RATIONAL PLANNING FOR HEALTH CARE DELIVERY: ASPECTS OF SUPPLY, DEMAND, AND EVALUATION

by

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A THESIS SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF BUSINESS ADMINISTRATION

in the Division
of
Management Science

We accept this thesis as conforming to the
required standard

THE UNIVERSITY OF BRITISH COLUMBIA
March, 1972

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Date March 27, 1972

Rational planning for the delivery of health care services is the primary concern of this thesis. Various aspects of the demand for, and the supply and characteristics of these services are discussed, since an understanding of these topics is essential to rational planning.

Chapter I examines the relative importance of the influences of health care services, socio-economic structures and life styles on individual and societal health status. Various criteria for the evaluation of health care services and for the allocation of societal resources between health care services and other social services influencing health and well-being are discussed.

Chapter II deals with consumer behaviour and the demand for medical services. This discussion entails individual perception of medical needs, factors influencing health knowledge, sources and effectiveness of health information dissemination, and various factors which inhibit utilization.

Chapter III is concerned with the supply of health care services, their financing and interrelationships. In particular, the role, characteristics, and costs of physician and hospital services are examined.

Chapter IV discusses the resolution of supply and demand with an emphasis on financial considerations and the organizational arrangements between the various components of supply.

Chapter V reviews and discusses some of the major problems of various techniques which have been employed to forecast future health care service requirements.

Various aspects of future modes of health care delivery are discussed.

Chapter VI presents a simulation model which may be used as an aid in regional planning of health care services.

Chapter VII illustrates several results for various simulated conditions and strategies.

Chapter VIII suggests future improvements to the simulation model and describes several possible experiments which are being planned.

TABLE OF CONTENTS

CHAPTER PAGE

CHAPTER PAGE

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENT

The cooperation and assistance of the U.B.C. Health Systems Group is gratefully acknowledged.

The contributions of the following persons are greatly appreciated:

Dr. I. Vertinsky, under whose supervision this thesis was written, for his guidance and many helpful suggestions.

Dr. D. Uyeno for his many comments and suggestions in the preparation of this thesis.

CHAPTER I: MEDICAL CARE AND HEALTH

A. Introduction

In examining the health care system, we must determine what it is that the consumer seeks and what benefits he derives from the health care system. This chapter examines the role of the health care and other systems and their relationships to health. Various measures of health status and the quality of medical care are discussed, for it is only through such measures that the impact of the health care system on health and the quality of life may be objectively evaluated.

B. Medical Care

It is commonly accepted that medical care services exist for the prevention and treatment of disease and disability. However, a substantial proportion of patient visits to physicians are in search of reassurance and psychological support. The consumer of medical care services seeks expected benefits in terms of improved or insured physical and mental well-being, rather than medical services per se.

Medical care is not a single service, but a mix of component services which include drug prescription, epidemic control, reassurance, hospital care, physiotherapy, physician advice, and psychiatric aid. These services, unlike the goods or services of most other industries, are largely of an informational nature, either in the form of physician advice or skilled care.

The effectiveness of medical care services and the satisfaction or dissatisfaction derived from them, by the consumer, depend on a number of different attributes.

The individual consumer is unable to adequately judge the quality of medical care services. Consequently the medical profession and various public agencies have been charged with the responsibility of insuring and improving the quality of medical care services. Efforts to do so involve an evaluation of various aspects of medical care services which are felt to be essential to the provision of good or adequate medical care. Unfortunately, there is no clearly defined and accepted standard of 'good health' nor is medical science advanced to the state of always being able to render a proper and exact diagnosis or to recommend with certainty a best course of treatment. These inherent difficulties have, to a large extent, precluded an objective measure of the efficacy of medical care services and evaluation has been primarily based on normative judgements and standards of the medical profession.

In attempting to rationalize the evaluation processes, various approaches have been made at quantifying attributes of medical care services. While it is desirable to be able to derive, from the quantified attribute values, an overall numerical evaluation score as a surrogate for the quality of a medical care system, such attempts are complicated by the conceptual difficulty of assigning appropriate weightings to the non-homogeneous attributes. There is, as yet, no satisfactory quantifiable objective function for the macro evaluation of a medical care system. Since any weightings

employed in weighted measures will incorporate subjective biases of the evaluators and may obscure important aspects, the methodology and assumptions should be explicitly stated and the spectrum of individual subcomponent evaluations presented.

In evaluating the quality of a medical care system, consisting of physicians, hospital inpatient and outpatient facilities and other services, patient progress through the system may serve as a logical means to segregate the system into three distinct categories for analysis: entry, in-treatment, and end-result. Alternate criteria may exist for the evaluation of the system at any of these three stages of patient progress and evaluation may entail combinations of criteria from the different stages.

1. Entry

At the stage of entry to components of the medical care system, the two most frequently considered evaluative criteria are the capability of the system to provide necessary and demanded services and the timeliness with which these services are provided.

The timeliness of receiving medical services may be regarded as important not only in terms of a patient's medical condition, but also in terms of his satisfaction with the system for other than medical reasons. Prolonged discomfort, anxiety, disability, and a loss of income while waiting to receive medical services contribute to a patient's dissatisfaction with the medical care system.

A proper evaluation of the importance of delays and unmet demands should focus on the seriousness of possible

consequences and alternative treatment patterns as well as the number of patients involved and the time period of delay.

A measure of the quality of medical services, in the context of system capability, could be the percentage of the time which the system is able to provide certain services without delay or the percentage of the time for which various services are provided within a given waiting time.

Many of the criteria chosen for adequate or good care are norms of a subjective nature and are open to question, since the impact of the delays is not fully considered.

2. In-treatment

The quality of care received while undergoing treatment is often evaluated on the basis of the services available, the qualifications and competence of the personnel or the organizational processes involved.

In terms of the physician's office, the hospital or other such facilities certain standards may be recognized or deemed to be necessary for the provision of an adequate level of care. Such an evaluation of hospitals is employed in the United States by the Joint Commission for the Accreditation of Hospitals, which has set minimum acceptable standards for facilities, equipment, administrative and professional organization and professional qualifications.

This evaluation process does not measure patient care directly, however it does measure the existence and availability of various components of care which are felt to be necessary for proper patient care.

One assessment of the quality of patient care may be

made in terms of the competence of medical and ancillary personnel, however, the emphasis has usually been placed on physicians and to a lesser extent nurses. Along these lines, Falk et al (23) have derived and quantified what "--- in the opinion of a team of selected clinical experts -- should be done as good medical care for prevention, diagnosis, treatment, or rehabilitation in the light of present day knowledge, skills and potential resources in personnel and facilities" in terms of the mix and quantities of services for some 230 diagnostic categories.

In addition to the proper mix and quantities of services, various aspects of competence in the delivery of these services may serve as an indicator of the quality of patient care. Along these lines, Price et al (52) have devised a profile for the measurement of physician performance, based on a number of factors. In hospitals, medical audits serve as the major means for such an evaluation. Typically the audit will examine hospital records for indications of diagnostic errors and subjective estimates of the quality of care provided, as well as various rates, by diagnostic category, such as preventable deaths, the incidence of specific complications, certain tests, consultations and the removal of normal tissue in operations.

Various organizational processes, within the hospital, may be regarded as indicators of quality. These indicators may be concerned with the number and mix of personnel, administrative and professional organizational structures, the manner in which records are maintained, admission and discharge policies, and the existence and functioning of tissue committees, libraries, refresher courses, internal medical audits, etc.

These evaluations may be made in terms of inter-institutional or inter-physicianal comparisons or in comparison to accepted standards. The basis for evaluation is not to judge the ability of medical science in achieving results, but to determine the degree to which good treatment is administered within the constraint of available resources and whether or not these resources are adequate.

3. End-result

Seemingly, one of the most relevant criteria for judging the quality of a service is the degree to which it is effective in fulfilling its purpose, that is, whether or not desired end results are attained. In the area of health care delivery, the end results of preventive and remedial programs, when they can be reliably measured, serve as the most valid indicators of the quality of a health care system.

In some aspects, end results can be well defined and readily measured such as various surgical fatality rates, perinatal mortality rates, puerperal rates, the incidence of preventable complications, and the rehabilitation of persons with drug and alcohol problems. However, various measures which have been employed were not always valid. Sheps (64) points to the use of post operative mortality ratios as one such measure. This ratio is derived by dividing deaths within 10 days of an operation by the total number of operations performed. This ignores deaths after 10 days and naively gives equal weightings to operations of varying risk, such as dental extractions and neurosurgery. Clearly, postoperative mortality ratios should be evaluated on the basis of operative procedure category and should

account for deaths after 10 days if they are related to treatment.

While some outcomes of treatment may be readily measured and well defined, others may be difficult to define or measure, such as social restoration and patient satisfaction or may require long periods of time before follow-up studies can validly determine the final outcome.

Although various criteria for evaluation may be well defined and easily measured, the relevancy of these criteria may sometimes be controversial, such as the issue concerning the prolongation of life under certain circumstances.

Factors other than medical care treatment may have an appreciable influence on outcomes and end results may vary as to the degree of success for a given treatment. Comparative studies under controlled conditions, therefore, serve as the only means of studying and drawing valid conclusions concerning the effect of particular treatments. In studying outcomes, under alternative treatment patterns, including non-treatment, care must be exercised to ensure the validity of control and that the treatment studied has been rigorously provided.

These outcome measures may serve as indicators of the degree to which medical science is capable of treating various conditions and as reference criteria in evaluating the performance of health care delivery.

"Probably no more fundamental information would facilitate the conduct of end-result studies than knowledge of the natural history of disease, the physical, social and economic consequences of disease during well defined intervals following onset, and the role of preventive and therapeutic medical care in altering the course of disease. This idea has been recognized

for a long time, but the methodological problems and the personnel and time requirements have proven to be formidable barriers to undertaking studies that deal comprehensively with the issue." (63)

Medical audits, accreditation of hospitals, and other evaluations of the quality of medical care provide a control mechanism and also a stimulus for improving the quality of health care delivery. As progress and changes in the delivery of health care occur, revision and validation of the criteria used in evaluating quality are necessitated.

There is a need for further research into developing valid and reliable criteria as indicators of the quality of health care delivery. In addition, "there is need for developing methods that review the quality of the entire episode of care -- and that review the contributions of all the care-providing personnel----. Since the methods now in use are almost entirely retrospective, it also is important to develop methods that rapidly provide information about deviations from accepted practice so that interventive action can be taken while care is still in progress." (18)

C. Socio-Economic Structures, Life Styles, and Health

As has already been stated, the expected benefits of a medical care system are improved or insured physical and mental being or health. The traditional health care system has been primarily concerned with diagnosis and treatment in the pre-clinical and clinical stages of disease, and is but one of the factors influencing the health of a population.

Individual and societal health status are influenced by

a number of other factors, of which some are considered natural such as bacterial and viral infections, whereas others such as alcoholism and malnutrition stem from socio-economic structures and life styles.

The influence of these other factors on the health status of a population is such that it has led Winkelstein and French (75) to conclude that the health status of a population is largely unrelated to the quality and quantity of medical services at its disposal. Furthermore, "much of the total use of health services is accounted for by the relatively small portion of the total population with serious illness episodes, -- people with illnesses requiring hospitalizations account for about one-half of all private expenditures for health (in the U.S.) but amount to only 8 percent of the population."(2) Thus, the health status of a relatively small percentage of the population is significantly affected by the medical care system.

While medical services may not have an appreciable impact on the health status of a population they may be considered essential for the improvement or maintenance of the health of certain individuals. When considering the medical care system as one component factor contributing to the health status and quality of life of individuals and of a population, it is necessary to assume a broader perspective.

A number of psychological and physical stresses, many of which have been shown to have a visible impact on morbidity, disability and mortality are a consequence of societal life styles. "Symptoms such as alcoholism, mental disorder, crime, suicide, absenteeism, and chronic maladjustments are only the

more obvious consequences of life styles which are vulnerable to crisis ----. The cumulative direct effect of life styles on physical health levels of the population, though invisible should be the major concern for the future." (73)

While there are a number of relevant factors, four of the most important have been chosen for discussion here, namely; individual life styles, pollution, occupational hazards and stress.

1. Individual Life Styles

Pratt (51) in a study of personal health care practices reported "that the higher the quality of personal health care practices the higher the level of health and the fewer the (past) health problems reported by the respondent".

Individual life styles characterized by such factors as hygiene, exercise, driving habits, alcohol consumption, diet, sleeping habits, and smoking are to a large extent influenced by acceptance and standards of the social groups with which an individual identifies or associates.

The effects of a number of these practices are well known and documented. Evidence is continually coming to light on the effects of a number of widely used drugs and toxics, both legal and illegal, and has recently caused concern over the use of hallucinatory drugs and the consumption of food additives. While various evidence points to possible hazards, the evidence is often inconclusive and controversial. It will probably be some time before the effects of a number of these substances, by themselves and in combination, will be adequately known.

2. Pollution

Societal life styles are largely responsible for the ever increasing amounts of pollution. Industrialization and rapid population growth have led to demands for increased production and natural resource consumption. Accompanying the resultant industrial, agricultural and population growth have been an increase in pollutants from these sources, and the introduction of heretofore unknown chemicals and toxics. Many of these pollutants have been recognized as being harmful to human health, and in extreme cases have been known to cause deaths.

The effects of various pollutants depend on their characteristic properties, concentration, duration and pattern of exposure and retention and accumulation by biological cells. In examining the effects of pollutants, great care must be exercised in identifying synergistic effects of multiple pollutants and of other variables influencing health.

Data on the adverse effects of pollutants is fragmentary and inconclusive. Often the only conclusive data is on exposures at high concentration levels. Little is known about the effects of prolonged exposure to low concentration levels of most pollutants.

A brief discussion of the major pollutants and their effect on biological systems is given in Appendix A.

3. Occupational Hazards to Health

Individuals are subject not only to the hazards of community environment and personal life styles but also to the hazards of their occupation. The individual may be exposed to

such actual or potential hazards as thermal stress, various forms of radiation, noise, accidental hazards from various types of equipment, chemicals either through skin contact or as air contaminants, mechanical vibrations, and various particulate air contaminants. Repetitive tasks may induce physical and mental stress. Shift work may produce physiological, psychological and social adjustment problems.

In addition to direct occupational hazards, changing patterns in employment often result in occupational obsolescence. The resultant displacement, relocation, retraining, unemployment, etc. may lead to financial and emotional hardships.

In the past, various efforts and legislation have been concentrated on the prevention and treatment of physical hazards through the development of safety standards and the provision of various treatment programs. Attention is now being increasingly focused on the preclinical detection of occupational metabolic body disturbances and the reduction and prevention of deleterious psychological consequences of occupation.

4. Stress

Prolonged or recurrent stress may induce gastrointestinal ulcers, kidney damage, hypertension, various other psychosomatic disorders and a number of psychoneuroses.

As many of the stresses to which man is subjected are a product of societal structures and life styles, to eliminate or significantly reduce such stresses calls for a radical social re-evaluation and a restructuring of man's societal environment.

In designing the future state of health care services, factors other than the health care system should be taken into

account as much as possible, both in predicting their effect on the demand for health care services and of alternative benefits to be derived under different strategies for the allocation of resources in and between the health care system, environmental control, and other societal coping mechanisms. This broader perspective considers the health care system as one component factor contributing to health status and quality of life.

D. Measurement of Health

In order to evaluate the benefits of medical care services and other programs designed to improve mental and physical being, it is desirable to have a quantifiable measure of individual and societal health. Unfortunately, there is no clear and absolute measure of health nor is it always easy to distinguish between states of individual health lying along a continuum varying from excellent health to normality, abnormality, preclinical disease, clinical morbidity, disability, and death. It is therefore necessary to employ proxies for the measurement of health status.

At one time, life expectancies and various death rates could adequately be employed as crude indicators of illness prevalence even though no account was made of morbidity conditions (not resulting in death) but which caused discomfort, impairment, etc. Changes in these values provided a useful proxy for evaluating the impact of medical treatment and health related programs.

In most developed countries, life expectancies have been prolonged such that half the female population can be expected to survive to over 75 and half the male population to over 70. While life expectancies have been prolonged, and natal mortality

rates reduced, such progress may have a negative impact on the health status of a population as measured by the prevalence of chronic and genetic illnesses and impairments.

Deaths among the aged population, are usually not attributable to a single cause. A degeneracy of one physiological system may trigger malfunctions in other related systems which no longer possess the stability and resilience that they once may have had, cummulating in death bearing little relationship to specific morbidity conditions. Under such conditions, life expectancies and mortality rates, by themselves, can no longer serve as adequate measures of health or illness in a population. A more appropriate assessment of community health must, in addition to mortality rates and life expectancies, involve other measures such as morbidity and impairment.

Logan (44) suggests a number of physical, mental and biochemical tests and indices for which a range of variability may be used to partially define a state of normality for given age, sex and, possibly, other characteristics. These measures may then serve as crude indicators of community health by identifying the proportion of the population which fall within the range of accepted normal variation.

Such an evaluation is merely a measure of the extent to which the surrogate measure of health status deviates from the often subjectively defined limits of variation of 'good' or 'normal health', rather than a measure of positive 'well-being'.

"In trying to obtain anything more realistic than the crudest of guesses at the prevalence of health, we are forced back into a variety of indirect measurements, which probably

reflect to some extent an impression of healthiness of the community without providing much of a measure of it." (44)

One of the first positive approaches to measuring health is due to Sanders (60) who proposed that the years of "effective" life expectancy be used. This concept was further extended by Sullivan (68) who proposed that general disability, relative to the social context, should serve as the basis for a health index. Various other research efforts concentrating on the ability to perform daily activities and to function within society have been attempted. (See Sokolow and Taylor (65), Hagner et al (34), Katz et al (40) and Fanshel and Bush (24).

An appropriate health status index should reflect the socio-economic consequences of mortality, morbidity, and disability. However constructed, such an index is a subjective evaluation on the basis of available information. Thus the use of such measures is not absolute, but rather an attempt to rationalize a subjective evaluation process.

E. Evaluation of Health Care Strategies

Different criteria may be employed in the evaluation of strategies for the allocation of resources based on changes which can be made in a health status index. Some strategies may be more desirable because they provide an improved or comparable value of a health status index than other more expensive strategies. In other cases a more expensive strategy may hold more attraction when pain, discomfort and other social values are considered.

One method which has been employed has been an economic cost-benefit analysis, which considers the cost of the provision

of various services and the economic losses in production due to morbidity and premature death.

The use of productivity losses is questionable, since it gives no weighting to persons not directly contributing to national productivity, and weights the value of other individuals solely on their relative contributions to GNP. In an economy with less than full employment, it is probable that the calculated losses in productivity are highly overstated, since production is likely to be geared to a level which takes into account absenteeism and other such factors which the analysis naively considers as losses in production.

The use of purely economic criteria is highly inappropriate to the evaluation of health care provision. Ideally the analysis should consider pain, loss of social function, psychological stress, etc. which are not measureable in monetary terms, as well as the economic consequences of mortality, morbidity, and disability.

F. Conclusions

It is recognized that medical care services are an important factor which influence certain individuals' health status, however their effect on population health status may not be appreciable.

In modelling a health care system, the interactions and influences of the various factors contributing to health status must be examined to determine the relevant factors to be modelled, their interactions and their influence on health.

There are numerous problems involved in the measurement of health status and of the influence of the factors contributing

to mental and physical health. There is, however, a need for quantifiable measures or surrogate measures of the above, if a rationalization of the evaluation processes is to be sought.

In developing criteria for the allocation of societal resources, it is necessary to consider the medical care system as one component of the milieu which contribute to health status, both of an individual and of a population.

CHAPTER II. CONSUMER BEHAVIOUR AND THE DEMAND FOR MEDICAL SERVICES

A. Introduction

In studying the delivery of health care services, the demand-supply interactions and characteristics of the various services should be investigated, as to the role they play in determining which services are performed, how they are delivered, in what quantities, and who consumes them.

Underlying the demand for medical services, are the needs and desires which motivate individuals to seek medical services. The concept of need for medical services must differentiate between medically determined need and societal and individual perceptions of need. These needs may be defined in terms of the quantities of various medical services which would be required to fulfill them.

The services required to fulfill medically determined needs depend on the state of existing medical knowledge and standards of the medical profession and are, thus, normative judgments of the profession.

Individual perception of medical needs may differ substantially from medically determined needs, as the consumer is not always aware of medical needs or of potential benefits which may be derived from utilizing various medical services.

Societal perceived needs may be defined as the quantities of various medical services which it believes it should consume on the basis of its perceived needs. It should be noted that these needs are not well defined in terms of either the quantity or the category of medical services, but are a general desire for

medical services and not for the mix and quantity of services which may be received or required, as will be elaborated in Chapter III.

The demand for medical services is the result of actions taken to satisfy wants. The transformation of wants into demands is not homomorphic, in that many wants fail to materialize as demands because of various inhibiting factors.

In order to analyze demand, one must investigate the possible impact of those variables which influence perception, needs, wants and the translation of wants into demands.

B. Individual Perception of Need

Medically determined needs may not be perceived by an individual, in some instances because of the asymptomatic nature of an illness or in other cases through a lack of knowledge of symptoms or 'warning signals' which are present. The extent to which medical need exists and is not perceived has been documented in a number of studies. Feldman (25) refers to a University of Michigan Medical School and Institute of Industrial Health report, in which 41 percent of a group of 500 business executives taking a company paid check-up had abnormalities of health of which they were not aware and which required medical treatment.

Population interviews compared with clinical examinations of a sample population point out both the extent of unperceived illness and also the unreliability of population interviews as a means of determining the prevalence of medical needs. Elison and Trussell (20) reported that only "about one-fourth of the

conditions found on a thorough clinical examination ---- and judged by these clinicians to have been present at time of interview, were reported previously in the family interview ----. For example, one-third of the cases of diabetes, over one-half of the cases of heart disease, and nine out of ten cases of neoplasms (both benign and malignant) were not reported in the family interview."

The extent to which individuals perceive various conditions as requiring professional medical attention without a knowledge of the particular diagnosis to which the symptoms pertain, is illustrated by Feldman (25). The percentage of the surveyed public which felt a physician visit was required for various common symptoms appeared to correspond fairly closely to the percentage of the surveyed physicians who also felt that a physician visit was required.

An individual's knowledge of symptomatic indicators of illness plays a significant role in his perception of need. To a lesser extent, the knowledge and awareness of those he associates with, sometimes, also, plays a role in perceiving his need. This is especially the case of small children whose need for medical care is perceived by their parents.

C. Factors Influencing Health Knowledge

Age, sex, urbanization, socio-economic status, and education have been shown to be correlated with health knowledge. The interdependencies among these variables often have created problems in determining the effects of the separate variables.

Feldman (25) suggests that the amount of health knowledge possessed by an individual is largely a result of general medical

interests and aptitudes and that "information materials generally reach and are assimilated by the better educated and most interested groups in the population .... the better educated are able to (and do) keep themselves better informed about health and illness because of essentially the same factors which underlie their superiority in almost all other realms of knowledge ---- a greater capacity and a greater desire for learning in general."

D. Sources and Effectiveness of Health Information Dissemination (in a developed country)

Mere exposure to health information is hardly sufficient to ensure increased utilization since it often does not reach the majority of the population or is not assimilated by them.

The main source of health information is the mass media. Organized campaigns and news coverage of new advancements or announcements such as Nixon's war on cancer appear to have the most effect on the public's awareness of health problems and of symptomatic indicators of illness.

Mendelsohn (45) states that "Research evidence has shown that rather than converting audiences, the mass media serve essentially to reinforce what they would like to believe or do. Furthermore, the mass media reinforce, more often than not, what audiences already like or dislike, and they serve to underpin what audiences have already learned in the past."

Health knowledge is not necessarily accompanied by attitudes which are predisposed to action. While individuals may believe certain health services should be sought under given conditions, their behavior is often not consistent with their beliefs.

E. Health Service "Wants"

Having perceived the need for some form of health treatment, an individual is faced with the decision as to the course of action to take. A subsequent translation into 'wants' or predisposition to action is determined by the individual's beliefs as to the seriousness of his condition and the possible consequences of the various courses of action. This task is reduced if the individual has formed some opinion of the possible diagnosis. The possible alternative decisions are illustrated in Figure 1.

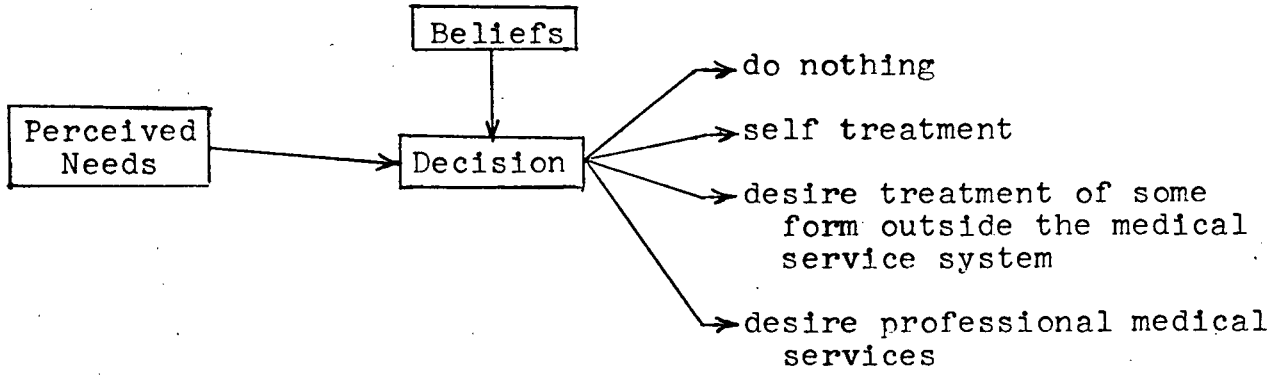

Figure 1: Alternative Decisions for Perceived Needs

This decision process may be iterative, in that the perception of needs and the beliefs may alter in such a manner that subsequent decisions are made.

F. Factors Influencing Utilization of Health Services

Although an individual may desire professional medical treatment, there are often other factors which contribute to a decision to actually seek such services.

1. Distance

Distance appears to play an important role in health services utilization, utilization decreasing with an increase in distance from the sources of provision of health services.

A study in a metropolitan area by Weiss and Greenlick (74) concludes that "distance affects the medical care process differentially by social class and interacts with social class as an explantory variable."

This study is based on the distance between the sample population's place of residence and the nearest clinic. This study and others which are based on the place of residence do not account for the effect of visits which may originate from other points such as the place of employment. Shannon et al (62) note that "The distance variable is only a crude surrogate for the human phenomena which are involved in travel. Human involvement in terms of effort, the distribution of effort over multiple purposes, choice between alternatives, and ease of transportation should be considered as these factors relate to medical care utilization. There is a pressing need to disentangle distance factors from locational factors, habitual paths, and social biases."

2. Economic Factors

Financial considerations often represent a limitation on health service utilization. Family income, the cost of health services and other consumer expenditures often influence a decision to seek professional medical services or not.

Unlike many other needs, such as food and shelter, individuals' felt needs for medical services often appear sporadically and may represent an unexpected financial burden.

Various health insurance plans provide against unexpected financial burdens and also make it financially feasible for some to greater utilize available health services. A number of

studies have shown that health insurance programs have increased utilization of health services, especially hospital care. Reed, (53) in a study of Canadian health insurance programs, found that hospital admissions and lengths of stay continued to increase, but at an accelerated rate with the inauguration of universal hospital insurance. It was found that increases in the length of stay were relatively greater than those in admissions.

Another economic factor, which sometimes may effect utilization, is a loss of wages incurred while making a visit to a physician or receiving some form of treatment. The possession of various sick leave and sick pay insurance schemes and job security clauses may be of considerable importance in this context.

3. Social Factors

The decision to seek professional medical care, especially hospitalization, may depend on the availability and ability of someone in the home to provide care. Marital status and family size may play an important role in this context.

It has been found that the single or widowed aged, as compared to the married aged, require more services not only because of a need for care but also because of psychological needs.

G. Utilization Modes

In seeking medical services, an individual usually seeks the services of a general practitioner who treated him in the past. In some cases, the individual may decide to seek the services of a specialist, although a patient is generally referred to a specialist by a general practitioner. An important consideration here, is that under some medical insurance plans, the patient may have to bear partial financial responsibility unless

he has been referred through a general practitioner.

The initial contact for a given incidence may take the form of a telephone conversation, an appointment, an unscheduled visit, or a house call. It should be noted that this last category has become an infrequently provided service. In seeking services for which the condition is perceived as requiring immediate medical attention, an individual may make an unscheduled visit to the physician's office, utilize the emergency services of a hospital or request a physician house call.

In a study (74) of the Kaiser Foundation Health Plan, it was found that the working class made more frequent use of hospital emergency services than the middle class which were more likely to make unscheduled visits to the physician's office. It was also found that the middle class utilized the telephone much more than the working class. The study suggests that sociological considerations play an important role in determining the manner in which individuals utilize the health care system.

H. Patients' Compliance With Doctors' Advice

Various studies indicate that from 15 to 93 percent of patients are not compliant with doctors' orders (16). Such factors as the influence of others, stability of conditions in the home, complexity of regimen, and restrictions on personal habits appear to influence a patient's compliance with a doctor's suggested medical regimen.

In a study, Davis (16) found "no significant relationship between compliance and any of the demographic characteristics investigated -- age, sex, marital status, religion, education or occupation." There was also found to be little correlation between any interactions in the primary visit and later compliance.

The study suggests that compliance is largely a result of patient-physician interactions on subsequent visits.

I. Conclusions

The primary demand or the general demand of consumers for medical services is the end result of a process involving perception of need, beliefs as to the seriousness of the perceived need, beliefs as to the possible consequences of the various courses of action, and the influence of utilization-inhibiting factors such as the distance from the source of medical care provision, and socio-economic considerations. It should be noted that some demands originate as prerequisites for employment, passports, etc. rather than in the consumer seeking improved or insured health.

Since many medically determined needs fail to materialize as demands, it is necessary to understand these processes in order to predict or influence primary demand for medical care services.

As has been noted, the general or primary demand of consumers for medical services is not well defined in terms of the quantity or mix of services. It is the suppliers of medical care services who determine the specific demands for the mix and quantity of services, based on the primary demands of the consumers.

CHAPTER III. THE SUPPLY OF HEALTH SERVICES

A. Health Services, An Interrelated Network of Component Services

The community health care delivery system may be viewed in terms of the community's needs and demand, the services and facilities required to provide specified fulfillment, the supply of services and facilities and the manner in which services are provided.

The component services of health care delivery must be considered in relation to one another since the degree of substitutability, relative cost, organizational arrangements, and availability and effectivness among other factors influence the mix and relative utilization of the component services.

Coordinated planning and the efficient utilization of various care and treatment services are complicated by the involvement of numerous organizations which often act independently of one another in the provision of health and health related services. This situation leads to a less than optimal benefit from the resources employed.

The complexity of interactions and interdependencies of various components of health services requires that policies and procedures within and between component parts must be viewed in the context of the total system in order to yield a meaningful appraisal of community health care services.

B. Community Care and Shelter Facilities and Services As Related To Health

Within most large communities, numerous services and

facilities exist to provide care and shelter to its citizens. These services and facilities range from preventive public health and home care services to such medical treatment centers as acute and chronic hospitals.

The manner in which various components are delimited, regulated, coordinated and financed may vary between communities. Although different organizational structures and patient category definitions exist, the following tables are felt to be representative, They are chosen here since they have been employed in the Greater Vancouver region.

Table 1: Health and Health-Related Services and Facilities in the Greater Vancouver Region

Type of Care	Services	Facilities
Preventive	Immunization Physical checkup Environmental public health	
Diagnostic and Ambulatory patient care	Physician services Dental services Radiological and other diagnostic services	Outpatient hospital departments
Home care	Voluntary organizations Public health nursing	
Residential care		Hostels/Missions Boarding homes Personal care homes
Skilled nursing care		Private hospitals Extended care hospitals
Intensive care		Public hospitals Federal hospitals
Teaching and Research		Universities Hospitals

Table 2: Patient Categories and Levels of Care in the Greater Vancouver Region

Types of Care	Patient Groups	Examples of Cases Included	Levels of Accommodation Required
ACUTE - A	Critically ill, high risk, requiring continuous round-the-clock nursing and possibly special resuscitative and supportive equipment.	Complex high risk medical and surgical cases; severe multiple injuries; shock, etc.	Intensive Treatment areas, e.g. Post-anaesthetic Recovery Room (PAR), Post-operative Recovery Room (POR), Intensive Care Unit (ICU), etc.
B	Acute medical and surgical conditions (including psychiatric).	Routine acute medical and surgical cases.	Regular wards and facilities Acute General Hospital
C	Ambulatory low risk patients.	Day Care, Night Care, Short Stay Care and Out-patient.	Reception areas Activity areas
REHABILITATION AND ACTIVATION	Patients requiring a planned physical rehabilitation program	Cases medically capable of improvement within a reasonable period of time.	Special activities and Rehabilitation hospital. Activation and Rehabilitation unit of acute hospital.
CONVALESCENT	Those patients requiring more than average length of time for recovery, do not require specially arranged rehabilitative programs or acute care level of accommodation.	Uncomplicated recovery phase of medical and surgical cases.	Areas of lesser care within or without the general hospital. Will require skilled nursing care.

Table 2 (Continued)

Types of Care	Patient Groups	Examples of Cases Included	Levels of Accommodation Required
LONG TERM CARE or CHRONIC CARE or EXTENDED CARE	Complete invalid, includes those continuing critically ill and those who have major illnesses with limited mobility.	Patients who are continuing critically ill and need intensive skilled nursing care 24 hours a day (some might be quite mobile). Patients with a terminal illness - all those with major illness and/or loss of mobility.	Extended Care Unit Acute Hospital Extended Care Hospital Private Hospital (Nursing Home) These patients require skilled nursing care.
	Semi-invalid - may have considerable illness but be quite mobile.	Patients who need skilled nursing care, but predominately personal care.	Personal Care Home. Private Hospital (Nursing Home).
	Elderly and frail people who require sheltered environment. (Custodial).	Patients who are up and look after most of their own needs. Limited personal care necessary.	Boarding Homes (Rest Homes) (Substitute for Patient's home)

Explanatory Notes:

1. It is difficult to define the categories of chronic illness because of the great variation in the needs of each chronic invalid. Patients with chronic illness do not usually remain static. They are generally improving and doing more for themselves or deteriorating and becoming more dependent. Although B.C.H.I.S.* establishes administrative categories of illness and disability for purposes of hospitalization coverage, illness does not fall into such well defined categories. It must be accepted that there be ease of transfer between different levels of care to meet the changing needs of each patient.

2. Skilled Nursing Care - refers to nursing services, continually available by qualified personnel provided to patients under regular medical supervision.

3. Personal Care - includes all care other than skilled nursing care; special help with dressing, washing,

getting around, help with meals, etc. Personal care indicates 24-hour supervision.

4. Extended Hospital Care - as defined by B.C.H.I.S.
A hospital facility operated by a non-profit hospital society or by the provincial Government. By definition, the patients in this facility must require 24-hour nursing care under the criteria established by B.C.H.I.S. (In essence, the patient requires assistance to be mobile).

5. Private Hospital (Nursing Home)
An institution providing 24-hour skilled nursing services under regular medical supervision. It is licensed by B.C.H.I.S. and subject to periodic inspection by B.C.H.I.S.

* B.C.H.I.S. - British Columbia Hospital Insurance Service.

Source: Patterns of Care, Greater Vancouver Regional Hospital District Advisory Committee - May, 1969.

Facility or Organization	Services	Type of Agency	Bed Capacity 1968 *	Regulation	Source of Operating Funds
Red Cross Canadian Arthritis and Rheumatism Society (CARS) Other voluntary organizations	Varied	Non-profit	---	---	Donations
Hostels/Missions	Food & Lodging	Non-profit	425	Welfare Institutions Licensing Board	Public or Social Assistance Payment
Boarding Homes	Food, Lodging and Limited Domestic Services	Proprietary Voluntary	2,089 994	Department of Social Welfare	Payments by users of facility and payment of welfare rates for qualifying patients
Personal Care Homes	Food, Lodging and a range of services intermediate between residential and private hospital care	Public Voluntary Proprietary	58 12 53	"	
Private Hospitals	Skilled nursing care under the supervision of a practicing physician	Proprietary	1,932	Department of Health Services and Hospital Insurance	
Extended Care Hospitals	"	Non-profit	695	Regional Hospital District Board	BCHIS & $1/day from patients

* A Total Concept of Care
United Community Services of The Greater Vancouver Area, October 1968

Table 3: Non-Public Care Facilities and Organizations in the Greater Vancouver Region

In comparison to the 6,263 beds in lower level care institutions there were 4,390 beds in rehabilitation, chronic care and acute general hospitals in the same region, in 1968.

C. Public Financing Of Health Services

Some health care services may be regarded as collective goods for which benefits may accrue equally to everyone. Such goods are sometimes financed and provided as public goods. This may be especially true of services requiring high capital investment, such as hospitals.

There are two major arguments for a policy of governmental intervention in the provision of various health services.

1. The access to medical services has come to be regarded, by many, as an individual right rather than a privilege of the wealthy. Without intervention, inequalities in individual wealth would prevent many people from seeking medical services which they need and desire, but which they also regard as financially infeasible.

2. Externalities, in the absence of intervention, would often result in an underproduction of some services which are felt to be essential, as in the case where benefits of research and communicable disease control may accrue not only to the purchaser but everyone else in the society.

Public intervention and the institution of regional planning of various services requiring high capital investment may avoid costly duplication and underutilization of services and allow for more diversified and specialized services through the coordination of resource allocation.

D. Scope Of Planning

Of necessity, planning for the provision of health services must be limited to those areas over which a planning body has responsibility, while taking into consideration other facilities and services outside its jurisdiction.

In view of this, the approach here is limited to the provision of hospital and related services under the jurisdiction of a Regional Planning Board and of physician services which are essential to the provision of health care services.

It is first necessary to consider the supply of these services and their characteristics.

E. Physician Services

1. The Role of the Physician

An individual seeking medical care seeks the advice, knowledge, and skilled care of a physician. The physician's role is to provide a service, ie. diagnosis, the prescription of drugs, tests, and therapy, the recommendation of hospital admission, etc. In fact, a patient must employ the services of a physician in order to gain non-emergency admission to a hospital or to legally obtain certain drugs.

Once the individual has initiated a primary demand for health services by visiting a physician, a secondary or 'prescribed' demand is generated when the physician determines the service requirements for the patient.

The determination of a medical regimen depends on the physician's perception of the patients needs, the state of medical technology, and on the interaction between physician and patient in arriving at a treatment acceptable to the patient. In choosing

among possible regimens, the physician may consider the economic cost to the patient and his past knowledge of the patient's preferences. Unless a patient indicates an objection or preference, the decision process usually does not involve the patient's participation and his various preferences are not considered. Often the lack of knowledge on the part of the patient as to possible alternatives and the social and professional status of the medical profession work to leave the selection of the regimen almost entirely up to the physician.

The physician's choice of treatment involves the availability of various resources and the alternative costs to himself. Preferences with regard to cost, risk avoidance and time may differ substantially between the physician and the patient. The mix of services specified by the physician may be governed more by his own preferences than those of his patient.

If a patient feels moderate dissatisfaction with the care he receives, he is often reluctant to seek the services of another physician because of the committment he has made in following a regimen, the delay and inconvenience of seeking the services of another physician, and his uncertainty as to any increased benefits.

2. The Supply and Characteristics of Physician Services

The supply of physicians and the cost of their services are not governed by competitive market forces. The supply is limited by restrictions on entry to the profession and on the right to practice. These restrictions include limitations on enrollment in medical schools, the high cost of a medical education, the screening process during medical school, licensing to practice, and the granting of hospital privileges.

The medical profession's regulation of entry and the right to practice serves not only to limit competition, but also to guarantee that certain standards will be maintained by medical practitioners.

Independent and organized groups of physicians cannot be regarded as competitive suppliers of medical services in the normal economic context of competition. Price as a competitive mechanism is generally considered to be unethical by the profession and overt advertising of prices does not occur.

In examining price behaviour of physician fees, Garbarino (31) suggests that "the most important cause for the observed fee behaviour has been the pressure of a growing demand for more medical care on an inelastic supply of services".

The supply of physician services is dependent both on the number of practicing physicians and on their productivity. Productivity is difficult to define in the context of physician services, as it cannot be measured solely on the basis of the number of patient visits and operations performed, but must also account for the quality of services rendered and the mix and severity of patient cases attended to.

Garbarino (31) has attempted to estimate output per physician between 1935 and 1951 in the United States (Table 4). He notes, however, that the increase in output may be overstated by 15 to 20 per cent between 1935 and 1944, since the percentage of billings collected rose from approximately 74 percent in 1935 to 87 per cent in 1944.

Table 4: Estimates of Output per Physician, 1935-1951

Year	Output/Physician I	Output/Physician II	Year	Output/Physician I	Output/Physician II
1935	100.0	----	1944	212.7	n.a.
1936	110.7	100.0	1945	234.4	213.9
1937	114.3	99.5	1946	212.9	190.0
1938	110.8	93.2	1947	214.6	195.9
1939	114.0	94.9	1948	220.5	204.0
1940	119.8	99.9	1949	225.4	214.2
1941	133.4	115.2	1950	233.4	225.8
1942	167.8	n.a.	1951	242.1	228.7
1943	210.6	n.a.			

Notes: Variant I -- Calculated by deflating the index of mean gross income per physician by the index of physicians' fees. Base -- 1935 = 100

Variant II -- Calculated by substituting median net income for mean gross income in the above. Base -- 1936 = 100

All income data are for "nonsalaried physicians."

Source: Garbarino (31)

In a later study, he found a 10 per cent increase in productivity for the entire period 1949-54 (32).

Time series studies such as this are subject to error introduced through changes and advancements in treatments and increased use of auxillary personnel and services.

In the past few decades the locale of much treatment has been shifted from patients' homes to physicians' offices and the hospital, thus reducing physician travelling time. This factor in itself should account for a substantial percentage of the

increase in productivity.

It is no doubt true that the quality of medical services has improved during this time and that many other activities such as research, teaching and continuing education have increased in importance and their demand on physician time.

Although throughput may be increased, the supply of physician services may be regarded as very inelastic, in the short-run, while the supply curve for physician services is likely to be positively sloped, in the long-run (41). In the short-run, the supply of physician services is limited by the number of physicians and the time they are willing to devote to their practices. In the long-run, the number of physicians, in a particular region, is likely to be influenced by the relative attractiveness of practicing in that region. Expected income is, of course, a major consideration.

An important development in physician services in the last 20 to 30 years has been the trend towards specialization and associated rise in the cost of medical services. Among other things the trend towards specialization has stemmed from a vast increase in knowledge and technology.

Specialization has led to a decline in the number of general practitioners and a concentration of physicians in urban areas. The concentration of specialists in urban areas is partially a result of the need for a large enough population and referral system to utilize specialists services.

The 1968 provincial distribution of specialists is shown below, where metro refers to Metropolitan Vancouver and Victoria and non-metro are all remaining regions. (61) As may be seen, there are more specialists than general practitioners in the

metropolitan regions, whereas the opposite is true of non-metropolitan regions.

	G.P.	Specialists
Metro	884	1060
Non-Metro	544	238

The two major criteria which appear to have governed physician location are available opportunity and size of community, with the smaller community being preferred (61).

The number of specialists in provincial non-metropolitan regions appears to be correlated with the population size of the region. The only provincial region which shows a major deviation from this is the Lower Mainland, excluding the Greater Vancouver region. This is explainable by its close proximity to Metropolitan Vancouver, which serves as a major referral centre not only for the Lower Mainland but also for the province as a whole (61).

It is interesting to note that half of the general practitioners have a special field of interest which accounts for as much as 30 percent of their practice time. In addition, specialists deal with cases outside their speciality with over 15 percent also engaged in general practice (61).

In addition, various specialists such as pathologists, anaesthesiologists, and radiologists, as hospital or private laboratory staff, provide services for other physicians.

Today, many physicians are engaged in partnerships and group practices. In a British Columbia survey of medical manpower (61), responses indicated that 15 percent of private practice physicians were in partnership and 49 percent were in

group practice. Of the surveyed physician population 70 percent felt that group practice was better than solo practice. The major advantages of group practice were given as; more free time, better organization of manpower, informal consultation, better patient care, continuity of care, better working facilities and fuller use of paramedical personnel. (61)

3. Modes of Reimbursement and the Effect of Third Party Payment

Governmental and other agencies have often made provisions for medical indigents, while the medical profession has employed sliding scale fees to make allowances for patients of limited financial means.

Although the use of sliding scale fees may be regarded as a form of price discrimination, Arrow (5) argues that this practice is not one which maximizes profit. The basis of his argument is that the price elasticity of demand is less than one for all income levels, but consistency with profit maximization requires that the elasticity of demand be greater than one in each segmented market.

In the past, although various allowances and provisions were made for individuals of limited financial resources, individual consumers of physician services were largely financially responsible for the services they consumed. This constituted the primary source of physician revenue. Insurance payments now account for a significant proportion of the revenue received by physicians.

Under insurance payment "three different methods of coverage of the costs of medical care have arisen: prepayment,

indemnities according to a fixed schedule, and insurance against costs, whatever they may be. In prepayment plans, insurance in effect is paid in kind ---- that is, directly in medical services. The other two forms both involve cash payments to the beneficiary, but in one case the amounts to be paid involving a medical contingency are fixed in advance, while in the other the insurance carrier pays all the costs, whatever they may be, subject, of course, to provisions, like deductibles and coinsurance." (5).

In many cases the rates of remuneration are negotiated between the physicians involved and the insuring party.

In British Columbia, governmental and governmentally regulated third party payment plans provide universal insurance coverage for physician services, various physician-prescribed services such as x-rays, physiotherapy, and laboratory tests, and other services such as those of chiropractors. The services covered are extensive. However, there are certain limitations on the usage of some services and a few services such as physical examinations required for employment or insurance purposes are not covered.

Insurance plans are of particular importance in their effect on the cost and quality of medical care.

While medical insurance coverage provides a means whereby certain needed services, which may have been foregone by various individuals because of financial constraints, are obtained, it also induces elements of abuse. When patients are covered by insurance they may seek additional services which are not really medically required. Some physicians may overprescribe services or select a more expensive form of treatment than is required

either at the patient's request or to increase profit, reduce risk or reduce the time and effort required.

On the other hand, the involvement of governmental and other third party payment plans may provide an impetus to reduce or control the costs of medical services and to improve the quality of these services. These collective organizations have greater bargaining power than individual consumers and also have the necessary resources to study various aspects of costs and quality of medical care.

Other organizational arrangements such as prepayment plans where physicians form the insurance group and arrangements of a profit-sharing nature such as the Kaiser Foundation Medical Care Program may provide strong motivation for the development of effective means of providing medical care services, however further research in this area is required. The impact of these arrangements is greatest in the area of hospital care and will be further discussed in the next section.

F. Hospital Services

1. The Development And Characteristics of Hospital Services

The role and effectiveness of the hospital have greatly increased during the last century. The discovery of anesthesia and antisepsis in the last quarter of the nineteenth century began the growth in hospital status from one which was not far different from the almshouse and shelter facilities for the poor to one of prominence.

Earlier hospitals were regarded as care facilities for the less wealthy who could not afford private nurses and other

home care services. With the improvement in medical science and recent proliferation of complex and expensive equipment, the hospital grew in stature and provided services which could not be provided in patient homes. Because of the increased stature, a number of services which were previously and still can be provided in the patient's home or physician's office are now largely performed in the hospital.

Hospitals offer a wide variety of patient care and diagnostic services. The following tables outline the classification and associated facilities and services of hospitals within the Greater Vancouver region.

As can be seen from the tables, some hospitals provide educational and research programs in addition to patient care and diagnostic services. In addition, hospitals serve as local centres of knowledge and provide opportunities for inter-physicianal contact.

Table 5: Classification of Hospitals

TERTIARY	Major Referral, Teaching and Research Centre Hospital facilities of a complex, highly specialized nature acting as a major referral centre for a large population group throughout a widespread geographical area (the Province). These centres will have a varying degree of teaching and research responsibility.
SECONDARY	Regional Referral Centres Regionalized hospital facilities of a less highly specialized nature than the major teaching, research and referral centres, but still providing more complex services and facilities than will be found in the majority of the community type hospitals throughout the area. Regional referral centres will provide specialized facilities in order to serve some of the special needs of a number of local communities. Some of the regionalized hospital centres will continue to provide general treatment for the populace in the area immediately adjacent to the centre, but its role in this respect should diminish in the future.

Table 5 (Continued)

PRIMARY	Community Hospitals	Hospitals of a community or general practice type, designed to serve the majority of hospitalization requirements of the populace of the local sub-communities of the metropolitan area.
	Specialized Disease Entity Hospitals	Hospitals in which one or a very limited number of clinical special services are provided; e.g., Obstetrics and Gynaecology, Cancer, etc.
	Jurisdictional Hospitals	Hospitals owned and operated by a government authority, to meet a specific province-wide need. The location of these hospitals within any particular region is of no special benefit to that region, in terms of availability of facilities, since these hospitals operate on a province-wide basis. They may provide a limited or broad scope of services; e.g., Tuberculosis or Mental Hospitals.
	Treatment Facilities Operated by Voluntary Agencies	Facilities such as the C.A.R.S. Treatment Centre, the Narcotics and Alcoholism Foundations of B.C., etc. These facilities should have an effective working arrangement with a hospital.

Source: Patterns of Care, Greater Vancouver Regional Hospital District, Advisory Committee, May, 1969.

Table 6: Facilities and Services Associated with Classifications of Hospitals

Major Referral and Teaching and Research Centres

The work done should reflect the investigation and treatment of less commonly encountered illnesses and also those requiring complex equipment and facilities and multiple clinical specialty personnel.

In-Patient Facilities - general and specialized services

Surgical Services

Very specialized surgical procedures such as organ transplants, open heart surgery, neurological, major abdominal, cardio-vascular, cancer procedures, etc.

Medical Services

Diagnosis and treatment of complicated blood diseases

Metabolic procedures

Rehabilitation and activation treatments

Etc.

Obstetrics and Gynaecology

Complication of maternity

High risk obstetrical and gynaecological cases

Paediatrics

Neo-natal problem cases

The high risk infant - transfusions - Rh factor

Restorative surgery, cardiovascular case

Multiple problem child, handicapped, speech problems, cerebral palsy, neurological, tumors, cancer, retarded children

Major endocrine disorders, etc.

Table 6 (Continued)

Psychiatric Services

Advanced psychiatric research and treatment

Group therapy

Drug therapy

Rehabilitation therapy

Etc.

Physical Medicine

Physio-, occupational and inhalation therapy facilities

Diathermy

Gymnasium, pool

Treatment of catastrophic cases, spinal cord injuries

Etc.

Laboratory

Complete facilities for the carrying out of expensive and complicated tests requiring extensive equipment which are not performed very often--the core of a regional referral program

Cytology laboratory

Acquire and test new pieces of equipment

Radiology

Complicated and expensive research and treatment investigative facilities

Preparation of video tape

Equipment for use in cardiology procedures

Experimenting and testing of new equipment

Nuclear Medicine

Radio-isotope laboratory and facilities appropriate to major referral function

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Table 6 (Continued)

Direct Patient Services

Intensive Care Units

Post operative recovery rooms

Hyperbaric Chamber

Burn Unit

Etc.

Supportive Services

Teaching Areas

Research Laboratories

Brace Shops

Biomedical Engineering Department

Library Facilities

Volunteers

Etc.

Emergency

24-hour emergency services in all specialties

Out-Patient Ambulatory

Complete range of diagnostic and treatment services on an out-patient, ambulatory basis, e.g. day/night care, day care medicine and surgery and short stay.

Regional Referral Centres

The work done should reflect the investigation and treatment of the commonly and less commonly encountered illnesses of the region.

In-Patient Facilities

Surgical Services

Limited teaching and research facilities

Table 6 (Continued)

Good surgical facilites, including some specialized surgical procedures for neurological and abdominal work.

Medical Services

Similar to those of the Teaching, Research and Major Referral Centre with the exception of treatment of complicated blood diseases.

Obstetrics and Gynaecology

Almost complete range of services.

Pediatrics

General range of services but no cardiovascular work, neurological, tumor.

Few cases of the multiple problem child

Etc.

Psychiatric Services

These are an essential part of the regional hospital facilities and should be in a separate area.

General range of services.

Physical Medicine

General services but no catastrophic cases; these would be referred.

Laboratory Services

Good range of tests; laboratory likely automated - not carry out the few very expensive tests.

Radiology

Good range of diagnostic services - limited therapy.

Nuclear Medicine

Radio-isotope facilities essential when regional referral functions developed.

Table 6 (Continued)

Direct Patient Services

Intensive Care Unit, post-operative recovery room but no Hyperbaric Chamber or Burn Unit.

Supportive Services

Good physi- and occupational therapy, Volunteers, Bio-Engineering to a limited degree.

Emergency

24-hour emergency services available in all specialties provided by that hospital.

Out-Patient Ambulatory

Varying degrees of diagnostic and therapeutic services available, e.g., Day/Night Care, Day Care Medicine and Surgery, Short Stay.

Community Hospitals

The work done should reflect the investigation and treatment of the commonly and some less commonly encountered illnesses of the region.

In-Patient Facilities

Surgical Services

General procedures. Referral of known high risk patients requiring specialty facilities and/or personnel.

Medical Services

General procedures. Referral of known high risk patients requiring specialty facilities and/or personnel.

Obstetrics and Gynaecology

General procedures. Referral of known high risk patients requiring specialty facilities and/or personnel.

Table 6 (Continued)

Paediatrics

General procedures. Referral of known high risk patients requiring specialty facilities and/or personnel. Special provision should be made for the adolescent.

Psychiatric Services

These are an essential part of the Community Hospital facilities and they may or may not be in a separate area.

Physical Medicine

May not be established as a separate medical department.

Laboratory Services

General laboratory services integrated with a regional laboratory program so that new procedures will be available.

Nuclear Medicine

Certain basic procedures available as part of general laboratory service.

Radiology

General X-ray procedures to meet the requirements of the clinical services.

Direct Patient Services

Post-operative recovery room with limited specialized services to serve surgical and obstetrical cases; Intensive Care Unit appropriate to the function of the hospital; activation and rehabilitation area; adequate isolation facilities.

Supportive Services

Physio-, occupational and inhalation therapy and education to meet local requirements; Volunteers.

Emergency

An essential integral department of the Community Hospital; the

Table 6 (Continued)

degree of development and operation are dependent on local conditions.

Out-Patient Ambulatory

Provision for diagnostic and treatment facilities to accordance with health services programs, Day care, Surgery, Medicine, Psychiatry.

A breakdown of facilities and services associated with other classifications of primary hospitals had not been performed at the time at which the report (49) was prepared.

Source: Patterns of Care, Greater Vancouver Regional Hospital District, Advisory Committee, May, 1969.

2. The Necessity and Urgency of Hospitalization

Surgery, medical treatment, and diagnostic investigation comprise the reasons for the majority of patient hospitalizations. The degree of necessity and urgency differs among these categories.

Although hospitalization is often necessary, all recommended admissions are not essential. In a Massachussett's study (50) of hospital admissions, it was found that physicians felt that 70 percent of the patient admissions which they recommended were "absolutely necessary" and that for another 20 percent of the cases the patient would be much better off in the hospital. Of the cases not judged as absolutely requiring hospitalization, the physicians felt that nearly 55 percent could have been treated at home, in the physician's office or on an out-patient basis. The physicians indicated that approximately another 40 percent of these patients could not be treated unless they were in the hospital. The study inferred that this last group probably was not in need of urgent medical care.

The physician's attitude toward the urgency of hospital admission was also studied. The surveyed physicians had advised immediate admission for 70 percent of the patients, within a few weeks or months for 21 percent and eventually for another 6 percent.

If the above figures are representative it may be inferred that a significant misutilization of hospital services occurs which warrants concern. Various studies both in Canada and the United States support the contention that such misutilization does occur. (See the Task Force Reports (69))

In order to understand the causes of misutilization we

must consider the behavioral aspects of hospital services.

3. Behavioral Aspects of Hospital Services

In most non-private hospitals there is little incentive for administrators to minimize costs, so long as budgetary constraints can be met. In fact, there are often a number of incentives for inefficiency both for physicians and for administrators.

Administrative innovation to minimize costs can result in opposition and conflict from medical staff and various hospital employees. In the case of public hospitals, the administration gains little benefit from cost savings while undertaking an increased managerial burden.

Both physicians and administrators are prone to view hospital expansion and the acquirement of expensive and complex facilities for their prestige value and sophistication rather than for their marginal societal benefit weighed against their cost. (22)

The availability of free diagnostic and hospital personnel services often afford a personal time saving to the physician. However, when individual physicians concerned with increasing their own throughput unnecessarily oversubscribe to these services the efficiency of the hospital and the health care system may be reduced.

At times, a physician may request patient hospitalization when a lower level of care is more appropriate. This situation may occur when a patient is covered by hospital insurance but has no coverage for lower-level facilites.

Inefficiency due to these causes and others may be reduced through various organizational controls such as regional planning and co-ordinating agencies which have control over certain activities such as expansion and which incorporate incentives for cost reduction.

The institution of successful organizational controls has been illustrated by the Kaiser Foundation Medical Care Program. It was found that the expenditure per member was 35-45 percent less than the expenditure of the average Californian with no significant decrease in the quality of care. (56)

Although there were a number of factors contributing to the lower cost, the main economy appeared to be the "control over what medical care is provided and where it is provided. This source of economy is most apparent in hospital care, with the age-adjusted days of hospital care per year for Kaiser members being only 70 percent of the State's per capita average." (56) It was suggested that it is the profit sharing and the cost consciousness of the individual physician which contributes most to the reduced cost. (56)

Although this type of plan is likely to form only a small percentage of the health care systems in North America, there are other structural and organizational controls which may be implemented to increase the efficiency of the health system.

4. Internal Structure and Control

A well managed admission and discharge system may reduce unnecessary hospital admissions and increase the efficiency of resource utilization. The admission policies and organizational arrangements of hospitals may serve as the most effective means

of controlling costly misutilization of hospital facilites.

Patient mix as well as occupancy rate are determinants of the utilization of various facilities and services within the hospital.

An imbalance in patient mix may result in a less than optimal use of resources, since some resources may be underutilized while other resources are overtaxed. As a consequence the length of some patient stays may be longer than necessary, since the patient may have to await the availability of overtaxed resources. Any resultant increases in patient stay also increase the waiting time of patients scheduled for elective admission.

While patient mix may be controllable to an extent, the major variable which may be used to regulate facility utilization is the occupancy level of the hospital.

The occupancy level of a hospital is a balancing of the need for slack and of the need for the full utilization of the facilities. Between 1961 and 1968 the average occupancy level of Canadian hospitals has been slightly in excess of 80%. (70) There are three major reasons for a less than 100 percent occupancy rate.

(a) Facilities have been built to meet projected demands for future years.

(b) Randomness in the discharge and admission processes.

(c) Intentional slack to allow for emergency admissions.

Most researchers believe that the extent of emergency slack and randomness of admission and discharge is a function of hospital size. From statistical considerations it can be shown that for an excess demand, hospitals with a greater number of beds

should have a higher occupancy rate than a greater number of smaller facilities serving an identical population with the same number of beds, since the deviation about the mean occupancy level will be less (see Berry (8)). However, the provision of a wider range of services by larger hospitals may reduce the occupancy rate of larger hospitals, since the total variability will depend on variations in a greater number of distinctive capability services. In addition, hospitals in the same region cannot be considered as independent units. The occupancy level of one hospital may depend on the availability of space in other hospitals.

Empirical evidence indicates that the daily census for certain distinctive patient facilities is Poisson distributed. To the extent that Poisson or other easily dealt with functions are applicable, statistical methods may be used to study the effects of alternative admission policies.

The applicability of the Poisson distribution rests on a number of conditions which may or may not hold. Of particular note are admissions such as elective surgery which are scheduled partially on the basis of patient convenience, and, thus, may not be describable by a Poisson distribution. In studying cases for which a Poisson or other easily handled distributions are not appropriate, other analytical techniques such as simulation, based on sampled empirical distributions, may be useful.

5. The Cost of Hospital Services

(a) The Theory of Cost. The costs of producing goods and services may be divided into two categories.

(i) fixed costs which do not vary with output, and

(ii) variable costs which depend on the amount of various services performed.

Economic theory makes use of three cost functions.

1. Total cost; the sum of variable and fixed costs

$$T = F + VC$$

where F = fixed cost

VC = variable cost

2. Average cost; the cost per unit of output

$$AC = \frac{T}{q} = \frac{F}{q} + \frac{VC}{q}$$

where q is the total units of homogeneous output.

3. Marginal cost; the cost of producing one extra unit of output,

$$MC = \frac{\partial T}{\partial q} = \frac{\partial (VC)}{\partial q}$$

Variable cost may be written as

$$VC = \sum_i v_i(q_i) \quad q_i$$

where $v_i\ (q_i)$ is the unit cost of service i at the output level q_i

In considering hospital costs the often followed procedure is to assume a relatively stable patient mix and, thus, to use a single appropriately weighted variable cost. Thus:

$$T = F + V(q)\ q$$

$$AC = \frac{F}{q} + V(q)$$

$$MC = V(q) + q\frac{\partial V(q)}{\partial q}$$

where q is a proxy measure of total output

The division of costs into fixed and variable costs depends on dynamic processes and hence on the time period. In the short run various costs such as physical depreciation of plant and equipment may be regarded as fixed. In the long run these costs are variable since equipment and physical plant facilities may be expanded or reduced.

Short run cost functions describe the costs of individual production units for different levels of production at given fixed capital investment, whereas long run average and marginal cost functions describe the cost of production for varying capital investment.

From experience in most production services there are reasons to believe that increased production leading to specialization of equipment and related labor skills increases productivity. A decreasing unit cost as production facilities are increased or increasing returns to scale is referred to as an economy of scale. Beyond a certain level of production, increasing complexity of managment may lead to a disproportionately large decrease in efficiency. With unit cost of output increasing as production facilities are increased, i.e. a diseconomy of scale. It is believed that most production services, therefore, have a U shaped long run average cost curve, as shown in the figure below.

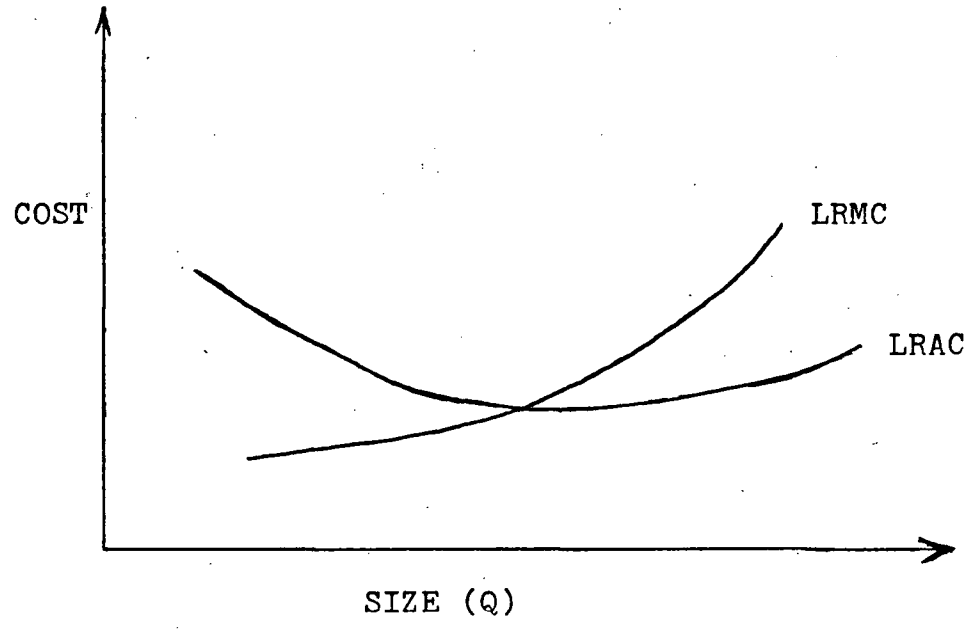


Figure 2: LRAC and LRMC as a Function of Hospital Size

The minimum long run average cost (LRAC) is given by

$$0 = \frac{\partial(LRAC)}{\partial Q} = \frac{\partial}{\partial Q}\left(\frac{F(Q) + V(Q)Q}{Q}\right)$$

$$= \frac{-F(Q)}{Q^2} + \frac{1}{Q}\frac{\partial F(Q)}{\partial Q} + \frac{\partial V(Q)}{\partial Q}$$

The minimum LRAC occurs where LRAC=LRMC. This can be shown as follows:

$$LRMC = V(Q) + Q\frac{\partial V(Q)}{\partial Q} + \frac{\partial F(Q)}{\partial Q} \quad \text{at the minimum of the LRAC curve,}$$

$$LRMC = V(Q) + \frac{QF(Q)}{Q^2} = \frac{F(Q)}{Q} + V(Q) = LRAC$$

If the LRMC is less than the LRAC then economics of scale exist, since by increasing the scale of plant and capital equipment we can reduce the average cost of a unit of output.

(b) Trends In Hospital Costs and Financing

The rapid rise in the cost of hospital services has been of concern and the subject of numerous studies. Ingbar and Taylor (38) note that the average per diem charge for non-federal short-term hospitals in the U.S. had increased 185 percent between 1950 and 1965, an average of approximately 4.2 percent yearly. This increase was noted to be accelerating, as the yearly average increase between 1960 and 1965 was 6.5 percent and in 1966 the increase was 8.3%. In Canada, expenditures on personal health care rose from approximately 2.8 percent of all national expenditures in 1953 to 4.6 percent in 1967. At the same time the proportion of expenditures for hospital care rose from almost 59% to over 63 percent. (70)

Increases in hospital expenditures have been influenced both by increased utilization and increases in the cost of providing services due to general inflation in the economy and increased use of sophisticated equipment.

Increased utilization (28 percent in Canada and 27 percent in the U.S., between 1950 and 1967) has occurred through an increase in both the admissions/1000 population (27 percent in Canada and 24 percent in the U.S. between 1950 and 1967) and the average length of stay. (A 6 percent decline between 1950 and 1958 in both countries followed by a 4 percent increase in Canada and 9 percent in the U.S. between 1958 and 1967). (3)

In Canada, the inauguration of universal hospital insurance arrangements has shifted financial responsibility for hospital payment from the individual to governmental agencies. In B.C. hospital patients pay $1 per day, plus additional

payments for special services, such as private or semi-private rooms, while the British Columbia Hospital Insurance Service (BCHIS) reimbruses individual hospitals at set per diem rates. These rates are set on an individual hospital basis, taking into account the different services offered, research, teaching, past financial records, etc.

The extent to which governments have assumed responsibility may be illustrated by the fact that the percentage of payments of active treatment hospital care made by governmental agencies in Canada rose from 36.2% in 1953 to 90.5% in 1967. (70)

Hospital services are characterized by high capital investment. In 1968, British Columbia with a population of slightly less than 2 million the total capital investment in hospitals was over $170 million. (55) Funds for capital investment in physical plant and major equipment are also largely derived from public treasuries as may be seen in the following table.

Table 7: Plant Fund - Source, 1968 (Public General Hospitals[1])

Source	Total Public General Hospitals
Provincial Grants	$2,423,165
B.C.H.I.S. Equipment Allowance	942,813
Federal Grants	1,540,206
Municipal Grants [2]	18,477,828
Donations	1,314,189
Interest	364,371
Total	$25,062,572

[1] Rehabilitation and extended care hospitals not included

[2] Including regional hospital district grants

Table 7 (Continued)

Source: Report on Hospital Statistics and Adminstration of the Hospital Act, 1968 (55)

(c) An Empirical Look at Hospital Costs. Tables 8 and 9 illustrate Canadian and British Columbian data on the major hospital expenditure categories and their relative importance.

From these tables it may be seen that wages and salaries are the largest component of expenditures, accounting for approximately 2/3 - 3/4 of the total. Wages and salaries also represent one of the fastest growing expenditures in Canadian hospitals. This increase is a result of increased paid hours of work per patient day (a 17% increase in non-medical staff hours - from 11.9 in 1961 to 13.9 in 1967 and a 22% increase in nursing hours per patient day - from 6.3 to 7.7 in the same period (70)), increased average level of skill and increased wage levels (a 57% increase between 1961 and 1967 with preliminary indications of an increase of 12% from 1967 to 1968 (70)).

Table 8: Operating Expenditures of Budget Review Hospitals

$ Per Patient Day (Excluding Newborn)

	1961	%	1967	%	Percent increase 1961-1967
Salaries & Wages	$14.84	64.5	$27.10	66.8	83%
Medical and Surgical Supplies	0.73	3.2	1.24	3.1	70
Drugs	0.99	4.3	1.42	3.5	43
Raw Food	1.46	6.3	1.75	4.3	20
Other Departmental	3.17	13.8	6.96	17.2	120
Other non-Departmental	1.82	7.9	2.06	5.1	13
	$23.01	100.0%	$40.54	100.0%	76%

Source: Canadian Hospital Association Trends in Health and Hospital Care Chart Book 1969, Vol. 1.

Table 9: Expenditures (Public General Hospitals[1]) in B. C.

	1964		1965		1966		1967		1968	
Gross salaries and wages	$53,316,952	(72.8%)	$58,960,066	(73.1%)	$67,284,459	(72.8%)	$79,699,927	(73.7%)	$100,044,467	(75.2%)
Medical and surgical supplies	2,529,254	(3.5%)	2,786,084	(3.4%)	3,241,747	(3.5%)	3,803,662	(3.5%)	4,629,812	(3.5%)
Drugs	2,886,176	(3.9%)	3,139,972	(3.9%)	3,594,893	(3.9%)	4,061,024	(3.7%)	4,550,057	(3.4%)
Dietary—food	3,844,900	(5.3%)	4,060,728	(5.0%)	4,423,947	(4.8%)	4,736,217	(4.4%)	5,274,827	(4.0%)
Other	10,605,591	(14.5%)	11,745,180	(14.6%)	13,859,558	(15.0%)	15,868,643	(14.7%)	18,550,279	(13.9%)
Sub-totals	$73,182,873	(100.0%)	$80,692,030	(100.0%)	$92,404,604	(100.0%)	$108,169,473	(100.0%)	$133,049,442	(100.0%)
Depreciation—										
Buildings and building-service equipment	$2,358,641		$2,988,832		$3,293,613		$3,459,556		$3,902,726	
Major equipment	1,633,112		1,562,555		1,793,940		2,008,751		2,309,864	
Sub-totals	$3,991,753		$4,551,487		$5,087,553		$5,468,307		$6,212,590	
Total gross expenditure	$77,174,626		$85,243,517		$97,492,157		$113,637,780		$139,262,032	
Average gross expenditure per patient-day (newborn days included at 100 per cent)	$25.86		$28.03		$31.14		$35.32		$41.38	
Average gross expenditure per patient-day (newborn days included at 25 per cent)	27.68		29.84		33.01		37.41		43.78	

[1] Rehabilitation and extended-care hospitals not included.

Source: Hospital Statisitcs and Administration of the Hospital Act - 1968 (55)

Numerous factors complicate empirical studies of hospital costs, especially those studies done on an inter-hospital comparative basis. Comparability of hospitals is hampered by differences in staff structures, wage and material costs, operating procedures, the range and quality of services, occupancy level and the scope of teaching and research programs.

Hospitals differ in the quality, number and mix of inpatient services and facilities offered. In addition, there is considerable variation in the extent of outpatient treatment and education and research programs. These differences may have an appreciable effect of the costs incurred by the different hospitals.

As noted earlier, wages and salaries account for approximately 2/3 - 3/4 of operating expenditures. In cross-sectional studies, it is therefore essential that wage differences be considered, especially if appreciable wage differences exist among hospitals. If aggregate wage costs are employed, in analyzing hospitals with different staff structures, biases may be introduced if an adjustment of wage rates does not take account of the differences in the average level of skill.

Additional problems arise from the use of hospital accounting data, which may be inappropriate and may necessitate the use of proxy measures, and from the use of time series analysis, which may be complicated by changes over time in any of the factors influencing costs and may offer only a limited range of output for study.

Many studies have attempted to examine the relationship between cost and size, in order to determine an optimal manner

of providing care for a specified average number of patients.

One of the major difficulties of studying hospital costs has been to select appropriate measures of two closely related variables; size and output. The most obvious approach to measuring size would be to use bed capacity. This, however, would ignore the effect of occupancy level which, as discussed earlier, may be size-dependent.

The usual manner in which this difficulty is avoided is to use measures related to output such as adjusted bed size and average daily census or equivalently the yearly or even monthly number of patient days.

Adjusted bed size allows for occupation level by subtracting the average number of unoccupied beds from reported bed capacity. This method is subject to error introduced by differences in the methods employed by hospitals in reporting bed capacity.

The use of average daily census may create errors in the measurement of costs due to the use of output measures reflecting short-run changes with delayed adjustment of the factors of production, or to the use of long-run measures of output which do not account for changes in production during the time period from which average values have been computed.

In studying the relationship between costs and size, it is often assumed that hospitals combine factors of production in a manner appropriate to the average measure of output.

The results of some of the major empirical studies of hospital costs are summarized in Table 10.

Feldstein (26) examined the relationship between the cost

of various factors of production and the monthly number of patient days in a general, short-term, non-research orientated hospital.

A month was chosen as the time unit for analysis, since it is sufficiently short to avoid complications due to changes in capital plant and equipment, while being long enough for variable factors of production to be adjusted to output levels.

The costs of plant, equipment, administrative services and skilled personnel showed no variation in response to changes in the monthly number of patient days, while the costs of unskilled labor, supplies, food, and drugs varied with the number of patient days.

Departmental costs were analyzed to derive a total cost function for the hospital. It was felt that the use of departmental costs would provide a more homogeneous measure of product. In addition, the influence of departmental costs on total cost and also the relationship between output and cost within each department could be derived.

The independent variables used were: number of med-surgical patient days (p.d.), number of obstetrical p.d., number of OB deliveries, number of laboratory patients, number of radiology patients, number of EKG patients, number of physical therapy patients, number of operations, supply expenses in the Operating room in the preceding month, food costs in the preceding month, and a continuous time variable.

The linear model was tested for curvature, and it was concluded that the linear model was the most applicable.

Feldstein states that "a decreasing short-run average

total cost curve may be interpreted in two ways: first, that excess capacity exists, in which case a smaller plant would be less costly, and second, that long-run increasing returns exist, and therefore increases in output should be met by increasing the size of existing hospitals." (26)

The hospital in the study had an occupancy level of approximately 90 percent indicating that excess capacity was not an explanation for the decreasing short-run average cost.

It is possible that decreasing short run average costs might exist for any size of hospital. It was, therefore, necessary to perform a cross-sectional analysis of hospitals of varying sizes in order to determine if long-run increasing returns existed.

The results of the study indicated a constant LRMC which was below the LRAC, i.e. there are economies of scale. Accounting for the broader scope of services in larger hospitals, it was inferred that the LRMC curve has a downward slope.

The cross-sectional study was later expanded and refined by Carr and Feldstein (10), the results of which are shown in the table. Average daily census was included as a linear and square term in the regression analysis. The measures of service capability and education programs used were: number of facilities and services, number of facilities and services times average daily census, number of outpatient visits, number of student nurses, number of internship and residency programs, medical school affiliation, existence of a professional nursing school, and the number of interns and residents.

The use of average daily census as a measure of scale

and average daily census times the number of services and facilities as a measure of service capability yields questionable results because of the collinearity between these two measures.

The authors did not consider the results of the first analysis to be conclusive because of the manner in which variations in service capability were handled. Therefore, the analysis was repeated, grouping the hospitals into 5 service capability groups by the number of facilities and services and excluding as an independent variable the number of services and facilities offered. The analysis indicated economies of scale over a wide range of output, the optimal size increasing as the number of services increased. The study suggested possible diseconomies of scale only for the largest hospitals in the highest service capability group.

In a study of 72 Massachussets community hospitals, Ingbar and Taylor (38) employed factor analysis and multiple regression to derive a non-linear long-run average cost curve. The resultant inverted U-shaped curve suggests that diseconomies of scale exist up to a certain size of hospital and that economies of scale exist beyond this. This may be consistent with costs increasing non-linearly as the scope of services increases and economies of scale predominating beyond a certain point.

Berry (8) attempted to overcome the problem of product differentiation by grouping hospitals by the availability of 28 services and facilities. On this basis it was assumed that the product within each group would be reasonably homogeneous.

Analysis of groups containing 10 or more hospitals showed that 36 of the 40 groups had decreasing average cost curves and that the negative coefficient of correlation between the average cost curves and patients days for 26 of the 36 equations were statistically significant but at a level of confidence of less than .84.

Following Berry's technique, Francisco (30) examined data on 4,710 short-term general hospitals, selecting 25 groups containing 30 or more hospitals.

For a linear regression relating total cost to patient days, 21 of the 25 groups had positive intercepts, indicating a decreasing average cost. However, only 4 of the positive intercepts, were significantly different from zero at a 5 percent confidence level.

In studying the relationship between average cost per patient day and output (patient days), 22 of the 25 groups showed the average cost to be less for the large hospitals in each group, but only 7 of these relationships were significant and 1 of the other 3 groups showed a significant relationship with a positive regression coefficient. All seven negative regression coefficients which were significant were for groups of hospitals with 56 beds or less.

In a further analysis, grouping the hospitals by the number of services and facilities, with no account made of the combination of facilities and services, 15 of the 17 groups exhibited a decreasing LRAC, but only 8 relationships were significant and of these 7 were for groups with 135 beds or less.

By grouping hospitals as small and large on the basis of the number of facilities and services, it was inferred from the results that smaller hospitals (less than approximately 100 beds with limited facilities and services) had increasing returns to scale and large hospitals have either constant returns to scale or decreasing returns to scale, though not appreciable.

Cohen (12 and 13), in two related studies, employed a sample composed of short-term general hospitals which were members of the United Hospital Fund of New York. All hospitals used an identical accounting system, thus avoiding difficulties in variations due to different accounting systems.

Service output as defined by the individual outputs weighted by their relative costs was used as an explanatory variable. The first study (12) used physical therapy treatments, electrocardiograms, x-ray treatments, blood transfusions, electroencephalograms, weighted operations, deliveries, diagnostic x-rays, laboratory examinations, newborn days, outpatient visits, emergency room treatments and adult and pediatric patient days as the component measures of output. The second study also added isotope treatments and ambulance trips.

The AC curve of the first study was U-shaped, with the minimum occurring at 85,000-90,000 patient days or about 290-295 beds. However, the manner in which output was converted to patient days is not clear.

The second study attempted to partially account for differences in quality by employing a dummy variable for affiliation with a medical school. Service output and patient days were employed separately as explanatory variables. The minimum

AC occurred for about 270,000 units of service and for 180,000 patient days, or approximately for a hospital size of 540-555 beds (at slightly more than 90 percent occupancy).

Allowing alternative weights for affiliated hospitals by assuming that a teaching hospital provides 10, 20, or 30 percent more service yielded a minimum average cost at approximately 640,700, 790 beds respectively.

The apparent inconsistencies in these and other studies are largely a result of the differences in the services offered, the groupings and measures of output employed, and the quality of services. It would appear however that economies of scale exist for small hospitals offering a limited range of facilities and services and that within relatively homogeneous groups of hospitals economies of scale also exist.

Dependent Variable	Independent Variables	Methodology	Sample	Result	Reference
Administration costs Equipment costs Skilled personnel costs	Monthly number of adult patient days	Scatter diagrams	A general, short-term, non-research oriented hospital in Indiana	No variation in response to changes in patient days	Feldstein (26)
Unskilled labour costs Supply costs Food costs Drug costs	Various monthly departmental patient days and expenses	Multiple regression, with account made of cost inflation, employee days off with pay, and changes in production		Cost of dependent variable increased with increases in patient days	
Total operating expense				Linear relationships between total expenditures and measures of output (patient days)	
Total operating expense excluding depreciation	Yearly number of adult patient days	Linear regression analysis	60 hospitals ranging in size from 48-453 beds	Constant LRMC with LRMC being less than LRAC	
Total operating cost	Average daily census and 8 measures of hospital service capability and educational programs	Multiple regression analysis	3,147 non-profit, general hospitals	Minimum LRAC (U-shaped cost curve) occurred for an average daily census of 190, assuming a mean number of facilities and services	Carr & Feldstein (10)
Average cost per patient day	Patient days	Linear regression analysis of hospitals grouped by the availability of 28 services and facilities	5,293 non-federal, short-term, general and other special hospitals	Downward sloping AC curve, implying economies of scale	Berry (8)

Table 10: Selected Empirical Hospital Costs Studies

Dependent Variable	Independent Variables	Methodology	Sample	Result	Reference
LRAC	Medical and surgical expense /p.d., weighted operations/p.d., weighted outpatient radiological films/p.d., private p.d./p.d., occupancy rate, and number of beds	Factor analysis and multiple regression analysis	72 Massachussetts community hospitals, ranging in size from 30 to 300 beds (1958-59)	Inverted U-shaped AC curve, with a maximum at 150 beds	Ingbar & Taylor (38)
			67 of the above hospitals (1962-63)	Similar shape curve, the maximum occurring at 190 beds	
Total and average cost	Patient days	Similar to Berry	American Hospital Association annual survey for 1966	Weak indications of economies of scale	Francisco (30)
LRAC	Patient days and number of facilities	Grouping by number of services and facilities (less than 6 facilities and 6 facilities or greater)		Decreasing average cost for small hospitals and constant returns to scale for large hospitals	
Total Cost	Patient days and various services weighted by their relative average cost	Multiple regression analysis	23 member hospitals of the United Hospital Fund of New York City	U-shaped LRAC curve with the minimum occurring in the range 85,000-90,000 p.d.. (approximately 290-295 beds)	Cohen (12)
"	As above, but including a dummy variable to account for affiliation with a medical school	"	46 member hospitals of the above Fund (operating at slightly more than 90% occupancy)	U-shaped LRAC curve, with the minimum occurring at 540-555 beds	Cohen (13)

Table 10: -- Continued

G. Conclusions

Within most large communities, numerous individuals and organizations are involved in the provision and insurance for the provision of health and health related services. Various of these agencies act largely independently of one another while there are significant, though not always direct, interactions and interdependencies between them. This may be exemplified by instances in which a physician may have to choose between placing a patient in a hospital or in a private nursing home. The final decision may be influenced by whether or not the patient can gain admission to a hospital or whether the patient is insured for hospitalization but not for nursing home care. In addition to interdependencies and a lack of overall coordination, the complexity of health care delivery systems is often increased by conflicts of interest which sometimes arise between various groups, as in the case of third party insurers and the suppliers of services or as in the case of physicians and hospital administrators.

Effective planning requires that the component services of health care delivery should be studied in relation to one another, as the degree of substitutability, relative costs, organizational arrangements, availability and effectiveness are determinants of the mix and relative utilization of the component services, and therefore of the cost and effectiveness of health care provision. Although planning is confined to those areas over which various planning bodies have responsibility, account should be made of the interactions and effects of other activities outside their jurisdiction.

CHAPTER IV. THE RESOLUTION OF SUPPLY AND DEMAND

A. Introduction

The manner in which supply and demand are resolved and the extent to which the delivery of health care services is effective depend on the features particular to any given medical services market. While a varied number of health care service market structures exist, this discussion will be primarily confined to financial and organizational characteristics particular to markets in Canada.

B. Distinguishing Features of the Health Services Market

In traditional economic theory, profit maximization is assumed on the part of the suppliers and the resolution of supply and demand occurs through the pricing mechanism of the market. The health services market differs substantially in these aspects from the markets normally dealt with in traditional economic analysis. The major characteristics of the health services market are briefly summarized below.

1. Monopoly Aspects: There is restricted entry to the medical profession and overt price competition is not practiced. The physician often performs services demanding little of his medical knowledge and skill, many of which could easily be provided by lesser trained personnel. However, substitutes, except those permitted to assist and aid physicians, are excluded, by law, from engaging in the provision of medical practice services.

2. Product Uncertainty and Competition: Knowledge,

either as physician advice or skilled care is a major component of pedical services. Unlike most other products and services, there is usually insufficient knowledge on the part of the consumer to be able to adequately judge the quality or benefit of the product. The medical profession does not overtly compete in the form of advertising of prices or quality, nor are the fees charged for similar services substantially different within a given specialty, from one physician to the next, except for specialties such as plastic surgery. This contributes to the public's image of limited differentiation in product, as between general practitioner and specialist.

3. Externalities: Externalities, especially in such cases as communicable disease control and research, have led to governmental and other interventions.

4. Profit Motive: The profit motive is subdued in the area of health services. The physician is supposedly governed by his concern for the welfare of his patients rather than maximizing his personal wealth. Hospitals are largely non-profit institutions, although, in the U.S., proprietary hospitals exist. These account for only a small proportion of hospitals. (In 1962, proprietary hospitals accounted for only 5% of hospital beds in the U.S. (36))

C. Market Resolution

1. Financial Considerations

As previously discussed, financial considerations play an important role in determining manifest demand, the services supplied, and the efficiency with which health care services are provided. One of the most important aspects of the health services

market is the increasing role of governments and third party payment arrangements which often void price as a market rationing mechanism.

In the United States, proprietary hospitals, sliding scale fees, and a coverage of only a part of the population by various medical care insurance programs complicates an economic discussion of the medical services market. Since we are primarily concerned with the Canadian market, in which universal coverage exists, and since the trend in many other countries, including the U.S., is towards increased governmental intervention and other third party payments, the current discussion of market resolution will be confined to a market in which price does not serve as a market rationing mechanism.

In a social context, and in the absence of price rationing, the concept of shortages may be introduced. These shortages may consist not only of services which are sought and not obtained, but also of delays in obtaining the sought after services.

D. A Surplus of Medical Services?

In a number of health service markets, including those in Canada and the United States, there are two major arguments which may be presented against the occurrence of a manifest surplus of medical services. The first argument is that the medical profession exercises influence over the number of physicians trained and the granting of practice licenses and hospital privileges. The second argument is that physicians, either for economic reasons or high risk avoidance preferences, may increase the demand for available medical services by prescribing additional services for their patients.

While the second argument may be applicable when physicians are paid on a fee for service basis, other payment arrangements offer inducement to maintain the amount of physician services at a level at which they are required.

Time, effort, and income are the three basic physician resource variables which may influence the manner in which the physician combines his own and other resources. The combinational processes which determine the ease with which the resources may be varied and the resultant marginal utility to the physician. Each physician will, of course, have varying preferences in the trade off between income, and time and effort.

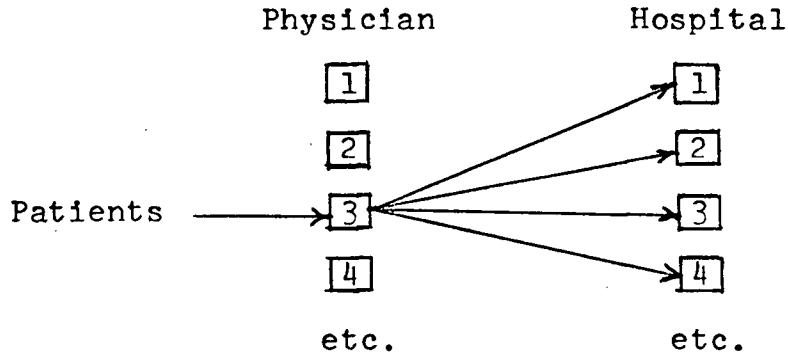
"So long as physicians are independent entrepreneurs paid on a fee for service basis, the incentives to expand the demands for medical services, expand the supply of (free) complementary factors of production, and to restrain the entry of substitute health care suppliers will persist. The industry cannot be made more efficient unless control over the supply of new entrants to medical care supply is taken away from professional groups and returned to the public and at the same time competitive forms of service supply are permitted and encouraged." (22)

While other forms of reimbursement such as on a capitation, or salaried basis may eliminate abuse by unscrupulous physicians who overprescribe their services, the incentives to over utilize complementary factors of production still remain. "The choice of factor combinations in health service supply is too important to be left to one group of suppliers who have no training in management and worse, every incentive to choose inefficient forms of supply." (22) It is only under such overall

profit sharing arrangements as the Kaiser Plan that physicians are motivated to balance complementary service costs. However, such arrangements presently account for a very small proportion of the total health care arrangements in North America.

E. Interaction Between Suppliers

The organizational arrangements between the various components of medical services, notably the system of referrals and hospital admissions, may vary between countries and even between regions within a given country. Figures 3a, 3b, and 3c schematically represent three idealized systems from the spectrum of systems which have emerged.



Filter I *	Filter II *	Filter III
Physician refers to any hospital (no hospital privileges)	Hospital administrative control according to (i) resources available and (ii) hospital policies and constraints.	Individual admission screening by full-time hospital specialists. Also policy screening.

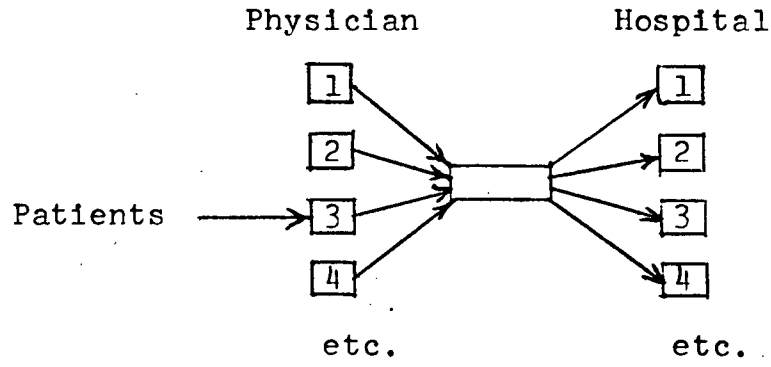
* These two filters are strongly coupled.

System Characteristics	Extended matching capability but with corresponding high search cost.	Accentuated random fluctuations in referred patient flow to each hospital.

Figure 3a. Centralized Admission System

Source: Milsum et al. (46)

Figure 3a is representative of a centralized system such as instituted by the government in Sweden and the Sick Funds in Israel. In this system the patient is normally treated by a general practitioner. In the event that the general practitioner feels that hospitalization is required, the patient is referred to any hospital where the patient is screened for admission by hospital staff specialists and subsequently treated by the hospital specialists and resident physicians if admitted.



Filter I	Filter II	Filter III
Referring physician	(i) Central admission bureau matches patients' needs with hospital resources available. (ii) Some further filtering by assigned hospital as in System A.	Individual admission screening by full-time hospital specialists. Also policy screening.

System Characteristics	
Optimal matching capability with minimal search cost to referring physician.	Flow fluctuations smoothed by central limit theorem.
Economy of scale accruing in centralized search and control system.	Flow responsive to each hospital's state.

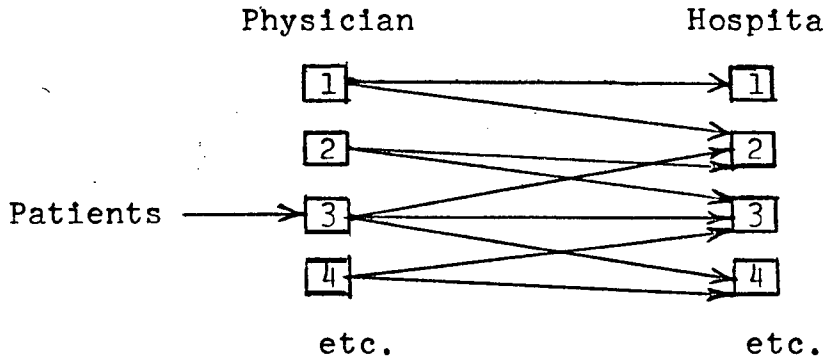
Figure 3b. Central Referral System

Source: Milsum et al. (46)

The city-wide central referral system (Figure 3b) is representative of an experimental program in Rotterdam, Holland. In this system, physicians with patients requiring hospitalization refer to a central agency which then screens patient needs and attempts to match patient needs to available hospital resources. Once a patient is referred by the physician to a hospital there is a further screening by hospital staff specialists.

Figure 3c is representative of the majority of situations in Canada and the United States. In this system a specialist or general practitioner with hospital privileges may recommend the admission of a patient to a hospital where he has been granted privileges. Although the private practitioner is not an employee of the hospital, he may make extensive use of hospital facilities and personnel in the treatment of his patients. The number of hospitals at which a physician has privileges, the number of beds which he can utilize in a hospital, and the priority given his patients by the hospital may differ considerably between physicians.

The physician's recommendation for hospitalization is not sufficient to gain admission for his patient. The admission policy of the hospital, its census state, the physicians status for having patients admitted, and the waiting list also determine when and if a patient gains admission.



	Filter I	Filter II	Filter III
	Physician with hospital privileges selects hospital in predictable ways	Hospital administration control according to (i) resources available and (ii) hospital policies and constraints.	Hospital medical utilization committee screening (policy rather than individual screening).
System Characteristics		Limited search range by each physician but correspondingly low matching capability.	Relatively uniform flow pattern over time of referral to each hospital by each physician.

Figure 3c. System typical of North America

Source: Milsum et al (46)

As indicated in the above discussion, the relationships between specialists, general practitioners, and hospitals may vary considerably. General practitioners may refer their patients to specialists or the patient may seek the services of a specialist directly. However, under various insurance plans, there may be a financial penalty to the patient, if he seeks specialist services without being referred by a general practitioner. This penalty often constitutes payment of the difference between the general practitioner's fee and the specialist's fee, as is the case under the British Columbia Medical Services Plan.

In some systems, patients admitted to a hospital are treated by hospital staff specialists and resident physicians.

In other systems, such as that typical of Canada and the United States, continuity of patient care is maintained by the patient's regular physician or specialist to which he has been referred. It should be noted that surgical procedures are often performed only by surgeons, that is, patients are referred to a surgeon (a physician specialty) for surgical treatment.

In the event that a patient is placed on a waiting list or is not granted admission to a hospital, the physician may prescribe an alternative pattern of treatment, or attempt to have the patient admitted to another hospital.

Within any hospital, services are generally segmented along service capability lines, such that the individual segments are restricted to supplying limited patient services. An imbalance in patient mix may thus result in a shortage of some services and a surplus of others, at any given time. Short run fluctuations in various demand categories may result in patients of low medical need receiving treatment before cases of greater medical need, because of variations in the availability of required services.

The central referral system offers the greatest potential for controlling and regulating patient mix, occupancy levels and the stability of patient demands on individual hospitals. This system also provides the greatest flexibility in matching patient needs to available resources.

Of the three systems, the centralized admission system presents the greatest uncertainty in predicting demands on individual hospitals' services. While eliminating the constraint of hospital privileges, it may require the greatest amount of

search effort on the part of the physician and the patient in obtaining hospital admission for the patient.

In the system typical of Canada and the U.S., the search effort to find available hospital services is limited to hospitals at which the physician has privileges and of which he is more aware of the possibility of having the patient admitted. This system also affords less possibility of duplicating diagnostic services than the other two systems.

It should be emphasized that these are only three idealized systems from the spectrum of existing systems and that there may be several different systems operative in any given region.

F. The Effect of Supply on Demand

Of particular note, in the discussion of the resolution of the demand and supply of medical services, is the effect of supply on demand. It is commonly believed that the supply of hospital beds influences the demand for them.

In a study of an upstate New York county, Roemer (57) found that following a sudden increase in bed supply, a statistically significant increase in utilization occurred. This increase was evident both in the number of admissions and the average length of stay.

Durban and Antelman (19) used multiple regression analysis to study utilization in 48 continental states. It was concluded that admission rates and average length of stay increase with bed supply. In the same study, the number of physicians per 100,000 population was also found to affect hospital utilization, admission rates decreasing and average length of stay increasing as the

physician/population ratio increased. It was postulated that as the ratio of physicians/population increases, a greater percentage of patients are treated without hospitalization, thus making greater use of available physician time. The average length of stay increases since the patients treated without hospitalization are likely to be primarily "short stay" patients.

G. Short Run Resolution

In the absence of price rationing, it is relative attractiveness in terms of availability, waitng time, costs both to the physician and patient, and certain priorities within the system that, in the short run, determine which demands are met, which demands are satisfied by alternative services, which demands are met with delay, and which demands go unmet. Relative attractiveness of physician alternatives is dependent both on the method of payment and the time and effort required of the physician under different system structures.

H. Long Run Resolution

In the long run, the resolution of supply and demand is influenced by past resolution. A manifest shortage of physician or hospital services may serve as an impetus for a future increase in supply.

It should be noted that financial and political constraints may play a large role in determining long run resolution.

Since a significant lag is likely tooccur between the time an impending or overt shortage of physician or hospital services is recognized and the time additional physicians are trained or

attracted to the region and hospital facilities built, it is necessary to project demands and to plan for the provision of adequate health services on a long range basis.

I. Conclusion

A rational approach to the provision of health care services necessitates many changes in the present system, both in financial arrangements and in the organizational arrangements between the various components of health care services.

The present system in North America, which is largely based on a fee for service payment to physicians, not only fails to provide motivation to balance complementary health care service costs, but often motivates physicians to misutilize complementary services in order to increase their own throughput. The efficient utilization of health care resources requires that incentives be instituted which motivate suppliers of health care services to balance complementary service costs and to provide only those services which are required.

The present Canadian system of admissions and referrals could be considerably improved in areas with several hospitals. The institution of some form of centralized coordination such as a centralized admission or referral bureau could better match patient needs with available resources and provide better control of the occupancy levels, and the mix and stability of patient flows in individual hospitals.

CHAPTER V. RATIONAL PLANNING FOR HEALTH CARE SERVICES

A. A Framework for Planning

Public Law 89-749, in the United States, views comprehensive health planning as

> "---a process that will enable rational decision making about the use of private and public resources to meet health needs. Its concern encompasses physical, mental, and environmental health; the facilities, service and manpower required to meet all health needs; and the development and coordination of public, voluntary and private resources to meet these needs." (37)

Health planning is based on cultural values which vary among cultures and which vary over time within a given culture. The problem of defining and assigning relative weightings to various aspects of cultural values relating to health and the quality of life is a difficult one. The methodologies and resultant quantified values are not absolute; however, they do provide a rational approach to a subjective evaluation process (see Chapter I).

A set of relative value weightings may be applied to the projected shortcomings of the future health care system. The value weighted shortcomings may then serve to provide an ordering based on relative importance.

An analysis of these problem areas in terms of their relative importance, the extent to which medical science and technology may be effective in reducing the problems and preliminary estimates of the costs involved may then serve to establish priorities for planning. This preliminary cost-benefit or cost-effectiveness analysis should recognize individual and societal

costs. The societal costs involved are not only the direct capital and operating costs for maintaining the health care system, but also the opportunity costs of alternative public goods which may have been foregone and of losses in productivity and well-being because of illness and disability.

Financial and other resource constraints set limits on the number of priorities which may be resolved. Given the constraints, it is necessary to choose subsets of priorities which may be dealt with in different, although often overlapping, time periods. The chosen priority subsets may then serve as a basis to define planning objectives.

Care must be exercised in the choice and definition of objectives. Operational objectives cannot be vaguely defined such as improving the level of population health. A measure of health must be defined and the objective stated in terms of this measure. We may define such objectives as reducing infant mortality or of providing the same level of service, but at a lower cost. To be valid and operational, the objective must be well defined and possess a basis for reliable measurement and evaluation.

Having defined a set of objectives, alternative strategies which may achieve the objectives should be enumerated. These strategies must then be evaluated by cost-benefit or cost effectiveness and a course of action defined.

Once a decision has been made on an appropriate course of action, resources must be allocated and the chosen strategies implemented.

The final step of a particular planning activity is to evaluate the extent to which the implemented strategies have

been effective in attaining the desire objectives.

It should be emphasized that planning is a continuous evaluation and decision making process, necessitated by the extent of success of implemented strategies and by changing value systems, needs, demands, medical technology, resource availabilities, etc.

This chapter will attempt to discuss some of the major problems encountered in planning, various techniques employed to forecast needs and demands, and fruitful areas in which to search for possible alternatives in the delivery of health care services.

B. Problems Encountered in Planning

Rational planning presupposes some knowledge of causal relationships. Planning for health care provision is hampered by a fragmentary and imprecise knowledge of the influences of social, cultural, and environmental factors on societal and individual health status. Furthermore, numerous causal and causal indicator variables are often difficult to quantify and may be interdependent. Causal variables such as pollutant levels and indcator variables such as age and sex classified disease incidence rates may be quantifiable; however, the exact nature of the causal relationships are not always known. Other variables such as measures of health status may have meaning only in normative terms. Various variables such as income and educational level are interdependent.

The above-mentioned problems, as well as the complexity of system interactions, the involvement of various groups and agencies that often act independently of one another, and the

sampling requirements for meaningful statistics have been major difficulties in studying health care systems and have resulted in a lack of much needed data for rational planning.

C. Techniques Employed in Predicting Future Requirements for Health Care Delivery

Knowledge gained from studies of the effects of selected variables on utilization of health care delivery services together with a knowledge of the functioning of the health care delivery system and an adequate data base can serve in planning for future health care delivery.

This section will attempt to review and discuss some of the shortcomings of the major approaches to forecasting health care needs and demands and their applications to planning.

1. Utilization Models

Methods based on utilization vary in sophistication from simple bed/population and physician/population ratios to models which project utilization through an analysis of demand.

(a) Planning by comparison

If the 'status quo' performance of health care delivery is deemed, by those responsible for planning, to be adequate, then current utilization appears to be an appropriate basis on which to plan for future service.

If an improvement of regional health care delivery is desired, another region may be found which will serve as a standard. This approach is subject to the precarious assumption that the needs and demands of the two regions are comparable. It is, however, possible to subjectively adjust current utilization rates for the region concerned

and to employ these estimates in planning.

The simplest form of planning on the basis of utilization rates is to compute such figures as bed/population and physician/population ratios. This has the underlying assumption that constant utilization for a given size population will hold in the future.

A more sophisticated variation, which has been employed, is to compute ratios of the utilization of selected health resources/demographically categorized population. Projections of population growth by demographic classification may then be used to predict future resource requirements.

In these and other methods, the validity of predicted requirements depends to a great extent on the reliability of population projections.

(b) Planning on the Basis of Existing Demand

Planning based on demand considers not only actual utilization, but also utilization which would occur if known unmet demands were satisfied.

A method which has been employed in England is based on Bailey's (6) concept of a 'critical number of beds'. This number represents the number of hospital beds which would satisfy current levels of known demand, and is determined as follows: "In any year the number of patients recommended for admission multiplied by the average duration of stay of the patients died and discharged gives the number of bed-days which would have been spent in hospital had all patients recommended been

admitted." (6) The number of patients recommended for admission is calculated as in-patient deaths and discharges plus or minus the change in waiting-lists.

Prediction of bed requirements on the basis of this model fails to take account of changes in population age and sex composition, which affect both the demand for admissions and the average length of stay. The effect of other variables is also ignored. Of special note is the effect of supply on demand. Should the critical number of beds be supplied and other factors having no influence, one might find unmet demand, as reflected by waiting lists, would still exist.

(c) Planning Based on Analysis of Demand

Predicting demand on the basis of an analysis of contributing factors offers a more attractive and sophisticated approach than the above methods.

Barr (7) in a study of the Reading County Borough derived sex-age-specific discharge rates of new admissions, staying for one night or more, for different hospital departments in different districts (classified as county borough, municipal boroughs, urban districts and rural districts).

This method may be utilized as a basis not only to plan for the number of beds required, but also for their distribution.

Using multiple regression analysis, Brooks, et al (9) have described a model to predict future demand in each of the categories listed below.

1. Obstetrics (O.B.)
2. Newborn
3. Medicine
4. Cardiology
5. Communicable
6. Dermatology
7. Neurology
8. Psychiatry
9. Surgery
10. Ear-Nose-Throat (ENT)
11. Gynaecology
12. Neuro-surgery
13. Ophthalmology
14. Orthopaedics
15. Proctology
16. Urology
17. Paediatrics (children under 14 years)

A number of factors, 117 in all, were selected for the analysis. "From two to five factors were finally established as being predictors for the cases considered." (9)

Rosenthal (58) has presented a utilization model with socio-demographic and economic variables. The model is a least squares linear multiple regression employing the following variables selected on the basis of their popularity in the literature.

1. % over age 64
2. % under age 15
3. % of females married
4. % male
5. % urban
6. % over 12 years education
7. % non white
8. population per dwelling unit
9. charges for 2 - bedroom
10. % over $5995 income
11. % under $2000 income
12. % hospital coverage

The alternate variables used to measure utilization in short-term general and special nonfederal hospitals in the United States were

1. patient days/1000 population
2. admissions/1000 population
3. average length of stay per admission

The analysis was performed for two years, 1950 and 1960. In both years the coefficient of multiple correlation was greater for length of stay than for admissions.

To take account of trends, the total observations for both years were pooled and a dummy time variable added. The results indicated that the relationships for patient days and admissions

displayed a significant time dependence. "The most interesting aspect of these relationships is the negative coefficient for the time period. This means that, for any given set of characteristics, there would have been lesser utilization in 1960 than 1950. It follows, therefore, that the increases in utilization noted over the 10-year period resulted from changes in overall social, demographic, and economic characteristics in the United States, rather than from an increasing propensity to consume hospital services at a given level of these variables."

To test the applicability of a linear model, a curvilinear model was employed, but little significant difference was found.

Feldstein and German (27) have presented an evaluation of three approaches to predicting hospital utilization. State data on short-term general and special nonfederal hospitals was employed to evaluate the predictive value of the following three approaches:

1. Trend line extrapolation
2. Bed supply extrapolation
3. Demand analysis

The results of the study are summarized in Table 11.

VARIABLE	OPERATIONAL DEFINITION	METHODOLOGY OF ASSESSMENT	SHORTCOMINGS AND/OR ADVANTAGES
Patient days (p. d.)	patient days/1000 pop. in non-federal, short-term, general hospitals	Trendline-Multiple regression (going back 1 year in time for each year projecting into the future) a) 5 year trend of absolute p. d. /population b) 5 year average of p. d. /population c) 5 year trend in changes in p. d. /population d) 5 year average in annual change in p. d. /pop.	a) multicollinearity between independent variables may cause problems b) avoids multicollinearity, however assumes equal weights for all years c) avoids multicollinearity and the use of equal weights d) implies equal weights for all years
Beds	number of non-federal, short-term, general and other special hospital beds/1000 population in each state	As above, except using bed/population ratios	
Income	median family income	Demand analysis - Multiple regression Determination of the dependence of patient days/1000 population on socio-economic variables and changes in these variables	Makes explicit account of variables influencing utilization
Hospital Insurance	proportion of population covered		
Cost of Hospital Care	2-bed room rate		
Age	proportion of population over 55 years of age		
Urbanization	proportion of population living in rural areas		
Race	proportion on non-whites living in the state		
VALIDATION: Historical data is used to test ; coefficients, standard error of estimation, coeficient of multiple correlation and standard error of the net regression coefficient			

Table 11: Evaluation of Three Approaches of Predicting Resource Requirements

It was found that trends in patient days/1000 and beds/1000 population were similar and much more reliable than the use of the selected socio-economic variables in predicting patient-day/population ratios.

The authors also incorporated a trend variable into the demand model which resulted in a lower standard error than any of the trend models. However, the authors cautiously state that "further research is still required to determine more accurate measures for the demand variables so as not to misinterpret their effects, and also to develop an appropriate trend variable." (27)

Multiple regression analysis may fail to satisfactorily account for interactions. Analysis of variance may be used to handle interactions, however, uneven distributions of observations among cells lead to orthogonality problems. It is for these reasons that Reinke and Baker (54) have employed the multi-sort technique, which is an approximation procedure following analysis of variance principles but simplifying computations. Multiple regression analysis was performed after the key variables had been identified. The authors, by a comparison of results using the multi-sort technique and of those from certain multiple re-regression and analysis of variance procedures conclude that "the multi-sort technique offers more promise in the evaluation of demographic data than previous applications of analysis of variance would indicate". (54)

2. Methods Based on Mortality

The availability and reliability of mortality data has previously attracted some effort to utilize this information for estimating required health resources.

Some measures based on mortality which have been employed are:

1. Life expectancy by age and sex grouping
2. Survival rate at various ages
3. Selected death rates such as
    (a) infant mortality
    (b) maternal mortality
    (c) still-births
    (d) mortality among children ages 1 - 4
    (e) post-neonatal mortality
    (f) major infectious disease mortality

The Commission on Hospital Care (35) derived a technique known as the bed-death ratio which considers the relationship between predictable deaths and an estimate of the proportion of deaths that will occur in the hospital. This technique has been employed in a number of states, including New York and Michigan.

Planning on the basis of mortality data assumes a static ratio of utilization to mortality. As proviously discussed, the use of constant ratios ignores the effects of changing demographic, socio-economic and other factors which influence utilization and incidence. As pointed out in Chapter I, mortality is not an appropriate basis for health care delivery planning.

3. Approaches Based on Morbidity

Morbidity is the underlying factor which initiates many of the processes leading to demand. Unlike death, which is characterized by a single state, morbidity is a continuum varying in duration and severity and having a number of possible outcomes. The problems of obtaining reliable morbidity data and of trans-

lating morbidity incidence into utilization have limited application of approaches based on morbidity. In addition, this approach is based on subjective 'expert' opinion of the needed health care resources and there is nothing to ensure that the needs will become translated into demands.

Surveys of morbidity such as those of Lee and Jones (43) and Kalimo and Sievers (39) have attempted to calculate needed health care resources to cope with existent levels of determined morbidity. However, surveys of this nature are few in number and are often dated.

D. The Need for Alternatives in Health Care Planning

Most of the techniques discussed above are employed to forecast requirements on the basis of past characteristics of the population at risk and the existing patterns of health care delivery.

Advances in technology and new drugs and approaches to treatment have been evidenced which have had appreciable impacts on disease incidence and medical practice, sometimes resulting in the obsolescence of service facilities, as in the case of active tuberculosis treatment.

A rational approach to planning requires that such possibilities be considered and that the design of various facilities be such as to be functionally flexible within the constraint of economic considerations.

While various advances in medical science may offer improvements in the quality and effectiveness of health care delivery, great potential lies in research efforts directed to-

wards studying alternate modes of providing health care services.

Little effort has been devoted to seeking alternative strategies for delivering health care services. "To date most attempts at health services planning have gone little further than efforts to collect census data, vital statistics, and aggregatae data on utilization of various health services which are then used in summary form to describe aggregate characteristics of the target population" (4).

With the prevailing high levels and spiraling of health care expenditures, we can no longer afford to accept existing patterns of health care delivery which have historically developed, often in a piecemeal fashion and without a valid assessment. Interest and research are increasingly being focussed on alternate patterns of health care delivery in search of more effective means of providing health care services. Such approaches to health care delivery are almost certain to be system oriented.

1. Systems Analysis Approach

The systems analysis approach attempts to evaluate some measure of performance of the health care delivery system or some subsystem thereof. This approach necessitates identifying inputs to the system, interactions within the system, and the output of the system. Evaluation is defined in terms of a relationship between input and output of the system, often with a restriction on some of the interactions within the system.

Most often, these approaches have dealt with subsystems, such as a ward (Fetter and Thompson (28), Gurfield and Clayton (33)), and the evaluation has been a measure of productivity.

The shift from acute to chronic care, shorter lengths

of stay for a given diagnosis, and ambulatory care have made it necessary to view the total care system rather than just hospital beds, since the largest percentage of health care is provided outside the domain of the hospital.

A recent approach along these lines has been described by Navarro. (47) The model employs a Markov chain to describe the stochastic interactions of the component parts of the health service system.

The subsystems are grouped by type of care i.e. population not under care, primary medical care, consultant medical care, nursing home care, hospital care and domicilary care. The input to each subsystem is the number of entries, as derived from demand data, during a selected unit of time. The output of each subsystem is the number of discharges per unit of time. The model allows for transfers and referrals within the system, with the throughput being defined as "the totality of utilization experiences for all patients". (47)

Underlying the model are two assumptions which weaken its applicability in its present form. These are:

(a) The transitional probabilities between states or subsystems are independent of the previous states, i.e. the past history of the patients in the system.

(b) The transitional probabilities are time invariant - i.e. the model does not account for changes in utilization patterns due to shifts in population age and sex structure etc.

Navarro has discussed three applications for which the

model may be used.

(a) Prediction: to predict required resources in future time periods on the basis of the productivity of various health care resources and current utilization patterns.

(b) Parametric study: to predict required resources if various changes occur in utilization, productivity or referral patterns.

(c) Goal seeking: to calculate the referral pattern which "will minimize an objective function such as cost or change in current resources in such a manner as to reach, in a given time period, specified utilization patterns --- or to require a specified amount of resources." (47)

An extension of this model to include changes in population size and age structure, and different utilization by different age groups has been described by Navarro, Parker, and White. (48)

E. Changing Patterns of Health Care Delivery

The systems approach provides a framework with which to analyze various aspects of alternative patterns of health care delivery. In some cases the parametric values of personnel requirements, etc. to be employed in the system simulation must be derived through subsystem models.

While there are many possible areas for research in health care subsystems, this section will discuss three aspects of health care delivery which are likely to have important implications

throughout the whole system of future health care delivery, namely;

(a) Ambulatory care

(b) Geographical and institutional distribution of facilities and personnel

(c) Greater use of auxilary medical personnel

(a) Ambulatory Care

Ambulatory care services have already gained acceptance in various areas of medical, surgical and psychiatric health care and are likely to find greater implementation in the future. The benefits of ambulatory care are both economic and therapeutic.

In cases where patients can be cared for on an ambulatory basis, treatment can be provided at a significantly lower cost than conventional hospital in-patient treatment. In a report recommending the institution of day care psychiatry for Vancouver General Hospital (71), J. S. Tyhurst states that "It has been estimated that the operating costs of day hospital care are from 1/3 to 1/2 of that of full hospitalization". In addition to operating cost savings, long run economic benefits may accrue since the capital costs of providing ambulatory beds are significantly less than for acute care beds.

The following example of one particular area of ambulatory care, day surgery for children, illustrates the possible impact of day care. "In Vancouver it has been shown that approximately one-quarter of all admissions to children's units in the regional hospital district can be cared for in ambulatory surgical units. Subsequently, controlled studies of medical complications

and parental attitudes towards surgical day care were undertaken, which demonstrated that day surgery was a safe and economical alternative to conventional hospitalization and was acceptable to parents and professionals alike" (15).

Patients receiving ambulatory care maintain social contact in the family and the community. In addition, ambulatory care may facilitate earlier treatment in some cases where patients possess anxieties concerning hospitalization and who might normally delay treatment.

Intermediate or self help wards for patients, not requiring full nursing and housekeeping services, also hold promise of providing health care services at lower costs than conventional full hospitalization. Like ambulatory care, patients may be motivated to be more self dependent, rather than becoming conditioned to invalid roles as sometimes occurs when treatment is provided in the conventional manner. Such wards have recently been instituted in Veterans' Administration hospitals in the United States, with some private hospitals now beginning to adopt this method of care as well.

What is believed to be the first satellite health centre in North America which is physically separated from a hospital is scheduled to open in Toronto in 1972. The centre is to offer a wide range of diagnostic services and emergency care. The institution of such centres holds promise of bringing health services to within shorter distances of more members of the community and of relieving unnecessary pressure on costly hospital facilities.

(b) Geographical and institutional distribution of facilities and personnel

The geographical distribution of hospitals and other service facilities plays an important role in influencing demand and also in determining travelling time and costs for patients, visitors, ambulances and physicians. More attention is likely to be placed on the distributional aspects of health care delivery services, and in this context the success or failure of community health centres may significantly influence future patterns of health care delivery.

In addition to the geographical distribution of institutions, the manner in which facilities and personnel should be distributed among the individual institutions is of considerable importance. To a large extent, the mix and distribution of personnel will be dependent on the distribution of facilities. However, within a particular service unit there are allowable variations in the mix and number of personnel. Such studies as those of the Stanford University's School of Medicine (11) dealing with various mixes and systems for providing nursing services, and Gurfield and Clayton's (33) study of cost savings resulting from more efficient allocations of capital and staff in a cardiac unit are likely to find more application in the future.

An analysis of the distribution of personnel and facilities should consider and attempt to balance the factors contributing to accessibility, development of specialized skills, possible economies of scale, increased problems of decentralized information exchange and coordination, and unnecessary duplication and underutilization of various services.

(c) Greater use of paramedical personnel

Many routine clinical or minor procedural duties are

performed by doctors and nurses which do not require much of their medical skill or knowledge and could easily be performed by lesser trained personnel. In some areas of health care, such as pediatrics in the U.S., auxilary medical personnel have been successful in relieving the physician of many routine duties (72).

A willingness of B. C. physicians to accept auxilary personnel is indicated by the Medical Manpower Survey (61). The following results show the reaction of the surveyed physicians to the question "Do you think that a medical auxilary of some kind could be trained to relieve you of part of the medical professional work load in your practice?"

	Yes	No	Undecided	No Answered or not applicable
Specialist	45%	37%	9%	9%
GP	53%	27%	18%	2%

The survey also reported that Hospital Directors of Nursing felt that nurses could be given special training to perform additional in-hospital tasks such as intravenous therapy, blood transfusion, vaginal examination during labor, care of incisions, and changing or removing complicated dressings.

The success of greater use of auxilary personnel rests largely on acceptance by the medical profession and their patients. It should be noted that in the above situations the physician's position is not threatened, and, in fact, his earnings may be increased. Under such circumstances, it is not surprising that physicians are willing to accept the performance of various tasks by auxilary medical personnel.

F. Conclusion

Greater emphasis is needed on rational planning of health care systems, especially with regard to seeking alternative modes of providing health care services. Such planning should be based on expected demands under alternative patterns of health care delivery and should be viewed in terms of a system, rather than a subsystem, such as one or two hospitals.

In addition, health care should be viewed not only within the context of what is traditionally regarded as the health care system, but within the broader perspective of those systems which have an appreciable impact on health and the quality of life. To this end, one such system model has been developed in the UBC Health Systems Group and is presented in the next chapter.

CHAPTER VI. REGIONAL HEALTH PLANNING MODEL

A. Objectives

The regional health planning model is a prescriptive model and is intended to serve as an aid in policy formulation and resource allocation in the Greater Vancouver region. The model is intended to provide estimates for future time periods of resource requirements and the effectiveness and efficiency of organizational structures and policies which determine the operational mechanism of the health care delivery system.

Although the model has been designed for the Greater Vancouver region, it is general enough in design that it may be readily modified and adapted for other regions, providing an adequate data base is available.

The health planning model is designed in such a manner that it can be interfaced with various other submodels to take into account the modifying and contributing effects of environmental and life style factors. This leads to the possibility of evaluating different alternative strategies and resource allocations, not just within what is traditionally regarded as the health care system but also including those systems having an appreciable impact on health and the quality of life. Although this does not permit a complete evaluation of the various opportunity costs, it does open the way to a more meaningful social evaluation analysis.

In its present state of development, the model utilizes,

U.S. data where Canadian data were not available and various aggregations of data which sometimes have had to be subjectively adjusted. It is intended, at present, to show the operational feasibility and applicability of the model, and to pursue refinements at a later time when the conceptual framework has been more fully developed and the appropriate data obtained.

B. Inter-Institutional Policy Simulation

The regional health planning model is one submodel of a larger simulation project. The overall project, the Inter-Institutional Policy Simulator (IIPS) is a large scale simulation of the Greater Vancouver region which is intended to simulate various aspects of activity and development in the region.

Within the IIPS project are ten subgroups which are described below, together with their existing and proposed links to the health planning model.

1. Population and Demographic Submodel

This model incorporates both natural population growth and migration. The migration model is to be interfaced with the economic and the environmental quality submodels to account for relative regional attractiveness compared to other regions.

This model now serves as a basic input to the health planning model.

2. Economic Submodel

The economic submodel utilizes an input-output framework with shift-share analysis to predict final demands in the region. The role of local governments in economic conditions and regional development is currently being studied.

It is proposed that this model be utilized in capital

budgeting decisions for the health care system and other submodels influencing the quality of life in the region.

3. Transportation Submodel

The transportation model is based on the behavioral assumption underlying the well-known gravity or potential model, i.e. persons are most drawn to locations of closest proximity, possessing the highest levels of activity. Distance is measured in terms of travel time along the most convenient arterial route.

The model should be able to provide data on traffic accidents and medical distance as input to the health planning model.

4. Land Utilization Submodel

The purpose of this model is to allocate subareas by activities such as agriculture, forestry, mining, recreation, employment and housing.

This model may provide useful demographic data for the health planning model.

5. Health Systems Submodel

This model will be discussed in detail in a subsequent section.

6. Pollution Submodel

The pollution submodel considers air, water, solid waste, and noise pollution and their ecological impact.

The levels of the various pollution types can be used as input to the health planning model as factors modifying various incidence rates. Together with the economic submodel a wider perspective of quality of life and alternative costs may be considered.

7. Human Ecology Group

This subgroup is concerned with human behavior and the effects of changes in the variables of the various submodels on human behavior.

The aspects of human behavior may form an important input to the evaluation of the consequences of alternative policies within the region.

8. Land Classification Group

The land classification subgroup provides data input for the land utilization model, classified by land use, soil type and other physical attributes of the land.

9. Data Management Group

The data management subgroup is responsible for the management and retrieval of data and for the development of computer graphic techniques.

10. Resources and Public Services Group

This subgroup is responsible for providing projections of the cost of site services such as streets, sidewalks, sewer and water, gas and electricity, and telephone. In addition, it will aid in forecasting energy requirements for the region.

C. System Priorities and Evaluation

As previously discussed, there is, as yet, no satisfactory quantifiable objective function for the macro evaluation of a health care system.

In an attempt to give one measure of psychological and physical well being, as influenced by the health care system, system shortages have been employed as a measure of performance. This would appear to be the only appropriate macro evaluative

measure which can presently be employed.

Recent work along the lines followed by Holmes and his colleagues (76) offers a quantifiable measurement of the above and appears to possess a valid basis.

Holmes et. al. have derived ordinal and cardinal rankings of the seriousness of 126 of the most common and representative illnesses. The Seriousness of Illness Rating Scale (SIRS) is based on individual perceptions of the seriousness of various illnesses in relation to a normalizing value of 500 for peptic ulcer. This scale has been shown to have a high degree of concordance between the ranking by medical and non-medical people (76) and to be satisfactorily reproducible. (77)

A system priority matrix having 6 priority classes (highest priority=1) was derived for each morbidity category from the medical rating scale. As the morbidity categories used in the model were aggregations, a weighted index was computed on the basis of the component conditions. Because of the aggregations and varying severity within morbidity categories, these priorities were adjusted by professional judgement to reflect varying priorities within each category. The resulting priority matrix represents the proportion of cases of each category belonging to a particular priority class. Thus, for example, heart disease and hypertension is represented by a discrete probability distribution, with 50 percent of the cases belonging to priority class 1, 20 percent to each of priority classes 2 and 3, and 10 percent to priority class 4.

In a few cases a rating was not given for a particular illness and not at all for services such as prophylactic innoculation. In these instances it was necessary to subjectively

extrapolate values.

The performance evaluation is based on an index employing the non-medical seriousness scale values as weightings for unmet demands. The evaluation is thus a measure of the social impact of the performance of the health care system, with larger values of the index of untreated cases signifying a poorer performance of the system.

D. Delegation Assumptions

At present there are 11 resource categories employed in the model; 9 physician specialties, beds, and nurses.

The model is prescriptive in nature and therefore allows substitutions of various resources which might not fully conform to a descriptive model of the health care system. The prescriptive orientation of the model is an attempt to evaluate the system at its greatest capability for given work loads, hospital occupancy levels, and standards of care, when there is greatest flexibility in substituting physician resources.

A number of physician categories often treat cases in the same demand category, for example upper respiratory conditions may normally be treated by a general practitioner, a pediatrician or a specialist in internal medicine. If the available amount of any one of the physician resources which normally are employed to meet the demand in a given category is insufficient to treat the normal proportion of these cases, delegation is allowed. The model prescribes that, if at all possible, other physicians normally treating these cases are utilized in the order of the specialty normally treating the greatest proportion of these cases. The underlying assumption is that this physician specialty will be

the most proficient resource to utilize.

If all appropriate physician resources have been depleted, other physicians are allowed to substitute, in the order of the greatest percentage of resources remaining available.

In allowing substitutions between physicians, exchange rates based on specialty work loads have been employed to reflect differing amounts of time required to treat a given case. This makes the simplified assumption that there is a constant trade-off ratio between physician specialties.

Additional physician visits are allowed to compensate in the event of a bed shortage. In the present model, a bed case shortage is compensatable by an additional number of physician cases (at present this number is 1) and this number has been assumed to be equal for all categories.

E. Data Base

The data base used in the initial runs of the model was derived from several different sources. It was necessary to process the data as described below.

1. Incidence Data

Categorized yearly incidence and prevalence rates/100 population in the U.S. classified by age, sex, and diagnosis (1, 14) were adjusted when appropriate to reflect local conditions.

In order that the various data be compatible, it was necessary to aggregate into broad diagnostic categories.

2. Demands on Physician Resources

Of the data pertaining to 16 specialties categorized in Specialty Profile (66) (accounting for approximately 90% of physicians with a private practice), all but that relative to the

Psychiatrist/Neurologist was used.

It was felt that, at this time, the project would not concern itself with psychiatric and neurological conditions.

In order to be compatible with available data on medical manpower in the lower mainland and greater Vancouver regions of British Columbia, it was necessary to aggregate various specialties as shown below:

(a) General practitioner includes dermatologist, allergist, and osteopathic physician.

(b) Internal medicine includes gastroenterologist, proctologist and cardiologist.

The relevant data given for each specialty was the number of specialists, reason for visit, and number of visits for a specified reason.

Multiplying the number of visits by the number of physicians active in a specialty gave the number of visits by specialty for a specified reason. This figure was then converted to visits/100 population.

From the data on incidence and visits, it was then possible to compute the number of visits/incidence by diagnosis and specialty. (Appendix D)

The number of visits available per year for each specialty at the work load level of the survey summarized in Specialty Profile was calculated as follows:

daily patient load* x number of specialists** x 220

---

* Based on a five-day week.

** In the lower mainland and greater Vancouver regions (61)

This was then adjusted for the physician work loads in the relevant regional areas on the basis of figures of sampled physician work loads published by the B. C. Health Resources Council (61). It was assumed that these values would then be representative of the region.

3. Bed Requirements

From the rate of hospitalization/100,000 population (67), average length of stay (67), and the incidence rate/100 population (U.S. data), the number of bed days/incident for the various aggregated categories of diagnosis were derived. (Appendix C).

The number of bed days available/year was calculated by multiplying the rated bed capacity of hospitals in the lower mainland and greater Vancouver region (55) by the number of days/year. For the purposes of the model an 85 percent occupancy rate was assumed on the basis of data indicating an 81-85% occupancy rate in B. C.

4. Graduate Nurses

From the Report on Hospital Statistics (55), the number of full-time equivalent graduate nurses working in the hospitals in the above region was derived. Using this figure, the number of graduate nurses/bed days as well as the yearly available graduate nurses/bed day was calculated. (Appendix B).

5. Other Considerations

Various service visits to physicians, i.e. checkups, innoculations, etc. and several diagnoses for which incidence data was not available were handled in a slightly different manner.

In order to utilize the simulation program and data relevant to the above cases the incidence/100 population was replaced by visits/100 populations and visits/incidence was set

equal to the fraction of visits seen by a specialty.

F. Model Logic

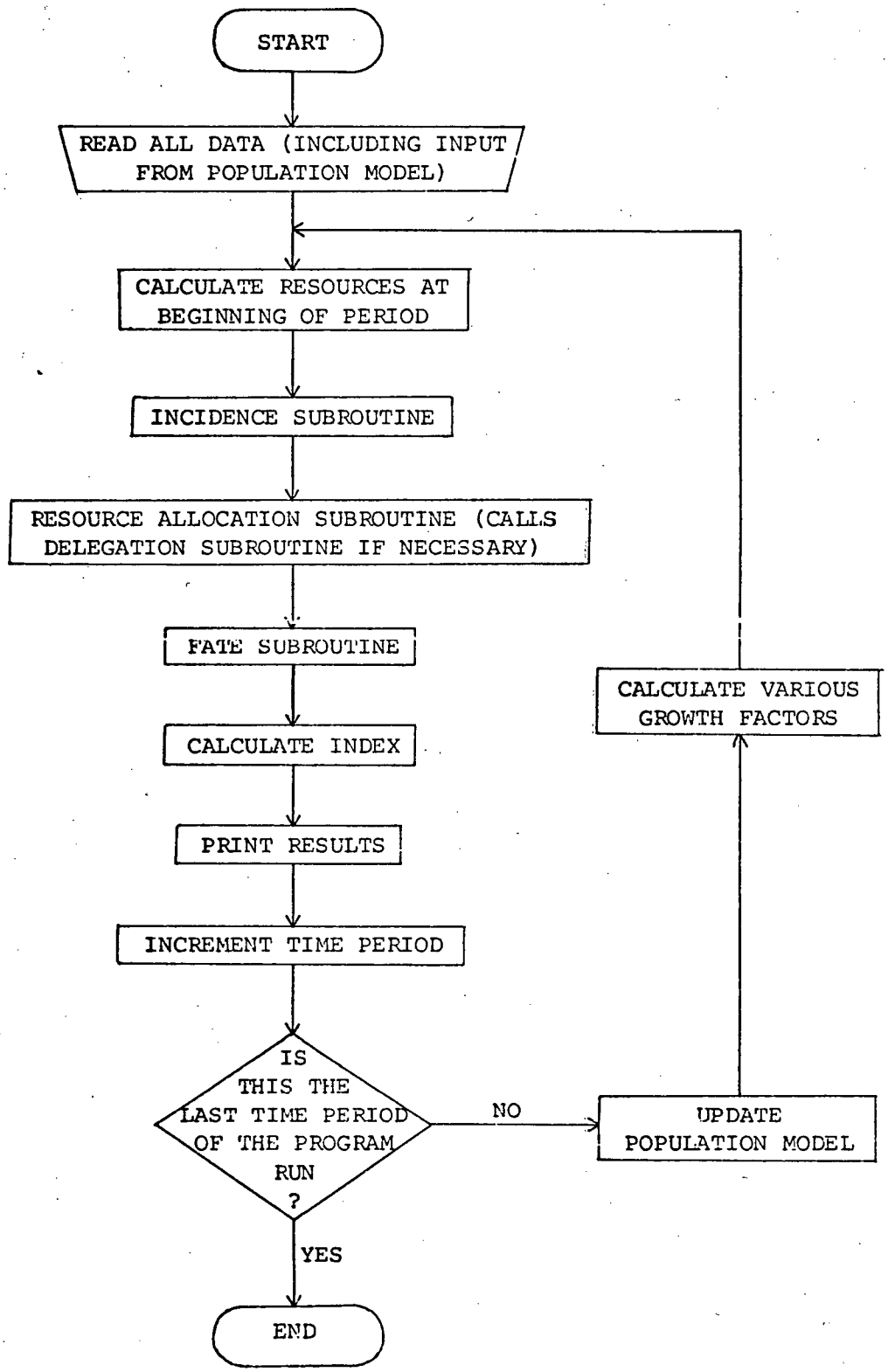
1. Overview of the Model

The model generates demands, allocates selected health care resources, on a priority basis, feeds back and evaluates system shortages.

Various interventions and policy alternatives are allowable for any year of the simulation. Utilization, resource requirements for demand categories, exogeneous variable impact (dominating factors), and available annual resources may individually be allowed to increase or decrease linearly or compoundly and these rates may be changed for any simulated year.

The yearly output is a listing of the total population, number of incidences in each demand category, available resources, resource surpluses or deficits if demands and resources are matched without delegation, the number of treated and untreated cases, the actual resource surpluses or deficits, and the value of the Social Impact Index.

While the output is currently available only in tabular form, a command language is being developed to provide on-line graphical displays of all IIPS submodel outputs as well as for the total regional simulation.


START
READ ALL DATA (INCLUDING INPUT FROM POPULATION MODEL)
CALCULATE RESOURCES AT BEGINNING OF PERIOD
INCIDENCE SUBROUTINE
RESOURCE ALLOCATION SUBROUTINE (CALLS DELEGATION SUBROUTINE IF NECESSARY)
FATE SUBROUTINE
CALCULATE INDEX
PRINT RESULTS
INCREMENT TIME PERIOD
IS THIS THE LAST TIME PERIOD OF THE PROGRAM RUN ?
NO
YES
UPDATE POPULATION MODEL
CALCULATE VARIOUS GROWTH FACTORS
END

2. Description of Subroutines

(a) Incidence Subroutine

(i) Variable Definitions

AGEF(K) = number of females in age class K

AGEM(K) = number of males in age class K

PDISM(K,I) = probability of category I incidence in males of age class K

PDISF(K,I) = probability of category I incidence in females of age class K

DOM(J) = value of Jth dominating factor

UTIL(I) = utilization factor for category I

CAT(I) = number of new cases in category I

NNBRC = number of non birth related categories

LDOM = the maximum number of dominating factors per category (presently this is 2)

JDOM(L,I) = the number of the Lth dominating factor relevant to disease I. If there are fewer than L factors relating to category I,

JDOM(L,I) = 0.

(ii) Program Logic

The population submodel provides input to the incidence subroutine in the form of age and sex classified yearly population projections.

The number of incidences or cases requiring services in each category are calculated from population data and age and sex classified morbidity incidence and service rates.

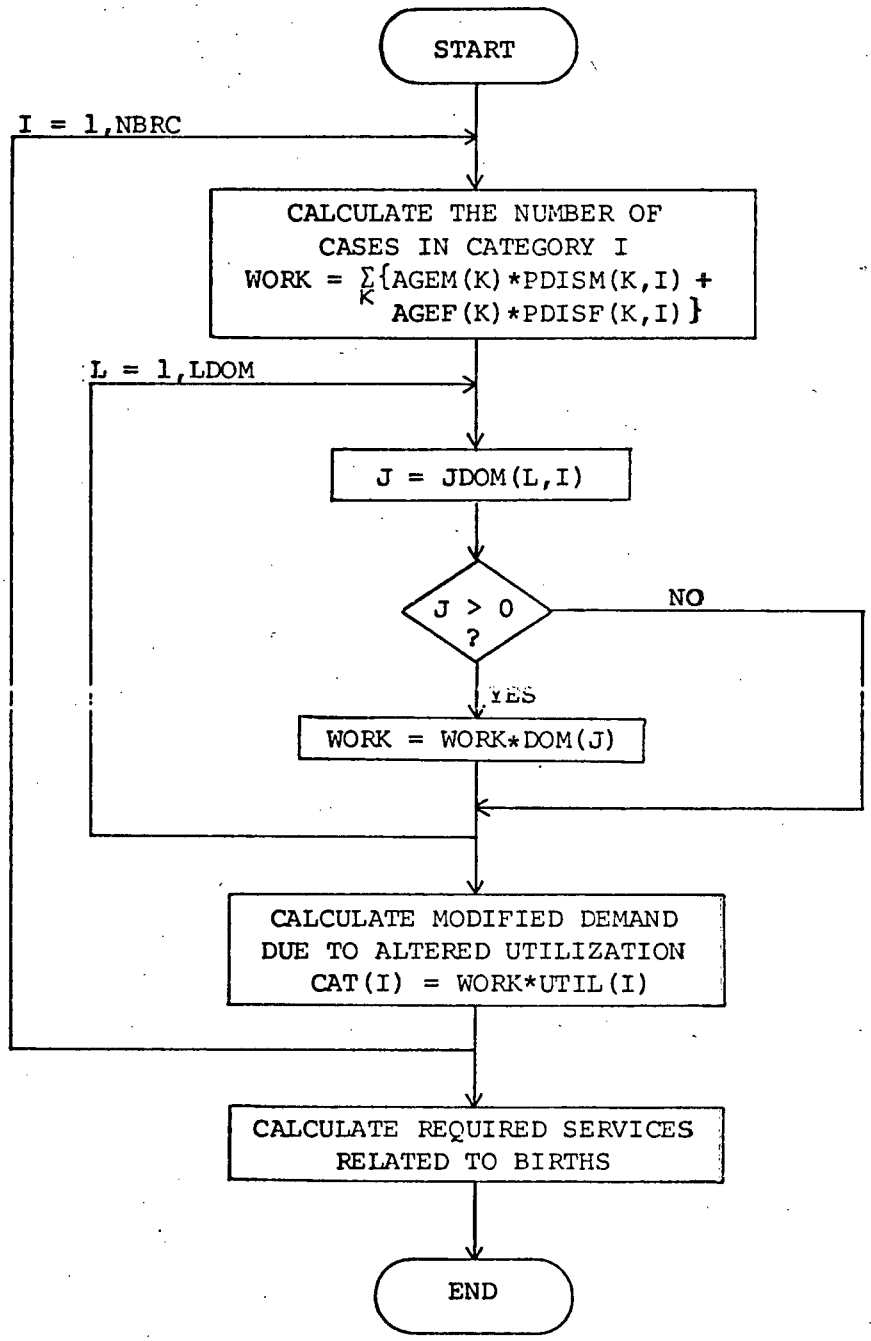
Exogenous data from other submodels or parametric estimates are used to alter "natural" prevalence rates of various morbidity categories. The exogenous variables influencing incidence rates have been termed dominating factors and are expressed as coefficients, which when multiplied by the natural prevalence rates yield modified rates reflecting the effect of the exogenous variables.

The extent to which demand is manifest depends on a number of factors previously discussed and is subject to change as these factors change. It was, therefore, decided to incorporate utilization factors for each category. Although in the program these factors modify incidence and service rates, a given percentage change in these rates will result in the same percentage change in demand.

Various services such as prenatal care etc., are related to the number of child deliveries. Required services related to births, are calculated from population model data by multiplying the number

of deliveries, account being made for multiple births, by the specific requirements per delivery. (Appendicies C and D)

INCIDENCE SUBROUTINE



(b) Priority Streaming Subroutine

(i) Variable Definitions

LPRI(I) = the highest priority to which cases in category I may rise.

STPRI(I,J) = the proportion of new cases in category I waiting for treatment at priority level J, including new cases plus cases carried forward from the previous year. The value in the first time period is read in, so that historical back logs may be accounted for.

NCAT = number of morbidity and service categories

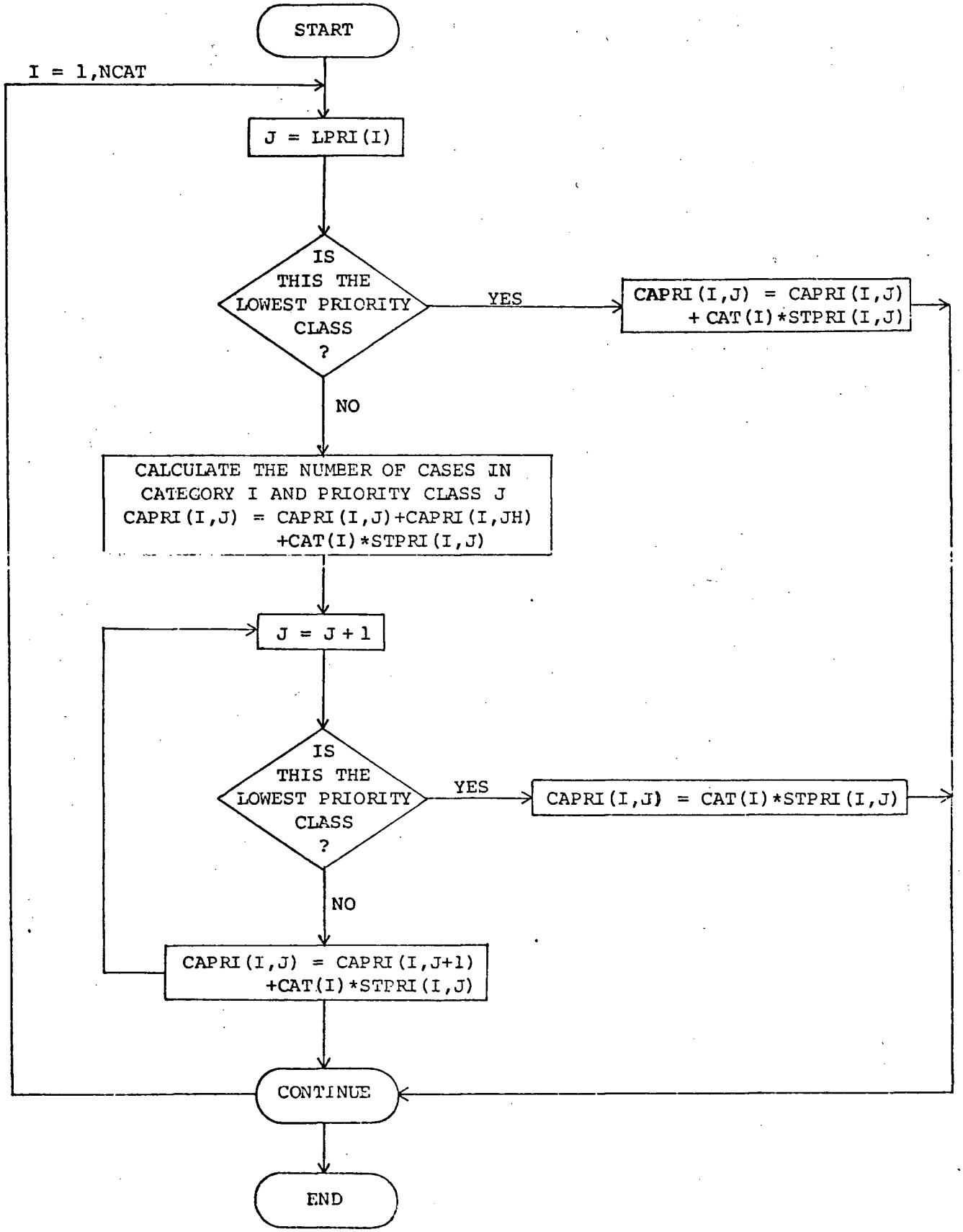
(ii) Program logic

This subroutine allows for priorities in providing service to the various demands. Each category is described by the proportion of cases in various priority classes, with 1 being the highest priority.

Patients who fail to receive treatment in one time period may move up one priority class in the succeeding time period, with the limitation that the highest priority to which a patient in category I may rise is LPRI(I).

The subroutine calculates CAPRI(I,J) from the number of new cases plus those returning from the previous year which have moved up one priority class where permitted.

PRIORITY STREAMING SUBROUTINE



(c) Resource Allocation Subroutine

(i) Variable Definitions

UNTRE(I) = the number of untreated cases of category I.

TRE(I) = the number of treated cases of category I.

NPRI = the number of priority classes

RES(K) = amount of resource K currently available. At present resources 1 - 9 are physician speciality resources, 10 is beds and resources, 11 is nurses.

REQU(K, I) = the amount of resource K required per case in category I.

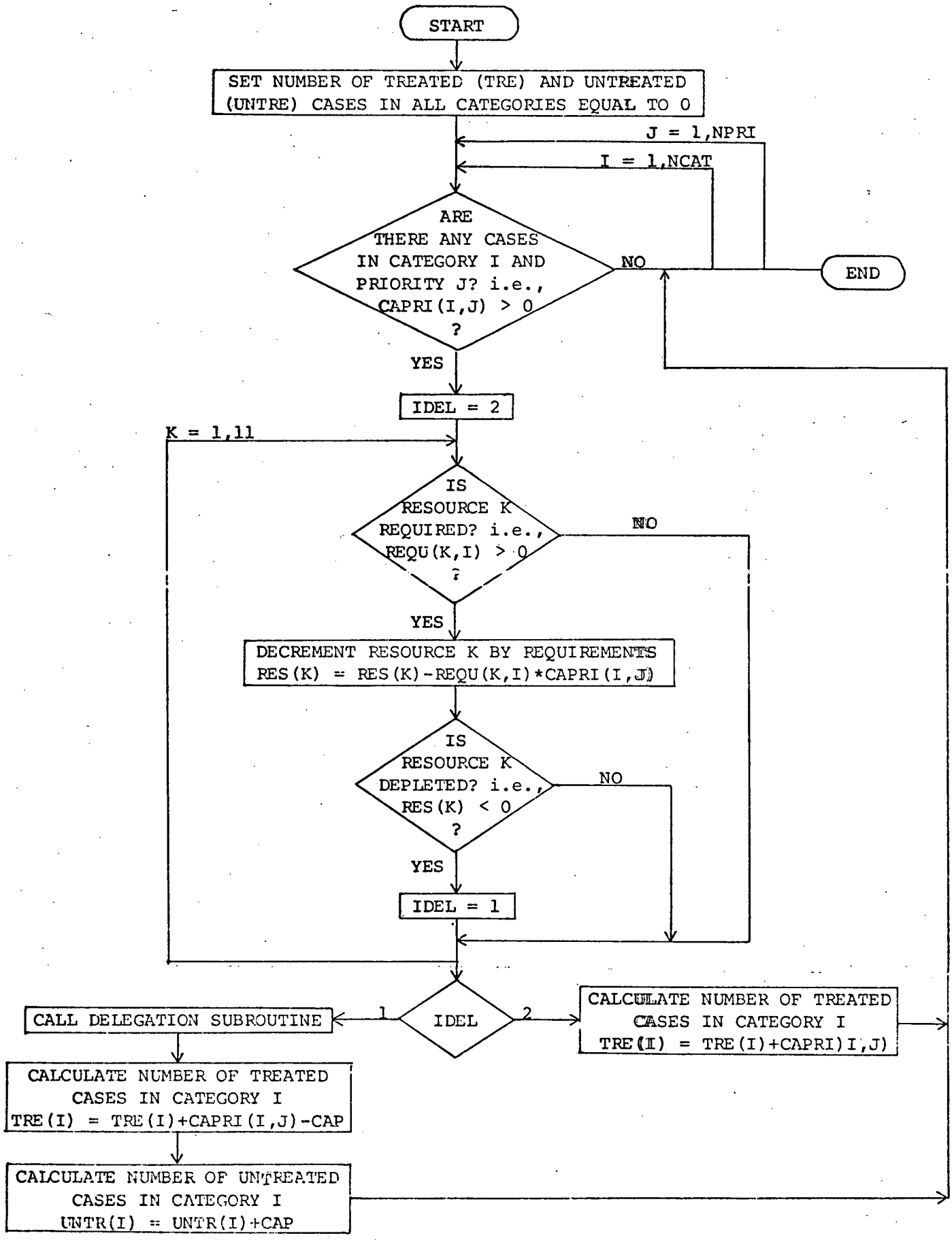
CAP = the number of untreated cases.

(ii) Program Logic

This subroutine allocates resources in order of priority class. Note that since the cases of equal priority are treated sequentially by category number, there is an implicit secondary priority. This is not intended to have any significant interpretation and is merely a result of programming constraints.

Appropriate resources are decremented on a priority basis to meet the requirements for each priority and category block, (I, J). If at any time, it is detected that the allocation of resources to a priority and category block (I, J) drives one or more resources negative, the delegation subroutine is called. Delegation is then attempted before the

RESOURCE ALLOCATION SUBROUTINE



next sequence (I, J) is processed. The number of cases which are not treated each time the delegation subroutine is called is calculated by the delegation subroutine and returned in storage area CAP.

The number of treated and untreated cases for each time period is calculated for all categories and stored in TRE(I) and UNTRE(I).

(d) Delegation Subroutine

(i) Variable Definitions

CAP = the equivalent number of untreated cases

ALPA = the additional number of GP equivalent cases required to compensate for a failure to provide a hospital bed for a case.

RES(1) = G.P. resources (visits)

EXCHA(K,1) = the exchange rate when using G.P. resources to substitute for physician resource K.

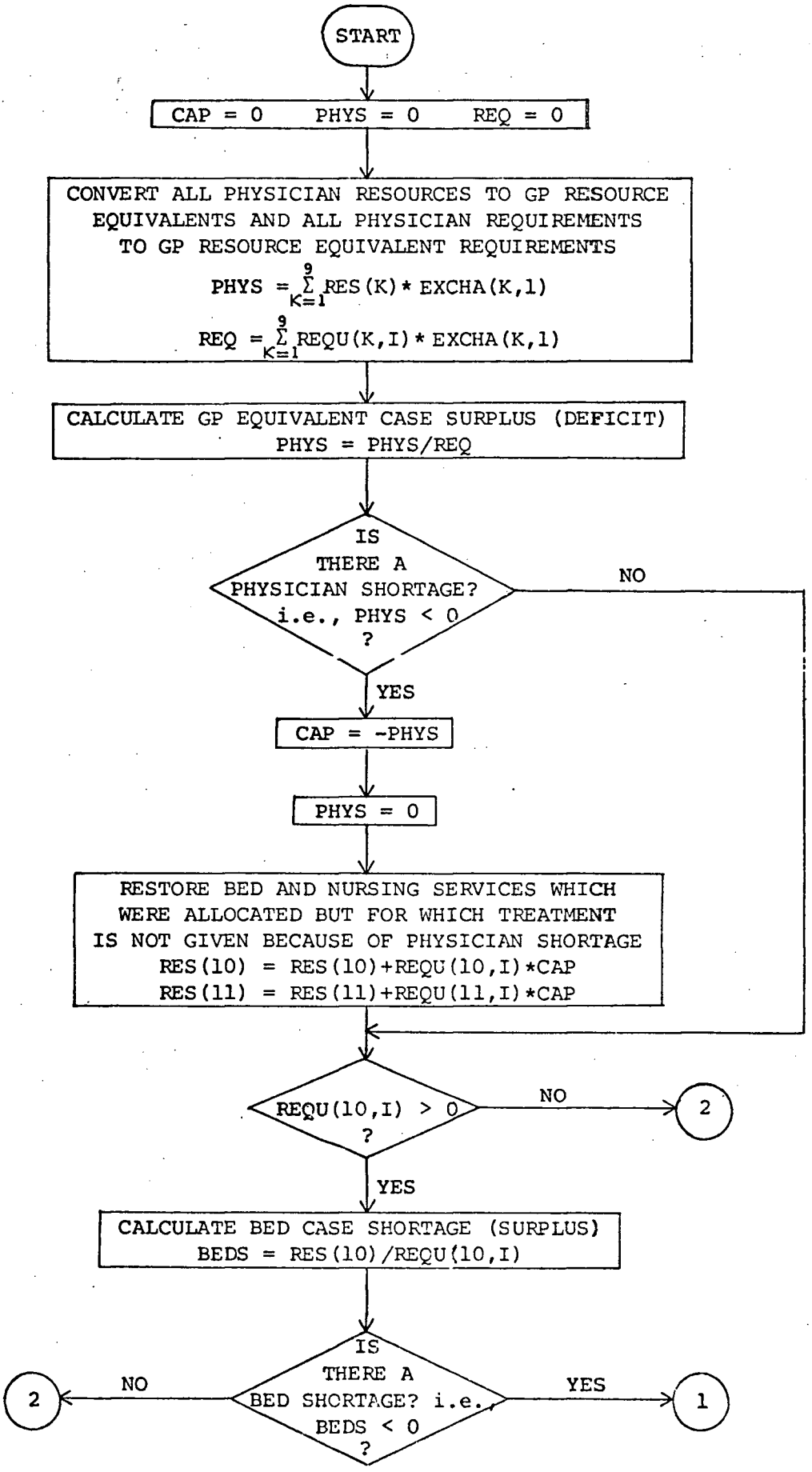
RESI(K) = amount of resource K at the beginning of the time period.

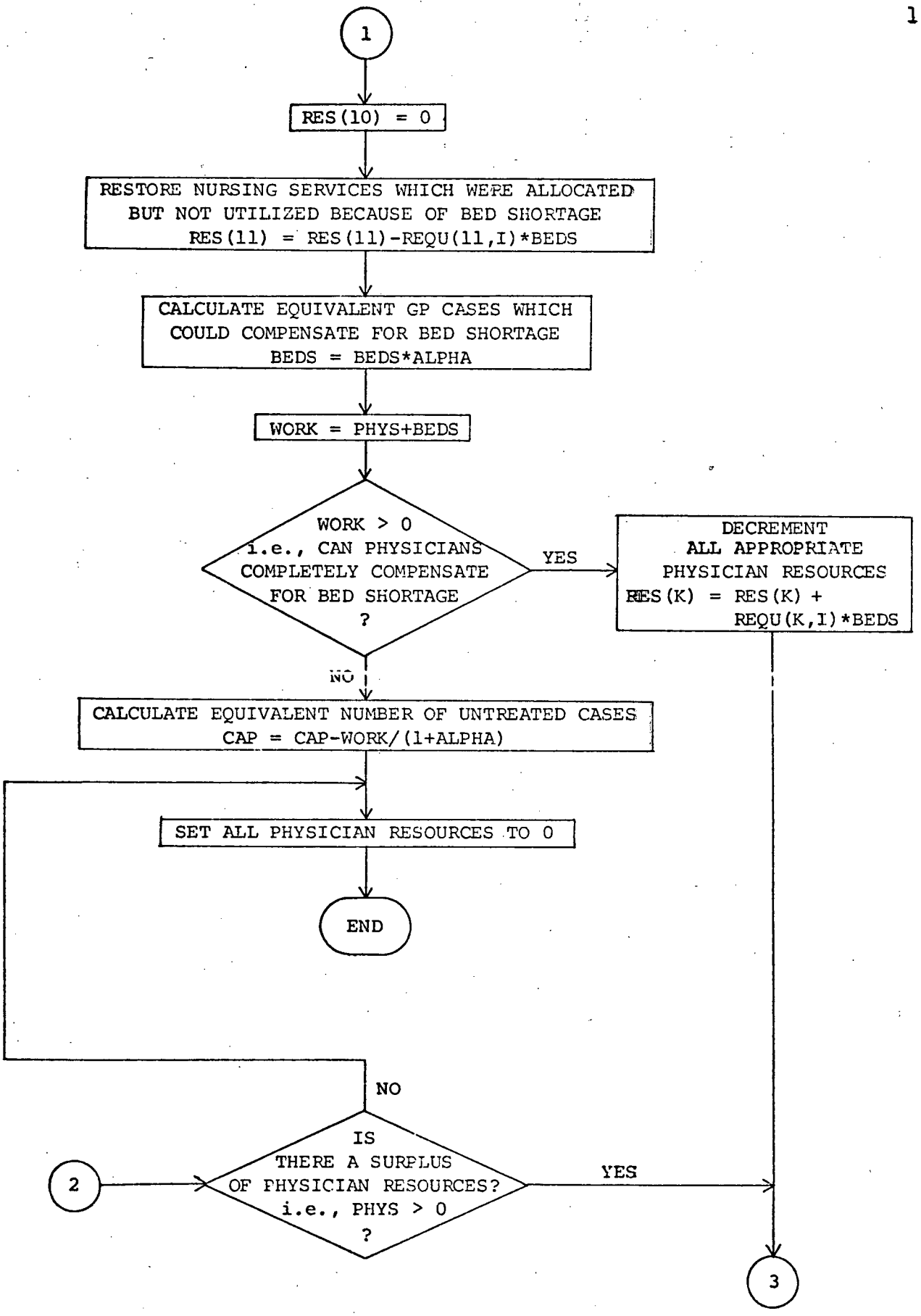
(ii) Program Logic

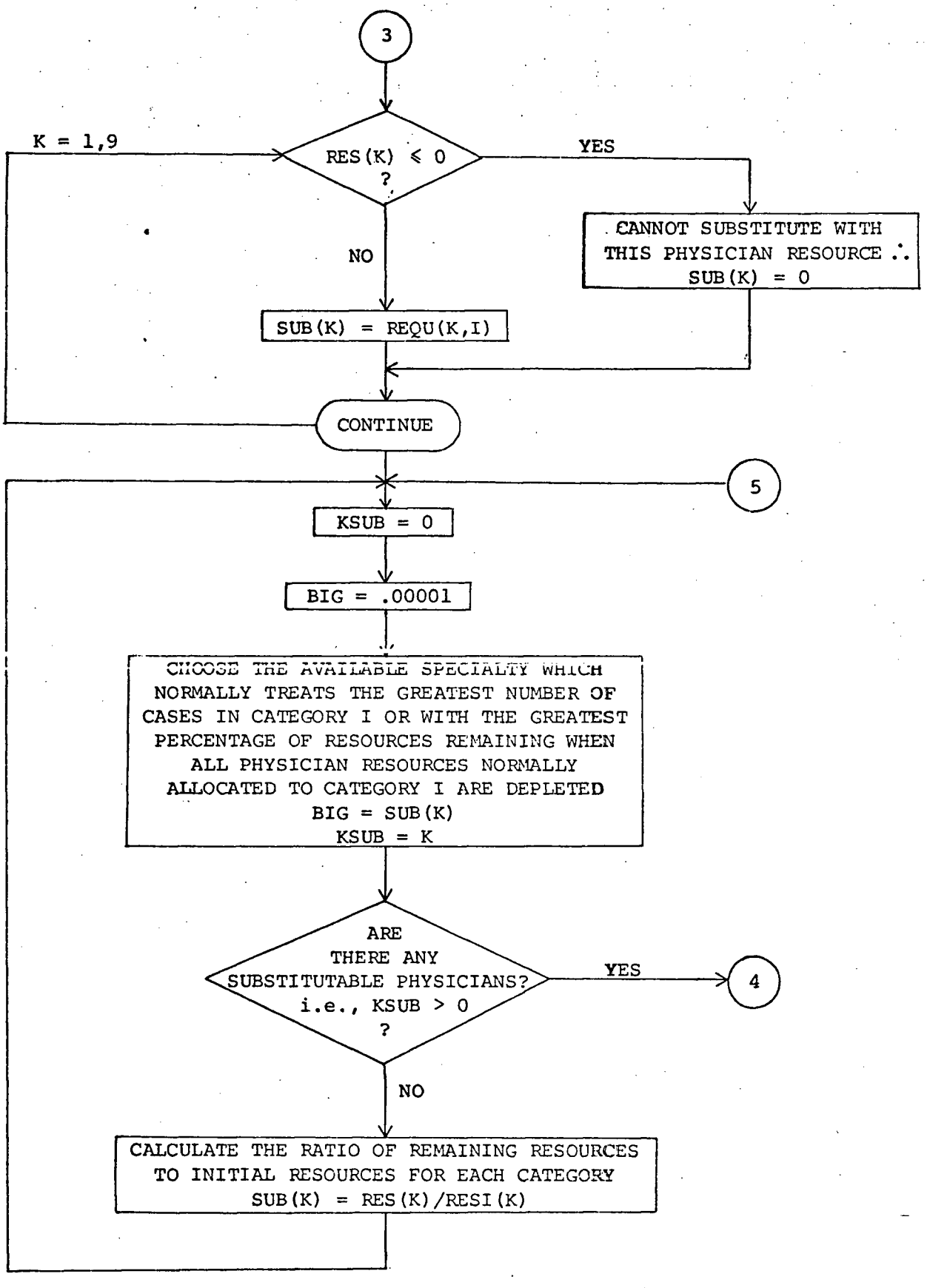
The flow chart is self-explanatory for the most part, except for the calculation of the equivalent number of untreated cases when a bed shortage exists for which physician resources cannot fully compensate. (see Section D)

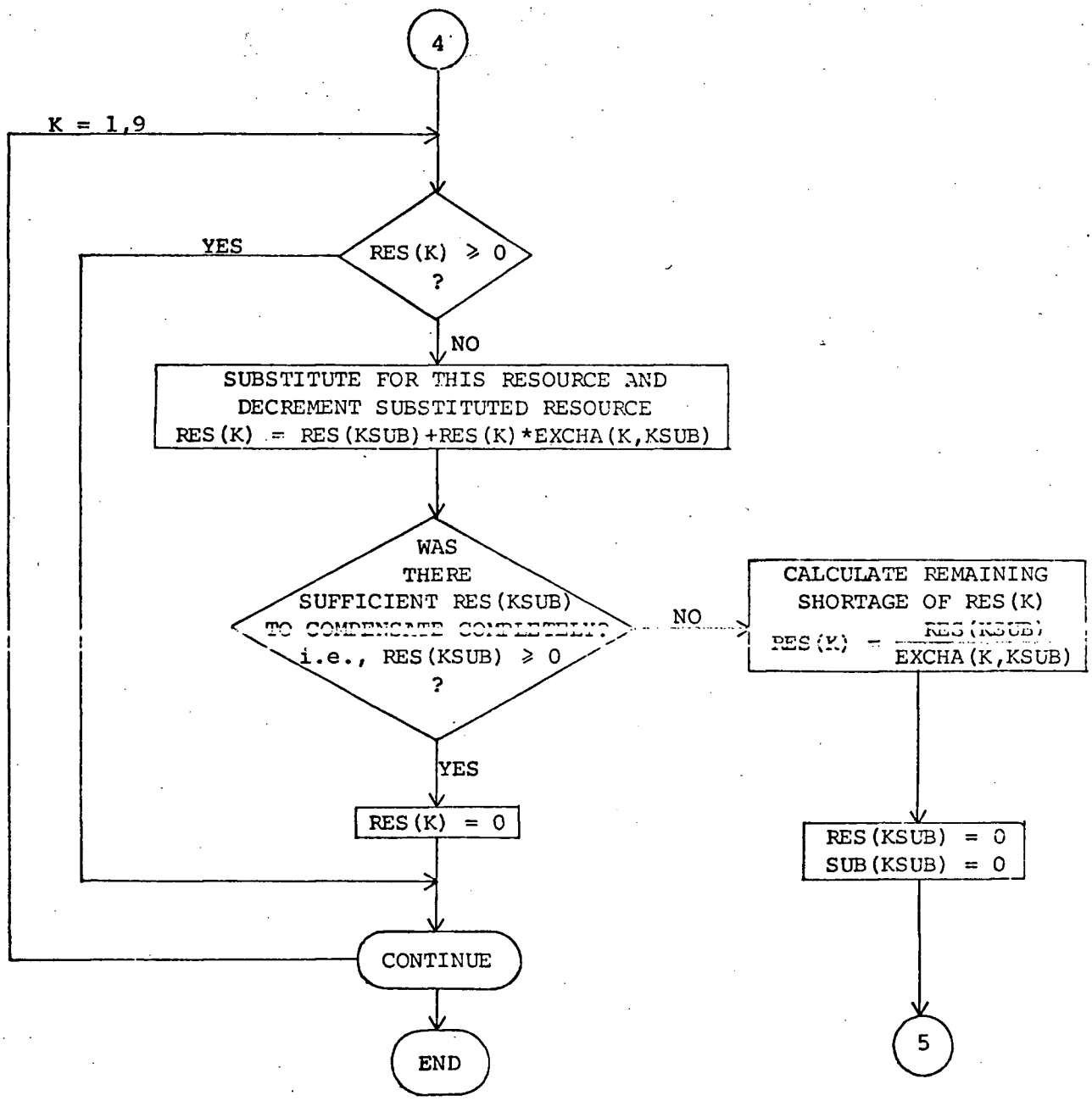
Each case requirement is assumed to be represented by one GP equivalent case requirement plus the GP equivalent of the case bed requirement, or

DELEGATION SUBROUTINE




1
RES(10) = 0
RESTORE NURSING SERVICES WHICH WERE ALLOCATED BUT NOT UTILIZED BECAUSE OF BED SHORTAGE
RES(11) = RES(11)-REQU(11,I)*BEDS
CALCULATE EQUIVALENT GP CASES WHICH COULD COMPENSATE FOR BED SHORTAGE
BEDS = BEDS*ALPHA
WORK = PHYS+BEDS
WORK > 0 i.e., CAN PHYSICIANS COMPLETELY COMPENSATE FOR BED SHORTAGE ?
YES
DECREMENT ALL APPROPRIATE PHYSICIAN RESOURCES
RES(K) = RES(K) + REQU(K,I)*BEDS
NO
CALCULATE EQUIVALENT NUMBER OF UNTREATED CASES
CAP = CAP-WORK/(1+ALPHA)
SET ALL PHYSICIAN RESOURCES TO 0
END
NO
2
IS THERE A SURPLUS OF PHYSICIAN RESOURCES? i.e., PHYS > 0 ?
YES
3


3
K = 1,9
RES(K) ≤ 0 ?
YES
CANNOT SUBSTITUTE WITH THIS PHYSICIAN RESOURCE ∴ SUB(K) = 0
NO
SUB(K) = REQU(K,I)
CONTINUE
5
KSUB = 0
BIG = .00001
CHOOSE THE AVAILABLE SPECIALTY WHICH NORMALLY TREATS THE GREATEST NUMBER OF CASES IN CATEGORY I OR WITH THE GREATEST PERCENTAGE OF RESOURCES REMAINING WHEN ALL PHYSICIAN RESOURCES NORMALLY ALLOCATED TO CATEGORY I ARE DEPLETED
BIG = SUB(K)
KSUB = K
ARE THERE ANY SUBSTITUTABLE PHYSICIANS? i.e., KSUB > 0 ?
YES
4
NO
CALCULATE THE RATIO OF REMAINING RESOURCES TO INITIAL RESOURCES FOR EACH CATEGORY
SUB(K) = RES(K)/RESI(K)


4
K = 1,9
RES(K) ≥ 0 ?
YES
NO
SUBSTITUTE FOR THIS RESOURCE AND DECREMENT SUBSTITUTED RESOURCE
RES(K) = RES(KSUB)+RES(K)*EXCHA(K,KSUB)
WAS THERE SUFFICIENT RES(KSUB) TO COMPENSATE COMPLETELY? i.e., RES(KSUB) ≥ 0 ?
NO
CALCULATE REMAINING SHORTAGE OF RES(K)
RES(K) = RES(KSUB) / EXCHA(K,KSUB)
YES
RES(K) = 0
RES(KSUB) = 0
SUB(KSUB) = 0
CONTINUE
END
5

(1 + ALPHA)GP equivalent cases. The number of deficit equivalent cases is given by WORK = PHYS + BEDS. Therefore the number of untreated cases is given by CAP - $\frac{\text{WORK}}{1 + \text{ALPHA}}$.

(e) Subroutine Fate

(i) Variable Definitions

HAPT(I,K) = the number of treated cases of category I resulting in outcome K.

HAPU(I,K) = the number of untreated cases in category I resulting in outcome K.

PHAPT(I,K) = the probability of outcome K for treated cases in category I

PHAPU(I,K) = the probability of outcome K for untreated cases in category I.

NHAP = the number of different possible outcomes.

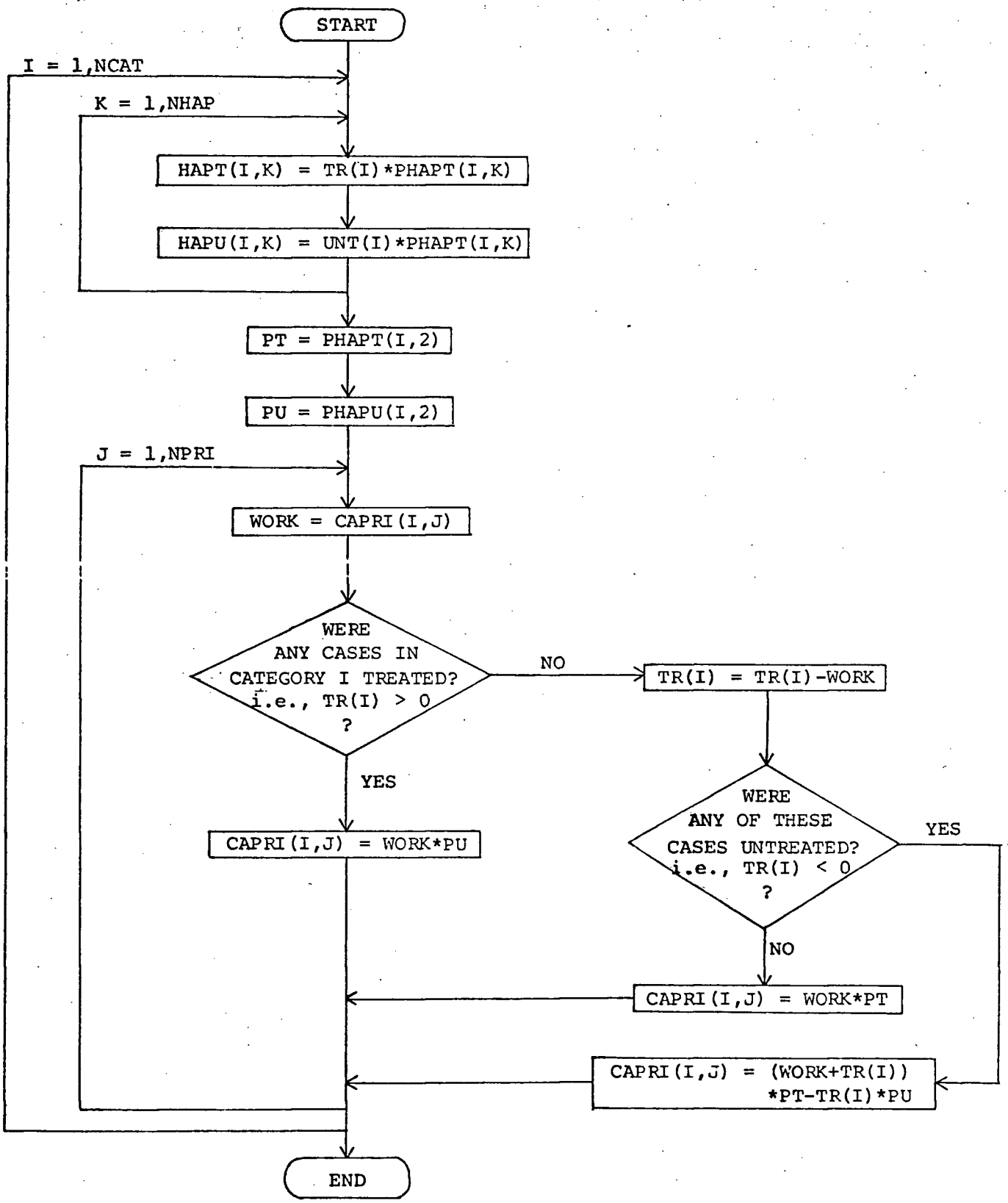
(ii) Program Logic

The subroutine calculates the various outcomes for all categories and the number of cases by category and priority to be carried over to the succeeding year.

At present only one possible outcome is considered (K = 2) for which treated and untreated cases return in the subsequent year for treatment.

PHAPT(I, 2) has been set equal to 0 and PHAPU(I, 2) has been set equal to 1.

FATE SUBROUTINE



CHAPTER VII. EXPERIMENTS

This chapter will present the results[1] of several pilot experiments which have been chosen to demonstrate some of the capabilities of the regional planning model. The experiments are designed to show the possible impacts of various resource growth rates and environmental factors. The impact is measured in terms of the social impact index and shortages or surpluses of resources.

Experiment 1

The model was run for a 25 year simulated time period, with projected regional population growth and constant resource growth rates of 1, 2, 3, 4, and 5%.

Various resources, even in the initial year of the simulation, were in excess of forecasted regional requirements, whereas others were in shortage. For illustrative purposes, obstetrician/gynecologist (OG) and urologist (UROL) resource surpluses (deficits) for a 4% constant resource growth rate are presented in Table 12.

Year	OBG visits	UROL visits
0	-22,230	15,026
5	-16,773	14,202
10	-54,340	8,657
15	-116,947	-3,150
20	-190,184	-22,434
25	-265,135	-49,464

Table 12. Obstetrician/Gynecologist and Urologist Resource Surpluses for a 4% Constant Resource Growth Policy

Since the model allows for substitution of various resources, the surplus resources compensating for deficit resources, an overall resource shortage, as reflected by a non-zero value of the social impact index, is not evidenced until years 4, 6, 8, 12, and 17 for the respective growth rates (Figure 4). The substitution process allowed in the model is paralleled in reality, since many specialists provide treatment for conditions which are not strictly in their field of specialization. This situation occurs frequently, as a number of specialists are also engaged, part-time, in general practice.

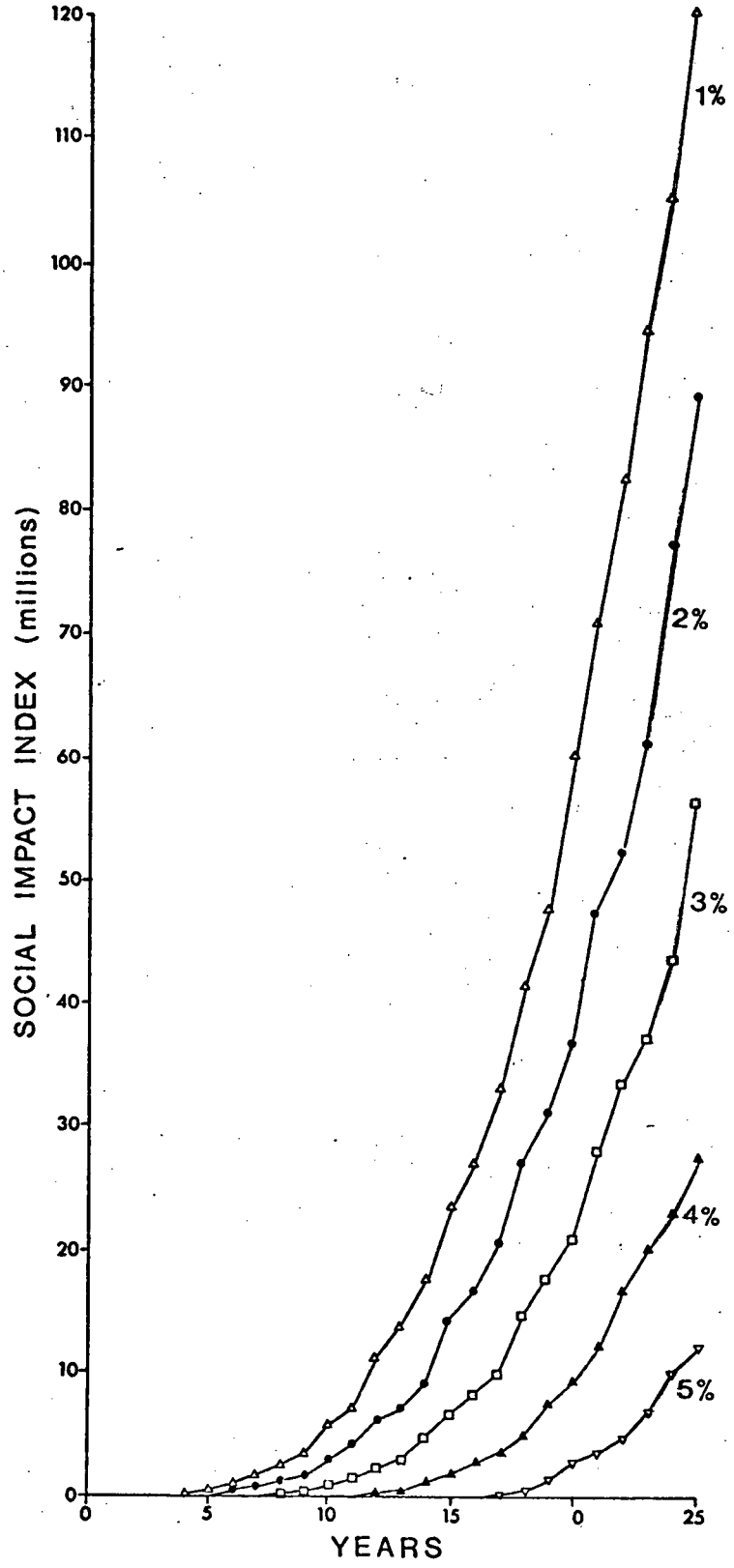


Figure 4: The Effect of Various Linear Growth Rates (for All Resources) on the Social Impact Index

For all five growth rates, the social impact index grows in an exponential or compound manner. This behaviour of the index is to be expected, since;

(a) the population and also the individual resource requirements increase at compound rates of approximately 4 - 5% (Table 13). As demand increases at a faster rate than supply, the shortages grow at an increasing rate.

(b) as the resource shortages increase, the untreated cases are of progressively higher priority classes. While all SIRS values within a given priority class are not greater than all SIRS values in lower priority classes, the average SIRS value increases as the priority class increases. The untreated cases are, therefore, generally weighted with increasing SIRS values, as the resource shortages increase.

(c) the present version of the model allows only one possible outcome, each, for treated and untreated cases. All untreated cases are returned for treatment with a probability of 1 and all treated cases are regarded as being completely recovered and are returned for treatment with a probability of 0. As resource shortages continue to increase, the cummulative effects of the demand carry-over increases the index at an accelerated rate.

While the untreated demands may properly be regarded as contributing to the social impact index in the year in which they are initially not met, it is not valid to assume that all such cases will be manifest as demands carried over into the subsequent year. Other outcomes such as death, partial recovery of treated and untreated cases, and the relapse of treated cases will,

therefore, be added to later versions of the model.

Experiment 2

The above experiment was repeated for compound resource growth rates. The first year in which overall system shortages were evidenced for growth rates of 1, 2, 3, and 4% were 4, 6, 9 and 22 (Figure 5). No overall shortage was evidenced for a 5% compound resource growth rate.

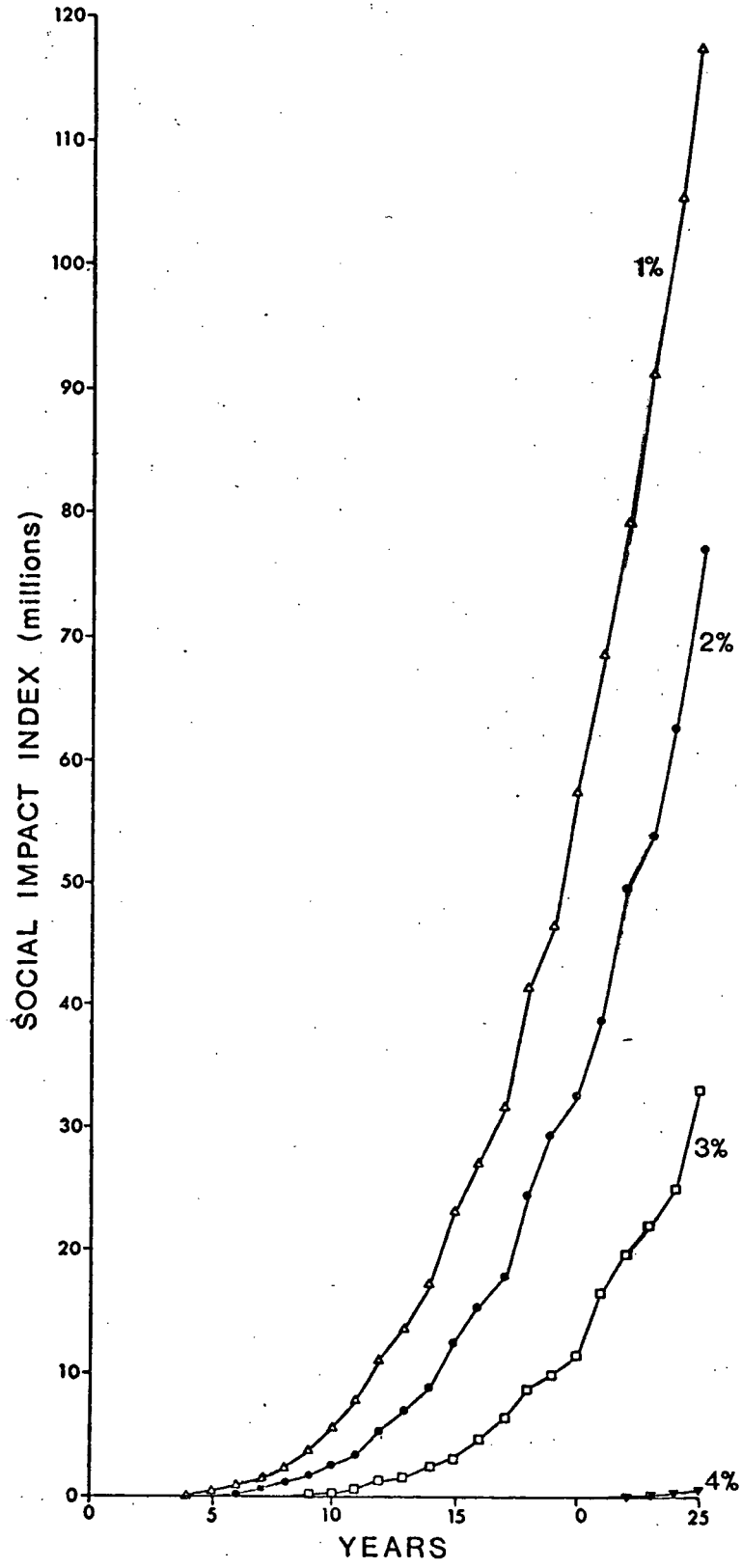


Figure 5: The Effect of Various Compound Growth Rates (for All Resources) on the Social Impact Index

In experiments 1 and 2, the social impact index has a value of 0 in the earlier years of the simulation, indicating that, overall, resources are initially in excess of regional requirements. This apparent surplus is largely due to the export of services to other regions, i.e. services utilized by patients referred to the Greater Vancouver region for treatment. Since the export of services has not been accounted for in the present version of the model, the results must be interpreted as the ability of regional resources to cope only with regional demands.

To obtain an impression of the manner in which regional resource requirements behave over time, the annual increases in resource requirements, for the projected population growth, are presented in Table 13. The more or less constant yearly increase in resource requirements is a result of a population growth rate which is approximately compounded at 4 - 5%, with very little change occurring in the age and sex structure.

In comparison, Table 14 illustrates the percentage change in resource requirements (for five year intervals) under conditions approximating zero population growth (no migration and births limited to 2 per susceptable women).

The following are some of the more important aspects observed in Table 14.

(a) As a result of a decrease in the birth rate, obstetrician/gynecologist resource requirements significantly decrease by 16.78% during the first five year period of the simulation. A decrease is again evidenced in the last five year period of the simulation, years 20-25. This decrease of 5.66% in the last five year period reflects the maturing of women who were born subsequent to the zero population growth intervention.

Table 13: Percentage Increases in Population and Resource Requirements* for Projected Population Growth

Years	Population	GP visits	IM visits	SURG visits	ORS visits	PED visits	OTO visits	OPH visits	OBG visits	UROL visits	Bed-days
1 - 2	4.58	4.55	4.56	4.38	4.48	4.45	4.57	4.64	4.96	4.66	4.38
2 - 3	4.58	4.55	4.56	4.38	4.48	4.47	4.58	4.64	4.97	4.67	4 36
3 - 4	4.59	4.56	4.56	4.40	4.50	4.45	4.59	4.63	4.95	4.67	4.38
4 - 5	4.60	4.60	4.59	4.43	4.51	4.55	4.60	4.68	5.12	4.68	4.49
5 - 6	4.62	4.63	4.59	4.48	4.55	4.62	4.62	4.40	5.12	4 69	4.53
6 - 7	4.63	4.68	4.62	4.56	4.60	4.73	4.63	4.70	5.19	4.70	4.68
7 - 8	4.65	4.70	4.64	4.57	4.61	4.74	4.65	4.71	5.24	4.71	4.69
8 - 9	4.66	4.72	4.65	4.55	4.58	4.75	4.66	4.72	5.31	4.73	4.67
9 - 10	4.68	4.74	4.68	4.57	4.59	4.80	4.68	4.76	5.38	4.75	4.72
10 - 11	4.71	4.79	4.70	4.63	4.65	4.86	4.71	4.78	5.41	4.77	4.80
11 - 12	4.72	4.82	4.73	4.65	4.66	4.91	4.72	4.81	5.35	4.78	4 83
12 - 13	4.74	4.83	4.75	4.65	4.66	4.93	4.74	4.83	5 33	4 80	4 82

* The key to physician abbreviations is given in appendix B

Table 13: -- Continued

Years	Population	GP visits	IM visits	SURG visits	ORS visits	PED visits	OTO visits	OPH visits	OBG visits	UROL visits	Bed-days
13 - 14	4.76	4.86	4.77	4.71	4.71	4.97	4.90	4.85	5.28	4.81	4.88
14 -15	4.77	4.86	4.79	4.68	4.68	4.96	4.77	4.89	5.18	4.82	4.82
15 - 16	4.77	4.86	4.78	4.69	4.69	4.97	4.77	4.87	5.01	4.82	4.78
16 - 17	4.77	4.84	4.79	4.69	4.69	4.96	4.77	4.89	4.79	4.81	4.74
17 - 18	4.75	4.82	4.77	4.65	4.65	4.93	4.75	4.87	4.58	4 80	4 65
18 - 19	4.73	4.79	4.75	4.65	4.65	4.91	4.73	4 85	4.35	4.78	4.59
19 - 20	4.70	4.75	4.72	4.60	4.60	4.86	4.70	4.82	4.15	4.75	4 49
20 - 21	4.67	4.71	4.68	4.58	4.58	4.83	4.67	4.78	4.00	4.71	4 43
21 - 22	4.63	4.66	4.64	4.53	4.53	4.78	4.63	4.74	3.85	4.67	4 36
22 - 23	4.58	4.61	4.59	4.49	4.49	4.73	4.58	4.69	3.71	4 63	4 28
23 - 24	4.54	4.57	4.55	4.46	4.47	4.69	4.54	4.64	3.64	4 58	4 25
24 - 25	4.50	4.52	4.50	4.39	4.40	4.62	4.50	4.60	3.56	4 54	4 18

Table 14: Percentage Increases in Population and Resource Requirements for Zero Population Growth

Years	Population	GP visits	IM visits	SURG visits	ORS visits	PED visits	OTO visits	OPH visits	OBG visits	UROL visits	Bed-days
0 - 5	.55	-.81	.29	-.77	-.20	-1.35	.55	.14	-16.78	.95	-5.93
5 - 10	1.24	1.13	1.06	.53	.72	.56	1.41	.87	7.11	1.58	1.28
10 - 15	1.96	2.07	1.89	1.46	1.46	1.95	1.92	1.73	6.66	2.25	2.42
15 - 20	1.99	1.86	1.96	1.38	1.34	1.85	2.04	1.84	.58	2.24	.94
20 - 25	.77	-.34	.66	.02	.04	-.27	.77	.53	-5.66	1.00	-1.84

The cohort of women with the highest fertility rates comprise a smaller proportion of the total population in this time period than in previous periods of the simulation.

(b) a similar result is evidenced in the requirement for pediatricians. The requirements decrease by 1.35% in the first 5 year period and the rate of increase has significantly declined from 1.85% in years 15-20 to 0.27% in years 20-25.

Experiment 3

As discussed in Chapter V, the use of constant ratios may not be an appropriate basis to plan for future health care delivery services. In order to determine to what extent this applies in the present case, bed day requirements/total regional population ratios were calculated. Table 15 shows these ratios for projected regional population growth over a 25 year period.

Year	Ratio	Year	Ratio	Year	Ratio
1	1.011	10	1.001	18	1.001
2	1.008	11	1.002	19	1.000
3	1.006	12	1.002	20	.997
4	1.004	13	1.003	21	.995
5	1.002	14	1.004	22	.992
6	1.001	15	1.004	23	.988
7	1.001	16	1.003	24	.985
8	1.001	17	1.003	25	.982

Table 15. Bed day requirements/total population for projected regional population.

As can be seen, the use of a constant value of approximately 1 bed day per person per year could adequately serve to determine regional bed requirements. However, in instances in which the underlying demographic variables undergo more radical changes, this may not be a very appropriate method.

The actual distribution of beds along functional lines

such as maternity, surgical and chronic care is not indicated at this level of granularity. Changes in population age and sex structure are likely to produce shifts in the demands for specific bed categories. Later more refined versions of the model will, therefore, classify beds and demands for beds by functional use.

Experiment 4

Little is known about the relationship between air pollution and morbidity. We may, however, parametrically examine the possible impact of air pollution on the performance of the health care system.

Lave and Seskin (42) suggest that a 50 percent reduction in air pollution in the major urban areas of the United States could result in a 25 percent reduction in morbidity and mortality due to all respiratory diseases. It was, therefore, felt that compound growth rates of up to 2% in the incidence of morbidity suspected of being related to air pollution would not be unreasonable to assume for the Greater Vancouver region, which currently experiences relatively low air pollution levels. Dominating factors 2 (gaseous air pollution) and 7 (particulate air pollution) were, therefore, allowed to increase in two separate runs of the model, at compound rates of 1 and 2%. (Figure 6).

While the effects of these exogeneous variables on the social impact index do not appear to be significant, it should be noted that some degree of caution must be exercised in interpreting the results. Changes in the social impact index provide a measure only of the ability of the health care system, with its predetermined priorities, to cope with any increases in demands as a result of the influences of the exogeneous variables. In many cases,

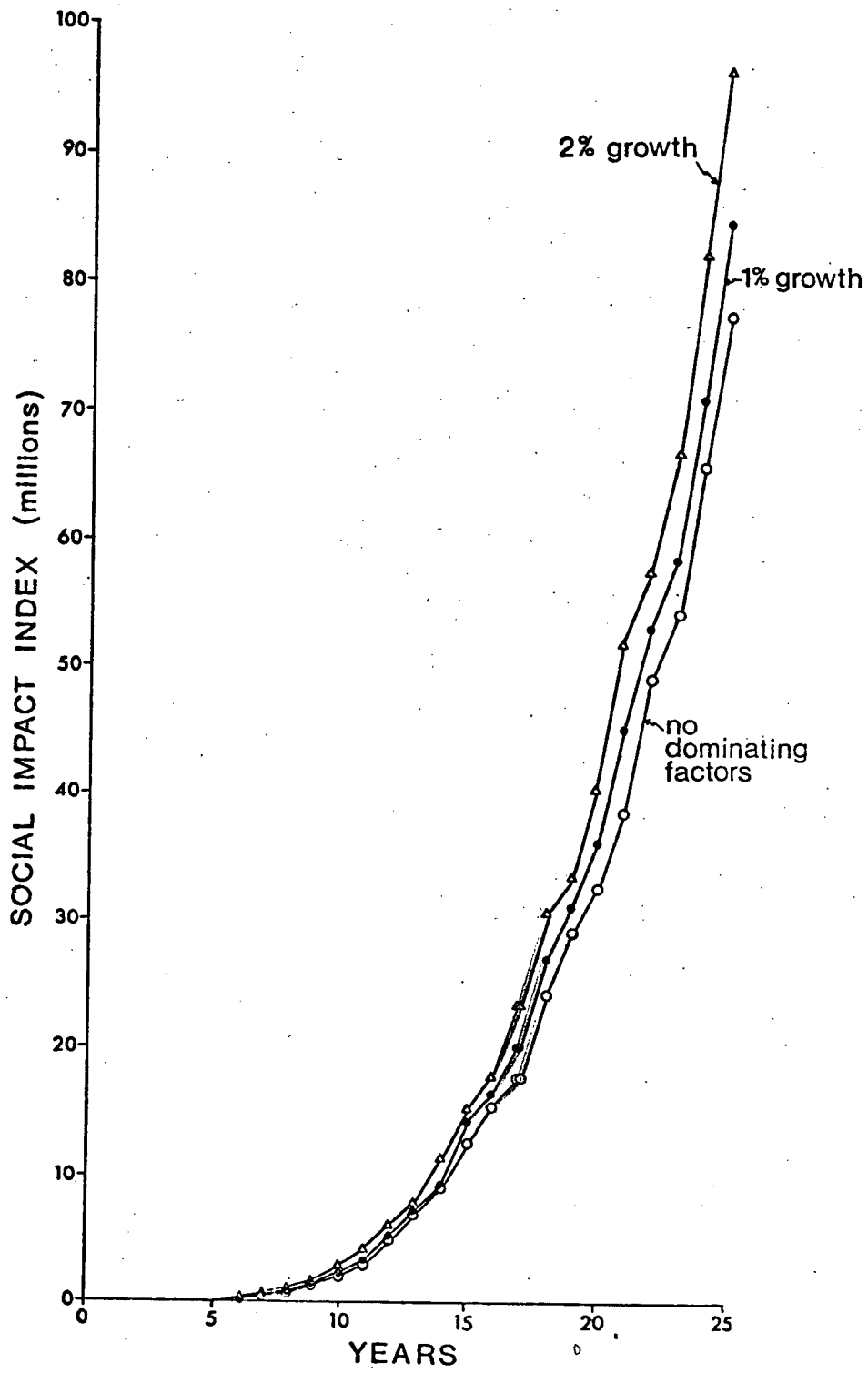


Figure 6: Social Impact Index for 1 and 2% Compound Growth in Air Pollution Related Morbidity

demands of lower priority may be displaced in order that resources may be allocated, in the model, to provide treatment for increased incidences of higher priority. In such cases, the index reflects the impact of the variables only in terms of an increase in untreated demands of lower priority. If the increased incidences receive treatment, no account is made of the discomfort, loss of social function, etc. experienced by these individuals. Only in the event that resources are insufficient to meet these increased demands, does the social impact index reflect more fully the seriousness of the increases in incidence.

The SIRS values which have been employed to derive the social impact index are measures of the public's perception of the seriousness of having specific conditions. These values do not differentiate between having a condition for which treatment is received and having a condition for which treatment is not received. In many cases, it is likely that the perceived seriousness of having specific conditions is influenced by perceptions of the effectiveness with which these conditions may be treated and the consequences of not receiving treatment. For these two circumstances the perceptions may be almost identical, in cases for which treatment is not perceived as being effective or may differ substantially, in cases for which the outcome may be dependent on whether or not treatment is received.

The above shortcomings of the social impact index necessitates a more refined approach. A methodology similar to that used in deriving the SIRS values should be employed to obtain values for

(a) the seriousness of having conditions for which treatment is received.

(b) the seriousness of having conditions for which treatment is not received.

Such measures would provide an improved weighting system for evaluating the social impact in terms of the ability of health care resources to meet demands. In addition, such measures would provide a means to measure the impact of exogeneous variables not only in terms of those who seek treatment, but also in terms of that segment of the population which are affected but which do not seek professional medical services.

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[1] Some of the results are also discussed in Ecological Planning of Health Care, I. Ventinsky and G. Povey, Unpublished Working paper of U.B.C. Health System Group.

CHAPTER VIII. FUTURE IMPROVEMENTS AND EXPERIMENTS

A. Extensions and Refinements

While, in its present stage of development, the described planning model can be utilized for demonstration purposes, further extensions and refinements are necessary before it can be operationally employed for real planning purposes in British Columbia. In addition to the extensions and refinements proposed in Chapter VII, this section will discuss other major improvements to the model.

(1) The present version of the model employs 27 aggregate demand categories. The weighting values used in deriving the social impact index are a composite of SIRS values. These composite values were arrived at on the basis of the relative composition of the aggregate demand categories in 1968, the base year of the simulation. The social impact index is, thus, insensitive to changes which may occur in the relative composition within the demand categories. In addition, resources are allocated on the basis of requirements for the aggregate demand categories. A change in the relative composition of a demand category may, in reality, require that the mix of required resources also change. It is, therefore, anticipated that a finer classification of the demand categories will be provided when compatible data become available.

(2) The simulation model employs visits as a measure of physician time utilization. The total number of available visits/year within each physician specialty is specified as the product

of the average number of visits/year/full time equivalent specialist and the number of full time equivalent physicians practicing in the specialty. Since the average time required per visit is not the same for all demand categories, visits may be an inappropriate measure of physician resource availability and utilization, especially if the composition of demand changes. Later versions of the model may, therefore, employ measures which better reflect physician time utilization.

(3) The logic of the current version of the model assumes that physicians may substitute for bed shortages. The ratio of substitution, ALPHA, is the same for all demand categories requiring hospital beds. For conditions requiring a major surgical procedure, physician time cannot substitute for the required hospital facilities. In other cases, the substitution which can be made differs between demand categories. The ratio of substituting physician resources for hospital beds should be reflective of the actual substitution which can be made in each demand category and in cases where substitution cannot be made, the demand should be regarded as being unmet. Future versions of the model will, therefore, attempt to correct this shortcoming.

(4) It is planned to expand the resource categories to include essential support services such as radiology, anaesthesiology, operating facilities, etc. This extension may also include alternative facilities and services such as private hospitals and chiropractor services.

(5) To provide a basis for cost-benefit or cost-effectiveness analysis, cost functions, both operating and capital, will be added to later versions of the model.

(6) If the social impact index is to reflect a social

evaluation of the ability of the health care system to meet demands, the shortcomings of the system should be examined in relation to the total demands placed on it. A normalized social impact index (SII) having the following form is proposed.

$$SII = \frac{\sum_i SIR(i)unt(i)}{\sum_i SIR(i)dem(i)}$$

where:

SIR(i) = the perceived seriousness of not receiving treatment for a condition in demand category i

unt(i) = the number of untreated cases in demand category i for which treatment is sought

dem(i) = the number of cases in demand category i for which treatment is sought.

By redefining the social impact index in this manner, a relative measure of system performance is obtained. The development of this index will necessitate obtaining data relating the number of visits/treated case or the number of incident cases for which treatment is sought/the total number of incident cases in each demand category. Further research will be required to define levels of system performance and to establish a correspondence between these levels and values of the social impact index.

B. Future Experiments

Some of the model's capabilities were demonstrated by the experiments presented in Chapter VII. These are but a few of the possible experiments which can be performed employing the model. This section will discuss two experiments which are now being planned.

(1) To date, only one priority system and one delegation routine have been employed in the model. There are numerous alternatives which may be studied. The sensitivity of the social impact index and resource shortages to priorities and delegation should be examined.

One aspect of medical care which is likely to be important in the future is the increased use of auxilary medical personnel. It is essential that the implications of an increased role for auxilary medical personnel be investigated.

The model offers one possible means of examining the economic implications as well as the maximum ability of given levels of physician resources to cope with demands when various delegations are allowed. The parameters to be used in the model may be a combination of data from empirical studies such as that of Uyeno (72) and subjectively extrapolated estimates.

(2) The present logic of the model assumes that current treatment patterns will persist in the future. Alternative patterns of treatment such as day care and satellite health centre services may have appreciable implications for future modes of health care delivery.

The model, with appropriate cost functions and estimates of the human and physical resource requirements/case, under alternative health care delivery patterns, may serve as a framework to study alternative capital and operating costs.

The institution of alternative patterns of treatment may relieve much of the commonly occurring demands of low medical priority which are placed on hospitals and other facilities. A complementary simulation should be developed to investigate the impact such changes will have on admission scheduling procedures

and the stability and mix of patient flows in hospital facilities.

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APPENDIX A - Major Pollutants

(a) Particulate Air Pollution

Little study has been made on the effect on health of specific particulate air pollution.

Some studies have indicated that carbonaceous soot is strongly associated with the incidence of gastric cancer and that asbestos particles are correlated with asbestosis and asbestos lung cancer.

(b) Carbon Monoxide

Carbon monoxide (CO), produced largely from the incomplete combustion of motor vehicle fuel has the highest concentration of any of the major gaseous pollutants.

In low concentrations specific symptoms are not evident. In high concentrations it can produce headache, vertigo, mental confusion, unconsciousness and death.

It is believed the CO may have an effect on some people with pre-existing medical conditions such as emphysema and coronary vascular disease. The evidence, however, is not conclusive.

(c) Sulfur Dioxide Air Pollution

Sulfur dioxide (SO_2), an industrial pollutant, is the major component of smog typical of London, New York and Tokyo.

Sulfur dioxide causes increased airway resistance and can adversely affect persons suffering from such respiratory diseases as chronic bronchitis, asthma, and emphysema. It has been correlated to chronic bronchitis deaths when particulate air pollutants are present.

(d) Photochemical Air Pollution

Energy from sunlight triggers chemical reactions of

hydrocarbon vapors and nitric oxide in the atmosphere to produce ozone, nitrogen dioxide and other photochemicals.

This form of pollution is characteristic of Southern California smog.

Ozone is highly toxic even in small concentrations and has been found to accelerate bacterial infections at low temperatures.

Other photochemicals can produce eye and respiratory irritation and other effects on the respiratory system, such as aggravating asthma and chronic bronchitis. It is also believed that they may have an effect on the cardiovascular system.

(e) Sewage

Sewage treatment has largely been concerned with reducing the transmission of communicable diseases such as typhoid fever, cholera and dysentry.

Primary and secondary sewage treatment is not effective in removing toxic heavy metals, detergents and nutrients.

Nutrients discharged into the waterways cause increased algae and other oxygen depleting plant growth. In a number of instances this excessive plant growth and organic pollution have resulted in the death of numerous fish.

(f) Mercury

Many organic mercury compounds from industrial and agricultural sources and inorganic mercury from industrial sources may be converted to methyl mercury by natural processes after they have been discharged into the waterways.

Methyl mercury is both highly toxic and stable and can be concentrated in biological tissues.

Organic mercury has been widely reported in fish and birds

and in isolated cases has resulted in human deaths from the consumption of food containing it in excess levels.

(g) DDT

DDT and other insecticides are carried great distances from their original sources by air and water with the result that organochlorine residues are widely distributed over the earth.

These residues are concentrated through the food chain, DDT occurring with an average of 12 ppm in human fat in the United States. (59)

DDT is suspected to be correlated with liver cancer and deaths due to hypertension and leukemia.

APPENDIX B - Available Resources in the First Year

Resource		Visits/year
1.	General Practitioner (GP)	3,922,424
2.	Internal Medicine (IM)	438,504
3.	Surgeon (SURG)	411,136
4.	Orthopedic Surgeon (ORS)	142,956
5.	Pediatrician (PED)	318,384
6.	Otolaryngologist (OTO)	286,286
7.	Ophthamologist (OPH)	202,048
8.	Obstetrician/Gynecologist (OBG)	218,240
9.	Urologist (UROL)	83,160
	Total graduate nurse bed days	399,483
	Available bed days (at 100% occupancy)	2,000,930

Demand Category	Hospital Bed Days/Incidence	Incidence/100 Population [Male / Female]			
		Under 6	6 - 16	17 - 44	45 & Over
Infective and Parasitic Diseases	.203	50.9 46.9	37.9 33.8	14.6 20.1	7.3 9.9
Common Cold	0	51.0 55.9			
Influenza	.024	34.8 37.7	40.7 39.6	29.2 41.9	24.2 24.6
Bronchitis	.325	13.5 9.0	3.8 3.3	2.4 3.2	2.5 2.5
Other Respiratory Conditions	.041	151.4 198.2	81.2 132.2	47.7 106.2	35.6 67.7
Digestive System Disorders (Acute)	2.785	14.8 13.1	8.7 9.6	7.0 9.1	7.0 6.0
Injuries and Adverse Effects	1.272	43.7 32.3	38.2 21.9	37.4 24.5	22.0 21.0
Diseases of the Ear	.607	4.9 4.6			
Genitourinary Disorders	7.883	0.8 5.4			
Diseases of the Skin	1.780	2.2 3.0			
Diseases of the Musculo-skeletal System	5.725	1.6 2.7			
		Under 45	45 - 64	65 and Over	
Heart Conditions and Hypertension	8.682	1.6 2.2	12.5 17.4	26.4 39.5	
Arthritus and Rheumatism	1.030	1.0 2.1	1.4 20.8	25.3 39.3	

APPENDIX C - Incidence Rates and Hospital Bed Requirements

Demand Category	Hospital Bed Days/Incidence	Incidence / 100 Population [Male / Female]		
		Under 45	45 - 64	65 and Over
Digestive Conditions (Chronic)	2.467	3.9 3.0	13.7 11.6	22.4 20.0
Visual Impairments	1.395	1.1 1.4	3.9 4.1	12.8 16.2
		Visits/100 Population		
Medical and Surgical After Care	-----	46.1		
Medical or Special Examination	-----	200.0		
Prophylactic Innoculation	-----	35.0		
Non-Endocrine Obesity	-----	8.4		
Diabetic Mellitus	.460	11.6		
Neoplasms	.260	11.7		
Well Baby and Child Care	-----	35.0		
Other Visits to Opthamologist	-----	11.0		
Other Visits to Otolaryngologist	-----	5.4		
		Visits/Delivery		
Post-partum Observation	-----	1.27		
Prenatal Care	-----	3.90		
Deliveries and Disorders of the Puerperium	5.9	----------		

APPENDIX C - Continued

Demand Category	Visits/Incidence or Proportion of Visits Seen by Specialty								
	GP	IM	SURG	ORS	PED	OTO	OPH	OBG	UROL
Infective and Parasitic Diseases	.018				.072				
Bronchitis	.901				.430				
Common Cold					.010				
Influenza	.085								
Other Respiratory Conditions	.247	.017			.110				
Digestive System Disorders (Acute)	.260	.028	.476		.115				
Injuries and Adverse Effects	.175		.260	.261	.071		.015		
Diseases of the Ear					.209	.117			
Genitourinary Disorders		1.901		.847				1.333	1.236
Deliveries and Disorders of the Puerperium	.193							1.426	
Diseases of the Skin	2.697								
Diseases of the Musculo-skelatal System				2.813					
Heart Conditions and Hypertension	4.763	6.668							

APPENDIX D - Physician Resource Requirements

Demand Category	Visits/Incidence or Proportion of Visits Seen by Specialty								
	GP	IM	SURG	ORS	PED	OTO	OPH	OBG	UROL
Arthritis and Rheumatism	.252	.343		.083					
Digestive Conditions (Chronic)		.145	.276						
Medical and Surgical (Aftercare)	.18	.12	.36	.08	.02	.05	.06	.09	.05
Medical or Special Examination	.75	.20			.01		.03	.01	
Prophylactic Innoculation	.50				.50				
Prenatal Care	.32							.68	
Well Baby and Child Care	.31				.69				
Visual Impairments							6.223		
Non-endocrine Obesity	.70	.22						.08	
Diabetic Mellitus	.50	.49					.01		
Neoplasms	.35	.36	.12	.03		.02		.12	
Post partum Observation	.30							.70	
Other Visits to Otolaryngologist						3			
Other Visits to Ophthamologist							1		

APPENDIX D - Continued

APPENDIX E - Priority Matrix

Demand Category	Priority 1	2	3	4	5	6
Infective and Parasitic Diseases	.2	.6	.2			
Bronchitis		.1	.1	.2	.6	
Common Cold				.1	.2	.7
Influenza			.1	.2	.7	
Other Respiratory Conditions				.2	.6	.2
Digestive System Disorders (Acute)		.1	.2	.5	.2	
Injuries and Adverse Effects	.4	.3	.2	.1		
Diseases of the Ear		.2	.3	.3	.2	
Genitourinary Disorders		.2	.3	.3	.2	
Deliveries and Disorders of the Puerperium	.8	.2				
Diseases of the Skin			.1	.2	.7	
Diseases of the Musculoskeletal System		.2	.3	.3	.2	
Heart Conditions and Hypertension	.5	.2	.2	.1		
Arthritus and Rheumatism		.1	.3	.3	.2	.1
Digestive Conditions (Chronic)	.1	.1	.3	.3	.2	
Medical and Surgical Aftercare	.1	.2	.3	.3	.1	
Medical or Special Examination				.1	.1	.8
Prophylactic Innoculation				.1	.1	.8
Prenatal Care			.1	.2	.6	.1
Well Baby and Child Care				.1	.1	.8
Visual Impairments			.2	.2	.2	.4
Non-endocrine Obesity					.2	.8
Diabetic Mellitus	.3	.4	.3			
Neoplasms	.8	.2				
Post partum Observation	.3	.4	.3			
Other Visits to Otolaryngologist		.1	.1	.2	.2	.4
Other Visits to Ophthamologist					.1	.9

APPENDIX F - Substitution Exchange Ratios

The rate of exchange between physician visits i to j (the amount of physician visits i needed to substitute for 1 visit of physician j) is calculated on the bases of work load ie

$$EXCHA(i, j) = \frac{\text{work load(daily visits) of physician i}}{\text{work load(daily visits) of physician j}}$$

The exchange ratios are given in the table below.

EXCHA(I, J)

	1	2	3	4	5	6	7	8	9
1	1	1.40	1.66	1.24	1.06	1.25	1.29	1.37	1.51
2	.71	1	1.18	.88	.75	.89	.92	.97	1.08
3	.60	.85	1	.75	.64	.76	.78	.83	.91
4	.81	1.73	1.34	1	.85	1.01	1.04	1.10	1.22
5	.95	1.33	1.57	1.18	1	1.19	1.23	1.30	1.44
6	.80	1.12	1.32	.99	.84	1	1.03	1.09	1.21
7	.77	1.09	1.28	.96	.82	.97	1	1.06	1.17
8	.73	1.03	1.21	.91	.77	.92	.95	1	1.11
9	.66	.93	1.09	.82	.70	.83	.85	.90	1

N. B. Physician specialty numbers are the same as given in Appendix B

APPENDIX G - Seriousness of Illness Rating

Demand Category	Index Rating
Infective and Parasitic Diseases	190
Bronchitis	270
Common Cold	67
Influenza	230
Other Respiratory Conditions	250
Digestive System Disorders (Acute)	160
Injuries and Adverse Effects	450
Diseases of the Ear	204
Genitourinary Disorders	506
Deliveries and Disorders of the Puerperium	550
Diseases of the Skin	55
Diseases of the Musculoskeletal System	400
Heart Condition and Hypertension	650
Arthritus and Rheumatism	444
Digestive Conditions (Chronic)	550
Medical and Surgical Aftercare	350
Medical or Special Examination	59
Prophylactic Innoculation	59
Prenatal Care	150
Well Baby and Child Care	150
Visual Impairments	350
Non-endocrine Obesity	267
Diabetic Mellitus	570
Neoplasms	650
Postpartum Observation	550
Other Visits to Otolaryngologist	230
Other Visits to Ophthamologist	230

APPENDIX H - Dominating Factors

Demand Category	Dominating Factor
Infective and Parasitic Diseases	1
Bronchitis	2
Influenza	1
Other Respiratory Conditions	2, 7
Digestive System Conditions (Acute)	3
Injuries and Adverse Effects	4
Diseases of the Ear	5
Heart Conditions and Hypertension	6
Visual Impairments	7
Non-endocrine Obesity	6

Key

1	Crowding
2	Air Pollution (gaseous)
3	Water Quality
4	Traffic Accidents
5	Noise
6	Nutrition
7	Air Pollution (particulate)