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Cost Effectiveness of Occupational Health Programs

A special section consisting of seven articles considers this controversial subject. Most of the articles are a result of a NIOSH-sponsored conference held at Fontana California last November, called to provide a critique of an approach to cost-benefit analysis developed at Kaiser Foundation International — **153-186**

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M. Moore

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Special Section

Cost Effectiveness of Occupational Health Programs

Editor's Note

James P. Hughes, M.D., Guest Editor

This issue of JOM is devoted to a consideration of the controversial subject of the cost effectiveness of occupational health programs. Most of the papers arose out of the proceedings of a NIOSH-sponsored conference held at Fontana, California, November 8-9, 1973. The subject was introduced by Professor Herbert E. Klarman of New York University Graduate School of Public Administration, whose recent "state-of-the-art" paper on cost-benefit analysis in the health field, reprinted in this issue, carries an excellent bibliography.

The Fontana conference was called to provide a critique of an approach to cost-benefit analysis that has been developed in Kaiser Foundation International under a NIOSH contract. The approach is defined in a generic model of occupational health programs, utilizing the in-plant program of the Fontana Works of Kaiser Steel Corporation in Southern California as the test site.

Among those invited to attend were health economists, mathematicians, operations research personnel, health care delivery specialists, labor relations people, industrial hygienists and occupational health physicians. These individuals came from corporate management, organized labor, universities, private research organizations, foundations and government.

The conference was a lively two days consisting of a plant visit, a description of the generic model, and a broad-ranging, critical examination of its attributes and its relevance to the practice of occupational health.

We are grateful to NIOSH for funding this effort, and to Dr. Irving R. Tabershaw, Editor of JOM, for encouraging us to prepare the proceedings for publication in this manner.

Dr. Hughes is Executive Vice President, Kaiser Foundation International, Oakland, California 94604.

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NIOSH Interest in the Cost Effectiveness of Occupational Health Programs

Raymond T. Moore, M.D. and A. Walter Hoover, M.D.

Opening Remarks by Doctor Moore

In 1971, when DHEW's activity in occupational health was given Institute status, Secretary Richardson put several questions to the Department. Among others, he asked "What is the real value of your activities? What is the value of a preventive health program or an occupational health program? How have you evaluated your work? How do you know you are doing any good?"

This request eventually reached us at NIOSH, having been routed through the appropriate channels. By that time, our questions read: "Can you, by tomorrow, give us evidence of the value of an occupational health program? If not, how much time do you need?" Of course, we couldn't do it in a day, so we started by looking at what had been written on the subject. We found a few helpful entries, but in general, the literature was sparse. We were quite heavy in NIOSH on the industrial hygiene aspects of occupational health, and we had a pretty good lead into epidemiology, but we did not then have a focus for in-plant occupational health programs.

Early in 1972 I was told by the staff of one large industrial medical department: "Ray, we have never looked at the benefits side. We assume that we are doing good because we are able to keep our budget and the company continues to employ us. But we don't have any figures of the type you are looking for."

Fortunately for us, when NIOSH was set up, it was given a unit called the Division of Occupational Health Programs. We didn't have anyone to man it, but we put it on the organization chart and we wrote statements for the Federal Register and we got the statements approved. Lo, we were in business.

Then we began the search for personnel to staff the division and to develop our answers to the Secretary's questions. At that time, we were operating under severe personnel hiring restrictions, but we found Dr. Walter Hoover, and with the help of the Intergovernmental Personnel Act, we persuaded Columbia University to release him to us. This was the first time that HEW had used the new law, and it took a while to get people accustomed to the idea. Eventually, we were able to bring Dr. Hoover and Mrs. Nelson to Rockville. With the help of a secretary, they set out to demonstrate the benefits of occupational health programs.

Over the past year there has been growing emphasis on cost-benefit evaluation of health services. The program of the Medical Care Section of the 1973 annual meeting of APHA carried ten or more papers on the subject, ranging from studies on the cost effectiveness of prenatal centers to the cost experience of a project to care for the victims of stroke.

I think that in the future we are going to have to show more on the benefits side of the equation than we have in the past. On many projects we can count the cost, adding up the dollars, although it becomes a little more difficult when one gets down to the fine points. But on the benefit side, what value does human life have? I don't know quite how to get into that question. At one time in one area, an industrial death was relatively easy to settle. There was a $10,000 payment and that was that!

Things have changed now. At NIOSH I know of hardly any of our programs that we are more excited about than the one that brings this group together. The expertise is here, and the timing is favorable. The protocol for the study project is such that should you have suggestions for changing it, these may be considered. But from our viewpoint, NIOSH is very much interested in seeing a successful outcome of this effort. It has a green light as far as we are concerned.

Secretary Richardson is no longer with DHEW. We have a new Secretary, Mr. Caspar W. Weinberger. The Health Services and Mental Health Administration disappeared after the most recent reorganization, and many who were in leadership positions a few months ago have gone. But there is something about federal bureaucracy that stays on forever. You may chuckle about that, but this concept of proving that there is a measurable benefit to your occupational health program will not go away. I suspect that in the future we will have to apply it even more than we do now. We must learn how to do it. There is an interest by the Congress in this problem. You are not in this alone. Many people are looking over your shoulder and wishing you well.

In an editorial entitled "Accounting to the Public" the New England Journal of Medicine of October 11, 1973 had a number of interesting things to say about the evaluation of health services. It concluded that "Cost effectiveness is new to the entire health industry, not just to local and state health departments."

I know that we must meet this challenge and I think we can.

Dr. Moore is Associate Director, NIOSH, and Dr. Hoover is Director, Division of Occupational Health Programs, NIOSH, Rockville, Md.

Reprint requests to Director, Division of Occupational Health Programs, National Institute of Occupational Safety and Health, DHEW, 5600 Fishers Lane, Rockville, Md. 20852 (Dr. Hoover).

Comment by Doctor Hoover

Just over a year ago I came to NIOSH in a somewhat bewildered manner on loan from Columbia. A number of things happened during my period of indoctrination. One of these was an attempt to clarify the role of a division that had been an empty box in the organizational structure. It was agreed that the box should be there, but nobody had put anything into it. That essentially is why I was asked to come in.

The emphasis of NIOSH prior to that time had been very much on the environmental aspects of occupational health, on the prevention of occupational disease, but they now hoped — in the mandate I received — to balance this approach by moving in the direction of stimulating more general programs, taking into consideration the preventive aspects of the health of the worker, as well as his general medical care.

After some soul searching we decided upon certain aims for the new Division. The first is to promote national education and voluntary guidelines for what an occupational health program should be, rather than for what they have been. They aren't very much in a great many places. We want to emphasize the entirety of the occupational health program in the plant, and not just certain elements of the program. We are directing our thrust at small industries in particular because they receive their medical care from vendors who may know very little about the nature of occupations in the plant.

We consider as our second task the development of new and innovative ways of combining community resources with those available in industry to meet the health care needs of workers in a more effective manner.

A third task, arising out of the second, would be to try to interface occupational health care, which has been parked somewhere out on the corner, with the delivery of general health care. All this was a big order for one person, so I was allowed to bring a second person with me from Columbia to help to fill my empty box.

One of the first things that became clear to me as we started selling plants on the idea of the entire occupational health program was that management always asked: "How much will it cost and what will it do for us." My reference to the literature didn't produce too much value. There was the paper by Peter Wolkonsky reporting the results of a questionnaire to determine certain things from the medical records of different industries. It was concluded that a cost-benefit analysis could not be done very well since data is being collected in so many different ways.

Recently the Department of Labor made an attempt, again by the questionnaire and consensus method, to determine whether it was feasible to set up a cost-benefit study of the plant safety program, which would seem at the outset to be rather easy to evaluate. It was found that the data, derived from over a thousand industries, was incompatible for reaching any conclusions, and the study was not done. Most of the difficulty was in the way the indirect costs were recorded.

There is another possible way to go at this problem. That is to formulate a conceptual model, hopefully evolved by an inter-disciplinary group, and apply it in a practical sense to a good medical department. To do that we had to find a good plant medical department. We came to the Fontana Works of Kaiser Steel and decided that it was suitable.

The second problem was to find someone with enough courage to tackle the job of cost-benefit analysis, recognizing that perhaps the initial results would not really indicate as much as we hoped because of the very great difficulties of doing this sort of a job. The only organization that came forward as willing to attempt this hazardous task was Kaiser Foundation International. We are happy with the combination, and with a company that is willing to cooperate in this effort.

What do we hope to get out of this to help us sell occupational health programs? Well, we may be able to show that many aspects of a good program may be expected to produce certain dollar and non-dollar benefits. This has been debatable in the past. In addition, perhaps we can evolve a management tool for use in an operating medical department that will tell us where we are spending money most effectively, and where we are not spending very effectively, so that emphasis may be shifted to where it can do the most good.

We are intrigued with the conceptual model that is being presented. We realize that the multi-disciplinary group attending this conference will produce many criticisms, and we hope that these criticisms will help in the evolution of a better model. So thank you very much for giving your attention to it.

A Method to Determine the Cost Effectiveness of Occupational Health Programs

James P. Hughes, M.D.

Among the aims of Public Law 91-596, the Occupational Safety and Health Act of 1970, Section 2.b.1 states the intent "to institute new, and to perfect existing, programs for providing safe and healthful working conditions," and Section 2.b.5 provides for "developing innovative methods, techniques and approaches." The "conduct (of) experimental and demonstration projects" (Section 2.b.11) is encouraged.

Since PL 91-596 has been in effect, a major effort has centered on the preparation of criteria on which standards of performance in maintaining a safe and healthful workplace may be based. As the employer is encouraged — and increasingly required — to comply with regulations that may be expected to arise out of performance standards, his costs are increased. He is obliged to weigh carefully the requirements of the Act, item by item, against his ability to meet this added cost of production. As new standards are promulgated, there is expectation of growing emphasis upon monitoring the impact upon the health of the workman of exposure to potentially hazardous physical conditions and harmful chemicals. Each dollar spent for health protection and health surveillance is subjected to closer scrutiny. Under these circumstances, the employer is justified in requiring reasonable assurance that specific benefits will accrue from his expenditures on employee health measures. He is inclined to subject his business operations to careful COST-BENEFIT ANALYSIS. The occupational health program is no exception, especially in this period of growing emphasis on the enforcement of PL 91-596.

Need for Data on Costs and Benefits

There have been few comprehensive COST ANALYSES of occupational health programs, and even fewer attempts to assess objectively the values derived. Costs, including the impact of PL 91-596, were considered by Wolkonsky[1] in a questionnaire survey of 29 major corporations. Remarkable variations in company policy and in occupational health practices were encountered. But little could be deduced from the data presented as to the effects of the Act upon organizations operating under a great variety of economic and environmental conditions.

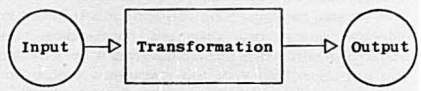
In two related fields, however, there is a rapidly growing literature on methods for the determination of cost-benefits of various public health measures,[2] and of the elements of medical care delivery systems.[3,4] It is timely that occupational health practices be examined with equal determination. There is an urgent need for a standard method of cost analysis that may be worthy of widespread adoption in industry.

Dr. Hughes is Executive Vice President, Kaiser Foundation International, 300 Lakeside Drive, Oakland, CA 94604.

Attempts to justify the Occupational Health Program (OHP) in economic terms have been generally unsuccessful. Some BENEFITS apparently derived from an effective OHP—such as reduced absenteeism, or improved experience of workmens compensation payments — may sometimes be translated into dollars with fair agreement, but even these results are open to challenge as being attributable in part to other factors in the employment situation. Most health professionals, and many business managers who have had direct experience with a sound OHP in an industrial plant, nevertheless recognize that there are other benefits, perhaps less tangible, that stem from such a program. We assert that these benefits have a measurable economic value, however difficult to quantify. We propose to identify these intangible benefits, which we term "value" benefits, so that the real worth of the OHP may be calculated more precisely.

In traditional public health practice, attempts have been made to calculate a dollar value for human life, and to assess different elements of the quality of life as these may be affected by illness or injury.[5] This effort results in the identification of an array of intangible factors, each of which is tentatively assigned a dollar value. Both the classification of benefits, and the dollar values, are arrived at somewhat subjectively. While it may be questioned whether dollar values assigned in this manner have a real economic meaning, the approach has recognized merit, in the opinion of Hanlon and others. We are now applying this method to the study of the OHP, and will endeavor to calculate a dollar equivalent for certain nondollar "value"

Input-Output Model



Inputs

- POPULATION
- CAPITAL
- OPERATING COSTS
- POLICY DECISIONS
  - Health Surveillance
  - Health Maintenance
  - Health Services

Outputs

- NET CASH VALUE
- NON $ BENEFITS

benefits, utilizing mathematical techniques designed to deal with intangibles, as well as more subjective measures such as those that may be derived from attitude survey.

The "Generic Model/OHP"

It is clearly desirable to have a standard method, based upon a generic model, for examining and comparing the effectiveness of occupational health units of different size and in different settings, both in terms of dollars and of nondollar benefits.

A well-constructed model should provide the opportunity to examine, both statistically and dynamically, responses of the system to changed conditions. It also should permit, through the simulation of potential variations, the accurate forecast of costs of an evolving OHP over a planning span of from three to seven years. This capacity of the model should be based upon acceptable standards of OHP performance capable of application to a variety of enterprises of different size, type of industry, and growth rate. The model should be responsive to the need to accommodate new requirements for health surveillance which may be imposed by future performance standards developed within the scope of PL 91-596. It also should permit changes in health maintenance procedures based upon new understanding that may be acquired of factors of health risk in an employee group.

The model should be formulated to accommodate changes in the OHP, it should be suitable for automation and computerization, and it should demonstrate a fresh approach to solving those problems of cost effectiveness that are unique to OHP's.

Our concept of a "Generic Model/OHP" is outlined in the Figure. The present study is designed in part to validate the model by means of demonstrating its application to a real-life situation, the OHP of the Fontana Works of Kaiser Steel Corporation in Southern California. This OHP has been recognized as being of high calibre — it has been the recipient of the Industrial Medical Association's "Health Achievement in Industry Award." We propose to calculate its costs by a standardized accounting method, and to assess benefits derived from it in a manner that is likely to command the concurrence of health professionals, economists, business managers, employees, and labor organizations.

The Generic Model/OHP is described in another paper.[6]

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Cost-Benefit Analysis of the Occupational Health Program: A Generic Model

Rondal M. Phillips, B.A. and James P. Hughes, M.D.

The purpose of the NIOSH-funded study of the cost effectiveness of the occupational health program (OHP) is to provide an effective tool for the measurement and analysis of costs on the one hand, and benefits to be anticipated on the other. The result must be expressed in a manner that is understandable to physicians, nurses, engineers, and accountants alike. It also should be acceptable to business managers as well as to other health professionals.

A method of interdisciplinary communication and problem solving has been evolved from pioneering efforts to apply scientific method to the study of military problems during World War II. It is now widely applied in the field of business management, and increasingly in public health practice. The method has been referred to most often as operations research, although the terms "management science" and "quantitative management" are coming more into vogue.

Management science is characterized by a "systems" approach; i.e., an effort to depict the relationships between the different elements of a situation or a problem, and the effect of each element on the outcome.

Problems are defined and analyzed in graphic terms, usually with symbolic modes of expression. The quantitative model is the hallmark of the process. This approach to problem solving in the health field was described recently by Levey and Loomba[1] in a series of papers that should be of interest to practitioners of occupational health.

We have chosen to undertake the task of cost-benefit analysis of the OHP by first constructing a model that would accommodate the large variety of conditions that occur in different industries and in plants of different size.

The model (Fig 1) is constructed around the concepts of INPUTS, OUTPUTS and TRANSFORMATIONS. This approach provides for the construction of several transitional matrices onto which collected data may be entered.

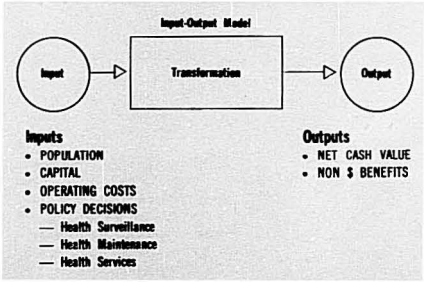
I. System Inputs

There is one primary input to the system — Population. There are three secondary inputs — Capital, Operating Costs and Policy Decisions.

From Kaiser Foundation International, 300 Lakeside Dr., Oakland, Ca. 94604. Reprint requests to Dr. Hughes

POPULATION is the Fontana plant work force. It fulfills the criteria for what is termed a "Markov Chain"; i.e., a cohort suitable for forecasting its future state based upon its historical characteristics. This type of population may be said to consist of several categories, termed states, based upon age. For example, State I may include employees under age 25, State II those from 25 through 35, and State III those 36 years and over. One year after startup of the system, some individuals will have advanced from State I to State II, and others from II to III. This is said to be a Markovian property, and the entire group constitutes a Markovian population. It has the additional characteristics of being affected by attrition and migration. Attrition is due to the expected coming and going within any employee group as from hiring, retirements and terminations. Attrition is distinguished from migration, a planned change in population due to increases in plant production or the addition of facilities. Both types of change affect the states of the population during a subsequent time period. As the primary input of the model, POPULATION—rather than company policy — is regarded as its driving force. It is so designated because in the construction of the model, the employee is regarded as the central figure in the Occupational Health Program (OHP). It is to meet his job-

Fig 1. — Input-Output Model.



related health needs that the OHP is designed. While company policy, or federal regulations, might also have been considered as alternate possibilities for the primary input, we have elected to focus on the workman as he is represented in the plant population.

CAPITAL. As a system input, capital is the monetary investment in plant and equipment that is in direct support of the OHP, referred to as MEDICAL CAPITAL, plus expenditures on physical modifications in plant process equipment designed to eliminate or to reduce health hazards, referred to as PLANT CAPITAL. MEDICAL CAPITAL can be calculated from historical data. PLANT CAPITAL, in contrast, is usually more difficult to calculate because of generally poor historical information, and because it is often lumped with the overall investment of the industrial enterprise in production facilities. The diversion of capital from strictly production facilities to health-related facilities is discretionary on the part of the parent enterprise. Capital is here considered as a system input because the funds come from outside the OHP system, are not produced by the system, but are demanded by the system for its operation. In this respect, the model differs from the customary system diagram describing a financial transaction in industrial management, where capital is usually listed as a resource, rather than an input.

OPERATING COST includes the actual dollar cost of all of the resources — facilities, equipment, supplies and personnel — required to conduct the OHP. The cost items, termed "prices" in some financial systems, are external to the system, and considered to constitute an input, since a small entity such as a plant OHP seldom has much control over the price of goods and services that are required in its function, and even less control over the supply of, and demand for, these resources in the community at large.

POLICY DECISIONS cover Health Surveillance, Health Maintenance and Health Services. These attributes of the model are termed "decisions," since one may decide whether the OHP is to provide a specific service, such as a hearing conservation program. If adopted, it becomes a system input. The OHP physician, in consultation with management, usually decides upon instituting a new program, as specific needs are recognized, perhaps stimulated by the expressed desire of employees, or by the anticipation of regulations. Then as the physician or the industrial hygienist identifies an adverse condition, a precise action can be taken according to the policy decision that has been reached. Performance under the policy can be monitored; both the physician and management can evaluate the effectiveness of application of the policy in relation to its cost and the benefits resulting. This feedback to the system may indicate the need for changes in the policy decision.

Health Surveillance is defined here as the policy decision that specifies the combination of biologic monitoring (such as urinary lead level or audiometry), and of environmental monitoring by industrial hygiene techniques, that together constitute those measures designed for the early detection of risks to health arising from the work environment. Each set of monitoring procedures is a subsystem related to a single hazard; for example, one subsystem may include audiometry and noise level measurement as related to a noise exposure. Different mixes of subsystems of Health Surveillance yield different outputs from the complete system.

Health Maintenance is here defined as the plant policy that guides the conduct of periodic health checkups offered certain personnel to assist them in achieving and maintaining an optimum state of health. This is the examination of the well person, perhaps in a managerial or technical assignment, who may or may not also be exposed to specific physical or chemical hazards in the work environment.

Health Services refer to the policy decision that provides for all of the other health services rendered by the medical and industrial hygiene functions, such as courtesy treatments for non-occupational illness occurring during the work shift, or the in-plant care of job injuries.

II. System Outputs

The system has two outputs — Net Cash Value, and Nondollar Benefits.

NET CASH VALUE is defined as the fund produced by cash flow from two sources: Operating Costs, and certain Dollar Benefits derived from services provided in the OHP, such as reductions in outside medical charges, or the savings in insurance payments achieved through the provision of in-plant physiotherapy treatments. If Operating Costs exceed the amount of the Dollar Benefits, then Net Cash Value is a negative quantity.

NONDOLLAR BENEFITS are those which cannot be expressed readily in dollars from the point of view of the industrial enterprise. Among the apparent nondollar benefits derived from an OHP, three are emphasized. First, the assurance that the plant conforms with all of the requirements of PL 91-596; second, favorable employee reaction to the OHP, and third; recognition of excellence of the OHP by its peer health professionals, perhaps formalized by some type of accreditation. Nondollar Benefits are subject to analysis by accepted mathematical techniques.[2]

III. Transformations

Inputs to the model proceed to outputs through transformations. A transformation is said to have occurred when an input vector, such as Population, is acted upon by some other factor, such as utilization of health services, thus producing an output, such as Nondollar Benefits.

The process of transformation may be quantified by developing matrices onto which data collected in the OHP may be entered. An example of a transformation matrix is given in Fig 2, "Population to Service." This matrix is derived from a simple numerical array (Table) which represents the utilization of all services by each member of the population as

Population to Service Utilization.

Sex: Male Age	No. in Group	S1 Industrial Injury or Illness	S2 Non-Industrial Injury or Illness	S3 Examinations	S4 Health Surveillance	S5 Health Maintenance	S6 Consulting & Counseling
18-25	733	2853	340	0	588	256	146
25-45	753	2559	677	451	1174	241	28
Over 45	252	1386	791	756	1368	605	38

$$[PS]^{*} = \begin{bmatrix} 3.89 & .464 & 0 & .802 & .349 & .349 \\ 3.40 & .899 & .599 & 1.816 & .803 & .050 \\ 5.50 & 3.139 & 3.0 & 5.429 & 2.401 & .151 \end{bmatrix}$$

Calculations from table data
* Population/Service

Fig 2. — Population to Service: A Transformation Matrix.

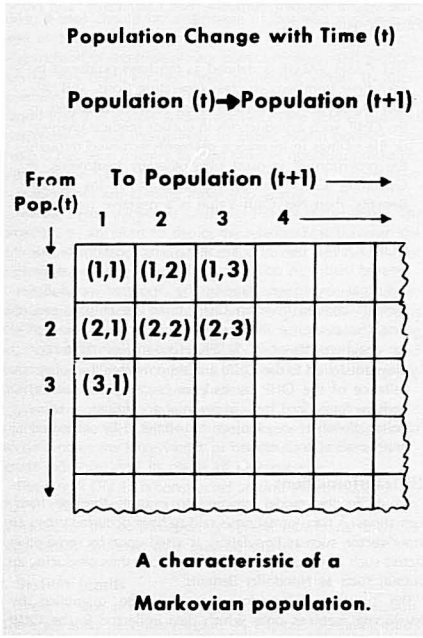


Fig 3. — A Transitional Matrix.

divided into age categories. The procedure is useful in forecasting the consumption of resources by the system.

Another type of matrix, termed the transitional matrix, may also be employed to describe, or to predict, passage from one state to another within a single vector, such as Population (P) acted upon by the vector, time (t). (Fig 3).

IV. Quantifying Nondollar Benefits

In calculating the benefits derived from an OHP, it is customary to measure savings derived from certain tangible effects, such as a reduction in absenteeism, by providing services at an in-plant medical treatment facility, or a reduction in payments to outside vendors of health care. The more difficult task is to assign a value to less tangible benefits, such as the enhancement of employee attitudes toward the work place that might be expected to result from a well run OHP.

One approach might be to identify some norms of employee health status, measure deviations from those norms, and then attempt to demonstrate improvements in health status as service aspects of the OHP are applied.

Another approach would be to set goals for different components of the OHP, such as the number of employees expected to participate in a hearing conservation program, and then score performance in meeting the goals. Employee attitudes toward the OHP might also be scored, or the achievement of accreditation of the OHP could be assigned a value for scoring purposes.

An intriguing concept is used in operations research to deal mathematically with multivalued goals. This is termed the "fuzzy variable." When adjectives such as large, small, substantial, significant or approximate (value) must be employed to quantify a goal, such as the level of employee participation to be expected in the hearing conservation program, the concept of the fuzzy variable is useful.

The concept provides a mechanism to determine probability where there is uncertainty as to whether a system output — a benefit, for example — might be attributable to a specific input. Mathematicians speak of degrees of fuzziness in relation to a certain value, and there is a method for dealing with fuzzy goals and fuzzy constraints in relation to an operations system.[3] There is even a mechanism for decision making by considering the confluence of the goals and the constraints that are characteristic of certain types of program. (Fig 4).

In spite of the whimsical terminology, these methods appear to be useful in dealing with data derived from the OHP, and with values calculated from these data through the use of transformation matrices.

Decision (d) = Confluence of goals (g) and constraints (c)

Programs →

	1	2	3
g_1	.0	.1	.7
g_2	.1	.6	.6
c_1	.3	.6	.7
c_2	.2	.4	1.0
d	.0	.1	.6

The "best" value (i.e., the decision) in each column is encircled.

Fig 4. — A Decision Matrix.

A basic precept of our approach to this project is that at each point along the way we will have progress to show for the effort expended. Having developed a conceptual model, we are now proceeding to verify its application to a real-world occupational health program, that of the Kaiser Steel Works at Fontana.[4] From this experience an improved model may be clarified.

It is through this evolving process that we hope to realize a sound cost-benefits system.

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The Fontana Occupational Health Program as a Data Base

Hallett A. Lewis, M.D.

The Fontana Works of Kaiser Steel Corporation is a fully integrated manufacturing facility employing 9000 persons at Fontana, California, 50 miles east of Los Angeles. Operations include blast furnaces, open hearth, oxygen shop, coke ovens, rolling mills for sheet, plate, pipe, hot strip, merchant bars and forms; galvanizing and tin plating; and various fabricating operations. Iron and steel production began in 1942.

The Occupational Health Program

The present Fontana in-plant medical department, established in 1956, provides health care around the clock in a 7000 sq. ft. facility. Equipment includes x-ray, laboratory, audiometry, pulmonary function units, and other clinical test modalities. There are three full-time physicians, ten nurses, an x-ray technician, a physical therapist, a dispensing optician, two industrial hygienists, and office staff under the direction of a clinic administrator.

Occupational health services include preplacement physical examinations, periodic examinations of several types, and specialized examinations of employees who are either exposed to specific occupational hazards, or are required to operate certain mobile equipment, such as overhead cranes or vehicles. Ancillary services include the fitting of safety eyewear, a rehabilitation program for problem drinkers, and drug counseling. Courtesy treatments are provided for medical conditions of non-occupational origin that require attention during the workday. There are approximately 30,000 visits per year to the department.

Some workmen are exposed to environmental conditions which include noise, heat, coal tar pitch volatiles, and carbon monoxide. The three most frequent types of minor injury are chemical or thermal burns, abrasions or lacerations, and foreign bodies in the eye. Most injuries are fully treated in the plant medical department. More serious injuries are transported by ambulance to a nearby general hospital for definitive care by consultants.

The medical department supervises the plant Hearing Conservation Program. Preemployment audiometric examinations have been done since 1957 and periodic audiograms on certain groups of employees since 1960. Ear protection devices are fitted and dispensed by this unit.

An industrial hygiene unit is housed in the medical department, providing environmental sampling, monitoring environmental exposures, consulting with engineers on appropriate controls for new plant construction, and evaluating the toxicity of raw materials and chemicals used on the plant premises.

Dr. Hallett A. Lewis is Director of Occupational Health Services, Kaiser Foundation International, 300 Lakeside Drive, Oakland, California 94604.

Classification of Services Rendered

For the purposes of this study, the occupational health services provided by the medical department are categorized as follows:

I. Treatments
II. Examinations
III. Health surveillance
IV. Health maintenance
V. Counseling

The scope of services within each category:

I. Treatments
  A. Industrial injury — first and repeat visits
  B. Industrial illness — first and repeat visits
  C. Nonindustrial injury — first and repeat visits
  D. Nonindustrial illness — first and repeat visits
II. Examinations
  A. Preemployment
  B. Periodic
    1. Firemen
    2. Moving equipment operators (cranemen, etc.)
  C. Special evaluations
    1. Return to work
    2. Job placement
    3. Job waiver
    4. Chronic absentee
    5. Disability pension
    6. Inspectors
    7. Transfers
    8. Apprentices
    9. Special driving privileges
III. Health surveillance
  A. Hearing conservation
    1. Audiometric testing
    2. Sound level analysis
    3. Dispensing of hearing protection devices
  B. Safety eyewear
    1. Dispensing
    2. Maintenance
  C. Radiation exposure
    1. Film badges
    2. Monitoring of sources
  D. Coke oven examinations
  E. Silica and asbestos examinations
IV. Health maintenance
  A. Management health examinations
  B. Alcoholism program
    1. Testing for insobriety
    2. Physician consultations
    3. Union representative counseling

C. Drug abuse program
   1. Drug screening
   2. Physician counseling
   3. Union counseling

V. Counseling supervisors and employees
   A. By physician
   B. By nurse
   C. By physical therapist

Composition of the Plant Population

Employees of the Fontana steel facilities are distributed as follows:

	Male	Female		
Salaried	1057	124		
Hourly	7711	271		
Total	8768	395	=	9163

Each employee is identified by badge number. Numbers are issued in sequence of date of hire; i.e., the longer term employees have the lower numbers. The badge number is permanently assigned to the individual, and is not reissued after termination. The badge number is the key to the employee's name, age, length of service, department and job classification.

The departmental listing includes:

Coke plant
Blast furnace
Open hearth
Oxygen shop
Blooming mill
Slabbing mill
Plate mill
Hot strip rolling
Finishing
Structural mills
Merchant mills
Pipe mills
Tin mill
Galvanizing
Cold rolling
Masonry
Maintenance
Roll shops
Central shops
Transportation
Materials handling
Utilities

There are over 1000 job classifications, of which some typical ones are:

Melter
Mixer operator
Casting man
Roller
Manipulator
Shearman
Transfer operator
Piler
Stamper
Scrapman
Craneman
Tractor operator
Buggy operator
Car dumper operator
Conveyor operator
Bin tripper operator
Crusher operator
Scale preparer
Laborer

The Medical Record System

For purposes of the study, a daily register form was designed on which each visit to the medical department is logged manually by the receptionist or nurse when the employee enters. The badge number and purpose of the visit is recorded. The completed register is sent out to be key punched and entered on tape. Information on each visit is also entered on the employee's personal health record. A census tape on the entire plant population carries badge number, job classification, and other biographic data.

A daily log of employee visits compiled by a slightly different method has been maintained since 1956, and is available for review.

Cost Accounting

Budgeting and accounting in the Fontana plant is done on a departmental basis. Medical and industrial hygiene represent a cost center. Budgeting is by a traditional line item method, covering such categories as wages, fringe benefits, supplies, and outside services. A monthly printout records cost performance in comparison with a standard.

Costing Medical Services for Study Purposes

The conceptual model[1] requires that each service rendered by the medical department carry a specific cost. This cost is to be arrived at by observation of a random sample of employee visits on which time-motion studies may be made. Added to the cost of personnel time will be factors for overhead, maintenance and the use of supplies. The unit cost of services arrived at in this manner, multiplied by service utilization, will be corrected to the total cost of medical department operation.

Cost records are available for over ten years of medical department activity, providing a means of historical review in relation to changes that have been made in the services rendered.

Comment

Having described the Fontana occupational health program and established its cost, we proceed to a definition of the benefits derived from it. Obviously, this is the most difficult part of our task. One of the main purposes of convening the critique conference was to obtain the views of a group of experienced observers in helping to arrive at an appropriate set of likely benefits that might be quantified in some manner. Their comments appear elsewhere.[2]

References

1. Phillips RM and Hughes JP: Cost-Benefit Analysis of the Occupational Health Program: A Generic Model. *J Occup Med* **16**: his

2. Hughes JP (ed): Critique of the Fontana Model. *J Occup Med* **16**:166-171, 1974.

The Value of an Occupational Health Model: A Systems Approach

Bela H. Banathy, Ed.D.

My point of view is of one who has been working in systems research — constructing system models and applying models to solve real problems. During the past two decades we have been faced with increasingly more complex technological and social problems. It has not been possible to find solutions to many of these problems by applying the skills of a single analytically-oriented discipline. We have had to develop a new way of thinking and a new approach to disciplined inquiry.

That new way of thinking is known as systems science. Systems science aims to examine isomorphism among concepts and principles operating in different fields of discipline and in many different applications. More specifically, it attempts to design models which can be used across disciplinary boundaries. It is developing a meta-language which can be used to communicate among different disciplines.

It has been obvious in this conference that such a meta-language would be extremely useful for communication among health professionals on the one hand, and economists or mathematicians on the other. We have had problems in the clarification of concepts and in their terminology. What systems science aims to develop is a common language which would be highly functional in use, along with specific generic models within the framework of which people can interact and solve complex problems. The integration in one's thinking of these concepts and principles enables a person to develop what we call systems thinking or a systems viewpoint.

In examining the elements of the present model,[1] I see a demonstration of this systems viewpoint. I now wish to examine the concept of isomorphism as it may apply to the model, and to certain general systems models.

Let me relate to the model a few systems concepts and principles in the functional context of occupational health services and, more specifically, a cost-benefit analysis of these services.

One of the main elements of systems inquiry is the understanding that one must first specify quite definitely what the key entity of the system is. In the study of many of our social and our service systems there has been confusion because of a lack of clarification of the key entity.

Dr. Banathy is associated with Far West Laboratory for Educational Research and Development, 1855 Folsom Street, San Francisco, California 94103.

For example, one could have said that in an occupational health program the key entity is the professional staff, or a unit of medical service. In education it was said for many years that the key entity of the educational system is the teacher, rather than the pupil.

Of course, these are false assumptions. As this model indicates, its key entity, or the reality which this model represents, is the individual user, the employee. Solutions are built around the individual. The model in fact follows this kind of systems thinking because it has demonstrated its consistent commitment to the key entity, the employee.

We must then clarify relationships between the key entity and those other entities which surround it. Those relationships have been indicated clearly in the presentation of this model.

A further refinement of those relationships, however, would be helpful; i.e., a deeper analysis of what other entities might be involved both in the systems space and in the larger systems environment which might influence the behavior of the system, or may be affected by it.

We must examine the relationship of the system to its environment in order to display certain laws which govern the interaction between the system and its environment. I am going to come back to this later.

The establishment of boundaries for both the system and its implementation is another requirement.

Although we are considering here what might be termed "open" systems, the more sharply we are able to clarify the boundaries, the better that we can identify the breaks on these boundaries over which interchange takes place, then the more likely we are to be able to control the system in question.

And so a further delineation and refinement of boundaries of the target system, its peer systems and its sub-systems would be helpful.

We should next consider specification of system levels. Obviously, there is a hierarchy in your model, and it is well stated and well defined. This is important because another common source of confusion is that we often fail to specify just what level we are talking about in any hierarchy of systems, either as a basis for design, or as a basis for analysis. A statement of the specific level of examination has to be made.

We must now make a sharp distinction between goals and objectives. Goals can be derived from the study of the system's

environmental relationships. The goals of cost-benefit analysis, should be stated as benefit goals. From these benefit goals we can then derive performance required in meeting the objectives of the target system, which in this case would be the occupational health services system. Based on the specified objectives, we can talk about the cost effectiveness of the performing system.

There is a distinction between cost-benefit analysis and the determination of cost effectiveness. There is a need, and this model calls for it, for a quite refined specification of performance objectives of the target system, which can be derived from the accurate determination of benefit cost goals. We can then examine further both cost effectiveness and cost-benefit at two different levels within the system.

The benefit goals can be stated in terms of the individual user, in terms of the service personnel who serve the individual user, or in terms of the interests of the management of the plant.

For example, lowering the rate of absenteeism — or more precisely, achieving a stated level of work attendance — might be considered as a management goal, but also as an individual goal. Therefore, it becomes an overall goal of the production system of the plant.

But we should go beyond the individual, and think also of the benefit to his family of reduced absenteeism, to his community, and in the larger sense, even the effect upon human resources at the national level.

I would suggest that we examine more closely the broader aspects of the system, in order to identify a larger set of benefits in terms of impact upon other various systems, displaying these benefits as priorities, and putting some value on them. We could then ask the question, "Given improved work attendance as a benefit requirement, how can we state the expected performance of objectives for the system itself?" We need a performance specification which the system has to display and then satisfy. Then we have something that we can measure in terms of cost effectiveness.

We might consider what may be termed the isomorphism of your model in relation to three types of basic, or generic, systems model:

1. As a Systems Environment Model
2. As a Process Model
3. As a Structural Model

Of these types you have used the Process form in constructing your model — actually a set of models which are basically process-oriented. By this I mean the model handles inputs, transforms inputs into outputs, and then dispatches outputs. However, there is one operation missing here — a feedback adjustment, as a fourth key step in the operation of the model. I suggest that by examining and displaying the characteristics of a feedback adjustment you would complete your process model.

The Systems Environment model provides a mechanism for examining the larger systems space in which the target system is placed. It also would help us to clarify the questions of why the target system exists, what requirements, coming from the environment, are imposed upon the target system, and what are their relationships.

The systems environment model that you now have can become a powerful planning model. You might spend more time in exploring the further refinement of the model in view of certain systems environment concepts and principles. There are a few specific laws that govern the relationships that have been mentioned.

Your structural model has a set of perhaps five subsystems, or service systems, which together represent the occupational health service of this plant.

I suggest a two-pronged approach to further exploration and refinement of the model. The first is to ask these questions, starting out with the five subsystems: what functions do the subsystems, each as a component of the larger target system, carry out; and then, having defined those functions, the next question is — to what objectives should these functions respond? Apparently you have not fully clarified your performance objectives.

The second approach would be to re-examine the benefit goals, develop from them a definite structure, a hierarchy of performance objectives, and then move from objectives to the specification of functions which have to be carried out to attain those objectives. Finally, you would move from a consideration of functions to a clarification and a selection of components which have the capability to carry out those functions, integrating those into a complete and viable system.

The conceptual model would then appear as follows:

1. Establish benefit goals
2. Derive performance objectives
3. Identify functions affecting performance
4. List capabilities required to carry out functions
5. Select components having these capabilities
6. Integrate the components
7. Test the system
8. Feedback to goals and objectives

In the matter of improving work attendance as one of our goals, for example, we might set a performance objective of perhaps a ten per cent improvement. This might require the capability of influencing employee health and attitudes. Components that we would wish to influence would include physical fitness and motivation. We could test these assumptions in practice, and if successful, we might set a higher performance objective.

Resources could be made available to effect favorable change of this type, perhaps providing a physician or a physical education specialist to guide a physical fitness program, or a skilled counselor in helping to improve motivation. We certainly could help supervisors to become more sensitive to the human needs of those responsible to them.

A number of alternatives which might be expected to lead to increased motivation could be considered, and if successful, the result would be improved attendance.

In conclusion, I am favorably impressed by the design of the Phillips model. It is a pioneering effort, innovative in many ways. It should have some predictive value, even beyond the scope of the occupational health program (OHP) for which it was designed. It has the potential for generalization to other systems.

Reference

1. Phillips RM and Hughes JP: Cost benefit analysis of occupational health programs: a generic model. *J Occup Med* **16**:158-161, 1974.

Critique of the Fontana Model

Editor's Note. The proposed model for study of the cost effectiveness of occupational health programs was examined by a multidisciplinary group meeting at Fontana, California, November 8-9, 1973. The deliberations were recorded by stenotype, and the record was edited to capture the principal contributions of each participant. The resource panel is listed below.

Bela H. Banathy, Ed.D., Director of Training, Far West Laboratory for Educational Research and Development, San Francisco.

Lowell E. Bellin, M.D., Professor of Public Health and Head of Division of Health Administration, Columbia School of Public Health, New York, N.Y.

James L. Craig, M.D., Medical Director, Tennessee Valley Authority, Chattanooga, Tenn.

M.A. El Batawi, M.D., Chief Medical Officer for Occupational Health, World Health Organization, Geneva, Switzerland.

Jean S. Felton, M.D., Director, Occupational Health Services, County of Los Angeles.

Robert K. Hayden, A.B., Legislative Representative, United Steelworkers of America, AFL-CIO, Washington, D.C.

William J. Higgins, A.B., Chief of Division of Voluntary Compliance, Occupational Safety and Health Administration, U.S. Department of Labor, Washington, D.C.

Emmett Keeler, Ph.D., Visiting Associate Professor of Economics, University of Chicago.

Herbert E. Klarman, Ph.D., Professor of Economics, Graduate School of Public Administration, New York University.

Wilfred Malenbaum, Ph.D., Professor of Economics, The Wharton School, University of Pennsylvania, Philadelphia, Pennsylvania.

John J. McCarthy, B.S., Manager of Industrial Relations, Kaiser Steel Corporation, Oakland, California.

Preston Probasco, Ph.D., Associate Professor of Manpower Administration, San Jose State University, San Jose, California.

Richard W. Stone, M.D., Medical Director for Research, American Telephone & Telegraph Company, New York, N.Y.

Barry J. White, A.B., Acting Associate Assistant Secretary for Regional Programs, Occupational Safety and Health Administration, U.S. Department of Labor, Washington, D.C.

Alonzo S. Yerby, M.D., Head, Department of Health Services Administration, Harvard School of Public Health.

Carl Zenz, M.D., Medical Director, Allis-Chalmers, Milwaukee, Wisconsin.

Professor Herbert E. Klarman

You should distinguish between the aims of a study of cost effectiveness, and an analysis of cost benefits. Cost effectiveness simply identifies the effects (benefits) of a program, while cost-benefit analysis measures certain values placed on those benefits. I would suggest that you defer placing precise values on the benefits derived from your occupational health program until your model has been refined through operation.

The most important thing in the entire exercise is to define and to understand the link between a cost and a benefit. Once you have clearly established this link you can begin to count the benefits, measure them, and perhaps even place a value on them. If you can apply a dollar sign, then you can add up the apples and the oranges. But whether or not you can come up with a set of ultimate values, the important thing is to develop the measuring stick. You may have to settle for certain rankings of benefits, rather than precise values. This still permits the expression of preference among possible benefits, each of which could be traced back to costs. I would like to see you push this project as far as possible in that direction before concentrating on a fixed dollar value of benefits.

In response to the comment that the scope of the occupational health program should be dictated by the expressed needs of the consumer, the employee, I would point out that this approach has not paid off in other studies of the impact of health measures provided a given population. An individual decision as to which health services a person uses is usually a matter of what is available or what is convenient to use, rather than an expression of need in any medical sense. I would rather be in the position of saying that for a given cost you get a certain benefit, rather than get involved in the question of how necessary is that particular service from the consumer's viewpoint. The latter tack forces you to make assumptions that are unwarranted. You should make only those assumptions that are absolutely necessary.

It is likely that you will have to try different methods of allocating costs to different elements of the program before arriving at a satisfactory method. You may have problems with the accountants in doing this.

It is extremely difficult to make a cost-benefit analysis of a given health project unless one has the means to modify experimentally the input elements of the program. It may be possible, however, to examine the results of past changes in the program on the basis of historical review. This requires the careful reconstruction of events that have occurred, an interesting exercise. This is a valid approach, although not as good as observing the results of changes made deliberately during the study period. One must also be aware of the effects of variations that may occur in the input element, as well as overt change. You must have either change or variation in inputs in order to detect effects. If you don't have change or variation, then statistical techniques will not produce the results you seek.

I understand that you have considered using the concept of discounted cash flow in calculating the value of benefits. This is an added technicality.

I would be inclined to simplify the input side of the model under the general heading of costs. I don't favor the assumption of fixed coefficients for resources required to deliver certain services; for example, stating that a given unit of service, such as a physical examination, always requires a fixed unit of resources, such as facilities or staff. This approach does not work out well in practice. For one thing, the use of fixed coefficients in predicting the cost of a given program does not take into account the economy of scale that accrues to the larger employee population versus the smaller. One of the best contributions that your model could make would be to develop a stochastic method to deal with populations of different size.

Your most difficult task will be to calculate the value of intangible benefits, such as a possible reduction in the statistical probability of death.

Not much of this work has been done. The most serious effort to measure the intangibles derived from a health project is that of Schelling.[1] I would recommend consideration of that approach, at least in arriving at judgments on the cost effectiveness of your program.

Dr. Lowell Bellin

The determination of benefits derived from any procedure of preventive medicine is extremely difficult, especially if one does not have access to a control population. Influenza immunization is a case in point. Aside from the difficulty in measuring a change in morbidity that may result in a group that has been immunized, the impact of adverse reactions must be assessed. If a lawsuit against the company for a case of anaphylactic shock happens to result, the benefits tend to be diminished. Yet, we should seek specific justification for each procedure that is undertaken, rather than just moralize that "It is the thing to do." Of course, peace of mind among immunized employees, enhancing their job satisfaction, might be considered. But we don't know how to quantify it. We do know that for a procedure that is repeated periodically, any favorable effect on employee attitude tends to diminish with time. We might say that, in the economist's terms, a nebulous value such as employee attitude might have a more rapid rate of discount than we have for something like dollar savings in workmens compensation costs. Attitude depreciates more rapidly.

In any event, one needs a baseline against which such an uncertain factor as change in attitude might be compared. From an established baseline, it should be possible to set up a scale of values on which attitude might be rated. The difficulties of determining attitude, whether by questionnaire survey, or by random interviews, or by level of employee participation in a voluntary procedure, should not be underestimated.

One of the hazards of assessing attitudes is that what the consumer perceives as the value of a program or a procedure may be quite different from its intended purpose. The famous Trussell study[2] of the quality of medical care provided the beneficiaries of a union health insurance program in New York City a few years ago showed that in about one third of cases, the care was rated by objective observers as poor. Yet 85% of the patients who received poor care were actually pleased with it. Somehow it made them feel better. While there may be a certain social value in being satisfied with poor medical care, the program was, in an objective sense, inadequate. I have no idea how one might go about adding an element of human gratification to the dollar benefits derived from a program, but as physicians, we must be, and often are, satisfied with such nebulous results in our patients.

I am troubled by the difficulty of identifying nondollar

benefits. We are tempted to make a series of subjective judgments, such as, "This procedure results in improved job satisfaction." We then regard job satisfaction as a "fuzzy variable." In doing that we may be departing further and further from objective truth. That is what worries me.

In determining the costs of the program, there may be a problem in assessing charges for certain backup administrative services provided the medical department by the parent entity, the plant or the company. For example, payroll services, or security. Some cost accounting methods simply put aside minor administrative costs as not being worth the time to calculate. However, this cost could become significant when a medical department is a large factor in a manufacturing facility such as a chemical plant.

I agree with the view expressed by others in the conference that for the results of this project to be useful to health administrators, it is imperative that descriptions be couched in language that we understand and can apply to real-life problems. Perhaps some specialized terminology is useful in the conceptualization of the model, but it must be translated into accepted language if the material is to be usefully applied. There must be a degree of simplification, even popularization, of the concept if the ideas and the findings are to be diffused throughout industry and the field of occupational medicine in particular. It should be worth the effort.

Dr. James L. Craig

The Fontana occupational health program seems to be suitable as the base for a cost-benefit study. The model is an interesting idea, and with some refinement, should result in a significant contribution to occupational health practice.

I believe, however, that the proposed method of data collection could be improved. As I understand it, you will manually log visits to the medical department, using a form arranged in columns according to the categories of service available. Moreover, you plan to project your total experience from a randomized sample in order to calculate the utilization of services by the entire plant population. While your conceptual model is a sophisticated one, you seem to be using a rather antiquated method of recording the data required by it.

I would suggest that a mark sense card be considered for use in compiling your daily log of visits to the medical department. It is simple, easy to use, and it leads quite readily into the electronic processing of medical data. Based upon some ten years of experience at TVA with this method, I can recommend it to you.

Let me explain how our medical record system operates, based upon the use of a mark sense card to record each visit to the medical department. The card is initiated by the receptionist or by a nurse when the employee walks in. One side of the card serves as a flow diagram for moving the patient through the department, starting usually with the nurse, then to the laboratory, perhaps x-ray and electrocardiography, and finally seeing the physician if his services are required. On the reverse side of the card the services performed are recorded, and whether or not the visit is for an occupational condition.

These results are tallied at the end of the day and the week. The cards remain available to make analyses of different aspects of the program at a later date.

Utilizing the mark sense card to record visits to the department, we have been able to calculate our costs with considerable accuracy. We first did a modified type of time and motion study of each of the services provided in the medical department. We assigned a value of one unit to the simplest and lowest cost service, such as an employee's question answered by the receptionist or a clerk. If a simple treatment by a nurse if required, that service has a value of two units. Each laboratory test is also assigned one or more units, depending upon the time required to perform it. The care of an industrial injury, requiring the attention of a nurse and a physician, amounts to perhaps seven units. A complete health appraisal, including a physical examination by a physician, adds up to ten units for a preplacement examination, and fifteen units for a periodic.

It is a relatively simple matter to total the units of service provided during a time period of one month or one year, and then to divide the total cost of operation of the department for that period by the number of units of service provided, resulting in a dollar figure that is the basic cost per unit of service. The cost of each medical procedure, or of each type of examination provided, is arrived at by multiplying the number of units the procedure represents, by the current cost per unit. The total cost of providing a given service over a given period of time is calculated from the volume of this service times the cost per service. In this way, we can readily determine the cost of our preplacement examination program, as an example.

In calculating the cost effectiveness of a procedure, we compare our determined cost with the cost of providing that procedure by the cheapest alternative that is available, perhaps sending out the employee to a hospital emergency room, or to the office of a private physician. The costs of transportation of the employee, as well as time lost from the job, are included. We are then able to determine if we have the more cost effective practice by providing the service in the plant medical department.

When the benefits to be anticipated from an occupational health program are mentioned, we all can make quite a list of ways in which we think the program makes life a little better for the employee. But in discussing benefits with management, I like to stick to things that I can measure, such as savings in the cost of workmens compensation. That is usually understood quite clearly. By identifying such savings with specific elements of the occupational health program, such as preplacement examinations, or in-plant medical treatments for job injuries, we can relate dollar benefits to costs. That is always an impressive demonstration.

Our entire system is based upon the use of the simple mark sense card to record employee visits. Unless this task is performed with precision, you don't have much to work with.

We have not made any surveys of employee attitude toward the medical program, but we get a fair number of favorable comments. We also consider it significant that when we offer a program in which participation is voluntary, such as periodic multiphasic examinations, we get around 95 percent of employees taking part in it.

Dr. Richard W. Stone

I agree that you may not be able to achieve your objectives in this study if the data collection system has too many constraints on it. The minimum essentials for each employee visit to the medical department should be (1) What service was rendered? (2) How much time was required to perform it? and

(3) What was the result? Since there are so many variables to deal with in the equation of health care, both the numerator — Costs, and the denominator — Benefits, must be clearly defined. In our company, AT&T, we concluded — somewhat reluctantly — that a recording system that provides for the electronic data processing of results was the only solution, in spite of its high initial cost. The value of a sound data base cannot be overstressed.

We employ a mark sense card to record each employee visit. It is initiated with identifying information on the employee as he enters, and it accompanies him as he moves through the department, clipped to his medical record. The services provided are entered on the card as the visit proceeds. Finally, diagnoses coded by the ICDA system are entered, a notation made of disposition of the case, and what follow-up may be required.

At the end of each week cards are processed through an optical scanning device, where errors are edited out, and the data translated into machine language. A paper tape is then prepared, providing a cumulative record of the week's activities.

At the end of each month the data contained on the paper tapes is transmitted by teletypewriter to a remote computer for processing, and a monthly report for each medical unit prepared. The computer reports are returned by teletypewriter, providing a monthly printout of all medical department operations.

As I toured the Fontana plant medical department it occurred to me that it includes a unit that may be ideally suited as a subsystem for cost-benefit analysis. This is the physiotherapy section. It is neatly confined to one area. There is equipment which carries a definite capital assessment. Other costs can be derived quite readily. The functions are easily identifiable and are time-oriented. The man in charge seems to be attuned to a systems approach. Why not use that unit as a sub-model to put to a first test the concepts that you have developed? It might be expected to yield interesting results of a cost-benefit nature.

The possibility of doing time-motion studies in the medical department has been mentioned. I wonder if that is feasible? There are other sampling techniques that may be used, such as the time-slice method, that do not produce as much bias as a person standing over one's shoulder saying, "You are taking two minutes for this task, and thirty-seven minutes for that". As attention is drawn to normal patterns of work flow, distortions may result.

Dr. Jean S. Felton

On examining the proposed operation of the model in the medical department, I don't see provision for recording the item of who has rendered a particular service during an employee visit. Most minor injuries can be fully cared for by a nurse alone, especially if a physician is available on stand-by. In the case of the physical examination, we see increasing numbers performed by nurse-examiners, rather than by physicians. Variations of these types should be accommodated by your system, since costs will be affected.

I would urge that before applying the model, each term that is used be defined with precision. For example, the pre-employment examination should list all of the procedures that it includes, and these should be standardized. As regards the job classifications of employees, it would be helpful if each job were described in the manner developed by Bert Hanman[3] at the Kaiser shipyards during World War II. You will recall that jobs were defined as to requirements for lifting, stooping, squating or pushing. It would be even better to add an industrial hygiene characterization of each job; i.e., exposure to carbon monoxide, or silica dust, or heat stress, together with some indication of the usual magnitude of the exposure.

In attempting to assess the benefits derived from a given type of physical examination, I would expect that your first efforts may result in only very rough findings. Then, as you develop better information with experience, you should produce stronger evidence in which you can have more confidence. But to assume that you can derive absolute data on benefits at the outset might be a delusion.

As regards the method of budgeting medical department expenditures, I understand that Fontana has utilized a traditional line item approach to listing expenses, such as wages and salaries, supplies, maintenance and so on. I would suggest that program budgeting be considered, at least as an adjunct. This would forecast the cost of health surveillance examinations, for example, or of an immunization program. This method has proved to be of considerable value in public health practice.[4]

I agree that there is great risk in this type of interdisciplinary effort that poor communication may be a bar to development. There is a serious problem of terminology. For example, the term "vector" means one or two specific things to me as a physician; either it is a line of force, as in an electrocardiogram, or it is an agent of disease transmission. The same word apparently means something entirely different in systems language. We should not take for granted that the terminology peculiar to our respective discipline is clearly understood by others. Each term and each concept should be carefully defined. Unnecessary specialized jargon should be avoided.

I believe that placing some introductory papers in the literature of occupational health, and adding to them as the project develops, is preferable to presenting the complex structure of the model in its entirety at the outset.

Professor Wilfred Malenbaum

From the viewpoint of the economist, the concept of Capital is not fully developed in the model. The distinction between Plant Capital and Medical Capital may be useful to the authors, but the significance of this distinction should be clarified.

The identification of "prices", as a synonym for medical costs, does not seem to me to be an appropriate input to the system, any more than "technology", or "tastes" should be broken out separately. These characteristics all bear on capital cumulation or depreciation. They cannot become independent variables, like population or services.

The outputs of the system need further definition, both the dollar benefits and the nondollar benefits. I would encourage the continuing search for a mechanism to combine the quantitative values expressed for both.

The flow of revenues through the system has the built-in property of diminishing returns. This has not been recognized in the model. Moreover, the relationship of revenues to system outputs should be considered more carefully.

It is essential that the data collection phase of the project

now be pushed along. As data is accumulated, and tried out in the system, other aberrations of the system will become apparent, and can be corrected as they arise.

I believe that the input-output sequence described for the model needs further clarification. In its present form it does not fit my experience, at any rate.

I would like to see a description of methods side-by-side with data accumulated in the conduct of a specific aspect of the Fontana occupational health program, such as hearing conservation. The subsystems underlying the data accumulation could be presented as an appendix.

The model that has been described is a comprehensive, imaginative, and quality system. But we have not had sufficient opportunity during this initial critical review to get into a number of troublesome problems that occur to several of us as conference participants. For example, we have not explored in sufficient depth the idea of discounting costs over projected periods of time into the future. That is a minor point, but it should be clarified in the system. We really feel the need for additional feedback from the system to us as observers if we are to make further contributions to the successful operation of the model.

Professor Emmett Keeler

Your transitional matrices would be clear or if you were to use representative numbers in the matrix cells rather than the notation which you propose: 1,1; 1,2; 1,3; etc. A matrix might then show that 90% of the population would remain in State I at t+1, or that each individual in State I uses, on the average, 2.4 units of a certain health service in a given time period. I would portray the sequence in this way:

$$\text{Population} \times \begin{matrix}\text{Average no. of}\\ \text{services used}\\ \text{per person}\end{matrix} = \begin{matrix}\text{Total}\\ \text{services}\end{matrix}$$

$$\begin{matrix}\text{Total}\\ \text{services}\end{matrix} \times \begin{matrix}\text{Resource}\\ \text{usage by}\\ \text{service}\end{matrix} = \begin{matrix}\text{Total}\\ \text{resource}\\ \text{usage}\end{matrix}$$

I believe it would be better to keep "hard" (dollar) benefits and "soft" (nondollar) benefits separate, rather than to attempt to integrate them.

You have listed compliance with PL 91-596 as a goal. One usually regards the necessity to obey the law as a constraint, rather than a goal. However, if minor infractions of the law are not challenged by government, or if the law is only occasionally enforced, then compliance might be considered a fuzzy objective.

I would reaffirm the importance of being certain that the language used in this type of project be clear to everyone. The language of systems analysis is, like Esperanto, fully understood by only a few. It is not necessary or even desirable to thrust it upon the users of a system when English will serve.

Professor Preston Probasco

I would like to offer a slightly different approach to the model, starting off with the employee, the user of the system. A set of objectives might be assembled for him. For each objective, certain tasks might be designed to meet it. The tasks would then be weighted, with cost as one consideration, and performance effectiveness as another. The results could be entered on a decision matrix. One might even convene an expert panel to help rate the effectiveness of different measures by a Delphi method.

Dr. Alonzo S. Yerby

In the determination of benefits derived from the occupational health program, I would suggest that the findings of all health examinations, whether for purposes of health surveillance (occupational) or health maintenance (nonoccupational), be searched to identify previously undetected conditions that might be expected to produce morbidity or mortality if untreated. There are methods for the calculation of the anticipated costs of medical neglect of a given condition.

Let us assume that your periodic examination of coke oven workers shows that these men in the Fontana plant have a lower level of morbidity, both in general and for specific diseases, than their counterparts in other steel plants. This is something on which you can place a definite value. Then, suppose that you could relate that experience, in part at least, to the effectiveness of your medical and industrial hygiene efforts. If you succeed in that, you may have the kind of results that you seek from the study.

The proposed classification system for health services provided is not clear to me. Perhaps, you could more precisely define the scope of the different types of physical examination that are offered.

Dr. Carl Zenz

I would be concerned that time-motion studies, or even time sampling, of tasks in the medical department may not give sufficient attention to the large individual variation in personal style among health professionals. Here is a physician who is quite meticulous. He acts slowly and deliberately. He might require one hour to conduct a physical examination that another physician may do in fifteen minutes. This is also true of nurses, and of clerical personnel as well.

There also is variation in the complexity of diagnostic problems that a set of physical examinations may produce, each requiring a different time input by the professional staff. This factor should also be accommodated in the cost analysis of a given service.

Certain services provided in the medical department are required by law, regardless of the cost incurred; for example, testing the vision of over-the-road truck drivers. I don't quite see how one determines the cost effectiveness of such a procedure, unless it be by comparing the cost between two or more methods of making the test.

Dr. M. A. El Batawi

The evaluation of the effectiveness of an occupational health program requires that its achievements be measured against stated objectives. The essential first step, therefore, is the identification of a hierarchy of objectives. These might include a reduction in the rate of absenteeism, or a reduction in the incidence of certain disorders, or even an increase in worker output. The second step is the definition of a baseline for each of the conditions for which improvement is sought. With these two elements established, it becomes possible to measure performance, and even to calculate the value of benefits derived from the program.

John J. McCarthy

A matter that has not been touched upon in open session, although it has been discussed in some of our corridor conversations, is the importance of keeping employees well informed on what you are doing, and trying to do, in the medical department. There is a difference between informing employees directly, and letting them find out what is going on from some other source. Their labor representatives also should be provided with adequate and accurate information, although I realize that some of the technical things being done may not be easy to describe.

It is essential that the medical department have credibility in the eyes of the employees. We have been fortunate in this respect at the Fontana plant, due to the acceptance earned by Hal Lewis and the other physicians. That rapport is extremely important, especially if you hope to get into something like an attitude survey, which has not been used much in heavy industry. There may be a tendency for some employees, especially the older ones, to resent being considered "guinea pigs," as they might term it. They will always want to know; "What is being done to us, and how is it going to benefit us?"

If a survey is considered, and I believe that it should be approached cautiously, there must be arrangements for feedback of information to each employee who participates. What was the result of the survey, and what does it mean?

If the communication aspect of the project is handled wisely, the study itself can have a positive industrial relations value, since it is likely to show that the occupational health program benefits the employee. The intention that it should must be spelled out so that everyone can appreciate it.

We should recognize, however, that describing the anticipated benefits of the program in advance of actually demonstrating these benefits brings some risk of experiencing a Hawthorne effect as the study proceeds; i.e., employees may, consciously or not, *want* to benefit from it. That could bias your results. Perhaps you have some mathematical means of erasing that bias.

Robert K. Hayden

I share the view that it is most important to inform the worker of what is going on in a project of this type, so that he does not get the idea that he is being placed in a test tube. The earlier that this is done, the better. Facts are always better than rumors.

In response to the question as to how the average worker might react to the idea of considering a good plant occupational health program as a trade-off for some other benefits in his compensation package, I doubt, first of all, that the health program can be quantified that precisely. There are too many variables in the equation. I just don't think that you could come up with a set of numbers that could be traded for something else in the course of labor negotiations. At most, the occupational health service might be considered as just one element of a company's industrial relations program. I just don't see it standing alone as a trade-off item.

Dr. James P. Hughes

We are grateful to you all for examining with us this model for a cost effectiveness study of occupational health programs. We needed these criticisms, and you may be assured that we will try to heed them. I want to emphasize that the study project is still in its early stages, and the conceptual model is subject to some significant changes. What we have presented is simply a first cut at the problem. We now want to take sufficient time to refine a model that can have the widest possible application in industry, and we feel a need for your continuing interest in it. In the meantime, we will do our best to disseminate information on the study as it develops.

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Application of Cost-Benefit Analysis to Health Systems Technology

Herbert E. Klarman

Introduction

The purpose of this paper is to discuss the application of cost-benefit (C-B) analysis to the assessment of technology in the health services. With the few exceptions that are noted, the focus of the paper is on services, not research.

To accomplish this task there is no substantial body of empirical research literature to draw upon, analyze, and synthesize. Accordingly, I propose to carry out my assignment in three steps. First I shall review the theory and practice of C-B analysis in general. Next I shall discuss its applications to the health field. Finally, employing concrete illustrations, I shall suggest the potentials and limitations of this type of analysis for the assessment of developments in health systems technology.

Cost-Benefit Analysis in General

As a formal and systematic approach to choosing among investments in public projects, C-B analysis is only a generation old. It derives from a marriage of necessity, if not convenience, of theoretical welfare economics and the previously undernourished public expenditures branch of public finance. In reviews of the C-B literature few references are encountered that antedate 1958.[20 84 103] Most of the theoretical, as well as empirical, research was carried out in connection with water resources projects.[19 48 61 62 67 70]

Aims and Criteria of Choice

C-B analysis aims to do in the public sector what the better known supply and demand analysis does in the competitive private sector of the economy. When market failure occurs, whether through the absence of a market or through the existing market's behaving in undesirable ways, public intervention comes under consideration.[5] C-B analysis is helpful in determining the nature and scope of such intervention.

The most egregious example of lack of a market is given by the case of the pure public good. Such a good is collective, usually entails governmental action, and is characterized by a particular feature: when more of it is consumed by A, B need not consume less.[98] National defense is one example, and the lighthouse is another. Certain aspects of basic research and the dissemination of research findings share this feature, since the acquisition of new knowledge by D does not diminish its value for C, the original investigator.

In the context of C-B analysis, the most important cause of market failure is the presence of substantial external effects. They are called economies if positive and diseconomies if negative. Vaccination against a communicable disease is perhaps the most commonly cited example of benefits accruing to a third party or to the community, in addition to the benefits received by the patient and the health worker, who are directly engaged in the transaction[114] (p. 18). Still another example from the health field is the protection accorded to the community by hospitalizing persons with severe mental illness[102] (p. 12).

The goal of public policy is to adopt those projects or programs of service that yield the greatest surplus of benefits over costs. Evaluation of projects is always prospective and oriented toward the future. The criterion of choice, analogous to that of maximizing profits in the market economy, is to maximize present value. Stated differently, the criterion is to equalize marginal benefit and marginal cost. Strictly speaking, as Stigler notes, maximizing present value is also the criterion for optimum behavior in the private sector[104] (p. 150). As Fuchs points out in his paper at this conference, this criterion is quite different from that of attaining the maximum amount of some indicator of benefit.[34]

However, the notion of balancing benefits and costs is not alien to medicine. Lasagna states, "Since no drug — free of toxicity — has ever been introduced that is effective for anything, those of us who are pharmacologists have learned to live reasonably comfortably with the notion of paying some sort of toxicological price for welfare[17] (p. 2)."

A possible source of misunderstanding about C-B analysis is that benefits are usually costs presently borne that would be averted if the program in question proved to be effective. It is essential to distinguish these present and potentially avertable costs from the resource costs required for mounting that program. Since the two types of cost are not always juxtaposed, the distinction is not an obvious one and the failure to make it is not evident.

The essentials of C-B analysis consist of two aspects: breadth of scope and length of time horizon. The idea is to include all costs and all benefits of a program, "to whom soever they accrue," over as long a period as is pertinent and practicable.[84]

Counting, Measuring, and Valuing Benefits and Costs

When an agency wishes to undertake a project or program, it may be tempted to go far afield in counting benefits and to neglect some costs.

In water resources projects, certain secondary benefits may be included improperly. In vocational rehabilitation programs both savings in public assistance grants and income taxes on subsequent earnings are sometimes counted as benefits, even though neither item entails a saving in the use of resources. Both grants and taxes are transfer payments, that is, represent a transfer in command over resources[52] (p. 47).

The distinction between costs and transfers is not meant to imply that the sole justification of public projects or programs is an increase in output or in gross national product (GNP). On the contrary, there is an increasing recognition that public projects or programs may entail multiple objectives, including income distribution, more jobs, regional growth, etc.[35 46 69 115] There is no reason why earnings on a job can-

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not be assigned greater weight than the same amount of money received in public assistance grants. However, such weights are judgmental, are likely to be arbitrary at least initially, should be derived in the public arena, and above all must be given explicit statement.

Similarly, as shown by our progressive individual income tax, we seem to believe in this country that an extra dollar accruing to a low-income person is worth more than an extra dollar accruing to a high-income person.[32] Again, assigning relative weights may help to improve analysis for policy. There is no reason to believe and no intention to claim, however, that agreement on such weights is now impending.

On the cost side a good example of a general tendency toward understatement is the neglect of compliance costs imposed on individuals and firms in estimating the costs of administering the individual income tax, Medicare for the aged, etc. Once the installation of seat belts in automobiles is made mandatory, the temptation arises to disregard the cost of seat belts to the car owners[111] (p. 1).

The preceding discussion deals with counting benefits and costs, what to include and what to exclude. If what may be properly included can be measured, the problem is that of valuation. The ease of valuation, indeed its possibility, depends largely on whether the item in question is traded in the market and therefore bears a price. In that case there are many good reasons for simply adopting that price.[71] When the market price is deemed to be a defective measure of value, however, an attempt is made to estimate an imputed or shadow price. One modification of market price that is generally accepted is to set a lower value on unemployed resources; the size of this adjustment may vary not only with the state of the economy but also by geographic region and occupation.[46]

When an item lacks a market price, it may be omitted from the calculations regardless of its importance. If total benefits are thereby understated, the program may be erroneously deleted. More important perhaps, programs with a sizable proportion of unvalued to total benefits stand to lose in competition for funds with programs that have few, if any, unvalued benefits.[23]

Among the items most likely to be omitted are the so-called intangible benefits; such benefits are especially prominent in the health field. It is not that they can never be valued.[116] Rather, one will distinguish between intangible benefits that still are difficult to value and pure public goods, for which there is no market and which therefore cannot be valued at all.

The dilemmas of valuation can be escaped by retreating from C-B analysis to cost-effectiveness (C-E) analysis. The latter is the less demanding approach, in that it does not require the valuation of all benefits in terms of a common numéraire. C-E analysis requires only that benefits be measured in physical terms. Once an objective or output is specified, the aim is to minimize the cost of attaining it. The cost data required for C-E analysis are, however, the same as for C-B analysis.[60]

Retreating from the valuation of benefits to their mere measurement entails a substantial loss: analysis no longer assists in determining priorities among several fields of public activity. The reason is simple. While C-B analysis cuts across diverse objects of public expenditure, C-E analysis can only help in choosing among alternate ways of achieving a given, presumably desired, outcome.[41] And it is C-E analysis that has been incorporated as a major element in the planning, program, and budgeting (PPB) systems of the Federal government. After initial development by the Rand Corporation, PPB was introduced by the Department of Defense in 1961 and extended to other departments and agencies by Executive Order in 1965[97] (pp. 1-34) [110].

Both C-B analysis and C-E analysis imply the measurement of outcomes that are associated with particular projects or programs of service. Presumably there is a link between inputs and outputs that is measurable and known. Whether behavior follows a deterministic or probabilistic pattern is of no consequence.

In the development of water resources, the design of a particular project almost guarantees the emergence of certain physical outcomes. So much land will be lost to flooding, so much more land will be protected from flooding, so much land will be irrigated, etc. In national defense the outcome of a proposed course of action is much more uncertain, since other countries can take evasive and retaliatory action. In the health field, as we shall learn, the presumed link between inputs and outputs is sometimes tenuous. The task of measurement, which necessarily precedes valuation, has been neglected too often.

The Rate of Discount

A wide consensus exists in economics that a dollar today is worth more than a dollar a year or two later, even if the overall level of prices remains constant. Consumers are believed to have a positive time preference as long as assets are safe, and for producers investment is productive either through the sheer lapse of time, as in wine making, or through the adoption of more roundabout methods of production. Borrowers are therefore willing to pay interest for the use of capital, and lenders in a capitalist economy expect to receive interest. In a socialist economy an accounting or imputed rate of interest is employed for allocating resources over time. The interest rate that helps to calculate the present values of future streams of benefits and future streams of costs for public projects or programs is the well-known discount rate of C-B analysis[52] (p. 165).

In marked contrast to the state of opinion among public health workers, there is little disagreement among economists that a discount rate is necessary for rendering benefits accruing and costs incurred at different times commensurate. Economists do not agree, however, on the level of the discount rate. Marked differences of opinion prevail for a number of reasons. One is that a diversity of interest rate structures exists in the real world, owing to capital market imperfections, differences in risk, and governmental monetary policies.[20 47 84] There is controversy on which imperfections to allow for and how to allow for them. Another reason for differences of opinion, as Musgrave makes plain, is whether the source of financing is private consumption or investment.[76] Still another reason for differences of opinion is a value judgment, whether the proper measure of the discount rate for public projects is the opportunity cost of capital in the private sector or, to the contrary, is the social rate of time preference. The private rate may be high, well above 10%, particularly when the corporation income tax of 50% is allowed for.[6] The social rate of time preference is usually much lower, based on a longer time horizon or greater readiness by the community than by individuals to postpone gratification in favor of future

generations. The social rate, which has been justified in terms of future risk and uncertainty, probability of personal survival, and the diminishing marginal utility of additional income or consumption as per capita income grows over time, is not a number that we know how to ascertain empirically[47] (pp. 99-100). Accordingly, still another procedure, which combines private opportunity cost and social time preference, is also not measurable.

In practice, the agencies of the federal government have employed a wide range of discount rates, usually without giving a reason.[51] Nevertheless, the consequences of choosing a high or a low discount rate are clear. A low discount rate favors projects or programs with benefits accruing in the distant future; a high rate favors projects with costs in the distant future. In effect, as Boulding has suggested, a high interest rate favors the aged and a low one favors the middle aged.[10] When a project or program is short lived, with both benefits and costs concentrated in the near future, the choice of discount rate is of minor or no consequence. Indeed, for a short-lived program discounting may be dispensed with.

Some economists are averse to selecting a discount rate, on the ground that they are in no position to choose between generations[114] (p. 57). The tendency is to display calculations of the present values of benefits and costs under two or more discount rates. It seems to me that such alternative calculations do not afford helpful guidance to the policymaker, unless he is also advised when to employ the one or the other.

Even in the present state of the controversy, there may be some merit to employing a single number for all public projects or for all public human investment projects. The combined method, recommended by a panel of consultants to the Bureau of the Budget in 1961 and subsequently developed by Martin Feldstein, can furnish an adequate rationale even if it does not yet yield a specific number.[24 49] Such a number admittedly would be arbitrary, a reflection of a value judgment.[20] Henderson reports that the French have adopted a centrally determined rate of discount of 7%, to be applied to all public enterprises[47] (p. 117). This is a higher rate than that encountered in many American studies.

Applications to the Health Field

The health services literature contains many statements that espouse the importance of C-B analysis for improving the allocation of resources to and within the health field. It may be a source of astonishment that relatively few complete C-B studies have been carried out.

Perhaps fewer C-B studies should be undertaken than are advocated. Where the aim is to minimize the cost of producing a given good or service, or even of constructing a hospital of specified size and with suitable appurtenances, the apparatus of C-B analysis clearly is superfluous.[56] It suffices to compare unit costs.

Criteria for Inclusion

Nevertheless, the major reason for the shortness of the list of complete studies in the health field is a definite lack in one or more respects on the part of most studies. Certainly in 1972 there seems little point to dealing with analyses that are other than empirical, that is, contain quantitative findings. The result is to eliminate from consideration Mushkin's seminal work in conceptualizing the application of C-B analysis to the health field.[78]

A second, perhaps more critical, requirement for including a study in the present context is that both the benefits and costs of specified programs be measured and valued simultaneously, with their respective present values juxtaposed and compared. As a result, the majority of empirical studies so far performed in the health field are excluded, including that by Fein on mental illness, by Rice on a number of diagnostic categories, and my own on syphilis and on heart disease.[22 53 55 88 89] While all these studies attempt to measure and value the cost of a disease, thereby in effect measuring and valuing the total benefits of eradicating that disease, none attempts to estimate the costs of mounting and operating programs with specified contents and aims. Although each study had made a contribution to the counting, measurement, and valuation of direct and indirect tangible benefits, and two have explored the valuation of intangible benefits, none has presented a comparison of costs and benefits under specified conditions.

The above two requirements, quantification and juxtaposition of costs and benefits, strike me as incontestable. I am prepared to defend a third requirement as equally necessary, namely, that of reflecting a known link, alluded to above, between program and outcome, between inputs and outputs. Such a link should be ascertained empirically; speculative or hypothetical relationships no longer suffice in 1972, a decade or more after the early phases of conceptualization.[73] To apply economic valuation to hypothetical relationships between programs and outcomes is to indulge in an academic exercise for the results of such valuation cannot transcend the quality of the underlying measurements. At this time such an exercise is not only idle, in that it makes no contribution to policy formulation, but it may be counterproductive if it obscures the fact that the relationships between inputs and outputs are not yet known and are still to be ascertained[102] (p. 29).

In another context Fuchs has shown the importance of information concerning the efficacy of health services.[33] The economist can indicate the types of data required. Seldom is he in a position to procure them by himself, and he must rely on other investigators in health services research to help him get them.

The third requirement implies an important corollary. The size of a problem, as measured by the total costs of a disease, is not a reliable guide for policy.[44 54] Even in communicable diseases, less than eradication may be an acceptable goal. For most diagnostic conditions, it is essential to know the amount by which a given program is likely to reduce the size of the problem.

This point is often overlooked. It lends itself to oversight particularly when benefits and costs are not juxtaposed. In the early C-B studies in the health field there may have been a further tendency to attribute greater efficacy to medical care than was perhaps warranted.[77]

Weisbrod performed the earliest of a small number of such studies, and his is still one of the most systematic.[114] He compared the benefits and costs of intervening in three diseases: cancer, polio, and tuberculosis. Drawing in a creative way on Bowen's work in deriving the demand for a public good,[11] Weisbrod was frequently reduced to obtaining cost data and some notion of the link between inputs and outcomes from personal communications with clinicians and administrators. His threefold classification of benefits, which followed

Mushkin, has become conventional. The three types of benefit are: direct, indirect, and intangible.

What follows is a discussion of how such benefits are measured and valued, as well as an assessment of the state of the art. The assessment presents both accomplishments to date and possible shortcomings in the accepted procedures.

Direct Benefits

Direct benefits are that portion of averted costs currently borne that are associated with spending for health services; they represent potential tangible savings in the use of health resources. Certainly in the long run, manpower not required to diagnose and treat disease and injury does become available for other uses. It is reasonable to suppose that our economy like others has a vast variety of wants in the face of relatively scarce resources, so that making resources available for other desired ends represents a contribution to economic welfare.

In the absence of a specific program of services to be evaluated, the measure of direct benefits is usually taken to be total resource costs currently incurred. The appropriateness of this measure as a basis for policy is questionable, as previously noted. In terms of resource use, diminishing marginal productivity is likely to set in. In terms of valuation of benefits, diminishing marginal utility may be a plausible assumption.

It seems to be taken for granted that direct benefits, or the cost of care, can be measured with precision. This is true only when a firm produces a single good or service, such as maternity care in a special hospital. In most instances several goods or services are produced jointly. Under conditions of joint production, it is possible to calculate extra cost or marginal cost for each product, but not its average cost[70] (pp. 44-45). When average unit cost figures are presented, they are the result of an allocation of overhead and joint costs; the latter is always an arbitrary accounting procedure, though it may be systematic and not at all capricious. An alternative procedure, which is no less arbitrary, is to assign to a diagnostic category its proportion of total costs, with the proportion taken from the percentage distribution of patients or of services. In the absence of facilities that produce but a single product, it might be helpful to analyze cost data for facilities with varying diagnostic compositions of patient load. However, other factors are also at play, and there is no logical solution to the problem of determining average cost under conditions of joint production of multiple outputs[52] (p. 166).

Another complication, which affects the calculation of direct benefits and also of indirect benefits, is the simultaneous presence of two or more diseases in a patient. The presence of disease B when intervention is attempted in disease A serves to raise or lower the costs of intervention and therefore the corresponding benefits.[153]

The reason that indirect benefits, defined in the next section, are also affected is that the presence of diseases A and B in a patient may reduce the probability of successful outcome from the treatment of either. The effect is to overstate the benefits expected from reducing the incidence of one or the other disease.[77] The magnitude of this effect is not known.

The prevailing tendency is to take direct benefits from a single-year estimate of costs.[89] Since survivors will also experience morbidity in the future, some medical care costs are being neglected. Initially this procedure may have been associated with an emphasis on single-year estimates to the exclusion of present value estimates.[54] Once the necessity of the latter is recognized, other explanations must be found for this shortcut. One explanation is that survivors will experience only average morbidity in the future; when extra morbidity is absent, there is perhaps no need to deal with morbidity at all. A more plausible explanation lies in the lack of longitudinal data on the morbidity experience of specified population cohorts.

However, the one-year estimate reflects the prevalence of a disease, not incidence. It may be that the prevalence figure is sufficiently greater for chronic conditions, so that it makes ample allowance for future events. Indeed, the prevalence figure in the base year is the same as the sum of the incidence figures for survivors to this year, if certain constants may be assumed in the size of population, death rates for the particular diagnostic group, and the incidence rate. When any of these factors follows a rising trend, the prevalence figure exceeds the sum of the past and present incidence figures and falls short of the sum of incidence figures in the future.

To the extent that unit costs or prices tend to increase faster in the health services sector than in the economy at large, the value of direct benefits will also increase. In my own work I have incorporated an adjustment for this factor into the discount rate, deriving thereby a net discount rate.[53 55] If economic growth were to slow down in this country, the lag in productivity gains of the health services sector behind the economy at large would be reduced, as would the size of this adjustment.

Transportation expenses for medical care are a resource cost that is disregarded in C-B analysis, although they are allowed as deductions under the individual income tax. When the physician made home calls, his travel expenses were automatically included in health services expenditures. The foremost reason for neglecting them today, I suppose, is lack of reliable data. Perhaps there is the further implicit assumption that patients' transportation costs are of a small order of magnitude.

Indirect Benefits

Earnings lost due to premature death or disability are indirect benefits. Debility as an impairing factor has not attained the prominence in empirical studies that Mushkin attached to it from a conceptual standpoint.[77 78]

Since the publication of Rice's studies it is no longer necessary to estimate loss of earnings.[90] Drawing fully on the data resources of the Federal government and using unpublished tabulations almost as much as published ones, Rice prepared her estimates in systematic fashion: apply to the population cohort in question labor force participation rates, employment rates, and mean earnings, inclusive of fringe benefits. She derived for men and women separately estimates of the present values of lost earnings due to mortality under alternative discount rates and a 1-year estimate of lost earnings due to disability or morbidity.[88 89]

Several elements of the benefit calculation that were at issue a decade or so ago appear to be more or less settled now, perhaps prematurely. A brief summary follows.

Our ordinary concern is with earnings, not income. The latter includes income from property.

Consumption by survivors is no longer subtracted from gross earnings to arrive at net earnings. From a prospective viewpoint everybody is considered a member of society, including patients.[74]

The value of housewives' services is recognized, despite the fact that such services are not traded in the market and are omitted from the GNP. Weisbrod developed and applied a complex method for measuring the cost of a substitute housekeeper,[114] (pp. 114-19), but subsequent writers have followed Kuznets in employing a simpler approach, putting the value of the services of a housewife at the level of earnings of a full-time domestic servant[63] (pp. 22-23). To employ a single number is the more practical procedure by far. The magnitude of that number is a separate question, however. It seems increasingly doubtful that the value given by the earnings of a domestic servant is adequate. Thus, the value of the housewife's contribution would increase substantially if day care centers for working women were expanded at public cost.

An alternative approach has been suggested by Edwin Mills, namely, to value the housewife's contribution at the opportunity cost of her staying out of the labor force.[53] Implementation of this approach is impeded by two considerations.[101] One, the method is complicated because values would vary with the individual housewife's educational attainments, type of occupation, amount of job experience, full- or part-time employment status, etc. Two, nonpecuniary factors, which certainly influence the labor force participation rates of women, are difficult to measure and may behave erratically. If total family income permits it, the pecuniary opportunity cost of the wife's staying home has been known to be as low as zero or even negative. Accordingly, the opportunity cost approach has been sidetracked.

The employment rate has been typically taken at 96% , or an overall level of 4% unemployment at the level of full employment.[89] In 1972 the magnitude of this rate is at issue. Whatever the magnitude, Mushkin's argument is accepted that the health services system should not be charged with failures by the economy to provide jobs to all who seek them.[78]

What is usually not taken into account is the tendency for persons rehabilitated after serious illness or injury to find fewer job opportunities than persons who have remained healthy and on the job. In my study of syphilis I recognized the loss of earnings due to the stigma attached to this and similar diseases.[53] When prevention is feasible, it seems appropriate to assign an extra weight or bonus to the indirect benefits of prevention.

Calculations of indirect benefits rest on the implicit assumption that the life expectancies of cohorts of potential survivors are known. Usually standard life tables are employed, separately for men and for women. For diseases of low frequency it seems reasonable to disregard any effect on the total death rate occasioned by the deletion of a particular cause of death. For major diseases the problem is important, although simple deletion may be incorrect. As Weisbrod recognized more than a decade ago, survivors who have avoided a particular cause of death may have a higher or lower susceptibility to other, competing causes of death[114] (pp. 34-35). I compared the effects of simply deleting heart disease as a cause of death on life expectancy and on worklife expectancy. The former was large, 11 to 12 years, and the latter was small, less than a year.[55] For a disease with heavier impact at the younger ages, the effect on worklife expectancy would be relatively larger; correspondingly greater attention would therefore have to be paid to the effect of competing causes of death.

Intangible Benefits

Pain, discomfort, and grief are among the costs of illness, and their lack constitutes the intangible benefits of an effective program of health services that averts them. The benefits accrue in part to the patients and in part to their friends, relatives, and society at large, to the extent that we take pleasure in the happiness of others. Positive external effects in consumption cannot be ruled out, and Vickrey points to the presence of personal gifts that are not subsidized by the deductibility provisions of the income tax.[112] Looming even larger perhaps is the averted premature loss of human life.

None of these effects is traded on the market. Accordingly, none carries a price tag. In attempting to put a value on them the question is what one would be willing to pay in order to avoid them.

In my paper on syphilis I attempted to estimate willingness to pay for escaping the early and late manifestations of the disease by looking at expenditures incurred in connection with other diseases that met certain conditions. After consultation with clinicians I adopted psoriasis as the analogue for early syphilis and terminal cancer as the analogue for its late stage.[53] The conditions specified were that the expenditures for medical care represented principally a willingness to pay for freedom from the particular disease, since in neither case could either direct or indirect tangible benefits, as defined above, be expected. To the extent that payments were made only by the patient, directly or through health insurance, willingness to pay by others was neglected and total willingness to pay was understated.

Neenan estimated the consumer benefit of a community chest x-ray program for tuberculosis.[80] With the help of some fee data indicating willingness to pay, he obtained very high estimates of value.

Five years and more have elapsed since the analogous diseases were valued. The approach has not been copied, which suggests that neither the estimates themselves nor the procedures for getting them have been found useful. One reason is obvious; the approach is highly specific, calling for the development of estimates disease by disease.

A larger body of literature exists on the value of human life than on the other types of intangible health benefits. Life insurance holdings are clearly not applicable to bachelors, and jury verdicts are inconsistent[114] (p. 37). The implications of policy decisions are difficult to elicit in the absence of information on the alternatives that faced the decisionmaker.[32] Moreover, such valuations may lack stability and consistency[1] (pp. 133-34).

Schelling has proposed a different approach. He would measure the value of human life, as distinguished from livelihood, by the amount people are willing to spend to buy a specified reduction in the statistical probability of death.[96] Acton applied this approach in his recent doctoral dissertation and derived an estimate of the value of human life of $28,000[1] (p. 258). This is a substitute for the net value of lost earnings, not an additional amount, as Mishan would agree.[74]

I am not sanguine about the applicability of Acton's numerical estimate to the evaluation of program alternatives. The author was the first to criticize the small size of his sample, its apparent biases, etc. These are remediable defects in the future. What troubles me is the likelihood that respondents to this type of question may not grasp its meaning. Do the

respondents know what are the actual probabilities of their dying in the coming year? How is a small, perhaps 1 percent, reduction in statistical probability perceived? How much more is a 10% reduction worth than a 1 percent reduction? Moreover, does not the value of a gain depend somewhat on the starting point[108] (p. 134)? If all payments come from the consumer, the distribution of income must exert a sizable influence; by how much would willingness to pay change if the task of reducing the death rate were viewed as a collective responsibility that is fully financed from public funds?

Titmuss, in his book on blood, regards the value of human life as priceless and beyond valuation[109] (p. 198). Yet implicit values are placed on human life whenever public policy decisions are made on highway design, auto safety, airport landing devices and traffic control measures, mining hazards, factory safeguards, etc. It seems to me that in his emphasis on voluntary giving, on the sense of community that the gift relationship in blood both reflects and promotes, Titmuss is pointing to a large external benefits component that tends to be neglected when lifetime earnings are taken as the proxy for the value of human life. Although the concern for the altruistic motive is salubrious and appropriate, the conclusion that human life cannot and should not be valued quantitatively does not follow.

As Mishan observes, a rough measure of a precise concept is superior to a precise measure of an erroneous concept.[74] It is agreed that the notion of the value of human life, apart from livelihood, is sound. And a numerical estimate of this value would be useful in comparing how worthwhile alternative programs are. Comparisons of programs would gain in relevance and aptness if all benefits were counted, including saving of human life or gains in life expectancy. This potential gain is much more likely to be realized if all benefits are entered into the model, rather than having some appear only in footnotes.

I am unable to say at this time how such a number or set of numbers for the several age groups can best be derived. Certainly Schelling's questionnaire method can be improved. Perhaps the implications of past or existing public policies will yield a narrower range than one expects. It is conceivable that a committee can do a better job in the realm of values than in the realm of fact. In any event, the value of human life is probably higher for identified and known individuals than for members of statistical populations.[96] If so, incurring extraordinarily large expenditures in behalf of the former is hardly conclusive evidence of irrational behavior.

Weisbrod avoided dealing with the problem of valuing intangible benefits by assuming that they were proportional to the tangible benefits[114] (p. 96). This is an unsatisfactory solution it seems to me in view of the differential impacts of various diseases on life expectancy, disability, and morbidity. Nor was a solution to this problem needed when the emphasis of public expenditures analysis shifted from C-B to C-E analysis. To repeat, in C-E analysis outcome is expressed in physical terms, e.g., years of life gained, and the task of analysis is to discover the program that will yield the desired outcome at the lowest unit cost. In the health services it goes without saying that desired outcome incorporates a constant level of quality or at least an acceptable level.

Cost of Program

The estimate of the cost of a proposed program with which benefits are compared poses no special difficulties. A budget is prepared in terms of the market prices of inputs, which may be adjusted by shadow prices if warranted.

If programs vary in size, it is appropriate to examine the possibility that economies of scale exist[102] (pp. 82-83). However, since health services are rendered in the local area, the prospects of realizing such economies are much more limited than in the manufacture of goods. Moreover, when the size of program increases, factor costs may rise. Finally, as the scope of program approaches the size of the population at risk, the extra cost of additional units of output increases when increasingly resistant groups are encountered.

Conversely, it has been suggested that in the early phases of a program unit cost is likely to be higher than later on, since people learn by doing[102] (p. 24).

Cost-Benefit Versus Cost-Effectiveness Analysis

While it is not especially difficult to estimate the costs of programs, it is difficult to formulate the contents and expected outcomes of programs. In my judgment this has been the chief obstacle to the useful application of C-B or C-E analysis in the health field.

Elsewhere I have listed the data required by the economist for valuing outcomes. A clear statement of each type of outcome is necessary. Certain events, such as death, disability, extra unemployment, and the use of medical care must be entered on a calendar, beginning with the base year, and assigned a duration. The data should extend as close to a person's lifetime as possible, with particular attention to possible recurrence of illness and its exacerbation.[55]

This list of data requirements implies a degree of knowledge about the effects of health services on the health of a population that is often lacking. The obstacles to the attainment of such knowledge are many. Medicine is not an exact science, and physicians may disagree among themselves and the same physician may disagree with his own past findings. Field studies are complicated by what Morris calls the iceberg phenomenon. Members of the designated control group, who are presumably normal, may in fact have the disease under investigation in asymptomatic form[75] (p. 45). The possibility of inducing iatrogenic disease means that only studies performed on normal populations in the community, which are far more costly than studies of captive clinical populations, can yield valid results.[95]

A serious gap in existing data arises from the lack of longitudinal studies of populations over long intervals. Not many investigators possess the requisite patience and dedication or experience the necessary career stability. The funding agencies, under budgetary restraints, have even shorter time horizons. Although statistical manipulation or existing cross section and time series data is a much cheaper and always available approach, it may not afford an adequate substitute in many instances, especially when a high degree of correlation exists among the independent variables under scrutiny.

In 1965 I reported that only one study, Saslaw's on rheumatic fever, met the longitudinal data requirements listed above.[94] Unfortunately, the report on this study was truncated in publication.

Neenan's 1964 study of chest x-rays for tuberculosis concentrated on the short term, on the ground that a recovered

patient suffers no impairment of earnings while early detection alone does not alter the long-term outlook[80] (p. 27). No evidence is adduced for these assumptions.

Acton has recently concluded a C-B analysis of alternative programs for reducing deaths from heart attacks. He considered five programs: an ambulance with specially trained nonphysician personnel; a mobile coronary care unit with a physician; a community triage center; a triage center combined with the ambulance; and a program to screen, monitor, and pretreat the population. The largest net benefit, whether measured by the number of lives saved or valued by the criterion of earnings or that of willingness to pay, is given by the screening, monitoring, and pretreatment program[1] (p. 258). However, the value of personal time lost in screening is neglected, and the screening program seems to display great variability in outcome.

The C-B analysis follows Acton's C-E analysis, in which lives saved are not assigned a value. The screening, monitoring, and pretreatment program yields the largest number of lives saved, but the average cost per life saved is second from the highest and the marginal cost of saving two additional lives is $24,000 each, compared with the estimated average and marginal cost of $3,200 for saving the first 11 lives under the ambulance program[1] (p. 117).

Acton's work is noteworthy for the wealth of detail on the epidemiology of heart attacks, physiology, treatment, and delivery systems for treatment or prevention. He drew extensively on the expertise of health services specialists and investigators.

The Gottschalk Committee's report to the Bureau of the Budget (BOB) contained a C-E analysis of alternative methods for treating chronic final-stage kidney disease.[42] The problem facing the BOB and posed to the committee was to define the appropriate role of the Federal government in this field. The conclusion that a substantially expanded Federal role was warranted was reached on other grounds, which did not entail any analysis. The grounds included the following reasons. Some veterans were already receiving free care in Veterans Administration hospitals; several foreign countries, each poorer than the United States, were committed to delivering this service to the entire population; voluntary health insurance in this country was not meeting the cost of hemodialysis and its leaders saw no prospects of doing this; the group requiring treatment was largely composed of middle-aged adults; and what was still a unique lifesaving measure was available for application to known individuals, persons who would otherwise die in short order. Once the recommendation was made in favor of an expanded role for the Federal government and a feasible mechanism was designed to finance the care rendered to individuals, the problem that remained for analysis was how best to discharge this responsibility, through hemodialysis in an institution, hemodialysis in the patient's home, kidney transplantation, or some mixture of these methods.

The C-E analysis clearly pointed to the superiority of the transplantation route, which incorporates hemodialysis both for initial and backup support. When hemodialysis is necessary, doing it at home is much cheaper.[60] These findings influenced the Gottschalk Committee's recommendations to the BOB. Again, as noted in Acton's study, the economic analysis drew heavily on the underlying epidemiological, physiological, and clinical data developed by and for the Committee.

Had the Gottschalk Committee performed a C-B analysis, it seems plausible to postulate that a shortage of kidneys for transplantation and the relatively greater ease with which hemodialysis facilities can expand might have yielded a higher net benefit value for dialysis, at least in the near future. However, allowance for the superior quality of life under transplantation would constitute a partial offset.[60]

Contrary to some impressions,[43] the Gottschalk Committee did examine prevention programs and decided that for the forseeable future the number of eligible patients would remain unchanged. The committee did not inquire into the dispersion of the distribution of life years gained. Thus, it did not consider whether an average gain of 10 years is worth the same when it is the product of 10 years each gained by 100% of the population at risk, or of 20 years each gained by 50% of the population, or of 40 years each gained by 25% of the population. May it be said that the marginal utility of an additional year is constant, or does the principle of diminishing marginal utility govern?

The Committee did not have to deal with two problems that might arise under different circumstances. One is that even C-E analysis is not so simple as it appears to be when two or more types of outcome are sought as goals. If only one outcome, such as life years gained, is preeminent, other outcomes may be neglected. Where all outcomes, reduced mortality, lower morbidity, and less disability, are important, it becomes necessary once again, as under C-B analysis, to arrive at common or weighted measures of outcome for alternative programs.[25] Only the problem of valuing intangible benefits is escaped. However, in C-E analysis the focus is confined to outcomes common to health services programs. The weighting problem is serious only when the several types of outcome do not occur in the same proportions for every program. The second problem not faced by the Gottschalk Committee is what the appropriate role for government would be if expensive lifesaving measures became practicable for other organs of the body.

Nor did the Gottschalk Committee attempt to deal with the question of increases in patient load if the very success of this program led to the relaxation of criteria governing patient eligibility for treatment. The effect of such relaxation may be appreciable.

In the years 1966-67, with the spread of PPB in the Federal government, a number of C-E studies were carried out in the Department of Health, Education, and Welfare.[43 44 111] Although costs and benefits were calculated simultaneously, the link between the inputs and outputs of programs was measured too often by means of hypothetical numbers. Once the relationships were postulated, no effort was exerted to pursue the measurement problem through empirical inquiry in subsequent budgetary periods. In certain instances only expenditures chargeable to the federal budget were counted as costs, neglecting expenditures incurred by individuals or by other levels of government[111] (p. 1).

Problems in Assessing Health Systems Technology

The discussion of the potential and hitherto modest achievements of C-B and C-E analysis in the health field bears directly on the analysis of the development and spread of health systems technology. However, changes in technology bring to the fore an additional factor, namely, a heightened

degree of uncertainty concerning future benefits and costs. One appropriate response to the prospect of uncertainty, according to systems analysis, is to perform a sensitivity analysis, concentrating on a few key factors or assumptions to which the measure of costs or benefits seems to be especially sensitive.[47 85] This proposition, too, strikes me as a formal one, which awaits empirical content.

Yet, within a decade, any allowance for uncertainty due to developments in technology may be excessive. What will be applied in the next 10 years, it has been suggested, is already known, and the pattern of technological diffusion is discernible[105] (p. 31)". This may be too sanguine a view of the matter, but the record of the Gottschalk Committee does not contradict it. By wisdom or good luck, its projections of survivorship of patients with transplanted kidneys and the cost of hemodialysis at home, both of which were originally supported by scanty data, have been borne out.[58]

If, in effect, technological developments over the next decade are already known to those gifted with early recognition, what can be said about their prospective benefits and costs? In a plea at a health services research seminar in New York City for more research and development funds, Ivan Bennett argued that the half-finished invention is the most costly product, so that technological progress is bound to bring lower unit cost of service and improved performance.[7]

In those cases where straightforward development takes place and serious adverse side effects are not encountered, Bennett's view of the cost-reducing and benefit-enhancing effects of technological progress is undoubtedly correct. However, in many respects the future is shrouded in uncertainties. The size and geographic distribution of population, value structures, political decisions, etc. are uncertain for the future, even when technological developments are not. Public policies are also known to create unintended and unanticipated side effects. An accepted way to deal with uncertainty is to provide for flexible operation by avoiding a fine-tuned operation that yields a minimum cost only for a particular scale of output. Similarly, if manpower is to be used flexibly in the future, it must be endowed with a more general education than otherwise. Thus, flexibility, whatever its cause or source, imposes a moderate extra cost over a moderate range of outputs[52] (pp. 105, 123-24).

The Historical Record

Rather than pursue this pro and con argument I propose to examine the historical record. What have been the effects of past changes in health systems technology on costs and on benefits? A review of the modest literature on this subject, which is still subterranean for the most part, reveals a sharp difference of opinion.

In a new monograph on hospital expenditures sponsored by the National Center for Health Services Research and Development, Martin Feldstein attributes most of the postwar increase in hospital cost to an increase in demand or, more precisely, to an upward shift in the demand curve[27] (pp. 36-51). To paraphrase his argument, technical change in the absence of scientific progress may occur for two different reasons. Economic analysis has emphasized technical change in response to a shift in the relative prices of inputs.[8] If wages rise faster than the price of other inputs, for example, hospitals will economize on labor by using more disposable items, by automating laboratory procedures, etc. The effect of such substitution is to prevent costs from rising as fast as they otherwise would have.

The second reason for technical change without scientific progress, which Feldstein emphasizes, is a change in demand for hospital care. This type of change generally yields a new product. The spread of high-cost techniques is primarily due to rising income and increased health insurance coverage. As income increases, patients tend to raise the valuation of more costly care by relatively more than the valuation of less costly care. An increase in the proportion of the hospital bill paid by insurance will necessarily shift hospitals to more expensive technology as the price per unit of benefit is lowered.

Gains in scientific knowledge, including managerial innovations, that have the potential of lowering the cost of care may actually have the opposite effect. This happens again if the new scientific knowledge raises the benefits of expensive care by relatively more than the benefits of inexpensive care. In addition, if patient preferences do not prevail and hospitals produce with the most expensive techniques at which benefits are not less than cost, scientific progress cannot lower cost per patient day.

In a completed monograph on physician expenditures by Fuchs and Kramer, which the National Center will publish in the near future, a sharp distinction is drawn between the effects of demand factors and those of technology. Their arguments concerning technology reflect a historical perspective, and may be paraphrased as follows[35] (pp. 35-42).

The late 1940's and early 1950's were marked by the introduction and widespread diffusion of many new drugs, particularly the antibiotics, which had a pronounced effect on the length and severity of infectious diseases. Since the mid-1950's, advances in medical technology have not brought about a similar improvement in the ability of physicians to improve health. Renal dialysis, cancer chemotherapy, and open-heart surgery may achieve dramatic effects in particular cases but make only marginal improvements in general indices of health.

Moreover, the early advances tended to be physician saving, while the later ones were characteristically physician using. The improvement in health resulting from the early advances was so great that it turned the anticipated slight rise in demand for physician services into a slight decline. The reason is, following Grossman; that healthier people have less objective need for physicians' services. By contrast, Fuchs and Kramer conclude that changes in demand factors had little effect on expenditures for physician services before the advent of Medicare and Medicaid in the mid-1960's.

In effect, the Fuchs-Kramer view is that technology and the conventional demand forces are independent of one another. Feldstein holds that the effects of technology may also be exerted through a shift in demand.

Each monograph makes its case ably and forcefully. As often happens, each raises more questions than it can answer. It would be premature therefore to attempt to pass judgment on the validity of the respective findings concerning the effects of technology in the postwar era.

I should like to turn to some of my own work, which focused on the marked acceleration in the upward trends of costs and expenditures for hospital and physician services in 1966. I have argued, though by no means conclusively, that the large expansion in the volume of hospital services subject to

cost reimbursement and the adoption of a new, previously untried method of paying physicians at reasonable and customary charges, subject to the prevailing distribution of fees in a local area, must have exerted strong effects of their own.[59] To concentrate on hospitals, cost reimbursement for most patients leads to an impairment of financial self-discipline since a dollar spent is reimbursed. In my judgment, this proposition holds true for any institution, whether it be under voluntary nonprofit, governmental, or proprietary auspices. So far I am not persuaded by the empirical studies that have reached conclusions to the contrary.[57 82]

A number of works have recently appeared that attempt to explain the behavior of the nonprofit hospital.[18 39 81 87] They are for the most part far ranging and therefore enlightening. One is even entertaining, positing a theory of conspicuous production, with the hospital's objective taken to be the closing of a status gap.[64] None really attempts to deal with the sharp discontinuity in hospital cost behavior beginning in 1966.

A rise in personal income may lead to greater reliance on technology for still another reason. For example, many persons are unable to stop smoking. A higher income enables them to pay more for cigarettes with a filter and with reduced tar and nicotine contents. Similarly a higher income permits people to spend more on automobiles with safety gadgets, reducing the need for exerting influence on the behavior of drivers. It has been suggested that it is more effective to operate on impersonal environmental forces than to try to change the behavior of individuals.[92]

From the above I conclude that there is no general answer to the question of the effect of changes in health systems technology on costs and on benefits. It happens only once in a generation, perhaps even less frequently, that an idea like early ambulation after surgery is born of necessity, effects huge savings in the use of health resources, and also exerts a positive effect on health. In most cases, the effects of technology will be mixed. Often the product is new in the sense that a treatment is created that was not available previously and therefore could not have been demanded. The decision whether or not to adopt a piece of technology and the extent of its spread will depend on a number of factors, including the values of consumers, the motivations of providers, the availability of funds, methods of provider remuneration, and the cost and efficacy of the service in question.

The Hospital as Example

Once again it strikes me that such a general formulation of the problem affords practically no guidance to decisionmaking. Only the concrete circumstances surrounding a project or program can indicate the special problems of measurement and valuation and the unique opportunities for solving them and what is to be emphasized in the analysis and what may be neglected with only a moderate degree of trepidation. Accordingly, I have selected two examples for detailed examination: the hospital, about which I know from experience and study, and automated multiphasic screening, about which I have read.[38]

Economists have offered essentially three views about capital investment in the hospital. One view is that hospitals invest too little capital, hence their lag in productivity gains behind the economy at large[40] (p. 55). The second view is that hospitals invest too much because grants and bequests accrue to them at zero price.[66] The third view is that there is no optimum amount of investment in hospital beds if all beds built tend to be filled under conditions of third-party payment.[4] Conceivably, each position may have some merit if it reflects what happens in different sectors of the hospital.

For simplicity I employ a threefold classification of hospital capital investment: patient beds, supporting housekeeping services, and ancillary medical services.[39] For each sector I attempt to explore the unique problems of measurement and valuation facing the application of C-B or C-E analysis.

Patient Beds

The heart of the exercise in evaluating a project to expand hospital bed capacity, in my judgment, lies in one's explanation of the phenomenon of hospital use. At one pole, if the primary determinants of use are biological in nature, an increase in bed supply beyond a certain point must result in additional empty beds. If hospitals are paid at stated charges, empty beds inflict a heavy financial burden on each institution.[57] The reason is that fixed costs constitute two-thirds to three-quarters of total operating costs.[28] Each institution would therefore be subject to financial self-discipline in building beds, and there would be little occasion for outside intervention beyond the provision of information on the building plans of other hospitals. The effect of introducing more technology might well be to increase the proportion of fixed costs to total operating costs, thereby reenforcing financial self-discipline.

On the other hand, if all beds built tend to be used under conditions of prepayment, as Roemer first suggested, there is no automatic criterion for an optimum bed supply.[91 98] In the absence of evidence that low hospital use has an unfavorable effect on health, the appropriate public policy is invariably to clamp a tight lid on bed supply.[57] The application of more or less technology in the hospital is beside the point, although operating cheaper extra beds would seem to be the preferable policy.

Patient census is a function of bed supply in the long run. Combined with patient mix, it sets the requirement for nursing personnel, which may be viewed largely as a requirement for personal services, with little or no substitution of equipment permitted. However, substitution is possible among levels of nursing personnel. The extent of actual substitution of low-paid for high-paid staff is probably overstated by the failure of hospital budgets to incorporate expenditures for special-duty nurses.

Housekeeping Services

I do not see any problems of sophisticated analysis in the area of supporting housekeeping services. Here the appropriate criterion for decisionmaking is that of cost minimization. Bed sheets and towels are to be washed as cheaply as possible for a given specification of whiteness. Patients' rooms and corridors are to be kept clean as cheaply as possible. Meals of a given quality are to cost as little as possible.

Once it is recognized that certain products or services need not be produced by the hospital but can be purchased from the outside, the problem is that of developing valid comparisons of unit cost. In addition, some administrators may wish to allow for certain risk factors. In the absence of competition among suppliers, the sales price may be quoted artifically low at the outset, only to be raised later. Also, in the

absence of competition, purchases from the outside may increase the risk of running out of inventory.

Apart from an allowance for lower risk associated with production within the hospital, estimates of internal cost of production should include only differential cost. No portion of overhead cost should be attributed, because these would continue in entirety after internal production ceased. Moreover, top management will perform the same role as coordinator whether some goods and services are produced inside the hospital or acquired by purchase.

In fact, the rise in hospital wages and gains in productivity attainable in large-scale manufacturing have led hospitals to increase the purchase and use of disposable items and already packaged supplies. As Flagle reports, gains in productivity from investment in large-scale plant have been achieved outside the health care system, which shares in them through purchase.[30]

If the objective of cost minimization is for a given level of cleanliness or nutrition, the question of how this level is determined arises. I doubt that much would be accomplished by searching for effects on the health of patients. Rather the criteria must be either patients' satisfaction or acceptability to management. Expressions of satisfaction are somewhat suspect since patients are likely to be impressed by any display of interest on the part of management in their opinions. The most practicable approach, it seems to me, is to compare alternative standards of service, none of them falling below adequacy with the additional cost of attaining successively higher levels.

In some respects the computer partakes of a supporting housekeeping service and in other respects, when participating in diagnosis, it is akin to an ancillary medical service.[99] The computer is a housekeeping service when it processes the payroll and issues bills to patients and insurance plans. As a substitute for older ways of bookkeeping and billing, the evaluation of computer performance is straightforward. Does it reduce costs and by how much?

Medical Services

Even when the computer helps in diagnosis the test is still cost reduction, if an older way of performing the same task is being replaced. There may be a complication, however. The cost of operating the computer falls on the hospital, while savings in physician time accrue to the attending physician. The presence of distributional considerations suggests that the decision reached is not independent of who is or who exerts predominant influence on the decisionmaker.

Apart from the distributional considerations of who pays and who saves, evaluation of the worthwhileness of the computer in assisting in diagnosis is no different from the way another ancillary medical service, the laboratory, is evaluated. With respect to services that were rendered in the past, the test is simple. Does the new equipment save money, or does it expand services for the same amount of money? In the laboratory additional and more costly equipment does replace technical personnel. A possible offset is the tendency to prescribe more services,[2] although within the limits of existing capacity of equipment and staff, the marginal cost of additional units of service is low. What is not known is how much good is accomplished, particularly in the absence of information on the timeliness of the reports on these services.

In his paper at this conference, Flagle reports economies achieved in patient surveillance due to continuity of use of the monitoring system in infusing blood.[30] This finding strikes me as analogous to the finding in his own early work that a single channel is more efficient than two channels when the demand for services varies stochastically.[31]

The intensive care unit is a more complex operation to evaluate. To the extent that it substitutes equipment for nurses it should cost less. However, the unit is also intended to save lives. The yield in years of life gained is properly subject to more sophisticated analysis.

From the preceding discussion it appears that C-B or C-E analysis should be used only if the service rendered is a new one or the old product has changed appreciably, gaining new dimensions. When all benefits take the form of savings in health resources, that is, are direct and tangible benefits, the appropriate form of analysis is cost-benefit. When the preponderant benefits are intangible or lifesaving, the dilemma is to choose between C-B and C-E analysis. On the one hand, C-E analysis is easier to perform since intangible benefits need only be measured but not valued. Indeed, according to Martin Feldstein, even the problem of choice of discount rate is simpler in the case of C-E analysis, with only the social time preference rate being relevant.[26] On the other hand, to resort to C-E analysis is to give up in advance whatever help analysis can offer in choosing among several objectives or program areas. It then becomes necessary to make the choice on other grounds, as the Gottschalk Committee did.

I am unable to see a general resolution to this dilemma. Certainly it is not evident how to establish priorities in a systematic way when C-B analysis is abandoned. Perhaps the choice can still be made in a practicable way with reasons explicitly stated when remarkable benefits are under consideration, as in the treatment of final-stage kidney disease. When the benefits in question are modest but difficult to value, the problem of deciding whether or not to adopt a particular piece of technology is very difficult. Following the lead of pace-setting organizations almost always leads to adoption. Perhaps we should put trust in our ability to continue to improve the valuation of intangible benefits in the future.[116] Setting conventional values on gains in life expectancy at various ages would seem worth exploring. However, I can also see increasing difficulty in the future in valuing direct tangible benefits if fewer market prices are available for health services in the event that provider reimbursement shifts away from a fee for service and toward capitation and salary methods.

Automated Multiphasic Screening as Example

Often cited and discussed as an example of technological development in the health field is automated multiphasic health screening[79] (pp. 96-104). The reports issued from the Kaiser-Permanente laboratories in Oakland and San Francisco have revealed a good deal about the organization and staffing of such a service and presented data on unit costs.[12-16]

No evaluation akin to C-B or C-E analysis has yet been attempted, and none is claimed. Collen and associates report that total costs for screening an individual are $21.32, which, they note, is only one-fourth or one-fifth of the cost of a periodic health examination employing more conventional methods.[14] The position of the authors, I take it, is that this comparison will serve for the time being, pending determination of the efficacy of multiphasic health screening. The fact is that some people do obtain a periodic health examination, whatever its efficacy may be.

Garfield's position differs from Collen's for he considers the effectiveness of screening in arresting or curing previously unknown disease beside the point. For Garfield automated multiphasic screening has assumed a useful social function by serving as a sorting mechanism for patients with prepayment who would otherwise flood the health services system.[36 37]

I have difficulty with both positions. Collen's comparison of cost with that of the periodic health examination reminds one that the latter procedure is notoriously controversial, with the central issue revolving precisely about its effectiveness. Among physicians there appear to be true believers, persistent skeptics, and ambivalent prescribers.[50 100 113] Furthermore, as emphasized in the Nuffield report, screening implies an invitation to the patient to come and see the doctor who promises him a favorable outcome.[72] This is in contrast to the more usual visit initiated by the patient who has symptoms and seeks relief.

My criticisms of Garfield's position are more serious. His view that automated multiphasic screening be regarded as a sorting mechanism, a substitute for the rationing of services by price, raises a host of questions. Apparently, judging from Dr. Garfield's paper at this conference, a good deal of his argument is based on an interpretation of what happened under Medicare and Medicaid. To my knowledge, the Medicare program experienced but a modest increase in the use of services and a huge, unexpected, increase in unit cost. I know of no way to interpret the unanticipated rise in expenditures under Medicaid, in the absence of data on trends in size of the eligible population, per capita use, and unit cost. My own guess is that the first component may have been a major culprit.

In his paper at this conference Garfield hypothesizes a difference in price elasticity of demand between the sick and his other three categories of patient: the well, the worried well, and the early sick. However, there are no empirical studies of the demand for physicians services in which people were so classified. From other studies it would appear that a host of factors, such as health insurance, earnings as an expression of the value of time, age, and the supply of providers, are important determinants of the demand for physician services.[29]

The assertion that the supply of services for sick care is inelastic is not unique to Garfield. My own reading of trends in the education of physicians, which takes longer and therefore responds more slowly than any other health occupation, is that even this system has been somewhat responsive while insisting that class size must be kept small and still more responsive after the policy decision to expand enrollment was made and implemented by funding. Whether the supply response has been sufficient to meet rising demand is, of course, a different issue.

My most serious reservation touches closely on the nature and function of C-B analysis. If complete prepayment serves to create a condition of excess demand, then some rationing or control measures are clearly indicated. Why assume, without comparing alternatives, that automated multiphasic screening is the most appropriate instrumentality? It seems to me that when the stated purposes of a program change, so should the alternatives to be considered.

Collen's two papers on the cost of screening fill a real need.[14 15] Two measures are presented: cost per test and cost per screening. Cost per test reflects only direct departmental costs, while cost per screening incorporates an allocation of overhead expense. The second article offers a costing rule: to allow for all costs incurred, double the reported cost per test. My reading of the earlier article, which appears to present essentially the same data, suggests an inflation of only 50%. I am unable to account for the discrepancy.

Since the screening process is automatic, the capital equipment is indivisible, all procedures are schedulable, and economies of scale are to be expected. The larger the scale of operation is, the lower the average unit cost. However, to achieve the lower cost, the full utilization of existing facilities is essential. Accordingly, it is said to be advantageous to have available a source of standby patients, such as those awaiting admission to the hospital.[16]

Collen's second article goes beyond cost per test or per screening and reports cost per positive case.[15] For mammography a prevalence rate of 1.2% converts the unit cost of $4.90 into a cost per positive case of $408.00. Since one-fifth of the women with positive mammograms have cancer of the breast, the screening cost per true positive case is $2,000. The cost of diagnosis for all five women and of treatment for one is still excluded.

It will be recalled from Blumberg's classic article that the proportion of false positives is a function not only of the accuracy of the screening test but also of the prevalence rate.[9 107] There are two reasons for aiming to keep down the number of false positives: to avoid needless anxiety and to prevent iatrogenic disease due to the diagnostic process itself.

The data reported so far from the Kaiser-Permanente laboratories suggest that automated multiphasic screening is both feasible and affordable. The question is whether it is worthwhile. Answers are conceivable on several levels.

One answer is in terms of its effect on health. The Advisory Committee on Automated Multiphasic Health Testing and Services (AMHTS) states that much of disease uncovered by testing will be chronic or not reversible; it will not yield a saving in the use of services or an improvement in health[3] (p. 31).

The second answer is Garfield's, which I have criticized at length. No reason is really given for choosing this way to control the use of physician services.

Possibly a third answer is that automated multiphasic screening is an integral part of a package of comprehensive health services to which everybody has a right. Usually the service is aspired to by the poor because the middle and upper classes are already getting it. Evidently this answer would be premature at this time.

I can see no reasonable alternative to a fourth answer, namely, an evaluation of automated health screening for its worthwhileness. The report by the Advisory Committee states, "There are elements of AMHTS that defy C-E analysis, but which depend primarily on medical, social, and scientific objectives[3] (p. 29)." If I understand the statement, I must disagree with it. It is likely, however, that I do not understand it. What are the medical, social, or scientific objectives that defy measurement?

Following the formulation of data requirements in applying C-B analysis to the health field, I propose this framework for compiling data to evaluate automated multiphasic screening: the volume of disease detected that was not previously known, what could be and in fact was done about all this disease, what were the outcomes in terms of health status and subsequent utilization of services, and at what cost, including diagnosis and treatment, were the outcomes attained[83 106] (p.

65). It is only fair to add that, as indicated by a recent, not yet published paper which compares study and control groups for such measures of outcome as work and health services utilization, Collen's group is compiling more and more of the requisite data.[86] Still lacking is information on costs corresponding to the specified benefits.

Barriers to Systematic Analysis

To give some focus to a discussion of the necessary steps ahead, I have prepared a list of barriers to the systematic and rational analysis of expenditures for health systems technology. At the same time I attempt to assess the prospects for lowering or overcoming each barrier.

When the costs of operation mount beyond all projections, the tendency is to argue that the computer or automated laboratory, as the case may be, is not merely providing services but is performing a research function. Yet doing things we know little about does not quite define research. Certain features of research, such as formulation of hypotheses, design of study, capability for statistical analysis of data, etc. are not available everywhere that services are rendered. Although some duplication of research is desirable, it should be intentional and need not be universal.[21] It follows that sources of research funds should exercise discrimination in allocating research funds. If the absorption of so-called research costs by patients is also precluded, this tendency will be minimized.

There is a tendency to expand the range of functions said to be performed by new equipment. Surely, data on payroll could assist management in controlling cost by department; data on billings could provide a proxy for cost data by diagnosis. The first of these applications can be evaluated according to a strict criterion: whether potential cost control is achieved and whether savings are realized. The second application can be judged on its own merits as an intermediate good: of what value is such information and to whom.

In the health field a tendency exists to adopt the best, available, and latest technology in every institution. This drive is promoted by the medical ethic of doing the utmost for the individual patient and reinforced by current methods of paying providers by third parties. The voluntary nonprofit form of organizing the hospitals is frequently mentioned as a factor. Still another factor is usually neglected, namely, the nature of the physician-hospital relationship in this country. Physicians who specialize in treating patients with a given disease will not accede to its exclusion from hospital A, where they hold a staff appointment, unless they are granted staff privileges in hospital B, where the planning agency would like to concentrate all facilities for diagnosis and treatment. Only in part are financial interests involved; equally, or even more important, is the preservation and employment of professional skills.

Economic valuation has no meaning without a firm basis in the underlying data on the link between the inputs and outputs of specific programs. It is not likely that economists can develop such data. Other investigators must be persuaded and enabled to do this by investing their time and energies in longitudinal studies of long duration.

It is discouraging to perform technical analysis, to persuade the decisionmakers of its usefulness, to have it adopted, and then to discover that funds are cut off because total government spending is being curtailed. Adjusting aggregate demand in the economy through changes in total expenditures is bound to result in the stop-and-go operation of individual programs. This is both wasteful and frustrating and poses a substantial threat to continuity in the provision of health services through public financing.

Since C-B or C-E analysis is economic evaluation of public projects or programs, it must inevitably take place in a political climate. While the economic tool of C-B analysis implies a delineation of goals and an articulation of values, the imperatives of the political process may call for a blurring of differences and potential conflicts to facilitate the building of coalitions aimed at the accomplishment of particular ends. Schultze has observed this paradox. PPB has been applied most in an area, national defense, where future uncertainty is greatest but value differences among citizens have been traditionally least; PPB is not applied much in the human resources area, where the problem of uncertainty is not so serious, but differences in values among citizens prevail, as well as a great many vested interests[97] (pp. 77-102).

Some political scientists, like Wildavsky, would agree with the description and say that such are the facts of life.[117 118] Most changes in governmental budgets are incremental anyway, and do not, indeed cannot, derive from base zero.[65] Within the boundaries set by defined political understandings, there are ample opportunities to improve decisionmaking through systematic analysis. There is no reason to believe that politicians prefer making poor decisions over good ones. In cases that are of vital importance to the body politic, many politicians, when persuaded of the right thing to do, would be willing to use up some of the credit they have accumulated and make the tough, though unpopular, choice. They cannot take such a stand on every issue, however. To understand these complexities is to recognize the existence of a political C-B calculus.[117] One characteristic of the unusually capable practitioner of economic C-B analysis is to know how and when to make an allowance for the political C-B calculus.

Summary

C-B analysis is an economic technique for evaluating specific projects or programs in the public sector. The technique is characterized by both breadth and depth.

The aim is to include all benefits and all costs, to whomsoever they accrue. Multiple objectives, such as income distribution, are increasingly recognized in principle. Accordingly, growth in the national income is not the sole criterion of the worthwhileness of an undertaking.

Usually benefits and costs are valued at market prices. However, intangible benefits and public goods, neither of which is traded in the market, pose problems. When these prove intractable, C-E analysis is resorted to. This technique is less powerful because it cannot contribute to a determination of priorities among program areas.

Whether the approach is that of C-B or C-E analysis, it is vital to ascertain the link between inputs and outputs, or between the activities of a program and its outcomes. Valuation based on poor measurement of effects is an idle exercise.

Evaluation through C-B analysis is always prospective, looking toward the future. To render benefits and costs commensurate over time, a discount rate is employed. The level of this rate is still a matter of controversy among economists. I suggest that a single rate would be most helpful to the decisionmaker in the absence of guidelines for choosing among alternative rates.

Within the health field relatively few empirical studies have been carried out that juxtapose costs and benefits and that base the valuation of benefits on a known relationship between inputs and outputs. Many studies have made substantial technical contributions but do not allow the drawing of implications for policy.

Benefits of health services programs are classified under three headings. Direct benefits are potential savings in the use of health resources. Their estimation appears to be more straightforward than it is in actuality, owing to the neglect or sidetracking of difficulties presented by joint costs of production, the simultaneous presence of multiple diseases, and the substitution of prevalence data on morbidity for incidence in the absence of longitudinal studies of population cohorts.

Indirect benefits represent gains in future earnings. Here Rice's contribution is noteworthy in obtaining access to unpublished data from diverse sources and in preparing tables of the present value of earnings for various population groups.

A consensus has almost emerged, perhaps prematurely, in handling the several elements for calculating indirect benefits. For example, it is earnings, not income, that are sought. The average value is given by the mean, not the median. By and large the value of consumption by survivors is no longer deducted. The services of housewives are counted, but valuing them at the wage of a full-time domestic probably yields too low a figure. Employment potential is taken at the level of full employment for the economy as a whole, with no allowance for the special problems of persons who undergo rehabilitation. Hitherto nothing has been done about adjusting the life table for competing causes of death.

The third set of benefits are intangible benefits. Some work was done in the mid-1960's on valuation by the method of analogous diseases, which has not been followed up. Valuation of human life, apart from livelihood or earnings, has received a new impetus following Schelling's paper. Here, too, I am inclined toward the application of a single set of numbers, varying by age.

In assessing previous studies of C-B analysis in the health field, two criticisms are stressed. One is the assumption of proportionality between tangible and intangible benefits. The other is the tenuous nature of the links between inputs and outputs.

The C-E analysis of the treatment of persons with final-stage kidney disease performed for the Gottschalk Committee in 1967 was based on close study of the effectiveness of alternative methods. The priority given to this group of patients was determined on other grounds. In retrospect, it is important to note that other expensive lifesaving measures were not then considered and multiple outputs, other than life years gained, could be safely neglected. Although C-E analysis appears easier to perform than C-B analysis, it may not be in actuality if multiple outputs are to be weighted.

Acton's recent work is recognized for its firm basis in medical technology, its implementation of Schelling's approach to the valuation of human life, and its application of both C-B and C-E analysis to the same set of problems and basic data. Questions are raised about how realistic current estimates of the value of human life are.

In light of my persistent emphasis on the application of C-B analysis to specific projects or programs, the method is applied to developments of health systems technology in two settings, the hospital and automated multiphasic screening. The desirability of this approach is reenforced by conflicting findings on the effects of technology derived from previous studies.

For the hospital three types of capital investment are considered: patient beds, supporting housekeeping services, and ancillary medical services. The conclusions of the analysis are that the desirability of investing in beds is a function of one's understanding of the phenomenon of hospital utilization and has little, if anything, to do with technology; that investing in supporting housekeeping services is a straightforward application of the criterion of cost minimization; and that investing in ancillary medical services entails simple cost comparisons for the performance of old services and raises questions appropriate to C-B analysis only when new services or previously unattainable outcomes are involved.

In discussing automated multiphasic screening Collen's and Garfield's papers are reviewed. It is argued on several grounds that determining the worthwhileness of this procedure cannot be avoided. The ultimate basis for valuing worthwhileness is outcome in terms of health status, including work. It is noted that Collen's work is moving in this direction.

Finally, barriers to the performance of sound and systematic analysis are listed. To overcome them it is necessary at least to acknowledge their existence and to recognize the political context of decisionmaking in the public sector.

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