AN ABSTRACT OF THE THESIS OF

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Title: THE ALLOCATION OF HEALTH-PRODUCING RESOURCES IN THE PACIFIC NORTHWEST

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In order to establish mechanics for comprehensive areawide and statewide planning it is imperative that objectives be defined and that analysis is undertaken to establish the interrelationships between the variables influencing these objectives. In this thesis a conceptual framework is developed that investigates the decision-making process in public health. The two-stage least squares method of estimating simultaneous relationships was used to empirically examine the contributions of environmental, social, economic and other related factors to the health status of Oregon, Washington and Idaho. The health status of a county reflects the economic loss due to mortality in 1970. It was assumed that one objective of public health is to increase the human capital of a community by viewing people as productive agents to be improved with investments in those services that yield a continuing return in the future.

The results indicate that there is some complementarity between the goal of better health and the social objectives of higher education, elimination of poverty and the reduction of population concentrations.

It was also found that there is an excess of hospital beds in the Northwest, and that instead of building new hospital facilities to treat patients and to attract doctors, it would be more efficient to increase the number of doctors directly, even if this requires paying higher salaries. When the costs of placing an additional doctor are compared to the benefits of a reduction in economic loss due to mortality, the costs exceeded the benefits for the Pacific Northwest as a whole. However, when the doctor distribution in the Comprehensive Health Planning districts was considered, 25 out of 36 districts had a shortage of doctors. Apparently there is not so much of a doctor shortage in the Pacific Northwest as a misallocation of existing doctors.

The Allocation of Health-Producing Resources in the Pacific Northwest

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I. INTRODUCTION

The Problem

There is a growing concern in this country with the general health status of the population and with the medical care industry. Steeply rising medical costs and inaccessibility of care to certain sectors of the population have created dissatisfaction with the delivery of personal health services. An increase in the supply of medical care inputs would not by itself alleviate the health care problem. Although the United States spends more on medical care (5. 3 percent of G. N. P.) than both Sweden (3. 5 percent of G. N. P.) and England (4. 5 percent of G. N. P.), infant mortality rates in these two countries were 63 and 87 percent of the rate in the United States, and the mortality rates for males aged 45 to 54 in Sweden and England were only 52 and 76 percent of the rate in this country (18, p. 73).

Several factors account for the low productivity of the health care delivery system (as measured by mortality rates) in this country. For one thing, this system consists of several hundred thousand independent producers who provide medical services with little or no coordination between or within geographical areas. This has created an "unbalanced" system--a surplus of some services in some areas, and a shortage of others. Another point is that the uncoordinated nature of the heatlh services industry has resulted in very little effort being devoted to methods of improving the effective utilization of health care resources (61, p. 140). A further reason for the apparent low productivity of medical care could be that the effects of the medical care input in increasing longevity have been offset by adverse changes in environmental and behavioural factors that are associated with rapid industrial growth.

Legislative Proposals

Numerous solutions, which reflect the public concern about the present allocation of health care resources, have been introduced in the federal legislative system. Some of these proposals, such as the Kennedy Plan and the Nixon administration proposal of federally financed health insurance, are designed to solve some of the problems of resource allocation in the health care area, and would no doubt bring about major changes in the system of medical care delivery in the United States. The major problems which these plans are designed to help solve are (a) a maldistribution of health care services and resources, (b) an inefficient medical care delivery system which is characterized by high health care costs, a lack of emphasis on preventative medical care, and poor quality control, (c) rapidly rising medical care costs and prices, and (d) inadequate health insurance for most Americans (61, p. 139).

A less specific program, the Comprehensive Health Planning Act of 1966 (P. L. 89-749) and the Partnership for Health Amendments of 1967 (P. L. 90-1974) establish the mechanism for comprehensive areawide and statewide planning, identifying health problems and establishing priorities in the allocation of resources (51, p. 15). At present it is difficult to separate the effects on the health status of a population that are attributable to medical programs from those attributable to better environmental conditions or different behavioral modes. Health planning must, therefore, consider a large number of different kinds of factors, such as socio-economic conditions, education, housing, and a host of other social and environmental conditions that influence the health status of a population. Thus, the participation of a variety of agencies and organizations traditionally considered non-health is essential in the comprehensive health planning process (51, p. 617).

Non-Market Characteristics

The education that is needed for an individual to make rational choices in allocating his resources toward health care, and the availability of some of the inputs, are the concern both of individuals and of public health officials. For the individual, the allocative process is difficult because he is both a producer and a consumer of health. He oversees the production of his own health in that he decides what inputs such as medical care, food and style of living to include; as a consumer he enjoys the benefits of this process through increased longevity and fewer future sick days.

Some 40 percent (25, p. 79) of the $60 billion health care industry (14, p. 1) is financed by the federal, state and local governments. Such a statistic suggests that society is not satisfied with the performance of the free market system in allocating medical resources. The failure of market prices as guides in the determination of optimal output can be traced to certain distinctive economic characteristics that set the medical care and health industries apart from most other service industries. These are:

Externalities

There are few commodities which have greater external effects than changes in health. The benefit of a vaccine, for example, which helps prevent the spread of disease such as measles or smallpox, reaches not only the person who receives the vaccine, but also all of the other members of the community. When making a decision on the use of medical inputs such as a vaccine, a person gains, in terms of a diminishing chance of becoming ill, some desired product. However, the price that an economically rational individual is willing to pay for this vaccination (according to economic theory) would be that price which would equate his marginal utility of a dollar in all uses--given a certain income. Since he usually gains no utility from the fact that other people are healthier because of his own expenditures on preventive medical care, he will tend to spend less than is socially desirable.

Public Good

A good is defined as a public good if one person's consumption has no effect on another person's utility. Weisbrod's example of a public good is a spraying campaign against flies and mosquitos (60, p. 17). The benefits of such a spraying campaign accrue to all residents of an area equally; each individual receives benefit of the whole campaign, not just for that part for which he may pay through voluntary contributions or taxes. The organization of the competitive market in such cases of public health campaigns may not insure that the set of prices will automatically reach an equilibrium. There is an economic incentive for the individual not to show his real interest, as long as he feels that the project will be funded, in the hope that others will pay for the project.

Declining Unit Costs

Certain public facilities such as water works and sewage treatment plants cannot be financed in small increments. If the service is to be provided, a sizable capital investment is required. Collective action, either through bargaining or government action, may be needed to take advantage of the declining unit costs of production.

Lack of Information

The "market" for health care is one in which a great deal of information is veiled from the consumer or investor, i. e., the consumer or investor is in many cases unable to pass judgement on the quality of services received, and he may be in a position (acutely ill) where he cannot shop around for services (58, p. 19).

Although a person may be aware of what his final demand for a better health status is, his use of inputs towards that end depends mostly on what he understands the relationship between health and the use of health care inputs to be.

The return for preventive care usually comes in such small increments and over such a long period of time that the individual many times cannot grasp the significance of proper health care practices. Preventive care in the early childhood years is probably the most important factor in reducing illness in the 40 and 50 age group; a child cannot be expected to grasp the significance of certain practices which may place a great burden on him and whose return in the future is only vaguely understood by him. Choices, therefore, have to be made for him by interested family members or by society as a group which is aware of the future added cost of a sick member of the group.

An appropriate allocation of resources cannot be expected to occur automatically via the market system in the presence of these non-market characteristics. Prerequisites for appropriate policy decisions are both a general understanding and specific estimates of the basic behavior relations of the health care system (14, p. 1). If Comprehensive Health Planning in the Northwest is "to promote efficient utilization of resources" (51, p. 619), information is needed about the process of producing health in this region. The Comprehensive Health Planning Board of Oregon states that:

> Problems, goals, objectives and recommendations for action should be stated in quantifiable terms. Such quantification provides not only for refined problem analysis but also for effective evaluation of accomplishments. Whenever possible, such quantification should relate to effects upon health status rather than activities (51, p. 619).

The Northwest region of the United States (Oregon, Washington and Idaho) was chosen for the area of study because of a belief that to contribute in any meaningful way at the state and regional levels, disaggregated empirical studies would have to be undertaken. Studies utilizing a higher level of aggregations have shown the importance of a disaggregated approach to health care policy (14, 21). A regional approach was used because of the simple statistical necessity of increasing the observations. The "unit" of area in this study is the county, mainly because of the availability of data.

It is believed that this project has accomplished the task of quantifying the cost of illness in its most obvious form, i. e., the economic loss of early death, and will provide information to public officials concerned with the health status of a region that will serve as a basis for responsible public decision-making in the development of new or additional health resources.

The method used to quantify the economic cost due to communicable diseases has serious limitations due to the unavailability of data. Yet it is believed that this dissertation will serve to focus attention on the inadequacies of data and the lack of any specified objectives in the area of Public Health.

Purposes and Objectives of the Study

The purpose of this study is to (1) develop a model of the health industry in the Northwest so as to provide a method for estimating the interrelationships between public expenditure, environmental, economic variables and the health status of a community, and (2) estimate the interrelationships between these variables and the availability of physicians.

Specific objectives of this study are to: (a) develop a conceptual framework which will relate the health of the population of Oregon, Washington and Idaho to environmental, social, economic and other related factors; (b) examine empirically the contribution of those factors to the health status of the population of this region; and (c) identify the policy variables in health resource allocation in this region.

The first two objectives are to create a model which can be used to test empirically the economic impact of public decisions on the health status of the population. The information provided can be used as an input in the decision-making process in ascertaining the social desirability of certain proposals that would affect the availability of medical care or change the general health environment.

Outline of Thesis

In Chapter II, the question of consumption versus investment in health resources is investigated. The empirical model of the production of health in the Northwest is developed in Chapter III. Empirical estimates of the contributions of several factors are arrived at. The information provided by these estimates is used to identify the relevance of public policy (Chapter IV) in ascertaining the social desirability of certain proposals that would affect the availability of medical care or change the general health environment.

II. THE ALLOCATION OF RESOURCES BETWEEN INVESTMENT AND CONSUMPTION

Investment and Consumption

What has traditionally been referred to as "expenditures" on health can be separated into categories of investment--increased longevity and lifetime labor productivity--and consumption--increased human happiness or decreased suffering. The concept of human capital formation through health and medical service inputs rests on the notion that people as productive agents are improved by investments in these services and that the outlays made yield a continuing return in the future by increasing the supply of potential man-hours through a reduction in mortality or in time lost because of illness and disability.

Since Adam Smith, consumption and investment have been used to distinguish between those uses of current output that provide for higher levels of output in the future and those that exhaust their use in the present. For the classical economists, additions to the stock of capital were vital to the growth of the economy and, since by their definition, investment was the difference between total production and consumption, it followed that for economic growth to be maximized, consumption should be minimized (34, p. 68). This is true if we conclude that human capital can be looked upon as being part of the productive process. However, Pigou's statement that "the most important investment of all is investment in the health, intelligence and character of the people" (45, p. 138), indicates that he did not view health simply as a factor used in the production of more quantifiable goods. Basic humanitarian philosophies of a society, especially one that has gone beyond a certain point of minimum economic existence, will demand a certain level of "unproductive consumption" (or what has been more recently called "extraneous final consumption") (34, p. 73).

There are justifications for expenditures on consumptive programs that seem to be

> . . . worsening allocation, and reducing output of medical care in any quantifiable sense by shifting medical inputs from treatment of people with their economically productive life mainly over, and of ailments which are largely incurable or irreversible (52, p. 121).

A community has the right to allocate its resources in a manner which gives the greatest satisfaction to itself. However, it should be accepted that any society cannot afford to do all the things that people feel they need. Allocative decisions which consider the costs of certain expenditures or actions versus the benefits derived therefrom must be made. Berg, a medical doctor, maintains that although physicians profess a philosophy that would have them behave as though they were guided by a fantasy that they always do everything for their patients, they do in reality make choices of how much time to spend with a certain patient, how long his stay in hospital should be, and how many tests to make.

> Saving lives has a very high priority, but it is clear that the saving of a life has a very different meaning for a young healthy person with a normal life expectancy than it has for an aged person with a very limited life expectancy (8, p. 3).

Both individuals and society place valuations on human life and on the avoidance of illness and disability, however much the notion of attaching material worth to these is abhorred in expressed opinions.

Sound economic analysis can play an important role in health care planning. Much of the work of economists concerned with policy issues is devoted to sorting out the ends of policy from the means intended to achieve these ends, and to assessing the relevance of various means proposed--in short, to determine what the problem really is, and to attempt to evaluate the various ways of solving it. The rigour and refinement of an economic analysis can only be employed as a rough guide to policy. In an open political system, the final decision can only be made by those that are financially or politically responsible for the consequences.

In order to make use of the tools of economics for a discussion of the problems confronting the decision-makers who realize the potential for human capital formation through health care and are aware of the need for adequate health care as a basic human requisite, it is necessary to review some of the concepts of production and welfare economics. It is the purpose of this chapter to bring together the relevant economic theory regarding production and distribution and to present a theoretical framework for determining and describing the economic consequences of alternative health resource allocations.

The theory presented is not particularly new; much of what is presented can be found in any basic economics textbook. It is the author's opinion that precise theory should be the first step in the development of an applied research effort. Harry Johnson states:

> The central concepts of relevant economic theory are, I believe, relatively simple and easy to grasp; the hard task . . . is to recognize their relevance to particular problems and apply them to finding the solutions (26, p. 21).

The production of health that is viewed as "investment in health" is defined to include such practices as pediatric care, school lunch programs, a certain style of life, tuberculosis treatment, and other programs designed to increase the productive life of a member of society. Production of health for the "consumption of health" includes those practices which do not increase the productive life of a member of a society, such as portions of the Medicare program and hospitals for the terminally ill.

Equilibrium of Production

The Production Diagram

Investment in health capital can be characterized by a production function whose direct inputs may include the time of the individuals and market goods such as medical care, housing and diet. The production function also depends on certain environmental variables such as the level of education and geographical location that influence the efficiency of the production process. The investment production function of a typical community can be written as

$$H = H(X_1, X_2, \ldots\ldots, X_n) \tag{2.1}$$

where X_1 through X_n are the factors of production, and H is the health status of a community as measured by the relative productiveness of that community.

Investments in health for consumptive purposes may include many of the same direct inputs of the previous production function, only a change in the combination in which these inputs are used would determine the outcome of the final product.[1] The production function for health as a consumptive good is written as

$$C = C(X_1, X_2, \ldots\ldots, X_n) \tag{2.2}$$

where X_1 through X_n are the factors of production and C is the health status of a community as measured by the relative consumption of health items of that community.

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[1] The two outputs, health as an investment and health as a consumptive item, may be technically interdependent, especially at lower levels of resources allocated toward investment, and the production process will then yield more than one output. It is assumed here that one or the other output is desired, and the interdependencies are ignored.

The production function of health (as an investment = H, or as consumption = C) may be represented by a surface in a three-dimensional diagram (Figure 1). Most production processes include more than two inputs. A graphic illustration of such a production function with more than two inputs is impossible. However, the relationships of the production process are the same irrespective of the number of inputs, and this graphic analysis will serve to illustrate the technical problems of the production and decision-making process in allocating health resources.

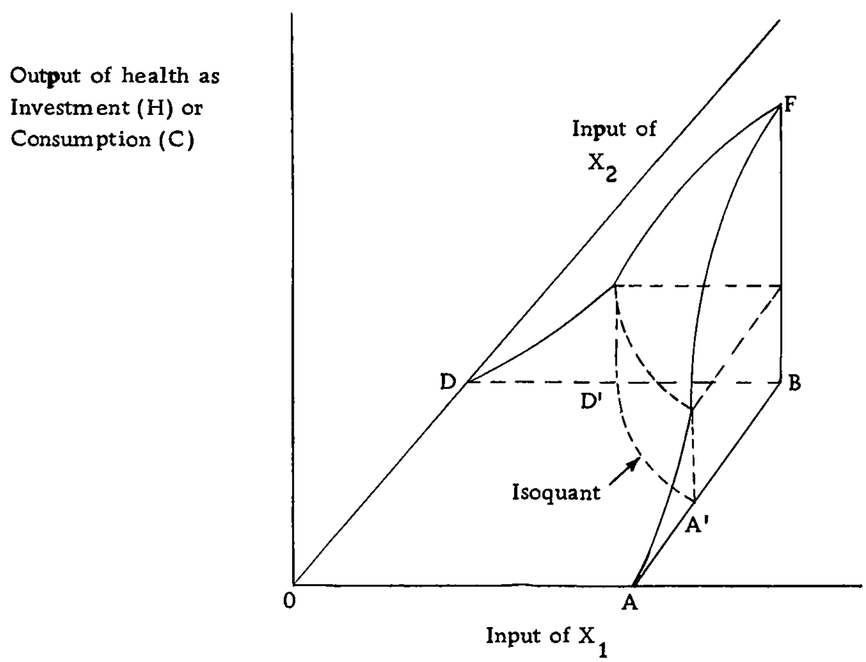

Figure 1. The production function.

The inputs X_1 and X_2 (for illustrative purposes X_1 will be defined to be the physician input and X_2 the number of paramedical personnel) are plotted on the base axes and the vertical axis H or C gives the maximum output corresponding to the combinations of services on the base plane. Thus, the surface OAFD represents the locus of the outputs of all possible factor combinations. When one of the input factors is kept constant, e. g., X_1 at the quantity of OA, the output increases as the other factor is increased, as shown along the curve AF. The rate of change of this curve, i. e., the partial rate of exchange of the output with respect to the input X_2, is the graphic representation of the marginal productivity of X_2 for a value of X_1 equal to OA. Correspondingly the slope of the curve DF represents the marginal productivity of X_1, when X_2 is equal to OD.

The Isoquants

By taking a slice out of the production surface of Figure 1 and projecting this slice (A'D') into a base plane, an isoquant is obtained (Figure 2). Such an isoquant shows the different combinations of two resources with which a decision-making unit can produce equal amounts of a product. Greater amounts of the product are represented by higher isoquants. The basic characteristics of the isoquants are that they do not intersect, they slope downward to the right, and are convex to the origin. They are convex to the origin because inputs

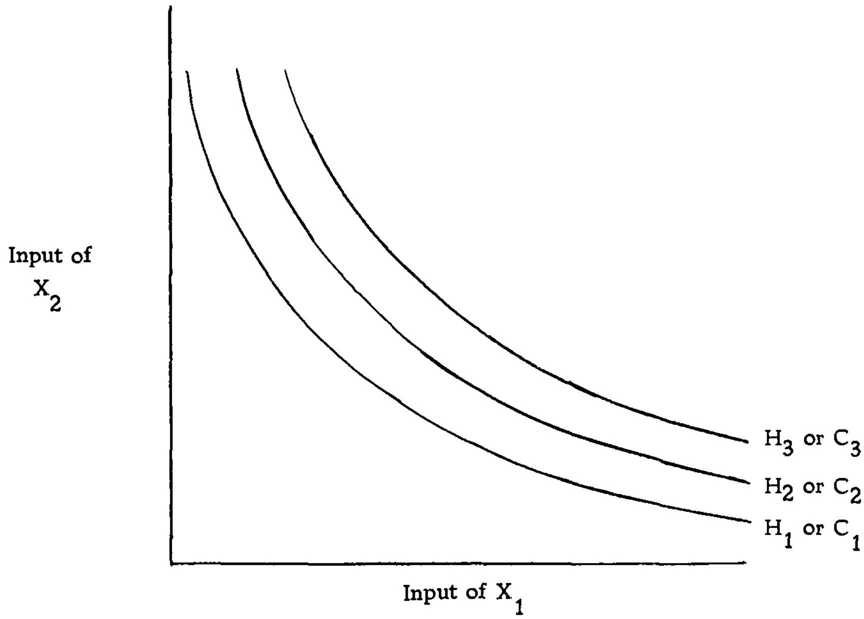

Figure 2. Isoquants.

are almost never perfect substitutes in production. If, for example, X_1 is for physicians and X_2 is for paramedical personnel, and the production problem is to produce a healthier community, the more physicians' input a community gives up, the more difficult it becomes to substitute paramedical personnel for the loss. This is called the principle of diminishing marginal rate of technical substitution of X_2 for X_1 and can be defined as the amount of X_2 which will just be compensated for by an additional unit of X_1 such that the level of output does not change.

The Contract Curve

We assume that a community has an initial fixed endowment of the factors X_1 (physicians) and X_2 (paramedical personnel) and strives to allocate these resources so as to maximize the production of health (defined previously as investment returns or consumption units).[2] The Edgeworth box diagram graphical technique can be used to illustrate the problem of producing two outputs when the quantities of the two inputs are fixed (Figure 3). From the given and unchanging production functions for health, the isoquant maps are drawn, as illustrated by the curves I_H - IV_H and I_C - IV_C.

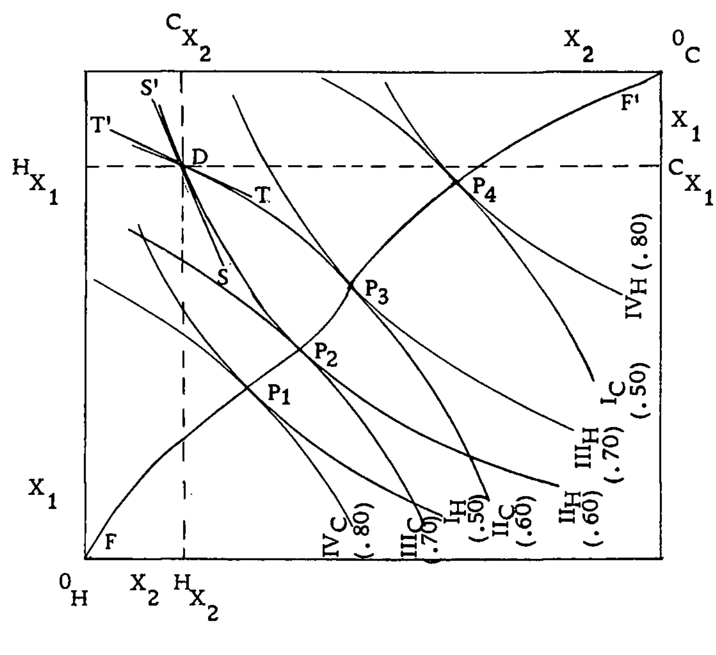

Figure 3. Deriving the contract curve.

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[2] This is a partial analysis involving two goods; the choice between H and C is assumed to be independent of choices made between other goods.

The inputs may originally be allocated between production of H or C so that $0_H H_{X_2}$ units of X_2 and $0_C H_{X_1}$ units of X_1 are used in producing H; the remainder, $0_C C_{X_2}$ of X_2 and $0_C C_{X_1}$ of X_1 are used in producing C. Such an allocation is represented by point D in the Edgeworth box diagram--the point at which II_x intersects II_y.

At the allocation D, the marginal rate of technical substitution of X_2 for X_1 in producing H, given by the slope S'S is relatively high. The marginal product of X_2 in producing H is high relative to the marginal product of X_1. The II_H (.60)[3] level of production can be maintained by substituting a relatively small amount of X_2 for a relatively larger amount of X_1. The opposite situation prevails in C production, as shown by the slope of T'T. The marginal rate of technical substitution of X_2 for X_1 in producing C is relatively low; thus a comparatively large amount of X_2 can be released by substituting a relatively small amount of X_1, while maintaining the II_C (.60) level of output. Therefore, from a point such as D, input substitution by the decision-makers in the production process will enable a community to move to P_2, P_3 or any point in between. At P_2 the output of H is the same as at D, but the output of C has been increased to the III_C level. If the movement is to P_3, the output of H increases

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[3]A 1.00 health investment index would mean that there were no deaths reported, while a C 1.00 index would designate a situation where all possible wants related to the consumption of health were fulfilled.

with no change in the volume of C production. Production of one or both goods can thus always be increased without an aggregate increase in inputs unless the marginal rates of technical substitution between the inputs are the same for both production processes.

The locus FF', called the contract curve, is a curve showing all input allocations that equalize the marginal rates of technical substitution--on the locus of tangencies between an H isoquant and a C isoquant.

This production equilibrium is not unique; it may occur at any point along the contract curve. The contract curve is an optimal locus in the sense that if the producers are located at a point not on the curve, the output of one or both commodities can be increased, and the output of neither decreased, by making input substitutions so as to move to a point on the curve (16, p. 370).

The Transformation Curve

Every community has a unique combination of human and natural resources which can be used in the production of health. This combination of resources defines the production possibility frontier, or the transformation curve, of the community. The

> . . . transformation curve is a locus showing the maximum attainable output of one commodity for every possible volume of output of the other commodity, given the fixed resource base (Figure 4). The curve so generated depends upon the

absolute endowment of each resource upon the aggregate input endowment ration, and upon the 'state of the art' (the production functions for both goods) (16, p. 371).

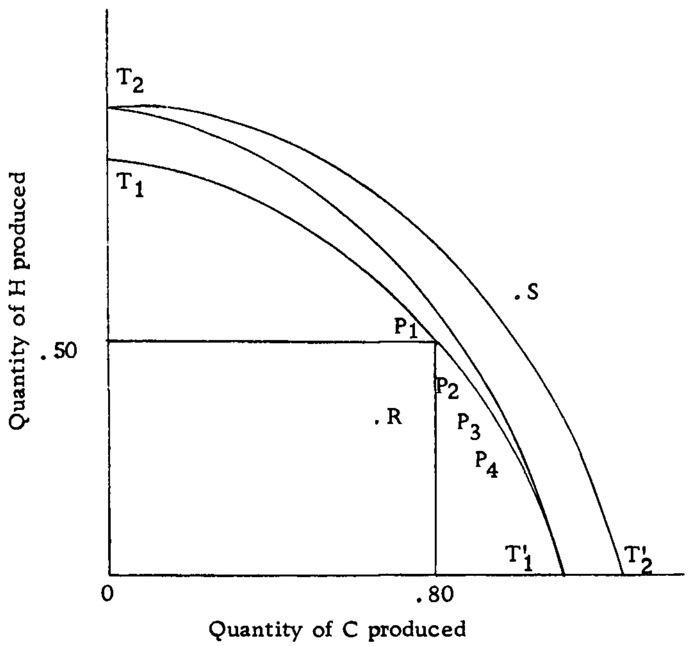

Figure 4. The transformation curve.

The transformation curve is obtained by mapping the contract curve from input space into output space. For example, with the allocation of the physician and paramedical inputs indicated at a level P_1 (Figure 3) and Health Investment index of .50, a Health Consumption index of .80 could be attained. By constructing a graph whose coordinate axes show the quantities of Health in Investment units (H) or Consumption units (C) produced, and plotting the output pairs corresponding to each isoquant tangency in Figure 3, a transformation curve such as T_1T_1' in Figure 4 is generated. This curve depicts the choices a society can make. It shows the various (maximum) combinations of H and C that are attainable from the given resource base. A point lying inside this curve (R) is neither necessary nor desirable because it would entail a needless sacrifice of goods attributable to the inefficient allocation of available resources. No output combination outside the curve can be attained; such a level would require a greater resource base or a different 'state of the art' of production.

Reallocation of Resources

Basically, three changes can occur that will reallocate resources used in the production of health.

Changes in the Production Function. Technological changes resulting from either the use of new inputs or quality improvements may be regarded as causing an upward shift in the original production function. Society has assumed a major role in furthering technological advance in health and medicine. Public funds are invested for research, education, and for new medical delivery systems. By improving the educational standard of physicians and paramedical personnel, greater production may be attained with the same quantity combination of these two outputs. A neutral technological innovation that affects both inputs the same would have the result of ultimately shifting out the transformation curve as shown by T_2T_2' (Figure 4).

Changes in the Marginal Rates of Factor Substitution. As the elasticity of substitution alters in favor of one factor by innovations, the entire production surface is altered. Thus, a condition may arise where a smaller quantity of one factor such as paramedical personnel will be necessary to replace a given quantity of another factor such as physicians after the innovation has been introduced. The shift of the transformation curve would depend on the use of the inputs in the production of H and C. Conceivably, if paramedical personnel are more desirable for consumption of health resources, a non-neutral shift such as T_2T_1' could take place.

Increasing the Endowment. So far the analysis has been concerned with an Edgeworth box diagram in which the world is made up of two medical inputs and two health outputs. Society is not only concerned with living better or longer medically. There are also concerns with building greater armaments or attaining discoveries in the universe. The health endowment (the dimensions of the Edgeworth box) could be changed anytime a new mandate develops to change these dimensions.[4] The retraining of aerospace professionals in Florida to become physicians and the use of the medics of the Vietnam

[4] This does not say that there are unlimited resources. The analysis might be made where all health items (investment or consumption) are on one axis of the transformation curve, while all other goods are on the other. If a society were to operate on this curve with no possibility of shifting this out, more health items would mean fewer units available of another good, such as road construction or recreation.

war to take over some of the roles of physicians in the state of Washington can be interpreted as an expansion of the dimensions of the diagram. An increase in the endowments, holding the technical coefficients constant, might shift the transformation curve outward--from T_1T_1' to T_2T_2'.

It has to be stressed that what has been discussed so far has been a description of what is. It would be inconceivable for society not to operate on the contract curve, but this assumes that such a process of receiving the greatest possible returns is taking place automatically in that the information is there for the decision-makers to make the correct economic decision. There are imperfections in the market place and there is inadequate information provided to the decision-making process. A community may, therefore, only be at the point R in Figure 4 because of these imperfections. The return from correcting these market imperfections or by gaining information about the production process now taking place could, therefore, be as great as the return from new production processes and could lead toward transformation curves which are further out in Figure 4.

Social Welfare Function

Welfare economics is that branch of economics which deals with the evaluation of alternative social actions. The inability of economists to quantify and sum individuals' desires leaves welfare economics not very useful for detailed prescription of how to allocate resources. This does not mean that the economist cannot provide the decision-maker with some basic concepts that have to be considered in the decision-making process.

At this stage of development of economic welfare theory, a social welfare function is impossible to construct. Even if it were possible for every individual to vote directly on every issue, Arrow has shown that inconsistencies in the decision-making process exist (5). However, for the sake of analysis and exposition, such a social welfare function for a community which is only concerned with two goods is assumed to exist. From such a utility function an indifference map for a community can be postulated. Each indifference curve is a locus of combinations, or "bundles," of goods between which the community is in some sense indifferent. The indifference curves are assumed to slope downward to the right, to be convex to the origin and not to intersect. In the public decision-making process of allocating resources toward health the indifference curves I_1, I_2, I_3 (Figure 5) can describe the system of preferences between health as a pure consumption good and as a process of human capital formation.

The marginal rate of substitution between Investment and Consumption becomes greater at a lower amount of consumption, i. e., it requires more investment units to compensate for the foregone unit of consumption of health. The indifference curves are asymptotic to OH

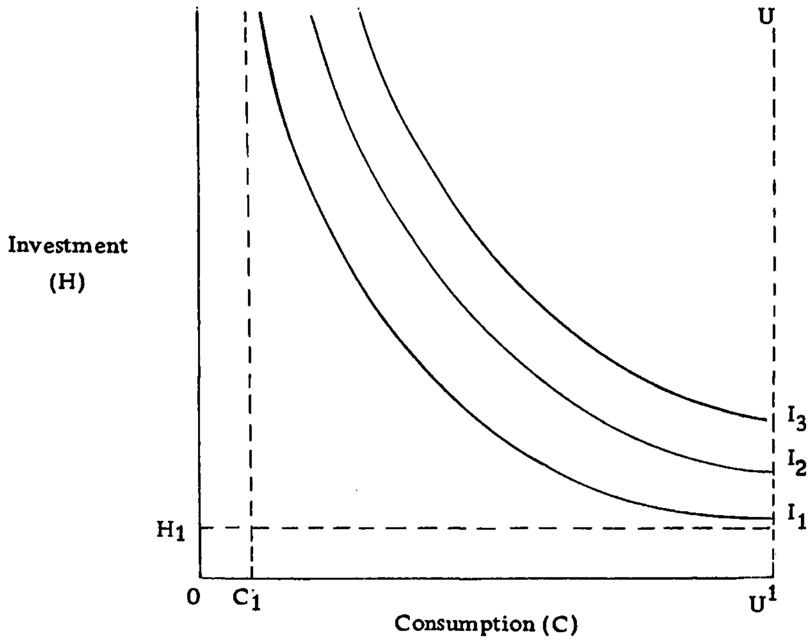

Figure 5. Indifference map between investment and consumption.

since it is inconceivable that any society will reach a plateau of longevity where no deaths are experienced. U U^1 designates the total amount of consumptive units available.

There most likely will be a basic minimum of consumption which is the subsistence consumption of health, C_1. Likewise there would also be a minimum amount of H, H_1, which any viable society requires.

The Decision-Making Process

Combining such an indifference map with the "product transformation curve" previously arrived at, the decision process in the area of health may be examined (Figure 6).

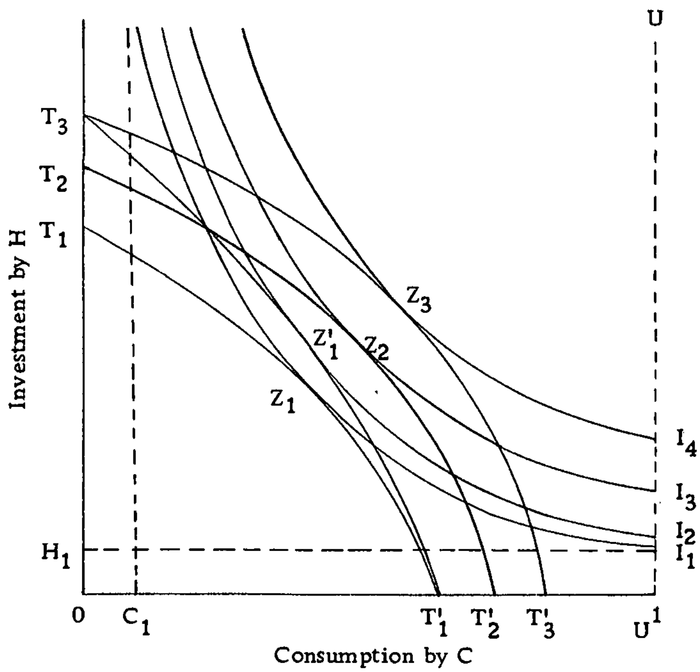

Figure 6. Maximization of social welfare.

The lines $T_1'T_1$, $T_2'T_2$, and $T_3'T_3$ represent the production possibility boundaries at what can be considered to be successively higher rates of return (with neutral technological progress) from a fixed endowment of inputs.

The "best" combination of consumption and investment, given the assumptions behind the model, is where the marginal rate of product transformation is equal to the marginal rate of commodity substitution (Z_1 Z_2 Z_3). The coordinates of these points represent that combination of consumption and investment which gives society the greatest total utility consistent with the production possibilities. In the case of non-neutral technological progress in favor of investment in Health, such as increasing the productivity of preventive care, a shift of the transformation curve $T_1' T_3$ could be expected, with the same endowments of inputs and unaltered social welfare function, a society can now attain a higher level of satisfaction Z_1' (instead of Z_1) while consuming more H units.

This is the theoretical case for reaching the "bliss point" of welfare economics, given that a society's social welfare function can be discovered. If economists were able to assign monetary values (or any other value that acted as a common denominator) to the costs and benefits of health, such an efficiency criterion could be employed. Methods are not available that allow quantification of all objectives that a society may have, therefore empirical analysis can only be provided for those goals that are measurable. The goal of society cannot be to maximize the amount of investment in health, and to maximize the consumption of health, happiness and well-being of all its members--given a limited resource base. At the same time "either/or" decisions have to be made. This thesis evaluates society's investment in health from the standpoint of production, but does not propose any method of evaluation of health as a consumptive good.

Constrained Decision-Making

A proposal by Marglin (38, p. 570) would attach a system of weights to the unvalued benefits and would incorporate a "minimum level of benefits" into the decision-making process. The "minimum level of benefits" assumes that the decision-makers can ascertain society's minimum acceptance level of one benefit and maximize the other benefits subject to this constraint. (Figure 6 showed constraints C_1 and H_1, but these are physical constraints which in almost all cases will be outside of the decision-making process.) A society that sets a lower limit of H_2 as the rate of economic growth (Figure 7), through the formation of human capital, would not consider alternatives below that level. Likewise, a minimum level of C_2 can be established, e.g., a certain number of nursing homes, and other relief programs.

If it is determined that the rate of return from a factor mix used in producing health for consumptive or investment purposes are such that the transformation curve which coincides with the output is $T_1' T_1$ then the decision-maker realizes, with the specified social welfare function, that Z_1 is to the left of the constraint C_2. He can move along the "trade-off" curve (I_1) to Z_1^* and be on the boundary. The productivity that is given up to reach the constraint is H''-H'. Economic efficiency is not attained, the marginal rate of product transformation does not equal the marginal rate of commodity substitution.

The alternatives to the society that has imposed a restriction on the market would be either to subsidize the producer to make

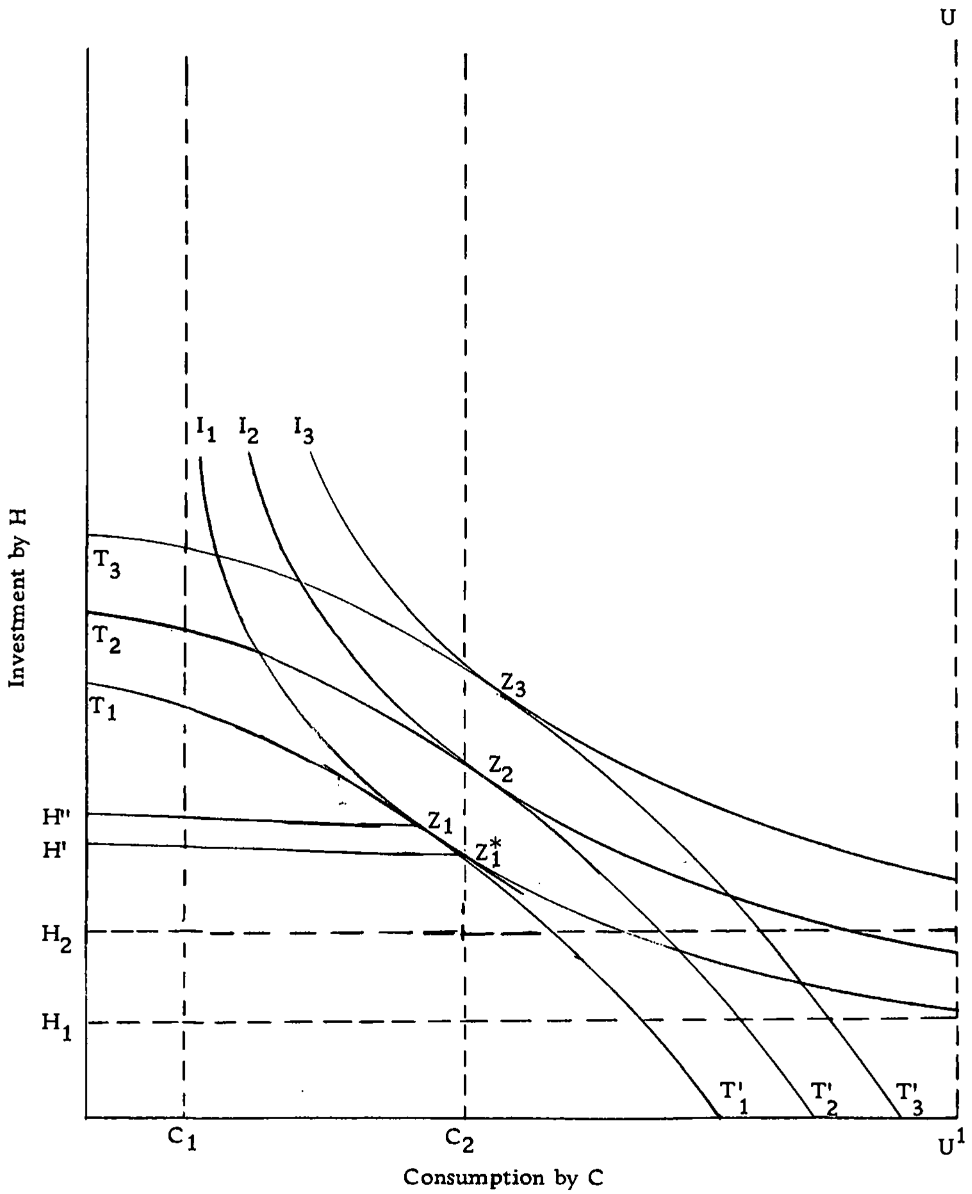

Figure 7. Constrained decision making.

up the difference between the market price and the artificial price or to pay the consumer the difference.[5]

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[5] This is similar to the theory of the "second best" developed by Lipsey and Lancaster.

The general theorem for the second best optimum states that if there is introduced into a general equilibrium system a constraint which prevents the attainment of one of the Paretian conditions, the other Paretian conditions, although still attainable, are in general no longer desirable. In other words, given that one of the Paretian optimum conditions cannot be fulfilled, then an optimum situation can be achieved only by departing from all the other Paretian conditions. The optimum situation finally attained may be termed a second best optimum because it is achieved subject to a constraint which, by definition, prevents the attainment of a Paretian optimum (35, p. 11).

III. THE PRODUCTION OF HEALTH

The Economic Cost of Ill Health

Production is the process of combining and coordinating materials and forces in the creation of some valuable good or service. The theory of production assumes that this valuable good or service is a well-defined homogeneous output, a condition that is seldom met in the real world where we find that the quality of products may vary widely within a given production process. A frequent solution in empirical research is to adjust the flow of heterogenous products by a common denominator--such as the dollar value of a certain unit--and to use this result as an index of the output produced.

Great difficulties have been encountered in developing adequate measures of medical care. Most appraisals of quality have been in terms of number of physician visits, number of patient days in hospitals, qualification of physical plants, and the use of "medical audit" (4). Perkinson (43) regressed the socio-economic characteristics of counties in Michigan on the number of hospital beds available. Other studies use physician to population ratios to measure the quality of health care received (28). Such approaches are unacceptable in measuring the output of health care because they do not appraise the end result--the health status of a community. Hospital beds, physicians and other such measures should be considered a resource (or input) to be used in attaining some objective (or output). The mere possession of inputs does not mean that they will be used in an optimal fashion.

Historically, mortality statistics have been used to describe the health problems of a community and also to measure the interdependence between medical care, social, economic and other variables, and community health. Recent examples are those studies by Adelman (1), Auster (6) and Larmore (33). Adelman, in a cross-country regression analysis, concluded that there was a systematic dependence of age death rates upon socio-economic variables such as economic conditions, economic growth, education and medical care. Auster reasoned that mortality measures are objective, reasonably accurate, readily available, and universally understood. In this regression analysis across states, the relationship of mortality of whites to both medical care and environmental variables was examined. It was found that urbanization did not appear to be an important variable. Interesting was the fact that income was positively correlated with higher death rates, while education had the highest negative response of the variables included.

Larmore uses the mortality rate as a proxy variable for health. She hypothesizes that mortality may be poorly correlated with specific kinds of illnesses, e. g., the common cold, but highly correlated with others.

> If the mortality rate in a county is high we would expect that the incidence of potentially fatal diseases or the hazards of serious accidents are also high. When adjustment is made for age, the mortality rate is a good indication of health status in an area and a partial indication of the loss in human productivity attributable to illness (33, p. 15).

Longevity is certainly not the only measure of improvement in health. How we live may be more important than how long we live. Some suggestions have, therefore, been made for indices of health that would combine mortality and illness rates. Sanders hypothesizes that by making it possible for the population to live longer, the incidence of chronic disease increases, and there probably is at this time on the average an inverse relationship between the death rate and the prevalence of disease (49, p. 106).

The problem is to quantify the output to be defined. If there is such an inverse relationship, the two types of output cannot be made commensurate to measure one overall level of health status. Instead it is believed that the interests of this society lie in both a longer life expectancy and a life with fewer illnesses. And a measure of health status using illness rates and one using mortality rates would give different signals to those concerned with the overall health of a community.

The monetary losses which a society sustains as a result of ill health may be: (a) the loss of production because of illness[6],

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[6] These may include psychic costs or costs due to debility--no attempt is being made to estimate these.

(b) economic costs of detection, treatment and rehabilitation of patients, or (c) the loss attributable to early death and its loss of future production.

Studies to estimate the cost of specific illnesses have been reported by Fein (13), Klarman (29), Mushkin (37), Rice (48) and Weisbrod (60) among others. These indicate that expenditures for medical care to treat an illness are not the total costs of that illness. The economic costs include direct and indirect costs, the former being those associated with expenditures for preventing or treating an illness, and the latter being the loss of output as a result of that illness, i. e., because of early death or disability.

Absence from work or school and even more so, mortality statistics, would seem to be a realiable estimate of illness. The direct cost of treatment is considered an independent variable to be included in public expenditures and other socio-economic variables.

Mortality

The loss of a life indicates to society an actual or potential loss of a productive and consuming unit. This actual or potential loss discounted to the present gives a measure of the costs of illness to society.

There is currently a debate taking place in the area of health economics whether to treat consumption[7] as a deduction from a person's contribution to output. Some economists, Weisbrod among others, and insurance companies measure the mortality effects of disease by determining the present value of the production which the deceased would have contributed, less what he would have consumed. Other economists reason:

> Certainly the net figure (gross value consumption) derived by Dublin and Lotka to indicate the money value of a man to his family is correct for their purposes. It is not at all apparent, however, that the net concept is the correct one when we deal with the economic value of a man to society. It is true that man consumes, partly in order to maintain himself, and in this sense some of his consumption may be considered as a gross investment to take care of depreciation; it is also true, however, that consumption is an end in itself and can be viewed as a final, rather than an intermediate, step in the creation of other products (13, p. 18).

In agreement with the above view, Dorothy Rice's method (48, p. 93) to estimate the losses to society due to early deaths was used. This project measured the losses to a community due to deaths in 1970 and not losses to the individual family; therefore, no allowance for consumption was made. A pragmatic case against including consumption may be made on the grounds that the resources required to determine or estimate the social costs and returns of prolonging human life would be beyond that available to the writer of this thesis.

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[7]Consumption here is used to define any goods used for the purpose of satisfying certain desires; health is only a part of the array of goods consumed.

It is difficult to measure the value of the services of housewives, since they occur outside the market place. However, when the housewife is sick, it costs money to have a replacement. Housewife services are estimated using average earnings of domestic workers. Rice reasons that

> . . . to omit the value of the services of a housewife would be to seriously underestimate the value of the lifetime earnings of females, owing to the fact that a relatively high proportion of females are not in the labor market (48, p. 88).

Table 1 and Figure 8 give present value estimates for Oregon, Washington and Idaho based on these procedures. The differences in the present value estimates among states are due to differential income levels and labor force participation rates.

The summation of the monetary loss to each county because of death can be represented by a health index:

$$He = \frac{\sum_{i=1}^{2} \sum_{j=1}^{19} M_{ij} Z_{ij}}{Re} \qquad (2.1)$$

where

He = health index of a county

i = sex

j = age of death incidence

M = number of sex-age specific deaths

Z = present value for sex-age group

Re = human capital inventory of a county

Table 1. Present value, in dollars, of lifetime earnings: amount discounted at six percent, for Oregon, Washington and Idaho, by age and sex.

Age	Oregon		Washington		Idaho	
	males	females	males	females	males	females
under 1	51,612	28,606	54,300	31,342	44,695	24,472
1-4	52,785	32,317	58,654	35,597	48,379	27,818
5-9	70,970	43,361	78,740	47,741	65,002	37,362
10-14	95,032	58,059	105,602	63,459	87,194	50,062
15-19	123,293	71,478	135,469	77,838	116,717	60,062
20-24	143,853	77,151	157,739	83,577	129,307	64,008
25-29	152,045	77,910	165,528	84,413	136,447	64,616
30-34	149,258	77,074	162,334	83,454	134,388	63,905
35-39	139,493	74,715	151,275	80,990	126,265	61,567
40-44	123,617	71,151	134,060	75,331	113,324	57,715
45-49	103,799	65,095	111,499	67,244	96,262	52,624
50-56	82,447	57,131	86,883	59,872	76,436	47,181
55-59	59,720	48,028	58,950	51,465	55,570	41,101
60-64	35,391	37,990	37,788	42,163	32,808	36,013
65-69	16,519	29,920	17,565	33,325	15,666	27,068
70-74	8,356	24,945	9,590	26,194	8,251	21,521
75-79	4,434	18,058	5,384	19,015	4,606	15,690
80-84	2,618	9,868	2,851	10,254	2,439	8,364
85 & over	696	1,269	760	1,551	639	1,249

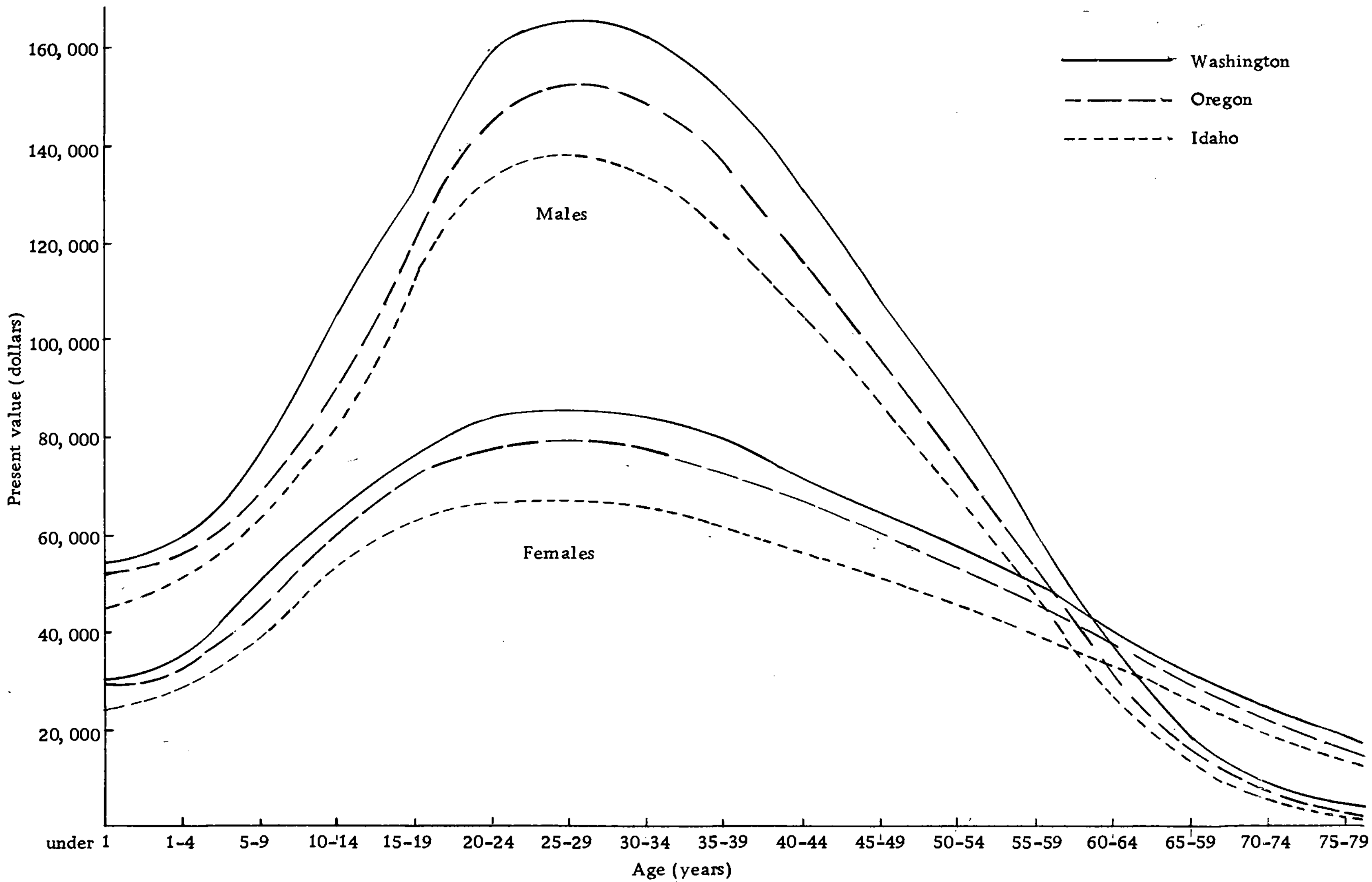

Figure 8. Present value of lifetime earnings; Oregon, Washington and Idaho, amount by sex and age.

The numerator would appear as a dollar figure and would be misleading in absolute numbers. The total human capital inventory of a county is, therefore, used to create a health index ratio designed to provide a method of comparing the health status of counties. The human capital inventory of a county is estimated by:

$$Re = \sum_{i=1}^{2} \sum_{k=1}^{19} N_{ik} Z_{ik} \qquad (2.2)$$

where

Re = human capital inventory of a county

i = sex

k = age group

N = number of inhabitants in sex-age group

Z = present value for sex-age group

The results are given in Table 1a of the Appendix.

Morbidity

The ideal measure of the cost of illness would be to sum the incidence of all diseases within a specified time for a geographical location. By determining the average duration of an illness and its age and sex incidence, and using an average amount of earnings for those in the labor force, or average investment by a community lost through a student's absence from school, cost of illness can be estimated.

Unfortunately, all this information is not available. Estimates by such agencies as the National Health Survey of the incidence of illness are usually obtained on a regional basis and would not provide the county data needed for this model. The data that are available for the counties in the Northwest are those collected by the Epidemiology sections of the Public Health Departments. It is not suggested that such county data can give us a complete view of the economic loss due to illness, but it can give us an estimate of the cost of communicable diseases and indicate the influence of demographic, economic, and public health expenditure variables on such costs.

The Vital Statistics and Epidemiology Sections, State Board of Health, collects data on certain notifiable diseases, and the ones used in this section were: rubeola, streptococcal infections, salmonellosis, newly reported T. B. , hepatitis serum and viral, meningococcal infections, aseptic meningitis, other meningitis, syphilis, gonorrhea, rubella, mumps and pertussis. Using this data on county, age and sex incidence, and by multiplying these reported cases (corrected for average duration of illness) (2) by the estimated mean annual earnings or average cost per student day, an estimate of the loss of earnings or school investment was calculated. Dorothy P. Rice (48, p. 5) in her study "Estimating the Cost of Illness" calculates mean annual earnings in 1963 of full-time, year-round, paid civilian workers, by age and sex. These estimates were adjusted to Northwest income, to

Northwest labor force participation rates, and to the year in which the data in this study was collected.

Housewife services are usually not included in the national income accounts. Omitting the value of such services in the calculation of indirect costs distorts comparison of costs among illnesses with different distribution by sex. Rice (48, p. 14) uses the earnings of a domestic servant to estimate the mean value of a housewife service. Using this estimate as a base, the mean value of housewife services in Oregon, Washington and Idaho was calculated.

Student days lost from school due to an illness may have an effect on the earning power of an individual, but these costs cannot be directly related to future output losses. These losses are part of the intangibles or psychic costs which are not readily measurable. However, the costs of educating a child are anticipated and are, therefore, allocated by the school district whether a student is in school or not. These costs can, thus, be considered as unrealized investments--a loss to the student and society.

The health index[8] (as calculated with illness rates) is represented by:

$$He' = \frac{\sum_{i=1}^{2} \sum_{z=1}^{19} \sum_{m=1}^{14} T_m W_{iz} I_{izm}}{Re} \qquad (2.3)$$

[8] See Appendix Table 2 for example.

where

He = health index of a county

i = sex

z = age of ill person

m = illness

T = average duration (days) of an illness

W = average sex-age per day income per person

I = incidence of illness

Re = human capital inventory of county

The Econometric Model

The econometric model that is to be used for estimation represents a summary "of the prior knowledge of the investigator concerning the phenomenon in question" (31, p. 532). Prior knowledge about the interrelationships between the health variables is used to explicitly hypothesize these relationships before they are empirically tested.

In regressing medical, social, economic and geographic characteristics of the counties on the health index of a county, to predict with this "health production function" changes in the health status of a county as resources are utilized at different levels, it is hypothesized that several explanatory variables are correlated with the disturbance term; that there is some interdependence between a community's health status, the availability of doctors, and the income of that community. The health status is determined not only by the availability of physicians, but also by the economic position of the individual in the community. The effective demand for the physician's services, in a society that is still dependent on the market place to provide most of the services, is a function of the health status and income. An individual's income could be dependent on his health status in two ways: an ill person may become lethargic and not have the drive to advance on his job, or if a person is ill and not working he receives no reportable income.

In order to deal with this problem of simultaneity, the two-stage least squares method is used. This technique replaces each independent endogenous variable by predicted values obtained by regressing that variable on all of the exogenous variables in the model. The health status (X_{18} or X_{19}), the availability of physicians (X_{16}) and the median income (X_{12}) variables are treated as endogenous, while the other social, economic and medical characteristics are exogenous.

The following equations represent the model that was employed:

[9] The necessary conditions for identification are met; equation 2.4 is identified, while 2.5 and 2.6 are over-identified.

Production of Health:

$$X_{18} = \beta_{1,0} + \beta_{1,1}X_1 + \beta_{1,2}X_2 + \beta_{1,3}X_3 + \beta_{1,4}X_4 + \beta_{1,5}X_5 + \beta_{1,6}X_6 + \beta_{1,8}X_8 + \beta_{1,9}X_9 + \beta_{1,10}X_{10} + \beta_{1,11}X_{11} + \beta_{1,12}X_{12} + \beta_{1,14}X_{14} + \beta_{1,15}X_{15} + \beta_{1,16}X_{16} + \beta_{1,17}X_{17} + \mu_1 \quad (2.4)$$

Doctor Availability Function:

$$X_{16} = \beta_{2,0} + \beta_{2,1}X_1 + \beta_{2,2}X_2 + \beta_{2,5}X_5 + \beta_{2,7}X_7 + \beta_{2,9}X_9 + \beta_{2,10}X_{10} + \beta_{2,11}X_{11} + \beta_{2,12}X_{12} + \beta_{2,14}X_{14} + \beta_{2,15}X_{15} + \beta_{2,17}X_{17} + \beta_{2,18}X_{18} + \mu_2 \quad (2.5)$$

Income Generating Function:

$$X_{12} = \beta_{3,0} + \beta_{3,1}X_1 + \beta_{3,2}X_2 + \beta_{3,3}X_3 + \beta_{3,4}X_4 + \beta_{3,5}X_5 + \beta_{3,6}X_6 + \beta_{3,7}X_7 + \beta_{3,8}X_8 + \beta_{3,9}X_9 + \beta_{3,10}X_{10} + \beta_{3,11}X_{11} + \beta_{4,13}X_{13} + \beta_{3,18}X_{18} + \mu_3 \quad (2.6)$$

where

X_1 = population concentration

X_2 = median education

X_3 = percent non-white

X_4 = percent under age 18

X_5 = percent over age 62

X_6 = percent in manufacturing

X_7 = percent professional workers other than in medical field

X_8 = percent farmers and farm workers

X_9 = percent migrated in the last five years

X_{10} = percent of families with less than \$3, 000

X_{11} = percent of families with income over \$15, 000

X_{12} = median income per family

X_{13} = per capita tax assets

X_{14} = number of inhabitants per hospital bed

X_{15} = number of inhabitants per paramedic

X_{16} = number of inhabitants per doctor

X_{17} = per capita Health Department budget

X_{18} = health status as measured by mortality losses

There are actually two measures of health status examined. One is the Health Status Index, using mortality statistics, and the other measure uses morbidity status which in the model is designated by X_{19}. The model does not change when X_{19} is substituted for X_{18}.

It may be that the second equation is not complete for the purposes of explaining the supply of physicians due to the absence of a price variable. Professional ethics in the medical field do not allow advertising and place restrictions on price competition, and so the exclusion of price in this model may not violate too greatly the supply response of private physicians.

The income determination equation is not a serious theoretical statement of income determination. Its variables are not particularly relevant to that theory, but are included in this equation because the information is available and because they are theoretically relevant to the theory of health production and the availability of physicians. It is agreed that if the specification of the income determination were more accurate, then the estimated coefficients would also be more accurate. However, bias is reduced in the estimation of the production of health and the availability of physicians by explicitly having the income depend upon the exogenous variables that appear in the other two equations.

The Relationship Between the Health Status and Several Variables

It is hypothesized that the health status of a county in the Northwest and the number of doctors available to the inhabitants is a function of the following geographic, demographic, medical and economic variables.

Geographic Variable

X_1 Index of population concentration with respect to health services. It is generally assumed that the population in the rural areas possesses characteristics that differentiate it from the urban population. Those characteristics that are believed to contribute to the rural health problems are:

1. rural family incomes are generally lower; a greater proportion of rural people live below the poverty line;
2. the rural population has more older persons and youths, but fewer adults of working age;
3. the average level of education of rural people is lower;
4. rural people must travel longer distances to health centers which adds to costs both in time and money (11, p. 4); (Karl Kraenzel has coined this the "social cost of space," associated with living in sparsely populated areas [32] .)
5. rural counties may have about as many practitioners and hospital beds as the urban counties, but have relatively fewer highly trained specialists, and the hospitals are smaller and more often inadequately staffed, poorly equipped and lacking in out-patient and extended care facilities (57, p. 73).

The measures used in previous research in evaluating the health status of a population using mortality statistics have either used density of population per square mile (33) or have taken as a measure of urbanization the percentage of people in SMSA's (Standard Metropolitan Statistical Area) (6). These measures are not suited for the Northwest because of the few SMSA's in this region. Density per square mile would be meaningless, since a county in eastern Oregon could have a very low density ratio, but still have its population concentrated in one town close to health care facilities.

An "index of concentration" was used to measure the rurality of a county. This index measures the amount of concentration of the population around the health facilities of a county. Since hospitals are the core for many health care facilities, provision and utilization of hospitals are used as a measure of availability of health services.

Measure of "Population Concentration" for Oregon. The "State of Oregon Comprehensive Health Plan" (51, p. 88) using data from the Oregon Regional Medical Program, determined the percent of patients in each county of Oregon who are hospitalized in Portland[10] (Table 2). A regression equation was used to estimate the relationship between distance in miles and hospital usage rates where miles from the center of population of a county to Portland was the independent variable (u) and usage rates, in percentages, of Portland hospitals was the dependent variable (Y_1).

It was found that a segmented line consisting of a quadratic curve for the counties in group (a) and a straight line for those counties that were a distance of 122 miles and further away from Portland, group (b)[11], gave reasonable estimates of hospital usage rates.

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[10] Gilliam, Sherman, Wallowa and Wasco counties did not provide this information.

[11] Jefferson County is included in both models.

Table 2. Counties in Oregon, distance from Portland, and their use of Portland hospitals.[a]

County	Miles from Portland	Use of Portland hospitals
1. Multnomah	1	1.00
2. Clackamas	15	.65
3. Washington	25	.58
4. Columbia	30	.50
5. Yamhill	40	.25
6. Marion	45	.14
7. Hood River	55	.25
8. Polk	59	.11
9. Linn	70	.09
10. Benton	85	.05
11. Clatsop	100	.19
12. Tillamook	114	.34
13. Lane	115	.05
14. Lincoln	115	.20
15. Jefferson	122	.10
16. Crook	152	.06
17. Deschutes	165	.05
18. Douglas	180	.06
19. Morrow	185	.05
20. Wheeler	189	.16
21. Umatilla	205	.05
22. Coos	215	.07
23. Josephine	250	.05
24. Union	257	.05
25. Grant	263	.09
26. Jackson	280	.03
27. Klamath	290	.06
28. Harney	294	.06
29. Baker	305	.09
30. Curry	305	.05
31. Lake	349	.10
32. Malheur	375	.03

[a] Gilliam, Sherman, Wallowa and Wasco counties did not provide this information.

The estimating equations were:

$$\hat{Y}_1 = \begin{cases} \underset{(10.3)}{1.05 - .029u} - \underset{(4.8)}{.00011u^2}, & 0 \leq u < 122 \quad (2.7a) \\ \qquad R^2 = .97 & \\ \underset{(1.1)}{.099 - .00013u}, & u \geq 122 \quad (2.7b) \\ \qquad R^2 = .08 & \end{cases}$$

where

$\hat{Y}_1$ = hospital usage rate in Portland

u = miles from the center of population of a county to Portland

The coefficients in parentheses are the respective t values of the regression coefficients. Equation (b) has a low R^2 since the estimated regression line is almost horizontal. ($R^2 = \hat{\beta}^2 (\Sigma u_i^2 / \Sigma y_i^2)$, if $\hat{\beta}$ is close to zero then it follows that R^2 is also close to zero (26, p. 31).) The results of regression estimate curve (b) will not affect the concentration index very much, since only a small percentage of a community's patients travel more than 122 miles for health services. The crucial distances are those between 5 and 50 miles. Because the estimate (a) gives a reasonable intercept, close to 100 percent usage rates, and high t values, it was decided to use this segmented curve for predictive purposes.

This curve was then used to predict usage rates for cities and towns that were a certain distance away from a hospital, e.g., Jefferson County has three centers of population: Culver, Madras and Metolious. These centers make up about 4.7, 19.8 and 3.1 percent respectively of the population of Jefferson County. They are about 13 miles, 1 mile, and 3 miles distant from the hospital within the county. (An average of one mile distance is used for all towns with a hospital.) Using the regression estimates these distances are converted to user rates of .796, 1.00 and .987 respectively for Culver, Madras and Metolious. On the average the rest of the population in Jefferson County is estimated to be 16 miles distant from the hospital in Madras, and has a user rate of .743.

The State of Oregon Comprehensive Health Plan indicates that of those people hospitalized from Jefferson County, 39 percent will be treated in Madras, 41 percent in Bend, and 10 percent in Prineville and Portland. The distances from a center point of population in Jefferson County is estimated to be 43 miles to Bend, 30 miles to Prineville, and 110 miles to Portland. These distances are converted to user rates of .356, .522 and .078.

Collecting all of this information into an equation will give an "index of concentration" in respect to health services:

$$I_j = \Sigma p_i \, (\Sigma s_i \, f_i) \qquad (2.8)$$

where

I = index of concentration

p = percentage of the population in a county in an area

s = percentage of hospital patients that receive treatment in a certain hospital

f = miles to a certain hospital, converted into a user index

i = all clusters of population within a county

j = counties

For Jefferson County, the "concentration index" is:

$$
\begin{aligned}
I = {} & .047[(.39)(.796) + (.10)(.078) + (.10)(.522) + (.41)(.356)] \\
& + .193[(.39)(1.00) + (.10)(.073) + (.10)(.522) + (.41)(.356)] \\
& + .031[(.39)(.987) + (.10)(.078) + (.10)(.522) + (.41)(.356)] \\
& + .724[(.39)(.743) + (.10)(.078) + (.10)(.522) + (.41)(.356)]
\end{aligned}
$$

The "index of concentration" for the counties in Oregon is shown in Table 3a. This measure includes both the concentration of the population within a county and the distance that needs to be traveled in order to receive medical treatment.

Measure of "Concentration" for Washington and Idaho. The Washington/Alaska Regional Medical Program provides information on hospitalization generated by each major zip code area as distributed by the hospitals to which patients went for service in 1967 (59). These are the crude data from which the Oregon State Comprehensive Health Planning Board estimated the hospital usage rates for counties in Oregon. By using this information and the estimated regression equations developed for Oregon between hospital usage rates and distances from a hospital as a guide, indices comparable to Oregon were developed for Idaho and Washington.

Table 3a. Index of population concentration based on hospital facilities for counties in Oregon.

County	Population concentration	County	Population concentration
1. Multnomah	1.00	19. Crook	.68
2. Benton	.88	20. Baker	.67
3. Jackson	.86	21. Douglas	.66
4. Deschutes	.85	22. Columbia	.64
5. Lane	.84	23. Wasco	.61
6. Yamhill	.84	24. Tillamook	.60
7. Marion	.83	25. Grant	.58
8. Union	.82	26. Klamath	.58
9. Umatilla	.80	27. Malheur	.56
10. Coos	.80	28. Wallowa	.53
11. Clatsop	.77	29. Jefferson	.52
12. Josephine	.76	30. Lincoln	.52
13. Linn	.76	31. Lake	.48
14. Washington	.74	32. Morrow	.45
15. Polk	.73	33. Sherman	.41
16. Clackamas	.71	34. Curry	.34
17. Hood River	.71	35. Gilliam	.27
18. Harney	.69	36. Wheeler	.11

Table 3b. Index of population concentration based on hospital facilities for counties in Washington.

County	Population concentration	County	Population concentration
1. King	.98	21. Whatcom	.69
2. Clark	.93	22. Whitman	.67
3. Spokane	.88	23. Douglas	.66
4. Asotin	.85	24. Lincoln	.65
5. Columbia	.84	25. Adams	.63
6. Pierce	.84	26. Stevens	.63
7. Snohomish	.83	27. Okanogan	.62
8. Thurston	.78	28. Pend Oreille	.60
9. Benton	.77	29. Kittitas	.59
10. Walla Walla	.77	30. Jefferson	.58
11. Garfield	.75	31. Clallam	.56
12. Cowlitz	.74	32. Ferry	.53
13. Grays Harbor	.74	33. Chelan	.48
14. Mason	.73	34. Grant	.45
15. Pacific	.73	35. Wahkiakum	.35
16. Yakima	.73	36. Klickitat	.34
17. Kitsap	.72	37. Island	.30
18. Lewis	.72	38. Skamania	.24
19. Skajit	.72	39. San Juan	.08
20. Franklin	.71		

Table 3c. Index of population concentration based on hospital facilities for counties in Idaho.

County	Population concentration	County	Population concentration
1. Ada	.93	23. Fremont	.69
2. Canyon	.91	24. Benewah	.68
3. Jerome	.90	25. Teton	.67
4. Bannock	.89	26. Caribou	.66
5. Bonneville	.86	27. Elmore	.66
6. Power	.84	28. Minidoka	.65
7. Gem	.82	29. Bear Lake	.64
8. Kootenai	.82	30. Gooding	.64
9. Butte	.80	31. Payette	.63
10. Madison	.79	32. Twin Falls	.62
11. Bingham	.78	33. Boise	.60
12. Nez Perce	.78	34. Lemhi	.59
13. Adams	.77	35. Clearwater	.57
14. Oneida	.76	36. Jefferson	.57
15. Cassia	.74	37. Idaho	.54
16. Latah	.74	38. Lincoln	.53
17. Blaine	.73	39. Bonnen	.42
18. Boundary	.72	40. Lewis	.41
19. Washington	.72	41. Camas	.29
20. Franklin	.70	42. Owyhee	.29
21. Shoshone	.70	43. Clark	.28
22. Valley	.70	44. Custer	.14

It was hypothesized that the most important factors determining the usage rate of a hospital are the total number of beds available in the hospital, the ratio of hospital beds to the population in the county, and the percent occupancy of hospital beds within that county.

Although quality of hospital care cannot be measured solely by the number of beds, it is generally assumed that the size of the hospital to some extent reflects the services available. The larger hospitals are better staffed with technical personnel and specialists and are generally better equipped (47, p. 16).

There is some desired ratio of population to hospital beds which would support the health care needs of a population at a minimum cost. While this study does not intend to speculate on this ratio, it is suggested that the inhabitants of a county will travel to neighboring counties as the population to hospital bed ratio increases. A negative relation is, therefore, hypothesized between the number of persons per hospital bed in the county and the hospital usage rates within that county.

Hospital planners have traditionally regarded 80 percent as the optimum occupancy rate in terms of services provided and financial returns received. "Klarman has pointed out, however, that 85 percent is more in line with current thinking" (10, p. 3). It is assumed that optimality in occupancy indicates better health care service and that patients prefer higher occupancy rates in hospitals.

Approximately 61 percent of the variation ($R^2 = .61$) in hospital usage rates for Oregon was associated with these three variables. The estimating equation was:

$$Y_2 = .51 + .00004H_T - .0005H_R + .61H_O \qquad (2.9)$$
$$\qquad\qquad (.90) \qquad (-5.42) \qquad (2.99)$$

where

Y_2 = hospital usage rate of patients from a county for that county's hospital

H_T = total number of hospital beds available in the county

H_R = the ratio of people per hospital bed for each county

H_O = occupancy rates of the hospital (or hospitals) within a county

The coefficients in parentheses are the respective t values of the regression coefficients. All coefficients have the signs we would expect. Using this equation, which regressed the three hospital variables on the usage rates from Oregon, the usage rates for hospitals in Washington and Idaho were predicted (Tables 4a and 4b).

The next step was to use these usage rates within the county as well as the Patient Origin Study (59) in order to get estimates of patient flows from counties toward hospital facilities in Washington and Idaho. For example, for Idaho it was estimated that 76 percent of the hospital patients from Blaine County were hospitalized within that county; of the rest, 6 percent traveled to Boise for their hospital care, while 7 percent and 11 percent went to Pocatello and Twin Falls respectively.

Table 4a. Hospital usage rates for patients in a county who are hospitalized in their home county in Washington.

County	Usage rate	County	Usage rate
1. Adams	.67	21. Lewis	.70
2. Asotin	.74	22. Lincoln	.84
3. Benton	.78	23. Mason	.76
4. Chelan	.73	24. Okanogan	.80
5. Clallam	.81	25. Pacific	.71
6. Clark	.79	26. Pend Oreille	.72
7. Columbia	.80	27. Pierce	.80
8. Cowlitz	.79	28. San Juan[a]	
9. Douglas	.49	29. Skajit	.82
10. Ferry	.71	30. Skamania[a]	
11. Franklin	.86	31. Snohomish	.76
12. Garfield	.76	32. Spokane	.95
13. Grant	.77	33. Stevens	.81
14. Grays Harbor	.79	34. Thurston	.79
15. Island[a]		35. Wahkiakum[a]	
16. Jefferson	.68	36. Walla Walla	.84
17. King	.96	37. Whatcom	.76
18. Kitsap	.70	38. Whitman	.66
19. Kittitas	.57	39. Yakima	.81
20. Klickitat	.81		

[a]Counties without hospitals

Table 4b. Hospital usage rates for patients in a county who are hospitalized in their home county in Idaho.

County	Usage rate	County	Usage rate
1. Ada	.93	23. Gem	.79
2. Adams	.65	24. Gooding	.67
3. Bannock	.82	25. Idaho	.70
4. Bear Lake	.66	26. Jefferson[a]	
5. Benewah	.77	27. Jerome	.83
6. Bingham	.59	28. Kootenai	.84
7. Blaine	.76	29. Latah	.66
8. Boise[a]		30. Lemhi	.75
9. Bonner	.72	31. Lewis[a]	
10. Bonneville	.90	32. Lincoln[a]	
11. Boundary	.83	33. Madison	.60
12. Butte	.93	34. Minidoka	.68
13. Camas[a]		35. Nez Perce	.86
14. Canyon	.89	36. Oneida	.64
15. Caribou	.68	37. Owyhee[a]	
16. Cassia	.81	38. Payette[a]	
17. Clark[a]		39. Power	.89
18. Clearwater	.64	40. Shoshone	.79
19. Custer[a]		41. Teton	.70
20. Elmore	.61	42. Twin Falls	.86
21. Franklin	.60	43. Valley	.73
22. Fremont	.72	44. Washington	.71

[a]Counties without hospitals

By using these estimated usage rates for hospitals in Washington and Idaho the "index of concentration" was calculated for counties in Washington and Idaho (Tables 3b and 3c).

Adelman, in a cross-country analysis, found that urbanization and industrialization seem to play a significant direct role in the reduction of mortality. She concluded that much of the effect of urbanization may be due to differences between city and country in environmental sanitation, type of housing, and availability of professional (as opposed to traditional) medical care (1, p. 328). For the United States as a whole, Auster (6, p. 423) and Larmore (33, p. 27) conclude that urbanization and population concentration may either not affect mortality or it may have a significant positive relationship with mortality.

The greatest concentration of the declining rural communities is in the southeastern and southwestern states. A glance at the maps in reports prepared by the President's National Advisory Commission on Rural Poverty (46, 47) should convince the observer that the rural counties in the Northwest are not markedly different in poverty and illness rates from the urban counties. It is, therefore, hypothesized that in the Northwest the differences in environmental sanitation (water supply and sewage) and housing are negligible, but that there is a negative relationship between the health status of counties and urbanization due to the stress of city life and the degradation of the physical environment.

Information on the other variables included in the model is available from several sources. The demographic and economic variables were obtained from the Census Reports (55, 56), while information about the health care variables was taken from the American Medical Association Report on Distribution of Physicians in the United States (23) and from correspondence with the Comprehensive Health Planning Agencies in each of the three states.

Demographic Variables

X_2 = median educational level of the population over 25 years. Information is probably more important in increasing healthiness of a population than any other factor. Information about a particular health hazard will not only protect its possessors from those hazards, but from other related hazards as well. Formal education tends to increase the search for and the acceptance of information relating to one's well-being. Higher levels of education may also be associated with more medical care at the preventive stage. In one study of medical care participation it was found that in more highly educated households there was greater participation in periodic medical check-ups (44, p. 7) and other preventive care (37, p. 136). Since it is accepted that preventive care at an early age has probably more to do with increasing the health of a person in his later years than the medical care inputs which are consumed in treatment at the breakdown stage of the human physiology, we expect a positive relationship between educational attainment and the health status of a community.

X_3 = percent non-white. it is often stated that at any given level of education, income, etc., non-whites tend to be less healthy than whites. Negroes, for example, have a shorter life expectancy, a high infant mortality rate, and a higher death rate from infectious diseases than non-whites (54, p. 2). Several counties in the Northwest have a substantial proportion of their population made up of American-Indians, living on or close to a reservation. Those familiar with the situation of the American-Indian would agree that the average Indian in the Northwest would expect the above facts to be true for his own people. It is conceded that the cultural factors affecting health are poorly understood, however, it is hypothesized that the health status of a county is negatively related to the percentage of non-whites residing in that county.

X_4 and X_5 = Percent of the population in a county under 18, and percent of the population in a county over 62. In a sense, the health index discussed earlier adjusts the model for age-specific deaths. Nevertheless, mortality and old-age are inseparable, and we expect a county that has a greater number of old people to have a greater economic loss due to higher mortality rates. A community with a higher proportion of young people might be expected to have a higher health index, especially as this study does not include externally caused deaths. Infant mortality would probably not be very significant in this model because of the relatively low infant mortality rates, and because of the low present value that is associated with very young children.

X_6, X_7 and X_8 = Percent in manufacturing; percent farmers or farm workers; percent of the population having migrated in the last five years. In disagreement with many studies that consider all agricultural workers in the United States to be a homogeneous low income, old and uneducated group, it is hypothesized that there may be special positive attributes in living and working in a rural area. This does not in any way suggest that the special groups within agriculture, for example the seasonal migrant farm workers, may not have serious health problems. The 1970 U. S. Census taken in April would have missed this large portion of agricultural labor, with which the occupational disease rates are usually associated, since most of the migrants from the Southwest would not yet have started their move into the Northwest.

Workers employed in manufacturing in the Northwest may share with agricultural workers many of the positive attributes of rural life, but in addition they have greater access to medical care facilities because of insurance plans in which larger manufacturing firms take part. Persons associated with agriculture or manufacturing (a large portion of people in the Northwest who are associated with manufacturing are in forestry-related industries) probably are in high accident employment. If accident rates had been included in this model, the hypothesis that these two occupational groups were positively associated with health could not be made.

Concerning migration, it is hypothesized that it is the more aware citizens who tend to migrate. This awareness may manifest itself in greater acceptance of preventive health actions. Another possibility is that the age group that is most likely to move in search for better opportunities is the lower middle age group, i.e., those persons least likely to die because of health problems.

Health Care Variables

The use of medical care inputs ultimately depends on the individual's ability to demand these inputs and on his readiness to accept and make use of the services of the physician, paramedical personnel and the facilities and prescription that are provided. Although the individual may be the entrepreneur who oversees the production of his health, the physician, because of the patient's ignorance and the many institutional constraints, such as the prescription of drugs, takes over the role of manager in the production process. He may be likened to a controlling institution, such as a government body or a powerful union, acting like a benefactor who determines what forms the inputs shall take and even what the final output will be.

Medical care provided by physicians, paramedical personnel and hospital beds can most usefully be separated into two main areas, namely prevention and treatment. Prevention in this context is defined to include obstetrical care, well-baby clinics and yearly check-ups. Treatment, on the other hand, would include those services needed by the chronically ill, such as broken bones, ulcer treatment and heart problem treatments.

Stewart concludes that "improvement in health resulting from better treatment has little effect on increased longevity" (52, p. 121). We would, therefore, expect the physician and paramedical personnel variable to be positively, and the hospital variable to be negatively, associated with the health index.

X_{16} = Number of inhabitants in the county per one medical doctor or osteopath. The physician's time is divided between treatment and prevention. In so far as it is assumed that prevention increases longevity we would expect physicians to be positively related to increased life span.

X_{15} = Number of inhabitants in the county per one paramedical personnel. In this model the term "paramedical personnel" includes chiropractors, optometrists, pharmacists, physical therapists, pediatrists, psychologists, registered nurses and sanitarians. The physician is the effective decision-maker in determining much of the use of paramedical personnel. We would, therefore, expect the same relationship toward the health status of a community to exist for paramedical personnel as exists for physicians, and considering that some of the specialties are even more oriented toward preventive medicine, this relationship might even be somewhat stronger.

X_{14} = Number of inhabitants in the county per non-state, non-governmental, short stay hospital. It was decided not to use state and federal health facilities in this model because the general public would normally be excluded from using these facilities. Long-term convalescent hospitals in many cases are used exclusively for fraternal organizations and are, likewise, not available to everybody.

Several recent studies have demonstrated that the hospital bed to population ratio is fairly constant across all geographic locations (11, p. 8; 54, p. 4). This does not rule out the argument that there may be definite differences in the quality of services provided by larger hospitals, nor does it take into consideration the occupancy rate. It could be that the areas that have stagnated economically are left with a greater percentage of older and less aware population who are served with out-of-date hospital facilities. The case may be made that hospitals are primarily used to treat ailments which are largely incurable or irreversible. It is possible, therefore, that hospital treatment has a negative relationship with increased longevity.

X_{17} = Per capita public health expenditures. These budgets include the Basic General Health Budget, the Home Health Agency Budget, and Budgets from other special programs. For Washington and Idaho such information was not usable for 1970 because the data that were collected from counties in many cases was not comparable. It was therefore decided to use 1971 data. The Comprehensive Health Planning Act was initiated in these states during 1970, and one of its functions has been to standardize much of the health data. It is assumed that the 1971 budgets reflect the commitment of the community toward increasing the health status of its populace--if this indeed is the objective of public health. In conversations with public health officials, it has not been possible to isolate a specific objective or goal of public health. It could be to collect statistics and to disseminate information to the public about health problems, with the hope that such actions will lead to wiser public decisions and, therefore, toward increasing the health status of its populace, in whichever way that is to be measured. If this is the goal of public health, then it is hypothesized that there is a positive relationship between public health expenditures and the health status of a county.

Income Variables

It was decided to use several measures of income in order to try to develop a clearer relationship between income and health. With the previous discussion in mind concerning the interrelationship between income and the health status of a county, a negative relationship between health and the low and median income variables is postulated.

X_{10} = Percent of families with income under \$3,000. In so far as poor people tend to have more chronic illnesses and are less aware of and less able to take part in the benefits of preventive health care, a shorter life span would be expected. We would expect total expenditures (private plus public) of low income individuals on medical care to be higher (62, p. 120) than other groups because of their greater need for medical treatment and their ability to secure free care under welfare and charity programs.

X_{12} = Median family income. It has been hypothesized often that the middle income group does not have the benefits of governmental income redistribution programs nor do they have adequate finances to effectively demand all of the health care inputs they desire. Assuming that all variables such as age, education, and urbanization are evenly distributed, it has been found that the middle income group has lower medical care expenditures than the poverty or high income groups (62, p. 120). This may be explained by the fact that the pressure of American life, contractual payments such as rent, mortgage payments, installment debt payments, life insurance premiums, taxes, etc., are relatively greater for the higher middle income groups and that these seemingly uncontrollable pressures take precedence over the less pressing problems of preventive care.

X = Families with income over $15,000. The same study by Wirick (62, p. 120) concluded that the medical expenditures by the high income families were half again as high as those in the average income group. A series of studies of income elasticity for physicians' expenditures or services have estimated the range to be from 0.2 to 0.8; that is for an average rise in income of 10 percent, the increase in expenditures or visits ranges from 2 to 8 percent (28, p. 363). These studies at first glance seem to contradict those of Wirick, except that the latter includes welfare expenditures and, therefore, is represented by a parabolic curve between actual expenditures and earned income. Access to medical facilities is only one of the important variables in determining the health status of an individual. The awareness of the importance of prenatal and other preventive care is assumed to be present in the high income bracket. This may be substantiated by an empirical analysis done by Silver in which he found an overall income elasticity of demand of 1.2 for medical care as a whole. The elasticities for its components ranged from .85 for physician expenses to 3.2 for dentist expenses (50, p. 139). A positive relation is therefore expected between percentage of inhabitants in the high income group and the health status of a county.

The Relationship Between the Availability of Doctors and Several Variables

Manpower remains the most important resource in the provision of medical care. Even though the physician only comprises six percent of all health manpower (21, p. 148), his services consume 23 percent (in 1967) of the consumer's medical care expenditure (15, p. 121); and it is the physician who controls and influences a large share of the use of other goods and services concerning health care.

In order to understand the placement of physicians, this section investigates the distribution of physicians in the Northwest and what influence is exerted on the placement of physicians by demographic, economic and social variables. Several studies have surveyed practicing physicians with regard to their attitudes toward the placement of their practice (9, 39, 42). These studies indicate that financial considerations, the availability of nearby medical facilities and consultive services, cultural or educational opportunities for their families, possible scarcity of non-medical professional comradeship were some of the most important factors considered when setting up practices.

Geographic Variable

X_1 = Population concentration. General practice physicians are approximately equally distributed geographically, but specialists tend to concentrate in the metropolitan areas (9, p. 4). This study includes all licensed physicians, no matter what specialty. There are sound professional reasons for higher physician-population ratio in metropolitan areas; one reason is that their highly specialized practices require the population concentration of larger cities. There is also some evidence that inhabitants of less concentrated areas have a fewer number of physician visits per year on the average (62, p. 8). Given these considerations and the attitudes of physicians toward rural areas cited above, we would expect fewer physicians to locate in rural areas.

Demographic Variables

X_2 = Median educational level. It is accepted that health of an individual is influenced by the level of health awareness. To follow the hypothesis, stated earlier in the measures of health, that education has a positive relation with the health status of a community because of the preventive care that individuals take part in, a negative relation between education and doctors would be expected. The purpose of preventive care, it is hypothesized, is to be healthier at some point in the future. This would mean fewer visits to the physician for treatment purposes since treatment and prevention are alternative means to the same objective. And if the predominant activity of physicians and hospitals remains treatment (52, p. 105), then we would expect a higher "one physician per number of inhabitants" ratio for those communities that have achieved a higher level of education.

X_5 = Percent over age 62. The aged, more apt to be suffering from chronic illnesses, put a greater strain on medical care services. They average 6.8 visits to a physician per year as compared to 4.8 percent for those under 65 (20, p. 333).

X_7 = Percent professionals. Non-medical professional comradeship is one of the factors that are considered to be important in the placing of a practice.

X_9 = Percent migrated within the last five years. This is a young middle-aged group who are more aware of their surroundings and most likely to migrate. They demand less treatment for acute or chronic illness and less physician visits. In that there is also a substantial investment involved in setting up a medical practice we would expect a time lag between the growth of a community and the willingness of a physician to establish an expensive practice in that community.

Income Variables

X_{10} = Percent in poverty

X_{11} = Percent with incomes over $15,000

X_{12} = Median income

Although ill health is likely to be more common among the poor, and even though there is some evidence that in Oregon at least the poor receive higher medical service levels (54, p. 3), most of which are provided by governmental agencies, it is hypothesized that physicians do not actively seek out patients in the lower income groups. Welfare medical payments are considered insufficient to cover the cost of services. Physicians are known to provide services but only reluctantly to welfare patients. (In Oregon, several Stayton doctors refuse to accept welfare payments for services reluctantly rendered to migrant agricultural workers.)

Physician services are considered to be a normal good; per capita demand for these services is therefore expected to increase with increases in income (28, p. 364). There may be other factors, such as those mentioned earlier, that make high income areas attractive to physicians, but it is assumed that the physician reacts to the economic incentives present. One factor closely related to income is the possession of health insurance, which tends to increase the demand for medical services. People who possess health insurance tend to have a higher number of physician visits, higher hospital admission rates and surgical rates than people without insurance coverage (24, p. 35).

The American Medical Association provides information about certain general economic characteristics of each county in the United States. "Inquiries received by the Association indicate that such information is of interest to individuals and organizations concerned with the provision of health care services" (23, p. 1). Since the only economic information provided by the Association is the per capita and per household income, it is hypothesized that physicians inquire about this information in order to provide their services to those areas which in their estimates can economically provide for another physician.

Health Care Variables

X_{14} = Number of inhabitants per hospital bed. In surveys, doctors have shown a preference to practice in areas that have medical care facilities to complement their practice.

X_{15} = Number of inhabitants per paramedic. In many areas of severe shortages of medical doctors, physician substitutes are being introduced by government programs. It is hypothesized that the natural order of correcting for shortages (i. e., the market place) has also been at work and that there is probably some substitution taking place between doctors and paramedical personnel within all of the institutional constraints set up by the professional associations.

X_{17} = Per capita health department budget. Feldstein found that physicians' fees respond positively to the provision of government medical services to make up for the loss in cases (15, p. 128). Even if the backwardly bending supply curve for physician services is accepted in the short run, it is hypothesized that in the long run the higher fees brought about by the provision of government medical services will attract additional physicians.

X_{18} = Health index (as measured by mortality losses). Increased need for medical services does not necessarily reflect itself in effective demand for these services. One of the basic requirements for a doctor visit is a physical condition, or a felt physical condition, that requires the attention of a physician. Holding everything else constant, such as income, education and place of residence, it is hypothesized that doctors respond positively to such requirements by moving to areas with lower health status.

By making it possible for the population to live longer some people speculate (49, p. 1066) we have increased the incidence of diseases, because their incidence increases sharply with advanced age. This may be true, but there are no empirical studies supporting the idea. The communicable diseases that are used in the "index of health" in this study have a higher incidence among the young and middle-aged, and are not found very frequently among the aged population. We would therefore not expect an inverse relationship between longevity and the incidence of these diseases. It is assumed that the same relationship exists between the predetermined variables and the health status of a community as determined by illness rates as they existed with these variables and the health status estimated by mortality rates.

The Results

Determinants of Health Status--Using Mortality Rates

Table 5 presents estimates for the determinants of health status (with mortality rates) using two-stage least squares regression. Eleven of the 15 estimates were significant at the 10 percent level. In the postulated model, 55 percent of the variation in the health status of counties in the Northwest was associated with the independent variables.

The correlation matrix for the variables included in the two-stage least squares model is given in Table 6. There is evidence that some problem of multicollinearity exists between some of the variables. The simple correlation coefficient between median income and percent with income over \$15, 000 ($\hat{X}_{12}$ and X_{11}) is .89. Farrar and Glauber (12, p. 99) suggest the use of the diagonal element r^{ii} to give further insight into locating the problem of interdependence. The diagonal element is calculated by the formula

$$r^{ii} = \frac{\left|(X^t X)_{ii}\right|}{\left| X^t X \right|} \qquad (2.10)$$

where $(X^t X)$ is the matrix of the simple correlation coefficients of the independent variables and $(X^t X)_{ii}$ is the correlation matrix, excluding the $\underline{i}^{th}$ variable which is X_i. r^{ii} is, therefore, the diagonal

Table 5. Two-stage least squares regression of health indices--using mortality statistics from counties in the Northwest--on selected independent variables.

	Variable	Coefficient	t Ratio
X_0	Constant	1.00	5.97*
X_1	Population concentration	-.002	1.55*
X_2	Median education	.001	1.39*
X_3	Percent non-white	-.001	.01
X_4	Percent under 18 years	.007	.92
X_5	Percent over 62 years	-.02	2.30*
X_6	Percent in manufacturing	.009	3.33*
X_8	Percent farmers and farm workers	.005	1.49*
X_9	Percent migrated	.006	1.54*
X_{10}	Percent in poverty	-.02	1.42*
X_{11}	Percent with incomes over $15,000	.01	.60
X_{12}	Median income	-.000002	1.73*
X_{14}	Inhabitants per hospital bed[a]	.000003	1.76*
X_{15}	Inhabitants per paramedic[a]	-.000007	9.18*
X_{16}	Inhabitants per doctor[a]	-.000001	11.88*
X_{17}	Per capita health department budget[b]	-.00008	.69
	R^2 =	.55	

[a] A positive sign designates a negative relation (or vice versa) since more hospital beds, paramedics or doctors are represented by a lower number.

[b] The observed sign is not consistent with the hypothesized sign.

*Significant at the 10 percent level.

Table 6. Correlation matrix for variables included in the two-stage least squares regression model.

		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	$\hat{X}_{12}$	X_{13}	X_{14}	X_{15}	$\hat{X}_{16}$	$\hat{X}_{17}$	$\hat{X}_{18}$
Population conc.	X_1																		
Education	X_2	.11																	
Race	X_3	-.02	-.03																
Under 18 yrs.	X_4	-.04	-.18	.12															
Over 62 yrs.	X_5	-.17	-.27	-.22	-.48														
Manufacturing	X_6	.10	-.24	-.05	-.04	.08													
Professionals	X_7	.03	.52	.04	-.03	-.25	-.18												
Farmers	X_8	-.33	-.19	-.12	.35	.07	-.56	-.39											
Migrants	X_9	-.09	.19	.16	-.29	-.29	-.05	.43	.26										
Poverty	X_{10}	-.20	-.43	.08	.14	.31	-.21	-.39	.43	-.14									
Over $15, 000	X_{11}	.30	.50	.12	-.25	-.25	.09	.47	.49	.16	-.58								
Median income	$\hat{X}_{12}$	-.29	-.21	.13	.30	-.20	-.04	.47	-.60	.14	-.83	.89							
Taxable assets	X_{13}	-.49	.01	-.04	-.04	.19	-.29	-.06	.46	-.05	-.05	-.13	-.03						
Hospital beds	X_{14}	-.07	-.10	.12	.08	-.24	-.02	.02	.02	.36	.05	.02	-.01	-.17					
Paramedics	X_{15}	-.42	-.07	-.10	-.01	.04	.01	-.10	.24	.05	.02	-.26	-.16	.30	.01				
Doctors	$\hat{X}_{16}$	-.29	-.21	.13	.30	-.20	-.01	-.35	.38	.28	.36	-.38	-.40	.07	.83	.14			
Health dept.	X_{17}	-.02	.06	.04	-.22	.20	.21	.09	-.39	-.00	-.09	.19	.22	.04	-.03	-.18	-.14		
Mortality	$\hat{X}_{18}$	-.29	-.21	.13	.30	-.20	.01	-.35	.38	.28	.36	-.38	.03	.07	.11	-.79	.07	-.07	
Morbidity	$\hat{X}_{19}$	-.43	-.16	-.42	.01	.23	-.19	-.14	.39	.25	.23	-.63	-.62	.03	.07	.22	.30	-.53	10

element of $(X^t X)^{-1}$, the inverse of the simple correlation matrix of the independent variables, corresponding to the $\underline{i}^{th}$ variable.

Should X_i be orthogonal to the remaining independent variables of X, then $\left|(X^t X)ii\right| = \left|X^t X\right|$ and $r^{ii} = 1.0$. If X_i is perfectly dependent on the remaining members of X, the denominator vanishes while the numerator, since it does not contain X_i, is not affected and r^{ii} becomes infinite. The variance of the normalized regression coefficient,

$$\mathrm{Var}\ (b') = \sigma_\mu^2 (X^t X)^{-1} \tag{2.11}$$

or

$$\mathrm{Var}\ (b_i') = \sigma_\mu^2\, r^{ii} \tag{2.12}$$

therefore, also becomes increasingly large when multicollinearity exists. The diagonal elements of the inverse simple correlation matrix are given in Table 7. For $\hat{X}_{12}$ in the first equation the variance --Var $(\hat{\hat{\beta}}_{12})$--is 58.20 times as high as it would be had $\hat{X}_{12}$ been completely independent of the other variables.

To eliminate those variables that apparently are the cause of some multicollinearity, such as $\hat{X}_{12}$ and X_{11}, would damage the specification of the theoretical model. The decision was made to use the results of the previous specified model with the awareness that the t values of the coefficient $\hat{X}_{12}$ (and some others) may not be as high as it would be if there were no interdependence.

Table 7. Diagonal elements of the simple correlation matrix for variables included in the two-stage least squares regression model.

	Independent variables	Dependent variables X_{18}	X_{19}	X_{16}	X_{16}	X_{12}	X_{12}
X_1	Population conc.	1.61	1.61	1.44	2.51	1.68	2.99
X_2	Education	2.37	2.37	1.86	1.86	1.86	1.86
X_3	Race	1.63	1.63			1.29	2.57
X_4	Under 18	2.74	2.74			2.57	2.83
X_5	Over 62	3.76	3.76	2.48	2.48	2.84	4.57
X_6	Manufacturing	2.83	2.83			2.65	2.78
X_7	Professionals			1.77	1.76	2.30	2.13
X_8	Farmers	5.93	5.93			4.61	4.12
X_9	Migrants	2.72	2.72	1.57	3.28	1.83	4.70
X_{10}	Poverty	12.92	12.92	8.71	16.64	2.23	3.91
X_{11}	Over $15,000	28.08	28.08	2.19	12.76	2.18	6.13
$\hat{X}_{12}$	Median income	58.20	58.20	31.93	46.35		
X_{13}	Tax assets					2.40	4.13
X_{14}	Hospital beds	13.12	13.12	1.28	1.30		
X_{15}	Paramedics	1.34	1.34	5.96	1.76		
$\hat{X}_{16}$	Doctors	19.73	19.73				
X_{17}	Health dept.	1.78	1.78	1.44	4.55		
$\hat{X}_{18}$	Mortality			5.68		1.90	
$\hat{X}_{19}$	Morbidity				16.75		11.24

A scatter diagram between the independent variables and the residual gave no evidence of any trends or evidence of heteroskedasticity.

In interpreting these estimates it must be understood that estimates of quality of health measures, or more specifically health production functions, are still in their infancy. Our knowledge of social systems in general and health care systems in particular is insufficient for building exact mathematical models. As Forrester states,

> What justification can there be for the apparent assumption that we do not know enough to construct models, but believe we do know enough to direct and design new social systems by passing laws and starting new social programs? I am suggesting that we now do know enough to make useful models of social systems. Conversely, we do not know enough to design the most effective social systems directly without first going through a model-building experimental phase. But I am confident, and substantial supporting evidence is beginning to accumulate, that the proper use of models of social systems can lead to far better systems, laws and programs (17, p. 2).

It is therefore suggested that these estimates be accepted as exploratory estimates of the health status of the Northwest region, and that when a priori notions concerning signs and relative magnitudes of parameter estimates contrast with our results, they be reconsidered.

Perhaps the most interesting result is the negative relationship between the concentration index (X_1) and the health status. When one considers such broad-worldwide studies as Adelman's (1), which used mostly the "developing nations" as observations, and found a significant direct role between urbanization and the reduction of mortality rates, and one compares this to the more disaggregated studies such as Larmore's (33), which finds a positive relationship between urbanization and mortality rates, one is inclined to conclude that there may be a sequence of relationships through stages of development between the concentration of populations and longevity. There is evidence that general environmental conditions seem to have played large but undetermined roles in reducing the death rate in the 19th and early 20th centuries in the western hemisphere, and that these environmental conditions may now be playing a substantial role in increasing the death rate (18, p. 76). Even though the inputs of the medical care industry have over time increased considerably, negative effects on the environment such as air pollution, lack of exercise and the tensions of urban life, may be offsetting the increased uses of medical care.

In addition, there is a positive relation between migration (X_9) and the health status, and a negative relation between the over 65 age group (X_5) and the health index. This leads us to cautiously advance a hypothesis that there may be stages of development of a region which have a direct effect on the health status of a community.

A community in its early stages of development has an influx of dynamic, aware citizens who contribute to the growth of that community more than they receive, in services, in return. As the community reaches a certain level where the detrimental effects of past economic growth are realized--pollution, urban slums, the deteriorated body of a former dynamic worker, and long ago depreciated public works--the health of its inhabitants declines.

Percent in manufacturing and in farming (X_6 and X_8) both are positively related to the health status of a community. In the Northwest, for most of the counties, the percent in manufacturing indicates those workers in the logging or food processing industries, which are usually in rural areas. Had this study included accidental deaths, these results could not have been accepted. But since obesity and lack of exercise are by far the greatest killers in our society, we would expect those vocations that include a lot of exercise to have a positive relationship with health.

If we consider the human body a part of human capital, then it would only seem logical that education and life expectancy be positively correlated. Whatever other reasons there may be for educated persons to be more aware of preventive health measures, our result gives some indication that the inhabitants at least act as if to optimize the return from earlier investment in themselves. A lengthening of average life expectancy through improved health reduces the rate of depreciation of investment in education and thereby increases the return to it.

The results fail to give evidence that the fact of being non-white has any influence on the health status of a community. Auster et al. dropped this variable from their model because, as they speculated, percentage non-white is correlated with many of the other variables (6, p. 422). There is no such evidence in our results (Table 6), although this does not exclude the possibility that there may be one or more variables in the system which are linear combinations of other variables. Most likely the relative homogeneity of population with respect to race in the Northwest reduces the cultural or genetic aspects in respect to health that may be present.

The low income variable (X_{10}) and median income ($\hat{X}_{16}$) were both negatively associated with the health index, while the high income bracket was positively associated with it, although not significantly. Previous studies resulted in mixed relationships between income and mortality rates. Adelman (1, p. 327) used a 16 age-specific regressions model and found per capita income to be negatively related to mortality rates, while Auster et al. (6, p. 420) had results that showed a positive relation. Larmore (33, p. 22) on the other hand used the extremes of the income distribution--under \$3,000 and over \$10,000 annually--and got a negative association for both groups. While questioning these results, Larmore noted that families in the extremes of the income distribution may have more access to medical facilities than do middle-income families. However, lower-income families can frequently obtain charity service, while upper-income families can usually finance medical care from their own resources.

It was these mixed results plus the belief that the A. M. A. publishes the "Income per Household" as useful information to the people in the medical field that led to all three measures of income to be included in this model at the price of risking the problem of increase in multicollinearity.

The medical care variables of one doctor per number of inhabitants ($\hat{X}_{16}$) and one paramedic per number of inhabitants (X_{15}) both show a positive and significant relationship with the health status of a county. This again contrasts with the study by Larmore (33, p. 22) and suggests that we may not yet have reached the point in the Northwest where mortality rates cannot further be reduced with an increase in the physician to population ratio. This decrease in the mortality losses could at the same time be attained by an increase in the substitutes for physicians, i. e., pharmacists, nurses or other paramedical personnel. Hospitals (X_{14}) in earlier western history were a place where people--especially the poor-went to die. There may still be a remnant of this relationship left in our society today. The per capita public health expenditures (X_{17}) variable is negative but not significant. These and the following results lead to the conclusion that some of our basic assumptions about the role of Public Health have to be reconsidered.

Determinants of Health Status--
Using Morbidity Rates

Only four out of 15 estimates of the coefficients were significant at the 10 percent level (Table 8). All four, i. e., population concentration (X_1), percent in poverty (X_{10}), median income ($\hat{X}_{12}$) and per capita health department budget (X_{17}), were negatively associated with the health index, as measured using morbidity rates. Twenty-four percent of the variation in the health status among counties ($R^2 = .24$) is associated with the independent variables included in the model.

These results lead us to the conclusion that the model using morbidity rates in the health index is probably not specified very well. As mentioned earlier, it was not possible to isolate one objective, or a group of objectives, of the Public Health Department in the state of Oregon. If the local public health services are organized for dealing privately with communicable diseases, then we would have expected the young age group variable (X_4) along with the above results of negative relationship between the health index, poverty and concentration to be significant and negatively related. Since the population age distribution is becoming more skewed toward the right, we would expect that public health would be more concerned with the chronic diseases such as heart diseases. No such information is kept by the states except in final count, i. e., as cause of death. Such information

Table 8. Two-stage least squares regression of health indices--using morbidity statistics from counties in the Northwest--on selected independent variables.

	Variable	Coefficient	t Ratio
X_0	Constant	1.00000	7190.00*
X_1	Population concentration	-.00001	1.35*
X_2	Median education	.000003	.36
X_3	Percent non-white	-.00004	.73
X_4	Percent under 18 years[a]	-.00003	.49
X_5	Percent over 62 years	-.00003	.40
X_6	Percent in manufacturing	.00001	.53
X_8	Percent farmers and farm workers[a]	-.00001	.35
X_9	Percent migrated	.00003	1.13
X_{10}	Percent in poverty	-.0002	1.80*
X_{11}	Percent with income over $15,000	.00009	.66
$\hat{X}_{12}$	Median income	-.00000001	1.58*
X_{14}	Inhabitants per hospital bed[b]	.000000001	.08
X_{15}	Inhabitants per paramedic[b]	-.000000003	.50
$\hat{X}_{16}$	Inhabitants per doctor[b]	-.0000000005	.10
X_{17}	Per capita health department budget[a]	-.000001	1.49*
	R^2 =	.24	

[a] The observed sign is not consistent with the hypothesized sign.

[b] A positive sign designates a negative relation (or vice versa) since more hospital beds, paramedics or doctors are represented by a lower number.

*Significant at the 10 percent level.

causes many problems because of the guesswork that is involved. If a person dies, only one disease is registered as the cause of death, whereas there may be several involved.

One Washington State public health official remarked that my model would probably result in a positive relation between disease and public health funds, which was shown to exist. There may, therefore, exist a "brushfire" psychology within public health that reacts swiftly to areas of public concern--such as the drug problem today--but has no definite long term well-defined goals. This is not to say that the control of communicable diseases or the other activities of the Public Health Department, such as sanitation and sewage disposal control, water purification and county health nurse visits, are not effective. This research has just not been able to isolate the objectives by which the effectiveness of these programs can be judged.

Determinants of the Availability of Physicians

Tables 9 and 10 present estimates of the coefficients that determine the availability of physicians. The results are basically the same for the model using mortality rates or the reportable diseases as a basis for the development of the health index. Using mortality rates, the variables X_5 (percent over 62 years) and X_{10} (hospital beds) are positively related to the availability of doctors and become significant at the 10 percent level, while the per capita Public Health Department budget

Table 9. Two-stage least squares regression of inhabitants per doctor[a]--using mortality statistics from counties in the Northwest--on selected independent variables.

	Variable	Coefficient	t Ratio
X_0	Constant	64588	.47
X_1	Population concentration	- 1244	2.37*
X_2	Median education	919	2.39*
X_5	Percent over 62 years	- 5300	1.31*
X_7	Percent professionals	-11272	4.19*
X_9	Percent migrated	2765	1.91*
X_{10}	Percent in poverty	9933	1.46*
$\hat{X}_{11}$	Percent with income over $15,000	-12336	2.06*
X_{12}	Median income	.39	.95
X_{14}	Inhabitants per hospital bed	2.40	10.03*
X_{15}	Inhabitants per paramedic[b]	- .69	.74
$\hat{X}_{17}$	Per capita health department budget	- 45	.83
X_{18}	Health index (using mortality statistics)	-74478	.54
	R^2 =	.67	

[a]The physician variable is a negative measure and the signs except for X_{14} and X_{15} have to be interpreted as the opposite of what they appear in the table.

[b]The observed sign is not consistent with the hypothesized sign.

*Significant at the 10 percent level.

Table 10. Two-stage least squares regression of inhabitants per doctor[a]--using morbidity statistics from counties in the Northwest--on selected independent variables.

	Variable	Coefficient	t Ratio
X_0	Constant	54,750,876	1.24
X_1	Population concentration	- 1732	2.55*
X_2	Median education	- 1041	2.66*
X_5	Percent over 62 years	- 1236	.31
X_7	Percent professionals	-11685	4.37*
X_9	Percent migrated	4517	2.16*
X_{10}	Percent in poverty	1118	.11
X_{11}	Percent with income over $15,000	-11540	1.92*
$\hat{X}_{12}$	Median income[b]	- .03	.06
X_{14}	Inhabitants per hospital bed	2.40	10.09*
X_{15}	Inhabitants per paramedic[b]	- .44	1.14
X_{17}	Per capita health department budget	-131.0	1.42*
$\hat{X}_{18}$	Health index (using morbidity statistics)	54,758,323	1.24
	R^2 =	.68	

[a]A positive sign designates a negative relation (or vice versa) since more doctors are represented by a lower number; except for inhabitants per hospital bed and inhabitants per paramedic.

[b]The observed sign is not consistent with the hypothesized sign.

*Significant at the 10 percent level.

(X_{17}) becomes significant and is positively related when morbidity rates are used to construct the health status variable ($\hat{X}_{19}$). In both cases the postulated model explains more than two-thirds of the variations in the availability of physicians in the Northwest.

The over 62 age group becomes more important when using mortality rates in the health index. The diseases that are used to estimate the health status of a county using morbidity data are all communicable diseases which tend to be associated with younger age groups.

One of the concerns throughout this project has been that the morbidity rates, as reported by the county Public Health Departments, are influenced a great deal by the existence of local health officials. Some estimates are that in cases of venereal disease, only about one-fifth of the actual cases are reported, and tend to be reported with greater accuracy as more effort is displayed by local health officials. If this is the case, then a stronger showing would be expected of the Health Department variable when using morbidity data.

There is no indication that governmental medical services decrease the availability of physicians, although the actual services supplied might actually be curtailed, as hypothesized by Feldstein (15, p. 131) in two ways: first, private practice physicians are drawn into governmental work on a part-time basis; second, the amount of urgent and interesting work available for private practice is reduced.

Instead, the case could be made that the introduction of public monies, such as the "Home Health Program," which allows greater expenditures on medical services by the older age groups (X_5), has some inducement for physicians to locate with the effective demand.

An interesting result is the negative relationship between education and the availability of doctors. An A. M. A. commission report found the same negative relationship between percentage of family heads having 12 or more years of education and medical expenditures. The commission hypothesized that this effect could be attributed to better preventive measures among educated persons, so that they require less medical outlay (3, p. 60). Klarman hypothesized that, because the better-educated are more health conscious and have a more positive attitude toward preventive care, these practices may later lead to a reduction in total medical services needed (30, p. 29).

Physicians have shown a definite locational preference pattern toward the amenities of the urban environment. The results of this study do nothing to question the conclusions of the survey of doctors' opinions--type studies which show the locational preferences of physicians to be: close professional ties with medical specialists, hospitals and other medical facilities, adequate educational and cultural facilities for their families, and other non-medical professional contacts (7, p. 339).

A positive and significant relationship exists in the results between the availability of physicians ($\hat{X}_{16}$), the population concentration (X_1), professionals other than in medicine (X_7), and hospital beds (X_{14}). It has been shown that areas with greater than average growth have not been able to increase facilities (especially hospitals) as regularly as the population has increased (43, p. 2). This collaborates with the results that show a negative and significant relationship between physicians and migration (X_9). Since physicians show such a large preference to be close to supportive facilities, we would not expect them to be the pioneers in any movement toward new areas. There is no evidence that physicians locate in areas that have higher median incomes ($\hat{X}_{12}$) although there is evidence, as was found in other studies, that physicians "have displayed a tropism for higher incomes that has caused them to migrate with the effective demand for their services" (7, p. 345).

However, the paramedic variable is negatively associated with physicians, although not significantly. While there may be some indication that there is some substitution taking place, the results are inconclusive. The various health manpower fields may both be complements and substitutes for each other (21, p. 156), and therefore negate any strong relationship in either direction. Nurses and other paramedical personnel may be substitutes for physicians in areas of shortage, but may only complement the physician in some areas because of technical, legal and social constraints to effective substitution that are present in areas where shortages of physicians are not in a crisis stage.

There is no evidence that physicians tend to locate in areas of low health status (X_{18} or X_{19}). Demand for medical services is most probably a function of illness, but the effective demand is a function of illness and the ability to complete a transaction. Although we have reached a point in our society where many of the basic medical needs are being provided through governmental services, much of the medical service provided is still a function of other variables other than a biological need.

This chapter has developed the model of health production and physician supply in the Northwest, and estimated the coefficients to the exploratory variables. Chapter 4 will discuss the policy implications of several variables, alone and in combination, and draw several conclusions.

IV. SUMMARY, CONCLUSIONS AND IMPLICATIONS

Summary

In Chapter I, the theoretical economic justifications for public interference in public health were reviewed. Chapter II outlined the problems inherent in quantifying the returns to health resources. The two-stage least squares method of estimating simultaneous relationships was used to empirically examine the contributions of environmental, social, economic and other related factors to the health status of the population of Oregon, Washington and Idaho. The health status of a county reflects the economic loss due to mortality in 1970. It was assumed that one objective of public health is to increase the human capital of a community by viewing people as productive agents to be improved with investments in those services that yield a continuing return in the future.

In the case of public health, as is true for other goods produced in the public sector, the role of the economist is to determine the objectives of the public and to analyze the interrelationships between the variables influencing these objectives in order to provide information needed for the allocation of health producing resources. However, economic analysis is only one factor in evaluating a program of health services. Ultimately, the preservation of life and the alleviation of pain represent value judgements which are transmitted to the decision-makers through the political process.

This thesis attempts to apply only one measure for "evaluating the health of the population and for assessing the impact on the health status of environmental, social, economic and other related factors" (51, p. 21). Using this measure it is hoped that an objective evaluation of the economic benefits of better health, compared with the costs of securing it, will be of aid to local and regional governmental units in making rational expenditure decisions.

It is emphasized that the estimates discussed in this thesis are based on conjectured relationships and on imperfect data. The estimates should therefore be treated as exploratory and subject to revision. Some of the conclusions, however, differ sufficiently from traditional health care policy to indicate the importance of reexamining methods for future public expenditures of health resources.

Conclusions

If the statistical relationships resulting from the empirical analysis are in fact the production function for health in the Northwest and the physician availability function, then several conclusions can be arrived at.

Marginal Products as Indicators of Policy

The marginal product for a factor of production is given by the first partial derivative of the total product function. Since the production function in (2. 4) is a first degree polynomial, the estimated marginal product of X_i is the estimated coefficient of X_i, or $\hat{\beta}_i$; that is:

$$MP_{X_i} = \hat{\beta}_i \text{ for } i = 1, \ldots, 17 \qquad (4.1)$$

The purpose of this empirical analysis was to evaluate the impact of several factors on the health status of a community. Several of the variables included in the equation are far removed from control of policy makers in public health. However, an understanding of the relationship between the health status of a community and several environmental and social factors can be a helpful planning tool for reaching multiple objectives. In terms of public policy we have rarely consciously tried to influence the flow of people away from areas of industrial growth; however, rapid technological growth and a very mobile population are exerting such strong pressures on the remaining natural resources in certain areas that there is a growing awareness for the need to plan the dispersion of people. The negative sign of the population concentration variable X_1 in Table 5 would indicate that the crowding of our population into metropolitan areas not only harms the natural environment, but also the health of its populace.

Education has long been accepted as a worthwhile investment by a community in itself. There is also a very conscious public policy in most societies to alter income distribution. The positive signs of X_2 (Median Education) and X_{11} (Percent with income over $15,000) and the negative sign of X_{10} (Percent in poverty) suggest that the social objectives of higher education and better health on the one hand, and eradication of poverty and better health on the other are quite complementary. A healthier person can benefit more from education by increasing his earning power, and an educated person can benefit more from policies to increase his earning potential. Health and education expenditures are principal means by which the quality of labor resources can be improved. In these ways the economy's production-possibility frontier (transformation curve of Chapter II) is pushed outward.

These results do not mean that more expenditures are warranted in order to increase the health status of a society. Under the assumption that a community attempts to receive the greatest return for its investment, economic theory suggests that the use of a resource be increased as long as its contribution adds more to total revenue than to total cost. That is until the marginal value product equals the marginal factor cost.[12] A positive marginal product would therefore

[12]There are several rather simplifying assumptions which have to be made in addition to the one made above. It is almost impossible to analyze the decision-making process under different economic

only indicate that additional units of that input could be used to increase the output as long as the cost of that additional input was not greater than the resulting output. For the population concentration variable, the cost of a decrease in the population concentration is not available, so that the sign of this variable as well as the signs of the other variables X_2 through $\hat{X}_{12}$ should only be considered as an indication of direction.

However, if education and income distribution are the only objectives, then the increase in the health status of a community related to increased expenditures in order to reach these objectives can be considered a free good. As long as the relationship between these objectives and the health status is complementary, and if increased health status is an objective in itself, then increased expenditures on education or income distribution will give a greater return than is directly observable.

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environments such as collusion of the suppliers of inputs (medical associations). Chapter I listed several failures of the market system which may be causes for a difference in observable value of output (or price of an input) and the real value. In order to expedite the analysis it is therefore assumed that we are living in a market system free of these aberrations. These _laissez faire_ assumptions allow the analyst to remove the uncertain factors affecting the problem. The conclusions reached based on the known factors should be taken as a point of departure for decision-makers.

Marginal Value Products of the Medical Inputs

The marginal value product for a factor of production is the marginal product of factor of production multiplied by the value of the product. The statistical relationship between the health index and the three significant medical care variables was:

$$I = 1.00X_0 + \ldots + .000003X_{14} - .000007X_{15} - .000001\hat{X}_{16} \qquad (4.2)$$

Because the three medical variables are a ratio between population and medical units available, a positive sign designates a negative relation (or vice versa). In order to take the partial derivation with respect to doctors, paramedics or hospital beds, this ratio was substituted into equation 4.2.

$$I_i = 1.00X_0 - \ldots - .000001\frac{N_i}{D_i} - .000007\frac{N_i}{P_i} - .000005\frac{N_i}{H_i} \qquad (4.3)$$

where

I = health index

N = population

D = number of doctors

P = number of paramedics

H = number of hospital beds

i = geographical area

The marginal value product for doctors is therefore:

$$T_i \times \frac{\partial I_i}{\partial D_i} = \frac{.000001\ (N_i)}{D_i^2} \times T_i \qquad (4.4)$$

where T_i = total human capital of the i^{th} area and will change as the population of a geographical area and the total human capital inventory changes. The marginal value products for paramedics and hospital beds are derived in similar fashion.

Tables 11a through d give the marginal value products for the medical inputs for the Northwest, for the three states of Oregon, Washington and Idaho, and for the Comprehensive Health Planning districts within these states. (The counties within each district are given in Appendix Table 3.)

Productivity of Physicians. It was decided to analyze the productivity of the medical inputs by Comprehensive Health Districts, because planning by the states is carried out by these local districts which follow approximate boundaries of economic social flows. For the entire Northwest the annual marginal value product of a doctor is estimated to be \$35,511; at that point, where the Northwest is employing doctors, if it were to employ one more doctor it would save the Northwest \$35,511 per year in economic loss due to productivity lost from early deaths. A glance at the Tables 11 a through d gives a better view of the distribution of physicians within the Northwest. The marginal value product ranges from \$22,106 in District II, Oregon

Table 11a. Marginal value product, in dollars, for doctors, paramedics and hospital beds in the Northwest.

Area	Doctors	Paramedics	Hospital beds
Northwest	35,511	12,518	-18,230
Oregon	35,809	15,474	-12,467
Washington	31,527	11,696	-24,767
Idaho	75,092	9,685	-14,541

Table 11b. Marginal value product, in dollars, for doctors, paramedics and hospital beds for the Comprehensive Health Planning Districts of Oregon.

District	Doctors	Paramedics	Hospital beds
I	76,287	12,116	- 4,099
II	22,106	10,971	-11,309
III	51,615	15,706	-24,923
IV	75,247	24,528	-19,694
V	53,168	19,333	-25,363
VI	96,738	33,089	-10,450
VII	122,974	33,192	- 5,633
VIII	18,061	20,671	-15,070
IX	83,205	16,853	-11,462
X	56,214	16,679	- 6,119
XI	74,479	31,745	-28,357
XII	115,917	23,675	- 5,697
XIII	122,695	25,760	- 8,028
XIV	86,660	26,095	- 5,360

Table 11c. Marginal value product, in dollars, for doctors, paramedics and hospital beds for the Comprehensive Health Planning Districts of Washington.

District	Doctors	Paramedics	Hospital beds
I	86,810	12,999	-22,903
II	200,717	25,192	-15,494
III	58,565	10,469	- 6,899
IV	24,162	12,998	-48,394
V	87,039	14,667	-48,465
VI	91,355	72,801	-25,211
VII	286,849	69,550	-56,708
VIII	53,396	5,150	-18,894
IX	83,904	13,183	-18,279
X	267,827	20,103	-11,387
XI	87,191	13,854	-24,229
XII	174,824	23,462	- 7,654
XIII	24,793	7,848	-12,335
XIV	153,976	13,023	-25,068
XV	35,529	2,404	- 1,917

Table 11d. Marginal value product, in dollars, for doctors, paramedics and hospital beds for the Comprehensive Health Planning Districts of Idaho.

District	Doctors	Paramedics	Hospital beds
I	104,360	14,909	- 4,376
II	66,779	8,849	-23,002
III	93,749	12,755	-13,775
IV	40,797	6,069	-20,581
V	85,806	11,719	-21,151
VI	57,073	5,913	- 6,501
VII	95,343	9,515	- 7,879

(Portland Metropolitan Area) to $286, 849 in District VII, Washington (Cowlitz and Wahkiakum counties). Without considering the costs involved this would indicate a much greater return in output to the districts with higher M. V. P. 's than those with low M. V. P. 's if all the population in a district goes to seek services in that district. The Oregon Comprehensive Health Plan determined the percent of patients in each county of Oregon who receive their hospitalization services in their respective districts and in other districts of Oregon (51, p. 88). Using these flows to weigh the populations of the districts according to the services provided by the district, the M. V. P. 's are determined for Oregon (Table 11e).

In order to allocate resources efficiently, costs have to be considered. The average annual gross earnings of a physician in the Northwest is $67, 396 (40, p. 77). In other words, it would cost the community $67, 396 in order to attract another physician to their community (considering that money alone will be enough incentive). Twenty-three C. H. P. districts, those that have M. V. P. > M. F. C. (marginal factor cost = the price of an additional doctor) would find it economically justifiable to try to seek the services of an additional physician. However, for the Northwest as one planning district, the shortage of doctors disappears. Table 11a shows that the return from an additional doctor is lower than the cost of securing a physician for the Northwest as a whole, or for the states of Oregon and Washington,

Table 11e. Marginal value product, in dollars, for doctors, paramedics and hospital beds for the Comprehensive Health Planning Districts of Oregon. Population in each district is weighted by the hospital services they provide.

District	Doctors	Paramedics	Hospital beds
I	47,276	7,508	- 2,540
II	26,543	13,174	-13,579
III	43,620	13,273	-21,062
IV	49,886	16,262	-13,056
V	57,465	20,895	-27,413
VI	59,541	20,366	- 6,432
VII	86,263	23,283	- 3,952
VIII	18,196	20,826	-15,270
IX	44,577	9,029	- 6,141
X	51,500	15,280	- 5,605
XI	53,092	22,628	-20,214
XII	115,770	23,646	- 5,690
XIII	91,676	19,247	- 5,988
XIV	77,849	23,442	- 4,815

and is higher for the state of Idaho. Apparently there is not so much a doctor shortage as a misallocation of the existing doctors. By solving for the number of doctors a district with a certain population and human capital inventory should have in equilibrium (where M. F. C. = M. V. P.), an estimate of the number of physicians needed in each district is arrived at (Tables 12a through d). The conclusion is that four districts out of 14 in Oregon (Table 12b), five out of 15 in Washington (Table 12c), and two out of seven in Idaho (Table 12d) have an excess of doctors. These excesses[13] are greater in the metropolitan centers than in the rural areas. If the movement of the inhabitants of the Northwest were toward these metropolitan centers in order to receive their medical services, then these differences would be alleviated. However, when the services rendered are considered in Oregon (for which state this information is available) the M. V. P. (Table 11e) and the shortage of doctors (Table 12e) change somewhat, but not enough to give any explanation to the fact that the Portland Metropolitan area has a favorable doctor/population ratio.

The excess demand for physicians'services that is indicated by

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[13] In order to be able to refer to these differences as excesses, it should be mentioned once again that all of these estimates are based only on the investment criterion as outlined in Chapter II. What these excesses may be are the doctors used for consumptive purposes in each district. Those districts that have shortages may not be meeting the need to fully take advantage of the returns that are available through increased productivity.

Table 12a. Difference between the actual number of doctors, paramedics and hospital beds in the Comprehensive Health Planning Districts and the number needed in equilibrium in the Northwest.

Area	Doctors in area	Doctors in equilibrium	Shortage of doctors	Paramedics in area	Paramedics in equilibrium	Shortage of paramedics	Hospital beds in area	Hospital beds in equilibrium	Shortage of hospital beds
Northwest	9,191	6,671	-2,520	40,956	28,982	-11,974	22,218	15,625	-6,593
Oregon	3,012	2,196	- 816	12,123	9,654	- 2,469	8,841	5,141	-3,700
Washington	5,522	3,777	-1,745	23,987	16,406	- 7,581	10,791	8,845	-1,946
Idaho	657	693	36	4,846	3,012	- 1,834	2,586	1,624	- 962

Table 12b. Difference between the actual number of doctors, paramedics and hospital beds in the Comprehensive Health Planning Districts and the number needed in equilibrium in Oregon.

District	Doctors in district	Doctors in equilibrium	Shortage of doctors	Paramedics in district	Paramedics in equilibrium	Shortage of paramedics	Hospital beds in district	Hospital beds in equilibrium	Shortage of hospital beds
I	36	38	2	239	166	- 73	269	89	- 180
II	1,665	954	-711	6,253	4,142	-2,111	4,023	2,233	-1,790
III	270	236	- 34	1,295	1,026	- 269	673	553	- 220
IV	153	161	8	709	702	- 7	518	378	- 140
V	258	229	29	1,132	995	- 137	647	536	- 111
VI	63	75	12	285	327	42	332	176	- 156
VII	54	73	19	275	316	41	437	170	- 267
VIII	260	135	-125	643	584	- 59	493	315	- 178
IX	33	37	4	194	159	- 35	154	85	- 69
X	56	51	- 5	272	222	- 50	294	119	- 175
XI	57	60	3	231	260	29	160	140	- 20
XII	48	63	15	281	273	- 8	375	147	- 228
XIII	31	42	11	179	181	2	271	97	- 174
XIV	28	32	4	135	137	2	195	74	- 121

Table 12c. Difference between the actual number of doctors, paramedics and hospital beds in the Comprehensive Health Planning Districts and the number needed in equilibrium in Washington.

District	Doctors in district	Doctors in equilibrium	Shortage of doctors	Paramedics in district	Paramedics in equilibrium	Shortage of paramedics	Hospital beds in district	Hospital beds in equilibrium	Shortage of hospital beds
I	43	48	5	294	212	-82	145	114	-31
II	47	81	34	351	352	1	293	189	-104
III	194	180	-14	1,214	785	-429	979	423	-556
IV	3,855	2,308	-1,547	13,906	10,027	-3,879	4,715	5,405	690
V	137	155	18	883	676	-207	318	364	46
VI	138	160	22	409	697	288	455	376	-79
VII	67	138	71	360	600	240	261	323	62
VIII	102	90	-12	869	394	-475	297	212	-85
IX	166	185	19	1,108	804	-304	616	433	-183
X	35	69	34	338	303	-35	294	163	-131
XI	91	103	12	604	449	-155	299	242	-57
XII	18	28	10	130	125	-5	149	67	-82
XIII	518	314	-204	2,436	1,364	-1,072	1,272	735	-537
XIV	41	61	20	373	269	-104	176	145	-31
XV	70	50	-20	712	220	-492	522	119	-403

Table 12d. Difference between the actual number of doctors, paramedics and hospital beds in the Comprehensive Health Planning Districts and the number needed in equilibrium in Idaho.

District	Doctors in district	Doctors in equilibrium	Shortage of doctors	Paramedics in district	Paramedics in equilibrium	Shortage of paramedics	Hospital beds in district	Hospital beds in equilibrium	Shortage of hospital beds
I	64	80	16	448	345	-103	305	186	-119
II	82	82	0	596	354	-242	242	191	- 51
III	81	96	15	581	414	-167	366	223	-143
IV	171	133	-38	1,173	577	-596	417	311	-106
V	88	99	11	630	431	-199	307	232	- 75
VI	91	84	- 7	748	363	-385	467	196	-271
VII	80	95	15	670	463	-207	482	222	-260

Table 12e. Difference between the actual number of doctors, paramedics and hospital beds in the Comprehensive Health Planning Districts and the number needed in equilibrium in Oregon. Each district's population is weighted by the hospital services it provided for its own district and other districts.

District	Doctors in district	Doctors in equilibrium	Shortage of doctors	Paramedics in district	Paramedics in equilibrium	Shortage of paramedics	Hospital beds in district	Hospital beds in equilibrium	Shortage of hospital beds
I	36	30	- 6	239	131	- 108	269	71	- 198
II	1,665	1,040	-625	6,253	4,519	-1,734	4,023	2,436	-1,587
III	270	217	- 53	1,295	944	- 351	673	509	- 164
IV	153	132	- 21	709	572	- 137	518	308	- 210
V	258	238	- 20	1,132	1,035	- 97	647	557	- 90
VI	63	59	- 4	285	257	- 28	332	139	- 193
VII	54	61	8	275	265	- 10	437	143	- 294
VIII	260	135	-125	643	589	- 54	493	316	- 177
IX	33	27	- 6	194	117	- 77	154	63	- 91
X	56	49	- 7	272	213	- 59	294	115	- 179
XI	57	51	- 6	231	220	- 11	160	118	- 42
XII	48	63	15	281	273	- 8	375	147	- 228
XIII	31	36	5	179	157	- 22	271	85	- 186
XIV	28	30	2	135	130	- 5	195	70	- 125

the high average net income of physicians in the Northwest (41, p. 207) has allowed the locational preference patterns toward the amenities of an urban environment to be realized.

Productivity of Paramedics. The term "paramedics" as used here includes most personnel involved in providing medical services except physicians. Because it is such an encompassing term, little can be said about the results. The M. V. P. for paramedics in the Northwest is $12, 518 (Table 11a), which would indicate that if a district is only concerned with future productivity as measured by mortality rates, then on the average throughout the Northwest a paramedic could be employed and give economic returns as long as the gross cost of the paramedic is less than $12, 518. The marginal value product by districts varies from $2, 404 (Columbia and Walla Walla counties in Washington) to $72, 404 (Clark, Klickitat and Skamania counties in Washington) (Tables 11b through d). Again the problem of allocation arises, and part of it may be due to the fact that some Comprehensive Health Planning districts are not drawn up according to service flows, but rather according to political definitions. Considering the actual service flow for Oregon once again the M. V. P. range of values narrows (Table 11e). If the gross earnings of an average paramedic were $25, 000, then Tables 12a through e give the difference between the actual number of paramedic personnel and the number needed in that district to reach equilibrium.

Productivity of Hospitals. A negative sign of a coefficient resulting from an analysis of a production function would designate a negative causal relationship between the input variable and the output. In this instance, where the sign of the hospital bed variable is negative this does not necessarily mean that hospital beds are the cause for greater death rates among the population. A more likely explanation is that hospitals are built for a group that requires greater treatment and that has a greater probability of dying in any one time period. By only looking at the investment output of health, this group's economic loss from deaths is proportionately larger. Medical treatment in almost every other study has a low marginal productivity with respect to longevity (52, p. 103) because hospitals serve a greater proportion of services as treatment than as prevention, and a minus productivity was expected.

Community pride or a feeling of altruism together with the Hill-Burton Act (at its peak it provided about 15 percent of construction funds) (19, p. 56) are other reasons for having larger hospitals than might be needed. Any input can theoretically be used in excess, so that the increased use of one more input actually results in an additional smaller output. However, the use of federal funds which the community does not have to bear would reduce the cost and therefore increase the use. In addition, if the concept of option demand[14] is

[14] Option demand involves the infrequency and uncertainty of use of a particular commodity. Hospital use for an individual is infrequent,

involved, then the total benefit that may be derived, in addition to the investment and consumption benefits, would also increase the use.

The Value of Hospital Beds in Decreasing Population/Doctor Ratios

Because measurement of health as an output is exceedingly difficult and because manpower remains the crucial resource in health services, doctor/population ratios have often been used to measure the adequacy of medical care. The signs of the coefficients of the variables X_1 through $\hat{X}_{12}$ (Table 9) do show the same complementarity between increasing the number of doctors and other desired social goals as existed between the increase in productivity and several other variables. If it is true, as hypothesized in Chapter III, that educated people use more preventive services and therefore use doctors less as treatment for ill health, then it would seem to be consistent to strive to attain a higher level of education and therefore reduce the need for as many doctors.

Decreasing poverty has become an accepted objective in our society; the negative sign of the poverty variable X_{10} is consistent with the overall objective of eradicating poverty and increasing the

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and a person may never use the services although he is willing to pay for the hospital through contributions for many years. The hospital is actually providing a service to an individual throughout the years of no use, though the use was only of a stand-by nature and was in fact never physically used.

quality of medical care. This conclusion is valid as long as the substitute effect is greater than the income effect resulting from an increase in education and income. If the increase in education leads to higher incomes, and the amount of doctors' services demanded with this additional income is greater than the reduction in demand for doctors' services because of greater use of preventive care associated with higher education, then the resulting demand for doctors would increase with a rise in the educational level of a community.

One of the more important factors that physicians consider in placing their practices is the availability of hospitals. If the doctor/population ratio $\hat{X}_{16}$ is considered the output, then the marginal value product of a reduction in the inhabitants per hospital bed ratio is:

$$\frac{\partial \hat{X}_{16}}{\partial X_{14}} = 2.4 \qquad (4.6)$$

That is, a reduction in the inhabitants per hospital bed ratio by one unit will decrease the inhabitants per doctor ratio by a multiple of 2.4. This does not necessarily mean that such a reduction is economically desirable unless the cost of decreasing the inhabitants per hospital bed ratio is less than the benefit in reducing the inhabitants per doctor ratio.

The average gross income for physicians in the Northwest was taken to be \$67,396 (40, p. 77) while the average cost of a hospital bed was estimated to be \$36,865 (53). For any geographical area, therefore, the per inhabitant cost of a hospital and per inhabitant benefit of an additional doctor would depend on the population of that area. By dividing the inhabitants per hospital bed into the cost of a hospital bed, the per inhabitant hospital cost was arrived at; the same procedure was used to estimate the marginal value product of increasing the marginal value product of inhabitants per hospital bed--using doctors as output (Tables 13a through e). If hospital beds were evenly distributed throughout the Northwest, the cost of decreasing the inhabitants to hospital bed ratio is about equal to the benefits derived therefrom (242 > 241). For the C. H. P. districts, however, in 17 out of 36 districts the cost would exceed the benefits derived therefrom. The rural areas especially would find the difference substantial.

From these statistical relations it would seem that hospital construction would not be a wise investment for rural areas whose main objectives for the hospital construction are to create facilities that will attract additional doctors.

Policy Implications

The objective of this thesis has been to show that health manpower is not a goal in itself but a means of providing services to a community. Services as factors to be allocated toward the production of health should be provided to the extent that they make a worthwhile

Table 13a. Marginal value product, in dollars, of a reduction in the population per hospital bed ratio by one unit, and the cost of such a reduction for the Northwest.

Area	Inhabitants / doctor	Marginal value product of inhabitants / hospital bed	Inhabitants / hospital bed	Hospital cost / inhabitant
Northwest	670	241	152	242
Oregon	694	233	237	155
Washington	617	262	316	116
Idaho	1,085	149	275	134

Table 13b. Marginal value product, in dollars, of a reduction in the population per hospital bed ratio by one unit, and the cost of such a reduction for the Comprehensive Health Planning Districts in Oregon.

District	Inhabitants / doctor	Marginal value product of inhabitants / hospital bed	Inhabitants / hospital bed	Hospital cost / inhabitant
I	1,289	125	173	213
II	546	295	226	163
III	840	192	337	109
IV	990	163	292	126
V	827	194	330	112
VI	1,139	142	216	171
VII	1,287	125	129	286
VIII	501	324	264	140
IX	1,075	151	230	160
X	875	185	167	221
XI	989	163	352	105
XII	1,262	127	162	228
XIII	1,308	125	150	246
XIV	1,085	145	156	236

Table 13c. Marginal value product, in dollars, of a reduction in the population per hospital bed ratio by one unit, and the cost of such a reduction for the Comprehensive Health Planning Districts in Washington.

District	Inhabitants / doctor	Marginal value product of inhabitants / hospital bed	Inhabitants / hospital bed	Hospital cost / inhabitant
I	1, 057	153	313	118
II	1, 603	101	257	143
III	852	190	189	195
IV	571	283	467	80
V	1, 046	155	451	82
VI	1, 061	152	323	114
VII	3, 263	50	838	44
VIII	824	196	283	130
IX	1, 024	158	276	134
X	1, 813	89	216	171
XI	1, 029	157	312	118
XII	1, 505	107	182	203
XIII	555	291	226	164
XIV	1, 332	121	310	119
XV	666	243	89	414

Table 13d. Marginal value product, in dollars, of a reduction in the population per hospital bed ratio by one unit, and the cost of such a reduction for the Comprehensive Health Planning Districts in Idaho.

District	Inhabitants / doctor	Marginal value product of inhabitants / hospital bed	Inhabitants / hospital bed	Hospital cost / inhabitant
I	1, 300	124	273	135
II	1, 011	160	343	107
III	1, 235	131	273	107
IV	790	205	324	114
V	1, 170	138	335	110
VI	723	224	141	261
VII	1, 208	134	200	184

Table 13e. Marginal value product, in dollars, of a reduction in the population per hospital bed ratio by one unit and the cost of such a reduction for the Comprehensive Health Planning Districts in Oregon. Population in each district is weighted by the hospital services they provide.

District	Inhabitants / doctor	Marginal value product of inhabitants / hospital bed	Inhabitants / hospital bed	Hospital cost/ inhabitant
I	693	233	93	396
II	595	271	246	150
III	771	209	309	119
IV	803	202	237	156
V	856	190	341	108
VI	891	182	169	218
VII	1,078	151	133	277
VIII	502	322	265	139
IX	787	206	169	218
X	833	194	159	232
XI	835	194	297	124
XII	1,184	137	152	243
XIII	1,130	144	129	286
XIV	1,017	159	146	253

contribution to the health of a population. The health status of a population has been measured by the amount of future productivity lost due to early deaths during a specified time period. While there are reasons for a society to allocate resources toward the non-productive health use, the returns from such programs were not measured.

With the analysis of Chapter II in mind, it is suggested that when there is an "excess" of doctors, paramedics or hospital beds, a community should investigate whether this excess goes beyond their "minimum acceptable level" of consumptive health units it wants to provide, and use the statistical results of this model as a rough guide to the costs involved in reallocating health resources.

It was indicated that there is some complementarity between the objective to raise the health status of a community and other social objectives. It would be desirable to be able to ascertain the benefits of these separate objectives in order to be able to analyze the costs of allocating resources to reach these objectives against the true benefits derived. For example, the benefits in increased health related to a reduction in the population concentration can be estimated using these statistical relationships, by investigating the relationship between other desired social goals and population concentration the total costs of planning and administering programs that influence the movement of people could be allocated to the different sectors receiving the benefits.

As has been mentioned, medical resource policy should move beyond the maintenance of specified manpower/population ratios. Planners in the past have used these ratios to suggest a shortage of medical inputs (doctors or hospital beds) in certain areas without considering the obvious fact that there are therefore also some areas whose population/medical input ratios are far in excess of the desirable ratio. It would seem to be desirable to be able to look at the contribution of each medical input to some specified objective. Using one objective, i.e., the increasing of productivity, results of this thesis indicate that there is an excess of hospital beds in the Northwest[15], and that instead of building new hospital facilities to treat patients and to attract doctors, it would be more efficient to increase the number of doctors directly, even if this requires paying higher salaries. A local community that is trying to place a physician may be allocating its resources more efficiently by subsidizing doctors with a minimum salary or by building clinics for the free use by doctors to attract them rather than indirectly trying to do so by building hospital facilities. Such a subsidy by a rural community

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[15] A recent article in the Oregonian reported

> The House of Delegates of the Oregon Medical Association adopted. . . a go-slow resolution on new hospital facilities. the governing body of the professional organization for approximately 2,400 Oregon physicians was responding to mounting concern that too many hospitals are being approved before adoption of statewide planning programs based on need (36, p. 11).

could be looked upon as the cost which it is paying presently for transportation to receive services in other areas.

A curious mixture of free-market and government control has emerged in the provision of physicians' services. A large part of the creation of the supply of physicians (medical schools, research grants) is borne by the community at large (state or federal money); however, the control of the supply in the past has been in the hands of the suppliers, the medical associations. On the demand side the consumer has been faced with the situation of having to accept medical services at increasing prices or to go without services he feels are needed. Local, state and federal governments have also undertaken to provide services for those sectors not able to take part in the market exchange, the poor. Such an arrangement has led to the situation where the payers of the creation of the supply, the taxpayers, subsidize the services the poor receive as well as the salaries of the members of the medical profession, but where they receive no extra direct benefits from their investments. It would seem that the consumer would insist on having a say in determining the supply of physicians in return for the contributions to medical schools.

Increasing the supply of physicians because some rural communities without adequate services is not likely to actually bring the physicians to these areas for some time. Because of the excess demand[16] that exists everywhere for physicians' services it is expected that an increase in the total number of physicians would serve to attract a large part of the increment to areas with already formidable physician to population ratios. Consideration should be given not only to programs that increase the supply, but also to specific proposals to place physicians in those areas that can point to a need for those services as well as the ability to support them.

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[16] There would not be an "excess demand" if prices were allowed to fluctuate freely. Medical associations discourage price competition so that a misallocation of resources may exist, since other factors are substituted for price that determine the allocation of medical resources.

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APPENDIX

Appendix Table 1a. Human capital inventory, in dollars, for Oregon by counties.

1.	Baker	1,037,027,312	19.	Lake	468,747,489
2.	Benton	4,514,142,589	20.	Lane	16,587,351,987
3.	Clackamas	12,511,984,750	21.	Lincoln	1,753,327,807
4.	Clatsop	1,999,367,507	22.	Linn	5,363,513,887
5.	Columbia	2,125,300,826	23.	Malheur	1,689,038,270
6.	Coos	4,219,192,057	24.	Marion	11,068,066,080
7.	Crook	730,908,282	25.	Morrow	317,152,166
8.	Curry	938,851,805	26.	Multnomah	40,576,986,034
9.	Deschutes	2,220,278,195	27.	Polk	2,612,133,888
10.	Douglas	5,351,774,730	28.	Sherman	154,022,052
11.	Gilliam	173,413,794	29.	Tillamook	1,267,268,773
12.	Grant	510,530,212	30.	Umatilla	3,272,687,422
13.	Harney	547,046,349	31.	Union	1,425,328,938
14.	Hood River	946,825,267	32.	Wallowa	445,910,185
15.	Jackson	6,915,451,360	33.	Wasco	1,454,408,475
16.	Jefferson	648,360,618	34.	Washington	12,169,087,215
17.	Josephine	2,456,282,851	35.	Wheeler	135,186,601
18.	Klamath	3,824,437,953	36.	Yamhill	2,905,070,848

Appendix Table 1b. Human capital inventory, in dollars, for Washington by counties.

1. Adams	993, 166, 894	21. Lewis	3, 507, 326, 955
2. Asotin	1, 055, 155, 480	22. Lincoln	718, 145, 096
3. Benton	5, 578, 932, 071	23. Mason	1, 670, 116, 174
4. Chelan	3, 216, 981, 294	24. Okanogan	2, 031, 517, 286
5. Clallam	2, 717, 069, 274	25. Pacific	1, 186, 955, 638
6. Clark	10, 468, 502, 213	26. Pend Oreille	454, 608, 330
7. Columbia	340, 830, 238	27. Pierce	35, 868, 134, 016
8. Cowlitz	5, 610, 061, 724	28. San Juan	267, 480, 124
9. Douglas	1, 364, 291, 554	29. Skajit	4, 106, 210, 180
10. Ferry	304, 293, 521	30. Skamania	467, 591, 958
11. Franklin	2, 155, 209, 262	31. Snohomish	22, 293, 622, 237
12. Garfield	225, 512, 977	32. Spokane	23, 140, 435, 296
13. Grant	3, 458, 112, 857	33. Stevens	1, 332, 396, 626
14. Grays Harbor	4, 697, 570, 481	34. Thurston	6, 224, 390, 823
15. Island	2, 309, 756, 396	35. Wahkiakum	279, 240, 184
16. Jefferson	825, 393, 598	36. Walla Walla	3, 393, 837, 724
17. King	96, 586, 565, 360	37. Whatcom	6, 659, 031, 269
18. Kitsap	8, 477, 854, 687	38. Whitman	3, 458, 902, 449
19. Kittitas	2, 194, 333, 999	39. Yakima	11, 405, 154, 810
20. Klickitat	944, 487, 698		

Appendix Table 1c. Human capital inventory, in dollars, for Idaho by counties.

1.	Ada	7,212,088,579	23.	Gem	568,920,457
2.	Adams	177,565,943	24.	Gooding	516,348,520
3.	Bannock	3,465,541,992	25.	Idaho	806,438,471
4.	Bear Lake	345,381,471	26.	Jefferson	734,563,258
5.	Benewah	380,896,581	27.	Jerome	632,308,340
6.	Bingham	1,856,657,836	28.	Kootenai	2,178,138,958
7.	Blaine	369,560,517	29.	Latah	1,760,825,504
8.	Boise	109,348,495	30.	Lemhi	339,104,700
9.	Bonner	935,213,304	31.	Lewis	237,125,710
10.	Bonneville	3,359,969,691	32.	Lincoln	186,595,114
11.	Boundary	384,223,712	33.	Madison	925,830,442
12.	Butte	183,264,966	34.	Minidoka	1,015,993,828
13.	Camas	45,525,672	35.	Nez Perce	1,905,461,082
14.	Canyon	3,813,358,916	36.	Oneida	163,773,660
15.	Caribou	418,728,642	37.	Owyhee	411,550,463
16.	Cassia	1,078,137,262	38.	Payette	732,372,842
17.	Clark	47,500,911	39.	Power	315,528,252
18.	Clearwater	706,854,538	40.	Shoshone	1,258,549,909
19.	Custer	183,676,268	41.	Teton	170,225,199
20.	Elmore	1,281,821,245	42.	Twin Falls	2,557,638,944
21.	Franklin	438,412,826	43.	Valley	228,048,328
22.	Fremont	552,182,357	44.	Washington	446,608,253

Appendix Table 2. Economic loss due to illness--Idaho, 1970.

		Elementary and high school			Community college			College and university			Labor			Housework			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Females (Ada County)	Days lost	Participation rate	Cost per day	Cost of loss from	Participation rate	Cost per day	Cost of loss from	Participation rate	Cost per day	Cost of loss from	Participation rate	Cost per day	Cost of loss from	Participation rate	Cost per day	Cost of loss from	Total cost
-1	39																
1-4	40																
5-14	98	1.000	2.51	246							.071	14.55	101	.033	9.65	31	378
15-24	417	.355	2.51	371	.102	4.06	171	.191	5.27	421	.444	12.42	2298	.266	9.65	1072	4333
25-34	116				.036	4.06	17	.054	5.27	32	.368	14.73	629	.580	9.65	650	1328
35-44	16										.467	15.40	115	.493	9.65	76	191
45-54	182										.498	17.42	1580	.388	9.65	681	2261
55-64	-										.394	18.74		.489	9.65		
65-74	182										.116	12.83	271	.774	9.65	1360	1631
75-84	-										.037	12.83		.808	9.65		
85+	-										.010	12.83		.140	9.65		

Appendix Table 3. Counties in their respective Comprehensive Health Planning District in the Northwest.

District	County	District	County	District	County
			Oregon		
I	Clatsop	V	Lane	XI	Klamath
	Tillamook				Lake
		VI	Douglas		
II	Clackamas			XII	Gilliam
		VII	Coos		
	Columbia				Grant
			Curry		
	Multnomah				Morrow
	Washington	VIII	Jackson		Umatilla
			Josephine		Wheeler
III	Marion				
	Polk	IX	Hood River	XIII	Baker
	Yamhill		Sherman		Union
			Wasco		Wallowa
IV	Benton				
	Lincoln	X	Crook	XIV	Harney
	Linn		Deschutes		Malheur
			Jefferson		
			Washington		
I	Clallam	VI	Clark	XI	Benton
	Jefferson		Klickitat		Franklin
			Skamania		
II	Grays Harbor			XII	Ferry
	Pacific	VII	Cowlitz		Pend Oreille
			Wahkiakum		Stevens
III	Island				
	San Juan	VIII	Chelan	XIII	Spokane
	Skajit		Douglas		
				XIV	Asotin
	Whatcom		Okanogan		Garfield
IV	King	IX	Kittitas		Whitman
	Kitsap		Yakima		
				XV	Columbia
	Pierce				
		X	Adams		Walla Walla
	Snohomish				
			Grant		
V	Lewis		Lincoln		
	Mason				
	Thurston				
			Idaho		
I	Benewah	II	Clearwater	III	Adams
	Bonner		Idaho		Canyon
	Boundary		Latah		Gem
	Kootenai		Lewis		Owyhee
	Shoshone		Nez Perce		Payette
					Washington

(Continued on next page)

Appendix Table 3. (Continued)

District	County	District	County	District	County
		Idaho (continued)			
IV	Ada	VI	Bannock	VII	Bonneville
	Boise		Bear Lake		Clark
	Elmore		Bingham		Custer
	Valley		Butte		Fremont
			Caribou		Jefferson
V	Camas		Franklin		Lemhi
	Cassia		Oneida		Madison
	Blaine		Power		Teton
	Gooding				
	Jerome				
	Lincoln				
	Minidoka				
	Twin Falls				