., 1993. "Health Indices as a Guide to Health Sector Planning: A

Demographic Critique." in James N. Gribble and Samuel H. Preston (eds.), The Epidemiological Transition, Washington, D.C.: National Academy Press.

Preston, Samuel H., 1996. "American Longevity: Past, Present, and Future," Policy Brief #7, Syracuse, NY: Center for Policy Research, Syracuse University.

Preston, Samuel H. and Michael R. Haines, 1991. Fatal Years: Child Mortality in Late Nineteenth-Century America, Princeton: Princeton University Press.

Preston, Samuel H., Michael R. Haines, and Elsie Pamuk, 1981. "Effects of Industrialization and Urbanization on Mortality in Developed Countries," in International Union for the Scientific Study of Population, International Population Conference Manila 1981, Liege, Belgium: IUSSP.

Preston, Samuel H. and E. Van de Walle, 1978. "Urban French Mortality in the Nineteenth Century." Population Studies 32, 275-297.

Pritchett, Lant and Lawrence H. Summers, 1996. "Wealthier is Healthier," Journal of Human Resources XXXI:4, 841-868.

Prost, André and Michel Jancloes, 1993. "Rationales for Choice in Public Health: The Role of Epidemiology," Appendix D in Jamison, Dean T., W. Henry Mosley, Anthony R. Measham, and José Luis Bobadilla (eds.), Disease Control Priorities in Developing Countries, Oxford: Oxford University Press, 741-746.

Reuschemeyer, Dietrich and Theda Skocpol (eds.), 1996. States, Social Knowledge, and the Origins of Modern Social Policies. New York: Russell Sage Foundation.

Rodrik, Dani, 1996. "Understanding Economic Policy Reform," Journal of Economic Literature, XXXIV (March), 9-41.

Roemer, Milton I., 1991. National Health Systems of the World, Vol. 1, The Countries. New York: Oxford University Press.

Roemer, Milton I., 1993. National Health Systems of the World, Vol. 2, The Issues. New York: Oxford University Press.

Rogers, Naomi, 1989. "Germs with Legs: Flies, Disease, and the New Public Health," Bull. Hist. Med., 63:4 (Winter), 599-617.

Rosen, George, 1958. A History of Public Health, New York: MD Publications Inc.

Rosen, George, 1968. "Public Health," in International Encyclopedia of the Social Sciences, Vol. 13, New York: Macmillan, 164-170.

Rosenberg, Charles E., 1979. "The Therapeutic Revolution: Medicine, Meaning, and Social Change in Nineteenth-Century America," in Vogel, Morris J. and Charles E. Rosenberg, The Therapeutic Revolution, Philadelphia: University of Pennsylvania Press, 3-25.

Rosenberg, Charles E., 1987. The Care of Strangers. New York: Basic Books.

Rosenberg, Nathan, 1976. Perspectives on Technology. New York: M.E. Sharpe.

Rosenberg, Nathan, 1997. "Endogenous Technical Change in the Twentieth Century." Unpublished paper, Stanford University, Stanford, CA.

Rosenkranz, Barbara Gutmann, 1972. Public Health and the State, Cambridge, MA: Harvard University Press.

Rostow, W.W., 1959. "The Stages of Economic Growth," Economic History Review, 2d ser., 12:1, 1-16.

Rostow, W.W., 1978. The World Economy: History and Prospect. Austin, TX: University of Texas Press.

Rotberg, Robert I. and Theodore K. Rabb, 1983. Hunger and History. Cambridge: Cambridge University Press.

Roth, Gabriel, 1987. The Private Provision of Public Services in Developing Countries, NY: Oxford University Press.

Sandiford, P., J. Cassel, M. Montenegro and G. Sanchez, 1995. "The Impact of Women's Literacy on Child Health and Its Interaction with Access to Health Services," Population Studies XLIX (March), 5-17.

Sawyer, Diana Oya, 1981. "Effects of Industrialization and Urbanization on Mortality in the Developing Countries: The Case of Brazil," International Union for the Scientific Study of Population, International Population Conference Manila 1981, Liege, Belgium: International Union for the Scientific Study of Population.

Schofield, R., D. Reher, and A. Bideau, 1991. The Decline of Mortality in Europe, Oxford: Clarendon Press.

Sen, Amartya, 1994. "Economic Regress, Concepts and Features," Proceedings of the World Bank Annual Conference on Development Economics, Washington, D.C.: The World Bank.

Shattuck, Lemuel et al, 1850 (1948). Report of the Sanitary Commission of Massachusetts 1850, Cambridge: Harvard University Press.

Simon, Sir John, 1890. English Sanitary Institutions, London: Cassell & Co.; NY: Johnson Reprint Co.

Smith, Stephen, 1911. The City That Was. New York: Frank Allaben.

Solow, R., 1957. "Technical Change and the Aggregate Production Function," Rev. Eco. Stat. 39, 312-20.

Starr, Paul, 1982. The Social Transformation of American Medicine. New York: Basic Books Inc.

Steckel, Richard H., 1995. "Stature and the Standard of Living," Journal of Economic Literature XXXIII (December), 1903-1940.

Steckel, Richard H. and Roderick Floud (eds.), 1997. Health and Welfare During Industrialization, Chicago: University of Chicago Press.

Stiglitz, Joseph, 1988. Economics of the Public Sector, 2nd ed., New York: W.W. Norton.

Strauss, John and Duncan Thomas, 1995. "Human Resources: Empirical Modeling of Household and Family Decisions," in J. Behrman and T.N. Srinivasan (eds.), Handbook of Development Economics, Volume III, 1885-2023.

Summers, Robert and Alan Heston, 1991. "The Penn World Tables (mark 5): An Expanded Set of International Comparisons, 1982-88" Quarterly Journal of Economics 106:2, 327-68.

Sundin, Jan, 1995. "Culture, Class, and Infant Mortality during the Swedish Mortality Transition, 1750-1850," Social Science History 19:1, 117-145.

Szreter, Simon, 1988. "The Importance of Social Intervention in Britain's Mortality Decline c. 1850-1914: a Re-Interpretation of the Role of Public Health," The Society for the Social History of Medicine.

Szreter, Simon, 1997. "The Politics of Public Health in Nineteenth Century Britain," Population and Development Review 23:4 (December), 693-728.

Taeuber, Irene B., 1962. "Asian Populations: The Critical Decades," in Committee on the Judiciary, Study of Population and Immigration Problems, Washington, D.C.: U.S. Government Printing Office.

Thomas, Lewis, 1983. The Youngest Science, NewYork: The Viking Press.

Thompson, Warren S., 1959. Population and Progress in the Far East. Chicago: University of Chicago Press.

Tomes, Nancy, 1990. "The Private Side of Public Health: Sanitary Science, Domestic Hygiene, and the GermTheory, 1870-1900," Bull. Hist. Med. 64:4 (Winter), 509-539.

UNESCO, 1994. Statistical Yearbook 1994. New York: United Nations.

United Nations, 1952. Preliminary Report on the World Social Situation. New York: United Nations.

United Nations, 1957. Report on the World Social Situation. New York United Nations.

United Nations, 1961. Report on the World Social Situation. New York: United Nations.

United Nations, 1963. 1963 Report on the World Social Situation. New York: United Nations.

United Nations, 1968. Demographic Yearbook 1967. New York: United Nations.

United Nations, 1973. The Determinants and Consequences of Population Trends. New York: United Nations.

United Nations, 1977. Population Bulletin of the United Nations, No. 8, 1976. New York: United Nations.

United Nations, 1982. Levels and Trends of Mortality Since 1950. New York: United Nations.

United Nations, 1985. Socio-Economic Differentials in Child Mortality in Developing Countries. Population Study 97. New York.

United Nations, 1991. Child Mortality in Developing Countries. New York.

United Nations, 1992. Child Mortality Since the 1960s. New York.

United Nations, 1995. Demographic Indicators 1950-2050 (The 1994 Revision). New York: United Nations.

United Nations Development Program, 1990. Human Development Report 1990. New York: Oxford Press.

United Nations Development Program, 1995. Human Development Report 1995. New York: United Nations.

United Nations Development Program, 1996. Human Development Report 1996. New York: Oxford Press.

Vallin, J., 1991. "Mortality in Europe from 1720 to 1914: Long-Term Trends and Changes in Patterns by Age and Sex," in R. Schofield, D. Reher, and A. Bideau (eds.), The Decline of Mortality in Europe, Oxford: Clarendon Press, 38-67.

Viscusi, W. Kip, 1993. "The Value of Risks to Life and Health," Journal of Economic Literature, XXXI:4, 1912-1946.

Vogel, Morris J., 1980. The Invention of the Modern Hospital. Chicago: University of Chicago Press.

Wainright, Milton, 1990. Miracle Cure: The Story of Penicillin and the Golden Age of Antibiotics. Cambridge, MA: Basil Blackwell.

Ware, Helen, 1984. "Effects of Maternal Education, Women's Roles, and Child Care on Child Mortality," in Mosley, W. Henry and Lincoln C. Chen (eds.), "Child Survival: Strategies for Research," Population and Development Review 10, Special Supplement, 191-214.

Warner, John Harley, 1986. The Therapeutic Perspective: Medical Practice, Knowledge, and Identity in America, 1820-1855. Cambridge, MA: Harvard University Press.

Weiss, Mitchell G., 1988. "Cultural Models of Diarrheal Illness: Conceptual Framework and Review," Soc. Sci. Med. 27:1, 5-16.

Wells, Robert V., 1995. "The Mortality Transition in Schenectady, New York, 1880-1930," Social Science History 19:3, 399-423.

Williams, Alan, 1987. "Public Health," in Eatwell, John, Murray Milgate, and Peter Newman (eds.), The New Palgrave: A Dictionary of Economics, New York: The Stockton Press, 3, 1066-1068.

Williamson, Jeffrey G., 1981. "Urban Disamenities, Dark Satanic Mills, and the British

Standard of Living Debate," Journal of Economic History XLI:1, 75-83.

Williamson, Jeffrey G., 1982. "Was the Industrial Revolution Worth It? Disamenities and Death in 19th Century British Towns," Explorations in Economic History 19, 221-245.

Winslow, C.-E.A., 1931. "Communicable Diseases, Control Of," in E. R. A. Seligman (ed.), Encyclopaedia of the Social Sciences, V. IV, New York: The MacMillan Co.

Winslow, Charles-Edward Amory, 1943. The Conquest of Epidemic Disease, Princeton, NJ: Princeton University Press.

Winslow, C.-E.A., 1951. The Cost of Sickness and the Price of Health, Geneva: World Health Organization.

Wohl, Anthony S., 1983. Endangered Lives, Public Health in Victorian Britain. Cambridge, MA: Harvard University Press.

Woods, Robert, 1985. "The Effects of Population Redistribution on the Level of Mortality in Nineteenth-Century England and Wales," Journal of Economic History XLV:3, 645-651

Woods, R. and J. Woodward (eds.), 1984. Urban Disease and Mortality in Nineteenth-Century England. New York: St. Martin's Press.

World Bank, 1989. Sub-Saharan Africa: From Crisis to Sustainable Growth, A Long-Term Perspective Study. Washington, D.C.: World Bank.

World Bank, 1993. World Development Report 1993, Investing in Health. Oxford: Oxford University Press.

World Bank, 1994a. Social Indicators of Development: 1994. Washington, D.C.: World Bank.

World Bank, 1994b. World Development Report 1994: Infrastructure for Development. Oxford: Oxford University Press.

World Bank, 1996. World Development Report 1996, From Plan to Market. Oxford: Oxford University Press.

World Health Organization, 1980. World Health Statistics 1980. Geneva: World Health Organization.

World Health Organization, 1991. The Public/Private Mix in National Health Systems and the Role of Ministries of Health, Report, Hacienda Cocoyoc, State of Morelos, Mexico, July 22-26. Geneva: World Health Organization.

World Health Organization, 1992. Global Health Situation and Projections, Estimates. Geneva: World Health Organization, Division of Epidemiological Surveillance and Health Situation and Trend Assessment.

World Health Organization, 1994. World Health Statistics 1993. Geneva: World Health Organization.

Wrigley, E.A. and R.S. Schofield, 1981. The Population History of England 1541-1871. Cambridge: Harvard University Press.

Table 1
Life Expectancy Improvement in the Half Century
Before and After Take-Off in Six Countries

Country	(1) Take-off date	(2) Life expectancy at take-off	(3) Change in half century before take-off	(4) Change in half century after take-off	(5) Ratio (4)/(3)
England and Wales	1871	41.0	3.0	12.0	4.0
Sweden	1875	45.4	4.6	17.2	3.7
France[a]	1893	44.9	3.4	20.3	6.0
Japan	1923	42.6	5.8	30.8	5.3
Brazil	1940	36.7	8.0	28.9	3.6
India	1945	32.1	8.3	28.3	3.4

a. Data are for females.
Sources: See notes to Figures 2-7.

Table 2
Take-Off Dates for Economic Growth and Life Expectancy
in Six Countries

Country	Economic growth	Life expectancy
England and Wales	1783-1830	1871
Sweden	1868-1890	1875

France	1830-1870	1893
Japan	1885-1905	1923
Brazil	1933-1950	1940
India	1952-1963	1945

Sources: Figures 2-7 and Rostow, 1978.

Table 4
Discoveries in the Control of Major Fatal Infectious Diseases since 1800:
Mode of Transmission and Causal Agent

A. Mode of transmission, 1800-1909

Date	Disease	Investigator
1847	Measles	Panum
	Puerperal fever	Semmelweiss, Holmes
1854	Cholera	Snow
1859	Typhoid fever	Budd
1867	Sepsis (surgical)	Lister
1898	Malaria	Ross, Grassi
	Hookworm	Looss
1900	Yellow fever	Reed
1906	Dengue	Bancroft
	Rocky Mountain spotted fever	Ricketts, King
1909	Typhus	Nicolle

B. Causal agent, 1880-1900

Date	Disease	Investigator
1880	Typhoid (bacillus found in tissues)	Eberth
	Leprosy	Hansen
	Malaria	Laveran
1882	Tuberculosis	Koch
	Glanders	Loeffler and Schutz
1883	Cholera	Koch
	Streptococcus (erysipelas)	Fehleisen
1884	Diphtheria	Klebs and Loeffler
	Typhoid (bacillus isolated)	Gaffky
	Staphylococcus Streptococcus	Rosenbach
	Tetanus	Nicolaier
1885	Coli	Escherich
1886	Pneumococcus	A. Fraenkel
1887	Malta fever	Bruce
	Soft chancre	Ducrey
1892	Gas gangrene	Welch and Nuttall
1894	Plague	Yersin, Kitasato
	Botulism	van Ermengem
1898	Dysentery bacillus	Shiga

Sources: Panel A: Winslow (1943), Rosen (1958), Duffy (1992).
Panel B: From Rosen (1958), p. 315.

Table 5
Discoveries in the Control of Major Fatal Infectious Diseases Since Around 1800:
Vaccines and Drugs

A. Vaccines

B. Drugs

Date	Disease	Developer
1798	Smallpox	Jenner
1881	Anthrax	Pasteur
1885	Rabies	Pasteur
1892	Diphtheria	von Behring
1896	Cholera	Kolle
1906	Pertussis	Bordet-Gengou
1921	Tuberculosis	Calmette, Guerin
1927	Tetanus	Ramon, Zoeller
1930	Yellow fever	Theiler
	Typhoid fever	Weigl
1948	DTP	(Multiple)
1950	Polio	Salk
1954	Measles	Enders, Peebles

Date	Drug	Developer
1908	Salvarsan	Ehrlich
1935	Sulfanomides	Domagk
1941	Penicillin	Fleming, Florey, Chain
1944	Streptomycin	Waksman
1947-	Broad spectrum antibiotics[a]	

Sources: Panel A: Parish (1965), Plotkin and Mortimer (1988).
Panel B: Baldry (1976).

a. Lappé (1982) pp. 22-24 provides a lengthy tabulation of major antibiotics in use as of 1975-81 in the United States. See also Brumfitt and Hamilton-Miller, 1988.

Table 6
Death Rate and Percent Distribution of Deaths by Cause,
England and Wales, 1871-1951
(age-standardized)

	1871	**1940**	**1951**
Death rate (per thousand)	22.4	9.3	6.1
All causes	100	100	100
Infectious diseases	31	10	6
Bronchitis, pneumonia and influenza	14	16	13
Diseases of the circulatory system	9	24	36
Diarrhea and enteritis	6	2	1
Accidents	4	10	6
Neoplasms	2	10	15
Other causes	36	29	24

Source: Caselli (1991), pp. 89-90. Data are averages
of males and females. Detail may not add to total because of rounding.