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New findings about trends in life expectation and chronic diseases: The implications for health costs and pensions

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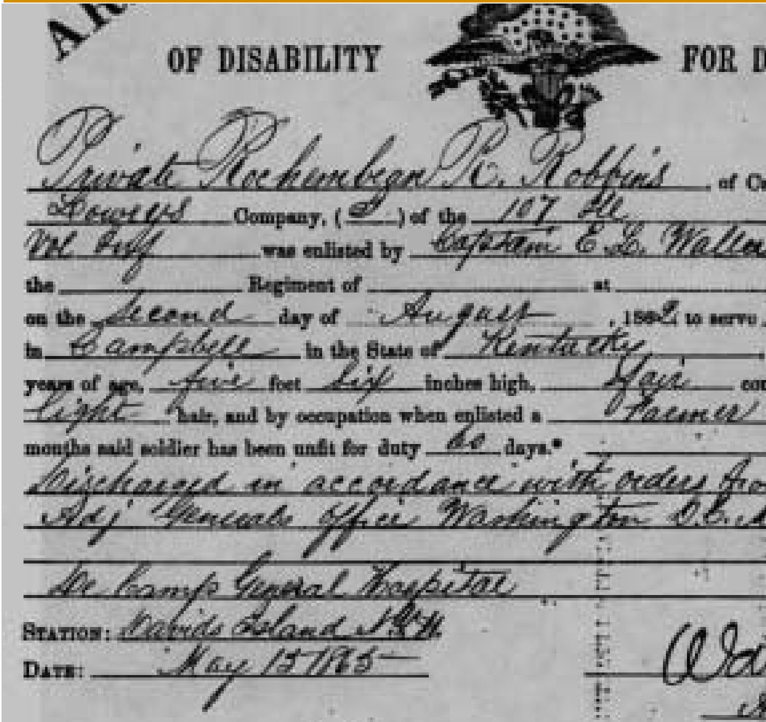

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New findings about trends in life expectation and chronic diseases: The implications for health costs and pensions*

Contemporary research indicates that life expectancy at birth has increased by about 47 years in the past three centuries, from about 30 years in 1700 to about 77 years today in OECD countries. In the whole previous history of human kind—about 200,000 years—the increase in life expectancy can have been at most five to ten years, since when life expectancy falls below 20 years, the fertility rate can not be high enough to sustain, let alone increase, the size of the population.

For the last several years, investigators at the Center for Population Economics and at other institutions have worked to develop a comprehensive theory of the secular decline in morbidity and mortality rates. Specifically, we have used biomedical and economic techniques to probe deeply into the extent of chronic malnutrition from the beginning of the 18th century in Europe and North America and to chart and explain the escape from such malnutrition. We

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believe the ongoing analyses have important implications for population forecasting, measurement of national income, demand for leisure, pension policies, and demand for health care.

A historical overview of theories of mortality

Prior to the 1920s, the Malthusian theory of mortality dominated demographic and economic thinking. Malthus believed that the normal average life span was about 40 to 45 years and that this had been the case as far back as anyone knew. He also believed that mortality rates fluctuated below this ceiling because of the pressure of the population on the food supply. He could foresee famines and pestilence that would periodically reduce life expectancies, but he did not foresee a further extension of life expectancy by more than 30 years.

When demographers first became aware of the long-term decline in death rates in the 1920s, the discovery delivered a body blow to the Malthusian theory of mortality. The discovery also spawned research in three directions: first, there was a concerted effort to develop extensive time series of death rates; second, mortality data were analyzed to identify possible predictive factors and patterns; and third, a widespread effort was launched to determine the relationship between the food supply and mortality. One aspect of this latter effort was the emergence of a science of nutrition that identified a series of diseases related to specific nutritional deficiencies and discovered the synergy between nutrition and infection.

Widespread improvements in record keeping years have yielded an impressive body of contemporary data over the last 80 years; improved computational capacity has yielded similar historical results over the past two decades. Working with church records and high-speed computers, historical demographers have been able to develop time series on mortality extending back to 1540 for the British and to 1740 for the French.

Analyses of the French and English series reveal that the long-term decline in mortality took place in two waves. In the English case, the first wave began during the second quarter of the 18th century and lasted through the first quarter of the 19th, after which mortality rates stabilized for half a century. The decline resumed toward the end of the 19th century and continues through the present. The French case is similar, except that the first wave of the decline in mortality began about half a century later in France, and its rate of decline during the first wave was more rapid.

Perhaps the most surprising aspect of the series is their implication that the elimination of crisis mortality, whether related to famines or not, accounted for less than 10 percent of the secular decline in mortality rates. By demonstrating that famines and famine mortality are a secondary issue in the escape from the high mortality rates of the early modern era, these studies shifted attention to the neglected issue of chronic malnutrition as the principal pathway through which malnutrition contributed to the high mortality rates of the past.

Generally, efforts to reconcile or replace Malthusian theory have taken place in three phases. The first phase ran from about 1920 to 1950, during which time life expectancy rose from about 54 to 68 years at birth. The increase led to an eclectic consensus that attributed the gains to a combination of factors, including public health reforms, improvements in personal health practices, increased medical knowledge, and improvements in the standard of living (which covered more abundant food supplies and better housing).

The second phase ran from about 1950 to 1970. During this 20-year period, wealthy countries' life expectancy, which had reached about 68 years at birth in 1949, remained roughly unchanged, rising a bit in some years and falling a bit in other years, depending on the country. This long hiatus led demographers and epidemiologists to reconsider the experiences of the mortality decline of the previous decades, and it promoted the "Theory of the Epidemiological Transition."

During and following this interregnum, investigators who reviewed the progress in mortality over the preceding century tended toward a consensus on three propositions:

1.) The century-long decline in mortality rates was unique and could not be repeated because virtually all of the gains made through the elimination of death from contagious diseases below age 60 had been made.

2.) Deaths, now concentrated at older ages, were due to degenerative diseases that were unrelated to the contagious diseases that they superseded. The degenerative diseases were caused by accelerated organ losses that were part of the natural process of aging.

3.) There was an upper limit to life expectancy that was genetically determined. One influential paper put that limit at 85, plus or minus 7 years.

The third phase, which began about 1968 and continues through today, has seen mortality above age 65 begin to decline at a relatively rapid rate. What's more, the fastest rates of decline have been above age 80. This decline has led contemporary reviewers to question the proposition that the upper limit of life is genetically fixed at about 85 years.

A recent study of 28 developed countries indicates that mortality rates above age 80 have been declining at about 1 percent per annum since 1950, and the decline shows no evidence of petering out. Similar results were obtained from a study of Swedish males who lived to age 90. A study of Danish twins also indicates that genetic factors only account for about 30 percent of the variance in age of death.

These epidemiological studies are buttressed by experimental studies of insect populations and of worms that indicate that variations in environmental conditions have a much larger effect on the life span than genetic factors and that reveal no pattern suggestive of a fixed upper limit. Collectively, these studies do not rule out genetic factors but suggest something much less rigid than the genetic programming of absolute life spans. An emerging theory of mortality combines genetic susceptibility of various organs with cumulative physiological insults as a result of exposure to risk.

Technophysio-evolution, the food supply, and the secular trend in body size

Together, these epidemiological and experimental studies suggest a new theory of evolution that I call "technophysio-evolution." Investigation of the causes of the reduction in mortality since 1700 point to the existence of a synergism between technological and physiological 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 theory of technophysio-evolution rests on the proposition that during the last 300 years—and particularly during the last century—human beings have gained an unprecedented degree of control over their environment, a degree of control so great that it sets them apart not only from all other species, but also from all previous generations of Homo sapiens. This new degree of control has enabled Homo sapiens to increase their average body size by over 50 percent, to increase their average longevity by more than 100 percent, and to greatly improve the robustness and capacity of vital organ systems.

Although the impact of technological changes in production techniques and in the biomedical sciences on the secular decline in mortality has been widely accepted, until recently little was known about the favorable impact of these technological changes on human physiology. Indeed, up to the beginning of World War I it was widely believed that the impact of industrialization on human physiology was negative. In England, for example, the large proportion of men rejected by recruiters for the Boer War set off an alarm among authorities that was exacerbated by data that seemed to show that recruits who reached maturity about 1900 were shorter than those who had reached maturity at the time of the Crimean War, in the mid-1850s. These results seemed to be confirmed by studies reporting that 27 percent of the British population was living in such deep poverty that their consumption of food and other necessities was below the level needed to maintain physical efficiency.

As a result of the work of agricultural historians, we now have estimates of British agricultural production by half-century intervals going back to 1700. Similar estimates have been developed for France that go back to 1780. These data pro-

Table 1
Estimated average final heights of men who reached maturity between 1750 and 1875 in six European populations, by quarter centuries

Date of maturity by century and quarter	Height (cm)					
	Great Britain	Norway	Sweden	France	Denmark	Hungary
18-III	165.9	163.9	168.1	-	-	168.7
18-lV	167.9	-	166.7	163.0	165.7	165.8
19-I	168.0	-	166.7	164.3	165.4	163.9
l9-II	171.6	-	168.0	165.2	106.8	164.2
19-III	169.3	168.6	169.5	165.6	165.3	-
20-III	175.0	178.3	177.6	172.0	176.0	170.9

Sources: Fogel 1987, table 7, for all countries except France. For France, rows 3–5 were computed from 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, 510, n. 14). The entry in row 2 is derived from a linear extrapolation of Meerton's data for 1815–36 back to 1788, with 0.9 cm added for additional growth between age 20 and maturity. The entry in row 6 is from Fogel 1987, table 7.

vide the basis for national food balance sheets that indicate that average daily caloric consumption in Britain c. 1790 was about 2,060 kcal per capita or about 2,700 kcal per consuming unit (equivalent adult males aged 20 to 39). The corresponding figure for France was about 2,410 kcal per consuming unit.

One implication of these estimates is that mature adults of the late 18th century must have been very small by current standards. Today the typical American male in his early thirties is about 177 cm tall and weighs about 78 kg. Such a male requires daily about 1,800 kcal for basal metabolism and a total of 2,300 kcal for baseline maintenance, which includes 500 kcal for digestion and vital hygiene. If the 18th-century British or French had been that large, virtually all of the energy produced by their food supplies would have been required for personal maintenance; hardly any would have been available to sustain work. To have had the energy necessary to produce the national products of these two countries c. 1700, the 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, on the previous page, provides estimates of the final heights of adult males who reached maturity between 1750 and 1875. It shows that during the 18th and 19th centuries Europeans were severely stunted by modern standards (cf. row 6 of Table 1). Estimates of weights for Europeans before 1860 are much more patchy. Those that are available, mostly inferential, suggest that c. 1790 the average weight of English males in their thirties was about 61 kg, which is about 20 percent below current levels. The corresponding figure for French males c. 1790 may have been only about 50 kg, about a third below current standards.

Switching from a focus on the mean levels of caloric consumption to the consumption distributions associated with these mean levels offers further insight into the extent of chronic malnutrition in Europe at the beginning of the 19th century. Table 2, opposite, shows the exceedingly low level of work capacity permitted by the food supply in France and England c.1790, even after allowing for the reduced requirements for maintenance because of small stature and body mass. In France the bottom 10 percent of the labor force lacked the energy for regular work and the next 10 percent had enough energy for less than 3 hours of light work daily. The English situation was only slightly better.

Table 2 also points up the problem with the assumption that for *ancien régime* populations, a

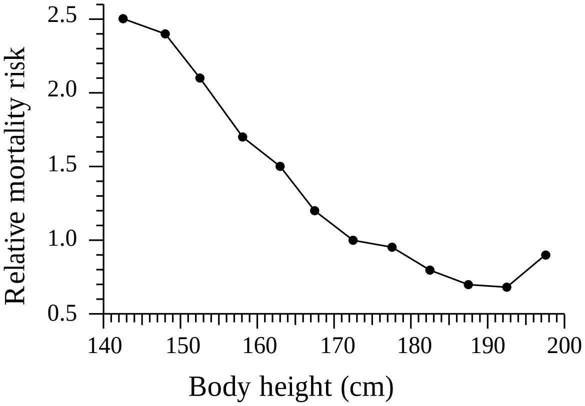
Table 2
A comparison of the probable French and English distributions of the daily consumption of kcals per consuming unit toward the end of the 18th century

Decile	France, circa 1785		England, circa 1790	
	Daily kcal consumption	Cumulative percentage	Daily kcal consumption	Cumulative percentage
Highest	3,672	100	4,329	100
Ninth	2,981	84	3,514	84
Eighth	2,676	71	3,155	71
Seventh	2,457	59	2,897	59
Sixth	2,276	48	2,684	48
Fifth	2,114	38	2,492	38
Fourth	1,958	29	2,309	29
Third	1,798	21	2,120	21
Second	1,614	13	1,903	13
First	1,310	6	1,545	6
$\bar{X}$:	2,290		2,700	
$s/\bar{X}$	0.3		0.3	

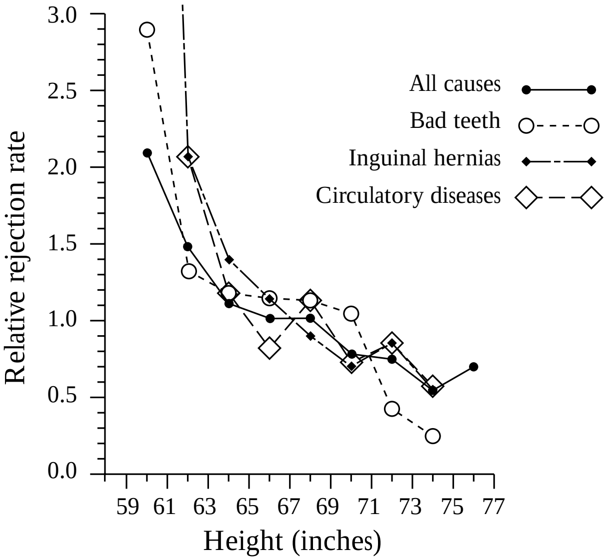
caloric intake that averages 2,000 kcal per capita daily (2,600 per consuming unit) was adequate. That average level of consumption falls between the levels experienced by the French and the English c.1790. In populations experiencing such low levels of average consumption, the bottom 20 percent subsisted on such poor diets that they were effectively excluded from the labor force. Many of them lacked the energy even for a few hours of strolling. Diet appears to be the principal factor explaining why beggars constituted as much as a fifth of the populations of *anciens régimes.* Even the majority of those in the top 40 percent of the caloric distribution were so stunted and wasted compared with U.S. standards that they were at substantially higher risk

Figure 1
Comparison of the relationship between body height and relative risk in two populations

Part A
Relative mortality risk among Norwegian men aged 40–59, between 1963 and 1979



Part B
Relative rejection rates for chronic conditions in a sample of 4,245 men aged 23–49 examined for the Union Army



Sources: For part A, Waaler 1984, for part B, Fogel 1993.

of incurring chronic health conditions and of premature mortality.

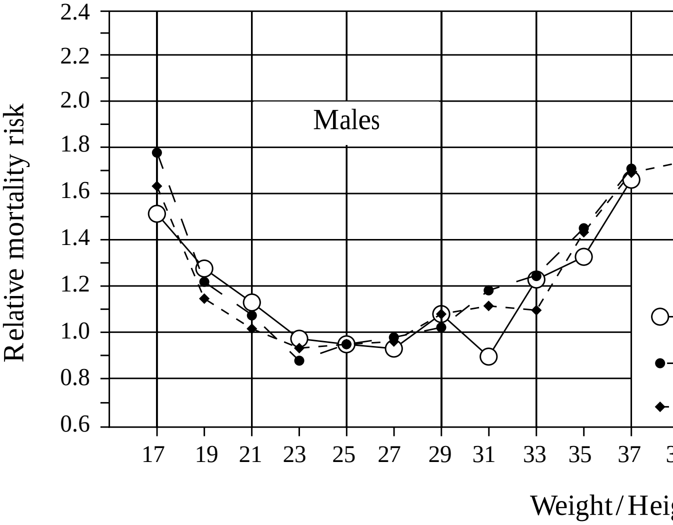
Forecasting trends in mortality and chronic diseases: Waaler surfaces

A number of recent studies have established the predictive power of height and body mass index (BMI, or weight in kilograms divided by height in meters squared, kg÷m^2) with respect to morbidity and mortality at later ages. The results of two of these studies are summarized in Figures 1 and 2. Part A of Figure 1 reproduces a diagram by the Norwegian epidemiologist Hans Waaler. It shows that between 1963 and 1979, short Norwegian men aged 40 to 59 were much more likely to die than tall Norwegian men. Part B shows that height is also an important predictor of the relative likelihood that men aged 23 to 49 would be rejected from the Union Army during 1861–65 because of chronic diseases. Despite significant differences in ethnicity, environmental circumstances, array and severity of diseases, and time, the functional relationship between height and relative risk are strikingly similar in the two cases.

Waaler has also studied the relationship in Norway between BMI and the risk of death in a sample of 1.7 million individuals. Curves summarizing his findings are shown in Figure 2 for both men and women. Within the 22 to 28 range, the curve is relatively flat, with the relative risk of mortality hovering close to 1.0. However, at BMIs of less than 22 and over 28, the risk of death rises quite sharply as BMI moves away from its mean value.

Although Figures 1 and 2 are revealing, they are not sufficient to shed light on the debate over whether moderate stunting impairs health when weight-for-height is adequate. To get at the "small-but-healthy" issue one needs an iso-

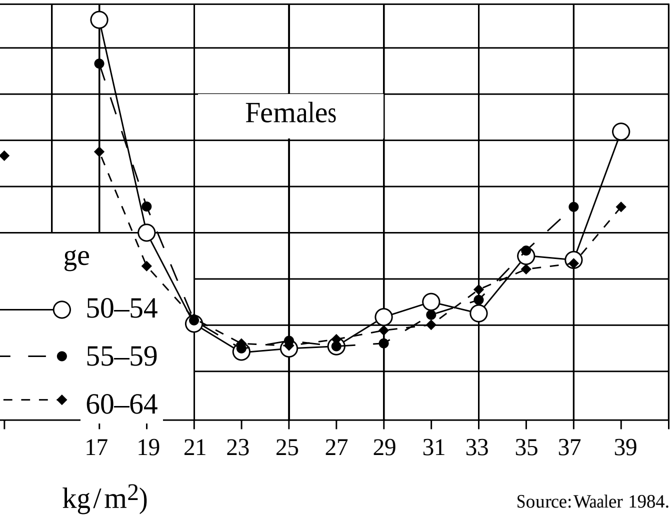
Figure 2
Relationship between BMI and prospective risk
(1963–1979)



mortality surface that relates the risk of death to both height and weight simultaneously. Such a surface, presented in Figure 3, was fitted to Waaler's data. Transecting the isomortality map are lines that give the locus of each BMI between 16 and 34 and a curve giving the weights that minimize risk at each height.

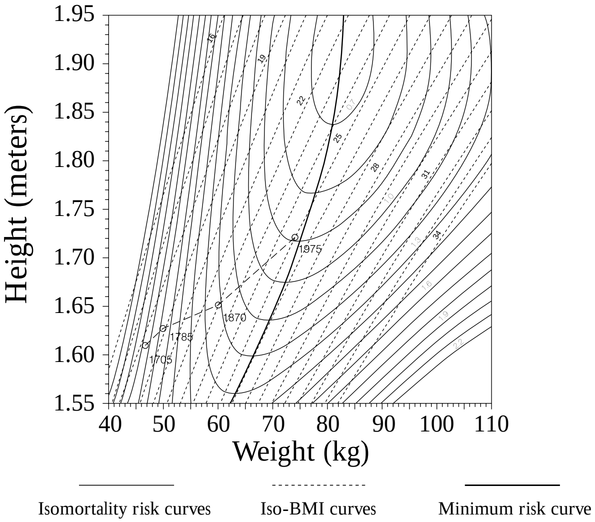
Figure 3 shows that even when body weight is maintained at what Figure 2 indicates is an "ideal" level (BMI=25), short men are at substantially greater risk of death than tall men. Figure 3 also shows that the "ideal" BMI varies with height. A BMI of 25 is "ideal" for men in the neighborhood of 176 cm, but for tall men the ideal BMI is between 22 and 24, while for short men (under 168 cm) the "ideal" BMI is about 26.

Superimposed on Figure 3 are rough estimates of heights and weights in France at four dates. In ong Norwegian adults Aged 50–64 at risk



Source: Waaler 1984.

Figure 3
Isomortality curves of relative risk for height and weight among Norwegian males aged 50–64 with a plot of the estimated French height and weight at four dates



1705 the French probably achieved equilibrium with their food supply at an average height of about 161 cm and BMI of about 18. Over the next 270 years the food supply expanded with sufficient rapidity to permit both the height and the weight of adult males to increase. Figure 3 implies that while factors associated with height and weight jointly explain about 90 percent of the estimated decline in French mortality rates over the period between c.1785 and c.1870, they only explain about 50 percent of the decline in mortality rates during the past century.

The analysis in this section points to the misleading nature of the concept of subsistence as Malthus originally used it and as it is still widely used today. Subsistence is not located at the edge of a nutritional cliff, beyond which lies demographic disaster. Rather than one level of subsistence, there are numerous levels at which a population and a food supply can be in equilibrium, in the sense that they can be indefinitely sustained. However, some levels will have smaller people and higher "normal" mortality than others.

The physiological foundation for Waaler surfaces

What is the basis for the predictive capacity of Waaler surfaces and curves? Part of the answer resides in the realm of human physiology. Variations in height and weight appear to be associated with variations in the chemical composition of the tissues that make up organs, in the quality of the electrical transmission across membranes, and in the functioning of the endocrine system and other vital systems.

Research in this area is developing rapidly, and some of the new findings are yet to be confirmed. The exact mechanisms by which malnutrition and trauma in utero or in 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.

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, such as the impairment of the fetal nervous system due to excess consumption of alcohol or smoking 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. Iodine deficiency in utero and moderate-to-severe iron deficiency during infancy also appear to cause permanent neurological damage.

Not all damage due to retarded development in utero or in infancy that is caused by malnutrition shows up immediately. In a recent series of studies published in the *British Medical Journal*, David Barker and his colleagues at University of Southampton Hospital 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 the mid adult years or later. 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 appears to be linked to inadequate cellular development early in life. Some, but not all, such cases are associated with low birth weight. Some babies are born in the normal weight range but experience below average infant weight gains. In other instances babies are small relative to the size of their placenta, short in relation to the size of their head, or long but thin.

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 dysfunctions includes the degradation of tissue structure, especially in such vital organs as the lungs, heart, and gastrointestinal tract. In the case of the respiratory system, for example, there is not only a decrease in muscle mass and strength but also impaired ventilatory drive, biochemical changes in connective tissue, and electrolyte abnormalities. Malnutrition also has been related to the atrophy of the mucosal cells of the gut, inhibition of wound healing, increased likelihood of traumatic shock and of sepsis, impaired functioning of the endocrine system, increased tendency to edema, electrical instability that can provoke acute arrhythmias, and degenerative joint diseases.

The impact of improved physiology on economic growth

So far I have focused on the contribution of technological change to physiological improvements. However, the process has been synergistic, with improvement in nutrition and physiology contributing significantly to the process of economic growth and technological progress. I alluded to the thermodynamic contribution to economic growth when I pointed out that individuals in the bottom 20 percent of the caloric distributions of France and England c.1790 lacked the energy for sustained work and were effectively excluded from the labor force. Moreover, even those who participated in the labor force had only relatively small amounts of energy for work.

Since the first law of thermodynamics applies as much to human engines as to mechanical ones, it is possible to use energy cost accounting to estimate the increase in energy available for work over the past two centuries. In the British case the thermodynamic factor explains 30 percent of the British growth rate since 1790. The increase in the amount of energy available for work has had two effects. It has raised the labor force participation rate by bringing into the labor force the bottom 20 percent of consuming units, who in 1790 had, on average, only enough energy for a few hours of strolling. Moreover, for those in the labor force, the intensity of work per hour has increased because the number of calories available for work each day increased by about 50 percent.

The physiological factor pertains to the efficiency with which the human engine converts energy input into work output. Changes in health, in the composition of diet, and in clothing and shelter can significantly affect the efficiency with which ingested energy is converted into work output. Reductions in the incidence of infectious diseases increase the proportion of ingested energy that is available for work both because of savings in the energy required to mobilize the immune system and because the capacity of the gut to absorb nutrients is improved, especially as a consequence of a reduction in diarrheal diseases. Thermodynamic efficiency has also increased because of changes in the composition of the diet, including the shift from grains and other foods with high fiber content to sugar and meats. These dietary changes raised the proportion of ingested energy that can be metabolized (or increased the average value of the "Atwater factors," to use the language of nutritionists). Improvements in clothing and shelter have also increased thermodynamic efficiency by reducing the amount of energy lost through radiation.

Moreover, individuals who are stunted but otherwise healthy at maturity will be at an increased risk of incurring chronic diseases and of dying prematurely. In other words, when considered as work engines, they wear out more quickly and are less efficient at each age. The available data suggest that the average efficiency of the human engine in Britain increased by about 53 percent between 1790 and 1980. The combined effect of the increase in dietary energy available for work—and of the increased human efficiency in transforming dietary energy into work output—appears to account for about 50 percent of the British economic growth since 1790.

Forecasting the cost of health care and pensions

Much current research is now focused on explaining the decline in chronic conditions. Part of the emerging explanation is a change in life styles, particularly reduced smoking, improved nutrition, and increased exercise, which appear to be involved in reducing the

Table 3
Comparison of the prevalence of chronic conditions among Union Army veterans in 1910, veterans in 1983 (reporting whether they ever had specific chronic conditions), and veterans in NHIS 1985–88 (reporting whether they had specific chronic conditions during the preceding 12 months), aged 65 and above, percentages

Disorder	1910 Union Army veterans	1983 veterans	Age-adjusted 1983 veterans	NHIS 1985–88 veterans
Musculoskeletal	67.7	47.9	47 2	42.5
Digestive	84.0	49.0	48.9	18.0
Hernia	34.5	27.3	26.7	6.6
Diarrhea	31.9	3.7	4.2	1.4
Genito-urinary	27.3	36.3	32.3	8.9
Central nervous, endocrine, metabolic, or blood	24.2	29.9	29.1	12.6
Circulatory	90.1	42.9	39.9	40.0
Heart	76.0	38.5	39.9	26.6
Varicose veins	38.5	8.7	8.3	5.3
Hemorrhoids[a]	44.4			7.2
Respiratory	42.2	29.8	28.1	26.5
Neoplasms	2.2	13.1	11.5	9.2[b]

[a]The variable indicating if the 1983 veteran ever had hemorrhoids is unreliable.
[b]This is the sum of the prevalence rates of neoplasms of the skin, digestive systems, prostate, and respiratory systems. We have not allowed for the fact that an individual may have multiple kinds of neoplasms, so this number should be interpreted as an upper bound. However, people with multiple neoplasms are more likely to be institutionalized and hence not included in the NHIS.

Source: Fogel, Costa, and Kim 1993.

prevalence of coronary heart disease and respiratory diseases. Another part of the explanation is the increasing effectiveness of medical intervention. Table 3, which compares the prevalence of chronic conditions among two groups of veterans, strikingly demonstrates this point. As the table shows, prior to World War II hernias, once they occurred, were generally permanent and often exceedingly painful conditions. However, by the 1980s about three-quarters of all veterans who ever had hernias were cured of them. Similar progress over the seven decades is indicated by the line on genito-urinary conditions. Other areas where medical intervention has been highly effective include control of hypertension and reduction in the incidence of stroke, surgical removal of osteoarthritis, replacement of knee and hip joints, curing of cataracts, and chemotherapies that reduce the incidence of osteoporosis and heart disease.

The success in medical interventions combined with rising incomes has naturally led to a huge increase in the demand for medical services. Econometric estimates suggest a long-run income elasticity in the demand for medical services across OECD nations in the neighborhood of 1.5. The rapidly growing level of demand, combined with the egalitarian policy of providing medical care at highly subsidized prices, has created the crisis in health care costs that is now such a focus of public policy debates across OECD nations, with various combinations of price and governmental rationing under consideration.

Growing opportunity to improve health at young ages, to reduce the incidence of chronic diseases at late ages, and to cure or alleviate the disabilities associated with chronic diseases raises two other post–Malthusian population issues. One is the impact of improved health on population size. A recent paper pointed out that if mortality rates at older ages continue to decline at 2 percent per annum, the U.S. elderly population of 2050 would be 36 million larger than forecast by the Census Bureau. That possibility poses policy issues with respect to health care costs (because total medical costs may rise sharply even if cure rates continue to improve) and to pension costs (because the number of persons eligible for benefits under present proposed rules and projected levels of compensation will become so large that outpayments will exceed planned reserves).

Some policy makers have sought to meet the pension problem by delaying retirement. Such schemes are based on the proposition that improved health will make it possible for more people to work past age 65. However, the recent findings on the secular improvement in health at older ages make it clear that worsening health is not the explanation for the steep decline since 1890 in labor force participation rates of males over 65. As Dora Costa of MIT has reported, the U.S. decline in participation rates of the elderly over the past century is largely explained by the secular rise in income and a decline in the income elasticity of the demand for retirement. It is also related to the vast increase in the supply and quality of leisure-time activities for the laboring classes.

In Malthus's time, and down to the opening of this century, leisure was in very short supply in the OECD countries and, as Thorstein Veblen pointed out, it was conspicuously consumed by a small upper class. Over the 20th century, hours of work have fallen by nearly half for typical workers. Ironically, those in the top decile of the income distribution have not shared much in this gain of leisure since the highly paid professionals and business people who populate the top decile work closer to the 19th-century standard of 3,200 hours per year than the current working-class standard of about 1,800 hours. Today, the typical worker spends two-thirds as much time in leisure activities as in work and looks forward to retirement.

Given the growing and income-inelastic demand for leisure that characterizes the post–Malthusian milieu of the OECD nations, it remains to be seen to what extent the demand for leisure and retirement can be throttled. Policy makers may encounter as much resistance to efforts to reduce the implicit subsidies for leisure as they have had recently in raising the taxes on work.

Because the process of technophysio-evolution is still in progress it is likely that even the most optimistic life tables now in use substantially underestimate the likely increase in life expectancies over the next two generations. A number of leading analysts now believe that life expectancy at birth may reach 90 to 95 years by 2050. If that forecast holds up, then existing pension plans, not just the government systems but the private ones as well, are seriously underfunded. It is time to reconsider the life tables on which current pension plans are based.

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