STUDIES IN

HEALTH ECONOMICS

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FOREWORD

The author of this study has during his work been associated with the section of Public Administrations at the Economic Research Institute, Stockholm School of Economics.

At the same time he has been employed by The Swedish Planning and Rationalization Institute of the Health and Social Services where he has gained valuable experiences for this study.

Rune Castenäs Director of the Institute	Thomas Thorburn Professor Section for Public Administration

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First of all I wish to thank professor Thomas Thorburn of the Stockholm School of Economics for all of his advice and encouragement.

This book has developed during the many years I have been a research associate at Spri (The Swedish Planning and Rationalization Institute of the Health Services). Spri is devoted to research and development activities for the health services in Sweden. An example of the work of Spri is the basis for chapter four here on computerized tomography; Spri report 9/76. Spri is characterized by its many comitted investigators. There is no doubt they have served as an essential stimulus for the work that is presented here. I am grateful to have the opportunity to work in such an environment and wish to thank all my colleagues at Spri.

This book contians a number of separate studies. Each of chapters two, three and four are based on several earlier published studies. However, no one of these are presented directly here since that material is restructured and adjusted to the overall context of the book. I owe thanks to all of my co-authors of these original studies; Bernhard S. Bloom, Marie-Louise Dolk, Ture Holm, Lars-Åke Marké, Duncan Neuhauser and Ulla Åhs. I also want to thank the doctors and nurses of Melrose-Wakefield Hospital, Mass., U.S.A. and of Landskrona Hospital in Sweden for their support in data collection for chapter two.

I want to express a deeply felt thanks to my colleague at Spri, Melinda Öjermark. She has sacrificed so many evenings to correct my English and has contributed with so many valuable thoughts.

Stockholm September 1980

Egon Jonsson

CONTENT

1 INTRODUCTION

During the last few decades, the Swedish public health care sector has been greatly expanded. In qualitative terms this has led to better preparedness, care and service for more and more people. Quantitatively, it has led to greater capacity, a larger arsenal of diagnostic and therapeutic alternatives, a wider range of services, and to rapidly rising costs. At present, about ten per cent of the gross national product goes to health care. Claims for more resources for health and medical care are in prospect. However, demands are increasing from other sectors of society as well, and it is doubtful whether the share allocated to the health care sector will be allowed to increase at the same rapid pace as before. There seems to be a general consent among the responsible physicians and politicians that new claims will be met by counterclaims for economizing with existing resources. Many health professionals also experience that desired developments within health care nowadays are less restricted by the present state of medical knowledge and the availability of medical technology than by the supply and coordination of resources for health.

In this context it is crucial that policy options for health care be identified and evaluated not only in terms of their risks and benefits but also in terms of their accompanying resource requirements. These assessments will require increased knowledge of the magnitude and composition of health services resources and their relation to the benefits derived from efforts to prevent, cure and alleviate disease and disability.

Two concepts fundamental to the practice of health and medical care are <u>benefits</u> of the patient and the associated <u>risks</u> of achieving these. Fundamental to economics is the ever-existing consideration of scarce <u>resources</u>, their efficient use and just allocation. This latter dimension is considered in the studies presented in this thesis as they deal with health issues from an economic perspective. This introductory chapter outlines the frame of reference from which the studies presented have emerged.

1.1 Framework of judgement of performance

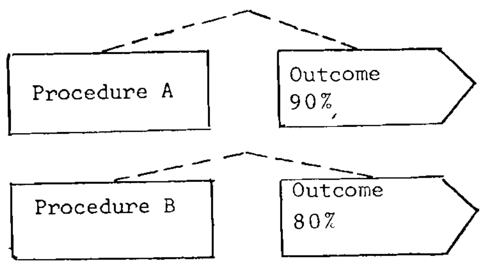
1.1.1 Medicine

"When responsible for serving and caring for the individual patient, the physician is obliged to make every effort, applying all available resources, until convinced that the battle has been lost: i e until he has identified the margin of the impossible for that patient" (1).

Medicine, deeply rooted in the values expressed in the Hippocratic Oath (2) is a synthesis of the natural sciences and humanistic ideals. One of its underlying assumptions is that the physician must do everything possible for the individual patient. To practice the art of medicine is, somewhat simplified, to do what is best for each individual patient. A good diagnostic work-up is one which is as accurate as possible in identifying the cause of a symptom, in locating the disease and in determining its prognosis. The best therapeutic measure is the one which improves the prognosis the most, cures, relieves and rehabilitates the patient, while entailing a risk which does not exceed what is considered acceptable by the patient or the medical profession.

The medical effectiveness of a particular procedure - diagnostic or therapeutic - might be simplified as in figure 1. The two procedures may represent alternative diagnostic or therapeutic measures or entire medical processes for an individual patient with a given disease. The outcome may represent the effects of these procedures on the health status of the patient. Assuming equal risks and quality procedure A is preferred since it here yields a 90 percent probability of attaining a desired outcome as compared with an 80 percent probability associated with procedure B.

Figure 1*



1.1.2 Economics

"As we develop more and more practices that may be beneficial to the individual but not to the interest of society, we risk reaching a point where marginal gains to individuals threaten the welfare of the whole." (3).

Many health practices have hitherto evolved without interference from the basic principle of economics, that is, that all resources are scarce. The need to economize with health care resources implies the necessity of rationing between different needs or competing ends. The evaluation of different medical procedures from an economic perspective would ideally involve a comparison of resource inputs related to outcomes. In theory, the approach is essentially to identify, measure and evaluate all relevant inputs and relate them to their outcomes. However, the calculation of advantages and disadvantages may be difficult in practice. Within medicine, it is often difficult even to identify clear-cut outcomes. Due to biological and environmental factors contributing to patient heterogeneity, it is even more difficult to establish a general and clear relationship between input and outcome.

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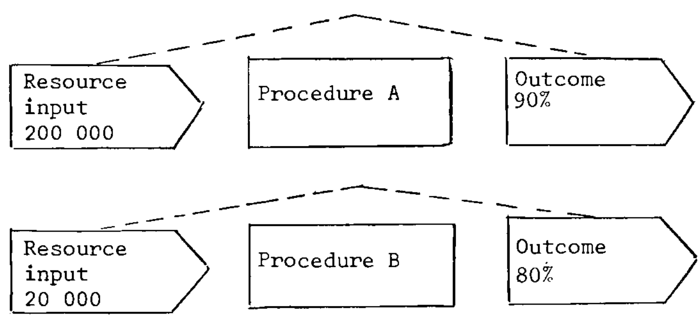
* The reality is much more complex than this model implies. The simplification here aims at illustrating the differences between medicine and economics, in the framework of judgment of performance. Resources are not included as part of the problem so far.

In introducing resource requirements - as an additional element to be considered in the judgment of performance - to the foregoing model, difficulties arise in determining which procedure is most effective. These difficulties include ethical dimensions. In figure 2, the resource requirements are arbitrarily assigned.

Figure 2



It is no longer à priori given that procedure A will be preferred as is illustrated in figure 2, since consumption of resources implies sacrifies of alternatives. What is consumed for one patient - or a group of patients - can be considered to undermine the conditions for others also in need of health services.

To judge which of the above options is most effective depends on, among other things, from which level of decision making the situation is viewed. From the politician's point of view the limited resources available must be allocated in such a way that the greatest possible benefits are achieved for as many patients as possible. In contrast to the social perspectives reflected in this type of decision making there are the individually-aimed considerations of the physician and other health professionals who wish to provide the maximum for each patient. There is an evident conflict between the ambition to do everything possible for the individual patient and the fact that resources are scarce. However, better knowledge regarding the amount and composition of the resource inputs and their relation to expected or actual outcomes could contribute substantially to the problems of priority setting at different decision levels. As was implied, a main condition for determining these relationships is the availability of measures describing and relating inputs to outcomes derived from the objectives of health services.

1.1.3 Objectives

The main objective of health care has traditionally been to prevent immediate death and to cure disease. This is still valid although a successively larger part of the work within health care now aims to prevent, alleviate and rehabilitate disease and to postpone disability and suffering, thus, to maintain quality of life. The objectives - partly conditioned by the values of society in different periods of time - are carried out in practice through medical ethics.

The main measurements used to evaluate the overall achievement in providing health care and services are crude and not always directly related to the objectives of health care. Within health services research, measurement of performance has primarily focused on quantity of services provided. During recent decades, however, increasing efforts have also been focused on the assessment of qualitative aspects of performance. This more subjective area of assessment poses many difficulties since there are many dimensions of the concept of quality and no universal definition of quality exists. However strict the criteria applied to measure quality of care or any of its equivalents are, such as "adequate", "acceptable" or "good" care, these fail in some degree as they ultimately rely on values referrable to the assessor and involve subjective judgments of the results of the patient-physician interaction. The following definition from a textbook in medicine would, however, probably be approved by many medical professionals:

"Good medical care is the kind of medicine practiced and taught by the recognized leaders of the medical profession at a given time or period of social, cultural and professional development in a community or population group" (4).

Such an explicit definition of good medical care, as well as the values inculcated in the teaching of medicine-"science and proven experience" (5) - suggest a source for a standard applied in defining quality and in making assessments of quality; namely, that quality medical performance should reflect the standards set by medicine's recognized leaders and/ or that which follows from science and proven experience.

The rapid growth in costs for health care has begun to link quality of care assessment to the assessment of corresponding resource requirements. This mergence of assessment interests requires finding a compromise between two crucial questions: does the health care provided benefit the individual and does it benefit society?* "Whether to maximize at the micro level or at the macro level of the health services system, or whether to coalesce the two levels to the extent possible, is a matter of social policy which incorporates elements of economics and philosophy" (6).

1.1.4 Decision levels and judgement of performance

The consideration of costs in the judgment of health care performance introduces not only problems of measurement but also a conflict in definitions of "good" care or quality of care and a conflict in values. The individual patient may desire health at whatever the cost. Likewise the physician is not trained to make decisions by weighing costs against improved quality, but rather to help individual patients and to achieve the desired objectives. The perspective of the economist - as

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* Society or community here representing all patients. Since resources are scarce the best care possible given to an individual patient may result in some other patients being deprived of care.

as well as the politician, planner and administrator - on the other hand, is primarily focused on equitable distribution of a limited supply of services for all*.

These different perspectives make the already elusive task of measuring performance or quality of care even more difficult. In practice good health care quality may mean, to the administrator, an optimal organization of services within a limited budget, the elimination of waiting lists and queues or adequate year-round staffing. To the physician it may mean the availability of medical technology for improved diagnostic accuracy and, the skills and resources necessary to implement highly effective therapy in the care of the individual patient. To the patient quality is synonymous with relief from and elimination of the physical, mental and social discomforts of disease. A definition of quality of care and a measurement instrument for its evaluation should attempt to satisfy all of these viewpoints. However, several researchers indicate that it is doubtful whether a universally acceptable definition of quality of care could be developed (10, 11, 12).

Measurement of quality of care has often been conceptualized in terms of structure, process and outcome. This classification system describes the types of elements which might be measured (13). Structure, process and outcome can also be used to illustrate decision making levels within the health services system and to distinguish areas of performance.

Structure refers to the adequacy and accessability of the physical facility and its equipment as well as the adequacy of staffing, administration and the information system. In terms of decision making regarding structural features of the health care delivery system, the planner and administrator have central roles. The inputs concerned are resources, measured in monetary terms as well as other quantities.

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* Lower cost does not predetermine low quality of care. Numerous disease-specific studies have illustrated that spending can be reduced substantially with no discernible loss in benefit to the individual patient (7, 8, 9).

Process refers to the interaction between the patient and the health care providers. This area of performance most frequently deals with the medical management of the patient. The measurements can reflect the capability of the health care provider in relation to norms or desired standards of care. Process is thus the domain of the physicians, nurses and other personnel directly involved in patient care. The inputs provided are clinical and interpersonal skills as they relate to patient care.

The outcome of care for the patient is, to varying degrees, the result of structure and process performance. It encompasses not only measures of morbidity and mortality but also proximate measures such as patient satisfaction and quality of life factors. The patient inputs in the care process are partly voluntary as in the case of patient compliance and attitudes to care, and partly involuntary - in the form of genetic and environmental factors particular to the individual.

Figure 3. Review of elements of structure, process, outcome and related decision makers and inputs (37).

	ELEMENTS	DECISION MAKING DOMAIN	INPUTS
STRUCTURE	Facility Equipment Staffing Administration Organization	Planners Administrators (Physicians)	Resources
PROCESS	History Physical Diagnosis Therapy Follow-up Rehabilitation Patient education	Physicians Nurses Other providers	Clinical skills Interpersonal skills
OUTCOME	Mortality Morbidity health status functional status Quality of life	Patient	Genetic factors Environmental factors Compliance

1.2 Measurement problems

Some of the problems in introducing economic considerations in the assessment of health care may be referable to the resource input side: the relevant variables and their measurement and evaluation. However, the main difficulty is to relate resource inputs to one or several measures of the effects or outcomes of these. Although a number of more or less clinically-oriented measures have been developed and recorded, it is far from given that they could directly be related to resource inputs or vice versa. The clinical measures of performance can be classified into those referable to the process; the handling of patient - and those referable to outcome; the final effect on the patient's health. There are also a number of performance measures which assess the adequacy of the structure of the system, including the magnitude and composition of the resource inputs. These structural measures generally reflect the utilization of the services but are sometimes also used as indicators of the total effects of the services.

1.2.1 Resource inputs

The first step in the measurement of inputs is to make these explicit. This involves the identification of all relevant input variables, the quantification of these and also, as far as possible, the translation of the identified and quantified variables into monetary terms.

It is common to calculate resource inputs in terms of costs referable to the medical care organization only, such as costs of personnel, facilities, equipment, material, service and maintenance and indirect cost such as administration, cleaning, heating, etc. It may also be essential to consider "costs" - or sacrifices of resources - which are not directly referable to the health and medical care organization. In some priority questions it may be valid to account for input of resources from other fields of activity, such as social welfare, care of the aged and home care, as well as for the various sacrifices that patients and their relatives have to make in the process of obtaining care, such as travel time, waiting time and loss of working time. In addition to the question of when it may be valid to consider sacrifices made outside of the health and medical care system, there arise problems as to how these can be measured and evaluated. Usually there are market prices on the goods and services provided by the health care system but this is not always the case when the concept of resource inputs is broadened.

The kinds of inputs to be taken into account depend upon the point of view taken. In making different kinds of inputs much more explicit, however, this information may alter the individual's choice as well as society's priority setting, particularly when it comes to the organization of health services - short term/long term care, inpatient/outpatient care - and also regarding decisions as to whether to interfere in populations, for example, by means of screening programs.

1.2.2 Structural measures of performance

In the practical work of health care administration, a variety of different measures are used today to describe the scope of the activities as well as to specify resource utilization. The most common measures of this type used within Swedish health care are number of outpatient visits, number of admissions to inpatient care, average length of stay, number of diagnostic and therapeutic procedures, number of bed-days, bed occupancy, cost per patient, cost per bed-day and cost per visit. Other measures used to a varying extent include median length of stay, preoperative and postoperative lengths of stay and various types of indices and point counts.

These measures do not necessarily indicate effectiveness of performance with respect to outcome. Measures of performance must be chosen with care if they are to be regarded as indicators of outcome or effectiveness. The objective is not the performance itself - for example, of a certain number of X-ray examinations, laboratory tests or operations - but their effects on the patient in various respects.

The weakness of these common performance measures as indicators of effectiveness are well documented (14, 15). Many of the measures stand in a mutual dependency on each other due to their purely statistical relationship. This is particularly true for the most widely-used measures: bed occupancy, average length of stay and number of patient days.

Bed occupancy statistically decreases with shorter lengths of stay. This measure does not always correspond to an increase or decrease in resource inputs since length of stay can be decreased if resources are increased. Correspondingly, no decrease in bed occupancy is reflected with increased lengths of stay. The bed occupancy rate also depends on activities outside the wards. In recent years the trend has been toward many empty beds over the weekends. Since operating costs are substantially higher than capital costs at acute hospitals and since the former are dominated by personnel costs, continuous operation over the weekends would be expensive. If the hospital wards were to be fully occupied even during weekends, then from a practical standpoint all other activity - surgery, laboratory, X-ray and other services - should continue as on weekdays. This should in fact be more justified since capital costs in these latter departments are relatively higher than those for the wards.

Average length of stay is used in several ways as a measure of performance of different health service delivery units. The aim is to keep the average length of stay as short as possible when this is seen as a rational utilization of health care resources. A reduced average length of stay can occur as a result of more intensive care, which however, is accompanied as a rule by higher costs per patient day. This is due to the fact that the first days of a hospital stay are usually more costly than the last days. If, consequently, the treatment is intensified so that the patient can be discharged earlier, this results in a decrease in the cost per patient and an increase in the cost per patient day. An increase in the number of cases treated at the outpatient level can lead to a greater number of more serious or complicated cases in the inpatient sector, which is reflected in a longer average length of stay. A reduction in average length of stay can also possibly be achieved at the cost of an increased burden on the ambulatory care sector. This might be less resource intensive than inpatient care but it is unclear if a decreased length of hospital stay - in terms of costs - can compensate for an increased period of outpatient care.

Like average length of stay, the concept of patient days has a shifting content in time, both within and between different health service units. The patient day concept gives no indication of, for example, the varying intensity or weight, of the care which different patients require, and consequently does not respond to changes in resource inputs.

Even if many of these common performance concepts have shortcomings as indicators of outcome and effectiveness, they have merits in other areas. For example they are useful as screening instruments for closer analysis of the real reasons for large differences between or within different clinics, wards and hospitals and for explaining structural differences between hospitals and other health services. Used in carefully executed analysis, it has been shown that structural measures can establish the relationship between resource utilization and process criteria (16) as well as the relation between structure and outcome (17, 18, 19).

1.2.3 Clinical measures of performance

1.2.3.1 Process

Process is the totality of interactions between the patient and the providers of care. Process features include the technical aspects of the quality of care, such as the adequate and appropriate use of laboratory tests or X-ray procedures, the use of the appropriate drug or blood type, the completeness of a physical work-up etc, and the psychosocial aspects of care as expressed in the providers caring and communication skills. It is not always possible to distinguish between structure and process since the elements of these may overlap in a complex relationship.

The general approach to process measurement is to develop and document a number of explicit criteria which represent good medical practice for specific diseases, disorders or symptoms. Performance is then measured against these assumed standards of good care via retrospective review of medical records. A second approach is to rely on implicit standards of good care. In this case professionals may, for example, review medical records or observe how medicine is practiced and study actual patterns of care. On the basis of this less-structured review they arrive at an opinion based upon their professional judgments. Under these circumstances, the criteria used are implicit.

The validity of using process measures alone as indicators of good care may be questioned. Among the criticisms raised are the questions of validity and reliability of criteria and/or standards used, the relationship between process and outcome, the confoundation by intervening variables and intra- and inter-judge variation (12, 16, 20).

A prerequisite for undertaking evaluations is that the process which is being studied must be goal-oriented. However, the objectives are changeable; not only due to changes in the social system and in values, but also due to changes in the existing body of knowledge. The clinical practice which is established today for various types of diseases including both diagnostic and therapeutic procedures is not static. In the first place, the course of medical action undertaken for a given condition will vary widely - depending on where and by whom care is given, type of hospital or outpatient setting, access to human and technical resources, level of training, personal interests, medical fashion, etc - and in the second place, more or less continuous changes in procedures will take place as new research findings are released. Explicit criteria for process analysis thus continuously have to be reviewed and eventually revised.

1.2.3.2 Outcome

The measure of health care outcome is subject to much controversy. The question of quality of outcome seems to be subject to what each professional chooses to believe in. Nevertheless, it also seems to be the most valid measure - the end result - in evaluating the overall efficiency of the health services.

"The two major reasons for focus on outcomes in assessing quality of care are the recognition that the purpose of medical care is maintenance or improvement of health status and the belief that a judgment about quality based on information about outcomes of care is more valid because it is based directly on measures of health" (16).

The outcome approach tries to find measurable aspects of health status and to decide what changes have occurred as effects of medical intervention. The basic assumption for this approach is that medical care has an effect on health. One of the main questions is what should be constituted as outcome or "health".

The most common outcome measures are death and/or incidence of major complication. These may, however, be rare and occur so long after the care episode that they may be difficult to follow. Other difficulties include the problem of getting information, missing data and the differences between recorded and actual data. Moreover, many factors other than medical care may affect the outcome, such as the influence of the natural history of the disease, patient characteristics, other external influences, such as the physical, social and economic environment, cultural factors, and emotional and nutritional status. All of these may be difficult to control for. Another main difficulty is establishing the validity of the outcome chosen. This may even apply to the most widely used and generally accepted outcome measure: mortality. The prolongation of life may not always be taken as evidence of good medical care.

One means of minimizing the problems of measuring long-term outcomes (disease complications, mortality) is via the use of intermediate or proximate outcomes. These measure aspects of the health or functional status of the patient shortly after the care episode (for example explicit proximal outcome criteria for a post-surgical patient might be: absence of fever, normal blood count and ambulatory on discharge).

The outcome of health care measures can, however, rarely be expressed in clear-cut quantitative terms. Sometimes mortality and morbidity figures may form a part of the outcome description, but such figures are far from being perfect measures since various other qualitative factors - psychological, social - are so important in the day-to-day activities of health care delivery. As was pointed out earlier, the primary function of health care formerly was to prevent immediate death and cure disease. Naturally, this is still true, but increasing emphasis is now placed on preventing, alleviating and rehabilitating disease and postponing illness and suffering as much as possible. In short, the current emphasis is on promoting what might be covered by the concept of quality of life, which is a much more comprehensive expression of outcome.

1.2.4 Quality of life

There is a diversity of opinion among researchers, grounded in basic philosophical differences, as to what is meant by quality of life.

The operational application of the term usually refers to levels of health status which, however, does not satisfy the diversity of opinion at the conceptual and methodological levels. Efforts to measure and evaluate health often focus on pathology, since throughout most of human history the primary health problem facing society has been that of overcoming disease; "Our concept and measurement of health has generally focused on ill health. Thus, when we say a person's health is good, we have in mind that he is not suffering from any identifiably, serious disease. If we say his health has improved, we mean that his disease is not severe. A nation's health is said to be good if a low mortality rate, especially infant mortality, prevails" (21).

These "negative" measures of health are inherent in the education and training of health professionals, which may help to explain the following: "The quality of life that follows intervention seldom receives attention. In part, this reflects the fact that the physicians are not trained to seek ways of assessing quality of life any more than they are trained in the mathematical techniques required for the development of clinical trial methodology. The inability of medical people to deal with such problems and the diffidence of many nonmedical professionals with the requisite skills to enter the medical arena have had adverse effects not only on the needed assessments, but also on the development of important methodology" (22).

Discussions concerning the possibilities of measuring and evaluating health status have gone on for a long time but only recently has wider interest developed in this subject (23). The literature now includes reports of a considerable number of methods which aim at measuring the state of health of populations or individuals. Apart from the difficulties of defining health, the literature deals with many other problems. The main problems dealt with are the collection of reliable data, the combination of various health indicators in a common index, and the difficult question of validity.

A common feature of most of the methods proposed is that they mainly aim at measuring and evaluating variables concerning the physical functions of the individual. Less attention is generally paid to other significant factors such as psychological and social factors, which are part of the more positive phenomenon "quality of life" (rather than deterioration of health status). Moreover, the evaluations are generally made by professionals and rarely by the patients themselves or their relatives (24).

Ideas differ concerning the possibilities of developing practically useful yardsticks for measuring health status or quality of life. In a survey of methods in this field, Brorson states - not without scepticism as to wider applications - "It is likely, however, that such measures, (health index) used for limited purposes and populations, will be possible to employ in research concerning cost/benefit calculations" (25).

Grogono and Woodgate (26), who made a widely-noted proposal on the measurement of quality of life, express a similar idea when they state: "We have no method of measuring a patient's health before and after treatment. If we had, we might be able to allocate limited treatment resources to areas where they would be most beneficial, and research to areas where it is most required; and we could also apply cost-effectiveness calculations to much medical work".

Many other investigators in this field of research have proposed the use of their method as applied to questions of priorities and resource allocation for health as well as for evaluating health programs (27,28,29). "Although much of health policy has been directed at specific attributes of the health care system such as cost containment, quality assurance, and financial measurements, there is increasing concern with the more general issue of how the medical system affects the health of the people it serves. The operating assumption has been that much of what we do in the medical system has no positive impact on the health of the people but may, in fact, have negative impact. As the increasing use of resources in the health care delivery system generates a great need for making effective use of those resources, the need for a means for measuring the state of the health of the population becomes imperative. For this reason, discussions of the measurement of health status have moved from independent research pursuits to becoming a line of inquiry essential to the policy and decision making process" (30).

In the Literature on the measurement of quality of life methods are proposed which either implicitly or explicitly aim at a quantitative approach to priority setting (26, 31). Some suggest that quality of life be measured in terms of health years, which is the fraction of a life year one would be willing to give up for full health during the remaining fraction of that year. The idea behind these methods, from a priority point of view, seems to be either that health years - calculated with the help of a health status index - compared to actual number of years would express the value of a certain intervention for a disease; or that the equivalent value would be expressed directly as a trade-off between quality of life and quantity of life. In the latter case the value in terms of life years would be calculated by probabilities for different risks for disease or set against the equivalent trade-off for not getting the disease.

In addition to the many ethical aspects which must be addressed with regard to these methods they must fulfill a range of requirements in order to be practically useful. First of all the methods have to be understandable to the people they may concern: decision makers, health professionals and patients. It must be possible for all to conceptualize the questions accompanying the methods. They must further be valid and reliable for the population at risk since priorities for health are not set at the level of the individual and they must include a mechanism that adjusts to changes over time in the intensity and strength of the different aspects of health status as well as the changes in preferences for quality versus quantity of life.

1.3 Summary and aim of studies

Most of the growing body of research within the field of health economics has so far been directed at developing a better understanding of the volume of resources for health care, the determinants of expenditures on health care, the issues of cost and financing of health care and of the structuring and substitution of resource inputs: labor, capital equipment, hospitals and facilities (32, 33, 34, 35, 36). Much less attention has been paid to the evaluation of different ways of providing health care; the relation between resource inputs and their subsequent effects in various respects. This line of research will require knowledge and instruments capable of measuring not only structural elements, but more importantly, the numerous interrelated human, biological and environmental factors which interact with the care process to determine patient outcome.

The analytical approaches available for comparing and assessing costs and benefits range from informal estimates to carefully conducted formal calculations. A formal analytical technique - well known in economics - for comparing the positive and negative consequences of alternative ways of allocating resources is cost-benefit analysis*. Usually in this approach the aim is to identify, quantify and measure all socially relevant costs and benefits in monetary terms. This will result in a net value of a project and allow for comparisons of programs of different types.

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* Another formal analytical technique is cost-effectiveness analysis. This is an analytical technique that compares the costs of a project or of alternative projects to the resultant benefits, with costs and benefits/effectiveness <u>not</u> expressed by the same measure. Costs are usually expressed in dollars but benefits/effectiveness are ordinarilly expressed in terms such as "lives saved," "disability avoided," "quality adjusted life years saved (QALY)," or any other relevant objectives. Also, when benefits/effectiveness are difficult to express in a common metric, they may be presented as an "array" (39).

Main problems in cost-benefit analysis are the definition of what is socially relevant, i e what costs and benefits should be included in the calculation and to put a price on all benefits. These difficulties are evident as cost-benefit analysis is applied in health care (38).

The studies presented here in chapters two, three and four are not formal cost-benefit analyses. However, each of the problems presented is approached by the quantitative analytic process used in economic appraisals. The contribution of each of the studies is to demonstrate how the problems will be structured and what key variables will be made explicit through quantitative analysis. Thus, it is the process of analyzing, which reveals factors for open consideration of the decision makers, rather than the results of the studies that is in focus here.

Although each of the studies is independent of the others their common perspective and aim is the search for measurable features which can be related to the resources involved. They will illustrate the use of some of the presently available quantitative measures for economic assessments of health care. The basic concepts of structure, process and outcome are put to use in the effort to identify measures. There are, in addition other concepts crucial to assessment efforts such as need, demand and supply of health resources; need being the subjective or objective requirement of health services, demand being the manifested part of need and supply being the amount of services provided for health and medical care, e g equivalent to structure. The measures attributable to each of these concepts are too numerous to be dealt with here. Also, it is not possible to quantify all possible events in the many interpersonal interactions characterizing the health care encounter and no universal methods are available for an all-encompassing assessment of the performance of the system. Rather a limited number of elements must be examined in relation to one another in numerous isolated studies to form a broader framework for viewing the health system. It is imperative, however, for the investigator to remain aware of the different dimensions within the measurement categories (see appendix 1:1) and their relationships, despite the limited scope of an individual assessment study.

1.4 Disposition

The international comparative study of chapter two focuses on the structural differences between hospitals in the United States and Sweden. The analysis is based on various structural data, mainly of two community general hospitals. The number of personnel, the mix of different health personnel categories, the number of beds and other facilities are related to data on the average length of stay, bed occupancy rates, number of admissions and visits and number of diagnostic tests and examinations. The reasons for the observable differences are discussed from the perspective of several decision levels: the macro-social level, the institutional level and from the micro-individual level.

The studies in chapter three focus on the utilization and distribution of coronary care units in the United States and Sweden. These studies deal primarily with structural elements. The study population includes all patients admitted to coronary care units during one year in the study areas. Discharge diagnoses, mortality, disease specific incidence, average length of stay, occupancy rates and discharges per bed are compared for different types of hospitals. Assuming that clinical effectiveness of this medical service is determined the analysis focus on structure and tries to assure a rational volume and distribution of coronary care units. This is done by the use of epidemiological data, population statistics, structural measures and a maximum travel criterion for accessability of the service.

Chapter four includes an analysis of the economic consequences of the introduction of a new diagnostic technology. The study deals with the case of CT-scanning of the head. Data is recorded from all Swedish hospitals having definable resources for neuroradiological procedures. The structural implications of the new technology are identified and the effects on available conventional diagnostic procedures are estimated. A cost-effectiveness calculation is carried out and a number of process-outcome measures - such as pain, anxiety, risk and morbidity - are implicitly evaluated in monetary terms.

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   "I swear by Apollo the healer, invoking all the gods and goddesses to be my witnesses, that I will fulfil this Oath and this written Covenant to the best of my ability and judgment.

   I will look upon him who shall have taught me this Art even as one of my own parents. I will share my substance with him, and I will supply his necessities, if he be in need. I will regard his offspring even as my own brethren, and I will teach them this Art, if they would learn it, without fee or covenant. I will impart this Art by precept, by lecture and by every mode of teaching, not only to my own sons but to the sons of him who has taught me, and to disciples bound by covenant and oath, according to the Law of Medicine.

   The regimen I adopt shall be for the benefit of the patients according to my ability and judgment, and not for their hurt or for any wrong. I will give no deadly drug to any, though it be asked of me, nor will I counsel such, and especially I will not aid a woman to procure abortion. Whatsoever house I enter there will I go for the benefit of the sick, refraining from all wrongdoing or corruption, and especially from any act of seduction, of male or female, of bond or free. In my attendance on the sick, or even apart therefrom, whatsoever things I see or hear, concerning the life of men, which ought not to be noised abroad, I will keep silence thereon, counting such things to be as sacred secrets. Pure and holy will I keep my Life and my Art.

   If I fulfil this Oath and confound it not, be it mine to enjoy Life and Art alike, with good repute among all men at all times. If I transgress and violate my oath, may the reverse be my lot".
   (The Hippocratic Oath, slightly abridged).

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Sample of measures of input, structure, process and outcome used in health care

INPUT*

Need

Subjectively persieved
health surveys

Objectively measured
incidence, prevalence — disease specific

Demographic characteristics
environmental factors
population(s) at risk

Socioeconomic characteristics

Demand

Number of people
on waiting lists:
diagnosis, age, sex specific

Rate of broken appointments

Structural measures
expected number of
admissions
visits
procedures

Epidemiological characteristics
disease specific risks
populations

STRUCTURE

Number of admissions/visits
variable specific:
diagnosis, age, sex

Length of stay:
mean
pre-postoperative
standardized

Number of beds
bed days
bed occupancy rate

Number of procedures
preventative
diagnostic
therapeutic

Personnel
number of personnel
categories of personnel

Facilities
number and type of facilities
number and type of specialities
level of education/training/experience

Equipment
laboratory
x-ray
intensive care
emergency

Administrative/organizational criteria:
actual versus expected
(explicit)

PROCESS

Professional criteria;
explicit/implicit
selected critical elements
of care:
preventative measures
diagnostic work-up
therapeutic procedures
drugs
patient information/education
referrals
consultations
measured as actual/expected
performance

Diagnostic rate of:
accuracy
sensitivity
specificity

False negative findings

False positive findings

OUTCOME

Mortality - longevity rates
disease specific
age specific
sex specific
population specific
time specific (5-year survival)

Morbidity - disability rates
health indicators
presence/absence of
signs/symptoms,
ability to work;
tolerance tests,
pulmonary function
health indexes
functional status (AVD)
all specific as above

Rate of complications
drug related
post-operative
preventable adverse events

Measures of patient compliance
specific as above

Measures of patient satisfaction
accessability of services
continuity of care
perceived humaneness/quality

Quality of life measures
specific as above
indexes

* Input = structure from the politicians point of view

2 STRUCTURAL DIFFERENCES BETWEEN A U.S. AND A SWEDISH COMMUNITY HOSPITAL

2.1 Introduction

The applied usefulness of international comparisons is in the observation of variance. It generates two directions of research: first, a rigorous analysis of the differential benefits of treatment variation; and second, inquiry as to why these variations exist. The question of why, which is the focus of this study, can be considered at various levels of analysis.

One level of explanation is from the nation-wide perspective, another relates to the delivery of health services and a third level is that of the individual patient. Different levels of analysis enrich the study, but result in a number of problems of definition and reliability of available data. For example, at the national level it is easy to lapse into sweeping generalizations about national character. At the organizational level there are problems of definition. At the patient level there is sometimes more within-country variation than between-country variation.* A further refinement is to consider the interplay of the various levels of analysis which is the analytic framework used here.

At the national level of comparison, both countries - the US and Sweden - are industrially developed and prosperous. At the health service level, there are major differences (1, 2, 3, 4).

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* For example, length of stay for elective inguinal herniorrhaphy in England - on the high side (up to 20 days), see: Heasman, M A "How Long in Hospital?" The Lancet (September 12, 1964) p 539. On the low side, see: Farquharson, Eric L "Early Ambulation with Special Reference to Herniorrhaphy as an Outpatient Procedure," The Lancet (September 10, 1955) pp 517-519. This variation led to a randomized clinical trial showing no difference in benefit. Morris, David; Ward, Audrey; and Handyside, Alan. "Early Discharge After Hernia Repair," The Lancet (March 30, 1968) p 681.

With regard to strictly structural characteristics, American general hospitals are largely independent, nonprofit organizations governed by self-perpetuating boards of trustees. Revenues are generated largely through billing insurers, including insurance companies, and government programs, such as Medicare for those over sixty-five and Medicaid for the indigent. Physicians usually are independent entrepreneurs charging their patient fees for service rendered. Typically, they have private offices where they see ambulatory patients and usually have permission to admit and care for their patients in one or two hospitals.

Swedish general hospitals are largely owned, paid for, and managed by the twenty-three county councils and three municipalities. Their revenue is generated from taxation via a yearly budget. There is a clear separation of office-based doctors and full-time salaried hospital-based doctors, who care for inpatients and ambulatory patients in the hospital clinics. Other differences will be considered below.

The American Hospital Association reports 7,123 hospitals in the US in 1973 and the Swedish Health Department reports 870 in 1973 (5). Data in table 1 refer to these hospitals. Of these US hospitals, 6,110 are short-term, general hospitals. US short-term, general hospitals include 345 federal, 151 state, and 1,648 local, government-owned, 3,243 voluntary (non-government, non-profit), and 723 proprietary (for-profit) hospitals in 1973.

Table 1. Hospital staffing ratios* bed occupancy and average length of stay for the US and Sweden, 1973.

	All hospitals (short and long term)	
	US	Sweden
Total personnel/10,000 population	129	174
Total personnel/bed	1.80	0.81
Admissions per year/total personnel	12.4	9.9
Bed occupancy %	77.5	86
Average length of patient stay	12.6	30.5

*) Equivalent full-time personnel

Sources:
1. American Hospital Association, Hospital Statistics: 1974 Edition, Chicago 1974.
2. DHEW Publication No HRA 76-14503: Health Planning Information Series; 1 US Department of Health, Education and Welfare. Washington DC 1976.
3. Statistical Abstract of the United States 1978. US Department of Commerce. Bureau of the Census. 99th Edition. Washington DC 1978.
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The fact that Swedish hospitals have fewer personnel per bed, fewer admissions per personnel and a longer average length of stay have been discussed in an earlier study which examined the differences in personnel mix and whether the difference in length of stay may influence the staffing ratio (6). It was shown in that study that the personnel mix between the two countries is different. Swedish hospitals have more nursing personnel, while American hospitals have more technical and administrative personnel. Explanations of these differences were found to be due to differences in definitions and due to the fact that the same tasks are performed by different types of personnel. It was further suggested that the differences in length of stay may be accounted for by a different mix of patients. Analysis of the average length of stay and hospital staffing ratios initially seemed the most fruitful approach to explaining the difference between US and Swedish hospitals although these measures, used exclusively, are very limited. If the number of diagnostic and treatment inputs (x-rays, laboratory tests, operations) is held constant, then the longer the patient stays, the less inputs per day (7); the less inputs per day, the fewer personnel per day. To consider this relationship, the number of inputs per case (that is to say, per admission) must be held constant. This is not easily done because similar patients admitted to different hospitals and cared for by different doctors may well have considerably different inputs. As an extreme example, perhaps the American patient with angina (heart pain) will have coronary artery bypass surgery at a cost of, say, $10,000, while the Swedish angina patient may be treated medically at far less cost (8).

2.2 Hospital sample and design of study

Since hospitals differ one from another, comparison of large numbers of hospitals would not allow control over the variation in tasks performed and mix of patients treated. To deal with this problem, two hospitals were chosen - one in each country - that were as similar as possible to each other and that could be examined in detail. These two hospitals were community general hospitals * with roughly the same number of beds and similar size of service (catchment) area.** Due to the limited scope of the comparison a descriptive approach to the study was taken.

During a four-month period daily observations were made and unstructured interviews were carried out at the selected hospitals. This subjective information provided possible explanations of differences observed. The objective data were mainly obtained from medical records and other existing data sources including reports from the x-ray and laboratory departments, internal hospital statistics on facilities, personnel, costs, admissions, visits, length of stay and bed occupancy (9, 10). If these hospitals followed the national aggregate patterns

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* In Swedish: normalsjukhus or länsdelssjukhus

** It was not possible to match catchment areas by demographic or socioeconomic characteristics.

Table 2. Continued

[a] At the time of study deliveries were done at another hospital, while postpartum care was offered at SWCH. According to statements issued by the research body of the county councils in Sweden, Swedish Planning and Rationalization Institute (Spri), there should be at least 1,500 deliveries per year to justify a fully-equipped obstetrics department. See: Spri Report 14/71: Health Care Planning, Stockholm (1971).

[b] To obtain equivalent full-time working personnel (that is, the total of full-time, part-time and personnel working on an hourly basis) for the Swedish hospital, an average for this particular county in Sweden has been used. For the US hospital, the information from the personnel department on the number of full-time personnel working respectively each year has been used. A full-time working employee has been defined as one working more than 30 hours a week and two part-time working people have been counted as one full-time working person. As to the number of full-time working physicians, this is for the Swedish hospital equivalent to the actual number of positions. Calculation of the number of full-time working physicians in the US hospital has been done in cooperation with staff well informed in these matters. Thus all consulting members of the medical profession, as well as all dental surgeons and half of the courtesy staff, are excluded from the calculations. Further, it is known that 20-22 percent of the remainder of the medical staff in this hospital accounts for 80 percent of the workload. These facts have been used as a basis for calculating equivalent full-time working physicians in the US hospital.

[c] The number of office visits to physicians in private practice is not taken into account. (This merely reflects the main differences in the system of delivering health services in the United States and Sweden.)

[d] According to the exchange rate, one US dollar equals 4.5 Swedish kronor.

2.3 Findings

2.3.1 General differences

Because life expectancy in Sweden exceeds that in the United States, a larger percentage of the Swedish population is aged 65 and over - 14 percent versus 11 percent in the catchment area. The SWCH has a higher percent of elderly admissions - 42 percent versus 20 percent for the USCH. This is probably explainable in part by the larger percentage of elderly in the Swedish population, the presence of a long-term care unit at SWCH. Moreover, that SWCH has no newborn deliveries.

(table 1) the Swedish community hospital (SWCH) would be expected to have fewer total personnel, longer average length of stay, fewer employees per patient day and, assuming roughly similar occupancy rates, fewer inpatient admissions. This was found to be the case, with the exception of the occupancy rate, as can be seen in table 2.

Table 2. Comparison of two matched United States and Swedish community general hospitals, 1973.

	US community hospital (USCH)	Swedish community hospital (SWCH)
Facilities (beds)	Medical (107) Surgical (75) Pediatrics (18) Obstetrics (26) Newborn Psychiatric (28) Surgical day care Outpatient care	Medical (60) Surgical (82) Pediatrics (22) Obstetrics extended care only (15)[a] Newborn extended care only Psychiatric day care Surgical day care Outpatient care Long-term care (56)
Population in catchment area	60,000	55,000
Population ≥ 65 years of age	11%	14%
Patients ≥ 65 years of age by admission	20%	42%
Frequent medical diagnoses (inpatient)	Pneumonia Cerebrovascular disease Ischemic heart disease Acute myocardial infarction Hip fracture Intervertebral disc displacement or disease	Ischemic heart disease Bronchitis/emphysema/asthma Acute myocardial infarction Cerebrovascular disease Cholecystitis and cholelithiasis Inguinal hernia
Staff (approximate equivalent working full-time)[b]	750 (including 33 physicians)	437 (including 17 physicians)
Number of beds	254	235
Occupancy	91%	79%
Number of admissions	11,236	4,232
Number of outpatient visits[c]	20,000	41,700
Employees per patient day (including physicians)	3.38	2.45
Average length of stay	7.6	16 (12.3 days, excluding long-term care)
Running costs 1972 (millions of US dollars)[d]	$11.1-million	$4.3-million

Rather, mothers gave birth at another hospital and were transferred to SWCH for postpartum care. This observation suggests that the populations within the catchment areas is not coterminous with admissions to SWCH and the same may be true of USCH. Also, frequent inpatient diagnoses are somewhat different.

The SWCH's occupancy rate is low, which will, if anything, give it a higher staffing ratio and fewer admissions than other Swedish hospitals, ceteris paribus. The US community hospital (USCH) has more medical beds, while the SWCH has a significant long-term care section (56 beds) and no inpatient psychiatric service. If one excludes the long-term care unit in the SWCH, the average length of stay falls from 16 to 12.3 days.

SWCH has more than twice as many outpatient visits as USCH. However, this distinction may be due to the organization of care in the two countries. A large proportion of all Swedish ambulatory visits take place at hospital outpatient departments, which is not the case in the United States, where the private office is the most common ambulatory setting.

There are more than 72 percent more personnel in the USCH than in the SWCH and operating costs in the USCH are 158 percent higher, but this may be relative to the substantially higher number of admissions at USCH. There are a host of problems in comparing costs between the two countries. Let it suffice to say that the difference in staffing ratios reflects a conservative measure of the differences between the two hospitals.

2.3.2 Personnel

There were almost twice as many full-time equivalent physicians in the USCH (33) as in the SWCH (17) in 1973. Such figures are difficult to estimate for US hospitals because there are over 100 physicians with admitting privileges in the USCH, and they spend a substantial part of their time in private practice outside of the hospital. It is likely, due to the shorter length of stay and more rapid turnover at USCH, that care of the individual patient is more personnel-intensive.

Table 3 shows the breakdown of staff personnel for these two hospitals over an eight-year period. In 1967, there were 476 employees for 251 beds with 1.90 employees per bed at the USCH. The SWCH had 331 employees for 283 beds, or 1.17 employees per bed. The figure for 1974 for the USCH is 2.83, and for the SWCH 1.90. In 1967, the USCH had 1.62 times more employees per bed than the SWCH. In 1974, the USCH had 1.5 times more employees than the SWCH. The number of personnel per bed, as an independent measure gives no indication of bed utilization. Thus, it should be complemented with admissions data. Although SWCH experienced a 36 percent increase in the number of personnel, there was an 18 percent reduction in the number of beds and a reduction in the number of admissions per year. Thus, productivity can be said to have decreased between 1967-1974 in the Swedish hospital. USCH had a 53 percent increase in the number of personnel, no significant change in the number of beds and a 41 percent increase in the number of admissions. Thus, in the US hospital there is an increase in productivity - measured as the relation between input of personnel and admissions.

Examination of the personnel categories - as percentages over time - reveals that the most significant variations between the countries are in the categories nurses and administrative personnel. In 1967 nurses comprised 45 percent of personnel at USCH and 60 percent at SWCH. Administrative personnel amounted to 17 percent in USCH and only 6 percent at SWCH. All categories of personnel remained relatively constant from 1967-1974, with the exception of technical personnel at USCH, which rose from 9 percent in 1967 to 17 percent in 1974.

Figure 1. Hospital staffing ratios in USCH and SWCH, 1974

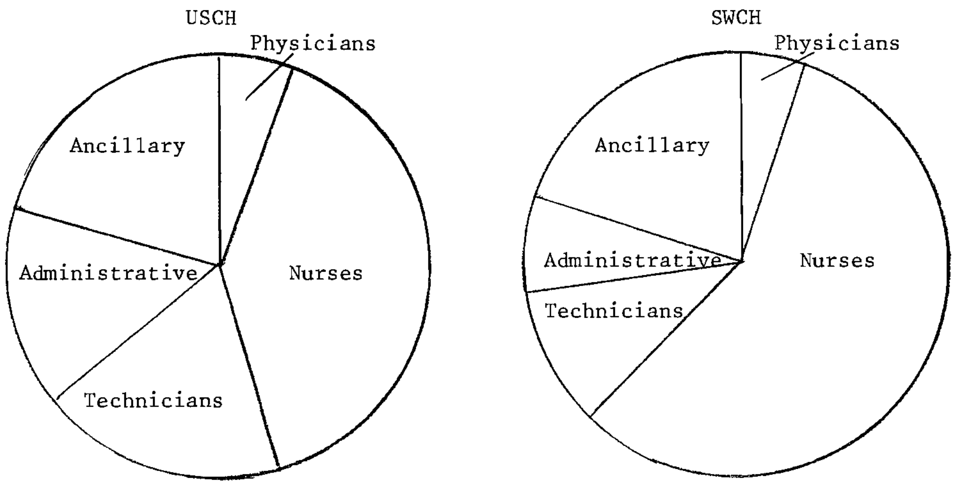

Table 3. Change in distribution of hospital personnel for one US and one Swedish community hospital (USCH and SWCH) 1967-1974.

		1967	1968	1969	1970	1971	1972	1973	1974
Physicians:	USCH	28	28	24	26	29	32	33	35
	SWCH	13	14	16	16	16	16	17	19
Nurses:	USCH	212	217	270	274	289	295	300	289
	SWCH	198	203	218	230	233	243	243	254
Technicians:	USCH	43	43	60	79	119	126	126	126
	SWCH	38	39	41	40	45	48	51	49
Administration:	USCH	82	90	94	104	123	123	123	113
	SWCH	21	23	25	27	31	33	37	36
Ancillary:	USCH	111	119	155	155	156	177	168	162
	SWCH	61	61	76	80	78	89	89	91
TOTAL	USCH	476	497	603	638	716	753	750	725
	SWCH	331	340	376	393	403	429	437	449
Beds:	USCH	251	251	251	251	254	254	254	254
	SWCH	283	283	267	267	267	267	236	236
Admissions:	USCH	7993	8839	9871	11555	11099	12221	11236	-
	SWCH	4457	4458	4432	4185	4738	4350	4232	-

Source: Internal hospital statistics.

2.3.3 Personnel task mix

Table 4 shows data on the distribution of tasks for nursing personnel in the two countries. In the US hospitals, dietary personnel may replace nursing personnel for meal-related activities. US nurses spend more time in patient contact activities. In the United States, specially-trained inhalation therapists administer oxygen to patients, yet such specialists did not exist in the SWCH and these tasks were performed by nurses. Unlike Swedish hospitals, a substantial administrative and clerical effort is required in US hospitals to itemize patient bills and negotiate payment from hundreds of different health insurers, all of whom have different policies and benefit packages. This seemed a clear example of size of the administrative and clerical component varying with the environment.

Table 4. The distribution of working time over selected activities for nursing personnel in Sweden and the US.

Activity	% of working time			
	General medicine		General surgery	
	USCH	SWCH	USCH	SWCH
Serving, feeding and other duties concerning meals	8.0	14.8	3.8	13.9
Cleaning and maintenance	7.7	8.6	3.6	13.2
Making beds	4.1	6.8	4.9	8.8
Patient hygiene	16.2	5.1	17.9	6.0
Moving patients	4.1	1.0	3.8	1.2
General observation of patients	2.4	8.1	3.4	0.9
Making or writing reports	8.2	4.1	8.2	3.9
Introduction, instruction, supervision	4.2	1.2	2.6	3.9
TOTAL	54.9	49.7	48.2	51.8

Source: Nurses in medical and surgical departments maintained activity logs for one week during the study period. The table reflects results for a selection of activities. (Se appendix 2:1).

2.3.4 Average length of stay

Within these two hospitals, average length of patient stay was compared for nine specific disease categories such as pneumonia, hernia, and hypertension. In seven of these nine categories, length of stay was slightly shorter in the SWCH. This suggests that differences in total stay are due to differences in case mix, not longer stay for similar disease categories.

Table 5. Average length of stay for frequent diagnoses, USCH and SWCH, 1973.

Diagnosis ICD code	Diagnosis	Average length of stay (days) USCH	SWCH
411-414	Ischemic heart disease except myocardial infarction	16.0	15.6
430-438	Cerebrovascular disease	13.9	14.5
480-486	Pneumonia	9.4	6.8
410	Acute myocardial infarction	20.5	11.7
489-493	Bronchitis/emphysema/asthma	10.1	7.2
	Diabetes	13.0	12.4
400-405	Hypertensive disease	10.7	12.2
550-552	Inguinal hernia	5.7	4.7
	Cholecystitis and cholelithiasis	10.4	7.9

Source: Medical records and internal hospital statistics.

Note: The length-of-stay figures for acute myocardial infarction, hernia and cholecystitis -cholelithiasis differ between tables 5, 7 and 8 for two reasons: first, figures in table 5 are for the entire year 1973, while those in tables 7 and 8 are based on a sample of cases for 1973. Secondly, table 5 includes cases with complications, including multiple operations during the same admission and multiple diagnoses, while tables 7 and 8 exclude cases with complications.

Table 5 does not reflect the high average length of stay of the Swedish hospital. However, length of stay is strongly correlated to patient age, and SWCH had a considerably greater proportion of elderly patients than USCH (11). One may conclude that a large proportion of elderly patients in SWCH have other diagnoses than those in table 5.

Average length of stay as a measure of performance, does not adequately reflect resources utilized. Medical care services tend to be concentrated in the initial days of hospitalization and not uniformly spread throughout an episode. However, by carefully matching hospitals and patients, and conducting a comparison, variations observed may indicate institutional differences.

2.3.5 Diagnostic inputs

One way to look at the different workloads in the two hospitals is to compare the number of diagnostic inputs per patient, which is shown in table 6. The diagnostic inputs are substantially larger per inpatient day at the USCH. There are 7.0 laboratory tests in the USCH versus 2.7 in the SWCH. Similar differences are shown for x-rays and electrocardiograms. Some of these differences could be accounted for by looking at inpatient days and outpatient visits separately.

When laboratory tests are assigned to inpatients and outpatients, the magnitude of the differences are reduced, but the USCH has a higher volume of inputs for both inpatients and outpatients. This may be partly attributable to the practice of "defensive medicine" in the US. It is probable that more diagnostic tests are carried out on an outpatient basis prior to admission in Swedish hospitals, thus reducing the pre-operative length of stay in Swedish hospitals.

Table 6. Comparison of laboratory test utilization and examinations for all patients[1] and by patient days, USCH and SWCH, 1973.

	USCH	SWCH
Laboratory tests[2]/patient[3]	7.0	2.7
X-ray examinations/patient[3]	0.8	0.3
Electrocardiograms/patient[3]	0.3	0.1
Laboratory tests[2]/inpatient day	2.58	1.25
X-ray examinations/inpatient day	0.22	0.05
Laboratory tests[2]/visit	1.91	1.12
X-ray examinations/visit	0.63	0.53

Source: Medical records and reports of x-ray, laboratory departments.

1) Including outpatients and inpatients.

2) It should be noted that discrepancies in definitions of laboratory tests may account for part of the observable differences.

3) All tests and examinations per year divided by the total number of inpatient days.

2.3.6 Pre-, post-operative length of stay and diagnostic inputs

Because these two hospitals have a different patient mix, it seems necessary to go to the micro level of analysis and consider what happens to similar patients within the two hospitals. Patients with three types of diagnosis are considered: uncomplicated inguinal hernia, cholecystectomy and acute myocardial infarction. Controlling for the age of patients, the length of stay is longer in the USCH and the diagnostic inputs are consistently higher (see tables 7 and 8).

Table 7. Comparison of length of stay and examinations, by age for treatment of inguinal hernia by the USCH and the SWCH, 1973.

Inguinal hernia*	USCH	SWCH
Average length of stay	5.0	3.7
Average pre-operative stay	1.0	2.0
Average post-operative stay	4.0	1.7
Laboratory tests/patient	18.5	7.1
X-ray examinations/patient	0.6	0.4
Electrocardiograms/patient	0.7	0.2

Inguinal hernia	Age 0-14		Age 15-64		Age 65 and over	
(age distributed)	USCH	SWCH	USCH	SWCH	USCH	SWCH
Average length of stay	1.6	3.5	4.9	3.0	7.2	4.2
Average pre-operative stay	1.0	2.0	1.0	1.5	1.2	1.6
Average post-operative stay	0.6	1.5	3.9	1.5	6.0	2.7
Laboratory tests/patient	15.6	6.5	19.9	7.1	17.0	7.8
X-ray examinations/patient	0	0	0.6	0.5	0.8	0.5
Electrocardiograms/patient	0	0	0.6	0.3	0.8	0.4

Source: Medical records and reports of x-ray, laboratory departments: a record sample consisting of all patients admitted during a representative period of 1973 for each hospital. The period in question accounts for 10 percent of the total (hernia) activities during the year.

* Pre-operative diagnosis: inguinal hernia, ICD code 550.
  Post-operative diagnosis: ICD code 550.
  Operation procedure: herniorrhaphy, single diagnosis.

Table 8. Comparison of length of stay and examinations for treatment of cholecystitis and cholelithiasis and acute myocardial infarction by the USCH and the SWCH, 1973

	USCH	SWCH
Cholecystitis and cholelithiasis[1]		
Average length of stay	7.4	5.6
Average pre-operative stay	4.3	1.0
Average post-operative stay	3.1	4.6
Laboratory tests/patient	57.2	16.0
X-ray examinations/patient	4.0	1.4
Electrocardiograms/patient	1.8	0
Acute myocardial infarction[2]		
Average length of stay	21.6	13.0
Laboratory tests/patient	47.6	31.8
X-ray examinations/patient	1.0	1.0
Electrocardiograms/patient	6.0	3.8

Source: A record sample consisting of all patients admitted during a representative period - one month - of 1973 for each hospital.

1) Single dx 574. Operation procedure: cholecystectomy, code 43.5, ICD code 574.

2) Due to a variety of disorders under this headline and to the frequency of multiple diagnoses, the sample size during the same period chosen for hernia and cholecystitis is limited to number of "plain" cases. Caution should, therefore, be exercised when interpreting these figures.

2.4 Structure - process - outcome

To obtain a comprehensive view in the hospital comparison, both structure and process measures should be examined and related to outcome measures. This would require following the process of care for matched groups of patients at both hospitals and comparing diagnostic and therapeutic measures, and relating these to outcomes of care. The relationship between structural and process data and outcome measures, such as mortality - both disease specific and overall measures reflected in infant mortality and life expectancy - and morbidity, was not considered in this study. However, a common view among researchers is that these means-ends relationships are unclear (11-18).

First, there are strong pressures on physicians to do something - anything - for the suffering patient. In the absence of controlled clinical trials, the placebo effect provides a systematic bias that makes any harmless treatment look beneficial in the short run - the real benefits or lack thereof being observable only in the long run (12, 13, 14). Secondly, treatment forms that are clearly beneficial to a small number of patients are applied to many more patients in hopes that they too will benefit. This is probably a widespread phenomenon because there is often no clear dividing line between the sick and the well. Third, failure to carry out randomized controlled clinical trials, as a rigorous way to evaluate benefit, has led to proliferation of treatment forms of unproven effectiveness, and once an unproven treatment form has been widely accepted it becomes unethical to withhold this treatment (11). Foruth, the confounding effects of personal behavior and environment are difficult to factor out (14, 15, 16, 17).

Finally, a large range of treatments provide benefits that are extremely difficult to measure, such as the relief of pain, inconvenience, mental anguish and so forth. The latter "effects" of health care are included among those factors associated with quality of life. Indices of quality of life are generally not considered in outcome assessments, but must ultimately be incorporated so as to reflect important but more subtle patient outcomes (e g patient satisfaction; functional status; social and psychological side-effects of care, etc.). Many approaches for assessing the effects of outcome have been suggested. Some assume that more and better facilities implies better service and simply make use of structural data as indicators of the quality of care (19, 20). Similarly economists have approached this issue by examining cost per patient or per patient day (21). Others use explicit or implicit professional standards of care or direct measures of outcome such as case severity adjusted death rates (22). The strength and limitations of such proposals have been thoroughly dealt with (23). As long as the effectiveness and efficiency of the range of clinical procedures has not been scientifically proven it is hard to relate structure and process to outcome.

2.5 Discussion

There are certain limitations inherent in the methodology of this study which limit the analysis; chiefly that the small scope - two matched hospitals - entails a descriptive approach and precludes broad generalization of the findings. However, some general conclusions can be drawn, since certain fundamental characteristics of the health systems (e g payment mechanism) are reflected in the individual hospitals.

The variations observed between the study hospitals can be explained at various levels of analysis. At the national level, the unit of analysis is the country as a whole. At the institutional-organizational level, there are two components. The first is the health service sector: the relevant laws, flow of funds, regulatory mechanisms and such. The second is the hospital. At the level of the individual, the patient, patient contact, or clinical decision is the unit of analysis. Although the units of analysis are clearly distinct in these different levels, the interpretation of findings becomes quickly blurred due to overlapping variables. As will become clear, empirical observations at one level are likely to be explained in terms of variables at the other levels. Explanations at each level can be considered as static, explaining current differences; and dynamic, explaining changes over time.

The different approaches towards equity in health care in the US and Sweden may account for differences also at the institutional and patient level. The concept of equity implies no limitations based on financial means, age, sex, race or insurance qualifications. In a national health insurance system, such as in Sweden, the financial burden of cost of illness has been moved from the individual to the society. It is possible that an absence of financial restraints may effect, for example, the extent to which a person will demand health services and consequently will possibly also effect the measures required. However, contrary to the US, Sweden lacks a structured system of reviewing the utilization of health services which may well induce differences at the institutional as well as at the patient level.*

The differences in the systems of financing health services - national health insurance versus private, group and federal insurance schemes - probably influences several differences at the institutional level. The relatively high proportion of administrative and clerical personnel in the US hospital might in part be a reflection of the itemized billing process for patients there **. The Swedish hospital has a budget which is not itemized per patient and per procedure.

The smaller proportion of physicians in private practice in Sweden, clearly explains the difference in organization of outpatient services and the number of visits at the hospitals. There may also be financial incentives to do more testing as well as personal incentives to recall the patients for more visits in the US.

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* The main objective of a national health insurance system is, however, not to contain costs, by a reduction of inputs and decreased length of stay, etc. but to eliminate the burden of cost of illness for families.

** There are 3 times as many administrative personnel in the US hospital as in the Swedish hospital.

The relatively low personnel-to-bed ratio in Sweden may be due to a tight labor market. Labor has been scarce in Sweden. There has been full employment, high prosperity and the temporary importation of workers from abroad. Nevertheless, many positions in health services have not been filled. Sweden has, up until 1974, had a shortage of skilled and unskilled native workers, unlike the US with its chronic unemployment of the unskilled worker. The shortage of physicians in Sweden is dealt with by a plan to greatly increase their numbers. The US approach seems to be a substitutional one; nurse practitioners and physician's extenders are being trained to take over some of the physicians' activity.

The amount and quality of supportive services outside the health services must be mentioned as an important possible explanation of observable differences in the health services. These include societal as well as individual efforts for preventive measures, rehabilitation, follow-up, social service, nursing homes and care for the elderly. These peripheral resources may differ in quantity, availability, accessibility, and quality between the US and Sweden.

A most important factor at the institutional level, which may account for the overwhelming part of the differences observed between the two countries, is the age- and case-mix differences. A reality in Sweden is a steady shortage of nursing home beds, mainly for long-term care and care for the elderly. This is particularly true for departments of internal medicine which may have half of their beds continuously blocked by patients no longer in need of this level of hospital care but in need of nursing home care or social home service.

The situation for the Swedish hospital thus is an overall lower turnover of beds to allow a flow through of patients waiting for care. Thus, compared to the US hospital, Swedish hospitals exhibited fewer admissions but a higher turnover at the non-blocked part of the department reflected in a lower disease specific average length of stay and an overall lower bed occupancy. It is also possible that the staffing ratios would differ in the Swedish hospital between the blocked and the flow through share of the department. In view of the fact that there may be many patients already treated and ready for other levels of care but still waiting for discharge, it could be expected that the Swedish hospital would carry out fewer diagnostic inputs per patient. However, this explanation does not suffice since the difference remains even for disease-specific cases which are chosen to reflect the flow through part of the hospitals. The different approaches to malpractice in the US and Sweden may be part of the explanation of these findings.

County council control and the absence of patient billing as reflections of the larger social system have been mentioned as possible explanatory sources of differences observed. Swedish hospitals are owned, operated, and largely paid for by the local government - the county council. The county council's members are directly elected and most of the county budget is spent on health care. Thus, there is a direct visible link between local taxes, election of the county council members, and budgetary control of the hospital. A similar direct system of control of health expenditures does not exist in the US.

Some other distinctions at the institutional level that may account for certain differences are the diversities in weekend staffing - less in Sweden - and in the volume of notes in the medical record - extensive nurse's notes about patients in the US. Swedish doctors are assigned responsibility for all patients in a ward while in the US it is not impossible to have, say, 30 different doctors for the patients in one floor. Also, while hospitals' primary service is inpatient care they also provide varying amounts of education and research which presents problems in measuring and controlling.

The less complex diagnostic work-up in Swedish hospitals has been discussed, and a number of explanations are available. First, there are variations in medical custom. A graduate of Lund Medical School may practice medicine very differently from a graduate of Harvard. Second, the fear of law suits that results in 'defensive medicine' in the US is much less in Sweden. That is to say, the US doctor may order marginally less useful tests for fear of malpractice suits. Third, the proprietary hospital in the US finds it financially rewarding to do a high volume of tests. In the Swedish system, however, no profit can be gained by overutilization. Fourth, it is likely that a high number of laboratory tests in the US is related to a general rapid technological expansion which strongly influences utilization of ancillary services - as also reflected in the increase in number of technical personnel in the US hospital. In Sweden, however, the diffusion of technology has been less rapid due to the financial control of the county councils.

2.6 Conclusions

Given the method used in the comparison, quantitative information about health care utilization in the study hospitals is provided and variations are identifiable. These quantitative variations may be related to quality of care, among other factors, however, this cannot be determined without studying the relation between structural characteristics and process and outcome variables. Thus, conclusions must necessarily be limited to structural variations.

To summarize briefly the main variations: The US hospital had a substantially higher number of admissions, a higher number of personnel per bed and a higher occupancy rate than the Swedish hospital. All of these factors are clearly interrelated. The USCH also had a higher number of diagnostic inputs per patient, which may be chiefly due to the threat of malpractice in the US. The Swedish hospital had more long-stay patients resulting in a higher average length of stay. This is attributable to the greater proportion of elderly patients at SWCH and to the practice of allowing patients whose treatment is completed to remain in the hospital while waiting for transfer to other levels of health or social care. SWCH had fewer personnel per patient, lower turnover and lower operating costs - features which are, again, interrelated.

There are many other differences of varying magnitude. It is proposed here that one key to the explanation of the variations is the absence of an input-output constraint that defines the effect of direct health care on the population served. The absence of this constraint leads one to seek explanations of the observed variations at the national, institutional and individual levels of analysis, and by examining the interplay between them. From an applied perspective, it is clear that if changes are made in a variable at one level, the consequences at other levels must be considered. For example, reducing the diagnostic work-up in US hospitals, if that were desired, might mean changing malpractice mechanisms at the institutional level, and this, in turn, may impact cultural values. Conversely, if one wished to increase the diagnostic work-up in Swedish hospitals, it would have an effect on demand for certain types of hospital personnel, and that, in turn, would have some impact on the broader problem of Swedish labor scarcity, county taxation rates and the balance of trade.

This study demonstrates differences in staffing patterns and utilization of resources in a US and a Swedish hospital and proposes some explanations. Available data to support some of these explanations are scarce and inadequate. An additional much-needed resource in conducting such a study is a refined instrument for measuring the complex and interrelated dynamics of health care. Such an instrument or instruments should incorporate relevant features of structure, process and outcome and provide both quantitative and qualitative assessment of the health service system.

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Nursing activity log used to determine the distribution of working time for nursing personnel *

Planning for patient care
Talk to patient
Assist physicians
Transcribe orders from physicians
Prepare equipment
Cleaning equipment
Prep and/or adm of IVS
Prep and/or adm of resp care
Routine testing (on admission)
Daily routine testing (blood pressure, temp etc)
Rounds
General observation of patients
Serving and feeding and other duties concerning meals
Cleaning and maintenance
Making beds
Patient hygiene
Dressing patients
Moving patients
Making or writing reports
General administrative work (paperwork)
Introduction, instruction and supervision
Meetings (e g dept meetings)
Answer telephone
Making telephone calls
Check medication
Give medication
Order medication
Order laboratory work
Check laboratory reports
Order X-ray works
Check X-ray reports
Order supplies
Check supplies
Pick up supplies
Coffee breaks, personal telephone calls etc
Contacts and communication with other depts
Other activities:

* This selection is based on: White B M: Importance of selected Nursing Activities. Nursing Research Vol 21, No 1, 1972.

3 UTILIZATION AND DISTRIBUTION OF CORONARY CARE UNITS

INTRODUCTION

Coronary care units (CCU's) for the intensive treatment of patients with myocardial infarction (MI) were first introduced in the United States in 1960 (1). Cardiologists and other physicians found that the concentration of patients with acute, severe coronary disease, under constant electronic surveillance, and in a separate, specialized hospital service, could reduce mortality substantially. Guidelines for the staffing and equipping of units and criteria for patient care were soon developed (2, 3, 4, 5). These standards were adopted so that CCU's were soon employing similar therapies. Within a decade, CCU's became widely distributed throughout the United States, in both large and small hospitals. About 4 500 US hospitals out of a total of 6 000 now have these units (6).

The concept of intensive treatment of MI in a specific hospital unit spread to other high-income countries, particularly in Europe. In Sweden, the first CCU was opened in 1966 (7). Since then, their numbers have increased, though more slowly than in the US, so that in 1975 there were 26 CCU's with 140 beds serving a population of 8.1 million spread over 450 000 km^2. Their diffusion was based upon clinical studies (8, 9, 10). A few such studies were carefully structured and analysed (11, 12). In a Swedish study by Hofvendahl (11), there was found to be a statistically significant advantage for the patients receiving intensive care compared to patients receiving ward care. The additional cost of treatment in the CCU was estimated at 60% above that for conventional care in the department of medicine. While all of the uncontrolled studies found CCU's to be effective, one controlled investigation demonstrated no important differences between intensive hospital care and home care for a selective group of patients (13, 14). Another cost-effectiveness study show no advantage of CCU care for MI after severity-adjustment of disease (15).

The issue of effectiveness will not be settled so long as study results differ. Thus, a second best solution was proposed, a planned CCU system rationally distributed and related to population need for care, while stressing good organization to assure economy and efficiency (16). Other countries have achieved such a system, but usually as a result of constrained resources within a national health system, rather than by conscious planning. Planning is, of course, not the only variable in determining the direction of a nation's health system. The historical course leading to the unique development of each nation's medical care system, its current practices and results, its social, political, and cultural patterns and its economic environment and demography are all more important factors. The process of planning in the United States is very different from that in Sweden, where the conflicting interests of many are resolved in the planning process at county or regional levels. One need look no further than the distribution of coronary care units in the United States and Sweden to see that the results of planning also differ.

This chapter, based on earlier published studies (17, 18), is comprised of two complementary studies of the utilization and distribution of coronary care units (CCU's). Study A uses structural data to examine the utilization of CCU's and the distribution of diagnoses, myocardial infarction rates and mortality in coronary care units from a sample of Swedish hospitals. Study B compares the Swedish data with data from a sample of US hospitals, discusses the discrepancies in distribution of CCU's between the two countries and includes a calculation of CCU's needed based on epidemiological data and the criterion of accessability.

3.A Utilization of coronary care units in Sweden

This examination of coronary care units in Sweden replicates the method used in an earlier study which considered in-hospital results of treatment, true hospital cost and economic efficiency of a random sample of CCU's in the United States (19).

3.A.1 Study design

A random sample of all hospitals in Sweden having definable units for intensive coronary care was selected. The universe of 26 hospitals was stratified into regional, county, and community hospitals. Two hospitals in each cell were selected for examination. It was determined that the CCU's had similar and well-accepted diagnostic criteria and admissions policies (2, 3, 5).

The study population included all patients admitted to the CCU's during the calendar year 1974. The data recorded for each patient included age, diagnosis at discharge from the unit, length of stay in the unit and death or survival in the unit. These data were obtained from the department log of each CCU. No clinical patient data were collected; thus there is no information on disease severity. Case fatality rates were age-adjusted by the direct method for comparisons between hospital groups.

3.A.2 Results

In table 1, the distribution of diseases by principal diagnosis upon discharge from the units is presented. Myocardial infarction was the most frequent discharge diagnosis, accounting for 58.5% of discharges. The proportion of MI patients varied by hospital from a low of 43% in a community hospital to a high of 69% in a regional hospital. The category: "other cardiovascular" consisted of patients with heart block, myocarditis, pericarditis, endocarditis, and the like. Patients in the noncardiovascular category had diagnoses of aortic aneurysm, pulmonary infarct or other serious disease often mimicking MI.

Table 1. Discharge diagnoses from coronary care units 1974

	Regional		County		Community	
Diagnoses	n	%	n	%	n	%
Myocardial infarction	1261	62.7	811	58.7	371	47.3
Arrhythmia	205	10.2	143	10.3	108	13.8
Angina pectoris	125	6.2	123	8.9	97	12.3
Coronary insufficiency	121	6.0	111	8.0	44	5.6
Congestive heart failure	120	6.0	34	2.5	41	5.2
Other cardiovascular	143	7.1	76	5.5	55	7.0
All non-cardiovascular	36	1.8	85	6.1	69	8.8
All hospitals	2011	100.0	1383	100.0	785	100.0

The overall mean age-adjusted MI case fatality rate was 13.9% (table 2), somewhat lower than other published CCU mortality rates including the counterpart US study (19). This table also relates MI age-adjusted fatality rates to the number of MI patients. As the units treated more MI patients, MI death rates declined. Age-adjusted death rates ranged from a high of 26.4% in a community hospital to a low of 8.1% in a regional hospital. The community hospitals were the smallest and had the fewest patients.

Table 2. Deaths in coronary care units and age-adjusted myocardial infarction death rates 1974

Hospital group	No of hospitals	All patients		MI patients		Age-adjusted MI deaths	All other patients	
		Tot	Deaths (%)	Tot	Deaths (%)	(%)	Tot	Deaths (%)
Regional	2	2011	6.8	1261	10.5	9.4	750	0.4
County	2	1383	7.4	811	12.3	14.5	572	0.3
Community	2	785	11.3	371	23.5	24.8	414	0.5
All hospitals	6	4179	7.8	2443	13.1	13.9	1736	0.4

Length of stay in the CCU's was longest in the community hospital group (table 3). The shortest mean length of stay for any study hospital was 2.0

days, while the longest was 3.5 days; all other hospitals clustered about the mean of 2.6 days.

Table 3. Length of stay in coronary care units 1974

Hospital group	No of hospi- tals	Mean no of beds	No of patients		No of patient days		Average length of stay (days)
			Tot	Mean	Tot	Mean	
Regional	2	8	2011	1006	5084	2542	2.5
County	2	7	1383	692	3615	1808	2.6
Community	2	5	785	393	2243	1122	2.9
All hospitals	6	6.7	4179	697	10942	1824	2.6

It was originally intended to determine the true cost of CCU care, as was done in the US study, but the budgeting system of Swedish hospitals did not allow accurate separation of costs for intensive care. It was, however, possible to obtain some measures of utilization in the form of occupancy rates and discharges per bed. Another measure, discharges per nurse, was also originally intended for analysis. However, nurses could not be accurately allocated to CCU's and other treatment areas and thus this important measurement could not be made. Table 4 shows that occupancy rates averaged 74.9%. These varied significantly and were highest in the regional hospital groups. There was some intragroup variation, especially that between community hospitals. Discharges per bed also showed variation, increasing with hospital size.

Table 4. Occupancy rate and discharges per bed in coronary units 1974

Hospital group	No of hospi- tals	Bed days available	Bed days utilized	Occup rate (%)	No of beds	No of dis- charges	Dis- charges per bed
Regional	2	5840	5084	87.1	16	2011	125.7
County	2	5110	3615	70.7	14	1383	98.8
Community	2	3650	2243	61.5	10	785	78.5
All hospitals	6	14600	10942	74.9	40	4179	104.5

3.A3 Discussion

This study of CCU's show differences between hospital groups in Sweden according to the variables measured. The differences are shown by both clinical and structural measures. The clinical measures are outcome in terms of case fatality rates, deaths among all patients, total as well as age adjusted death rates for myocardial infarction and death rates for patients with diagnoses other than myocardial infarction. The structural data are number of beds, number of patients and patient days and their measures of utilization, average length of stay, bed accupancy rates and discharges per bed.

The reasons for the observed differences are many and complex. In the first place it should be noted that patient selection may be involved and account for the differences observed. Assuming this is not the case a few suggestions can be made. The higher proportion of patients with MI or other serious, acute heart disease at regional hospitals may be due to size of catchment area, travel distance and greater pressure upon available beds, which may create stricter admission and diagnostic criteria. This may lead to the allocation of available beds to those patients with the most serious illness. (This raises the question of need for coronary care versus the distribution of this medical service.) The greater experience gained by treating larger numbers of patients may also aid in MI diagnosis. The relation between clinical experience and end results has been found in many studies, for example cancer survival (20), neonatal mortality (21) and post-operative deaths (22) as well as for MI (19).

The rapid growth in the use of CCU's for the treatment of MI has been based on studies which showed the decline in mortality in a hospital following the inauguration of a CCU. Other attempts have been made to assess or evaluate CCU effectiveness (24, 25, 26). The goal of improving health requires decisions and action based on medical evidence, including epidemiologically-derived information on patient and population needs. Since funds for health and medical care are finite, efficiency and economy must also be assured. To assure efficiency and economy the health system requires a sound organization and an equitable distribution of health services according to need. This will be dealt with further in the next part of this chapter.

3.B Utilization and distribution of coronary care units in the U.S. and Sweden

This study, comparing the distribution, use and outcome of care in coronary care units in Sweden and the United States grew out of study 3A and two earlier reports (16, 19). The first part of this study - on the utilization of coronary care units in Sweden and the US - makes use of the results of study 3A and one of the earlier reports which emphasized the great variation in output, cost, productivity and mortality in CCU's in the United States (16). The second part here - on the distribution of coronary care units in Sweden and the US - is based on a study showing the potential results of epidemiologically-based planning in meeting population need for intensive coronary care in Massachusetts (19).

3.B.1 Utilization of coronary care units in the U.S and Sweden

The study design has been described in detail elsewhere (19). In brief, a sample of hospitals was randomly selected, after stratification by number of CCU beds and teaching function, from all the hospitals in New Hampshire, Massachusetts, Rhode Island, Connecticut, and New York City. In addition, all Vermont hospitals having a CCU were studied. Data were collected on all CCU patients during one year, including diagnosis at discharge from the CCU, length of stay in the unit, death or survival in the unit and cost of CCU care. Comparable data were collected from the similarly stratified random sample of CCU's in Sweden, However, the Swedish hospital budgeting system did not allow accurate CCU cost data to be abstracted and thus important cost comparisons with the US sample could not be made. Both US and Swedish hospitals often combine their CCU and other intensive care. However, in every instance it was possible to separate strictly coronary care from other intensive care for this analysis.

3.B.1.1 Distribution of diagnoses

The United States had an age-adjusted MI rate of 3.8/1 000 population (30) while Sweden's was 3.4/1 000 (29, 30), or 10.5% lower. Table 1 presents the distribution of diseases by the principal diagnosis on discharge from the CCU in a random, stratified sample of 31 hospitals in the US and 6 hospitals in Sweden.

Table 1. Discharge diagnoses. United States (1972) and Sweden (1974)[1)]

Diagnoses	SW Regional (%)	US Univers related (%)	SW County (%)	US Other teaching (%)	SW Comm (%)	US Non-teaching (%)
Myocardial infarction	62.7	54.9	58.7	51.6	47.3	46.8
Arrhythmia	10.2	14.5	10.3	19.2	13.8	15.3
Congestive heart failure	6.0	7.2	2.5	5.6	5.2	7.9
Coronary insufficiency	6.0	2.3	8.0	5.5	5.6	6.3
Angina pectoris	6.2	3.3	8.9	1.7	12.3	4.7
Other cardiovascular	7.1	12.6	5.5	7.8	7.0	13.2
All non-cardiovascular	1.8	3.3	6.1	1.8	8.8	4.3
Diagnosis unknown	0.0	2.0	0.0	6.8	0.0	1.4
All hospitals	100.0	100.0	100.0	100.0	100.0	100.0

1) It is assumed that SW Regional/US University-related, SW county/US other teaching, and SW community/US Non-teaching are comparable pairings based on similarities in size, volume, teaching status and specialty distribution.

Myocardial infarction was by far the most frequent diagnosis in all hospitals but more often so in the Swedish hospitals, especially in the regional and county hospitals. An important difference was the high rate of angina pectoris in patients discharged from the Swedish study CCU's. The "other cardiovascular" category of both the Swedish and US hospitals included patients with myocarditis, pericarditis, endocarditis, heart block and the like, but was less prevalent in Sweden.

In the non-cardiovascular category of Swedish hospitals there were patients with aortic aneurysm, pulmonary infarct and other serious, acute disease. However, US patients in the non-cardiovascular category had a wide range of usually low-risk conditions (19).

If patients with severe coronary disease other than MI (serious arrhythmias, coronary insufficiency, angina pectoris, plus those with higher degrees of heart block and cardiac arrest) are added to the patients with MI, then the proportion of patients with serious episodes in Swedish regional hospitals was about 85%, while in county and community hospitals it was 80% and 70% respectively. The proportions in the US were 65% in university-related, 60% in other teaching and 55% in non-teaching hospitals. One possible explanation of these differences can be found in the organization of the two services. In US hospitals, CCU's are seldom directed by a hospital-based physician as is the case in Sweden. There are many more CCU beds per population in the US than in Sweden. Stricter admission criteria may exist for admission to Swedish CCU's than to those in the US. In Sweden, hospitals operate on an annual budget, while US hospitals are reimbursed for the cost of care they give and US physicians are paid fee-for-service while Swedish physicians are salaried. Thus the incentives to economical operation differ between the two nations.

3.B.1.2 Average length of stay

The average length of stay in US CCU's was 81% longer than that in Swedish CCU's with each hospital category exhibiting similar differences (table 2). This is in sharp contrast with mean stays for all hospital patients, including those with severe coronary disease, which averaged about 8 days in the United States and about 14 days in Sweden. The longer US CCU lengths of stay may have been a function of the large number of CCU beds in relation to the population at risk. However, no data were collected on the length of hospitalization of CCU patients once they were discharged from the CCU to other hospital wards.

Table 2. Length of stay in coronary care units.
United States 1972 and Sweden 1974.

	SW Re- gional (%)	US Univers related (%)	SW County (%)	US Other teaching (%)	SW Comm (%)	US Non- teaching (%)
Average length of stay (days)	2.5	4.4	2.6	4.5	3.2	5.1

3.B.1.3 Productivity

Table 3 shows the results of two measures used to evaluate CCU utilization and productivity. Occupancy rates, which are a measure of capital resources utilized, differed within hospital categories. The overall occupancy rate was about the same for Swedish (75%) and US (76%) CCU's. Larger differences were found when discharges per bed were measured. This is a measure of combined labor and non-labor productivity and is also interdependent with length of stay. Within each hospital category, the Swedish CCU's were more productive by this measure than CCU's in the United States.

Table 3. Occupancy rate and discharges per bed in coronary care units.
United States 1972 and Sweden 1974.

	SW re- gional (%)	US Univers related (%)	SW County (%)	US Other teaching (%)	SW Comm (%)	US Non- teaching (%)
Occupancy rate (%)	87.1	78.8	70.7	76.9	69.5	70.6
Discharges per bed	125.7	64.3	98.8	62.3	78.5	48.5

The results, although varying between groups showed greater productivity for regional than university-related hospitals, for county than other teaching hospitals and for community than non-teaching hospitals.

In earlier publications, it was shown that increasing economies of scale, and higher productivity, were a function of unit size (16, 19), the larger the CCU, the greater the output per unit of input per year (productivity). The average number of beds in the Swedish CCU's was greater than that of US CCU's, which thus might be one reason for their greater productivity.

3.B.1.4 Outcome

Overall, patients in Swedish CCU's had lower case fatality rates, particularly those with MI, (table 4) although US non-teaching hospitals had lower mortality rates than their Swedish community counterparts.*

Table 4 . Deaths from myocardial infarction and other causes. United States 1972 and Sweden 1974.

	SW Regional (%)	US Univers related (%)	SW County (%)	US Other teaching (%)	SW Comm (%)	US non-teaching (%)
Percent deaths from MI	10.5	16.3	12.3	19.2	23.5	18.7
Percent deaths other causes	0.4	0.6	0.3	0.6	0.5	1.4

While these differences were all technically significant, no clinical information was available from US hospitals to ensure patient comparability. Patients who did not have MI's had the same low case fatality rates in both Swedish and US hospitals.

* There are always dangers in comparing results from two countries such as the US and Sweden because of differences in culture, demography and genetics.

Within the Swedish regional and county hospitals, there was close similarity in MI death rates, while the community hospitals showed high and variable mortality rates, much as their US counterparts. In the US, 86% of MI patients who die do so within 72 hours of the onset of symptoms, and of those who die, one-half succumb before hospitalization.

3.B.2.1 Population and coronary care units

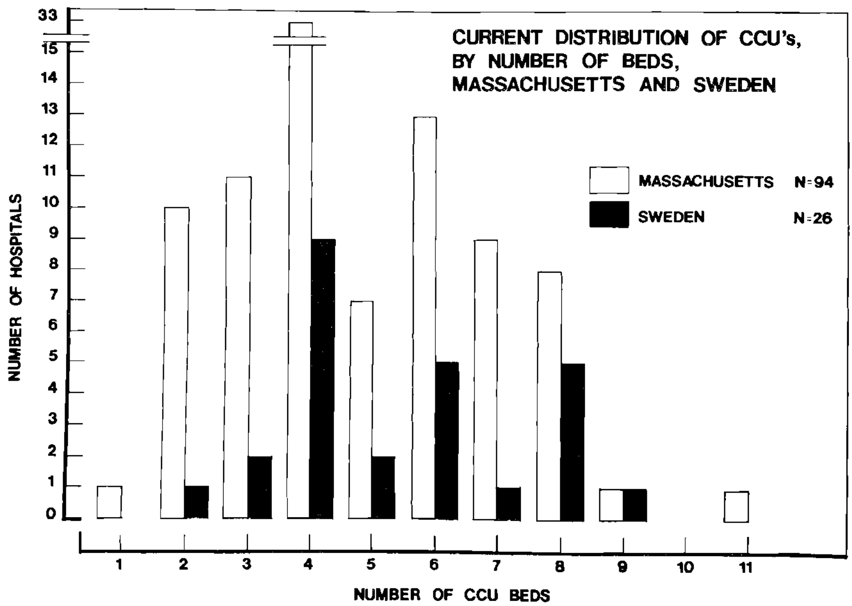
Massachusetts had approximately 5.6 million people living in an area of about 21 000 km^2 in 1973 (27). There were 94 hospital coronary care units with a total of 446 beds. The population was highly urbanized, with 83 percent living in 10 standard metropolitan statistical areas (SMSA). The greatest distance between any two CCU's was less than 40 km.

Sweden has a population of about 8.1 million living in an area of approximately 450 000 km^2 (28). In 1975, there were 26 hospital CCU's with a total of 140 beds. A large majority of the population lived in urban areas. The greatest distance between CCU's was 560 km, in the northern, sparsely inhabited region of the country. In southern Sweden, where the great majority of the population lived, the greatest distance between CCU's was 220 km, although the large majority of the population was within 75 km of a CCU (See also appendix 3:1, 3:2, 3:3).

Massachusetts is 1/20 the size of Sweden and had 30 percent fewer inhabitants, but nearly four times as many CCU's and more than three times as many CCU beds as Sweden at the time of the study. Seventy-three percent of Massachusetts' hospitals and 28 percent of Swedish hospitals had CCU's. Sweden has fewer hospitals than the US, but they are generally larger. There has also been a greater concentration of regional services than in the US (29).

Figure 1 presents the distribution of CCU's by number of beds during the study years in Sweden and Massachusetts.

Figure 1. Current distribution of CCU's by number of beds.
Massachusetts 1972 and Sweden 1974



It was concluded in an earlier study that a major problem with CCU's in the State of Massachusetts was inappropriate and inefficient distribution which did not bear a relation to the true medical needs of the population. Epidemiologically derived incidence rates for specific diseases would help meet the health care needs of CCU services and facilities (19). Assuming that the majority of studies published to date determine the clinical effectiveness and the continued use of this medical service, the analysis here will concentrate on appropriate organization and rational distribution of CCU's. A regional distribution of health care services could be based on epidemiologically-determined need, when known. The incidence of severe coronary disease has been determined for both Sweden and the United States. Statistics on the distribution of the population are also available. The use of these two statistics to allocate populations to each unit according to predefined criteria is the basis here of a rational system of resource distribution.

3.B.2.2 Method

The methodology for estimating numbers of patients with severe coronary disease and allocating them to CCU's has been described in detail in the previous study (19). In brief, for Massachusetts, annual age-specific and sex-specific incidence rates from the Framingham Heart Study (30) were applied to the 1970 population (age 30 and over) of each city and town in Massachusetts to determine anticipated cases in each area. For Sweden, annual age-specific and sex-specific incidence rates from a study by Elmfeldt (31) were applied to the 1974 population of each commune (33). To the total of MI's occurring each year was added a further 30% to account for false-positive diagnoses and other severe coronary disease. Total estimated demand (table 5) is exaggerated, since 40% of patients with acute, serious manifestation of heart disease will not be hospitalized, as they either have silent infarcts or else sudden and unexpected death intervenes (32). Thus the estimated number of patients at risk of being hospitalized* has been distributed among a system of CCU's in Massachusetts and in Sweden. The large number of Massachusetts patients with other coronary and non-coronary disease was probably due to the large number of CCU beds available (19).

The allocation criteria used for CCU's in Sweden were the following:

- All patients should have ready access to a unit. In the study of Massachusetts the maximum travel criterion for 95% of potential patients was 30 minutes, or 48 km. The maximum travel criterion for Sweden has been set at 50 minutes, or 75 km. Sweden's population is less dense than that of Massachusetts and thus travel time or distance must be greater.

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* Number with MI plus false-positive x 0.60

- Every patient should have at least a 95% chance of finding an available bed in the nearest unit. Each CCU is assumed to have an 80% occupancy rate and an average length of stay of 3 days.

3.B.2.3 Results

Table 5 summarizes the estimated number of patients with severe coronary and other diseases and calculated hospitalizations in CCU's for the State of Massachusetts and Sweden. (See also appendix 3:4, 3:5).

Table 5. Estimated number of patients with severe coronary and other diseases and calculated hospitalizations Massachusetts 1972 and Sweden 1974.

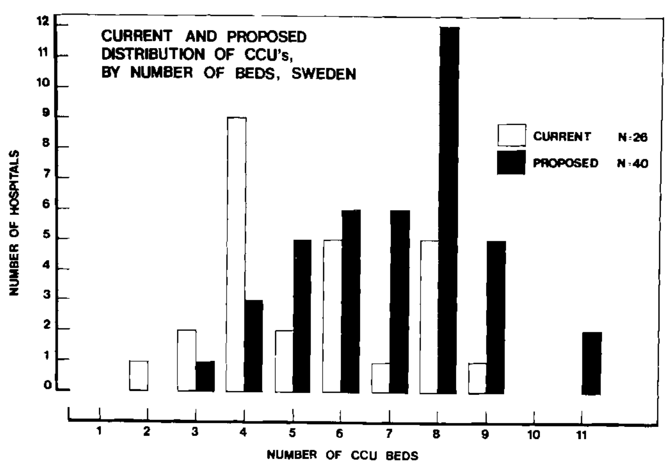
	Massachusetts	Sweden
Age-adjusted rate of MI/ population	3.8	3.4
Number with MI	21 065	27 670
False positives	3 947	8 300
Total with severe coronary disease	25 012	35 970
Number of MI and false-positive patients hospitalized	15 975	21 582
Patients in CCU's with other coronary and noncoronary disease	8 215	4 043
Total patients in CCU's	24 190	25 625

In the study of the distribution of CCU's in Massachusetts an excess of beds was found. There were many small units serving overlapping populations. The plethora of units was accompanied by high admission rates of patients with mild heart disease and non-cardiac disease. However, the current CCU system in Massachusetts with its abundant supply of units and beds appeared to be accepted by physicians and the public (16, 19). Sweden has a quite different distribution pattern.

The relationship between current distribution of CCU's and need of this medical service as judged from estimates based on epidemiological data shows a shortage of beds.

There are two basic options available with regard to the distribution of CCU's in Sweden. One option is no change. The second policy option is an increase in the number of units and beds as well as a redistribution of units to regional and county hospitals. Figure 2 shows the current and proposed distribution of CCU's in Sweden if the second option were used. The earlier, more rational and far more restrictive supply of CCU's suggested for Massachusetts (16) is still quite liberal by the standard proposed by this second option for increasing the number of Swedish CCU's.

Figure 2. Current and proposed distribution of CCU's by number of beds, Sweden 1974.



3.B.2.4 Summary

The second policy option is suggested here for the sake of distributional equity. It would allow more people with myocardial infarction or other severe coronary disease easier and earlier access to a CCU. It might seem difficult to support a distributional equity argument since any increase in the number of units will cost money and deter funds which are being competed for by other health care and other social needs. As Feldstein has pointed out: "Increasing demand has been identified as the primary reason for the unusually rapid rate of cost increase (in hospital costs). Higher demand has induced a change in the technology of hospital care to a better but more expensive product" (33).

However, since this study is making an argument for a more economical system of coronary-care units, the possible effects of a different organization on quality of care must be considered. Care at lower cost with poorer patient survival is not "more economical". Much of medical-care quality is judged by the quality of the inputs - number and training of physicians and other personnel, adequacy of facilities and service organization. Other things being equal, better staffed and equipped units with greater experience should provide assurance of care quality. However, it is output measures, or end results, that ultimately determine the quality of care.

Planning in the United States is based on an institution's perceived need, whereas in many other countries it is based on population need. These unique approaches to planning have led to widely differing distribution of facilities and services. Planning by the US method leads to a more generous provision of services than does population-based planning.

In both the Swedish and US health care systems the planning process appears to be of paramount importance, while the fundamental questions of effectiveness, outcome and impact of medical care services are usually ignored. Even population-based planning either cannot or will not deal with the conflict between professional desire for highly developed technology on the one hand and treatment effectiveness on the other. Nevertheless, population-based planning, using epidemiologically derived data and stressing economical organization of medical services, has at least the virtue of providing a more equitable distribution of health services. Finally, it should be emphasized, once again, that study results cannot be interpreted in the absence of knowledge of patient health outcome. A comprehensive judgement of the need of this medical service also should include an assessment of the value of alternative use of health resources.

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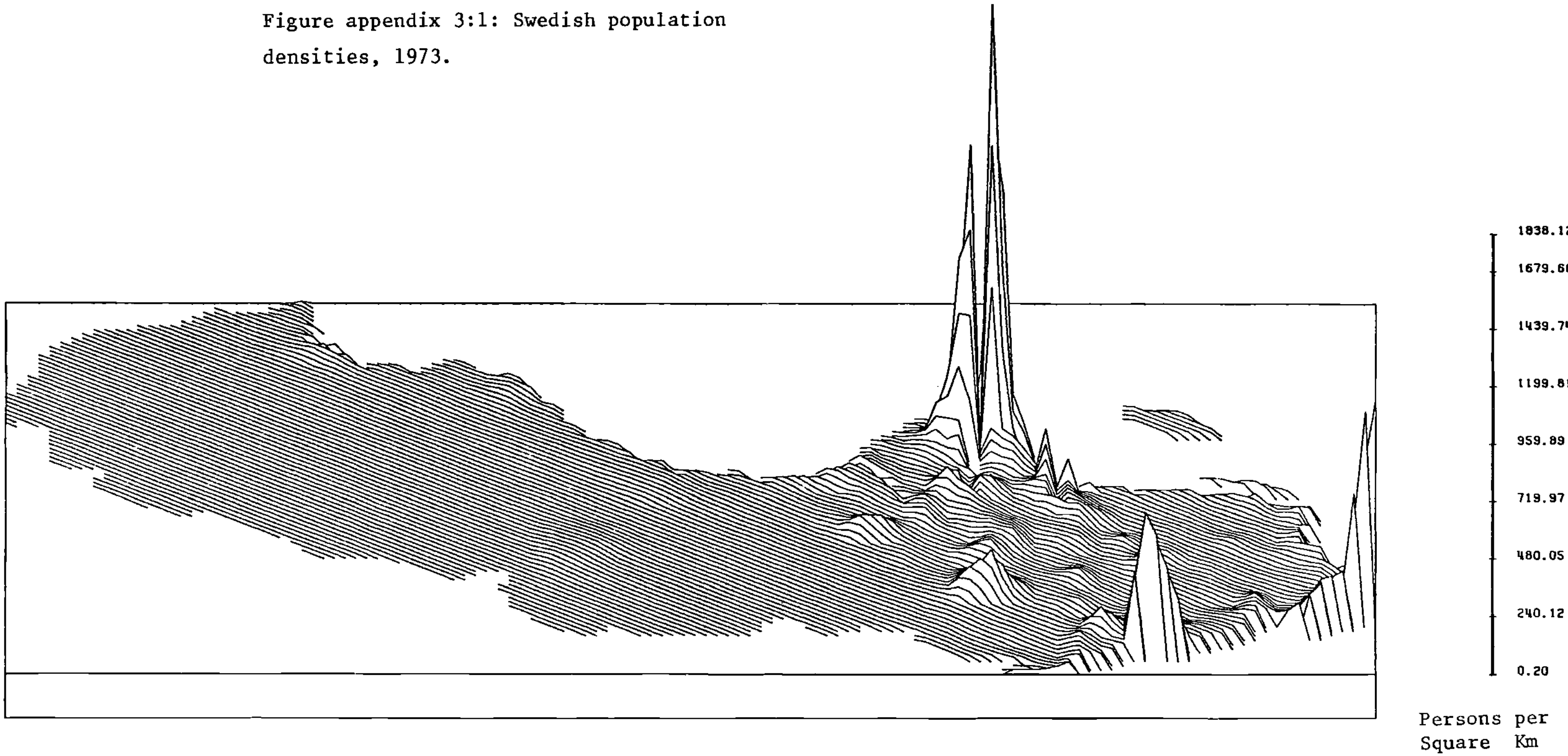
Figure appendix 3:1: Swedish population densities, 1973.



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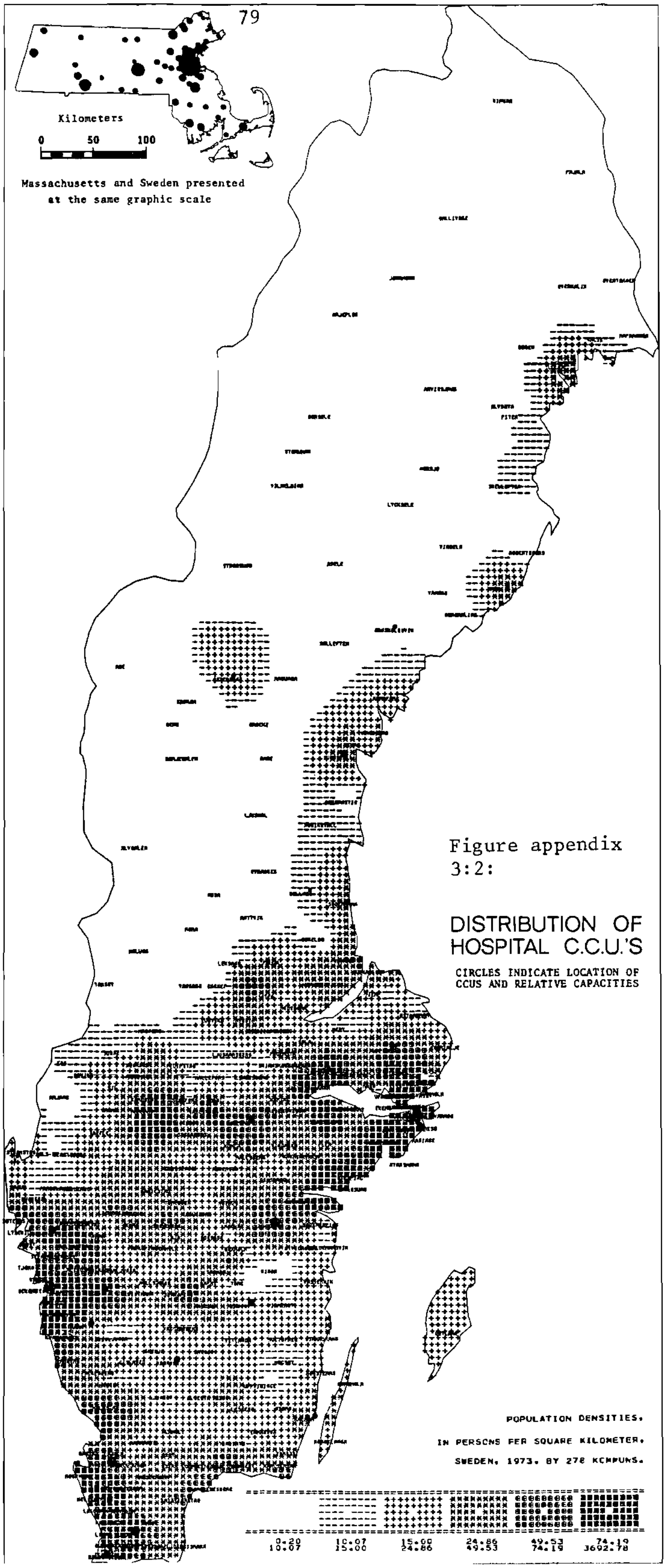


Figure appendix 3:2:

DISTRIBUTION OF HOSPITAL C.C.U.'S

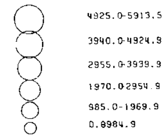
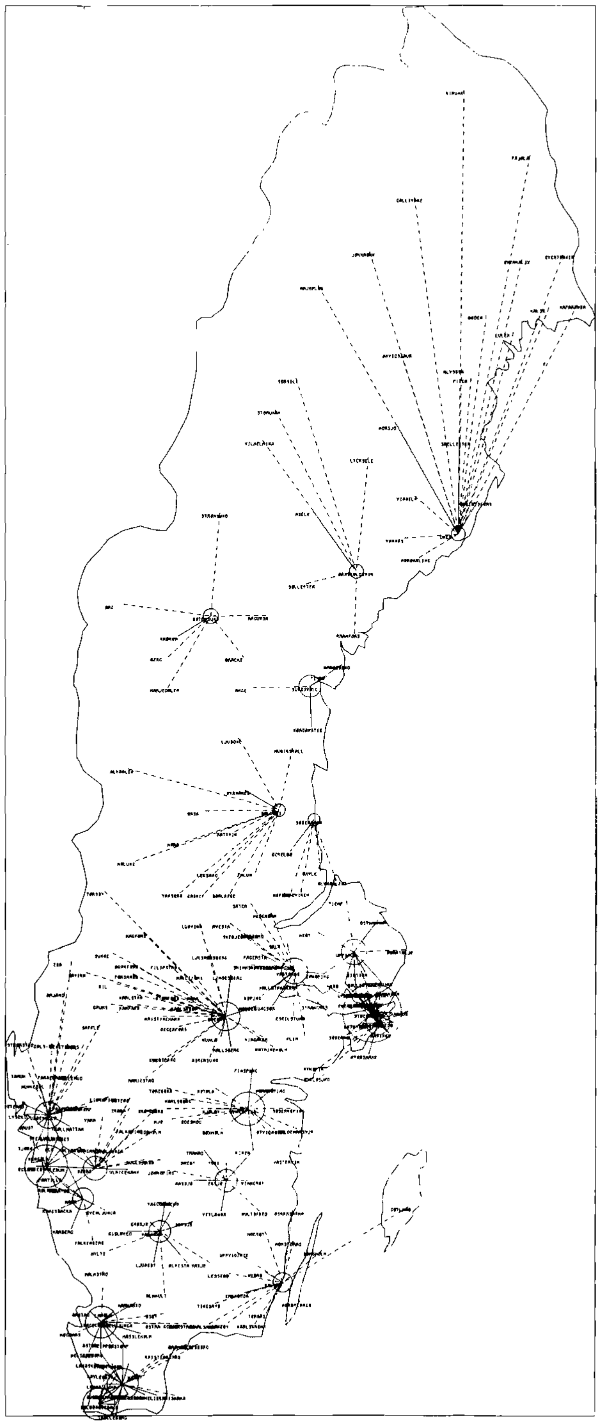


Figure appendix 3:3: Flow of patients to CCU's. Circles proportional to demand.



FLOW OF PATIENTS TO CCU'S. CIRCLES PROPORTIONAL TO DEMAND.

Figure appendix 3:4: Density of expected cardiac cases in places outside of CCU service areas.

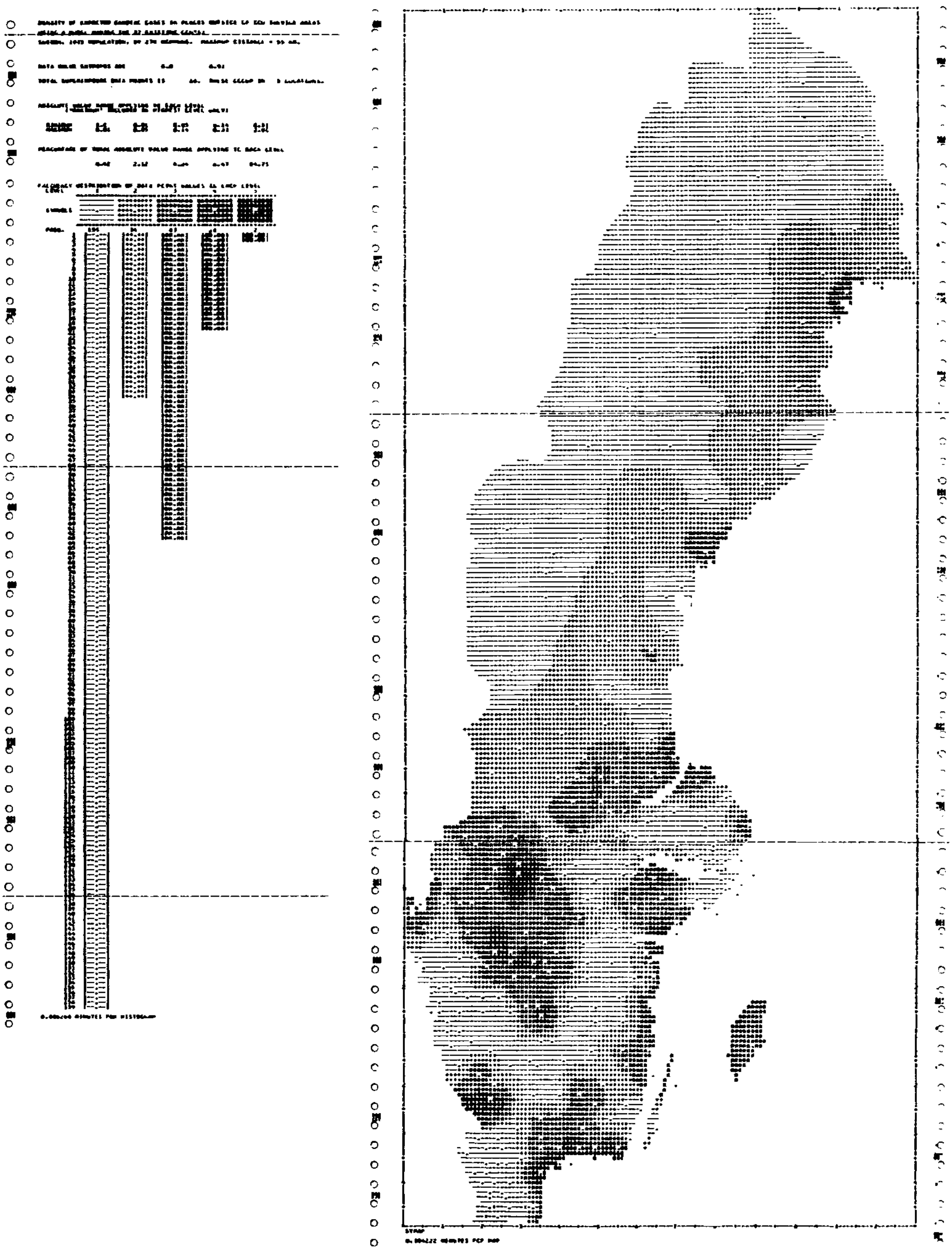


Table appendix 3:5: Age-Specific and Sex-Specific Rates of Heart Disease for Sweden, Based on Swedish & US Coronary Statistics

	MALE					FEMALE				
	MI	F+[1]	SD[3]	NSD[3]	TOTAL	MI	F+[1]	SD[3]	NSD[3]	TOTAL
40-44	46	14	6	1	67	8	2	-	2	12
45-49	194	58	31	8	291	32	10	-	1	43
50-54	399	120	81	52	652	77	23	13	-	113
55-59	789	237	209	65	1300	196	59	25	34	314
60-64	1135	340	203	125	1803	210	63	53	44	370
65-69	1031[2]	309	152	183	1675	290[2]	87	97	64	538
70+	1130[2]	339	507	304	2280	1210[2]	363	596	357	2526

[1] False Positive (F+) cases are estimated as 30% of MI rate.

[2] Highest 2 cohorts are estimates based on US (Framingham) data, scaled down to be roughly proportional to the overall Sweden/US ratio.

[3] Sudden Death (SD) and Not Sudden Death (NSD) rates are estimated as follows:

$$SD_{Sweden} = MI_{Sweden} \times (SD_{US}/MI_{US})$$

$$NSD_{Sweden} = MI_{Sweden} \times (NSD_{US}/MI_{US})$$

Underlined figures are Swedish Data. Other figures are estimates, SD and NSD figures based on Framingham heart study applied as specified in note 3 above.

4 ECONOMIC EVALUATION OF DIAGNOSTIC TECHNOLOGY THE CASE OF CT—SCANNING OF THE HEAD

4.1 Background

Ever since Wilhelm Roentgen made his discovery in 1895, X-ray technology has been one of the most important diagnostic aids available in the field of medicine.

X-ray technology has been improved over the years, but up to the 1970's, it was associated with difficulties in producing images in which different organs of similar tissue densities could be directly distinguished.

Attempts to overcome these problems have led to the development of tomography** whose theoretical basis was laid down as far back as 1917 (1). In tomography, the reconstructed image represents a "slice" or section through a given part of the body in which the rest of the anatomy has been "erased". Tomography was developed for practical use in the 1920's, but was accorded relatively limited importance. With the aid of modern computer technology, tomography was further developed during the 1960's (2, 3, 4).

The first commercially available computer tomograph was designed by the researcher G N Hounsfield of the English corporation EMI Ltd. Hounsfield's invention was considered to have paved the way for a major breakthrough in medical diagnostics (5, 6, 7).

The first computerized tomographs were put into clinical use in 1972. They were designed for examinations of the head, but since 1974, techniques have also been developed and made available for whole-body examinations (8, 9).

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* CT = computerized tomography

** Tomo: from the Greek "tome" (slice)
Grafi: from the Latin "graphia" (write)

4.1.1 Existing techniques for examinations of the head

Head examinations can be undertaken using different methods and are used to diagnose such disorders as headache, dizziness, psychological and psychosomatic dysfunctions, epilepsy, paralysis, head injuries, etc.

X-ray examination of the brain is carried out today either in the form of cerebral angiography, where a contrast liquid is injected into one of the major blood vessels in the head, or as pneumoencephalography, where the cerebral ventricles are filled with contrast-producing gas. The blood vessels or ventricles are then reproduced on the X-ray film using conventional radiographic technique. Conclusions can be drawn regarding morbid changes on the basis of the location, appearance, and so on of the vessels or ventricles.

Such neuroradiological examinations are laborious for radiology departments and very inconvenient for the patient. Pneumoencephalographic and cerebral angiographic examinations usually cause pain and often fear on the part of the patient and can also lead to other unpleasant side-effects such as headache, vomiting and nausea. They are also associated with a significant risk of complications (10, 11).

Approximately one-fifth of patients are anaesthetized prior to pneumoencephalographic or cerebral angiographic examination (12), and in 10-20% of these cases, this is done because the pain would otherwise be unbearable (13). After a pneumoencephalographic examination, the patient must remain in bed for about three days, and a total of about one week of hospitalization is required on the average for all patients who are to be examined neuroradiologically.

In most cases, pneumoencephalographic and cerebral angiographic examinations are preceded by other examinations such as head X-ray, choencephalography, EEG or gamma-encephalography and, in some cases, pneumoencephalography must be preceded by drilling the skull. Diagnostic decisions and choices of therapeutic measures are made on the basis of evaluations of one or more of these examinations.

4.1.2 The new method

Since 1972, a clinically proven method has been available which makes better use of X-rays. An X-ray source and a number of detectors are moved around the head step by step and the absorption of the X-rays at each point of a given cross-sectional "slice" of the brain is recorded by a computer, which then processes the data and produces scans of the brain in the examined slice.

This method makes it possible for the first time to obtain a direct image of the brain itself and the contents of the orbits, and very detailed interpretations can be made. As a rule, eight scans are made from the top to the base of the skull, permitting a determination of the location and extent of any changes. The new method for X-ray tomography of the brain is termed "computer assisted tomography (CAT or CT) of the head". Computer assisted tomography is a painless examination method which can be performed without hospitalization of the patient. The X-ray dose is the same or less than that to which the patient is exposed by conventional cranial radiography.

4.1.3 Clinical experiences of CT of the head

Since the CT head scanner was introduced on the market a large number of computer tomographs have been manufactured and sold throughout the world. The roentgenological experiences and the clinical consequences of computer assisted tomography of the head are fairly well-documented. The literature indicates that computer assisted tomography has led to a considerable improvement in the chances of diagnosing cerebral haemorrhages, infarctions, tumors and head injuries as well as various conditions in the ear and eye sockets. This has led to a considerable reduction of the number of examinations employing previous diagnostic techniques, especially pneumoencephalographic and cerebral angiographic examinations as well as radioisotope studies (14, 15, 16, 17, 30).

In addition to providing more rapid and more reliable diagnoses, experiences show that the number of exploratory surgical procedures required for head injuries can be reduced (18) and dose planning for radiation treatment can be improved. In addition, CT-scanning of the head makes it possible to distinguish haemorrhages from infarctions, opening up real therapeutic possibilities for these conditions.

In Sweden at the time of this study (1976) computerized tomographic scanners for the head had been installed at the Karolinska Hospital in Stockholm (1973) and at the Regional Hospital in Umeå (1975).

4.1.4 Economic implications

The sharp rise in the demand for head tomographs is said to be due mainly to the great advantages entailed by the new technique for the patient, but also because the new examination method is thought to carry direct economic savings. All financial calculations made thus far have indicated that considerable savings may be achieved by the introduction of computerized tomography of the head.

In a study conducted at Toronto General Hospital, where a computer tomograph was installed in 1974, 30 physicians who had used CT-scanning of the head for their patients were interviewed. The questions dealt with how many pneumoencephalographic and cerebral angiographic examinations would have been necessary in the absence of CT. The physicians were also asked to estimate the number of hospital admissions which had been avoided by the availability of CT-scanning of the head. The results of this study indicated a possible cost savings of about Skr 10 million (19). It should be noted that this figure is not attributable to this hospital alone. The introduction of CT of the head at Toronto General Hospital has led to a reduction in the number of pneumoencephalographic and cerebral angiographic examinations resulting in an annual savings of Skr 1.2 million (20).

A similar study of the possible reduction of the number of pneumoencephalographic and cerebral angiographic examinations was carried out at the Department of Neurology at the Southern Hospital in Stockholm. This study was not, however, based on interviews but rather on evaluations of various medical reports. The annual savings in operating costs was estimated to be about Skr 1 million (21).

A study of the patients treated at the departments of neurology and neurosurgery and the resources they required was carried out at the Sahlgrenska Hospital in Gothenburg. This study served as a basis for an estimate of the number of days of hospitalization and visits to the hospital as well as the type and number of examinations which could have been avoided if CT-scanning of the head had been available. The cost savings per year was estimated to be Skr 1 million (22, 23). A comparison of the estimated costs of CT-scanning of the head versus the costs of pneumoencephalographic and cerebral angiographic examinations was made at the University of Uppsala. The calculations indicated a cost ratio of 1:10:16 (12).

In these previous economic studies, special emphasis was placed on the savings which can result from a reduction in the load on the various wards due to the fact that the CT examinations can be carried out on an out-patient basis. The reduced burden on the radiology departments entailed by the considerable reduction in the number of pneumoencephalographic and cerebral angiographic examinations was also pointed out.

4.2 Evaluation

An evaluation of CT-scanning of the head may be undertaken from many different perspectives. For example, purely technical considerations of safety and capability, medical questions regarding the diagnostic information and its accuracy, therapeutic implications and impacts on the ultimate outcome on the patinent's prognosis or health status can be investigated.

From an economic point of view it is important that financial and other kinds of resources required for computerized tomography are considered in relation to the value or benefit exerted by the technique. By benefit is meant here not only quantitative gains, but also "non-economic" qualitative factors such as the possible elimination of pain, anxiety and fear, the reduced risk of complications, etc. It further refers not only to the immediate value of being able to make a better and more precise diagnosis, but also the consequent value of such an improved diagnosis on the choice of alternative courses of therapeutic action and ultimate health outcomes. These factors should in turn be evaluated in comparison with corresponding results for examinations employing other diagnostic techniques. Such an evaluation will depend on the availability of data which could be measured and assessed. However, when a new diagnostic technology is introduced in medical care, it often takes a long time before any data become available for making general conclusions concerning its value. In general, purely medical viewpoints are reported first, and only then is attention shifted to the comparative diagnostic benefits and costs of conventional and new technology. After additional time has passed, the results of studies concerned with the question of how the new technology influences therapeutic measures are published, and eventually data on the effect of the new technology on health outcomes are reported.

Some of the immediate questions in the evaluation of CT-scanning of the head are the following:

- What diagnostic alternatives to computed tomography are available?
- What diagnostic advantages does computed tomography have compared with other conventional techniques?
- To what extent can computed tomography replace other - perhaps less effective - types of examination?
- What does a computed tomography examination cost in relation to other diagnostic means?
- To what extent will the availability of computed tomography affect the choice of therapy?

- Can the possible influence of computed tomography on the choice of therapy affect the treatment outcome, and if so, how?

The experience of computed tomography is far from sufficient to permit full answers to be given to all of these questions. However, a partial analysis of the cost-effectiveness of this new technology will be presented here.

4.2.1 Measures of effectiveness

In view of published material so far (May 1976) on CT-scanning of the head the most notable effects of the introduction of this medical technology appear to be:

- New diagnostic possibilities
- Possible therapeutic improvements
- Elimination of pain, anxiety and fear
- Reduction of risks involved in the examinations
- More rapid information for the patient
- The possibility of obtaining results which indicate the advisability of shifting from advanced technical therapy to general medical care.
- The possible replacement of costly and, in some cases, less effective diagnostic procedures
- The freeing of personnel resources
- A reduction in the load placed on the hospital wards

Different elements of these effects may constitute measures of effectiveness. In general effectiveness here refers to the least costly way of achieving a stated objective. In the health context the objective is generally assumed to be optimal health outcome. However, a diagnostic technology usually does not itself affect the health outcome of patients. Therefore, a more complex definition of the effectiveness of CT-scanning of the head will be needed.

The technical capacity and the diagnostic supplementary strength of CT-scanning are two structural elements by which effectiveness may be established. The same is true of two process elements: diagnostic accuracy and therapeutic impacts. The contribution of CT-scanning to the ultimate outcome in terms of health of the patient will mainly depend on the technology's influence on therapeutic plans.

The effectiveness of CT-scanning of the head in terms of diagnostic accuracy and technical capacity have been assessed (14, 15, 16, 17). It is assumed here that the effectiveness of CT-scanning in these respects is equal to alternative diagnostic technology. The aim of this study is to investigate the structural implications of the introduction of CT-scanning of the head and to establish at what level this technology may prove to be cost-effective, in terms of supplementing neuroradiological procedures. Such a calculation is only one of the many elements the assessment of the CT-scanning technology.

4.3 Structural implications of CT-scanning of the head

Practical experience with computer assisted tomography has shown that previous diagnostic techniques can to some extent be replaced or rendered unnecessary, permitting a reduction in hospitalization. Furthermore, CT-scanning has made it possible to achieve certain cutbacks or redistribution of personnel and has made it possible to reduce the number of invasive surgical procedures. The structural considerations here will be limited to the extent to which CT-scanning of the head may substitute for other diagnostic inputs. In the literature it is indicated that CT-scanning of the head may partly replace the following procedures:

- pneumoencephalographic examinations
- cerebral angiographic examinations
- radioisotope examinations
- echoencephalographic examinations
- exploratory surgery

4.3.1 Reports on the U.S., Canada and England

In a report on developments at 20 hospitals in the USA and two in Canada where CT-scanning of the head had been introduced, a significant reduction in the number of cerebral angiographic and radioisotope examinations was found (26).

At the Mayo Clinic in the USA, the number of pneumoencephalographic examinations was reduced by 80% (26). At Toronto General Hospital in Canada these examinations were reduced from 250 per year to about 25 per year, (i e by about 90%), by the introduction of CT-scanning (20). At Atkinson Morley's Hospital in England, the number of pneumoencephalographic examinations was reduced by 90% and the number of cerebral angiographic examinations by 50% with the installation of a computer tomograph (35).

Two hospitals, one in England and one in Canada report that the availability of CT-scanning has permitted a reduction of the number of surgical exploratory operations for the diagnosis of head injuries by 80% (18, 35) and 30-50% (20).

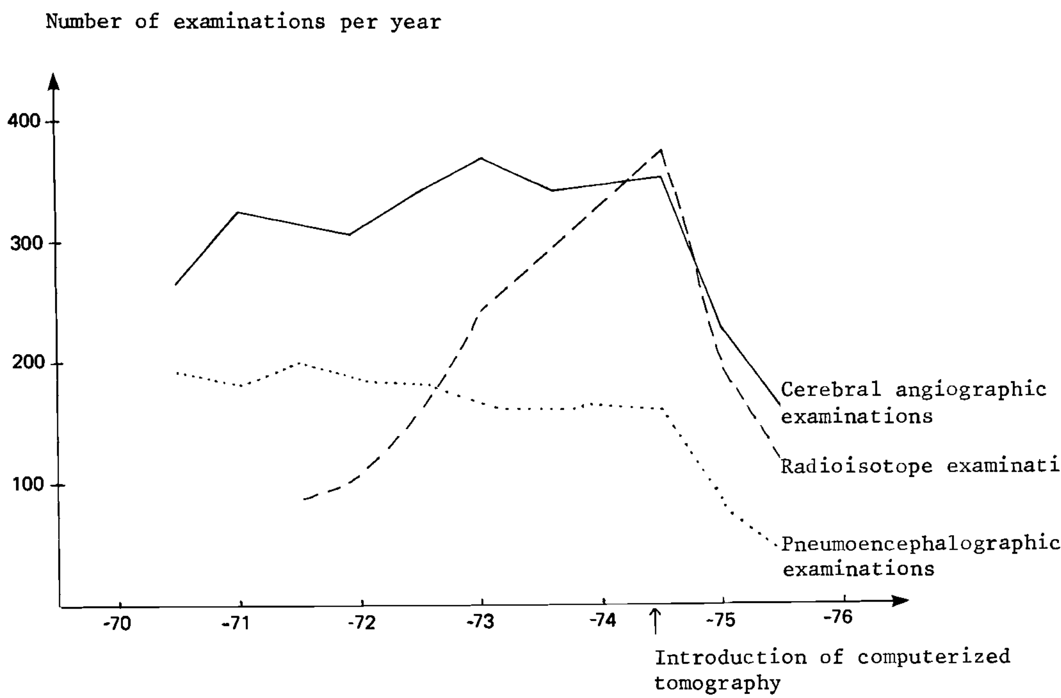
Hospitals in Manchester and Boston report that most head injuries are now examined by means of CT-scanning and that pneumoencephalographic, cerebral angiographic examinations and radioisotope examinations have been reduced substantially as shown in table 1 (30).

Table 1. Reduction in the number of cerebral angiographic pneumoencephalographic and radioisotope examinations at two hospitals in England after the introduction of CT-scanning of the head (18,30)

Examinations	Percentage reductions Hospital I	Hospital II
Cerebral angiographic examinations	81	65
Pneumoencephalographic examinations	68	26
Radioisotope examinations	27	91

Frenchay Hospital in Bristol, England reported a reduction in the number of pneumoencephalographic examinations by about 75%, cerebral angiographic examinations by about 40% and radioisotope examinations by about 70% after the introduction of computerized tomography (25).

Graph 1. The number of cerebral angiographic, pneumoencephalographic and radioisotope examinations at Frenchay Hospital during the period 1970-1975.



4.3.2 Data on Sweden

4.3.2.1 Pneumoencephalographic and cerebral angiographic examinations

A total of about 2 500 pneumoencephalographic examinations and 12 000 cerebral angiographic examinations are performed each year in Sweden at some 80 radiology departments (31).

The number of pneumoencephalographic examinations has exhibited a clear downward trend for several years, from a total of about 3 850 in 1972 to about 2 400 in 1975, while the number of cerebral angiographic examinations has remained relatively constant since 1970.

Table 2. Breakdown of the number of cerebral angiographic and pneumoencephalographic examinations into hospital categories (31).*

	Pneumoencephalographic examinations			
	1972	1973	1974	1975
Regional hospitals	-	1 900	1 800	1 700
County hospitals	-	1 000	700	550
Community hospitals	-	400	250	150
Total	3 850	3 300	2 750	2 400

	Cerebral angiographic examinations			
	1972	1973	1974	1975
Regional hospitals	-	6 600	6 700	6 900
County hospitals	-	3 500	3 400	3 300
Community hospitals	-	1 500	1 500	1 500
Total	11 700	11 600	11 600	11 700

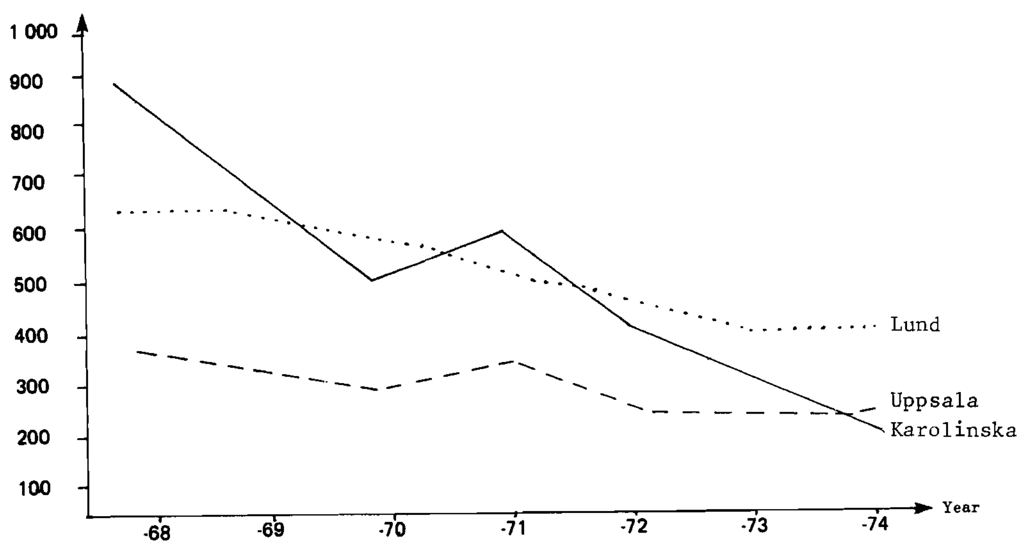
* In Swedish: Regionsjukhus
Länssjukhus
Länsdelssjukhus

The following figures illustrate the trend followed by the number of pneumoencephalographic and cerebral angiographic examinations from 1968 to 1974 at three different regional hospitals in Sweden.

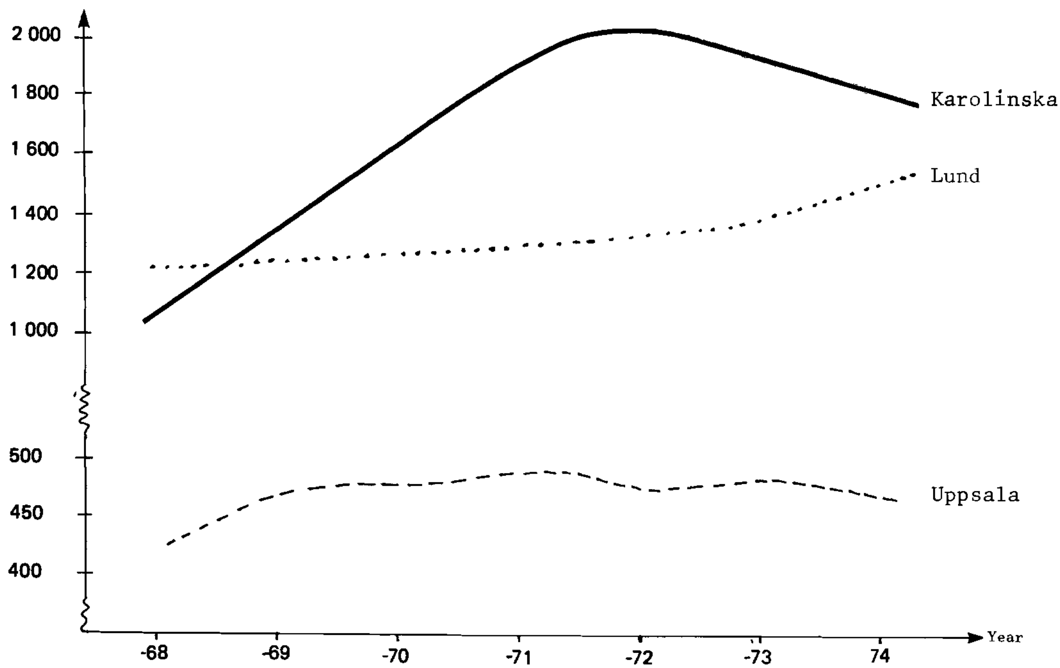
The figures also show that there are some substantial differences among regional hospitals in the number of examinations carried out per year. However the regional hospitals perform a much higher volume of these examinations than do most of the county and community hospitals.

Graph 2. Number of pneumoencephalographic examinations at regional hospitals in Uppsala, Stockholm and Lund 1968-1974 (21, 31, 32)

Number of examinations per year



Graph 3. Number of cerebral angiographic examinations at regional hospitals in Uppsala, Stockholm and Lund 1968-1974 (21, 31, 32)



The number of pneumoencephalographic examinations carried out each year at different county hospitals varies significantly. At some county hospitals only a few (1-5) examinations are made per year while others carry out close to 200 examinations per year. At eight of the county hospitals, less than 15 pneumoencephalographic examinations are conducted each year, and more than 50 such examinations are carried out at only two of the county hospitals each year. Approximately half of the community hospitals carry out fewer than five pneumoencephalographic examinations per year, and more than 20 such examinations are carried out at only three of these hospitals each year.

With regard to the number of cerebral angiographic examinations, the spread between the county hospitals is not particularly great. Most county hospitals carry out between 100 and 200 cerebral angiographic examinations each year. However, the variations in the number of cerebral angiographic examinations carried out at the community hospitals is great, from two to about 200 examinations per year. Approximately half of all local hospitals carry out 25 to 50 cerebral angiographic examinations each year.

Neurological experts generally agree that hospitals must carry out about 100 pneumoencephalographic examinations and/or cerebral angiographic examinations each year in order to maintain an adequate level of competency and skill in the performance of such examinations (39). Theoretically, this should mean that pneumoencephalographic and cerebral angiographic examinations should be concentrated in far fewer units than they are today.

The pre-CT decline in the number of pneumoencephalographic examinations may be due partly to an increasing realization of the real value of these examinations and a concomitant sharpening of the requirements on indication for referrals to neuroradiological testing. A computer tomograph has been in use at the Karolinska Hospital in Stockholm since November of 1973. About 2500 CT-scanning examinations were performed at the Karolinska Hospital from 1974 to 1976. At the same time the total number of neuroradiological investigations - including CT-scanning - was slightly reduced (39). The experience of CT-scanning so far indicates a possible reduction of pneumoencephalographic and cerebral angiographic examinations by 65% and 75% respectively.

Experiences of CT-scanning of the head at the Regional Hospital in Umeå also indicate a considerable reduction in the number of both pneumoencephalographic and cerebral angiographic examinations (28). The results of a retrospective case record study carried out at Sahlgrenska Hospital in Gothenburg indicated a possible reduction in the number of cerebral angiographic examinations by about 65% and the number of pneumoencephalographic examinations by about 70% (22, 23).

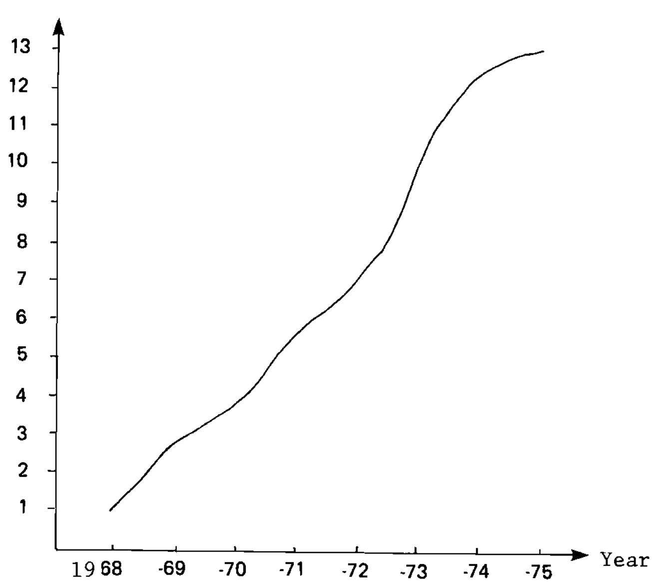
4.3.2.2 Radioisotope examinations

In a radioisotope examination, a radioactive trace element is introduced into the body, normally by means of injection. The trace element emits radiation which can be followed by, for example, a gamma camera, permitting the distribution of the element in the body to be recorded. Presence of the element in the brain can indicate brain pathology since a healthy brain possesses a barrier function which prevents foreign elements such as isotopes from entering the brain. If the brain is damaged, for example due to a tumor, infarction, hemorrhage or infection, the barrier function is usually defective, in which case the isotope leaks through the blood vessel system into the brain tissue and the gamma camera records an increased absorbtion of the element in this area.

Since the middle of the 1960's, these examinations have increased sharply in number due to the increased availability of gamma cameras. Today, some 14 000 scintographic radioisotope examinations of the brain are carried out annually in Sweden (33).

Graph 4. Number of radioisotope examinations carried out annually during the period 1968-1975 in Sweden.

Number of radioisotope examinations - thousands



A radioisotope examination costs about Skr 250 (1976 price-level) and CT-scanning can replace this type of examination in many cases. In several reports of experiences of CT-scanning of the head, a reduction in the number of radioisotope examinations by 30-90% is reported (25, 30, 35). In the Gothenburg study, it was estimated that radioisotope examinations could be reduced by 75% if CT were available (22, 23).

4.3.2.3 Echoencephalography examinations

Echoencephalography is carried out with the aid of transmitters and receivers of ultrasonic signals which are transmitted through the patient's head. The echo which is obtained when the signals are reflected from various interfaces in the brain can be registered and deviations from the normal pattern can give rise to suspicion of hemorrhage, tumor or other sources of pressure on the brain. The method is used to determine the need for further examination.

An echoencephalographic examination costs about Skr 150 (1976) and some 10 000 examinations are carried out each year in Sweden. According to the Gothenburg study (22, 23), it should be possible to eliminate about 70% of such studies by the introduction of the CT-scanning technique. This figure applies only to cases where echoencephalography would otherwise be prescribed as one in a series of examinations and where CT could eliminate the need for echoencephalography.

4.3.2.4 Other examinations

It is claimed in the literature that CT-scanning of the head can do more than reduce the number of pneumoencephalographic, cerebral angiographic, radioisotope and echoencephalographic examinations. In the Gothenburg study (22, 23), it was concluded that it should also be possible to reduce the number of electroencephalographs, skull X-rays and spinal taps, as well as the need for eye and ear consultations by the introduction of CT-scanning technique. Ambrose et al have presented a study which shows that the availability of CT-scanning has led to a drastic reduction in the number of surgical procedures undertaken for diagnostic purposes in head injury cases (18). The Ambrose study shows that about one third of patients with head injuries might require exploratory surgical procedures and that this can be rendered unnecessary in most cases when the CT-scanning technique is available. Theoretically this means that about 80% of all patients suffering from head injuries could be examined by CT-scanning instead of surgery.

4.3.3 Summary

The following table summarizes the findings of the diagnostic impact (ability to replace other diagnostic means) of computerized tomography of the head.

Table 3. Survey of diagnostic impact of CT-scanning of the head. (Figures in brackets are references)

Diagnostic method	Effect of CT-scanning
Pneumoencephalography	-26% (30), -68% (30), -70% (22), -75% (25), -90% (20), -90% (35)
Cerebral angiography	-40% (25), -50% (35), -65% (22), -65% (30), -81% (30)
Radioisotope examination	-27% (30), -70% (25), -75% (22), -90% (30)
Echoencephalography	-70% (22, 23)
Exploratory surgery	-30-50% (20), -80% (18, 35)
Electroencephalography	-23% (22, 23)
Skull X-ray examination	-29% (22, 23)

The overwhelming majority of studies in the field of computerized tomography of the head are concerned with technical and medical considerations. The relatively few studies on this technology's diagnostic impact are generally not comprehensive. Some are based on small patient material and some draw their results from retrospective data. However, there seems to be sufficient evidence in studies reported to conclude that CT-scanning of the head will have a strong substitutional impact on pneumoencephalographic and cerebral angiographic examinations. In the following study the analysis will therefore be restricted to the diagnostic impact of CT-scanning of the head on these two types of neuroradiological investigations.

4.4 Cost calculation

As was seen in section 4.3.2,the number of neuroradiological investigations varied considerably between different hospitals in Sweden. To allow for a comparison between different neuroradiological methods,the cost calculations here will be based on the assumption that the equipment is operating at full capacity.

The investment cost of a pneumoencephalography laboratory is about 950,000 Skr (1976). The equivalent figure for cerebral angiography is about 1,400,000 Skr and for CT-scanning of the head about 2,500,000 Skr (24). Annual operating costs are dependent on the depreciation period and number of examinations. To permit a comparison of computer assisted tomography with other examination methods, the capital outlay is distributed here over a period of ten years. This is the usual depreciation period calculated for an angiography laboratory. However, it is possible that the economic life of the computer tomograph will be of a different length. The following cost calculations are based on data obtained from Karolinska Hospital, the Academic Hospital in Uppsala and from references indicated in the appendix. The appendix also provides a more detailed account of what is included in each cost item.

4.4.1 CT-scanning of the head

The number of examinations possible varies between different types of computer tomographs. However, it is not only the capacity of the CT-scanner which determines the possible number of examinations but also other circumstances, mainly training in and experience with computer assisted tomography. Experience shows that the number of examinations during the first year the computer tomograph is in use is about 1,500 - 2,000, which then increases (25, 26, 27). At present in Sweden about 1,800 examinations per tomograph can be carried out per year. With the latest types of computer tomographs and with ideal or optimal conditions it may be possible to conduct about 10 examinations per day in the future (28). This latter examination frequency will be used here in cost comparisons with pneumoencephalographic and cerebral angiographic examinations. The full capacity performance in a laboratory for pneumoencephalographic and cerebral angiographic examinations is 750 and 1,500 examinations per year respectively (39).

The dominant cost item in medical care generally is the cost of personnel. This is also the case for conventional neuroradiological procedures. However, CT scanning of the head has proven to be relatively more capital intensive than conventional techniques and this cost item accounts for roughly half of the total costs of CT-scanning. A CT-scanning examination takes about 45 minutes. The personnel requirements for CT-scanning include a full-time radiologist, a full-time X-ray assistent, a part-time radio-physicist and an assistant chief physician. Anaesthesia is used in some examinations in which case an anaesthetist, a nurse anaesthetist and an anaesthetist's aid are also required. The material costs are mainly for anaesthesia, contrast agent and X-ray film. Service and maintenance costs comprise six percent of the purchase price, equivalent to fully comprehensive service offered by the manufacturers. Table 4 summarizes the cost per examination of CT-scanning of the head.

Table 4. Cost per examination of CT scanning of the head given an annual capacity of 2500 examinations (10 per day). Cost in Skr. 1976 price and wage level

Personnel cost	90
Material cost	30
Service and maintenance	45
Capital cost	150
Total cost per examination	315

Capital cost is here calculated conventionally according to a depreciation period of 10 years at 8.5 percent interest rate. The problems of determining the depreciation period for medical equipment in rapid development are not addressed nor are the problems of selecting the rate of interest.

4.4.2 Pneumoencephalographic and cerebral angiographic examinations

A neuroradiological angiographic examination takes one and a half to three hours to perform - one hour more when anaesthesia is used. It requires a radiologist, two other physicians and an X-ray and photo assistant. When anaesthesia is used it requires further personnel for technical assistance as in the case of CT-scanning. However, the use of anaesthesia is more frequent in these types of examinations. Contrary to CT-scanning, an angiographic examination requires hospitalization of the patient. The cost of inpatient care is the dominant cost item for angiographic examinations.

Table 5. Average cost per pneumoencephalographic and cerebral angiographic examination for an annual capacity of 750 and 1500 examinations respectively. Cost in Skr 1976 price and wage level.

	Pneumoencephalographic examination 750 /year	Cerebral angiographic examination 1 500/year
Personnel cost*	820	390
Material cost	185	340
Service and maintenance	65	50
Capital cost	195	140
Hospitalization cost	2 250	1 350
Total costs Skr	3 515	2 270

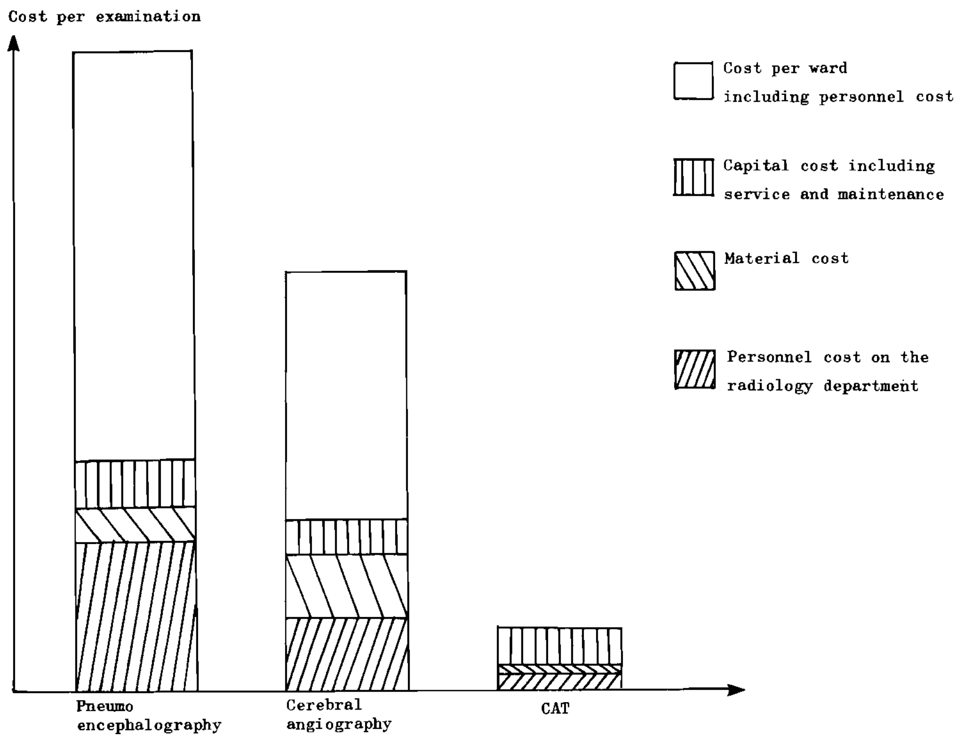
* Including personnel costs for technical assistance and anaesthesia

4.4.3 Cost comparisons

Of the total average costs for a pneumoencephalographic examination, about 75% are personnel costs. The corresponding figure for a cerebral angiographic examination is about 65%, while personnel costs represent only about 30% of the costs of CT-scanning.

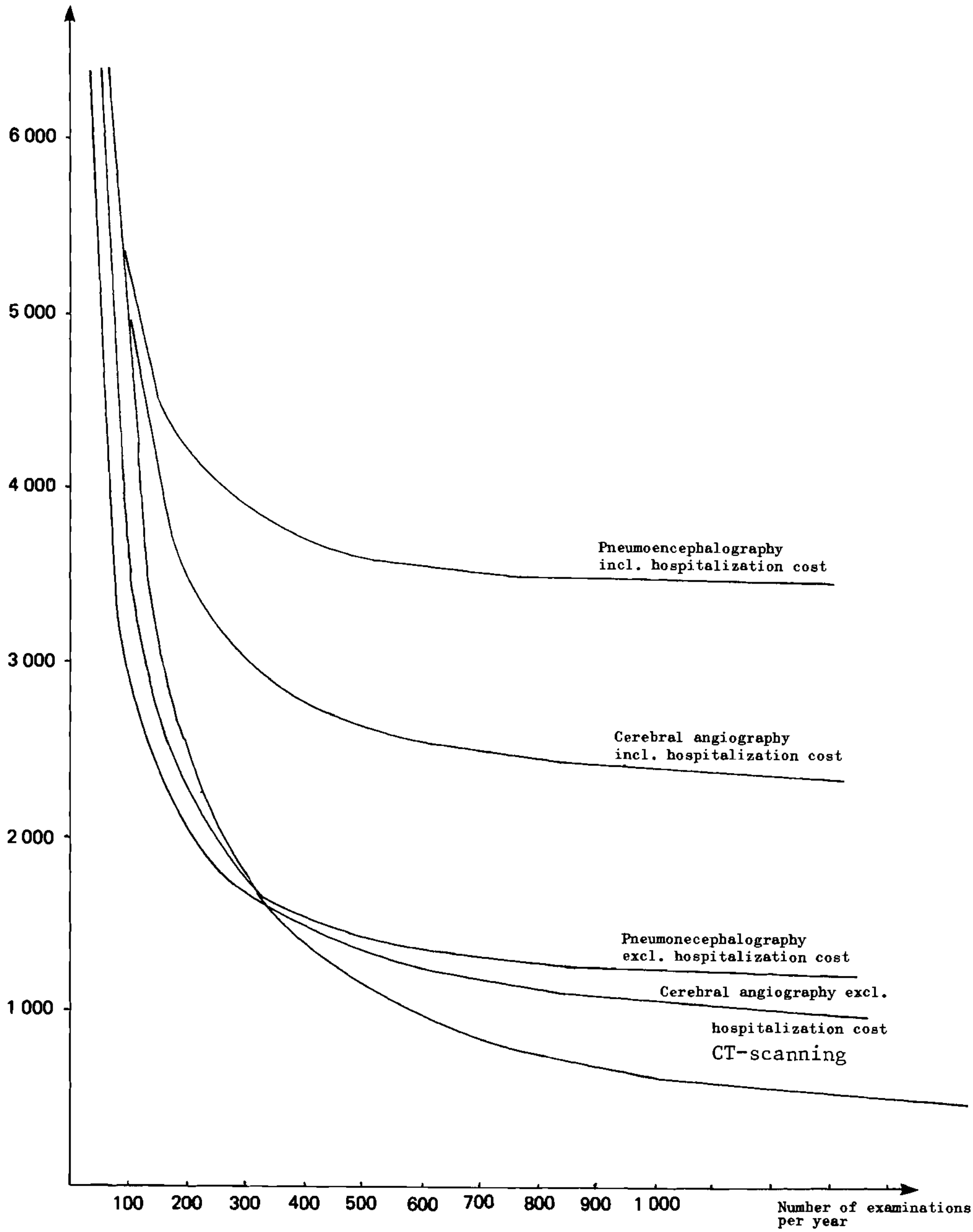
The cost ratio of CT-scanning, cerebral angiography and pneumoencephalography is 1:3:4 if only the costs incurred by the radiology department are considered. Even though calculated savings of reduced number of hospitalization days cannot be realized in the existing department, due to the fact that other examinations will utilize this capacity, hospitalization costs should be included, since in the long run it should be possible to reduce the need for new resources. The overall cost relation is therefore 1:7:11.

Graph 5. Relative proportions represented by different cost items in the total costs of pneumoencephalographic, cerebral angiographic and CT examinations



Since most of the fixed capital costs for CT-scanning are relatively high, the cost per examination will decrease rapidly as the number of examinations increases. However, at a certain volume level, this cost will cease to decline until the level of full capacity is reached. This is illustrated in the following graph, which shows how the cost per examination varies with the number of examinations.

Graph 6. Cost per examination in Swedish kronor at different volumes of cerebral angiographic and pneumoencephalographic examinations as compared with CT examinations



4.5 Estimated savings by a trade-off of examinations

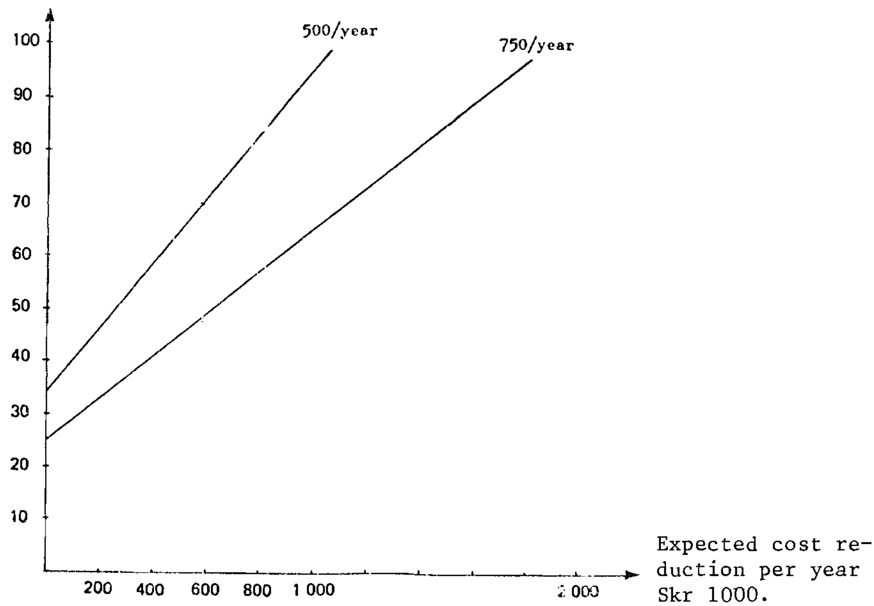
Since conventional neuroradiological diagnostic means to some extent can be replaced by CT-scanning without loss in clinical information, savings can be obtained by a trade-off of these examinations. The savings obtainable are largely dependent on the number of conventional examinations which are currently carried out and to what extent this number could be reduced by the introduction of CT-scanning. At present, CT-scanning does not provide adequate information on the anatomy of the blood vessels and, for example, the location of an obstruction to make it possible to completely eliminate cerebral angiographic and pneumoencephalographic examinations.

The large variations in the possible reduction of the number of pneumoencephalographic and cerebral angiographic examinations reported to date (50-90% and 25-70% respectively) appear to be primarily due to differences in capacity of CT-scanning and to differences in the indications for referral for pneumoencephalographic or cerebral angiographic examination. In addition, many hospitals currently evaluate the results of CT-scanning in order to obtain material for clinical comparisons and thereby build up a body of experience with this new technology.

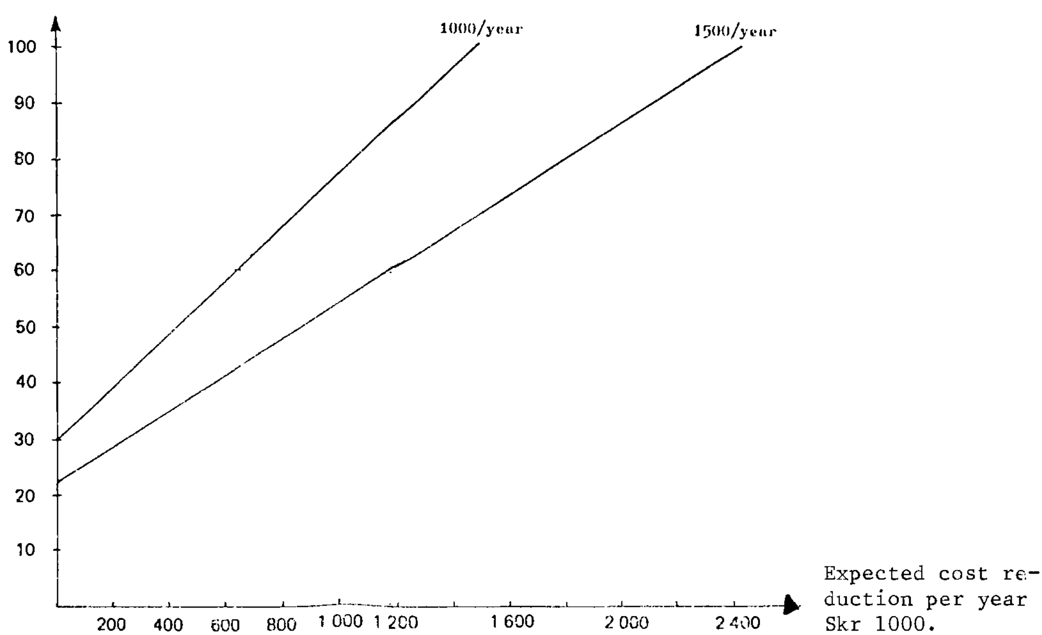
The degree to which the number of pneumoencephalographic and cerebral angiographic examinations can be reduced by the introduction of the CT-scanning technique may be shown in relation to the cost entailed by CT-scanning.

Graph 7 and 8. Cost reduction achieved by the trade-off of pneumoencephalographic and cerebral angiographic examinations for CT examinations.

7. Expected percentage reduction of number of pneumoencephalograms



8. Expected percentage reduction of number of cerebral angiograms



At most of the radiology departments in Sweden which have examination rooms for pneumoencephalographic and cerebral angiographic examinations, so few examinations are carried out per year that not even a 100 percent reduction of pneumoencephalographic or cerebral angiographic examinations would provide a pure economic justification for the acquisition of CT equipment. In order to be economical, CT capacity must be coordinated for an entire medical care area and, in many cases, several medical care areas. If a medical care area carries out two pneumoencephalographic examinations per day (i e, about 500 per year), and anticipates that 70% of these examinations can be replaced by CT-scanning, then the annual operating cost savings will be about Skr 600 000. In a medical care area which currently carries out, say, 1 500 cerebral angiographic examinations per year (i e six per day) and which expects to reduce the number of such examinations by about 60% by the introduction of CT-scanning, the annual savings of this trade-off will be about Skr 1.2 million.

However, it should be emphasized that CT-scanning does not only affect pneumoencephalographic and cerebral angiographic examinations. It also has an effect on certain other diagnostic procedures, and possesses a number of qualitative advantages some of which are extremely difficult to describe and evaluate in economic terms.

4.6 Cost - effectiveness analysis

A comprehensive evaluation of the introduction of CT-scanning technology would require a considerably more detailed analysis of the nature and scope of its consequences than that which is presented here. Among other things, it would be imperative to deal with the effects on the number of false-positive and false-negative findings. Also the impact of diagnostic information on clinical decision making and its effects on therapeutic measures and patient outcome would require consideration. However, currently available data on experience of computer assisted tomography of the head are not sufficient to make such a comprehensive evaluation in a quantitative manner.

The major structural and clinical implications of the introduction of CT-scanning are identified here as the following:

- a reduction in the number of
  - pneumoencephalographic examinations
  - cerebral angiographic examinations
  - radioisotope examinations
  - echoencephalographic examinations
  - electroencephalographic examinations
  - skull X-ray examinations
  - exploratory surgical procedures

- an increase in diagnostic possibilities

- a reduction in morbidity from invasive investigations and attendant anaesthetic

- a reduction of risk of radiation compared to invasive angiography

- patient relief of pain and anxiety

Many of these implications are possible to quantify and, in principle, are also possible to measure in monetary terms. However, the degree to which CT-scanning of the head may have an influence on most of these identified components are - at this stage of experience - uncertain. The many reports on the impact of CT-scanning on pneumoencephalography and cerebral angiography suggest these to be the basis for a cost-effectiveness calculation. Thus, the measure of effectiveness will be the trade-off ratio of CT-scanning versus pneumoencephalography and cerebral angiography.

The results of such a calculation cannot be appropriately used in the absense of other considerations. It is of course unperative to be aware of the possible but uncertain further effects on costs from investment in CT-scanning.

The following cost-effectiveness calculation will assume optimal performance in each laboratory category as defined in the appendix. CT-scanning will be assumed to be cost-effective at the trade-off ratio where costs become less than that of conventional techniques. Such a calculation will also provide an implicit monetary value on all other variables neither quantified nor measured. The matrix in table 6 shows CT-scanning of the head as being cost effective at any level above 120:70 or 225:5 of the number of cerebral angiographic/pneumoencephalographic examinations substituted.

Table 6. Cost increase (-) or decrease (+) in thousands of Skr per year resulting from substituting cerebral angiographic and pneumoencephalographic examinations for CT-scanning

Number of cerebral angiographic examinations eliminated	Number of pneumoencephalographic examinations eliminated											
	5	10	15	20	25	30	35	40	45	50	60	70
5	487	471	453	437	420	403	386	368	352	335	301	267
10	476	459	442	426	408	392	374	357	341	323	289	256
15	465	449	432	415	398	381	364	347	330	313	279	246
20	455	439	421	405	387	371	354	336	320	302	269	235
25	444	427	410	393	376	360	342	325	308	291	257	223
30	433	417	399	383	366	349	332	314	298	281	247	213
35	423	406	389	373	355	339	321	304	288	270	236	203
40	411	395	378	361	344	327	310	293	276	259	225	191
45	401	385	367	351	333	317	300	282	266	248	215	181
50	390	373	356	339	322	306	288	271	254	237	203	169
60	369	352	335	319	301	285	267	250	234	216	182	149
70	348	331	313	297	279	263	246	228	212	194	161	127
80	325	309	291	275	257	241	224	206	190	173	139	105
90	304	288	270	253	237	220	203	186	169	152	118	84
100	282	266	249	232	215	199	181	164	147	130	96	62
110	261	244	227	211	193	177	159	142	126	108	74	41
120	240	224	206	190	172	156	139	121	105	87	54	20
130	218	202	184	168	151	134	117	99	83	66	32	2
140	196	180	163	146	129	112	95	78	61	44	10	24
150	175	158	141	124	107	91	73	56	39	22	12	46
175	122	105	88	71	54	38	20	3	14	31	65	99
200	68	51	34	17	0	16	34	51	68	85	119	153
225	14	3	20	37	54	70	88	105	122	139	173	207
250	40	57	74	91	108	124	142	159	176	193	227	261

When the number of cerebral angiographic and pneumoencephalographic examinations reaches such a level as is normally found in each health care region in Sweden, operating cost savings alone - from supplementing by CT-scanning - are decisive.

Table 7. Cost savings in 1 000 Skr for various levels of supplementing cerebral angiographic and pneumoencephalographic examinations with CT-scanning of the head

Number of cerebral angiographic examinations eliminated	Number of pneumoencephalographic examinations eliminated						
	200	*250*	*300*	*350*	*400*	*450*	*500*
500	1 240	1 410	1 580	1 750	1 920	2 090	2 260
600	1 450	1 620	1 990	1 960	2 130	2 300	2 470
700	1 670	1 840	2 010	2 180	2 350	2 520	2 690
800	1 880	2 050	2 220	2 390	2 560	2 730	2 900
900	2 100	2 270	2 440	2 610	2 780	2 950	3 120
1 000	2 310	2 480	2 650	2 820	2 990	3 160	3 330
1 100	2 530	2 700	2 870	3 040	3 210	3 380	3 550
1 200	2 740	2 910	3 080	3 250	3 420	3 590	3 760
1 300	2 960	3 130	3 300	3 470	3 640	3 810	3 980
1 400	3 170	3 540	3 510	3 680	3 850	4 020	4 190
1 500	3 390	3 560	3 730	3 900	4 070	4 240	4 410
1 600	3 600	3 770	3 940	4 110	4 280	4 450	4 620
1 700	3 820	3 990	4 160	4 330	4 500	4 670	4 840
1 800	4 030	4 200	4 370	4 540	4 730	4 880	5 050

Judging from clinical experience of CT, it would not be unrealistic to expect a total reduction of at least 70% in the number of pneumoencephalographic examinations and at least 50% in the number of cerebral angiographic examinations by replacement with CT-scanning of the head. In calculating these various percentage reductions for the entire country of Sweden this would yield a total of about 15 million Skr in savings of annual operating costs for neuroradiology.*

* Total number of pneumoencephalograms x cost/examination x 0.7 + total number of cerebral angiograms x cost/examination x 0.5 ./. cost of CT-scanning

4.7 Limitations of the calculations

The first step of this study includes an identification of the clinical consequences, i e the diagnostic impact, of the introduction of CT-scanning of the head. By a review of studies reported to date it further revealed the supplementary strength of CT-scanning of the head for established diagnostic procedures within neuroradiology. The following steps include cost analysis and calculations of increase/decrease of costs at different levels of trade-off of pneumoencephalographic and/or cerebral angiographic examinations for CT-scanning. One of the assumptions in calculating the cost-effectiveness of CT-scanning of the head was that the diagnostic values of this technology would be equal or superior to other available procedures. The assumption also refers to its ability to exclude investigations in a diagnostic pattern and work as a screening device for changing the pattern to a more accurate and less costly diagnostic work-up. It does, however, not include the important question of whether this process will have implications for the therapeutic planning process or, finally, whether these measures will improve outcome. Here, outcome would need a wide and complex definition since CT-scanning of the head "... is employed in the diagnosis of serious neurologic conditions where even the best available therapy may not affect longevity, studies of the effectiveness of CT for such patients must be sought in treatment changes that affect morbidity and quality of life" (34). These are general methodological concerns in the assessment of medical technologies which will be discussed further below.

4.7.1 Non-quantified effects

The calculations of the possible economic consequences of the introduction of computer assisted tomography are not exhaustive. In the first place, it should be emphasized that the estimates are limited to certain effects of neuroradiological diagnostics and, to some extent, departments of neurology. As was pointed out, the availability of the CT-scanning technology does not only bear implications for the number of conventional neuroradiological procedures but also carries the potential of several qualitative, and often intangible, effects. However, given the assumptions on optimal capacity for neuroradiologic laboratories, all non-quantified effects of the introduction of CT-scanning of the head are given an implicit monetary value from table 6 as illustrated by the following:

Table 8: Illustration of effects of CT-scanning of the head identified, quantified and either explicitly or implicitly evaluated in monetary terms.

IDENTIFIED	QUANTIFIED	EVALUATED	
Decrease of pneumoencephalographic examinations	Yes	Yes	Explicit monetary value
Decrease of cerebral angiographic examinations	Yes	Yes	
Decrease of radioisotope examinations	Partially	No	Implicit monetary value
Decrease of echo-encephalographic examinations	Partially	No	
Decrease of exploratory surgical procedures	Partially	No	
Increase of diagnostic possibilities	No	No	
Reduction of risk	No	No	
Relief of pain, anxiety, fear	No	No	

4.7.2 Volume changes

There are no community hospitals and few county hospitals in Sweden that will comply with the important assumptions made as to full capacity of neuroradiological equipment. The cost of these examinations thus is reduces to a level corresponding to full capacity. The validity of the cost calculations will depend on the utilization pattern for other types of investigations. Unless an excessive diffusion of CT-scanners develops, the cost savings likewise are at a minimum. The realization of possible savings in operating costs rely on the assumption of a rational distribution of resources for neuroradiology. In turn, this will rest on coordinated efforts within medical care areas, and often between counties. It will furthermore require that agreements be reached on guidelines, i e medical indications, governing the use of computerized tomography of the head.

The cost-effectiveness analysis is a static one in the sense that it does not consider possible changes in the total volume of diagnostic testing over time. Economic implications certainly arise if, for example, the volume of CT-scanning procedures increased at a much faster rate than the rate of decrease of conventional examinations substituted. Such an effect could in principle be referred to either one or both of the following: changes in the medical indications for neuroradiological investigations, extension of neuroradiological diagnostic services to cover unmet need of this service. Expanding indications for use as new medical technology diffuses is a quite common phenomenon (40) but its magnitude is difficult to foresee as long as the technology is at an early stage of penetration into medical practise. In view of the low risk and speed of CT-scanning, it could meet the need of patients who in the absence of CT-scanning possibly would not be examined neuroradiologically, for example due to patient-specific characteristics such as age and severity of disease which would not permit invasive diagnostic procedures. Another possible reason for changes in the total volume of diagnostic testing as a consequence of introducing CT-scanning would be a generated need for more testing to confirm or reject a finding or a diagnosis.

Whether the total volume of CT-scanning procedures will have an amplifying effect on costs and thereby outweigh the potential cost-savings calculated here remains to be seen as the technology reaches a higher level of diffusion. Carefully conducted clinical studies will be necessary in order to establish the reasons behind such changes in volume.

4.8 General methodological concerns in the assessment of diagnostic medical technology

A main methodological concern in economic appraisals of diagnostic technology is the question of what should be constituted as an end-point (41, 42) in establishing the relationship of cost to effectiveness. Ideally the benefits derived from the technology could be sought stepwise by first examining measurable structural implications, then in terms of impact on the therapeutic process and finally in measurements of patient outcome.

The structural impact of a diagnostic technology - disregarding therapeutics and treatment outcome - could be measured according to its ability to:

- produce accurate information measured as single true positive, true negative findings or as accuracy ratios or agreement ratios

- produce intermediate outcomes such as reduction of risk, relief of pain and discomfort measured as number of patients affected and in terms of actual consequences of physical and psychological risk

- directly eliminate other examinations (which implies the technology's ability to entirely replace an alternative method as opposed to an indirect elimination due to findings in the process of the diagnostic work-up) measured in volume and cost

The next step would require process studies. These could focus either on the ability to change the pattern of a range of examinations or the ability to influence therapeutic planning. The end-points here could be based on the technology's ability to:

- provide guidance in choosing among several therapeutic alternatives measured in terms of expected versus actual measures

- provide more precise guidance for planned therapeutic procedures measured directly in terms of outcome

The third and final step in the search for end-points would be to measure health outcome. In certain cases it should be possible to arrive at a common manifestation of the diagnostic and therapeutic values in changes in treatment outcome. This would be the case if the diagnostic technology provided an opportunity to:

- detect a preventable or curable disease at an earlier stage

- define the location and extent of a disease more precisely, therefore improving its prognosis

Many studies on diagnostic technology in general, and on CT-scanning in particular, have initially focused on diagnostic accuracy (43, 44, 45, 46). Usually this is done on subjects whose pathological conditions can be verified by means of other examination methods including autopsy. In this respect a diagnostic technology also can be assessed by measuring its ability to improve the accuracy of other procedures. For example, some studies have emphasized the possibilities of making more reliable diagnosis through greater accuracy in biopsy position with the aid of the CT-scanning technology (47). The economic implications of the measurement of diagnostic accuracy are concerned with the number of false-positive findings which may generate costly follow-up examinations, as well as the number of false-negative findings which may induce later and more expensive treatment. Further, from an economic point of view, it seems important to get information on the relative sensitivity and specificity of diagnostic technology for different diseases. Such information may facilitate the search for end-points among structure, process and outcome.

The measurement of impact of a diagnostic technology on the process, in the sense that it may alter a clinician's further diagnostic approach and/or therapeutic plans, would require some kinds of baseline data and prospective follow-up studies. Changes in diagnostic plans may reduce risk of complications and/or provide additional information from other tests, induced by the diagnostic technology initially used, which in-directly could affect patient outcome. Excluding the possibility of measuring this through a randomized controlled clinical trial, the measurement of therapeutic impact will rely on subjective clinical judgment since, with few exceptions, therapeutic plans cannot be precisely predicted.

As was pointed out earlier, measures of outcome may be possible to obtain in cases where a diagnostic technology had the ability to defect curable disease at an early stage or improve the precision in therapeutic interventions and thereby alter outcome. It seems reasonable to suggest that the end-points always should be sought in terms of effects on patients' health status. However, in quantitative analysis this approach will rarely be possible due to shortcomings in the measurement of outcome. Moreover, a diagnostic technology may not directly affect prognosis of disease or longevity but may for certain patients affect quality of life. Until this latter can be conceptualized and measured quantitative analysis may have to rest on end-points of structural and process characteristics. When no reliable relationship is known of a diagnostic technology and its effect on outcome the solution in quantitative analysis appears to be to confine it to what can be measured in an acceptable manner and let the uncertain effects rest on the judgment of the final decisionmaker.

4.9 Summary

Computed tomography (CT-scanning) of the head was introduced in 1972, since which time a large number of CT-scanners have been manufactured and sold around the world. The practical experience and clinical consequences of computed tomography of the head are well documented. The literature indicates that computed tomography has led to considerable improvement in the possibilities of diagnosing cerebral hemorrhages, infarctions, tumors and skull injuries as well as various conditions in the ears and eye socket.

The sharp rise in the demand for CT head scanners is mainly due to the medical advantages entailed by the new technique, but also because this examination method is thought to result in direct economic savings. Practical experience of computed tomography has shown that previous diagnostic techniques can to some extent be replaced or rendered unnecessary, permitting a reduction of hospital stay and reduction in the number of admissions. This study focuses on CT-scanning as a supplementary diagnostic device for two conventional neuroradiological procedures: pneumoencephalography and cerebral angiography.

A total of about 2,200 pneumoencephalographies and 11,700 cerebral angiographies are performed each year in Sweden. A pneumoencephalography costs about Skr 3,500 and a cerebral angiography about Skr 2,200 including hospitalization costs. The corresponding figure for a CT-scan of the head is about Skr 300-350. Cost-effectiveness is calculated at the rate of substitution - of pneumoencephalographies and cerebral angiographies by CT-scanning - where total costs will diminish. However, this level is dependent on certain assumptions regarding an optimal capacity and a rational distribution of resources for neuroradiology. Estimated savings achievable by the introduction of CT-scanning of the head rest on a coordination of this medical service within and between different medical care areas.

ASSUMPTIONS USED IN THE COST CALCULATIONS

- 1976 wage and price level
- 250 working days per year
- full capacity utilization
- full capacity of pneumoencephalography laboratory 750 examinations per year
- full capacity of cerebral angiography laboratory 1 500 examinations per year
- 2 500 examinations per year of computerized tomography examinations
- Discount rate 8.5%
- Equal indirect costs

PERSONNEL COSTS

Assumptions for personnel cost calculations:

- number of working hours per year, 1980
- wage supplements 18%, personnel insurance 37%

Personnel category	Annual wage SKr (39)	Personnel cost SKr	Hourly cost SKr
Assistant chief physician	141 432	228 637	115
Anaesthetist	131 772	213 021	108
Department physician	131 772	213 021	108
Assistant hospital physicist	78 832	127 438	64
Radiologist	44 952	72 668	37
X-ray assistant	40 608	65 646	33
Photo assistant	40 608	65 646	33
Nurse anaesthetist	44 952	72 668	37
Junior nurse	42 348	68 458	35

Personnel costs* for pneumoencephalographic examinations

Without anaesthesia

Personnel	Time	Hourly cost SKr	Examination cost - SKr
Assistant senior physician	60 min	115	115
Department physician	180 "	108	324
Radiologist	180 "	37	111
X-ray assistant	180 "	33	99
Photo assistant	60 "	33	33
Total SKr			682

With anaesthesia

Personnel	Time	Hourly cost SKr	Examination cost - SKr
Assistant senior physician	60 min	115	115
Department physician	180 "	108	324
Radiologist	240 "	37	148
X-ray assistant	240 "	33	132
Photoassistant	80 "	33	43
Anaesthetist	60 "	108	108
Nurse anaesthetist	240 "	37	148
Anaesthetist's aid	240 "	33	132
Total SKr			1 150

The weighted average personnel cost for a pneumoencephalographic examination, assuming an anaesthesia frequency of 30%, is about SKr 820.

* The figures are obtained from a study of personnel and time required for pneumoencephalographic examination at University Hospital in Uppsala (12).

Personnel costs for cerebral angiographic examination (12)

With anaesthesia

Personnel	Time	Hourly cost SKr	Examination cost - SKr
Assistant senior physician	30 min	115	57:50
Department physician	90 "	108	162:00
Radiologist	90 "	37	55:50
X-ray assistant	90 "	33	49:50
Photo assistant	30 "	33	16:50
Total SKr			341:00

With anaesthesia

Personnel	Time	Hourly cost SKr	Examination cost - SKr
Assistant senior physician	30 min	115	57:50
Department physician	90 "	108	162:00
Radiologist	150 "	37	92:50
X-ray assistant	150 "	33	82:50
Photo assistant	50 "	33	27:50
Anaesthetist	30 "	108	54:00
Nurse anaesthetist	150 "	37	92:50
Anaesthetist's aid	150 "	33	82:50
Total SKr			651:00

The weighted average is about SKr 390, assuming an anaesthesia frequency of 15%.

Personnel costs for computer assisted tomography

The number of CAT examinations which can be carried out during an 8-hour work day varies, depending on a number of factors, such as:

- The technical capacity of the computerized tomograph
- Anaesthesia requirements
- Contrast requirements
- Organizational factors

The average time required for a CAT examination is about 45 minutes (12). CAT requires a full time radiologist and a full-time X-ray assistant. It also requires a radio-physicist or engineer plus a physician for the times given in the following table (12, 29).

Personnel	Time	Hourly cost SKr	Examination cost - SKr
Assistant chief physician	10 min	115	19
Radiologist	45 "	37	28
X-ray assistant	45 "	33	25
Assistant hospital physicist	6 "	64	6
Total SKr			78

Anaesthesia is used in about 8% of the examinations and contrast is used in about 20% of examinations. When anaesthesia is used, the examination takes about 2 hours (28).

With anaesthesia

Personnel	Time	Hourly cost SKr	Examination cost - SKr
Anaesthetist	24 min*	108	43
Nurse anaesthetist	120 "	37	74
Anaesthetist's aid	120 "	33	66
Total SKr			183

* The anaesthetist is required for about the same relative period of time as in the case of cerebral angiographic examination, i e about 1/5 of the total examination time.

The weighted average cost is thus about SKr 90.

MATERIAL COSTS

Material costs for a pneumoencephalographic examination (12)

Materials	Cost SKr
Syringes	4:60
Needles	1:15
Film	143:75
Sterilization, towels	8:05
Sterilization, sheets	6:05
Steridrape	2:30
Cushions	2:30
Gloves	3:45
Hose	2:60
Gauze	3:60
Foam rubber	2:30
Total SKr	180:15

When anaesthesia is used, additional material costing a total of SKr 20:30 is required. Thus, the total material cost with anaesthesia is SKr 200:40, for a weighted average cost of about SKr 185.

Material cost for a cerebral angiographic examination (12)

Without anaesthesia

Materials	Cost SKr
Film	219
Contrast	37
Catheters, conductors, needles etc	55
Miscellaneous	29
Total SKr	339

When anaesthesia is used, an additional SKr 21 is added. The weighted average cost is thus about SKr 340.

Material cost for CAT (12)

With anaesthesia and contrast

Materials	Cost SKr
Computer tape	0:60
Television reels	0:25
Ink ribbon	0:25
Rubber hood	1:25
Contrast	1:85
Polaroid film	19:55
Total SKr	23:75

Added to this cost are the direct material costs for anaesthesia, approx SKr 21 (i e the same cost as for a cerebral angiographic examination), and about SKr 30 for contrast agent, etc.

The weighted average cost for materials is thus about SKr 30.

EQUIPMENT, SERVICE AND MAINTENANCE COSTS

Assumptions

- Investment cost for pneumoencephalography laboratory, approximately Skr 0.8 million, cerebral angiography laboratory, approximately Skr 1.2 million, and for CT, approximately Skr 2.1 million, not including value added tax (21, 24, 37).
- 10-year depreciation period and 8.5% internal interest (38).
- Service and maintenance cost for equipment estimated at 6% of purchase price (24).

EMI offers the following alternatives for service and maintenance:

1. Fully comprehensive service including:
   a) service labor costs
   b) labor costs for routine service 12 times per year
   c) all spare parts and other costs
2. Routine service 12 times per year, not including emergency service and spare parts
3. Service as required

The first alternative costs about 6% of the purchase price of a computerized tomograph, and this alternative is assumed in the above calculations. The second alternative costs about SKr 40 000 per year.

Calculation of capital cost

Pneumoencephalography laboratory

Investment cost including value added tax, about SKr 950 000. The annual capital service cost will be about SKr 145 000.

Cerebral angiography laboratory

Including value added tax, the laboratory costs about SKr 1 400 000. Annual capital service cost about SKr 213 000.

Computerized tomograph

The computerized tomograph costs about SKr 2 500 000, including value added tax, which means about SKr 380 000 in annual capital service costs.

Calculation of service and maintenance costs

Pneumoencephalography laboratory

Annual maintenance cost 6% of SKr 0.8 million, or about SKr 48 000.

Cerebral angiography laboratory

Maintenance cost 6% of SKr 1.2 million or about SKr 72 000 per year.

Computerized tomograph

The maintenance cost for a computerized tomograph is 6% of SKr 2.1 million or about 126 000 per year. During the first year, the manufacturer provides free service and maintenance, which, when distributed over the first 10 years, reduces the annual cost of maintenance to about Skr 113 000.

CALCULATION OF COST PER HOSPITAL DAY FOR PNEUMOENCEPHALOGRAPHIC AND CEREBRAL ANGIOGRAPHIC EXAMINATIONS

Assumptions

- An average of 5 hospital days are required for a pneumoencephalographic examination and 3 hospital days for a cerebral angiographic examination (12, 21, 23).

- Patients scheduled for neuradiological examination are hospitalized in the department of neurology.

The table below gives the preliminary cost per hospital day for all of Sweden's departments of neurology (36, 38).

Hospital	Preliminary cost per hospital day, 1976 SKr
Southern Hospital	440
Huddinge Hospital	640
University Hospital of Uppsala	410
Regional Hospital in Linköping	500
Lund General Hospital	558
Sahlgrenska Hospital	580
Regional Hospital in Örebro	495
Umeå General Hospital	380
Central Hospital in Borås	450

The average cost per hospital day for the above neurology departments is about SKr 495. The neurology department has been charged by the radiology department for the indirect costs associated with the X-ray examination. These costs, an average of SKr 45 per hospital day, have been subtracted from the cost per hospital day for the neurology department in order to avoid counting them twice. The cost per hospital day is thus SKr 450.

EXPLANATION OF CALCULATIONS FOR TABLES 6 AND 7

The annual cost savings is calculated as follows:

a x 3515 + b x 2270 - c x 120 - 493 000

where

- a is the number of pneumoencephalographic examinations
- b is the number of cerebral angiographic examinations
- c is the number of CAT examinations
- The cost of a pneumoencephalographic examination is SKr 3 515 and of a cerebral angiographic examination, SKr 2 270.
- The variable cost for a CAT examination is SKr 120 and the annual fixed cost is SKr 493 000.

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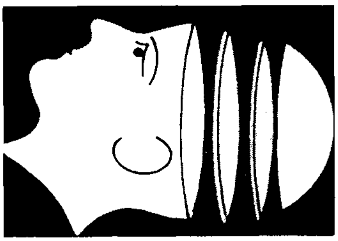
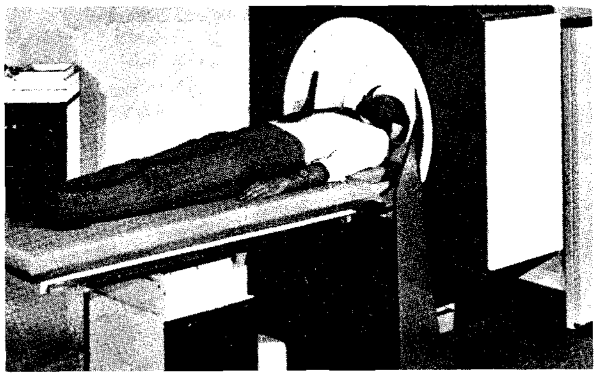
EQUIPMENT FOR COMPUTERIZED TOMOGRAPHY

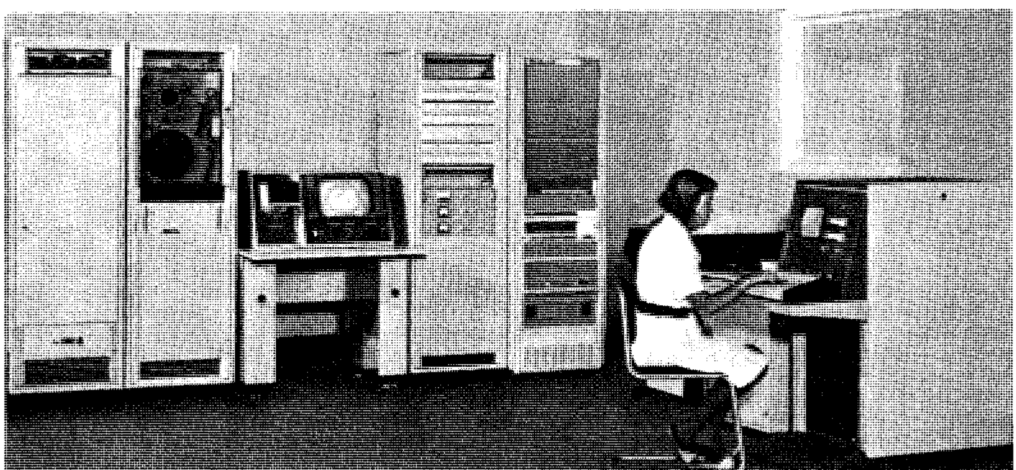
Computerized tomography of the head



Scanned slices



X-ray unit and patient table



Other equipment for computerized tomography

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5 SUMMARY AND CONCLUDING REMARKS

During the last decades the share of resources allocated to health care has reached such a magnitude in most western nations that a broad interest in the determinants of these expenditures and their relation to health effects has emerged from several scientific disciplines (1). Economic appraisal of health care is a relatively new development in the field of economics. A main feature of interest in health economics is the allocation of resources aimed at health care.

The research done so far in health economics has mainly been preoccupied with the determinants of need and demand of health resources. Dominant characteristics in assessing these have been financial and socioeconomic; studies of the basic forces influencing costs of health care, hospital use and structural characteristics, variations in medical expenses, insurance schemes and relation to utilization, analysis of manpower substitution, budget- and finance systems and availability and accessability of health resources (2, 3). Less research has been devoted to the expansion of knowledge of the effects of health resources on the health of a population and to measurement problems in identifying and evaluating different ways of providing health care. A few efforts have been made to develop measures in assessing policy options for the diagnosis and treatment of certain diseases and some cost-benefit analysis of health care programmes have also been carried out (4, 5, 6, 7, 8, 9).

The contribution of the studies presented here; a comparison of hospital performance, a calculation of the distribution of a therapeutic medical technology and an assessment of a new diagnostic medical technology, is in the structuring of problems and in quantitative analysis. Their common perspective is also found in the search for measurable features which could be related to resource consumption associated whith the different problems presented. The studies illustrate the use of some of the presently available quantitative measures classified in terms of structure, process and outcome.

The first study in chapter two compares a Swedish and a US community hospital as to their structural differences. The two hospitals chosen were matched on the basis of volume and specialized services, number of beds and size of catchment area. Data on aggregate hospital personnel, admissions, visits, length of stay and costs were obtained from internal hospital statistics. Information on diagnoses, disease-specific data on preoperative, postoperative and total average length of hospital stay as well as number of diagnostic procedures were drawn from samples of medical records. Data on the distribution of tasks for nursing personnel were obtained from a separate study in which nurses in medical and surgical departments maintained activity logs.

The US hospital was found to have a substantially higher number of admissions, a higher number of personnel per bed and a higher occupancy rate than the Swedish hospital. All of these factors are clearly interrelated. The US hospital also had a greater volume of diagnostic procedures both overall and for certain defined diagnoses; inguinal hernia, cholecystitis and myocardial infarction. The Swedish hospital had a higher overall lenght of stay. However, this difference varied according to diagnosis. Also the Swedish hospital had fewer personnel per patient, lower patient turnover and lower operating costs than its US counterpart. Again, factors that are clearly interrelated. There were more nursing personnel in the Swedish hospital and marked differences in the distribution of working time for selected activities of nursing between the two hospitals. Other differences included substantially more administrative and technical personnel in the US hospital as compared to its Swedish counterpart.

The structural differences observed are discussed from various levels of analysis. Although the national, institutional and individual levels used are clearly distinct the interpretation of findings become obscured due to overlapping variables. Among explanations put forward were differences in the system of financing health services in the two countries, the accompanying differences in preferences and incentives for the patient to demand care and for the physician to perform different procedures.

Another hypothesis was related to possible differences in quantity, availability, accessability and quality of supportive services out of the hospital, e g long-term care facilities, social services, primary care and care for the elderly. Patient age and case-mix differences were suggested to explain several variations at the institutional level such as staffing and patient turnover. Variations in medical custom and different approaches to malpractice were suggested as important explanations for diversities in volume of diagnostic tests and procedures.

As was shown in this study it is difficult to draw general conclusions from structural analysis alone when there is such a complex production mix as produced by a hospital. The structural differences observed are ultimately dependent on reliable and comparable outcome measures, i e in terms of health effects on the patients served. Also, the key explanation is proposed to be found in the absence of an input-output constraint that defines the effect of direct health care on the population served.

The problem of relating structural measures to outcome is present also in the following studies on a therapeutic and a diagnostic technology. However, the nature of the problems faced in these studies allow for reasonable assumptions about outcome and its relation to structure which in turn let the analysis concentrate on other variables.

Chapter three contains two studies on a defined medical service, intensive treatment for coronary disease. They concentrate on efficient volume and equitable distribution of this therapeutic medical technology. The first part in chapter three examines the distribution of diagnoses, number of patients, death rates and discharges per bed in coronary care units at regional, county and community hospitals in Sweden. Data were drawn from the department logs of a sample of hospitals having definable units for the intensive treatment of coronary disease. The differences observed as measured in clinical and structural terms may be due to patient selection. In turn this may reflect differences in catchment areas; travel distances and accessability of the service. The question arises as to whether there is an appropriate volume and an equitable distribution of coronary care units in relation to epidemiologically derived need of treatment for coronary disease.

The second part of this study initially compares the Swedish data on diagnosis patterns, average length of stay, productivity and outcome with data on the US from an earlier study. The Swedish coronary care units show substantially shorter average length of stay for each hospital category. This is in contrast with mean stays for all hospital patients in the US and Sweden. Productivity as measured in the number of discharges per bed also was higher for the Swedish hospital categories while the overall occupancy rate was higher in the US coronary care units. Assuming that the majority of studies published so far determine the clinical effectiveness and continued use of this medical service, chapter three finally concentrates on the question of rational volume and equitable distribution of coronary care units. Population statistics and epidemiological data on the incidence of coronary heart disease were used as a basis for the calculation of a need-determined distribution of coronary care units. Criteria on both maximum travel distance and bed availability were added to this calculation. The estimated need of coronary care units in Sweden, based on the data used, indicate that a substantial increase in the number of facilities is required. This increase would allow more patients with coronary disease easier and earlier access to intensive coronary care treatment. The relevance of this policy option will ultimately depend on not only the assumed effectiveness of intensive coronary care assessed in terms of patient outcome but also on the relative value of investment in this medical service versus other actions for the same objective.

Chapter four comprises a quantitative assessment of a new diagnostic technology, CT-scanning of the head. The study reviews the development and the structural implications of this technology and identifies its diagnostic impact. This is done by a survey of the literature and by the examination of data from hospitals which have gained clinical experience of CT-scanning of the head. Information is used also from studies from departments of neurology and neuroradiology. These studies assessed the potential impact of the introduction of CT-scanning of the head on other diagnostic procedures. Usually a diagnostic medical technology does not itself directly affect the health outcome of patients. Measures of effectivness therefore will have to be sought in a less definitive context.

The practical experience of computer assisted tomography of the head has shown that previously used neuroradiological procedures can be replaced. This will sometimes permit a reduction in hospitalization due to invasive diagnostics. In the review of studies reported and of data available it is concluded that CT-scanning of the head has a strong substitutional impact on pneumoencephalographic and cerebral angiographic examinations. Data for the cost calculations are obtained from the literature and from a neuroradiology department in Sweden employing CT-scanning. In assuming full capacity for each laboratory these calculations show CT-scanning of the head to be substantially less expensive, as counted per examination, than comparable available diagnostic procedures. Diagnostic accuracy and patient outcome was further assumed to be equal among the alternative neuroradiological procedures. CT-scanning of the head was then determined to be cost-effective at the trade-off ratio where costs of this procedure become less than that of conventional neuroradiological investigations. This way of calculating the cost-effectiveness of CT-scanning also yields an implicit monetary value for a variety of qualitative variables such as relief of pain and anxiety and rapid information. However, it is concluded that the total savings obtainable depend not only on the assumptions made but also on a rational distribution and coordination of services for neuroradiology within and between different medical care areas.

The quantitative analysis of CT-scanning of the head is static in the sense that it does not include possible changes in the total volume of diagnostic testing over time. Economic impacts would occur if the use of a new a new technology increased at a much faster rate than the decrease in use of examinations that it is meant to replace. Such an effect could be due to changes in medical indications and/or expansion of coverage to meet unmet need of certain types of investigations. However, a possible additive effect on cost, because of changes in total volume of tests, must be related to the subsequent effects of this change.

Some of the main methodological concerns discussed in chapter four are relevant not only in the assessment of diagnostic technology but in economic appraisals in health care in general. One crucial question is what should be constituted as the end-point in the evaluation of cost to effects. This seems to be a less troublesome undertaking concerning therapeutic technology since here there is more immediate link to patient outcome than in cases of diagnostic technology. The latter is subordinated to the former, i e the efficacy of treatment, which is directly connected to patient outcome and should be measured accordingly.

All of the studies presented here have focused on patient outcome as the end-point to allow more general conclusions to be drawn from study results. It seems to be a general consent that patient outcome - in mortality, morbidity and quality of life measures - should also remain the ultimate validator of health care performance. However, by whatever method this might be established - trial and error, professional consent, epidemiological and statistical analysis, randomized controlled clinical trials, - it is still difficult to establish the true state of the outcome of resources spent for health care. Let it suffice to recall that both diagnostic and therapeutic technology are subordinated to a number of important external factors such as the natural history of the disease, environmental circumstances and patient compliance in its broad sense.

Patient health outcome cannot be used as a direct end-point for diagnostic technology, except for occasions where successful intervention in the natural history of a disease is clearly dependent on early detection and/

or precise location. However, health outcomes such as the elimination of unnecessary operations or reduced morbidity of the investigation would be possible end-point measures for diagnostic medical technology. This is, however, dependent on available methods to quantify the importance of obtaining such outcomes, i e knowledge of society's willingness to spend health resources on short-term health effects. It may be more advisable to try to find measurable end-points of diagnostic technology in terms of improved diagnostic information or possibly in terms of impact on therapeutic planning. This is, however, also accompanied by many pitfalls.

To use measurement of process or structure alone generally require acceptance of explicit or implicit standards of practice. The end-point here being expected performance against which actual performance can be measured. This approach relies on the assumption that such standards actually produce good care and outcome, which may or may not be true.

The difficulty in measuring patient outcome and relating both structural and process characteristics to outcome, however, does not severely undermine the arguments for quantitative economic analysis. The quantitative approach at least helps in structuring a problem and also often assists in the identification of key assumptions usually held implicit; this process forces factors relevant to resource consumption into open consideration for final decision making even if efforts to quantify and evaluate may be weak.

The contribution of the studies presented here is in the way problems are structured and in the illumination of factors and relationships which are ususally not made explicit. The analyzing process then may yields certain limited but important information for assessment of health care performance. However, neither this information nor the results of the studies can be effectively used in the absence of other, mainly clinical, information. The future of this line of research in health economics thus will most likely rest on multidisciplinary work.

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