Macroeconomics of Disease Prevention in the United States

Prevention of major causes of mortality would alter life table assumptions and economic projections.

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During the first half of this century the health and average life span of Americans improved considerably; epidemics of infectious diseases ceased to be a serious threat, and acute nutritional diseases were greatly reduced (*1*, *2*). More recently, however, the aging of the population and certain life-style habits have brought about increasing rates of chronic illnesses (*3*). Healthy longevity has wide appeal, and over the last three decades the United States has invested an unprecedented portion of national income in the study and care of disease, but the health and longevity of Americans during that time have not shown commensurate improvement (*4*); a 1967 study suggested that neither a rise nor a decline in disease care expenditures would have a further impact on life expectancy (*5*). Of course, purely economic considerations ignore the fact that modern medicine aims beyond simple longevity scores and that it has made real advances, though difficult to measure economically, in improving the patient's quality of life and outlook for hope and in relieving societal and family anxieties about coping with the ill.

Evidence accumulated during the last 20 years indicates that the most important of modern diseases are caused by a variety of factors, most significantly by reckless personal and social habits such as improper diet, excessive drinking, smoking, drug abuse, lack of exercise, unsafe driving and working conditions, and inadvertent and deliberate environmental pollution (*3*). This suggests that at least partial prevention of important diseases may be possible.

Initially prevention can be expected to prolong life in the productive age groups, but with time the lives saved will accumulate in older brackets, aggravating the aging of the U.S. population projected by the current census and augmenting the consequent socioeconomic complications that some experts forecast (*6*, *7*). Here we attempt to assess the economic

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potential of disease prevention and to evaluate some courses of action that may avert undesirable outcomes. Estimates of population changes resulting from disease prevention are introduced into a recognized model of the American economy—the Wharton long-term model (*8*)—to predict their effect on specific and general economic indicators into the next century. The predicted economic impact is compared to that expected if current mortality rates remain unchanged. Naturally, predictions deteriorate as time expands; this analysis, however, has no numerical or normative pretentions; rather, it is intended to provide a signal of the economic trends that may result from an effective disease prevention policy, and of some corrective actions likely to be of use.

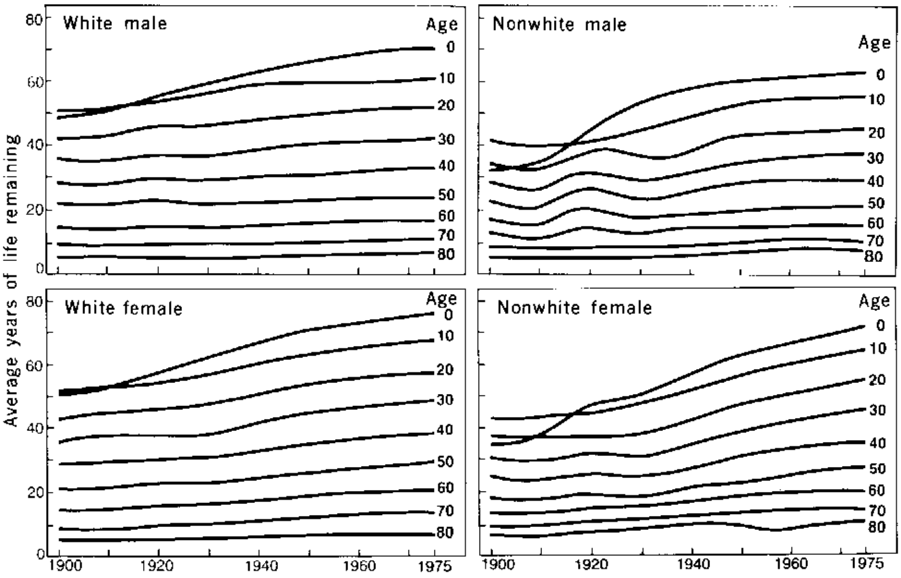

Fig. 1. Trends in life expectancy at different ages for U.S. white and nonwhite populations since 1900. [Data from (*2*)]

Trends in Life Expectancy and Disease Care Costs

Life expectancy trends in the United States since 1900 (Fig. 1) indicate that gains have been small for white males over 30, and only slightly better for the corresponding age groups of white females and for both sexes in the black population. The moderate increases in life expectancy are traceable to the decline of infectious diseases through effective measures of prevention. Not surprisingly, the major gains are observed for the very young and for women of childbearing age in all population groups, reflecting dramatic changes in infant and child survival, reduction of maternal fatalities, and the results of better hygiene, nutrition, and other prevention measures. Improvements were largely completed by 1950, since which time overall trends have stabilized (Fig. 2). Economists note that between 1940 and 1975 the average life span increased 15 percent while per capita disease care expenditures increased 314 percent in constant 1967 dollars (9).

All this seems to imply that if healthy longevity is a desirable goal other ways of accomplishing it in addition to disease care are needed, and lends appeal to a policy of primary disease prevention. Most likely such a policy would run parallel, and not in competition, with current therapeutic interests, because it is doubtful that preventive measures could significantly reduce the cost of disease in the near future. Indeed the dynamics of disease prevention would slowly reduce—but not extinguish—the incidence patterns of chronic diseases as known today, thus increasing life expectancy and perhaps moderating current disease care costs. At the same time, a population of increased age is likely to suffer from new causes of morbidity and mortality, imposing new costs for disease care.

Opportunities for Prevention

Many suggestions and priority analyses have been offered on the actions necessary for a national prevention program. The problem appears to be not so much what to do in prevention as where to direct priorities of funding, resources, training, and legislation (*1–3*, *10*). It would seem natural that these priorities should be determined by epidemiologic evidence identifying the most common, costly, and feared diseases and other causes of morbidity and mortality.

However, with some notable exceptions, current proposals for prevention have dealt with topical issues and not with the development of overall strategies and balancing of priorities. For instance, massive government organizations and funding preside over an unprecedented regulatory effort to protect the environment. Yet, important as this is, it would seem reasonable to think that human health gains from these efforts are likely to be modest, because the epidemiologic record of modern diseases in the United States (Table 1) indicates that an even more determined and massive action is required in respect to diet, smoking, alcohol and drug abuse, and

Table 1. Influence of preventable factors on mortality. Very high (VH), 30 percent; high, 20 to 30 percent; medium, 10 to 20 percent; low, 5 to 10 percent; very low, below 5 percent. [Data from (*1-3*, *11*, *13*)]

Factor	Cause of death: Major cardio-vascular-renal diseases	Malignant neoplasms	Accidents, motor vehicle and other	Respiratory diseases	Diabetes mellitus
Smoking	VH	VH	L	VH	VL
Diet	VH	VH	VL	VL	VH
Occupational hazards	VL	L	VH	H	VL
Alcohol abuse	L	L	VH	L	L
Drug abuse	VL	VL	H	VL	VL
Radiation hazards	VL	L	VL	VL	VL
Air and water pollution	VL	VL	VL	L	VL
	Number of premature deaths				
In 1973	395,000	90,000	44,000	16,000	24,000
In 2000*	595,000	127,000	71,000	33,000	30,000

*If current trends remain unchanged.

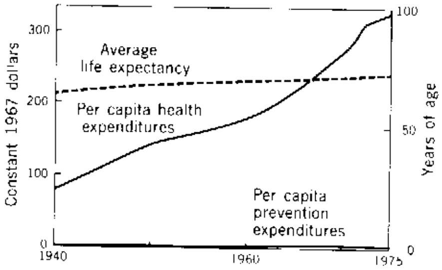

Fig. 2. Life expectancy trend versus national expenditures for disease care since 1940. [Data from (*2, 9*)]

automobile and occupational safety. Such action of course presents greater difficulties than do simple engineering approaches to environmental preservation, because it calls for a conscious commitment to modify life-styles and to reconsider social and economic conventions such as the preoccupation with continuing economic growth and the concept of dutiful labor.

Demographic and Economic Impact of Prevention

The estimates of prevention potential for the major disease categories considered in this study are given in Table 2.

Many studies have produced estimates of absolute prevention potentials for specific diseases by comparing the highest and lowest mortality rates from those diseases throughout the world (*3*). Mortality rates are customarily used because incidence figures from many parts of the world are very unreliable. Mortality is of course affected by the availability of medical care and its quality, but these factors would tend to make estimates of prevention potential for the United States conservative, when based on comparison with countries where medical care is much less substantial.

Critics also point out that when the lowest rates occur in underdeveloped countries they may be the artifact of marginal methods of data collection and of demographic and epidemiologic distortions caused by competing diseases, high infant mortality, and shortened life spans, all of which would make comparison with more developed countries difficult, even after the usual precaution of age standardization. Moreover, critics say, differences in rates in far-apart populations may reflect inborn genetic differences rather than preventable risk factors. These notes of caution are undoubtedly significant, but not to the point of negating the validity of estimates of prevention potential.

For the purpose of our analysis we thought it prudent to arrive at moderate estimates, not so optimistic as to impair the plausibility of the demographic and economic forecasts that follow. Estimates based on mortality variations within the United States were considered, but it was apparent that the life-styles of the nation are rather homogeneous and do not represent the range of possibilities. It was then decided to base the estimates on the difference between U.S. rates and the next-to-the-lowest rates observed in industrialized countries (*11*). This was done because the differences with the lowest rates in countries classified as industrialized (*12*) would have produced estimates that some could consider excessive and because some of the general criticism of such estimates noted above could still be raised validly.

These criteria result in rather conservative estimates: for instance they underrate considerably the potential for preventing diseases related to smoking, because the habit is so pervasive in industrialized countries. It should be noted also that somewhat larger or smaller estimates would obviously modify the numerical results of the forecasts but not the trends and warning message at the core of this analysis.

The increase in life span, if the preventable portion of diseases represented in Table 2 were eliminated, is given in Table 3, based on 1969–1971 U.S. mortality data (*13*). Delayed mortality would have the effect of increasing the survivors in subsequent age groups; the resulting cumulative population effects from 1980 to the year 2000 are shown in Table 4. It is assumed in the calculations that the minimum prevention rates of Table 2 started to be fully and immediately effective in 1975. There is a progressive accumulation of survivors in the higher age groups, which stabilizes sometime in the next century.

Table 2. Mortality from the five major causes, 1973, and prevention potential calculated by comparing U.S. mortality rate with next-to-the-lowest (min) and lowest (max) rates among industrialized countries. [Data from (*2, 11*)]

Causes	Number of deaths	Percent of total mortality	Prevention potential (%)*	
			Min	Max
Major cardiovascular renal diseases	1,012,341	51	39	77
Malignant neoplasms	351,055	18	25	77
Accidents—motor vehicle and other	115,821	6	38	39
Diseases of the respiratory system	92,267	5	17	38
Diabetes mellitus	38,208	2	63	74
All other causes†	363,311	18		

*The minimum estimates have been used in all calculations of prevention effects in this article. †Individual diseases in this category accounted for less than 1.7 percent each of the deaths in 1973.

Table 3. Life expectancy before and after elimination of minimum preventable portion of five major causes of death (*13*).

Age	Remaining years of life expected		Difference (%)
	Before*	After	
0	70.75	74.22	4.90
10	62.57	66.00	5.48
20	53.00	56.41	6.43
30	43.71	46.95	7.41
40	34.52	37.65	9.07
50	25.93	28.84	11.22
60	18.34	20.52	11.89
70	12.00	13.23	10.25
80	7.10	7.94	11.83

*Based on 1969–1971 U.S. mortality data.

Econometric Models

Econometric models have been successfully used for a long time to simulate and to forecast the effect of variable social or environmental conditions. Whatever tools are utilized in macroeconomic modeling, the analysis describes supply, demand, and market-clearing sectors. There are several established macroeconomic models involving supported data bases and equations that are reestimated on a regular basis. Fundamental results of using these different models do not differ greatly. Fromm and Klein (*14*) compared 11 macroeconomic models of the United States and concluded:

> Comparison of solution error and dynamic multipliers of major U.S. econometric models shows, despite some exceptions, that errors are within reasonable bounds and that there is relatively uniform agreement about the pattern and magnitude of fiscal policy impacts.

The Wharton long-term model was selected because it allows easy access to and changing of the input variables and their values (*8*). In this model, changes in the labor force affect employment, which in turn causes consumption, wages, and prices to change; the process then cycles. In its standard format, the model handles the adult population homogeneously by sex, and considers as labor force the population over 16 years of age. Under this assumption, the longevity increases resulting from disease prevention would add considerably to the labor force and possibly to unemployment, and to the constricting effect that a top-heavy age structure would create for the younger groups in the labor force.

To offset the forecast of economic complications that increased longevity is likely to create, two basic input changes have been introduced:

1) The labor force has been restricted to those aged 16 to 65. This has the effect of excluding age groups that would artificially swell estimates of the labor force; it implies the possible need to regulate the employment of the elderly or the desirability of lowering the mandatory retirement age, or both.

2) Transfer payments from the federal government to individuals were deliberately increased as an exogenous input. This is to cover the increased social security benefits that would result from the introduction of the first modification. This increase, artificially added to the model, is an example of some necessary decisions that government might likely face.

The more detailed analysis that follows will be highlighted by the following output variables of the Wharton model, selected for their easily recognized relevance to policy setting. (Many other variables, of more specialized interest, are available.)

1) The gross national product (GNP) is the sum of final products such as consumption, gross investment, government expenditures, and trade balances. It is a conventional measure of productivity in an economy. By expressing GNP in constant dollars or real GNP one can eliminate the effect of price changes and measure only output changes.

2) Housing starts, both single and multiple, are leading economic indicators and are valuable in predicting the scope of the market for new consumer durable goods (appliances, furniture, and so forth). The multiple-unit private housing starts are more sensitive to growth in population, credit conditions, and relative prices as the model now stands. Single-unit housing starts appear less sensitive to growth in population and more sensitive to changes in real disposable income. The value of these housing starts is aggregated to obtain investment in residential structures.

3) The civilian labor force is a measure of the supply of labor and is an important factor of production in our economy. Because the output of a nation at any given moment varies closely with its level of employment, labor force variations are very closely related to GNP. The labor force equations within the model are dependent upon population and labor market conditions. Both male and female labor force equations are sensitive to a lagged distribution of the reciprocal of the unemployment rate. The model suggests that males and females are drawn into the labor force in a nonproportionate way over the course of the cycle.

4) Government receipts, essentially tax receipts, are a quick initial measure to balance whatever governmental costs of a prevention strategy may be (*15*). Their volume is also closely related to GNP and economic growth rates, and to a fiscal policy that the Wharton model assumes remains traditional. In the Wharton model taxes include personal income tax, corporate profits tax, indirect business taxes, and contributions for social insurance.

5) The federal surplus or deficit variable is the difference between federal receipts and expenditures. Our reason for including it is to show the differences between the baseline solution and our various scenarios, particularly with reference to the effects of increased transfer payments as well as the population changes.

Table 4. Age-specific population increases (thousands) over current census projections if total elimination of minimum preventable portion of five major causes of death started in 1975.

Age bracket	1980	1985	1990	1995	2000
10-19	13.8	29.8	54.8	74.0	80.0
20-29	71.1	110.1	116.4	119.0	139.4
30-39	59.5	143.0	229.7	273.0	264.6
40-49	94.4	164.4	254.0	369.7	483.4
50-59	351.8	507.5	575.4	678.3	864.4
60-69	607.3	1114.0	1439.9	1509.9	1534.8
70-79	504.6	1065.0	1538.9	1974.9	2206.8
80+	430.1	963.8	1279.5	1683.1	2060.6

Table 5. Change in Wharton model forecast based on full achievement of minimum prevention potential starting in 1975. Upper figure in each pair is percent difference, lower figure is numerical difference.

Item	1980	1985	1990	1995
Gross national product	0.8	1.4	0.5	−4.7
(billions of 1972 dollars)	(11.5)	(24.1)	(9.2)	(−106.4)
Private housing starts	12.4	14.7	0.8	−31.6
(thousands of units)	(191.0)	(208.8)	(11.6)	(−547.9)
Multiple-unit housing starts	27.3	25.2	13.4	8.4
(thousands of units)	(155.7)	(144.7)	(78.5)	(64.8)
Civilian labor force	1.6	2.7	3.4	3.8
(millions)	(1.6)	(3.0)	(3.9)	(4.6)
Unemployment	14.9	27.3	40.7	126.2
(millions)	(1.1)	(1.8)	(2.7)	(7.4)
Government receipts	0.7	1.3	5.1	−2.8
(billions of 1972 dollars)	(3.8)	(8.5)	(0.7)	(−22.3)
Transfer payments	2.0	2.8	2.1	−2.4
(billions of 1972 dollars)	(2.6)	(4.1)	(2.0)	(−4.5)
Supplemental unemployment insurance benefits	16.7	32.2	48.8	156.9
(billions of 1972 dollars)	(1.8)	(2.7)	(4.2)	(11.4)

Table 6. Age-specific population increases (thousands) after gradual elimination of minimum preventable portion of major causes of death. Complete attainment by the year 2000 according to a cumulative normal function starting in 1975 is assumed.

Age bracket	1980	1985	1990	1995	2000
10-19	0.0	0.6	27.1	73.2	80.0
20-29	0.2	4.2	26.1	64.5	115.8
30-39	0.1	3.7	28.6	94.4	157.8
40-49	0.2	6.2	48.7	155.8	267.4
50-59	0.9	20.6	128.5	368.3	630.2
60-69	1.4	36.3	248.8	683.6	1053.6
70-79	1.0	27.4	200.1	688.6	1221.4
80+	1.0	44.7	253.2	717.2	1170.4

Table 7. Change in Wharton model forecast after gradual elimination of minimum preventable portion of major causes of death starting in 1975. In column a, labor force includes all persons aged 16 and over; in column b, labor force includes ages 16 through 65; in column c, labor force includes ages 16 through 65 and transfer payments have been increased to compensate for additional social security recipients. Upper figure in each pair is percent difference from standard Wharton forecast, lower figure is numerical difference (23).

Item	1980			1985			1990			1995			2000		
	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
Gross national product	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.1	0.3	0.9	0.3	1.0	0.3	0.1	0.7
(billions of 1972 dollars)	(0.0)	(0.0)	(0.0)	(0.7)	(0.3)	(0.8)	(5.9)	(2.3)	(6.5)	(19.6)	(7.1)	(22.7)	(7.3)	(1.3)	(19.7)
Private housing starts	0.0	−0.0	0.0	1.0	0.4	0.4	5.4	2.1	3.4	11.4	4.4	8.8	4.1	1.5	5.6
(thousands of units)	(0.1)	(−0.1)	(0.1)	(13.6)	(5.0)	(6.3)	(81.9)	(31.9)	(51.6)	(198.5)	(76.4)	(152.9)	(98.5)	(35.0)	(133.1)
Multiple-unit housing starts	0.0	−0.0	−0.0	2.2	0.8	0.8	11.4	4.5	4.4	19.1	7.3	7.2	13.6	5.2	5.2
(thousands of units)	(0.0)	(−0.1)	(−0.1)	(12.7)	(4.7)	(4.6)	(66.4)	(26.0)	(25.5)	(147.6)	(56.7)	(55.8)	(128.7)	(49.4)	(49.2)
Civilian labor force	0.0	0.0	0.0	0.1	0.0	0.0	0.6	0.2	0.3	1.7	0.7	0.7	2.5	1.0	1.1
(million)	(0.0)	(0.0)	(0.0)	(0.1)	(0.0)	(0.0)	(0.7)	(0.3)	(0.3)	(2.0)	(0.8)	(0.8)	(3.2)	(1.2)	(1.4)
Unemployment	(0.0)	(0.0)	(0.0)	(1.4)	(0.5)	(0.3)	7.3	2.9	0.9	21.3	8.4	−0.4	44.7	17.7	3.6
(million)	(0.0)	(0.0)	(0.0)	(0.1)	(0.0)	(0.0)	(0.5)	(0.2)	(0.1)	(1.3)	(0.5)	(−0.0)	(2.3)	(0.9)	(0.2)
Government receipts	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.4	0.9	0.3	1.2	0.7	0.2	1.4
(billions of 1972 dollars)	(0.0)	(0.0)	(0.0)	(0.3)	(0.1)	(0.3)	(2.1)	(0.8)	(2.5)	(7.1)	(2.6)	(9.3)	(6.0)	(1.7)	(12.4)
Federal surplus or deficit (−)	0.0	0.0	0.0	1.5	0.6	7.7	1.6	1.3	75.2	−59.2	−19.9	201.4	−65.5	−23.4	53.7
(billions of 1972 dollars)	(−0.0)	(−0.0)	(−0.0)	(−0.1)	(−0.0)	(−0.4)	(−0.0)	(−0.0)	(−2.1)	(1.5)	(0.5)	(−5.0)	(6.9)	(2.5)	(−5.7)
Transfer payments	0.0	0.0	0.0	0.1	0.1	0.4	0.6	0.3	2.1	1.4	0.6	5.9	0.8	0.3	8.6
(billions of 1972 dollars)	(0.0)	(0.0)	(0.0)	(0.2)	(0.1)	(0.5)	(1.1)	(0.4)	(3.6)	(2.6)	(1.0)	(10.8)	(1.7)	(0.6)	(17.9)
Supplemental unemployment insurance benefits	0.0	0.0	0.0	1.6	0.6	0.4	8.5	3.4	1.0	26.0	10.2	−0.4	56.5	22.2	4.7
(billions of 1972 dollars)	(0.0)	(0.0)	(0.0)	(0.1)	(0.1)	(0.0)	(0.7)	(0.3)	(0.1)	(1.9)	(0.7)	(−0.0)	(3.5)	(1.4)	(0.3)

6) Transfer payments are expenditures of the government for which it receives no goods or services in return. Our analysis is concerned only with transfer payments from the federal government to persons. In effect, transfer payments alter private goods production in favor of the recipients of the payments and augment the flow of income. Supplemental unemployment insurance benefits are transfer payments from the federal government to persons and are dependent upon the number of unemployed.

Economic Forecasting

Introducing the population changes of Table 4 into the Wharton model results in some initial economic gains as the initial survivors cumulate in productive age groups, followed by a rapid deterioration as the demographic surge reaches older brackets. However, it is difficult to accept at face value the rather dismal forecast of Table 5, because it is conceivable that, among other things, the cycling mathematical features of the Wharton model may overreact to so rapid and abnormal a swelling of an aging labor force; even with a fully sound forecast it is unlikely that the postulated prevention scenario could ever be realized so suddenly. Thus the significance of Tables 4 and 5 is very hypothetical. Table 4, however, gives a credible assessment of the substantial demographic losses to be expected from the diseases considered if current mortality trends are left unchanged.

A more realistic appraisal of prevention consequences —and one that would avoid dynamic stresses in the Wharton model—considers that prevention policies are likely to be implemented only gradually, the earliest effects beginning after a delay of many years; a plausible if optimistic forecast would be that total effectiveness in the elimination of premature mortality from the preventable portion of diseases could be achieved by the year 2000, probably following a cumulative normal function (16). Such a period of time would be necessary for any prevention scheme to have its full impact, whether that means the partial elimination of one disease or complete elimination of another. Table 6, based on this scenario, shows the calculated population gains for different age groups from the present to the year 2000 resulting from the gradual elimination of the minimum preventable portion of the diseases listed in Table 2.

Introduction of these demographic changes into the Wharton model yields the economic forecast of Table 7, columns a, up to the year 2000. Life expectancy will increase for all ages, but change will be most evident in the groups between 40 and 80 years. Initially the economic sector will show the effect of lives saved during the productive years with gains in gross national product and government revenues, increases in living and housing requirements, and so on. However, the growing increase in the retired population could result in economic difficulties. Pension funds and social security payments would be required by a greater segment of the population than is now forecast, necessitating increases in taxes to meet future retirement expenditures, while the work force may not increase accordingly. In addition, unemployment would be likely to rise, as old people are limited in available job opportunities.

If we compare the hypothetical situation of Table 5 and the more realistic one of Table 7, columns a, it is clear that a less rapid achievement of prevention may retard but probably could not alone reverse the recessive trends forecast. These trends are particularly evidenced by a massive increase in unemployment and in the related insurance benefits. The Wharton model considers as labor force the population above 16 years of age. This assumption is somewhat justified by current practices of employment after age 65, but a possible action to contain the surge of elderly workers that disease prevention would produce is to impose mandatory retirement at age 65. Columns b of Table 7 give the Wharton model solution if the labor force input from Table 6 is limited to the ages between 16 and 65. Predictably the unemployment forecasts drop, but because the earnings of the elderly would also drop the model also predicts a progressive economic slump, with lower GNP, housing starts, and government receipts.

Traditionally, government has assumed an effective role in influencing demand and supply, and it would seem reasonable to postulate that such measures could improve the forecast of Table 7. Indeed it is reasonable to expect that total government transfer payments to individuals would be increased to reflect the changing number of social security recipients, and this change alone would restore economic balance, as columns c of Table 7 predict.

Not surprisingly then, disease prevention would create demographic pressures that would require appropriate fiscal and monetary tuning to avoid a recessive potential. As a particular example, disease prevention will have a major impact upon our social security system. In fiscal 1976 approximately 95 percent of the people aged 65 and over and 58 percent of those aged 62 to 64 were eligible for social security. The number of beneficiaries projected from those percentages is shown for every fifth year between 1980 and 2000 in Table 8. The Social Security Administration estimates a social security tax rate of 11.8 percent to be necessary between 1976 and 2000 to prevent a budget deficit, by forecasting dependency ratios, that is, the number of working-age people needed to support a retirement-age person at different time periods (*17*). With the projected life expectancy increases and resultant population changes from a prevention strategy that would attain full efficiency by the year 2000 the rate would be 13.4 percent (Table 8). This estimate is crude but it suggests the magnitude of the impact that a disease prevention policy would have on the social security system.

Table 8. Social security beneficiaries (thousands) before and after gradual elimination of minimum preventable portion of major causes of death.

Year	Before	After	Difference (%)
1980	26,527	26,530	0.01
1985	28,914	29,007	0.32
1990	30,995	31,599	1.95
1995	32,096	33,908	5.65
2000	32,446	35,442	9.23
	Tax rate needed (%)		
	11.81	13.41	13.55

Invoking legislative or monetary remedies for the potential problems of an increased aging population and labor force may appear simplistic and almost naive. Also, the Wharton model, like other such models, functions according to the rules of today and assumes social, political, and legislative continuity, which is clearly an uncertain prospect. The significance of the model rests not on numerical accuracy but rather in suggesting the directions and general degree of change, for which only broad corrective measures can be anticipated a priori.

In considering the structural constraints of the Wharton model, other observations come to mind.

The model does not handle the health care system as a separate sector, and as such it does not take account of changes in disease care expenditures due to the elimination of any given disease or to changes in population composition; nor does it include the cost of prevention strategies.

Limitation of a major cause of death by a successful prevention strategy could have several effects for the health care system. First, the population will become older, and the elderly tend to have more physician visits and more and longer hospital episodes (*18*). Second, if a disease is curtailed, demand for particular services may decrease. Providers may then raise prices, especially as over 88 percent of the population has its hospital bills paid by third parties (*19*), or the supply may create its own demand (*4*, *20*). Lastly, competing risk factors may appear; elimination of one disease could result in the increase or development of other health problems, although at later ages (*21*).

Such developments and others could affect the economics of the disease care system, which currently absorbs nearly 10 percent of GNP and is likely to continue to expand (*22*). Prevention would also alter a variety of factors of economic significance, in ways that are not easily analyzed and that the Wharton model—or any other model—could hardly incorporate at this time. These include patterns of morbidity and disability, the demand for recreation and education, and the relative importance of manufacturing and service industries (*7*), to mention but a few.

To study these numerous interactions is beyond the scope of our analysis, which simply points to the need to consider the dynamic interplay of health, disease, and the economy. Moreover, retrospective studies, however revealing, tell of things past and of scenarios not likely to be played out again; matching them with some judicious prospecting seems desirable, and we hope we have encouraged such a trend.

Summary

Disease prevention is not a prescription for immortality, but it could prolong life expectancy to where the ultimate exitus is determined by what we now consider to be natural deterioration of vital functions in old age. Prevention of some significant fraction of current causes of morbidity and mortality in the United States appears possible, with the potential of extending useful and healthy longevity.

It is by no means clear that prevention of what are now the major causes of morbidity and mortality can reduce the costs of disease care, because a surge of competing causes is likely as the population becomes older. Longevity gains are more predictable.

If current social, legislative, and economic rules remain unchanged, a successful policy of disease prevention has a recessive economic potential, as more people will reach and live well beyond retirement age. The prospect, however, of longer and healthier lives is one for which advanced societies are likely to be willing to make the necessary social and economic adjustments. The necessary adjustments, if foreseen in good time, need not be traumatic, because mortality and morbidity changes from disease prevention would evolve through slow secular trends. Among changes to be expected is a major restructuring of the financing of old age pensions and social security.

A comprehensive policy toward health and longevity gains would imply an efficient organizational framework for disease prevention, and a vigorous research commitment to the clarification of competing etiologic factors of morbidity and mortality, of preferred control strategies, and of better therapeutic approaches.

References and Notes

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   The Wharton Annual and Industry Forecasting Model is composed of eight sectors: the final demand sector, the input-output sector, the labor requirements sector, the wage sector, the industry price sector, and final demand prices sector, the other income sector, and the monetary sector.

   The final demand sector basically comprises consumption, investment, foreign trade, and government spending. It consists of 131 equations and identities. Consumption is assumed to be dependent upon income, prices, wealth, credit conditions, and tastes. There are 11 consumption functions. Investment is modeled upon neoclassical theory, being dependent upon capital stock outputs, user costs, and sector prices. Currently investment is disaggregated into 26 separate industries and as may be expected is highly dependent upon the input-output sector. Foreign trade is also connected to the input-output sector but is somewhat more aggregated, consisting of six stochastic equations. Government spending is actually six sectors: two for the federal expenditures and four for state and local. In effect, the final demand sector determines the economy's final product and its results are fed into the input-output sector. Once industrial output levels have been determined which satisfy the expenditure levels coming from the final demand side, many of these indicators are fed directly back into the demand side of the model.

   The input-output sector actually contains 47 subsectors based upon "the Bureau of Economic Analysis 1967 Input/Output Table of the U.S. Economy." They form the link between final demand and the industrial outputs. The coefficients in the table are revised when necessary to reflect changes in prices and technology. The output then influences labor requirements, prices, and investments.

   The labor requirements sector is broken down into 28 manpower requirement functions, including 5 nonmanufacturing and 21 manufacturing functions. (All government employment, including the military, is exogenous.) The more important independent variables of these functions are output, capital stock, and technological change. Actually this sector is concerned with manpower requirements in terms of employment and man-hours. Both are determined by using Cobb-Douglas production functions.

   Population comes into play in this sector. The labor force equations, both male and female, are dependent upon population and a lagged distribution of the reciprocal of the unemployment rate to measure job availability. The equations also include trends for increasing female participation and a somewhat decreasing male participation. Unemployment is then determined by subtracting the labor requirements from the labor force and the unemployment rate calculated. Employment results lead into wage and price sectors.

   The wage or price-of-labor sector contains 28 subsectors, as does the labor requirements sector, and estimates total compensation. Independent variables used in this sector include prices, productivity, labor market conditions along with Phillips curve effects and lead or lag relationships of various industries' wages because of union strength or weakness, and so forth. The results of this sector are fed into personal income and the price sector.

   The industry price sector is also disaggregated into 28 subsectors. These equations estimate price deflators that are value-added deflators which are consistent with GNP measures as opposed to wholesale price concepts. The sectors that influence this one are the input-output sector, the production functions, investment functions, and the wage sector. Output from this sector feeds the investment sector and the final demand prices sector.

   The final demand prices sector takes results from the input-output table and weighs the respective sector prices with them. All intermediate goods used in making a final product are then averaged, the weighted results being the final demand prices.

   The other income sector includes depreciation, nonwage income, inventory valuation adjustments, dividends, transfer payments, and taxes. Transfer payments are exogenous except for state unemployment insurance benefits. Taxes are divided into personal income, corporate profits, and indirect business taxes, and social insurance—all on both a federal and a state and local level.

   The last major sector is the monetary, which estimates various bank deposits and interest rates. These outputs have influence on consumption and investment.

   Currently the model has 265 stochastically estimated equations, 207 exogenous variables, and 324 identities. While the model is solved in sections, there are, as noted, feedbacks. However, the model is solved in essentially the same order that the sectors are listed in above.
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    The prevention potential estimate is based on the comparison of U.S. mortality rates for the causes of death of interest with the rates in other "developed market economies." The countries considered are Canada, Mexico, Japan, Denmark, Finland, France, Federal Republic of Germany, Iceland, Italy, Netherlands, Norway, Switzerland, England and Wales, Scotland, Sweden, Portugal, Austria, Luxembourg, Belgium, Australia, and Israel.

    A comparison of rates was made and it was observed that there was often a very large gap between the lowest rate and the second lowest and that the gap between the second and third lowest rates was usually small. Because of this and in order to be conservative in approach, we used the second lowest mortality rate by cause of death in our calculations. The countries that had the second lowest rates for the given causes of death were Canada, Iceland, Israel, Japan, Norway, and Portugal.

    These second lowest rates were expressed as percentages of the respective U.S. rates and then subtracted from 100 percent to arrive at what we define as the minimum prevention potential. The maximum prevention potential is the value obtained when the death rates of the lowest mortality rate countries are used.

    Actual comparisons by country were made of sex-specific death rates. When the second lowest death rate for males from, for example, malignant neoplasms was determined, age-specific comparisons were made between that country and the United States. In cases where the United States had a lower age-specific death rate for a particular age group, it was used in our further calculations. When the other country's rate was lower for a particular age group, it, of course, was used.
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    $${}_np_{x,-i} = {}_np_x^{(1-a)}$$

    where $a = {}_nr_{x,i}$. The equation defines the probability of survival for a person aged x to $x + n$ years, given the i^{th} cause of death eliminated; ${}_nr_{x,i}$ is the proportion of deaths recorded during the 3-year period 1969-1971 in the age interval x to $x + n$ attributable to the i^{th} cause of death. This equation can be made to handle the elimination of more than one disease at a time by simply defining the cause of death to include two or more causes. For example, diseases of the heart are a cause of death which includes other causes such as ischemic heart disease, acute myocardial infarction, and so on. Since we do not assume any cause of death to be eliminated completely, we define r to include only those deaths which were assumed to be preventable on the basis of factors obtained from (*11*). The program we used in creating the life tables was essentially the same as that written by R. Foster, Office of the Actuary, Social Security Administration, for the National Center for Health Statistics Life Tables.
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    $$PA - \int_{1975}^{x} [1/(3.25 \times \sqrt{2\pi})] \times \exp[-(x - 1987.5)^2/21.125]\, dx$$

    That is the equation for a cumulative normal distribution with a mean of 1987.5 and a standard deviation of 3.25.
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