Volume Title: Investment in Human Beings

Volume Author/Editor: Universities-National Bureau Committee for Economic Research

Volume Publisher: The Journal of Political Economy Vol. LXX, No. 5, Part 2 (University of Chicago Press)

Volume ISBN: 0-87014-306-9

Volume URL: http://www.nber.org/books/univ62-3

Conference Date:

Publication Date: October 1962

Chapter Title: Health as an Investment

Chapter Author(s): Selma J. Mushkin

Chapter URL: http://www.nber.org/chapters/c13577

Chapter pages in book: (p. 129 - 157)

HEALTH AS AN INVESTMENT

SELMA J. MUSHKIN[1]
Advisory Commission on Intergovernmental Relations, Washington, D.C.

A THEORY of human capital is in the process of formulation. The primary question is "What is the contribution of changes in the quality of people to economic growth?" The academic economists first raised the question after their research showed that production in developed economies had been increasing much faster than could be explained by inputs of physical capital and additions to the labor force.[2] But the wide interest which the question has aroused indicates much more than academic curiosity. It reflects the desires and aspirations of people throughout the world—people anxious to add weight to their demands for action against disease and illiteracy by showing that such action is not only humanitarian, but will make a major contribution to economic growth as well. Though research on the return to investment in people is barely getting started, even the most tentative conclusions have been widely quoted. Preliminary indications that the rate of return on investment in people is high have been seized upon in a growing number of countries as justification for including investment in people in economic development programs.

In 1961 two important international conferences were held on investment in people as a facet of economic development.[3] One of these discussed health programs, the other education. Given the climate of thought today it seems difficult to imagine that only four years ago authorities writing on economic development, with few exceptions, omitted consideration of investments in people. A footnote in one such volume may be cited as illustrative. In explaining the omission, the authors write, "once one leaves the *terra firma* of material capital and branches out into the upper aether of human capital there is endless difficulty in finding a resting place."[4]

Research leading toward a theory of human capital formation has been largely pioneered by Professor Theodore W. Schultz and supported by the Ford Foundation's Fund for the Advancement of Education. This work centers on investment through education. Basic economic research on investment through health programs is receiving far less attention, and sustained financial support for such research is even at this time uncertain. But out of the work that Schultz has done and the work of others whom he has encouraged has come a better under-

[1] This article necessarily was prepared in a short period of time. The views expressed are the author's own and do not necessarily accord with those of the Advisory Commission on Intergovernmental Relations.

The author is indebted to I. M. Labovitz for his insistence on somewhat less speed and more clarity, and to Alice Rivlin and Burton Weisbrod for their comments on the first part of this paper.

[2] S. Fabricant, *Basic Facts on Productivity Change* ("Occasional Papers," No. 63 [New York: National Bureau of Economic Research, 1959]), and R. M. Solow, "Technical Change and the Aggregate Production Function," *Review of Economics and Statistics*, Vol. XXXIX (August, 1957).

[3] World Health Organization and Pan American Sanitary Bureau, thirteenth meeting of Directing Council, October, 1961, Washington, D.C.; and the OEEC Policy Conference on Economic Growth and Investment in Education, Washington, D.C., October 16–20, 1961.

[4] P. T. Bauer and B. C. Yamey, *The Economics of Underdeveloped Countries* (Cambridge: Cambridge University Press, 1957), p. 27.

standing of the economic processes that apply to health programs as well as to education. The far more intensive work on education as an investment suggests that it may be useful to start this paper with a comparison of health and education as types of investment. The first part of this paper, therefore, states briefly some of the similarities between the two programs, as well as characteristic differences between them.

The second part deals with capital formation through health care and returns to investment in health. Some empirical work on specific diseases has been done; work has also been done on the over-all problems of disease. Although I do not review these specific empirical studies, I attempt to summarize the basic assumptions underlying their estimates and to point to examples of the "payoff" on investment in eradication of disease.

Throughout I address myself to the economic effects of health programs—public and private, curative and preventive. Promotion of health patently involves more than health services and the related commodities used in the provision of these services. It includes food, housing, recreation and clothing. Although they contribute importantly to health, the present inquiry is limited to investment in health services and their component commodities. It appears necessary, however, in the present context to include water supplies among the investments in health. Environmental health programs, including safe water supplies, are largely responsible for the rate of decline in death rates in the United States between 1900 and 1917. In this period the over-all age-adjusted death rates decreased at 1.074 per year, a higher rate of decrease than took place in the subsequent period 1921–37. Diseases that can be controlled through sanitation and safe water supplies—typhoid, diarrhea, and dysentery—are among the major diseases today in the underdeveloped countries which give a high priority to investment in water supplies and sanitation.

I. EDUCATION AND HEALTH: SIMILARITIES AND DIFFERENCES

The concept of human capital formation through both education and health services rests on the twin notions that people as productive agents are improved by investment in these services and that the outlays made yield a continuing return in the future. Health services, like education, become a part of the individual, a part of his effectiveness in field and factory. The future increase in labor product resulting from education or from health programs can be quantified to an extent useful for programming purposes. While there are apparent limitations to such measures, these limitations can be identified.

COMPLEMENTARY CONTENT OF INVESTMENT

Health and education are joint investments made in the same individual. The individual is more effective in society as a producer and as a consumer because of these investments. And often the return on investment in health is attributed to education.

The interrelations between health and education are many, as suggested by the illustrations which follow. Some types of health programs essentially depend upon education in personal hygiene and sanitation. On education falls responsibility for training of health personnel (both professional and ancillary) to provide the health services. A child's formal schooling is impossible unless he is well enough to attend school and to learn. Loss in

days of schooling due to ill health, which in the United States in 1958 averaged 8.4 days per school year, reduces the effectiveness of investment in education. And death of children of school age adds to the cost of education per effective labor-force member. A lengthening of life expectancy through improved health reduces the rate of depreciation of investment in education and increases the return to it. An increase in productive efficiency through improved education, on the other hand, increases the return on a lifesaving investment in health.

It is a fairly simple bit of arithmetic to determine the differences in human capital formation through education, given the mortality experience of the early 1900's and today. Differences in years of work expectancy on the average between two periods will change the value of lifetime income differentials between the high-school and the college graduate, for example. It is also simple arithmetic to compute the value of future earnings, on the average, of a death postponed to old age when the number of years of schooling approximates the norm of the early 1900's and the norm of today. But far more difficult is the problem of assessing the loss to the country from the early death or incapacity of a would-be inventor, scientist, or political leader. What would have been the loss if Einstein had died during the flu epidemic following World War I, or had Keynes' last work been his *Treatise on Money?*

Educational levels determine to a large extent the seeking out of health services and the selection of appropriate kinds of services. A large body of information exists pointing to a high correlation between use of health services and educational status.[5] And one of the major health problems that confronts public health officers is education of groups in the community to use available public services, for example, Salk vaccine. Delays in seeking care, due to ignorance, intensify disease problems and convert cases that could be prevented or controlled into serious disabilities or premature deaths.[6]

Health services are similar to education, too, in that they are partly investment and partly consumption, and the separation of the two elements is difficult. An individual wants to get well so that life for him may be more satisfying. But also when he is well he can perform more effectively as a producer. What part of the expenditure made to cure his illness is a consumption expenditure, and what part is an investment in a producer? The type of issue involved is familiar to those who have been working on investment in education.

As consumer goods, both education and health are extraordinary. They are not sought simply to satisfy human wants but are essential ingredients of human welfare. The distinction I have in mind was made several years ago by Munoz-Marin, the governor of Puerto Rico, when he proposed an "Operation Serenity" through which society "would use its economic power increasingly for the extension of freedom, of knowledge, and of understanding imagination rather than a rapid multiplication of wants." Levels of education and health are implicit components of a standard of living.[7] When

[5] E. L. Koos, *The Health of Regionville: What the People Thought and Did about It* (New York, 1954).

[6] J. W. Bergsten, "Volume of Physician Visits, U.S., July 1957–June 1959," *Statistics from the U.S. National Health Survey* (Ser. B-19 [Washington, 1960]).

[7] World Health Organization, "Measurement of Levels of Health" (Technical Report No. 137, 1957), and United Nations, International Labour Office, and UNESCO (jointly), "Report on International Definition and Measurements of Standards and Levels of Living" (Committee of Experts E/CN./179, 1954).

man does not have sufficient vitality to function normally, other consumption loses its significance, and without education the distinctive qualities of the human being are lost.

Return to investment in both health and education accrue in part to the individual who makes the investment and in part to other individuals. Purchase of health services for the prevention of contagious and infectious diseases, such as smallpox, poliomyelitis, and whooping cough, benefits the community as a whole. Curative health services, such as those for the treatment of tuberculosis or syphilis, help prevent the spread of the disease; thus an individual's purchase of services for his own care benefits his neighbors. By his improved health status and by that of his neighbors the productivity of the economy is increased.

Health, like education, is being financed largely out of current consumption funds. Denison has pointed out that whether the individual spending for education thinks of himself as consuming or investing is not so important as whether the resources used for financing the services have come from consumption funds or investment funds.[8] He emphasizes that funds used for education—both public and private—largely reduce consumption and thus make a positive net contribution to economic growth. Educational outlays, assuming this diversion of funds from consumption to investment, increase the total volume of investment even if the rate of return on educational investment is considerably lower than that on investment in physical capital. Denison's observations on the sources of educational funds apply by and large to sources of health funds as well. But here we have the perhaps curious juxtaposition of circumstances that funds, at least in the United States, are withdrawn from alternative investments primarily to finance those health-service costs that most clearly could be classified as consumption—costs of major medical incidents that lead to disabling chronic illness and to death.

It must be remembered that health and education services in most countries are financed in part through the public sector of the economy and in part through the private sector. The mixture of public and private varies widely, however, from nation to nation, and the mix may not be the same for health as it is for education within a nation. Expenditures for health in the United States amount to more than $25 billion; expenditures for education also are about $25 billion. But public outlays for health account for less than 25 cents of each $1 spent; and private outlays for the remaining more than 75 cents. In the case of education the proportions are reversed; about 80 cents of each $1 of educational costs is publicly financed and about 20 cents privately financed.

DIFFERENCES BETWEEN HEALTH AND EDUCATION

There are these important similarities between health and education as investments. But the differences between them necessitate different approaches to the problem of measurement of human capital. As I see the differences, they are:

1. Health programs increase the numbers in the working force as well as the quality of labor's product. Education chiefly affects quality of the producers. The people added to the work force through a reduction in number of deaths and in disability provide a direct measure of the units of labor resulting from im-

[8] E. F. Denison, *The Sources of Economic Growth in the United States and the Alternative before Us* (New York: Committee for Economic Development, 1962).

provement in health status. By valuing these added workers at the present value of their future earnings, the capital stock in health status can be determined. This is analogous to valuing physical capital, such as real property, on the basis of its rental income. But as indicated below, the health-program content of this health status is difficult to disentangle from other factors affecting health of a population. And valuation of changes in quality of the work force attributable to health programs presents an additional problem.

The number of potential workers that may be added through health programs is especially large in the non-industrial nations. Average life expectancy at birth in many nations of Asia and Africa—nations that include almost two-thirds of the world population—was until recently about thirty years. This may be contrasted with almost seventy years of life expectancy achieved in the United States. Large increases in life expectancy for these non-industrial nations can be brought about quickly and with fairly small direct outlays. Spraying with DDT, immunization with BCG, and treatment with penicillin have yielded dramatic results in reduced mortality from malaria, tuberculosis, syphilis, and yaws. An intensification of programs to control these diseases could reduce death rates rapidly.

2. Units of quality change through human capital formation by health programs cannot be defined as tidily as units of education embodied in the labor force. There is no quality unit comparable to that of the number of years of schooling, devised by Schultz as a measure of educational stock in the labor force.[9] To assess the quality changes resulting from the health-program content embodied in the labor force, a positive measure of health status would be required. The most frequently used indexes of health status, however, are negative—death rates and morbidity rates that reflect changes in numbers rather than quality. There are two other types of indexes in use: first, measures of the relative availability of health facilities, for example, the number of physicians or the number of hospital beds per 1,000 population. Second, the number of services rendered is used, for example, the number of children vaccinated or the number of births in hospitals.

Some indicators of change in health status exist, but they have a limited use; for example, in the United States and Great Britain children in each age group are taller today than their fathers and grandfathers were at the same age. Puberty comes at an earlier age. More recently work has been done on physical fitness, which may have some application in the future to the measurement of work capacity of a population. Physiological tests have been developed of the individual's total ability to perform prolonged physical work. "For all practical purposes, this means the ability of the cardiopulmonary system to take up, transport, and give off oxygen to the muscle tissue for the performance of physical work."[10] Muscle strength, oxygen uptake, and pulse responses have been combined in a series of tests.

At present, it is difficult to disentangle the effects on the health status of the population that are attributable to health programs from those attributable to bet-

[9] T. W. Schultz, "Education and Economic Growth" in *Social Forces Influencing American Education*, ed. N. B. Henry (Chicago, 1961).

[10] T. Hettinger *et al.*, "Assessment of Physical Work Capacity: A Comparison between Different Tests and Maximal Oxygen Intake," *Journal of Applied Physiology*, XVI (1961), 1; see also K. Rodahl *et al.*, "Physical Work Capacity," *Archives of Environmental Health*, II (May, 1961), 23–24.

ter nutrition, better housing, better working conditions, and higher incomes. Sickness is a cause as well as a consequence of poverty. Tuberculosis, for example, is closely related to housing conditions. "Lung block" in New York City conveyed the image of this association. Indeed, Lowell after a detailed study of the tuberculosis problem in New York City, wrote: "if optimum benefits are to be realized in mastering tuberculosis progress in medicine and public health, they must be accompanied by comparable and parallel socioeconomic improvements in living conditions."[11] Communicable diseases generally have a higher rate of incidence among the poor than among the rich. Conditions of poverty give rise to the easy transmission of infectious diseases; thus improved living standards contribute importantly to reduction in prevalence and incidence rates. The improvement in health status in the past six decades in the United States is in part the result of health services that brought the infectious and contagious diseases under control. (In part, too, it is the result of the growth in the economy.) For example, of one hundred white males born in 1900–1902, seventy-nine reached age fifteen and thirty-nine will reach sixty-five years of age. In 1958, out of one hundred white males born, ninety-six will reach age fifteen and sixty-six will reach age sixty-five. Isolation of some of the major factors responsible for prolonging life would help to identify the contribution of health programs as well as the contribution of specific aspects of health programs such as sanitary control of the environment, widespread immunization, better medical care, and community health services. But we are a long way from identifying the contribution of health programs.

3. Closely related to the problem of measuring quality changes attributable to health programs is the question of assessing earning differences. In assessing the private return to investment in education, one begins with data on differentials in earnings according to years of schooling. Average differences in lifetime incomes of high-school and college graduates, for example, corrected for differences in ability and other factors, serve as an index of return to higher education. We now have no similar indexes of differences in income associated with gradations in health. More particularly, we have no indexes of differences in earnings reflecting such gradations.

The National Health Survey provides information on the time lost from work because of temporary sickness. Bergsten, analyzing the results of this survey, shows an inverse relation between family income and time lost from work. While persons (usually working) in families with income under $2,000 lose an average of 10.3 days a year from work due to illness and injury, those with income of $7,000 or more lose only 5.9 days.[12] Data on differences in sickness rates by income class, however, reflect the interaction of illness and income.

We have some negative measures that indicate the market's evaluation of risk of sickness and death and potential loss in earning due to permanent impairment. Rates under workmen's compensation laws reflect differences in the risk of death and injury in different occupations. If a correction is made for the effects of statutory limits on benefit payments,

[11] A. M. Lowell, *Socio-economic Conditions and Tuberculosis Prevalence in New York City, 1949–51* (New York: New York Tuberculosis and Health Association, 1956).

[12] J. M. Bergsten, "Disability Days, U.S., July 1957–June 1958," *Statistics from the U.S. National Health Survey* (Ser. B-10 [Washington, 1960]).

workmen's compensation rates should reflect the "charge" for the risks of death and disability. Rates levied in the states vary widely for different employers depending upon their industrial accident experience. For certain types of iron and steel erection in the construction industry, for example, rates are in the neighborhood of 20 per cent of wages, while in the same state, large retail trade outlets pay premium rates in the neighborhood of only 0.5 per cent. If workmen's compensation charges, as adjusted, can be used to measure the risk of death and disability, it may be possible to use premiums paid for extra occupational risks —or "hazard pay"—as an index of the market evaluation of the risk of continuing debility. Hazard pay is paid to persons in occupations such as airplane pilots, undersea divers, and longshoremen handling dangerous cargoes. And injury rates become one of the many factors considered in wage negotiation even when separate hazard premiums are not paid.

4. Educational investment is a developmental process, which ferrets out and encourages native talent. It proceeds step by step from one level to another, transmitting a cultural environment by building on the existing store of knowledge. Health programs seek basically to prevent a hostile environment from killing and crippling. They seek to stay the natural forces of biological selection.

Peoples throughout history have invested in health; even the most primitive of peoples have invested in a selectivity process whereby those most fit for their environment survived. The survivors developed immunities to the diseases of their environment, but the price of these immunities (the investment in health) was the early deaths of the less fit with the consequent loss of their net productive contribution. In some early cultures an even larger investment was made in the selectivity producing a health status through the killing of the disabled and the weak.

Many underdeveloped countries or regions within these countries have progressed in health programs little beyond sustaining a natural death rate—a rate reflecting the early deaths of those unable to withstand the dangers of a hostile environment. And while modern medicine has been brought into such regions and has lowered death rates, modern civilization in some remote places has destroyed the earlier investment of the people in these places in building immunity to disease. New diseases have been brought in.

In a modern economy biological selection is no longer an acceptable method of investing in health, not only because our humanitarian instincts rebel against it, but because it costs too much. The cost of foregoing the productive contribution of those who would die early is now too great. In our present economy, in the United States and other industrially developed nations, physical strength of the human hand is not often used in the production processes. People with so-called impaired lives can and do make great contributions to our national output. Brain power and other human capabilities and talents are far more important than physical stamina. In replacing the physical energy of people by inanimate power, and crude natural products by synthetic substitutes, mankind has altered the nature of its investment requirements, both human and physical.

The significance of the difference between education and health as an investment lies in the range of choices to be considered in the regions of the world that are in the twilight of a cultural transition from the ancient to the modern.

The choice in the case of health is not between some investment and no investment; it is between investment in biological selection and investment in modern public health measures or in other measures that indirectly promote health.

One word of further qualification is needed so that I will not be misunderstood. Biological selection does not necessarily result in a strong and virile and creative people; it results only in the survival of those best able to withstand the rigors of their physical and biological environment.

These then are some important differences between health and education investments. Some of the differences are pertinent only to consideration of health programs in the underdeveloped nations; others to industrialized countries.

II. MEASURING CAPITAL FORMATION THROUGH HEALTH CARE

In its simplest form the economic resources (labor and commodities) devoted to health care represent in some part an investment in health. In some part, that is, the health outlays improve the labor product and continue to yield a return over a period of years. The labor product created by this care and savings in health expenditures in the future, if any, as a consequence of reduction in disease is the yield.

Just as the stock of physical capital may be measured in a number of different ways, so the stock of health capital in people may be variously measured. This human capital formation by health care for a population may be counted, for example, at cost—the cost of environmental and curative health services embodied over their life spans in each of the age cohorts in the present labor force. Cost for this purpose may be set at the cost of acquisition of the health services in the years they were acquired; they may be determined on a replacement cost basis, or at constant prices prevailing in a base year.

At today's prices if we valued the health care received by persons currently in the labor force, for example, we might arrive at a figure of, let us assume, about $250 billion. Is the yield on this $250 billion stock $12 billion, $25 billion, or of what order of magnitude? What, in other words, has been the money value of the annual labor product added as a consequence of the health investments made?

A study of the stock of health-program capital on a cost basis stimulated by the Exploratory Conference on Investment in Human Beings is in progress. This study has not progressed sufficiently to describe fully its scope nor patently to yield findings. Some preliminary and very partial figures may illustrate the possible quantities, however. Medical care costs of child-bearing in 1957–58 averaged $272;[13] the health costs for an infant and child (at 1957–58 prices) come to about $45 a year. If we include all medical care expenditures for a child up to age eighteen, the average child uses more than $1,000 in health and medical services.[14] To produce a labor force member aged eighteen at today's quantities and quality of health care and at today's prices, accordingly, upward of $1,000 is spent in health resources alone. For the seventy-three million persons in the labor force of 1960 this would mean a $73 billion stock of health care up to age eighteen when valued on replacement costs basis, without adjustment for losses due to early death. At pre-World War I

[13] Health Information Foundation, *Progress in Health Services* (New York), Vol. X (March, 1961) (newsletter).

[14] These figures are approximate and may be revised substantially when additional research is done.

quantities and quality of health care and medical prices prevailing then, the health stock in a labor force of 1960 size (counting costs only up to age eighteen) would have been about $5.5 billion before addition of costs lost through these earlier deaths prior to age eighteen. Data on per capita expenditures for health care are shown in Table 1.

The capital stock of health services may also be measured as the present value of the added labor product acquired through health programs, that is, the stock may be valued at the present value of the future earnings generated through the health programs. In some health programs, the labor product added is contingent on the services received by a specific individual, and on his death or retirement the capital value of health services is lost. Accordingly, the future earnings to be valued for the present period are limited by survival and retirement rates.

The present value of future labor product created by health care becomes a second measure of capital value. The question that is being asked in this measurement of investment is: "What is the expected return from the health care which in turn determines its value?"

The cost in terms of health-program expenditures and, in turn, in terms of resources devoted to health care may be greater or less than the capitalized value of the added labor product created through improved health status.

TABLE 1

HEALTH-CARE EXPENDITURES, SELECTED YEARS, 1914 TO 1958–59

Year	Amount (In Millions)	Per Capita	As Percentage of Gross National Product
1914*.....	$ 1,091	$ 11	2.7
1921*.....	2,024	19	2.7
1927*.....	3,030	25	3.1
1956*.....	18,358	109	4.4
1928–29†.....	3,650	30	3.6
1939–40†.....	3,915	30	4.1
1949–50†.....	12,365	83	4.7
1956–57†.....	21,027	125	4.9
1958–59†.....	25,196	145	5.4

* Compiled from United States Bureau of Census, *Historical Statistics of the United States, Colonial Times to 1957*. Includes personal consumption expenditures and also public outlays for health programs, federal, state, and local.

† From Ida C. Merriam, "Social Welfare Expenditures, 1958–59," *Social Security Bulletin*, November, 1960, p. 43. Includes industrial-in-plant services and philanthropy as well as personal health expenditures and public outlays for health programs.

This measure of the capitalized expected income over the productive life span of the new labor product added through a health program takes account of the depreciation on the investment by the loss of labor product through retirement and death. There are types of health programs, however, which yield returns into perpetuity. The asset created in the main does not depreciate. The value of the health services continues beyond the life span of the individuals for whom the services initially are provided. For example, complete eradication of malaria or of typhoid from an area means that indi-

viduals of succeeding generations are not subject to these diseases. In instances where there is a return into perpetuity, in effect the labor product added through a health program may be capitalized without allowance for depreciation, that is, for retirements from the labor force and deaths.

As this brief summary of measures of capital formation through health programs suggests, a central problem in assessing yields and investment in health is the measurement of labor product added through health care.

LABOR PRODUCT MEASUREMENT[15]

The resource gained as a result of prevention or cure of sickness is human labor. In order to value the gain in dollars it is necessary to estimate the output added. There are two types of questions —one in the future; the other in the past. If there were no sickness how much would those persons who are now sick have produced? How much has been added to national income by health care —by the prevention and therapy measures now in use for specific diseases?

The effects of sickness upon the amount of human labor available for productive purposes can be summarized under three headings: (1) deaths (loss of workers); (2) disability (loss of working time); and (3) debility (loss of productive capacity while at work).

Essentially there are two stages in calculating the output added: (*a*) estimating the gain in productive work time and (*b*) assigning a money value to the output that this added work time represents. The result is then a dollar figure which represents the value of the gain in output attributable to reduction in deaths, disability, and debility. In other words, it would be a rough estimate of the increase in output attributable to eradication of a specific disease or improvement in health status.

Conceptual problems.—An estimate of gain in work time due to elimination or cure of a specific disease involves the assumption that if it were not for the disease those persons in the productive age groups stricken by the disease would have been working. In fact, where there is unemployment or substantial underemployment, improved health may result in more unemployment rather than more output. One obvious reason for using the simplifying assumption of full employment is that, unless we do, we cannot arrive at any definite concept of what the resource gain is. Apart from this, however, the fact that production losses resulting from poor health cannot be realized in an unemployment situation should be attributed to unemployment, not to ill health. Unemployment has its own cost, which in effect may cancel out reductions in the cost of sickness, but for analytical purposes it is necessary to distinguish between the two. We therefore measure the gains of disease eradication or cure in the assumed absence of costs of unemployment, recognizing, however, that unemployment itself may have an effect on the incidence of illness.[16]

There is another assumption implicit in the view that gains in production due

[15] The discussion of labor product measurement which follows is, with minor exceptions, from S. J. Mushkin and Francis d'A. Collings, "Economic Costs of Disease and Injury," *Public Health Reports*, LXXIV (September 1, 1959), 795–809.

[16] However, it is desirable to make an allowance for frictional unemployment, that is, the essential unemployment that exists even at full employment levels as when persons change jobs or are temporarily laid off. It is also desirable to allow for absenteeism over-employment, which is normal absence of workers from jobs because of vacations, bad weather, and temporary sickness. These adjustments may be applied to the final estimate of productive work time added due to prevention or cure of a disease in terms of a full-time equivalent number of man-years.

to reduction in death, disability, and debility of workers can be attributed to a particular disease, namely, that persons who die from, or are disabled by, the disease would otherwise be in good health. Here again, it is possible that persons saved from one disease may promptly die of another, and their production thus be lost in any case. It seems reasonable enough to disregard this possibility for clearly defined diseases that strike primarily at persons of working age; but it is less reasonable if the disease, or treatment required to overcome it, weakens the patient by making him more prone to other ailments, and if the disease strikes mainly at persons who are constitutionally weak in any case, as with the diseases of old age. In these cases, the gains in production from prevention or cure can less clearly be identified as an effect of a single disease. The result of disregarding the presence of multiple diseases is an overestimate of the gains from eradication or control of any single disease. At some later stage in refinement of the concepts, a methodology must be developed to deal with this multiple-disease problem.

Moreover, the assumption that side effects of other diseases may be disregarded in order to measure the direct effects of the disease in question means that the gains from prevention or cure of each disease, taken individually, cannot be added together to make a meaningful total of gains from prevention or cure of all diseases.

In practice, the three categories of gains due to reductions in death, disability, and debility need closer definition; and it may be necessary to subdivide them further to make them correspond to available data.

Death is unambiguous in meaning, but cause of death is sometimes not. In estimates of gains from prevention or cure caused by a particular disease, deaths from multiple causes may need to be treated differently from those caused by the disease in question alone. Disability caused by sickness may be partial or total, and it may be short term or long term. Cases of long-term disability, especially when total, may be found primarily in institutions, and thus it may be convenient to subclassify again into institutional and non-institutional populations and use data available on institutional cases to measure a part of the disability caseload.

The division between disability and debility, furthermore, will not be clear-cut in many cases. For example, a blind person may be excluded altogether from the work force (total disability) or he may find some sheltered employment where his contribution to production is small (debility). He may also become a scientist, a writer, or a musician, where his contribution is average or above average, reflecting effects of neither disability nor debility.

The impact of diseases which cause debility, or loss of working efficiency, is no simple matter to define or to measure. In its broadest dimension, a measure of gain in output due to reduction in debility by prevention or cure of a disease requires formulation of a standard of output in the absence of the disease, from which shortcomings may be measured. While work on this concept is going forward, there still remain difficulties in applying the notion in terms of added product per unit of work time.

Working time added.—The gain in resources through prevention or cure of disease and reduction in death, disability, and debility must, for the first stage of the estimate, be stated in terms of units of productive work time added. The sec-

ond stage, to be dealt with later, is to assign a value to these units. In the case of reductions in death and long-term disability, the gains will take the form of periods of added time on the job, and these may be converted into equivalent units of full-time work added. Debility, defined as reduced productive efficiency per man, too may be converted into full-time equivalents. For convenience, the following discussion will refer to man-years as the units of productive work time.

How the equivalent of the full-time work force is defined operatively is of central importance to the estimate. A decision must be made on the age limits within which persons who contract disease will be considered as productive workers. In the United States, the age of entry into the work force is usually considered as fourteen years. This starting age is largely an historical carry-over in definition which has been perpetrated for comparative purposes in spite of the trend toward later entry into the work force. The retirement age varies widely among different groups and in different areas; the average age of retirement for the United States is estimated at present at sixty-eight years of age for men.[17]

The consequence of this limitation of work-force participation is to count the resource gain from reduction in death, disability, and debility of children and the retired aged as zero when measuring annual output gains. This is consistent with the definition, since persons outside the work force are not considered to contribute anything to production in the year in question. For a capital formation analysis, however, infant and childhood deaths represent a future loss to society and must be allowed for, although the time interval between death and anticipated entry into the work force may be such that the present value of the future loss of working time is small.

The importance of the retirement-age assumption will vary with different social and economic settings. In some economies, the urgency of production for survival leaves little room for retirement prior to death or total disability; with higher productivity and industrial advances, cessation or work activity becomes feasible before extreme old age is reached. In an industrial community, therefore, it seems reasonable to exclude retired persons who cease to contribute to production, but in others retirement may be disregarded.

Whatever age limitations are set upon the productive work force, further qualification is necessary because not all persons of productive age are actually engaged in production. At full employment, only a certain proportion of the members of each age group will be productively employed, and the gain in man-years of work attributable to reduced deaths and disabilities among these persons alone should be counted in the estimate of work time added. Here again, this implies that death or disability of a person not in the active work force occasions no loss of productive resources.

Special problems arise in the case of women working in the home. Such women are not normally included in standard definitions of the work force, and their product, unlike that of paid domestic workers, is not included in the national economic accounts. Thus defined, their death or disability is not an economic cost—reductions in the number of such deaths in a year not an economic gain. However, this is highly anomalous; it im-

[17] R. J. Myers, "Some Implications of a Retirement Test in Social Security Systems," *Proceedings of the Conference of Actuaries in Public Practice*, VII (1957–58), 337–50.

plies that the national product is increased if every wife does housework for pay for the family next door and lowered if every man marries his cook. The only alternative is to impute some value to the services of housewives in the home, thus imputing an economic gain to reduction in their deaths or disabilities. Although proposals have been advanced for broadening the concept of production used for national product purposes to include such non-market services, no generally agreed way to do so at present exists.[18] To simplify the estimate and to follow an approach consistent with national product accounting it seems desirable to omit the valuation of housewife services.

A related problem concerns the method of counting deaths and disabilities among unpaid family workers. In the United States and several other countries, unpaid family work is included in the national product accounts, in effect requiring a prorating of income among the working members of the family. In this case, there is a basis for allocating a value to the services of such a worker. The importance of this problem obviously varies in different social settings, but in countries where a large proportion of production is carried on on farms and in other family enterprises it would be clearly advisable to count the gains from reduction in deaths and disabilities among those who work within the family unit without money wages.[19]

In estimates over a life span, work-life tables developed by the Bureau of Labor Statistics may be applied which identify the remaining years of work life at each age group. Estimates of work-life years have been developed for 1940 and 1950 for both men and women; and historical changes in the pattern of work-life expectancies have been estimated for 1900 and projected to the year 2000.[20]

Data on deaths are collected by the National Vital Statistics Division of the United States Public Health Service. Data on absences from work due to sickness are collected as part of the National Health Survey and published as *Health Statistics* (Series B). A total of 371 million days of work loss by persons 17 years and over were reported for 1960 by those working or who had a business during the two previous weeks. The comparable figure for 1961 was 365 million days. Assuming an average of 250 working days a year for each full-time worker (5 days a week for an average of 50 weeks), the 5.6 average work days lost per person in 1960 is equivalent to a 2.24 per cent loss of working time on the average due to sickness and injury. These figures exclude persons who withdraw from the labor force due to illness; some of these former workers are in institutions, others at home. When adjusted for withdrawals from the labor force, the 2.24 per cent

[18] M. A. Copeland, "The Feasibility of a Standard Comprehensive System of Social Accounts," in *Problems in the International Comparison of Economic Accounts* ("National Bureau of Economic Research, Studies in Income and Wealth," Vol. XX [Princeton, N.J.: Princeton University Press, 1957]), pp. 19–95.

[19] Further problems arise in connection with part-time workers. The gain in productive work time from reduction in a given impact of disease among these persons will be less than that among full-time workers, and this gain will have to be converted to a full-time equivalent for purposes of the estimate. The most practical solution to these definitional problems may be to use existing concepts of "work force" and "labor force" (converted to full-time equivalents) to estimate the gain in working time from prevention or cure of disease.

[20] See United States Department of Labor, Bureau of Labor Statistics, *Tables of Working Life: Length of Working Life for Men* (Bull. No. 1001 [Washington, 1950]), and *Tables of Working Life: Length of Working Life for Women, 1950* (Bull. No. 1204 [Washington, 1956]); see also S. Garfinkle, "Changes in the Working Life of Men, 1900–2000," *Monthly Labor Review*, LXXVIII (March, 1955), 297–301.

work-time loss may be doubled to about 4.5 per cent. This 4.5 per cent figure sets the upper limit of the potential gain in work time from eradication of the disabling effects of disease and injury.

Absence from work due to disability is in part a result of the physical or mental condition of the individual but it reflects other factors affecting decisions to be absent from work. These decisions change with an individual's knowledge about health care, the institutional arrangements for social protection against wage loss, the net income consequences of the decision, and the nature of an individual's job and his employment relationships. A total of $0.7 billion was excluded from income taxable under the federal income tax as sick leave and insurance compensation for wages lost due to sickness in 1959.

Estimates on numbers of workers at work on a day but suffering some restriction in their usual activity may be derived from information collected by the National Health Survey.[21] The conversion of such information to full-time equivalent workers, however, poses additional difficulties.

Several different yardsticks of the effect of debility on worker efficiency have been used. Several others have been discussed. These include:

1. Output in a plant with recorded information on number of machines in operation, before and after disease control work is instituted.[22]
2. Wages earned on a piece-rate basis by those with a disease and those free of the disease.[23]
3. Wages of workers in an area with a high disease prevalence compared to wages of similar workers in areas free of the disease.
4. Output on a farm in which a disease problem is controlled, measured against output of a control group of workers.
5. Laboratory tests of work energy of groups of workers afflicted with a disease, measured against work capacity of a normal control group.

There are records of studies of increased worker output after disease control is instituted. The control-group type of experiment has been discussed and a beginning toward such experimentation has been made. Demands from the control groups for treatment in an area with a high rate of endemic disease have been met, and I am told that no experiment has been carried through to definitive findings. The laboratory approach to the problem of work energy grew out of a meeting with the productivity analysis staff of the Department of Labor and—though implementation has been considered—no steps toward it have been taken.

The alternative to these case studies is to compile mass data on output and on disease prevalence among workers and to analyze the data to find the effects of pertinent variables, including the extent of the disease.[24]

[21] We are a long way, however, from having data on work time lost through debility comparable to that on disability.

[22] R. H. von Ezdorf, "Demonstrations of Malaria Control (1916)," *Public Health Reports*, XXXI, 614–29.

[23] I. Fisher, "Report on National Vitality: Its Wastes and Conservation," *Bulletin of One Hundred on National Health*, No. 30 (Washington, 1909).

[24] Gains in working time due to reduction in debility from diseases now virtually eradicated have played a role in the economic growth of the United States. An analysis of the effect of reduced debility due to control of malaria and hookworm in the South would, I think, yield added perspective on the relative economic growth rates of the South and other sections of the country. Irving Fisher, writing in 1908 on the prevalence of hookworm disease in the South stated: "The disease is remarkable not so much for its fatality . . . as for the chronic incapacity for work which it produces. For this reason, the hookworm has been nicknamed the 'germ of laziness.'" In the same report Fisher noted that there were probably three million cases of malaria—another debilitating disease—in the United States, mostly in the South. In the early 1930's it was estimated that at the height of the malaria season there were 6.8 million cases of malaria in the South—a figure well over one hundred times the number of annual deaths from malaria reported then.

Gain in output.—The previous stage in the computation has resulted in an estimate of the productive man-years added by reduction in deaths, disability, and debility from sickness. This in itself may prove a useful piece of political arithmetic, but in most cases it will be desirable to translate this into dollar cost by assigning a value to the man-years added to production.

In the available studies on losses from illness, two essentially divergent approaches have been used in assigning a value to each unit of labor work time. The first is to value each unit by an amount equivalent to total product per worker; the other is to use earnings as a measure of labor product per worker.

The first of these assumes, as Fein has indicated, "that all of the national product (income), and therefore any gains in national product, are attributable to labor rather than to some combination of joint factors of production, land, labor, capital, etc. Although it may indeed be true that if there were no labor there would be no product, it is equally true that if there were no capital there would be very little product."[25] The total-product-per-worker approach was used by Reynolds in his study of the cost of road accidents in Great Britain and also in the National Planning Association study on the costs of tuberculosis in the United States.[26]

The second alternative—to use earnings as a measure of the output attributable to labor—is more appropriate for purposes of estimating labor product added. Earnings, in this case, must be distinguished from income, which includes returns on property or capital; earnings consist only of wages and salaries (or equivalents for the self-employed). These wages and salaries are paid in direct return for productive services and correspond to the individual's contribution to production. The estimate of labor product added put in these terms thus measures the gain in production attributable to labor.

Average earnings multiplied by the number of man-years added as a result of the prevention or cure of disease yields the dollar estimate of resource gain. We are now in a position to define the result more closely. It is, essentially, an estimate of the money value of the labor product lost as a result of death, disability, and debility. The prevention or cure of these provides a labor product that is added and gives an estimate of added income flow, or it can be converted into an estimate of capital formation through health programs by capitalizing this annual added labor product attributable to health care.

REDUCTION OF DEATHS AND ECONOMIC GROWTH

Health programs use economic resources—men and materials; they also create economic resources. Viewing expenditures for health programs as an investment helps to underscore the contribution of health programs to expansion of income and economic growth. As the earlier discussion on the measurement of added labor product indicates, reductions in deaths are easier to quantify than reduction in disability or debility.

I attempt here to estimate the contribution to economic growth resulting from the enlargement of the work force through reductions in death rates over

[25] R. Fein, *Economics of Mental Illness: A Report to the Staff Director, Jack R. Ewalt* (Joint Commission on Mental Illness and Health Monograph, Series No. 2 [New York: Basic Books, 1958]).

[26] D. J. Reynolds, "The Cost of Road Accidents," *Journal of the Royal Statistical Society*, CXIX, Part 4 (1956), 393–408; and National Planning Association, *Good Health Is Good Business: A Summary of a Technical Study* ("Planning Pamphlet No. 62" [Washington: National Planning Association, 1948]).

the past decades. The first question for which an estimate is sought may be put this way: how large would the 1960 work force be if death rates of earlier decades had prevailed and other factors remained unchanged? The second question: what is the value of the work force added by reduction in deaths, in terms of both the annual added product and the capital value of the future stream of earnings of the additional workers?

Denison analyzes the potential contribution to economic growth rates of a series of labor-market and other measures, including improved health status of the population.[27] He assumes, as a first approximation, that a given percentage change in the size of the labor force produces a constant percentage change in output. This constant return to scale assumption is modified so that over the twenty-year period ahead (1960–80) a 1 per cent rise in inputs of each of the factors of production—labor, land, and capital—is assumed to yield a 1.09 per cent rise in output. A 1 per cent rise in number of workers, other factors held constant, is assumed to yield an 0.843 per cent rise in national output.

Within this framework, Denison assesses the effects of a reduction in the death rate on the rate of economic growth. He shows the maximum change in rate of growth that is attributable to the change in the number of workers, assuming no one died in the two decades of the 1960's and 1970's before reaching age sixty-five. Under this extreme assumption the labor force in 1980 would be 4.8 per cent larger than is now projected, and the national income would be 4 per cent higher; averaged over the twenty-year period this would mean an 0.20 percentage point rise per annum in the growth rate. If death rates were reduced 10 per cent, which would be "an extraordinary achievement," the growth rate would be increased by 0.02 per cent.

He applies a similar analysis to the loss of work days through illness and injury, as reported in the National Health Survey, and adds the loss attributable to the population in mental and tuberculosis institutions. Together the work loss of the institutional and non-institutional population for 1958 amounted to 4.4 per cent of work time. A reduction of one-fourth in this lost time, Denison estimates, would increase labor output by 1.1 per cent by 1980 and total national income by 0.9 per cent; the 1960–80 growth rate would be raised by 0.05 per cent.

While the contribution to economic growth of the sizable changes in mortality and morbidity assumed by Denison is not large percentagewise, a 1.5 per cent rise in the labor force by 1980 (1.1 per cent disability and 0.4 per cent deaths) converted to absolute amounts would be the equivalent of well over $5 billion.

Addition to employment and national income.—Denison estimates the effect of improvement in education of the labor force on the national income over an historical period, but he does not apply his analysis to historical trends in health status. It is possible, however, to estimate employment increases attributable to the improvement in life expectancy over the past decades and to estimate the growth in employment and national income resulting from this improvement. One method is to estimate the size of the work force in 1960 under the hypothetical condition of death rates of early decades and to compare the actual work force in 1960 with these hypothetical estimates.

Estimates of the number of persons in civilian employment in 1960 who survived to that year because of improved

[27] Denison, *op. cit.*

life expectancy are shown in Table 2. These estimates are computed by applying to the 1960 employed population, by age and sex, the ratio of the number of survivors in earlier decades (per 100,000 born) to the actual number surviving to these ages in each generation (per 100,000). In developing these estimates, the mortality experience of white males from 1900 to 1920, but had remained at the 1920 rates thereafter. Reductions in mortality rates made possible these additions to the work force and also added their labor product. The labor product added by the additional thirteen million survivors, when valued at average earnings of 1960, amounts to a more than $60 billion addition to national income. The

TABLE 2

ADDITIONAL PERSONS IN WORK FORCE IN 1960 ATTRIBUTABLE TO IMPROVED LIFE EXPECTANCY, BY AGE AND SEX

(In Thousands)

SEX AND AGE GROUP	AVERAGE NO. EMPLOYED 1960	PERSONS EMPLOYED IN 1960 WHO WOULD NOT HAVE SURVIVED TO 1960 IF MORTALITY EXPERIENCE WERE THAT OF YEAR DESIGNATED					
		1950	1940	1930	1920	1910	1900
Male	44,484	235	864	2,245	3,647	7,081	8,743
14–24 years	6,695	3	47	292	576	998	1,192
25–34 years	9,759	10	98	332	859	1,532	1,923
35–44 years	10,551	24	179	496	876	1,783	2,279
45–54 years	9,182	55	220	542	808	1,322	1,772
55–64 years	6,106	79	208	397	427	995	1,130
65 years and over	2,191	64	112	186	101	451	447
Female	22,195	75	474	1,285	2,362	3,464	4,467
14–24 years	4,457	4	32	178	348	611	740
25–34 years	3,871	4	46	147	368	585	743
35–44 years	5,046	10	91	257	515	817	1,080
45–54 years	5,055	19	116	313	581	698	1,006
55–64 years	2,884	26	124	260	392	519	643
65 years and over	882	12	65	130	158	234	255

Sources: Based on estimates by Dr. Monroe Sirken, of the National Vital Statistics Division, United States Public Health Service, of 1960 white labor force by age, assuming specified changes in mortality experience. Estimates presented above apply mortality experience of white males and females to total employed persons and make no allowance for added births due to increased numbers in child-bearing ages.

and females is applied to all employed persons and no allowance is made for the added births due to the increased number in the child-bearing ages; nor is a correction made for immigration. Educational levels and employment patterns are assumed to be the same for the additional survivors as for others.

The employed population in 1960 would have been over thirteen million less than it was if death rates had not declined since 1900; it would have been six million less if death rates had declined six million additional survivors, attributable to the decline in mortality since 1920, added almost $28 billion to the nation's output of goods and services (Table 3).

Stated differently, the labor force in 1960 about was 25 per cent higher than it would have been if 1900 mortality rates continued unchanged throughout the sixty-year period 1900–1960, and about 10 per cent higher than it would have been if 1920 mortality rates had continued from 1920 to 1960. The decline in mor-

tality rates in the 1950's increased the 1960 labor force by an amount equivalent to a .05 per cent rise per annum in employment, but not all of the gain for the first years of life is reflected as yet in the labor force and will not be until about 1970.

National income was increased by an amount equivalent to a 0.3 per cent rise per annum due to the decline in mortality rates from the 1900 level (assuming, as does Denison, that a 1 per cent rise in number of workers, other factors held constant, yields a 0.73 per cent rise in national income for this period). The decline in death rates in the past sixty years thus accounts for over 10 per cent of the over all 3 per cent growth rate in the economy.

An alternative analysis of the effect of declining death rates on economic growth may be made. In the figures presented above, the base in each case is the actual civilian work force in 1960 compared to the hypothetical 1960 civilian work force. A set of estimates similar to those presented here for 1960 may be developed for each of the earlier decades. These ad-

TABLE 3

ESTIMATED EFFECT ON GROWTH OF WORK FORCE AND NATIONAL INCOME OF IMPROVED LIFE EXPECTANCY FROM 1900 AND OTHER YEARS AS DESIGNATED TO 1960

A. ADDITIONAL CIVILIAN WORK FORCE AND LABOR PRODUCT

(In Millions)

	Work Force in 1960 If Mortality Rates Had Continued Unchanged Since	Additional Work Force in 1960 Attributable to Reduced Mortality Rates	Value of Added Labor Product in 1960
1960.....	66.7	.....	.....
1950.....	66.4	0.3	$ 1,390
1940.....	65.3	1.4	6,489
1930.....	63.2	3.5	16,222
1920.....	60.7	6.0	27,810
1910.....	56.2	10.5	48,668
1900.....	53.5	13.2	61,182

B. PERCENTAGE INCREASE IN CIVILIAN WORK FORCE AND LABOR PRODUCT

Increase in 1960 Attributable to Reduction in Mortality Since	Percentage by Which 1960 Work Force Raised	Percentage by Which 1960 National Income Raised	
		Total	Per Annum Equivalent
1950.....	0.5	0.4	.04
1940.....	2.0	1.5	.07
1930.....	5.6	4.0	.13
1920.....	9.9	7.2	.18
1910.....	18.8	13.7	.26
1900.....	24.7	18.0	.27

ditional estimates would permit comparison of the growth of employment under conditions of varying mortality.

For example, Denison estimates employment in 1957 at an index of 144.1 with 1929 as 100. If 1930 death rates had continued unchanged throughout the twenty-eight years between 1929 and 1957, the index of employment in 1957 would have been 136.7 and not 144.1. The difference, 7.4 percentage points, is attributable to the decline in death rates. Accordingly, 20 per cent of the *rise* in employment in the twenty-eight-year period (1929–57) is due to lower death rates. A 20 per cent employment increase, assuming labor inputs account for 73 per cent of the total factor income, again results in about a 15 per cent rise in national income.

These figures assume, as I have indicated, that other things remained unchanged. Hours of work, educational investments, labor productivity, immigration policies, and labor-force participation rates, among other factors, undoubtedly were influenced by the decline in mortality but the purpose here is to consider the effect of the single factor—the decline in deaths—on employment and national income. Not all of the decline in deaths is, of course, a consequence of medical advances and improved health care. Productivity increases, which have enlarged earnings, reflect technological progress and improved education of the labor force, both formal education and on-the-job training. While it is difficult to assess the role of health programs in the over-all lengthening of life expectancy, such an assessment can be made for specific diseases over a relatively brief span of years, and when new therapies can be identified as the cause of a decline. Dauer estimates that 1.1 million lives were saved in the period 1938–52 as a result of the use of antibiotics and chemotherapy in pneumonia and influenza cases.[28] Given the age distribution of the saved lives and also labor-force participation rates, I calculate that the labor force in 1952 was almost 0.5 per cent higher than it would have been had the new therapies not been used. The national income in 1952 was as a consequence enlarged by well over $1 billion.

Capital formation.—The future earnings stream created by the additional workers and their labor product may be capitalized and converted to a capital stock figure. Persons at work in 1960 who would not have survived to that year if mortality experience of earlier decades had prevailed contributed to national output in 1960, but they also continue to work during their remaining lifetimes. The present value of the future earnings of these additional workers at different ages is shown in Table 4. The estimates of the assets created by improved life

TABLE 4

1960 DISCOUNTED VALUE OF FUTURE EARNINGS AT SELECTED AGES, MALES AND FEMALES*

Age	Males	Females
20	$ 89,270	$49,460
30	101,394	50,931
40	88,170	44,982
50	62,179	33,380
60	30,200	16,131
65 and older	12,003†	6,141†

* Computed by Mr. Robert J. Myers, chief actuary of the Social Security Administration, on the basis of United States Life Tables for 1959, using average earnings by age in 1960 estimated from 1960 average income data (Census Bureau) as indicated in text; and applying a net discount rate of 5 per cent per annum. (See text for discussion of the net discount rate.)

† Based on three years' earnings at age sixty-six average earnings rate.

[28] C. C. Dauer, "A Demographic Analysis of Recent Changes in Mortality, Morbidity, and Age Group Distribution in Our Population" (paper given at the Institute on Medical History, New York Academy of Medicine, June 2, 1955).

expectancy are presented in Table 5, based on the estimated additions to the civilizan work force (Table 2). While the additional survivors reflect the improved health status of the work force, the added earnings reflect the composite effects of many factors contributing to the trends in earnings. Among these factors are increased educational levels of the work force and improved industrial organization and techniques.

TABLE 5*

CAPITAL VALUE IN 1960 OF LABOR PRODUCT ADDED BY IMPROVED LIFE EXPECTANCY, 1900–1960

(In Billions)

CHANGE IN MORTALITY EXPERIENCE SINCE	CAPITAL VALUE IN 1960 ADDED BY		
	All Additions to Employment†	Added Male Workers	Added Female Workers
1950.....	$ 12.0	$ 10.0	$ 2.0
1940.....	65.3	51.0	14.3
1930.....	194.7	151.4	43.3
1920.....	365.9	280.1	85.8
1910.....	649.2	519.3	129.9
1900.....	820.5	652.0	168.5

* Based on Tables 2 and 4. Represents the 1960 value of the future lifetime earnings of persons added to the 1960 work force by changes in mortality experience, discounted by 5 per cent. (See text for underlying assumption on trend in average earnings and interest rate.)

† Totals may not add due to rounding.

The question answered by the figures presented is: what is the value of product that will be contributed after 1960 by the additional workers when we view this product as a capital asset? Or stated somewhat differently: how large a holding would be required to yield a sum equivalent to that of the added labor product over a period of years comparable to that of the work life expectancy of the additional workers?

The asset value in 1960 of the added labor product attributable to the workers added to the work force by the reduction in mortality rates since 1900 is $820 billion. Or it would require a capital stock of $820 billion to replace the product equivalent of the additional workers. The reduction in death rates since 1930 contributed to the creation of a capital asset of over $190 billion.

In developing these estimates the years of work-force participation beyond 1960 for the additional workers in each age-sex group is computed based on 1959 United States Life Tables for men and for women, without an allowance for any further gain in life expectancy. Retirement at age sixty-eight is uniformly assumed for both men and women. Average future earnings by age and sex are estimated from 1960 Census data.[29] These average earnings by age and sex are adjusted upward to a full-time earning base, an adjustment made so that the average of earnings is conceptually the same as the additional employment figures.

It is also assumed that average earnings continue to rise in the future as they have in the past decades. (A composite rise in earnings of 3 per cent per annum is assumed.) Uniform gains in average earnings each year are assumed for all age groups, although a more precise formulation may suggest relatively higher gains in productivity at the younger ages because of their longer period of education. Earnings from 1960 to the end of their working life of those persons added to the 1960 civilian work force through improvement in life expectancy over the past decades are dis-

[29] The 1960 earnings by age are derived from a free-hand plotting of cross-sectional curves of 1960 average earnings by age groups. The average earnings figures, in turn, were derived from average income figures by age and sex for 1960 as estimated by the Census Bureau. The conversion of average income to average earnings by sex and age is made on the basis of the ratio of median earnings by age to median income by age in 1951, the latest date for which these data appear to be available.

counted at an arbitrary interest rate of 8 per cent, a rate used in recent studies of returns on educational capital.

The growth in earnings and the discount rates are essentially combined in the mechanics of the estimating procedure. A 5 per cent *net* discount figure is used (that is, an 8 per cent discount rate, less a 3 per cent increase in average earnings per annum). Different sets of assumptions could be substituted without altering the estimates shown in Tables 4 and 5. For example, a 7 per cent discount rate and a 2 per cent rise in earnings per annum would also indicate a net figure of 5 per cent, as would a 5 per cent interest rate without allowance for future increases in earnings.

Net discount rates other than 5 per cent, however, will affect the rapidity of the decline involved in placing a present value on earnings far in the future. The influence of different interest rates on valuing future earnings is illustrated in Weisbrod's study in which he uses alternatively interest rates of 4 and 10 per cent—these being based, respectively, on the cost of long-term government borrowing and the rate of return on corporate investment.[30]

The estimates considerably overstate the magnitude of capital formation through improved health care. Not all the gains in life expectancy originate in medical advances and health programs. And gains in productivity are mainly attributable to non-health factors such as improved education and technology. However, the estimates make no allowance for any reductions in disability or debility. The overstatement of the effect of health programs on improved life expectancy is not necessarily balanced by the omission of any gains from reduced disability and debility. Data are not readily available by which to assess this problem. Far more research is needed before we can measure the shares of added capital values attributable to health care, research that would yield data on the capital formation due to reduced disability and debility.

[30] B. A. Weisbrod, *The Nature and Measurement of the Economic Benefits of Improvement in Public Health with Particular Reference to Cancer, Tuberculosis, and Poliomyelitis* (St. Louis: Washington University, 1958).

EARLIER STUDIES

Two concepts of a system of measurement of human assets created through health programs may be identified in the work that has been done. The first is the measurement of the costs of rearing a child, or of developing a productive labor force, an investment that is lost if premature death occurs. The second is a capital stock measure of the present value of future work that may be gained through eradication or control of disease. A third line of inquiry has been followed in the measurement of the contribution of health programs to annual output and to economic growth.

Developmental-cost concept.—The developmental-cost approach compares the lost investment in the rearing of a child who dies before making his full contribution to production with the investment required to enable him to make that contribution.

The developmental-cost approach was used by Richard Contillion in his essay on "The Nature of Commerce in General" published in 1755, and by Quetelet, a social statistician who wrote in 1835: "In his early years, man lives at the expense of society; he contracts a debt which he must one day discharge; and if he dies before he has succeeded in doing so, his life will have been a burden rather than a benefit to his fellow citizens."[31]

[31] Quetelet as quoted in Rene Sand, *The Advance to Social Medicine* (London, 1952), p. 584.

Edwin Chadwick, while serving as secretary to the Poor Law Commission, was struck with the extent to which sickness produced poverty. For the first time a group of physicians systematically studied environmental conditions resulting in preventable illness. Chadwick's report in 1842 on the *Sanitary Conditions of the Laboring Population of Great Britain* created an urgent demand for environmental sanitation measures; it also established the idea of health programs as an integral part of economic policy. Fein quotes Chadwick as writing: "The economist for the advancement of his science may well treat the human being simply as an investment of capital . . ." and cites Chadwick's detailed money estimates of the value of individuals based on the costs of rearing a child, taking account of the factor of death before he became productive and the number of his productive years.[32]

The investment in bringing up a child has been measured for a number of purposes, including (*a*) farm family budgetary needs,[33] (*b*) indemnity insurance,[34] (*c*) the setting of amounts of family allowances,[35] and (*d*) assessing child welfare levels.[36] This concept recurs in analyses of economic development. For example, Singer writes: "Thus it may be said, perhaps somewhat paradoxically, that one of the troubles of underdeveloped countries is not so much that there is not enough investment but rather that *there is too much unproductive investment.* Practically all investment . . . is investment in the feeding and bringing up of a new generation for productive work. . . . If that is included as investment—as it should—it may well be found that investment in underdeveloped countries is much higher in relation to national income than in the more developed countries, with their low birth rates and low death rates, perhaps even higher on a per capita basis. The trouble is that so much of this investment is unproductive because high death rates prevent the repayment, with interest, of the capital sunk in the younger generations."[37]

[32] R. Fein, "The Interaction of Health and Economic Development" (paper delivered at the Third Annual Conference of the Society for International Development, April 28–29, 1961).

[33] J. D. Tarver, "Costs of Rearing and Educating Farm Children," *Journal of Farm Economics*, XXXVIII (February, 1956), 144–53.

[34] L. I. Dublin and A. J. Lotka, *The Money Value of a Man* (New York, 1946).

[35] A. Henderson, "The Cost of Children," *United Nations Department of Economics and Social Affairs Population Studies*, III (September, 1959), 130–50.

[36] W. F. Ogburn, "The Financial Cost of Rearing a Child," *Standards of Child Welfare*, Sec. 1 (Children's Bureau Conference Series No. 1 [1919]), pp. 26–30.

[37] H. W. Singer, "Population and Economic Development" (United Nations E/Conf/13/30, Meeting No. 24 [n.d.]), and his "Some Demographic Factors in Economic Development" (New York: United Nations, n.d.). However, A. J. Coale and E. M. Hoover, in *Population Growth and Economic Development in Low-Income Countries* (Princeton, N.J.: Princeton University Press, 1958), state that the thesis developed by Singer and others on developmental investment is fallacious. If more children are enabled to survive to their adult years, they say, there will not only be more workers but also more parents and the increased numbers of parents will produce more children, if birth rates remain unchanged. In fact, Coale in other research studies has shown that the rise in the number of children is somewhat greater than the rise in the number of workers. The argument is advanced to the point of concluding that, since the proportion of children rises slightly with typical mortality improvements, the economy "wastes" *more* (not less) of its substance on nonproductive resources as a consequence of improved mortality.

Health care which reduces mortality, however, also raises the output of workers in a nation by increasing the vitality of these workers; many diseases with high prevalence rates in underdeveloped nations—diseases such as malaria, yaws, trachoma, schistosomiasis, and bilharziasis—moreover, are chiefly cripplers of mankind rather than killers. Enterline and Stewart, applying an age cohort analysis similar to that used by Coale and Hoover, estimate that less than a 20 per cent rise in productivity per worker over a seventy-five-year period (a percentage equiva-

In this development-cost concept, health programs are not the sole measure of investment; the yardstick used is the total cost of rearing a child. Essentially, it is the child that is viewed as an asset to yield a future return, and all the cost of upbringing, including food and clothing, are included in the investment outlays. The child's production after it is grown to adulthood is counted as the yield on the investment.

Capitalized earnings.—The second system of measurement had its origins primarily in insurance and actuarial theory. In one study it was used to compare the value of life insurance in force with the total value of insurable individuals.[38] Dublin and Lotka, demographers and actuaries rather than economists, contributed the major work on the methods of evaluating the capital represented by man. For their purposes of insurance claims and indemnity of families they define capital value of man as the present and discounted value of future earning power of the wage earner, reduced by the costs of birth, upbringing, and maintenance during a working life and retirement.[39]

In their study Dublin and Lotka trace the thinking on man's capital value through the works of Sir William Petty, Adam Smith, William Farr, E. Engel, Irving Fisher, J. M. Clark, and others. Petty, in his *Political Arithmetic* measured the value of the whole population by determining their total earnings and capitalizing these earnings so as to derive the equivalent capital sum, which would yield such earnings, if invested at a given rate of interest. He wrote of the per capita values he set forth, "from whence we may learn to compute the loss we have sustained by the plague, by the slaughter of men in war, and by sending them abroad."[40]

William Farr in his 1853 article in the *Journal of the Statistical Society* and in his later volume on *Vital Statistics* (1885) computed the economic value of a human life by discounting the value of future earnings taking account of average life duration at different ages. Farr deducted from these earnings the discounted value of maintenance costs, including the cost during the period of childhood dependence and "helpless old age." Farr applied his estimates of human values to problems of public policy, including tax policies, as well as health programs, as did Petty before him.

Beginning with Chadwick's studies, health workers have repeatedly applied the concepts of the value of a human life to problems of health program expenditures. Hermann M. Biggs expressed the health administrator's concern in his slogan coined almost four decades ago for New York City's health department: "Public health is purchasable; within

---

lent to less than a quarter of 1 per cent rise in productivity per annum) would be needed to achieve an advancing level of real income per capita at the same time as life expectancy is increased from thirty years at birth to sixty-eight years at birth—the level in the highly industrial nations of the world. A less than 20 per cent rise in productivity over a seventy-five-year period would compensate for the combined effects of (*a*) the larger number of births due to increased numbers in the child-bearing ages, (*b*) the increased proportion of dependents in the population, and (*c*) the increased investment in physical capital goods required to maintain a consistent ratio of marginal capital to workers. I conclude on the basis of information about the debilitating effects of disease on worker productivity that the wastes in the investment in children resulting from high mortality rates can be prevented and economic growth advanced rather than delayed by improving health conditions. (A more detailed, although preliminary, analysis of this problem was included in an earlier draft of this paper.)

[38] E. A. Woods and C. B. Metzger, *America's Human Wealth: The Money Value of Human Life* (New York, 1927).

[39] Dublin and Lotka, *op. cit.*

[40] Quoted in *ibid.*, p. 9.

natural limitations a community can determine its own death rate." Valuation of human life and the economic effects of health programs through reduction in deaths and disability have been measured for a series of disease problems over many decades.

At the beginning of this century, President Theodore Roosevelt by executive order called for the co-operation of executive agencies in the work of the National Conservation Commission chaired by Pinchot. "The problem of conserving natural resources is only one part of the larger problem of conserving national efficiency. The other part relates to the vitality of our population." In carrying out the work of the National Conservation Commission, Irving Fisher wrote his "Report on National Vitality: Its Wastes and Conservation." Fisher points up the relation between health and conservation of physical assets indicating that in its broadest view health is the primary form of wealth. "Without enlarging or insisting upon this concept, it is obvious that by the conservation of health we may ultimately save billions of dollars of wasted values."[41]

Fisher's estimates of disease-cost include (*a*) a cost of premature death measured according to Farr's method of determining the present value of net future earnings, (*b*) the loss of working time of those in the working ages who are sick, and (*c*) the cost of medical attendance, medicine, and nursing. The cost of illness, including loss of wages and cost of care is set at $1 billion. Fisher also estimates the human assets of the United States' population of over 85.5 million people (1907) at $250 billion, "which, though a minimum estimate, greatly exceeds value of all other wealth." The current value of net future earnings which could be gained by eliminating preventable deaths, Fisher estimates, would add another $1 billion.

Fisher draws on studies made during the early 1900's on the economic cost of tuberculosis, hookworm, typhoid, malaria, and smallpox. And during the next decades, additional studies were made on special disease problems and on the costs of preventable deaths.[42] These studies fell into disrepute in the health field and interest lagged. The reasons for this can be found in part in the use of aggregate estimates of costs of preventable deaths and disabilities in the arguments in favor of a national health insurance program,[43] a program about which even now there continues to be much political controversy. Some of the objections to these studies are familiar to those doing research in investments in education—one is the "crass" valuation of human life.

Nevertheless, in three health-program areas cost-benefit estimates have been applied effectively. Occupational health programs have been urged in terms of the "payoff" in reduced absences and

[41] Fisher, *op. cit.*, p. 125.

[42] L. I. Dublin and J. Whitney, "On the Cost of Tuberculosis," *Journal of the American Statistical Association*, Vol. XVII (December, 1920); L. L. Williams, "Economic Importance of Malaria Control," *Proceedings of the Twenty-fifth Annual Meeting of the New Jersey Mosquito Extermination Association* (Atlantic City, N.J., March 24, 1938), pp. 148–51; F. S. Lees, *The Human Machine and Industrial Efficiency* (New York, 1918); J. C. Cummings and J. H. White, *Control of Hookworm Infection at the Deep Gold Mines of Mother Lode, California* (Department of Interior, Bureau of Mines Bull. 139 [Washington, 1923]); Rockefeller Foundation International Health Board, *Bibliography on Hookworm Disease* (Publication No. 11 [New York, 1922]); B. E. Ashford and P. G. Igaravidez, *Ucinariasis in Puerto Rico: A Medical and Economic Problem* (61st Cong., 3d sess., Senate Document 808 [Washington, 1911]).

[43] O. R. Ewing, *The Nation's Health: A Report to the President* (Washington: Federal Security Agency, September, 1948).

workmen's compensation premiums.[44] Extension of vocational rehabilitation services has been advocated in terms of tax payments by those rehabilitated, amounting to many times the cost of rehabilitation. And health-research agencies have pointed to economic gains through improved health far in excess of the medical research outlays.[45] "When the capital value of human beings is once recognized, the tremendous importance of movements for conserving and lengthening life is better appreciated."[46]

The origin of recent economic research on the value of human capital created by health care lies in the development of public expenditure theory and the emphasis given to cost-benefit analysis. The economist, in attempting to identify an objective function for decisions on expenditures, has evaluated benefits from programs in the social welfare field.

The allocation of economic resources is generally determined in the market by the preferences of consumers for work, leisure, and income. These preferences, as expressed in the market, are a guide to optimum use of resources. But there are a number of reasons why consumer preferences are not a wholly reliable guide to optimum use of health resources, even when the word "optimum" is used in this special sense.

First, the consumer would prefer to avoid both illness and the purchase of health services. An individual's purchase of some medical services is of benefit to others. Purchases by some consumers, for example, of influenza vaccination during an epidemic prevent further spread of the disease. The value of the medical services to each consumer does not depend upon his consumption of medical services alone but upon decisions of his neighbors as well. Those who make no purchases of influenza vaccine also benefit. Thus, the social value of medical services is far larger than the private marginal value to those making the investment in themselves. Individual decisions of a consumer are therefore inadequate as an efficient guide to the optimum allocation of resources for health purposes. For these individual decisions tend to undervalue health services and result in an underproduction of these services.

Second, some health services entail processes which have in them "indivisibilities" which do not lend themselves to pricing on the market so that society's preference for them cannot be adequately valued on the markets.[47] Air and water pollution control, fluoridation of water supplies, and mosquito control are examples of these services. Furthermore, the price system for individual services is not applied to all cases: (*a*) the medically indigent are not excluded from care when they are sick, and (*b*) public safety and health sometimes require direct provision of health services and the removal of the individual from the community. Public hospital services for the mentally ill and for persons with tuberculosis are examples of services that are outside the price-market system.

[44] M. C. Klem and M. F. McKiever, *Small Plant Health and Medical Programs* (Public Health Service Publication 15 [Washington, 1950]); M. C. Klem, M. F. McKiever, and W. J. Lear, *Industrial Health and Medical Programs* (Public Health Service Publication 15 [Washington, 1950]); G. W. Bachman *et al.*, *Health Resources in the United States: Personnel, Facilities, and Services* (Washington, 1952); University of Michigan Survey Research Center, *Employee Health Services* (Ann Arbor: Institute for Social Research, University of Michigan, 1957).

[45] National Health Education Committee, *Facts on the Major Killing and Crippling Diseases in the United States Today* (New York, 1959).

[46] Woods and Metzger, *op. cit.*

[47] For a discussion of this problem see J. M. Clark, *Social Control of Business* (Chicago: University of Chicago Press, 1926).

Third, the allocation of health resources is determined by a mixture of private market decisions and administrative decisions. "Administrative decisions" include those decisions made by the government, by private non-profit agencies, and by professional organizations. Decisions concerning some health facilities (the size of a general hospital, for example) are made by voluntary agencies. In many communities, the Visiting Nurses Association determines the availability of part-time nursing care. In some places the content and quality of rural health services are determined by a regional organization associated with a medical school. The principles underlying these administrative decisions and the way in which they influence the allocation of health resources need to be explored.

Emphasizing that much health care is provided outside of the market mechanism and that the market test of efficiency is not applied, Weisbrod states the economic problem as follows: "With all of the many health-promoting activities that could be carried on, with all of the many demands upon limited public health funds, administrators of public health action programs . . . are sorely in need of some meaningful, scientifically defensible standards against which to appraise contending expenditure proposals. The economist should be able to contribute to the establishment of such standards by specifying, within limits, the social benefits from alternative health programs."[48]

Weisbrod outlines a procedure to aid in the making of rational choices among alternative public health projects and to establish a framework for estimating the social benefits of improved health. He applies this method to selected disease problems in the hope that the procedures will assist in establishing priorities among public health projects.

Drawing heavily on the work of Dublin and Lotka, Weisbrod assesses the comparative costs of three diseases—cancer, tuberculosis, and poliomyelitis. He includes in each case, in addition to the direct cost of medical resources devoted to the care and treatment of the diseases, the loss of manpower through death and disability. He measures the economic value of a life saved by the present value of future average gross earnings, less consumption of a person at age n, taking account of the remaining years of workforce participation of males and of females at each age and making allowance for frictional unemployment. He defines earnings and consumption more precisely than Dublin and Lotka do, and he neatly formulates and measures "earnings of a housewife" and "consumption by an added member of a family." The costs of disability are measured as the product of the number of new cases of disability at each age group, the average time lost from production and the average annual earnings. As Weisbrod suggests, the resultant ranking of diseases according to monetary losses leaves out non-monetary losses such as the psychological burden carried by the victim's family. A study by Laitin, limited to the costs of cancer, applies a similar method.[49]

Fein, in the only recent study by an economist that was published under the auspices of a health agency, makes explicit some of the underlying assumptions.[50] In addition to estimating the cost of mental illness in the United States as it affects each year's output, he calcu-

[48] Weisbrod, *op. cit.*

[49] H. Laitin, "The Economics of Cancer" (unpublished doctoral dissertation, Harvard University, 1956).

[50] Fein, *Economics of Mental Illness . . .*, *op. cit.*

lates the present value of the loss in future earnings of persons hospitalized for mental illness in a year, basing this calculation on the number of their remaining years of work expectation and their average earnings. But he refrains from comparing his estimates with others on different diseases. Suggesting that it would be both interesting and useful to make such comparisons, he emphasizes the lack of comparability of the existing estimates as to concept and statistical adequacy so that they in fact measure different things (see Table 6 for illustrations of the different methods currently in use). Fein emphasizes instead the interrelation of direct outlays for mental illness, defining such outlays to include medical care costs and transfer payments and the indirect costs due to losses in economic production.

A series of studies on highway accidents include the cost of impairment and loss of human life. The Eleventh International Road Congress, after review of the problem of human costs of highway accidents as part of cost-benefit analysis of highway construction, concludes: "However repellent it may be to assess human life, it does not seem that such a valuation can be dispensed with. . . . Decisions attribute unconsciously in each case a value to human life and suffering. It seems preferable to make this more conscious and systematic."[51] And Thedie and Abraham, French engineers, in an interesting analysis of the capital value of man point out, "every day decisions are taken. A crossroad is laid out, but a sharp turn remains. Some hospitals are built. Why not more? Certain sums are spent on medical research. Why not larger or smaller amounts?" Thedie and Abraham, while refining the methods of measurements used in an earlier study by Reynolds on human costs of highway accidents, draw on his classification of costs and add to them. Their objective is to find a rule making it possible to decide on a certain investment or to refuse it.

[51] Quoted in J. Thedie and C. Abraham, "Economic Aspects of Road Accidents," *Traffic Engineering and Control*, II, No. 10 (February, 1961), 589–95.

TABLE 6

ILLUSTRATIVE ESTIMATES OF EARNINGS LOSS DUE TO DEATHS AND DISABILITIES FROM SPECIFIC DISEASES USED BY PRIVATE RESEARCH ORGANIZATIONS

Disease	Earnings Loss (In Billions)
Arteriosclerosis and hypertension:	
One year's added work for persons 25–64 years times median family income, 1957	$1.1
Heart disease:	
Man-years lost in a year times median family income, 1957	3.2
Cancer:	
Man-years lost in a year times median family income, 1957	0.6
Mental illness:	
Work lost by resident patients in mental hospitals and through absence of non-hospitalized patients (1952 and 1954) valued at average earnings	0.7
Arthritis and rheumatism:	
Basis of computation not fully stated	1.2
Blindness:	
Cash transfer payments	0.09
Cerebral palsy:	
Estimated on basis of cash assistance required to maintain those not self-supporting	0.2

Source: Compiled from National Health Education Committee, *Facts on the Major Killing and Crippling Diseases in the United States Today* (New York, 1959).

In Reynolds' estimates of economic cost he attempts to assess the net loss in output of goods and services due to death or injury and the expenditures necessitated by the accident, including medical-care expenditures. Thedie and Abraham question the omission of evaluation of a human life that makes no contribution to production. They argue that it does not follow that because the death of an individual costs the community nothing

(in terms of production), no attempt should be made to avoid the death. The value of a human life without regard to whether the person is a producer or not, they suggest, should in fact be the outcome of a collective decision concerning the expense that the nation is willing—as a moral judgment—to undertake, to save one of its members. In addition, they reject Reynolds' view that pain and suffering cannot be evaluated. They classify moral (non-economic) losses due to accidents as follows: (*a*) affective injury to the family from the loss of one of its members, (*b*) affective injury to the nation from loss of one of its citizens, (*c*) loss of capacity to enjoy life caused by an accident, (*d*) pain and suffering of the accident victim. Last, they include a value for "the desire to live" on the part of a person whose life is threatened and they suggest a term for this injury, "the price of living." They include these "non-economic" losses and "value" them by using the amounts determined by the courts as compensation in accident cases.

Cost-benefit analysis more recently has been extended to water-supply systems with a measurement of benefits from reduction in disease as part of the analysis.[52] Pyatt and Rogers include the costs of waterborne diseases with a view to developing a method that would be applicable to decision-making in the construction of municipal water systems. They define the money value of a man at a particular age as the stream of his future earning discounted to the year of evaluation, less future consumption also discounted to the year of evaluation. While the general outlines of the Wiesbrod method are followed, the formulas for computation are revised to fit the types of data available.

These authors set forth the benefit-cost ratio, taking account of reduced mortality and morbidity for a period of fifty years—the estimated life of a water-supply system. Taking account of the minimum exposure to the water-supply system of children born in the year 2010 they lengthen the study period to 2010, plus seventy-five years, the length of life expectancy of those born in the last year of useful life of the water-supply system.

Contribution to national income.—A still different approach is followed in several studies of the problem of the economic contribution of disease eradication and control—an approach designed to illustrate the yield from health expenditures in terms of annual labor product added, rather than the human assets or human capital added. These studies are concerned with the change in size of an annual income flow and with economic growth rates.

In an earlier article Frank Collings and I emphasized the usefulness of estimates of annual labor product gains through disease control as a basis for health program planning.[53] The labor-product change attributable to eradication of mental illness is the subject of the Fein inquiry.[54] A similar method is used in a study of the costs of peptic ulcers and ulcerative colitis. The total economic cost of these two ulcerative disorders in the nation is measured by Blumenthal in terms of annual loss of earnings due to disability and death. The costs of medical care for those disabled by ulcerative disorders are added. Blumenthal places the costs of $0.5 billion and contrasts this

[52] E. E. Pyatt and P. P. Rogers, "On Estimating Benefit-Cost Ratios for Water Supply Investments" (paper presented at the Annual Meeting, American Society of Civil Engineers, Phoenix, Arizona, April 10, 1961, prepared in Civil Engineering Department, Northwestern University, Evanston, Illinois). (Mimeographed.)

[53] Mushkin and Collings, *op. cit.*

[54] Fien, *Economics of Mental Illness . . . , op. cit.*

with the $5 million being spent for research on these diseases.[55]

A Public Health Service study of the economic benefits of murine typhus control also uses an income flow analysis to tell a success story of a public health program.[56] Estimates are made of the average losses that would have been incurred by (*a*) the economy at large, (*b*) the individual's own family, and (*c*) the tax assessor, if 1944 incidence rates of murine typhus had continued into 1958. Estimates are made showing the loss from non-fatal and also from fatal cases, assuming alternatively that losses may be valued in terms of gross product per worker and of average earnings (with self-employed persons assumed to have the same average earnings as wage and salary workers). The figures are developed on a one-year basis over a thirteen-year period. The authors conclude that the earnings gained through the working time "saved" far exceed the cost of the disease eradication. The additional taxes paid on the added annual earnings were about five times as large as expenditures for typhus control in the years for which expenditure data were available.

The murine typhus study is especially noteworthy. It illustrates the types of adjustments that are necessary in morbidity and mortality statistics before these statistics can be used for economic analysis. The work done strongly suggests the need for a team approach to the study of the costs of individual diseases. A team consisting of a biostatistician and a physician, as well as an economist, would help to improve the quality of the studies.

The staff of a subcommittee of the Senate Committee on Government Operations, in a 1961 report of its findings and recommendations on the budgeting and accounting of health expenditures, emphasizes the need for measurement of the economic costs of disease. While the task is not easy, "it is both possible and desirable if the nation is in the future to allocate its health resources—men, money and material—on as objective a basis as possible. . . . It is the staff's judgment that it would be in the interest of the U.S. Government to develop in cooperation with private authorities, a sound economic-statistical framework for estimating the toll of disease and disability."[57]

[55] I. S. Blumenthal, *Research and the Ulcer Problem* (Rand Corporation Report R-336-RC, June, 1959).

[56] E. L. Hill and B. S. Sanders, "Murine Typhus Control in the United States: A Success Story of Public Health Practice" (Washington: United States Public Health Service, November 29, 1960). (Draft.)

[57] United States Congress, Report of the Senate Committee on Government Operations Made by Its Subcommittee on Reorganization and International Organization, *Coordination of Federal Agencies' Programs in Biomedical Research and in Other Scientific Areas* (87th Cong., 1st sess., Senate Report 142 [Washington, 1961]).