NBER WORKING PAPER SERIES

SECULAR TRENDS IN PHYSIOLOGICAL CAPITAL: IMPLICATIONS FOR EQUITY IN HEALTH CARE

Robert W. Fogel

Working Paper 9771
http://www.nber.org/papers/w9771

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
June 2003

Secular Trends in Physiological Capital: Implications for Equity in Health Care
Robert W. Fogel
NBER Working Paper No. 9771
June 2003
JEL No. I12, I18

ABSTRACT

Over the past three centuries there has been a rapid accumulation of physiological capital in OECD countries. Enhanced physiological capital is tied to long-term reduction in environmental hazards and to the conquest of chronic malnutrition. Data on heights and birth weights suggests that physiological capital has become more equally distributed, thereby reducing socioeconomic disparities in the burden of disease. Implications for health care policy are: (1) enhanced physiological capital has done more to reduce inequities in health status than has wider access to health care; (2) the main contribution of more advanced medical treatment so far has been to retard depreciation in individuals' physiological capital; (3) prenatal and early childhood care and environmental issues are key for interventions aimed at enhancing physiological capital and at affecting its rate of depreciation; (4) lifestyle change is the most important issue affecting health equity in rich countries; and (5) greater access to clinical care should be promoted through aggressive outreach, since expanded insurance coverage by itself is inadequate.

Robert W. Fogel
Graduate School of Business
University of Chicago
1101 East 58th Street
Chicago, IL 60637
and NBER
rwf@cpe.uchicago.edu

Secular Trends in Physiological Capital: Implications for Equity in Health Care

The Malthusian world was a terrible world for health in general, but it was especially bad for the lower classes. Chronic malnutrition was so severe that the bottom 20 percent of the English income distribution lacked the energy for regular work. From the Elizabethan Age to the end of the nineteenth century, one-fifth of the potential English labor force lived out their brief lives as paupers and beggars. These potential workers were excluded from the labor force not because of an inadequate demand for labor, as was the case during the Great Depression of the 1930s, but because they lacked entitlements to food. The situation in France and the rest of Western Europe was even worse than in England. Chronic malnutrition was the fate of the majority of the population prior to the twentieth century.

The problem was not only that most of the population of Western Europe lacked adequate amounts of energy for work, but also that their food supply was typically too small to allow for their proper physiological development. Energy available for work is a residual. It is the difference between the food metabolized (chemically transformed so that its energy is available for use by the body) and the energy that the body requires for baseline maintenance. Baseline maintenance has two components. The larger component is the basal metabolic rate (or BMR), which accounts for about four-fifths of baseline maintenance. BMR is the amount of energy needed to maintain body temperature and to keep the heart and other vital organs functioning when the body is completely at rest. The other 20 percent of baseline maintenance is the energy needed to digest food and for vital hygiene. It does not include the energy needed to prepare a meal or to clean the kitchen afterwards.

The amount of energy required for baseline maintenance depends on the size of an individual. The typical American male today in his thirties is about 69.7 inches tall and weights about 172 pounds. Such a male requires daily about 1,794 calories for basal metabolism and a total of 2,279 calories for baseline maintenance. If either the British or the French had been that large during the eighteenth century, virtually all of the energy produced by their food supplies would have been required for maintenance, and hardly any would have been available to sustain work. The relatively small food supplies available to produce the national products of these two countries about 1700 suggests that typical adult male must have been quite short and very light.

This inference is supported by data on stature and weight that have been collected for European nations. Table 1 provides estimates of final heights of adult males who reached maturity between 1750 and 1975. It shows that during the eighteenth and nineteenth centuries Europeans were severely stunted by modern standards (cf. line 6 of Table 1).

The Concept of Physiological Capital

Individuals who are stunted and wasted are at much higher risk of the early development of chronic disabilities and premature death. Over the past three centuries human beings in OECD countries have increased their average body size by over 50 percent, their average longevity by over 100 percent, and they have greatly improved the robustness and capacity of vital organ systems. I shall refer to this enhanced physiological capacity as *physiological capital*.

Physiological capital is a relatively new concept for economists. It differs from, but is related to, the better known concepts of human capital and health capital. The human capital concept was developed to explain differences in earnings by occupation, over the life-cycle, by

Table 1

Estimated Average Final Heights (cm) of Men Who Reached Maturity between 1750 and 1975

in Six European Populations, by Quarter Centuries

(1) Date of maturity by century and quarter		(2) Great Britain	(3) Norway	(4) Sweden	(5) France	(6) Denmark	(7) Hungary
1.	18-III	165.9	163.9	168.1			168.7
2.	18-IV	167.9		166.7	163.0	165.7	165.8
3.	19-I	168.0		166.7	164.3	165.4	163.9
4.	19-II	171.6		168.0	165.2	166.8	164.2
5.	19-III	169.3	168.6	169.5	165.6	165.3	
6.	20-III	175.0	178.3	177.6	172.0	176.0	170.9

Sources and notes: Lines 1–5: Great Britain: all entries were computed from data in Floud, Wachter and Gregory 1990. Norway: Floud 1984, who cites Kiil 1939. Kiil estimated the height of recruits who were aged 18.5 in 1761 at 159.5 cm, to which I added 4.4 cm to obtain the estimated final height 163.9 for 18-III. Sweden: Sandberg and Steckel 1987, Table 1. Decades straddling quarter centuries were given one-half the weight of decades fully within a quarter century. France: rows 3–5 were computed from von Meerton 1989 as amended by Weir 1993, with 0.9 cm added to allow for additional growth between age 20 and maturity (Gould 1869: 104–5; cf. Friedman 1982, p. 510 n. 14. The entry to row 2 is derived from a linear extrapolation of von Meerton's data for 1815–1836 back to 1788, with 0.9 cm added for additional growth between age 20 and maturity. Denmark: the entries are from Floud (1984), who reported data analyzed by H. C. Johansen (1982) and communicated privately. Hungary: all entries are from Komlos 1987, Table 2.1, p. 79. Line 6: the entry for Great Britain is from Rona, Swan, and Altman 1978, Table 3. The entries for Norway, Sweden, and Denmark are from Chamla 1983, Tables VII, XII, and XIV. Norwegian and Swedish heights are for 1965, Danish for 1964. The entries for France and Hungary are from Eveleth and Tanner 1976, p. 284.

industries, and by regions. It focuses especially on the contribution of education (including on-the-job training) to an individual's stock of human capital and to the rate of return on investments in education. The health capital concept was developed to explain the demand for goods and services that offset the depreciation in the initial endowment of health over the life-cycle.

Health capital presupposes physiological capital, but does not explicitly deal with it. Health capital assumes the health stock that each individual is born with and considers how investment in health care can reduce the rate of depreciation in that stock. It does not address why some people have a greater initial stock than others. It does not recognize the relationship between the size of the initial stock and its rate of depreciation. It does not take notice of the effect of the date of birth on the size of the initial stock or on the rate of depreciation. In other words, it does not confront the issue of how the average initial stock of physiological capital has been changing from one generation to another.

These are all issues that are central to the concept of physiological capital. Since the beginning of the eighteenth century physiological capital has been accumulating very rapidly. Much of this improvement is the result of a process that Dora Costa and I have called technophysio evolution, a synergism between technological advances and physical improvements that has produced a form of human evolution that is biological but not genetic, rapid, culturally transmitted, and not necessarily stable. This process is still ongoing in both rich and developing countries.

The rapid accumulation of physiological capital is tied to long-term reduction in environmental hazards and to the conquest of chronic malnutrition (made possible by technophysio evolution) that is reflected in the improvements in stature and the Body Mass Index

(BMI), which is a measure of weight standardized for height. Variations in height and weight are associated with variations in the chemical composition of the tissues that make up vital organs, in the quality of the electrical transmission across membranes, and in the functioning of the endocrine system and other vital systems. Nutritional status, as reflected in height and weight, thus appears to be a critical link connecting improvements in technology to improvements in human physiology.

Research on this connection is developing rapidly and the exact mechanisms by which malnutrition and trauma *in utero* or early childhood are transformed into organ dysfunctions are still unclear. What is agreed upon is that the basic structure of most organs is laid down early, and it is reasonable to infer that poorly developed organs may break down earlier than well-developed ones. The principal evidence so far is statistical and, despite agreement on certain specific dysfunctions, there is no generally accepted theory of cellular aging (Tanner 1990, 1993).

With these caveats in mind, recent research bearing on the connection between malnutrition and body size and the later onset of chronic diseases can conveniently be divided into three categories. The first category involves forms of malnutrition (including the ingestion of toxic substances) that cause permanent, promptly visible physiological damage, as is seen in the impairment of the nervous systems of fetuses due to excessive smoking or consumption of alcohol by pregnant women. It appears that protein calorie malnutrition (PCM) in infancy and early childhood can lead to a permanent impairment of central nervous system function. Folate and iodine deficiency *in utero* and moderate-to-severe iron deficiency during infancy also appear to cause permanent neurological damage (Scrimshaw and Gordon 1968; Chávez, Martínez, and Soberanes 1995).

Not all damage due to retarded development *in utero* or infancy caused by malnutrition shows up immediately. In a series of studies D. J. P. Barker and his colleagues (1998) have reported that such conditions as coronary heart disease, hypertension, stroke, noninsulin dependent diabetes, and autoimmune thyroiditis begin *in utero* or in infancy, but do not become apparent until mid-adult or later ages. In these cases, individuals appear to be in good health, and function well in the interim. However, early onset of the degenerative diseases of old age is linked to inadequate cellular development early in life.

Certain physiological dysfunctions incurred by persons suffering from malnutrition can, in principle, be reversed by improved dietary intake, but they often persist because the cause of the malnutrition persists. If the malnutrition persists long enough these conditions can become irreversible or fatal. This category of consequences includes the degradation of tissue structure, especially in such vital organs as the lungs, the heart, and the gastrointestinal tract. In the case of the gastrointestinal system, atrophy of the mucosal cells and intestinal villi results in decreased absorption of nutrients. Malnutrition also has been related to impairment of immune functions, increased susceptibility to infections, poor wound healing, electrolyte imbalances, endocrine imbalances, and in adults, dangerous cardiac arrhythmias and increased chronic rheumatoid disorders (McMahon and Bistrian 1990).

So far I have focused on the contribution of improved nutrition and technological change to physiological improvement. The process has been synergistic, however, with improvement in nutrition and physiology contributing significantly to the process of economic growth and technological progress. For example, technophysio evolution appears to account for about half of British economic growth over the past two centuries. Much of this gain was due to the improvement in human thermodynamic efficiency. The rate of converting human energy input into work output appears to have increased by about 50 percent since 1790 (Fogel 1994).

Equity Implications of the Accumulation of Physiological Capital

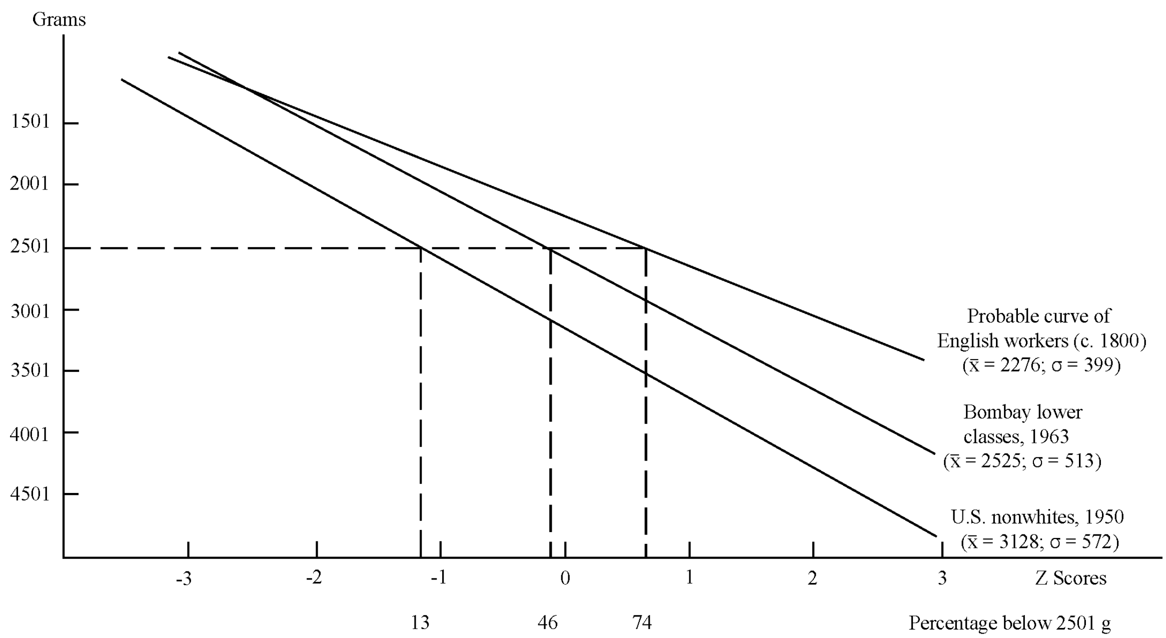
The process of accumulating physiological capital has had an effect on health care by *reducing* socioeconomic disparities in the burden of disease. I have italicized "reducing" because so many recent epidemiological studies in OECD nations find strong relationships between SES variables and health status. However, these relationships are what is left of a nexus that used to be much stronger than it is today.

The progress toward greater equity in health status between 1800 and the second half of the twentieth century is illustrated by Figure 1. The lines on this graph are normal approximations of the frequency distributions of birth weights. Birth weight is represented on the vertical axis, and the horizontal axis represents *z*-scores (deviations of birth weight from the mean measured in units of the standard deviations). Hence, the cumulative frequency distribution is represented by a straight line. The lowest line represents the distribution of United States nonwhites in 1950. They had a mean birth weight of 3218 grams and, as indicated by Figure 1, about 13 percent of the neonates weighed less than 2501 grams at birth. The second line is the distribution of birth weights for lower-class women in Bombay (Jayant 1964). Figure 1 indicates the mean birth weight in this population was just 2525 grams. In this case nearly half (46 percent) of the births were below the critical level, although the women in the sample were not the poorest of the poor.

The third curve is the probable distribution of the birth weights of the children of impoverished English workers about 1800. The distribution of the birth weights in this class

Figure 1

The Percentage of Male Births with Weights below 2,501 Grams in Two Modern Populations and of Poor English Workers during the Early Nineteenth Century



around 1800 probably had a mean of 2276 grams, which is about 249 grams (about half a pound) below the average in the deliveries of the lower-class women in Bombay. It follows that about 79 percent of the births among impoverished English workers around 1800 were at weights below 2501 grams.

The implication of this distribution of birth weights is revealed by Table 2. Column 2 represents the actual schedule of neonatal death rates by weight for nonwhite United States males in 1950, and column 3 gives the actual distribution of their birth weights. The product of these two columns yields an implied neonatal death rate of 26.8 per 1,000, which, of course, was also the actual death rate. If, however, this United States population had had the distribution of the birth weights of the impoverished English workers of 1800, their neonatal death rates would have been 173.0 per thousand (see col. 3). The implication of Table 2 is that improvements in nutrition sufficient to have shifted the mean birth weight from 2276 grams to 3128 grams would have reduced the infant death rate by 83 percent.

Figure 1 reflects an important intergenerational influence on heath before the era of cesarean sections and of neonatal intensive care units. Malnourished mothers produced small children not only because of deficiencies in their diet and exposure to disease during pregnancy, but also because their short stature was associated with small pelvic cavities. As a result, the birth weight that minimized perinatal deaths was about 700 grams below that of the U. S. women referred to in Figure 1. In other words, a condition for surviving the birth process was such a low birth weight that the neonate was at very high risk of dying shortly after birth. The escape from that dilemma is now almost universal in OECD nations. Poor women accumulated physiological capital at an intergenerational rate that was rapid enough to shift the birth weight of their children

Table 2

Effects of a Shift in the Distribution of Birthweights on the Neonatal Death Rate,

Holding the Schedule of Death Rates (by Weight) Constant

Weight (grams) (1)	Neonatal Death Rate of Singleton Nonwhite U.S. Males in 1950 (per 1,000) (2)	Distribution of Birthweights of Singleton Nonwhite U.S. Males in 1950 ($\bar{x}$ = 3,128 g; σ = 572 g) (3)	Distribution of Birthweights in a Population with $\bar{x}$ = 2,276 g σ = 399 g (4)
1,500 or less	686.7	0.0117	0.1339
1,501–2,000	221.3	0.0136	0.2421
2,001–2,500	62.1	0.0505	0.3653
2,501–3,000	19.7	0.1811	0.2198
3,001–3,500	10.7	0.3510	0.0372
3,501–4,000	12.1	0.2599	0.0017
4,001–4,500	13.0	0.0865	—
4,501 or more	23.2	0.0456	—
Implied neonatal death rate (per 1,000)		26.8	173.0
Possible infant death rate (per 1,000)		48.9	288.3

Sources: Cols. 2 and 3: U. S. National Office of Vital Statistics 1954; col. 4: see Fogel 1986, nn. 21, 23, 24, and 26.

Note: The infant death rate in the last line of col. 4 is estimated at 1.67 times the neonatal rate.

to a range that is about 1.7 times what it was two centuries ago. This means that less than 8 percent of all births in OECD nations are now below 2501 grams. (Martin et al. 2002; Graafmans et al. 2002; Wilcox et al. 1995).

Further evidence of the secular trend toward the more equal distribution of physiological capital over the past two centuries comes from the changes in adult heights among the British. Data collected on the stature of the British upper classes when combined with data on the lower classes make it possible to estimate how much of the improvement in the average stature in Great Britain between 1820 and 1978 was due to a closing of the gap between the upper and lower classes and how much was due to an upward shift in attainable average height. By "attainable" I mean not genetically attainable but, within genetic constraints, attainable under the most favorable prevailing socioeconomic circumstances. It appears that about three-quarters of the increase in the mean final heights of British males since about 1820 was due to the decrease in class differentials in height and the balance to an upward shift in the mean final heights of the upper class (which may be taken as a measure of the attainable mean height at any point in time) (Floud, Wachter, and Gregory 1990). In this connection it is worth noting that Sweden and Norway, which have relatively low after-tax Gini ratios, also have low height differentials by socioeconomomic class. The means of adult height in these nations now exceed those of nations with relatively high Gini ratios, such as the United States and Great Britain, by several centimeters (Kuh, Power and Rogers 1991; Cavelaars et al. 2000; Fredriks et al. 2000; World Bank 2002).

What can be said about the factors responsible for the rapid increase in the national stocks of physiological capital in OECD countries and for its more equal distribution? The central scientific issue is, how much of the improvement in physiological capacity is due to improvements in the environment, especially between the 1880s and the end of World War II? And how much is due to advances in medical technology and the development of effective systems for delivering health services? These two aspects of the accumulation of physiological capital are not neatly separated, since physicians and biochemists played a large role in environmental improvements. Moreover, some important steps in the improvements of the environment, such as the draining of swamps, were byproducts of the growth of agriculture, while others awaited the development of new technologies for waste disposal in the urban sector.

Measurement of the relative importance of these and other factors, such as improvements in the diversity and year-round supply of food, to the accelerated accumulation of human capital is still elusive, partly because of the complex interactions that are involved, but mainly because of the absence of a database containing information on the relevant explanatory variables. However, the Center for Population Economics at the University of Chicago has launched a major project to create such a database for the United States. The aim is to provide information by small geographical units (wards or census tracts) in the 24 largest U.S. cities in 1900 and in subsequent years, down to the end of the twentieth century.

Although much was done to eliminate environmental barriers to the enhancement of physiological capital during the course of the twentieth century, the process of improvement is not yet complete, since environmental factors still contribute to low birth weight. As a result, deficiencies in physiological capital continue to influence health status and rates of the deterioration in health over the life cycle. Studies of a British cohort born in 1958 reveal that low birth weight children were not only stunted at maturity (by about 2 inches compared to children of optimal birth weight) (Teronishi, Nakagawa, and Marmot 2001), but they were also disadvantaged in their cognitive development, as reflected in school performance, which was aggravated by the social class of their parents at the time of birth (Jefferis, Power, and Hertzman 2002). Some of the problems persisted even after the emergence of neonatal intensive care units in the 1970s (Hack et al. 2002). Low birth weight children also have elevated risks of behavioral problems, psychiatric disorders, linguistic defects, and motor disabilities (Elgen, Sommerfelt, and Markestad 2002; Yliherva et al. 2001). Although recent advances in neonatal technology appear to be improving long-term outcomes (McCormick and Richardson 2002), they have not eliminated the need to confront continuing environmental hazards.

Implications of Enhanced Physiological Capital for Egalitarian Health Policies

Recognition of the substantial role of the secular enhancement in physiological capital has a number of implications for those concerned with designing policies to reduce inequities in health status by socioeconomic class. Since research bearing on secular trends in health status and the factors responsible for the decline in disabilities over the course of twentieth century is still at an early stage, I will summarize my current views as a set of theses.

Thesis 1: The more egalitarian health status that exists today is due primarily to environmental improvements that enhanced the physiological capital of successive cohorts rather than to greater access to health care services. Support for this proposition is to be found in a series of recent studies that have linked events early in life, including the intrauterine period, to the onset of chronic conditions at middle and late ages. The strongest evidence for such links pertain to hypertension and coronary heart disease (Cresswell et al. 1997; Barker 1998; Scrimshaw 1997). A review of 32 papers dealing with the relationship between birth weight and hypertension (Law and Sheill 1996) showed a tendency for blood pressure in middle ages to increase as birth weight declines. Evidence of a connection between birth size and later coronary heart disease has been found in England, Wales, Sweden, India, and Finland (Frankel et al. 1996; Koupilová, Leon, and Vågerö 1997; Forsén et al. 1997; Stein et al. 1996).

The theory of a nexus between environmental insults *in utero* or at early postnatal ages, and the risk of chronic health conditions half a century or more later, calls attention to the rapid improvement in the environment between 1890 and 1940 to which I have already alluded. This period also witnessed improvements in the diversity of the food supply throughout the year and the beginnings of dietary supplements that improved year-round consumption of vitamins and other trace elements. Two recent studies have shown strong correlations in month of birth and the longevity of middle-aged men in Austria, Denmark, Australia, and the United States that reflected differences in the availability of food to pregnant mothers over the seasons (Doblhammer and Vaupel 2001; Kanjanapipatkul 2002). These developments largely preceded the revolution in health care services that followed World War II.

Further evidence that a substantial part of the improvement in health status during the twentieth century was not due to direct medical care is provided by Table 3. It shows that the proportion of white males who were still free of chronic conditions during ages 50-69 was substantially higher in the mid-1990s than a century earlier. This improvement was not due primarily to the curative interventions of health care providers with persons already afflicted with chronic diseases, because we are looking only at the subset of people who were not yet afflicted by chronic diseases. Table 4 shows that for those who did develop four common chronic diseases, the average age of onset was between 7 and 11 years later for men who reached age 65 in the 1980s or later than for those who reached age 65 in 1910 or earlier (cf. Costa 2000).

Thesis 2: Although the more extensive and more effective medical interventions of the last third of the twentieth century have contributed to the enhancement of the physiological capital of successive birth cohorts, their main contribution has been to slow down the rate of depreciation in the stock of the enhanced physiological capital that the members of these cohorts accumulated during developmental ages. This distinction between the increasingly enhanced physiological capital of successive cohorts and health care interventions that retard the rate of depreciation in the initial stocks of physiological capital in a specific set of cohorts is what is overlooked in the conventional theory of health capital.

The underestimation of the extent of the increase in physiological capital may explain the tendency of some economists to slight the role of improving environmental factors and to attribute all of the decline in morbidity and mortality during recent decades to improved medical technology.

Moreover, while it may be true that most of the effort of health care providers is directed at reducing the rate of deterioration in health, there are also significant contributions of physicians to enhancing physiological capital. These include encouraging appropriate behavior by pregnant women, administering nutritional supplements, correcting birth defects, and treating a variety of diseases that interfere with normal growth patterns during developmental ages.

Thesis 3. The evidence currently in hand points to the importance of prenatal care and environmental issues in both the enhancement of physiological capital and in affecting the rate of depreciation in that capital. Used in this context the word "environment" has a dual meaning. The uterus is a crucial environment for the developing embryo and fetus. And the quality of the external environment has an effect on the environmental quality of the uterus. Pregnant women exposed to high levels of pathogens and suffering, for example, from frequent bouts of diarrhea, will have intrauterine environments that retard the development of the children they are bearing.

Table 3

The Increase in the Proportion of White Males without Chronic Conditions

during the Course of the Twentieth Century

	Proportion without Chronic Conditions	
Age Interval	**1890–1910**	**c. 1994**
50–54	0.33	0.41
55–59	0.21	0.29
60–64	0.10	0.25
65–69	0.03	0.14

Sources: Col. 1: Union Army veterans; Col. 2: HRS waves 1 and 3.

Note: Col. 1 is based on examinations of physicians. Col. 2 is based on recall of previous diagnoses of physicians.

Table 4

Average Age of Onset of Some Chronic Conditions among American Males near the Beginning and near the End of the Twentieth Century

Condition	**Men Born 1830–1845**	**Men Born 1918–1927**
Heart disease	55.9	65.4
Arthritis	53.7	64.7
Neoplasm	59.0	66.6
Respiratory	53.8	65.0

Sources: Col. 2: Union Army veterans; Col. 3*:* HRS waves 1 and 3.

Studies in underdeveloped countries have revealed that the neonates of women who suffered from diarrhea were lighter, and at higher risk of perinatal mortality, than mothers who escaped the diseases during their pregnancies (Mata 1978; Martorell and Habicht 1986).

Neonatal care and early postnatal care present opportunities for physicians to affect the enhancement of the physiological capital. Providing nutritionally stressed pregnant women with such supplements as folate and iodine will not only reduce the rate of spontaneous abortions but will also reduce the risk of permanent damage to the central nervous system. Counseling pregnant women to avoid smoking and alcohol consumption during pregnancy can reduce a major cause of low birth weight and of perinatal mortality. Effective measures to promote breast-feeding can substantially reduce morbidity and death rates among infants who are bottle-fed (Forste, Weiss, and Lippincott 2001).

Thesis 4. From the standpoint of health equity the most important issue today in rich nations is not the cleaning up of the environment, as it was a century ago, but the reformation of lifestyle. Practices which undermine the accumulation of physiological capital (such as bottle-feeding instead of breast feeding infants) or which accelerate the depreciation of physiological capital (such as recreational drugs, smoking, excessive alcohol consumption, and overeating) are more frequently practiced among the poor and the poorly educated than among the rich and the well-educated sectors of the population.

As with the public health reforms a century ago, the campaign to change lifestyle in ways that promote the accumulation of physiological capital and retard its depreciation must be a joint venture between government authorities (especially at local levels), the private sector (including commercial and voluntary organizations), and health providers. The local level is the key arena for government operations, not only because conditions and issues vary from one locality to another, but also because education in the school system is a key site in the campaign to change lifestyles.

The joint-venture tactic also applies to cooperation between churches and secular authorities because of the vast pool of potential volunteers for mentoring those suffering from detrimental lifestyles. And the tactic applies to the government and commercial sectors because businesses, including the media, are needed both to propagate healthy lifestyles and to enforce them in the work place.

Health care providers are needed not only because of their expertise in helping to formulate public policies, but also because teaching their patients about lifestyle issues is one of their central missions. Doctors play a crucial role in helping patients to implement changes in lifestyle that are promoted in the media and taught in the schools. Moreover, specific treatments are required for those deeply addicted to drugs, excessive eating (or excessive dieting), and other detrimental lifestyles.

Thesis 5. Greater access to clinical care is a high priority in promoting greater health equity, but implementing this goal requires new approaches. It is not enough to wait for poor and poorly educated individuals to seek out available services. Outreach programs need to be developed to identify programs for the needy, making use of a variety of community organizations already engaged in outreach activities for other purposes. In this connection local officials should consider the reintroduction into public schools, particularly those in poor neighborhoods, of periodic health-screening programs, using nurses and physicians on a contract basis.

To some extent the focus on the extension of health insurance to the 15 percent of the population not currently covered is a diversion from the effective delivery of health care services to the poor. Severe problems of underserving the poor exist in rich nations with universal national health programs; what is needed is aggressive outreach, including the establishment of public-health clinics in underserved poor neighborhoods that can supplement the emergency rooms of regular hospitals, which are a frequent source of routine health-care services for the poor. Convenient access is a key issue, because even individuals with insurance, such as those on Medicaid, may fail to take advantage of available facilities if they are inconvenient. Basements of churches and space in public schools after normal teaching hours can be good locations for community clinics, both because they help to stretch available funds and because they provide familiar settings.

Concluding Comment

Physiological capital is still a new concept. It is only recently that data sets needed to measure changes in this form of capital have become accessible. The loci of changes in both time and space are just now being assayed. Much remains to be learned about how large the effect of the changes in the physiological capital of pregnant women was in contributing to the decline in infant mortality rates, but the analysis in Figure 1 and Table 2 suggests it was quite large.

The work undertaken to date suggests that environmental changes, particularly the synergy between technological and physiological improvements, explains not only a large part of the increase in life expectancy at age 50, but as Tables 3 and 4 indicate, a large part of the twentieth century delay in the average age of incurring particular chronic conditions and in the increased age-specific odds of being free of all chronic conditions after age 50. As the physiological basis for these changes is identified, forecasts of trends in health care costs will become more reliable.

References

Barker, D. J. P. 1998. *Mothers, babies, and health in later life*, 2d ed. Edinburgh: Churchill Livingstone.

Cavelaars, A. E. J., et al. 2000. Persistant variations in average height between countries and between socioeconomic groups: An overview of 10 European countries. *Ann. Hum. Biol.* 27(4):402–21.

Chamla, M. C. 1983. L'évolution recente de la stature en Europe occidentale (Périod 1960–1980). *Bull. Mem. Soc. Anthropol. Paris*, t. 10, serie 13: 195–224.

Chávez, A., C. Martínez, and B. Soberanes. 1995. The effect of malnutrition on human development: A 24-year study of well-nourished children living in a poor Mexican village. In *Community based longitudinal studies of the impact of early malnutrition on child health and development: Classical examples from Guatemala, Haiti and Mexico*, ed. N. S. Scrimshaw, 79–124. Boston: International Foundation for Developing Countries.

Costa, D. L. 2000. Understanding the twentieth-century decline in chronic conditions among older men. *Demog*. 37(1):53–72.

Cresswell, J. L., et al. 1997. Is the age of menopause determined in utero? *Early Hum. Dev.* 49(2):143–48.

Doblhammer, G. and J. W. Vaupel. 2001. Life span depends on month of birth. *Proc. Natl. Acad. Sci. U S A* 98(5):2934–39.

Elgen I., K. Sommerfelt, and T. Markestad. 2002. Population based, controlled study of behavioural problems and psychiatric disorders in low birthweight children at 11 years of age. *Arch. Dis. Child Fetal Neonatal Ed.* 87(2):F128–32.

Eveleth, P. B. and J. M. Tanner. 1976. *Worldwide variation in human growth*. Cambridge: Cambridge University Press.

Floud, R. 1984. The heights of Europeans since 1750: A new source for European economic history. NBER Working Paper No. 1318. Cambridge, MA: National Bureau of Economic Research.

Floud, R., K. W. Wachter, and A. Gregory. 1990. *Height, health, and history: Nutritional status in the United Kingdom, 1750–1980*. Cambridge: Cambridge University Press.

Fogel, R. W. 1986. Nutrition and the decline in mortality since 1700: Some preliminary findings. In *Long-term factors in American economic growth*, ed. S. L. Engerman and R. E. Gallman, 439–55, Chicago: University of Chicago Press.

Fogel, R. W. 1994. Economic growth, population theory, and physiology: The bearing of long-term processes on the making of economic policy. *Am. Econ. Rev.* 84(3):369–95.

Forsén, T., et al. 1997. Mother's weight in pregnancy and coronary heart disease in a cohort of Finnish men: Follow-up study. *BMJ* 315(7112):837–40.

Forste, R., J. Weiss, and E. Lippincott. 2001. The decision to breastfeed in the United States: Does race matter? *Pediatrics* 108(1): 291–96.

Frankel, S., et al. 1996. Birthweight, body-mass index in middle age, and incident coronary heart disease. *Lancet* 34(9040):1478–80.

Fredriks, A. M., et al. 2000. Continuing positive secular growth change in the Netherlands. *Pediatr. Res*. 47(3):316–23.

Friedman, G. C. 1982. The heights of slaves in Trinidad, *Soc. Sci. Hist.* 6(4):482–515.

Graafmans, W. C., et al. 2002. Birth weight and perinatal mortality: A comparison of “optimal” birth weight in seven Western European countries. *Epidemiology* 13(5):569–74.

Gould, B. A. 1869. *Investigations in the military and anthropological statistics of American soldiers*. New York: Hurd and Houghton.

Hack, M., et al. 2002. Outcomes in young adulthood for very-low-birth-weight infants. *N. Eng. J. Med.* 346(3):149–57.

Jayant, K. 1964. Birth weight and some other factors in relation to infant survival: A study on an Indian sample. *Ann. Hum. Genet.* 27(3):261–67.

Jefferis, B. J. M. H., C. Power, and C. Hertzman. 2002. Birth weight, childhood socioeconomic environment, and cognitive development in the 1958 British birth cohort study. *BMJ* 325(7359):305–8.

Kanjanapipatkul, T. 2001. The effect of month of birth on life span of Union veterans. Center for Population Economics, University of Chicago.

Kiil, V. 1939. *Stature and growth of Norwegian men during the past two hundred years*. Oslo: I Kommisjon hos. J. Dybwad.

Komlos, J. 1987. Stature, nutrition and economic development in the eighteenth-century Habsburg monarch: The "Austrian" model of the Industrial Revolution. Ph.D. diss., University of Chicago.

Koupilová, I., D. A. Leon, and D. Vågerö. 1997. Can confounding by sociodemographic and behavioural factors explain the association between size at birth and blood pressure and age 50 in Sweden? *J. Epidemiol. Community Health* 51(1):14–18.

Kuh, D., C. Power, and B. Rogers. 1991. Secular trends in social class and sex differences in adult height. *Int. J. Epidemiol*. 20(4):1001–9.

Law, C. M. and A. W. Shiell. 1996. Is blood pressure inversely related to birth weight? The strength of evidence from a systematic review of the literature. *J. Hypertens.* 14(8):935–41.

Martin, J. A., et al. 2002. Births: Final data for 2001. *Natl. Vital Stat. Rep.* 51(2):1–103.

Martorell, R. and J.-P. Habicht. 1986. Growth in early childhood in developing countries. In *Human growth: A comprehensive treatise*, 2d ed., ed. F. Falkner and J. M. Tanner, vol. 3, *Methodology. Ecological, genetic, and nutritional effects on growth*, 241–62. New York: Plenum Press.

Mata, L. J. 1978. *The children of Santa María Cauqué: A prospective field study of health and growth*. Cambridge: MIT Press.

McCormick, M. C. and D. K. Richardson. 2002. Premature infants grow up. *N. Eng. J. Med*. 346(3):197–98.

McMahon, M. M. and B. R. Bistrian. 1990. The physiology of nutritional assessment and therapy in protein calorie malnutrition. *Dis. Mon.* 36(7):373–417.

Rona, R. J., A. V. Swan, and D. G. Altman. 1978. Social factors and height of primary schoolchildren in England and Wales. *J. Epidemiol. Community Health* 32(3):147–54.

Sandberg, L. G. and R. H. Steckel. 1987. Heights and economic history: The Swedish case. *Ann. Hum. Biol.* 14(2):101–10.

Scrimshaw, N. S. 1997. More evidence that foetal nutrition contributes to chronic disease in later life. *BMJ* 315(7112):825–26.

Scrimshaw, N. S. and J. E. Gordon (eds.). 1968. *Malnutrition, learning and behavior*. Cambridge: MIT Press.

Stein, C. E., et al. 1996. Fetal growth and coronary heart disease in south India. *Lancet* 348(9037):1269–73.

Tanner, J. M. 1990. *Foetus into man: Physical growth from conception to maturity*, rev. ed. Cambridge: Harvard University Press.

Tanner, J. M. 1993. Review of *Fetal and infant origins of adult disease*, ed. D. J. P. Barker. *Ann. Hum. Biol.* 20(5): 508–9.

Teranishi, H., H. Nakagawa, and M. Marmot. 2001. Social class differences in catch up growth in a national British cohort. *Arch. Dis. Child.* 84(3):218–21.

U. S. National Office of Vital Statistics. 1954. Weight at birth and its effect on survival of the newborn in the United States, early 1950. *Vital Statistics Special Report*, vol. 39, no. 1.

Von Meerton, M. A. 1989, Croissance économique en France et accroissement des français: Une analyse "Villermetrique," Typescript, Center voor Economische Studiën, Leuven.

Weir, D. R. 1993. Parental consumption decisions and child health during the early French fertility decline, 1790–1914. *J. Econ. Hist.* 53(2): 259–74.

Wilcox, A., et al. 1995. Birth weight and perinatal mortality: A comparison of the United States and Norway. *JAMA* 273(9):709–11.

World Bank. 2002. World development report 2003: Sustainable development in a dynamic world: Transforming institutions, growth, and quality of life. New York: Oxford University Press.

Yliherva, A., et al. 2001. Linguistic and motor abilities of low-birthweight children as assessed by parents and teachers at 8 years of age. *Acta Paediatr.* 90(12):1363–65.