OPERATIONS RESEARCH AND SYSTEMS ANALYSIS IN HOSPITAL ADMINISTRATION

by

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INTRODUCTION

What do operations researchers and systems analysts have to offer hospitals at a time when mounting criticism is forcing hospital administrators to seek ways of improving service? For a number of years these researchers and analysts have studied various aspects of hospital operations. Now that more and more hospitals are hiring specialists, what can be learned from the experience of the past twenty years? This monograph reviews and evaluates the literature and suggests directions for the future.

Hospitals[1] in the United States today find themselves the focus of many pressures: (1) pressure to control rapidly increasing costs dramatized by the increase in the average per diem expense from $44 in 1965 to $70 in 1969 (323, 365); (2) pressure to improve quality of care, resulting in part from court decisions and legislation (277, 372); (3) pressure to extend the scope of community services by adding or enlarging programs such as extended care, organized home care, ambulatory care, and hospital based preventive care (287, 381); (4) pressure to utilize manpower more effectively because of perceived shortages and rising salaries of trained personnel (241, 242, 364); (5) pressure to expand and modernize physical plant to meet increased demands resulting from increase in population, rise in personal income, advances in

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[1] The study is restricted to the short-term, non-federal, general hospital, i.e., what the layman in the United States ordinarily regards as a community hospital. Teaching hospitals are included; psychiatric hospitals are not.

science and technology, and expansion of public and private health insurance (363); (6) pressure to plan the future size and functions of a hospital in the framework of a regional plan as set forth in federal legislation for comprehensive health planning (224); and (7) pressure to redefine the hospital's functions and broaden its responsibility to improve accessibility to medical care (83, 279, 396). It is no wonder that hospital administrators seek assistance in coping with the problems caused by these pressures.

Operations researchers and systems analysts have conducted many studies of hospital operations. Several surveys are available of studies done in the United States and elsewhere (25, 67, 111, 148, 149, 150, 154, 163, 177, 208, 432). In England the Nuffield Provincial Hospitals Trust has published a number of studies on hospitals and health care (105, 159, 160, 268, 269, 270, 271, 272, 302).

It might be thought that the findings of such studies would be widely implemented by hospital administrators, but that apparently is not the case. Although such studies have been available in the literature since the early 1950's, hospital administrators for the most part have not applied the results. An extensive review of what operations researchers have studied and why these studies have not had more influence on hospital operations should therefore be of interest to administrators, researchers, and those who fund research.

This study is limited to a review of the professional journals and books available to a hospital administrator if in seeking a solution to a specific problem he were to go to the trouble of reviewing the work of operations researchers and systems analysts over the past twenty

years.[2] A drawback of this approach is, of course, the probable omission of significant work not reported in the published literature. To partially compensate for this the authors talked with hospital administrators and others knowledgeable in the hospital field to learn about various experiences in individual hospitals. They also visited several hospitals to observe at first hand certain operations research and systems analysis work. However, the number of hospitals, management consulting firms, individual consultants, and research projects is so large that interesting applications and studies have undoubtedly been overlooked. The authors would welcome information about any studies omitted.

The view taken by the authors of what operations research and systems analysis[3] studies should include obviously affects their evaluation of such studies in the field of hospital administration. Hertz's statement, "Operations research continues to defy precise definition," (195, p. v) illustrates the difficulty in defining operations research. Beer's statement, "What then is operational research? There are roughly as many definitions of the subject as there are OR scientists," (51, p. 87) points up that there are quite different definitions of

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[2] Many of the studies discussed in this paper are listed in two standard references developed for the hospital field -- Abstracts of Hospital Management Studies (4) and Hospital Literature Index (210).

[3] The difference between operations research and systems analysis is difficult to state precisely. Following Raiffa (319) and Quade (318) we shall let systems analysis describe decision analyses of very complex problems which are rather loosely specified [i.e., strategic problems] and let operations research refer to decision analyses of problems of a more limited character in which the structure and goals are rather well defined [i.e., tactical problems]. Because most studies in the hospital field are of narrow scope and limited character, the term operations research is most often used in this paper.

operations research. These range from a narrow view of operations research as simply a continuation of the engineering oriented "scientific management" movement made popular by Taylor and Gantt in the early 1900's (316) to a much broader view of operations research as "the attack of modern science on complex problems arising in the direction and management of large systems of men, machines, materials and money in industry, business, government and defense" (51, p. 92). The authors tend toward the broader definition, and in particular, the viewpoints expressed in the writings of Churchman (88, 89), Ackoff (6), and Beer (51). In sum, this approach places many responsibilities upon the operations researcher. These include the responsibility (1) to define the problem, not to take it as stated by the manager, (2) to determine what goals are being pursued by the manager and the organization, and to make the choice of whether or not to assist in the pursuit of these goals, (3) to engage in a mutual learning process with the manager and others within the organization so that all participants are educated by the study, (4) to build a model of the system in which the variables and the relationships among them are specified, and in which the relationships of the variables to the goals (the objective function) are clearly stated, (5) to state the criteria by which alternatives are to be ranked in order of preference and to state the method by which measurements are made, (6) to state how the data were generated, what possible errors there are in the data, and how these errors might affect the outcome of the study, and (7) to include the implementation of the results of the study as an integral part of the study, rather than assuming that implementation is someone else's job.

This partial list may seem to require a lot of the operations researcher. But in view of the time and money which have been expended

in operations research studies and with every expectation that much more will be expended in the future, these responsibilities do not appear to be unreasonable.

REVIEW OF OPERATIONS RESEARCH STUDIES

For purposes of this review of the literature[4] on operations research in hospital administration, studies are grouped in the following categories:

1. Scheduling in Outpatient Clinics
2. Staffing Studies, Especially the Assignment of Nursing Personnel
3. The Interrelated Areas of Admission and Discharge, Utilization of Inpatient Facilities, and Length of Patient Stay
4. Inventory Control and Menu Planning
5. Computer Applications, Total Hospital Information Systems, and Models of Hospitals

In each of the sections devoted to one of the above categories there is first a brief review of the literature, then a discussion of the additional effort required of an administrator and his staff if the

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[4] There are many industrial engineering studies of hospitals which utilize only the traditional engineering approaches of work measurement, methods improvement, and work simplification. Such studies are largely ignored in this paper unless the authors of these studies call their work systems engineering or operations research. Hospital location studies and studies by economists on hospital costs and on the optimum size of hospitals are also ignored.

Much work is being done in biomedical instrumentation (71) and biomedical engineering (340). Manufacturers such as General Electric use labels for their equipment which contain the word "systems," e.g., patient monitoring systems, pacemaker systems, and X-ray procedures systems. These developments are of great importance to patient care in hospitals and do create administrative problems. However, they are not discussed in this paper.

findings of the studies are to be implemented, and finally an evaluation of the benefits and costs of implementation.

Because information gained from almost any study could be used for planning, no separate category of planning studies is included in this paper.[5]

Scheduling in Outpatient Clinics

Outpatient clinics have been the delight of queueing theorists and more recently of computer simulation advocates. For the past 20 years the studies have focused on the relation of patients' waiting time and physicians' idle time under various appointment systems. In general these studies have found that patients are usually on time for their appointments but that doctors are almost always late. A few examples will suffice.

The pioneering studies were conducted in England in the late 1940's and early 1950's (26, 27, 410, 411, 412, 413). One finding of these studies was that physicians made little attempt to be punctual for the start of their clinics. In contrast, patients were usually on time.

> There is plenty of evidence that doctors, on the whole, are late for their clinics. If they could be more punctual a first and important step would have been taken towards making clinics more civilized as well as more efficient (413, p. 1108).

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[5] The literature on planning in the health field is vast. The huge sums of federal funds allocated especially since the passage of the Comprehensive Health Planning legislation have created university graduate programs in comprehensive health planning; have financed local, regional, and state health planning agencies; and have supported innumerable conferences, workshops, symposiums, and meetings (224). Everyone writes about his experience in planning and the result is a deluge of printed material. We have even reached the point of having a bibliography of bibliographies of health planning literature (58).

A 1965 report by the Nuffield Provincial Hospitals Trust showed some improvement although waiting in outpatient clinics remained a problem. This report revealed that only 11 of 60 hospitals surveyed reached the Ministry of Health's suggested standard that 50 per cent of the patients should be seen within fifteen minutes, 75 per cent within half an hour, with not more than 3 per cent waiting an hour. In addition, only one clinic in five started early or on time, and at only one hospital out of the 60 did all the clinics observed start punctually. The survey concluded that the two major causes for patient waiting were physician tardiness and the poor design of appointment systems (303).

One important point made by the 1965 study was that the difference in waiting times between one clinic and another was not related to the work of the clinics, the newness of the clinics, or to differences in clinical competence of the physicians. The difference was related to the degree of interest shown by physicians in the managerial affairs of the clinic. Those clinics in which physicians recognized the importance of organizational matters had fewer long waits and less overcrowding.

In the United States findings were similar. A study of 60 clinics by the United Hospital Fund of New York found that only one-fifth of the clinics started on time (395). The most frequent reason for failure to start on time, and the main cause for the breakdown of the clinic schedule, was physician tardiness. Poor appointment procedures also contributed substantially to increased waiting by patients. Another study of clinics in eight New York City hospitals found similar conditions (232).

In general, the past 20 years have seen study after study with more variables, more complex queueing models, and more use of computers

directed to scheduling patient arrivals (144, 145, 203, 204, 229, 232, 333, 366, 412, 415, 418). It seems obvious that different appointment procedures would help. Thus if all patients who are to be seen in a clinic between 2:00 p.m. and 5:00 p.m. are told to arrive at 1:30 p.m. their waiting time is likely to be longer than if their arrivals are staggered throughout the clinic session. However, physician idle time is likely to be the same in either case. Rockhart and Hofmann found that physicians' behavior seemed to reflect Parkinson's Law. When schedules were light or few patients were waiting they took longer with each patient, but when the queues were long they worked faster (333).

Resistance to recommended change in appointment procedures has been reported even though such change would seem to benefit everyone. Rockhart and Hofmann in their studies of appointment procedures in various clinics reported that in each case the clinic personnel believed that the appointment system currently used in their clinic was best accommodated to that clinic's particular circumstances (333).

The studies are silent on how to change physicians so they will arrive at the clinic on time except when there is a real emergency which detains them. One study said that they should be requested to be more prompt for the clinic appointments (405). However, the response of the physicians was not given.

Several studies did suggest that it will be difficult to change physicians' habits with regard to clinic starting time (145, 232). Because outpatient clinics have historically provided free care for the poor, the aura of charity persists. Habit patterns and attitudes of physicians as a group developed at a time when they were sometimes

unwilling volunteers forced to provide outpatient services in order to maintain position and privileges within the hospital medical staff. These habit patterns over time became normal and expected behavior and now may be difficult to change.

Of course, it is not only physicians who resist change. Stewart and Sleeman in their investigation of why so few hospitals had reached the standard set by the Ministry of Health for patient waiting time listed many reasons given by hospital personnel for not making changes (375).

How could a hospital administrator use the results of these studies? If the clinics in his hospital now schedule all patients to arrive before or at the start of the clinic, he could establish alternative appointment systems as suggested in the operations research literature to reduce the waiting time of patients with little or no increase in the idle time of physicians. However, if physicians and other clinic personnel feel that the findings in the literature are not applicable to their hospital, the administrator would be faced with conducting a major study in order to convince them. Many clinic sessions in his hospital would need to be studied to get patterns of arrival and waiting time of patients, consultation and treatment time, and idle time of physicians and clinic personnel. The administrator could then try various patient appointment procedures and staffing patterns to see what changes occur in patient waiting time and idle time of staff. Manual, or more likely, computer simulation would be required to obtain solutions.

There are several management problems not dealt with in the operations research literature on scheduling in outpatient clinics.

One, of course, is the failure to deal with the important problem of how to get physicians to the clinics on time. But the administrator also has to deal with such matters as how to finance a study in his hospital and how much to spend to improve the management of the clinics. Fetter and Thompson pointed out that it is difficult to determine the payoff from more efficient clinic operation since physicians and medical house staff are usually not paid specifically for their work in the clinics. Patients "pay" with waiting time, but a saving here cannot be converted into operating income for the hospital (145). At best such a saving would enhance the public image of the hospital.

Another management problem that an administrator must consider is that the cost of care in an outpatient clinic is generally not fully covered by part-pay fees from patients or by government reimbursement. Thus a more efficient scheduling system might result in an increased patient load but at the same time might cause an even greater deficit for the hospital. On the other hand, if the clinic were operating at capacity, as many are, more efficient scheduling could postpone capital expenditures for additional facilities.

Staffing Studies, Especially the Assignment of Nursing Personnel

Staffing-to-meet-fluctuating-demand is a well known problem in operations research. The previous section dealt with some aspects of this problem in outpatient clinics while this section deals with different aspects in inpatient units of hospitals. Because nursing personnel are the largest single category of hospital employees and their salaries

form the largest single item of a hospital's operating budget, most staffing studies focus on nursing activity.[6]

As might be expected, articles on nurse staffing are part of the nursing literature. For many years it was assumed that the only information needed to make staffing decisions was the average number of nursing hours required by each type of patient (e.g., medical patient, surgical patient, obstetrical patient) and the number of patients. As early as 1940 a study of nursing costs by Pfefferkorn and Rovetta used this approach (315). In 1950 the American Hospital Association and the National League of Nursing Education collaborated in preparing guidelines for hospital nursing. Their method of calculating the number of nursing personnel needed consisted of multiplying the average number of nursing hours required per patient per day by the number of patients (18). Similarly, George and Kuehn in 1955 multiplied the average daily requirement for nursing hours by seven times the average daily census to calculate the number of hours of nursing service required per week for a ward (166).

In some of the nursing studies in the 1950's researchers classified patients into categories according to their individual needs for direct nursing care (54, 55, 90). However, information on the number of minutes of direct nursing care required by each patient in each category was used in a static way. For purposes of staffing it was thought sufficient to assume that on the average a given ward would have

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[6]Some studies have dealt with staffing of laundries, pharmacies, dietary units, and the like (44, 45, 46, 47, 48). However, the approach used by these investigators is more like that of traditional industrial engineering than operations research.

a certain number of patients in each category. Once the average mix of patients was determined for a given ward the staffing requirements for that ward were assumed to remain constant.

Much of the work done by Flagle and his group at Johns Hopkins in the late 1950's was directed to the study of staffing for inpatient care (96, 155, 156). Their formulation of a "direct care index" to allocate nursing personnel on a daily basis was an important advance. Their observations over time had shown that there are wide swings in demand for nursing care within each ward from day to day because of variations in the distribution of patients in the various "need" categories.[7] They showed that the variation among categories is such that even if the total number of patients remains the same, no single level of staffing is satisfactory all of the time.

The "direct care index" was used every day to estimate the number of hours of direct nursing care required in each ward to meet predetermined standards of care. To calculate this index patients were divided into three categories based upon their needs for nursing care: total care, partial care, and self care. After many observations the average time required for direct nursing care for an individual patient in each category was obtained. Because of the fluctuation in numbers of persons in each category (even if the total number on the ward remained constant) the direct care requirements for each ward were calculated daily. To calculate the hours of direct nursing care required, the number of patients in each care category was multiplied by the average number of minutes of nursing care required and summed. To make daily

[7] It should be noted that Jelinek did not find these variations in the hospital he studied (227).

use of the index operational the investigators provided the head nurse with a simple check list by which she could assign patients to one of the three categories on the basis of observable characteristics of the patients. Late in the afternoon or in the evening the assignment of patients was made and the number of patients in each category was multiplied by the average time and summed. The total was then used as an estimate of the amount of direct nursing care required the following day.

Another finding of the Johns Hopkins group was important in staffing for inpatient care. Extensive analysis of various wards in the same hospital showed that the work loads were statistically independent. That is, a heavy work load in one ward was not associated with a heavy work load in another ward. By considering several wards as one for the purpose of nurse staffing, fluctuations were reduced to achieve better utilization of personnel. In one example in which nurses were shifted from one ward to another to handle heavy work loads, only some 20% of the total staff needed to be "floaters" (96). Alternatively, the work load could be smoothed by moving patients as in "progressive patient care" plans[8] or by some combination of shifting nurses and patients.

Wolfe and Young (423, 424) extended the staffing procedures just discussed by using linear programming to assign different classifications of nursing personnel to different tasks. Their assignment technique strives to match in some optimum fashion personnel with different levels and mixes of skills to jobs which have varying requirements.

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[8]Some hospitals have adopted an arrangement called progressive patient care. Under this plan patients are placed in units according to their needs for medical and nursing care (408). In such hospitals the variations in nursing care within units is much less than variations within the units in the study just cited (208). Hence the procedure described above to allocate nursing staff is not as applicable to hospitals which have adopted the progressive patient care concept.

There are other approaches to the automation of nursing care requirements. Thomas developed a Markov model which utilizes four recovery states each subdivided into three recovery phases (383). Jelinek used multivariate regression analysis to relate the hours spent by various classes of nursing personnel in three activities (direct patient care, indirect care, and nonproductive and miscellaneous) to such variables as nursing hours available and distribution of patients among nursing care categories (226, 227).

The General Electric Company has announced a time-sharing, computer program to schedule hospital nursing personnel. However, not enough details were given in the descriptive brochure to see how this program relates to the other studies just described (275).

Temporary shifting of some nursing personnel from one unit to another to meet a heavy demand for nursing care has long been a common practice in hospitals. As Flagle pointed out, the findings of the operations research studies in effect give official approval to what was already being done (148). The work at Johns Hopkins should enable the administrator to consider his problem in a more rational fashion and if applied should result in more efficient use of nursing personnel. In addition, it would help him to evaluate possible alternative approaches to reducing fluctuations in patient census such as "progressive patient care" or controlled staffing and admissions.

However, a hospital administrator wishing to take advantage of the work at Johns Hopkins on nurse staffing could not adapt the findings without first doing some studies in his own hospital. Although two studies (54, 268) found the ratio of time for direct nursing care among

the three categories of patients to be approximately the same as the ratio at Johns Hopkins; another study did not (55). Hence the hospital administrator would have to take a sample of patients in each category in his hospital and get the distribution of the time spent in giving direct patient care in each category by various classes of nursing personnel during each shift. Unfortunately, the operations research literature doesn't give the hospital administrator much information on the cost of doing such a study or of switching to the "direct care index" method of nurse staffing. Neither does the literature tell him what increase in efficiency he might expect should he do so. One administrator who uses this technique in his hospital told the authors that he found it very effective. He continued that one needs to add "a good dose of practical experience" and "adjust the standards" as the results of the studies are applied.

Several administrators have indicated to the authors that most nurses do not like to be "floaters." Three reports in the nursing literature confirm this statement (276, 311, 382). Temporary assignments make it difficult for nurses to learn to know patients well enough to provide good patient care. Moreover, administrators say that patients place a high value on receiving care from nurses they have come to know. Thus, the administrator is faced with the complex problem of weighing nurse satisfaction and patient satisfaction against dollar savings.

Much more work would be required to use the assignment technique suggested by Wolfe and Young (423, 424). The matrix of costs is the main problem. The entries in the matrix are numbers which represent the cost of having a particular classification of nursing personnel perform

a particular task complex. Each number is a composite of a dollar cost and disutility cost. While the calculation of the dollar cost is simple (time required for the task multiplied by the hourly wage of the employee group performing the task), the calculation of the disutility cost is not. The authors define the disutility cost as "a measure of the loss or disutility incurred through personnel assignments not entirely acceptable to the medical or nursing professions or to the public" (424, p. 302). The less desirable it is to have a specific category of personnel perform a task, the higher its disutility cost. No explanation was given of the specific technique used to obtain the disutilities. The article referred the reader to the doctoral dissertation of one of the authors. In any event, measuring utilities is a complex matter (377). Moreover, the authors did not show how their method compares in efficiency with the "direct care index" method, or the informal approach to staffing now taken in most hospitals.

The usefulness of the regression model (226, 227) may be questioned. Although Jelinek suggested that the hospital administrator could use the results to analyze his present operation, to predict the outcome of various staffing decisions, and to control or plan, the benefits are not self evident. No examples of actual use in hospitals are cited. In addition, the many pitfalls of multivariate regression analysis are not discussed in the article. Finally, the behavioral reasons which might explain the results shown in the computer output are omitted. There is, therefore, little to motivate a hospital administrator to select this particular model to investigate nurse staffing. Why should one use this particular set of variables with these mathematical relationships?

There is a strong tendency in operations research studies to see nursing as merely a set of highly visible and well-defined tasks -- giving medications, taking temperatures, bathing patients, charting, and the like. An industrial engineering approach to analyzing nursing as if it were an automobile assembly line could have serious consequences for the quality of patient care. A review of the literature reflects an emphasis on the industrial engineering approach (129, 192, 309), tempered to some extent by involvement of nurses in setting standards. Although articles in the nursing literature have stressed the need to modify the approach which defines nursing as a set of highly visible tasks (8, 136) there has been little recognition of the nurses' suggestions in the operations research literature.

In addition, it appears that most operations research studies fail to recognize the larger system in which nursing is imbedded. Because of changes in the larger system there is a great deal of ferment about what nursing is and what nursing should do. Quite different roles for nurses have been discussed in the nursing literature for over 20 years (3, 22, 68, 190, 286, 353) and are now developing in many different settings (70).

The nursing literature (e.g., 1, 2) may help to explain some of the findings in the operations research literature.[9] For example, operations researchers have mentioned morale problems of nursing personnel (148) and have commented on the finding that increasing the

[9]There is a large literature on the effect of direct nursing care on patient recovery (e.g., 1, 2, 125, 283, 304). However, the patient is rarely mentioned in the operations research studies except as the thing that requires the expenditure of hospital resources. It seems unfortunate that so few of these studies of hospital activities have included patients.

number of registered nurses in a unit resulted in little additional direct patient care (95, 227). The works of New (292, 293) and Walker (406) offer possible behavioral reasons for these findings beyond those mentioned in the operations research literature.

In particular Walker's book contains much information that puts in a different perspective the activities performed by nurses which the operations researchers so diligently measure. Walker was interested in the underlying reasons why nurses perform certain tasks and procedures. One example she cited was the case where a physician used a standard operating procedure to apply pressure on the hospital administrator. The physician demanded that the nurse complete an incident report every time a cardiac chair was not available when one of his coronary patients needed one. His purpose was to flood the administrator with so many of these reports that the administrator would have to purchase more cardiac chairs. One wonders if an operations researcher measuring the time the nurse spent in filling out these forms would have recognized the dynamics of the situation which caused the overt behavior he was observing and recording. There is little evidence in the literature to indicate that he would. Without a knowledge of the causal factors the recommendations of operations researchers may not be relevant.

The Interrelated Areas of Admission and Discharge, Utilization of Inpatient Facilities, and Length of Patient Stay[10]

Several early operations research studies and studies of hospital care identified the stochastic nature of the demand for hospital beds and facilities and suggested that the problem of the number of beds or facilities (e.g., delivery rooms, operating rooms) required to satisfy a given demand distribution be based on queueing theory (28, 34, 94, 156).

[10]Many studies which have a larger scope than the individual hospital are excluded. Examples of these studies are those which deal with the difference between "demand" and "need" (e.g., 344), and those which concern areawide planning for hospital beds (e.g., 142).

It was also recognized that demand distributions differed among surgical, medical, and obstetrical units (61, 385).

Presumably the desire to predict occupancy rates or to compare various rates grows out of the intent to do a better job of planning for adequate beds and other facilities and to arrange for appropriate staffing and sufficient supplies -- in short, to consider the impact upon the entire organization. However, most authors have concentrated on the demand for beds in a particular unit or the demand for a particular facility (e.g., delivery rooms, operating rooms). The analysis usually concentrates on the number of beds in a ward or on the size of a facility in relation to the probability of overflow (demand greater than supply); or it shows the reduction in number of beds or size of facility which would result from treating several separate units as if they were one (24, 61, 135, 144, 170, 294, 295, 385, 389, 390, 407).

Queueing theorists often take the posture that the data on whatever they are studying are generated by factors not subject to control. Many of the above authors seem to have adopted this approach. However, in dealing with a seemingly random process, one managerial strategy is to ask how the process might be partially controlled, and then to compare the costs and benefits of imposing such controls. Some studies have followed this approach.

Newell in 1954 (294) and Bailey in 1956 (28) noted that admissions to hospitals are really of two main kinds: non-acute cases from a waiting list and emergency cases requiring immediate admission. Hence there is a problem of allocating beds between the two groups. In practice hospital administrators deal with the situation by reserving a certain number of beds for emergencies. But given that a waiting list

exists, emergency beds are reserved only at the expense of waiting list patients. As the number of beds set aside for emergencies is increased the probability of being able to handle all emergencies increases but the overall per cent of occupancy falls. Newell's formulation set out clearly the trade-off involved (294).

Newell used the poisson distribution in a study of emergency admissions. He found that whenever the average demand for emergency admissions was between 1 and 30 per day, only 2 beds more than the average were needed to satisfy the demand 95% of the time (294, 295). Newell further showed that his results supported the establishment of a pre-discharge ward in a hospital (295). In another study of English hospitals he found that the supply of beds modified the demand for beds. Because of this finding he concluded that the existing models of queueing theory could not yield useful estimates of bed requirements (296).

Others have mentioned that recognizing and dealing with the two kinds of admissions, scheduled and emergency, could result in increased occupancy (385). However, it was not until the middle 1960's that articles began to appear which developed further the work of Newell and Bailey. Young's two articles advanced the understanding of the basic nature of the problem (429, 430). To illustrate his points Young posed two fundamentally different models: (1) a rate control model in which the hospital administrator selects some constant number of patients to be admitted daily as scheduled admissions regardless of the census on any particular day, and (2) an adaptable control model in which the hospital administrator sets aside a certain number of beds for emergency admissions and accepts reservations for the remaining beds. Call this latter number "B." When the daily census falls below B,

persons are called from a waiting list to raise the census back to B. The higher the administrator sets B the higher will be the average occupancy rate, but the average overflow (or the probability of not being able to meet demand and being forced into overflow procedures) will also be higher. Given a probability distribution for emergency admissions, computer simulation may be used to obtain the results of selecting different numbers for B and to compare the two models. Although Young was dealing with only a single ward of a hospital his formulation brought more of the decision making process into the scope of formal analysis.

Bithell used Markov chains to model the same situation that Young studied and found that the scheduling of patients to bring the census up to a desired figure provided a considerable reduction in variance and an improvement in efficiency (56). Kolesar also suggested that Markov models be used to analyze the scheduling of hospital admissions (244). And Balintfy developed an interesting Markov model in which patients were classified by their condition (good, fair, critical) and could move from one state to another as well as to discharge (36). Finally, Robinson, Wing, and Davis used computer simulation to compare alternative methods for scheduling elective patients. Emergency admissions were excluded from their analysis (332).

Fetter and Thompson used computer simulation to demonstrate the effect of scheduled elective admissions on the utilization of a maternity suite (beds, labor rooms, delivery rooms, postpartum rooms). The per cent of those with elective inductions was set at 0%, 10%, and 20% for the computer simulation. Admitting times and patient load were also variables for the simulation runs. One finding was that a policy of 20% elective admissions scheduled throughout the day compared with a policy

of no elective admissions had an important smoothing effect on the use of the suite. Under the former policy the same level of service was maintained with one less bed (144).

Fetter and Thompson also mentioned a computer simulation model of a surgical pavilion whose input was made up of a scheduled component and a random component (144). This model was extended by Kavet and Thompson. They used computer simulation to compare the present policy of handling surgical patients in a Boston hospital with a proposed policy of separating preoperative and postoperative patients. The results showed that more beds would be required should the hospital adopt the proposed policy. The simulation gave the administrator a better idea of the costs of the proposed policy against which to weigh the benefits (235). Esogbue also used computer simulation to study the scheduling of operating rooms (135). On the basis of waiting times under varying load conditions he compared four scheduling policies a hospital might adopt. As the per cent of load changed, the "best" scheduling policy varied. Whitston discussed the use of queueing theory and what he called "idle time prevention theory" in scheduling surgery (416). Barnoon and Wolfe simulated various schedules for operating rooms in an all-surgical hospital (43).

Rickli and Allen surveyed computerized patient admission, transfer, and discharge systems currently operational in nine hospitals (328). Cross, Droar, and Roberts gave much detail (e.g., forms, punched cards) about such systems, which are used by the United Birmingham Hospitals in England (102). These systems may be quite extensive and may include in their output such reports as daily census by care units, bed utilization by physicians and by specialties, prediction of future

bed occupancy, scheduling of routine laboratory tests, special workups ordered by physicians, and so forth.

Accurate prediction of the length of patient stay or date of discharge of patient is an important factor in improving the scheduling of elective admissions. Various investigators have used different theoretical distributions to approximate the observed distribution of the length of patient stay. Bailey used the negative exponential (28), Balintfy used the lognormal (34), and Young used the gamma (429). Handyside and Morris reported that none of these distributions fitted their data (182). Robinson, Wing, and Davis used a computer simulation model to study the effect of improved knowledge of length of stay upon the occupancy rate (332).

Kolouch in his study of the length of stay of surgical patients pointed out how much there is yet to learn about the factors which determine length of stay (245). Acheson and Feldstein studied the length of stay of normal maternity cases of several doctors practicing in various hospitals.[11] They found significant variations among doctors and among hospitals. An analysis of ten social and biological factors relating to the mother did not account for the observed variations in the length of stay (5).

The above suggests that an alternative way to get an estimate of the length of stay or discharge date is to ask the attending physician for his prediction. Bithell and Devlin reported that physicians did fairly well in predicting patients' discharge dates one or two days in advance (57). Robinson, Davis, and Leifer reported an experiment involving 46 physicians at one hospital. At the time of admission of a patient the admitting physician estimated the length of stay. The

[11]Many studies show how length of stay varies in different sections of a country or differs between countries even when "standardized" cases are compared. However, most of this work has not been done by operations researchers and is excluded here.

results were not too accurate. For patients who were hospitalized more than three days a second estimate was made. The second estimate was more accurate than the original estimate though not as good as one might imagine. However, the prediction of discharge one day in advance was 87.2% accurate (331). Barnoon and Wolfe used physician estimates of length of stay in their study of an all-surgical hospital. The accuracy of the estimates was not reported (43).

Gustafson compared five methods of predicting the discharge dates of eight hernia patients. The five methods were physician estimates, regression analysis, historical average, direct posterior odds estimation, and Bayes' theorem with three variations. Bayes won (180).

One study reported that initial results from a hospital simulation which used physicians' estimates of length of stay enabled the hospital to increase its average occupancy rate 5% with no change in the rejection, rescheduling, or turnaway rates when compared to a scheduling system with no predictive information (331). A later simulation study by some of the same authors showed that the 5% improvement in occupancy rate occurred only with a perfect forecast of length of patient stay (332). As studies of physician estimates have shown, a perfect forecast mechanism is not likely to be found (57, 331). Because of this and because hospitals often have some predictive information on date of patient discharge, presumably the increase in average occupancy in a typical hospital would not be as great as 5%. One article did report a 4% increase in average occupancy following the installation of a computerized admission system. However, it appeared from the article that the manual system could have been improved considerably without the use of a computer (426).

As this brief review of the literature indicates, many persons have written about various aspects of scheduling hospital admissions. A steady and relatively high occupancy rate is important in keeping a hospital financially solvent. A fall in the occupancy rate results in an increase in average hospital costs per patient day which may create problems for the administrator when he negotiates with Blue Cross or other third parties for reimbursement of costs.

If a hospital administrator wanted to implement the findings in the operations research studies described in this section, what would he have to do? He would have to do much work to get the hospital data required for the models.[12] Data on admissions and discharges for several years would have to be examined in detail. Changes in such things as hospital size, procedures, diagnostic mix, and services offered would have to be considered for their possible effects on the historical data. Changes outside the hospital would also have to be considered. New hospitals or neighborhood health centers would be two obvious examples. A computer program would have to be written because the complexity of the problem requires simulation for solution rather than analytical methods.

A hospital administrator considering the use of physician estimates of length of stay or discharge dates would have to consider his present relationship with the medical staff, review the other programs he is pushing which require physician cooperation, and evaluate the desirability of asking the physicians to take on an additional responsibility. Where physicians have multiple staff appointments, if a single hospital requires such estimates, that hospital may lose patients to other hospitals and thus experience a reduction in occupancy.

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[12] Of course, such developments as federal requirements for utilization review under the Medicare legislation may force hospitals to collect data on all patients by length of stay, by diagnostic category, by surgical procedures if any, by complications if any, and so forth. These data could

Unfortunately the literature does not contain much information to aid the administrator in deci ing whether it would be worthwhile to follow up on the suggestions. As indicated above, costs are obviously involved. Because the literature does not contain detailed information on costs the administrator must make his own estimates.

A priori, an increase in the occupancy rate and a reduction in its fluctuation should mean more efficient hospital operations. For example, a 2% increase in occupancy in a 250-bed hospital could result in over $100,000 additional annual income with little increase in operating costs. Benefits could also occur in improvement in day-to-day operations and in long-run planning. If advance forecasts of patient discharge were available, the scheduling of many support services (e.g., housekeeping, dietary) could be improved.

However, in looking at occupancy the hospital administrator may be more concerned about the pattern of usage of certain special services of the hospital than the overall usage of beds. The occupancy rate tends to fall on weekends, during the summer months, and during holiday periods. In many hospitals operating rooms are little used on weekends and often underused on weekdays. Laboratory and X-ray services have similar patterns of usage. A hospital administrator might think that more even use of these facilities and services would do more to smooth the occupancy rate and reduce length of stay than operations research studies on the same subject which do not deal with these problems. If he wants confirmation about variations in hospital admissions and length of stay which do not seem related to the health needs of patients, Lew's study provides detailed statistical verification (257). Davis and Reed show the gains to be obtained if operating

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then be used by the hospital administrator should he wish to try some of the operations research applications suggested in this section.

room usage could be increased (106). However, neither paper nor the others cited have anything to say on how to bring about this desirable state of affairs.

Other benefits might result from studies of admission and discharge, length of stay, and utilization. For example, the historical data on admissions and discharges which the administrator would have to collect might show a slow increase in average daily census and give some indication of the reasons for it. The administrator would then have to think of alternative ways to meet increased demand. One possible alternative is to expand. Here the models discussed in the literature might assist the administrator. They could help him to answer such questions as: "If the average number of admissions increased to X per day, how many beds would I need to guarantee that 99 per cent of the time I would be able to meet this demand without resorting to overflow procedures?" (Of course, the models would not help him in actually predicting future demand, but they would help him in thinking about how his hospital might operate if increases were to continue.) In order to decide if 99 is the "correct" per cent to use, the hospital administrator would have to do further work to obtain the costs of underutilization and the costs of overflow for different percentages.

Most of the studies deal with single wards or specific facilities within a hospital. The problems which arise when one has to deal with the interaction of wards and facilities or with the overall situation are usually not even mentioned. One case study showed that these problems are formidable (115). In addition, the articles often start with the statement that admissions scheduling or length of stay will be studied because such knowledge is needed to enable the hospital to

allocate efficiently its facilities, equipment, and manpower resources. However, for the most part the studies fail to show how their findings relate to the allocation of these resources.

Although in some of the studies cited the operations researchers did collect hospital data for use in numerical examples of their models or for use in computer simulations, there is little evidence that the models have ever been used to improve actual operations. However, one administrator reported to the authors that he gained a lot by capturing the essence of the queueing studies on hospital admissions even though he did not have the background to understand all the mathematical details. He wrote:

> I could grasp the notions of trying to smooth the peaks of elective admission reservations, varying the length of queue in response to occupancy . . . . I think I installed in the admitting department a crude procedure which probably captured 75% of the full value of such an approach.

Inventory Control and Menu Planning

Some operations research studies do not fit into the categories previously discussed. Because studies dealing with menu planning and with various uses of inventory theory seem to make up most of these other applications, this section will deal with these two only.

Inventory Control

Inventory problems were among the first business problems studied extensively by operations researchers. Because hospitals carry inventories of many items it is only natural to apply inventory theory.

Boodman explained the concepts of inventory theory, discussed how they could be applied in hospitals and indicated the information required (64). Smalley, et al. discussed different inventory policies

and factors which should be considered in deciding upon inventory policy (359). Reed and Stanley brought in demand forecasting and lead times to help determine reorder points and quantities. They divided all items into three classes based upon per cent of total annual dollar usage. In their one example some 10% of the items made up over 70% of the total dollar usage. Different procedures for determining reorder points and quantities were used for each class of items (322).

A different approach to controlling inventory was used by Flagle, et al. By use of regression analysis they found that linen usage was related to the census and the number of patients requiring intensive care. Because this information was available from their prior work on nurse staffing, they were able to reduce the linen inventory (156). Kilpatrick and Freund used both a computer simulation model and an analytical model to relate the number of tanks of oxygen held in inventory to the probability of being able to satisfy a demand for a tank at any time (238).

Inventory theory has been used to analyze inventories of whole blood. Rockwell, Barnum, and Giffen evaluated two policies (constant replacement cycle and constant size) a hospital might adopt to manage its whole blood inventory (334).

Two articles gave information about the operation of a blood bank which serves 28 hospitals with a total of 4,600 beds. Because of the time limitation on usability of whole blood the computerization of the data collection and transmission system was judged more important for the success of the operation than the use of inventory theory (80, 355).

In order to apply inventory theory the hospital administrator will have to obtain certain information some of which may not be readily available. Presumably usage rates, by day, week, or month, of individual

items stocked are available. Forecasts of usage may not be available and some study may be needed to see if anything more sophisticated than naive forecasting models is required. Carrying costs, ordering costs, and costs of shortages have to be determined. Computing the costs of shortages would require the most thought.

One advantage of studying inventories is that the investigator is almost sure of making some improvement over the present operation. Typically, inventories can be reduced without adversely affecting performance. Also, the inventory control system installed after an operations research study usually makes available to the administrator information that he did not have before. What this is worth depends on how such information is used.

Benefits resulting from a blood inventory control system were described by Singman, et al. They reported that inventories of blood were reduced 15% to 20% and the per cent of blood outdated was reduced (355). None of the articles reported what it had cost to analyze the present inventory control process or if the proposed new system would cost more to operate than the present process. Singman, et al. did report that the computerized system for inventory control represented a considerable investment.

Inventories carried by hospitals include such items as food, pharmaceuticals, surgical supplies, medical supplies, cleaning supplies, and so forth. The inventory of a 300-bed hospital might represent an investment of $130,000. If a study were to show that the inventory could be reduced by 20%, there would be a one-shot reduction in inventory of $26,000. One way a business firm might estimate the value of such a reduction would be to assume that the money no longer tied up in

inventory could be invested in the company's business and would be worth the average return on the company's invested capital. Or it could be seen as a reduction in working capital requirements and thus be valued at what it would cost the company to borrow money. For a hospital the cost of borrowing money would probably be a good measure. If we arbitrarily set this at 10% for purposes of illustration, the reduction in annual interest charges for a 300-bed hospital is $2,600.

Viewed in the perspective of an annual operating budget for a 300-bed hospital of approximately $7,000,000 and with the consideration that the new inventory control system might cost more to install and operate than the former system, the possible savings from the use of inventory theory are not as large as one might expect.

Menu Planning

Most operations research studies in the hospital dietary department have concentrated on menu planning. However, some studies have been done on the department as a system. Gue provided a brief introduction to the use of systems analysis in the dietary department (178). Konnersman viewed the dietary department as a logistics system and flow charted food processing and the department's information and control characteristics (246).

Menu planning is an extension of a well known and long studied operations research problem -- the diet problem or the nutrition problem, as it is sometimes called. The standard formulation of this problem minimizes food costs subject to meeting certain nutritional requirements. Obviously some changes have to be made in this formulation if it is to be used to plan menus for hospitalized patients. Such considerations

as medical restrictions, choice among entrees, and day-to-day variation of menus need to be included. Other factors which have to be taken into account are aesthetic ones such as color, texture, shape, and flavor (127). Preparation times and costs are also needed in addition, of course, to the raw food costs.

Balintfy has written extensively about menu planning. One of his articles gives details on how linear programming may be used in menu planning (35). An example of planning breakfast appetizer items for a 31-day period showed a savings of 58 cents per patient for the month. In a later article Balintfy and Dennis reported that four hospitals had implemented a menu planning model and all had achieved cost savings (112).

In one experiment with 16 dietitians Balintfy and Nebel gave each the problem of planning economical, nonselective (i.e., patients have no choice among items) menus which would satisfy daily dietary requirements for seven consecutive days. The dietitians were given a list of 200 items divided into 15 menu categories from which to prepare the seven daily menus. Each dietitian prepared the menus alone and then prepared them while interacting with a computer. The computer presented each dietitian with a minimum cost solution which the dietitian could change if for any reason it did not appear to be a satisfactory menu. Analysis of the results showed that the menus prepared by the dietitians alone cost more but had a higher nutrient level and were preferred by an expert panel to the menus prepared with computer assistance. It should be noted that cost minimization had not been stressed in the instructions to the dietitians. They had been told to select "moderate cost" menus and apparently were not given cost information on the 200 items (37).

Other work in this area includes the discussion by Gue and Liggett of the different mathematical programming formulations for selective and nonselective menu planning (179). Taylor described a system for 79 state institutions in Pennsylvania. His computer routine, based upon a suggested food plan of the U.S. Department of Agriculture, takes into consideration the age and sex characteristics of the population at each institution and attempts to provide a low cost but nutritional diet (380). Fellers reported on a study under way at the University of Florida where the computer routine will produce 21-day selective menus for various diets (143).

In order to use linear programming for menu planning, the nutrient content and costs per serving for each item must be known. Dietitians and food managers probably have this information. Recommended nutrient requirements would be the standard ones published by the National Research Council. Other factors previously mentioned such as variety and choice would have to be decided. In cases where patients will be given a choice among items (selective menus) some forecasts of demand would also be needed.

The costs associated with changing menu planning from the present method to one using linear programming are not given in the literature. The costs to a hospital of doing the preliminary feasibility study are not mentioned nor are the costs of maintaining the computerized operation.

However, in some studies savings have been reported. Gue and Liggett reported cost savings of 6 cents per patient day at the University of Florida teaching hospital (179). Dennis and Balintfy gave results from four hospitals which showed savings ranging from 7.9 cents to 19.2 cents per patient day (112). To put these figures in perspective we

might assume a 300-bed hospital with 85% occupancy. Savings of 15 cents per patient day would mean a total annual savings of approximately $14,000. If savings were 10 cents per patient day the total savings would be less than $10,000. Although other benefits in terms of better control of the dietary process may well exist, the cost savings alone are not impressive. In addition, not all of the cost savings may be due to the linear programming model. A careful analysis of the dietary process may well result in substantial improvements even if no computer routine is ever used. Gue and Liggett thought the small saving of only 6 cents per patient day in their study reflected the relative efficiency of the traditional method of menu planning at the hospital they studied.

A discouraging report on computer assisted menu planning was given at a recent symposium on computer applications in the health field. The director of the department of nutrition and dietetics at the University of Missouri Medical Center reported that her project, considered one of the more successful undertakings in this area, had been five years in development but was still not operational. Even though management decision making had been improved it was difficult to specify real returns from using the computer in the dietary department (421).

Computer Applications, Total Hospital Information Systems, and Models of Hospitals

Another broad category of operations research and systems analysis studies in hospital administration deals with computer applications other than those discussed in earlier sections, total hospital information systems, and preliminary attempts to build models of hospitals. Even though most of the articles do not give any details about the systems analyses, if any, which preceded the computer applications, some

discussion seems warranted. In reading the literature it is often difficult to determine whether an article describes an operations research study which has as one of its findings the need for computerization or whether it simply describes the computerization of a previously existing system. Sometimes the use of computers is equated with operations research. Of course that is not the view in this monograph.

Computer Applications

In the late 1950's and early 1960's automation and computerization in hospitals were hailed as the solution to the problems of increasing complexity and mounting costs. Titles of articles that appeared in various hospital journals at that time would indicate that the millennium was almost at hand for the harrassed administrator:

Applying Automation to the Hospital Business Office

Automation Offers Savings Opportunities

Automation for Hospital Central Service: A New Concept

Proposed Electronic System for Medication Orders

Automation Cuts Costs, Increases Efficiency

Push-Button Medicine? It's Here

Modern Hopsital Electronics

Patient Data: A Computer-Based System

Hospital Research and Administration with a Digital Computer

In the early 1960's several operations researchers wrote general articles which suggested that certain hospital functions and activities could be automated or computerized. To some extent they tried to assess the impact such changes might have on the hospital's organizational structure (49, 60, 185, 370). Hospital administrators began writing

articles, usually for hospital journals, telling of projects involving computers which were planned or under way in their hospitals (74, 164, 250, 320, 338, 391).

Later in the 1960's surveys of computer applications began to appear. Several described and compared various computer applications undertaken by selected hospitals across the United States (328, 329, 347, 348). Other surveys did not identify the specific hospitals where the projects were undertaken (39, 212, 263, 354). Individual hospitals continued to report upon their computer projects (162, 267). There was an interesting series of articles based upon the work of the Hospital Computer Project in the Laboratory of Computer Science at the Massachusetts General Hospital (39, 40, 41, 175, 201, 202).

Now in the 1970's an increasing number of companies are offering an increasing variety of computerized applications to an increasing number of hospitals who wish to try applications which go beyond routine accounting. The present ferment both in the health care field and in the computing industry makes it difficult to predict the future. However, the pressure to do something about the rapid rise in hospital costs (apparently without much analysis of whether or not the cost increases are justified) appears to be greater than ever. Since hospital costs are now the subject of political debate, the growing demand for greater efficiency seems sure to bring about changes in hospital operations. This alone will ensure more attempts to control costs through automation and more efforts to rationalize hospital activities through operations research and systems analysis. These developments will undoubtedly increase the interest in using computers in hospitals.

A sampling of the literature reveals many computer applications[13] in hospitals in addition to those already discussed (e.g., patient admission, transfer, and discharge systems; blood inventory control systems). The studies which follow either were not done by operations researchers or were judged by the authors as not requiring the extended treatment given other studies in the earlier sections of this monograph. The references cited are obviously not exhaustive of computer applications or of literature about such applications but are included to illustrate the previously mentioned ferment which is going on in hospitals today throughout the United States.

The most comprehensive listing of actual applications in specific hospitals resulted from an extensive survey undertaken by the National Center for Health Services Research and Development (397). Lamson, et al. compiled a list of eleven computer applications together with the names of the hospitals in which the applications had been successfully implemented (251), an appendix to Schwartz's article listed many potential computer applications (347), a Department of Labor study listed numerous possibilities for the use of computers in hospitals (400), and an article by Levy and Cammarn discussed several of the more widely used applications (255).

Routine accounting functions such as payroll and patient billing were relatively easy to put on computers. Similar applications had

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[13] Because of the focus of this paper on hospital administration, many important studies on the use of computers in medical care and clinical medicine are omitted. Although these computer applications often affect hospital administration, the major emphasis of the studies is on other areas. The studies omitted are those in the following categories: automated multiphasic screening, computer diagnosis, automated laboratory testing, automated medical history taking, medical record linkage, computer interpretation of diagnostic tests, and patient monitoring in intensive care units.

become commonplace in large corporations some years before. Now many organizations (e.g., IBM, Honeywell, NCR, Lockheed, Bank of America) offer accounting packages especially designed for hospital business offices. Ball, Magnier, and Raney gave an interesting case history of the computerization of a hospital business office (38).

The automation of medical records is the subject of several articles (32, 175, 240, 247, 256, 428). Brown pointed to some of the problems which exist in this area. These include unique patient identification, insuring confidentiality of stored information, and many technical problems of file construction. He suggested that it is very important to improve internal hospital communications before starting on the task of automating medical records (72).

The quantitative nature of the output of the hospital clinical laboratory has made it an attractive area of study for those working in data processing and transmission. The extent of the work done is demonstrated by the number of articles cited in a recent literature search by the National Library of Medicine (399). Another well worked area is the hospital pharmacy. One issue of the American Journal of Hospital Pharmacy discussed various EDP applications (132). Also, a survey of computer based pharmacy systems is available (173).

Most of the articles on computer applications deal with current operating problems. The use of data generated from these applications for planning is not stressed, although the payoff to the administrator from improved planning may well be as great or greater than that from current operations. One specific example of a computer application used in planning will have to suffice. Thompson and Fetter used computer simulation to study the economics of a maternity service. When plans

for expanding the maternity unit were developed, the information generated by this study was very useful in determining the most economic size for the unit (386).

The following comments on lack of evaluation of computer applications refer to all such applications, not just those mentioned in this section.

Singer's recent survey found that the justifications for computers in hospital support service areas were not well documented nor were evaluations based on adequate before and after comparisons (354). Feldman argues that we don't find cost-benefit analyses of the introduction of computers into hospitals partly because of the difficulty in measuring benefits but primarily because we don't measure the cost of doing what is done before and after the computer is introduced (138). A survey of computer applications in medicine in the United States and England led Shegog to conclude that although speculation about possible uses of computers for patient care procedures abounded, it was unusual to find a critical assessment of any particular achievement (348). One teaching hospital did report that the development costs of a computerized appointment system for its outpatient clinic was $60,000. This figure does not include the development cost of the overall system software which was borne by the vendor of the time-sharing system. The appointment system operated successfully and pleased both physicians and staff. However, automation increased the clinic's operating costs. Computer costs alone for the appointment system added $50,000 per year. The authors stated: "The financial outlook is not encouraging . . . . The aggregate cost of automation is high . . . . It is obvious that cost is presently prohibitive"(229, pp. 244-5).

One example of a hospital that did report successful applications is the Winnipeg General Hospital. Their computer operation which began in 1962 has been developed with much thought and care (267).

Total Hospital Information Systems

Because most information systems are computer-based the assignment of articles to this category rather than to the preceding computer applications category is somewhat arbitrary. However, the studies cited in this section tend to be broader in scope. Several surveys of the literature on hospital information systems are available (11, 110, 169).

More patients and more procedures per patient have created mounting information and communication problems in hospitals. For example, Hofmann and Barnett estimated that between 1960 and 1965 at the Massachusetts General Hospital patient admissions rose 12% while X-ray examinations increased 32% and laboratory procedures increased 66% (201). In a study of three hospitals Jydstrup and Gross found that information handling costs amounted to approximately 25% of each hospital's total operating costs (233). The proliferation of paperwork and amount of resources devoted to information processing in hospitals has forced attention to ways of coping with those management problems.

Since "management information systems" has become a popular although controversial topic in business administration (e.g., 7, 321, 374), it is not surprising to find that operations researchers suggest that hospital information systems are necessary for the modern management of hospitals. Most of the discussion which follows refers to the more ambitious proposals for information systems (on-line, real-time) which call for remote video terminals throughout the hospital, immediate access to computerized patient records, and so forth.

Less complex communication systems are, of course, available. Medelco is an example of such a system now in use in hospitals (65, 147). This system is designed to eliminate most of the written and some of the oral communication in transmitting patient information and requisitioning drugs and services throughout the hospital. A communication network links the admitting office, nursing station, laboratory, X-ray, pharmacy, business office, housekeeping, dietary, and so forth. Communications are facilitated by means of prepunched cards (e.g., patient cards, drug cards, cards with prepunched routine messages). The use of such cards probably results in fewer errors in data transmission and saves employees' time. Relatively simple systems such as these may well obtain much of the benefit of the more sophisticated systems at a fraction of the cost. The addition of a means for quick data return (e.g., reports of laboratory tests) would make the Medelco system an even more powerful management aid.

Aerospace companies (e.g., Lockheed) and computer manufacturers (e.g., IBM) have seen the health field as a potentially profitable area in which to use their expertise in systems analysis. These companies view hospitals as information processing systems and tend to recommend sophisticated technology to replace the manual procedures now used in handling data (223, 261, 262, 263). Management consulting firms (e.g., Community Systems Foundation) appear to rely more on traditional industrial engineering techniques (76, 341). The proprietary nature of the development by these companies probably inhibit them from publishing much about what they have achieved. The most detailed study readily available is the one by Lockheed on the information needs on nursing stations (263).

Lockheed chose to study nursing stations because of their importance as the focal point for the exchange of virtually all patient medical information. They observed 160 nursing stations in nine hospitals. The detail given in their report shows the great amount of work involved in analyzing information handling in hospitals. Such a study involves a major commitment of time, manpower, and money. One well known part of Lockheed's system is the structuring of medical information so that the physician may interact with the computer to initiate medical orders for patients by using a light pen at remote video terminals (237, 351). Nurses may also use the same procedure to enter data on patients. The computerized system encompasses the business office, admitting, food service, pharmacy, laboratory, and X-ray.

Because there has not yet been a full-scale demonstration of the Lockheed system, an assessment of costs and benefits is premature. Lockheed hopes to achieve a variety of benefits. These include accomplishment of physician orders more quickly and rapidly, increased legibility of orders, reduction in errors in order transcription, reduction in routine clerical work, improved charting, reduced paperwork, increased efficiency of personnel, and better facility utilization. However, Lockheed has reported difficulties in implementing its computerized information system (421).

Lockheed has made other system studies of medical facilities. However, the nature of the contracts under which these studies were done limited the studies to surveys of the existing information systems and to proposals to design new systems (211, 317). Apparently the necessary financing to undertake the design and implementation studies was not forthcoming.

Several other large scale computerized systems are either in operation in hospitals or are about to be installed. The National Data Corporation has a system similar to Lockheed's called REACH (Real-time Electronic Access Communication for Hospitals) which they are installing in several hospitals (361). Analysts at the new Loyola University Hospital had the advantage of designing their information system prior to the opening of the hospital (162). A psychiatric hospital, the Institute of Living, has reported an operational version of remote, input-output terminals (310, 338). The State University of New York-Downstate Medical Center at Brooklyn reported that portions of their "Total Hospital Operating and Medical Information System" computer program were operating (350). The Veterans Administration runs a large medical care program which includes 166 hospitals. An automated management information system collects data on outpatient and inpatient work loads for use at the central office in Washington. Data on individual patients are also kept (337). The managers of Biomedical Computer Services have ambitious plans for their hospital information system. Among other things they intend to enlarge the system beyond the hospital by installing terminals in physicians' offices (248, 249). At the University of Washington Hospitals a long-range goal is a total information system. They are proceeding on their five-year plan by considering eight major application areas as separate sub-systems with a priority for study assigned to each one (168).

The Kaiser Foundation Research Institute has started a pilot medical data system in one hospital. Their long-term objective is to develop a multifacility computer-based system that will support the medical data requirements of one million people in the San Francisco area.

one thousand physicians, and a large corps of professional and paramedical personnel involved in patient care (404).

In the Johns Hopkins Hospital, Hsieh evaluated the effectiveness of alternative inpatient medication information systems in terms of completeness of information, reliability of information, and efficiency in generating needed information (218). His work is quite interesting conceptually although many problems of measurement exist in his method of evaluation. For example, two measures are needed to determine performance capability. The first is a measure of the relative importance of a class of information in comparison with other classes of information provided to a hospital function (e.g., patient care, clinical research). The second is a measure of the relative importance of the given information to a particular hospital function compared with the importance of the same information to other hospital functions. Another problem arises because evaluation implicitly assumes that a model of the optimal system exists. For example, in the medication information system each person "should be provided selectively with information that is pertinent to his problem." But how can one determine what is pertinent to each person without knowing what an optimal system would be?

Besides articles such as the foregoing which illustrate specific applications, there are articles oriented toward conceptual discussions. For example, the September, 1968, issue of Inquiry was devoted to "The Computer and Hospital Information Systems," but contained very little about systems studies in individual hospitals (369). Another example of conceptual thinking is the model proposed by Dixon of a patient medical information system (116).

In two prescriptive articles Young pictured an ideal information and decision making system for hospitals in which the total hospital organization is viewed as a communication network (431, 432).

> Changes must be detected as soon as they occur or as soon as they can be predicted, and administrative action must be taken, based on sound quantitative information that permits evaluation of the departure of the state of the system from that desired. Under these circumstances, effective decision-making must necessarily be a dynamic, never-ending process that accurately anticipates needs, appraises the disparity between indicated needs and their fulfillment, and selects from among many possible courses of action those which will optimally satisfy these needs (432, p. 81).

He also believes cybernetics has particular applicability to health services and believes the computer will become the "central cybernetic processing tool." Unfortunately for this vision of the cybernetic hospital, Young reports that "attempts to extend computer-system capabilities to deal with decision processes have been slow and painful and have resulted in only marginal successes" (432, p. 84).

Because of the scarcity of published case studies a detailed evaluation of hospital information systems cannot be made. However, some information is available. Hofmann and Barnett reported that more than 100 man-years of effort had gone into the development of a time-sharing computer system at the Massachusetts General Hospital. Based on years of experience in computer applications at that hospital they concluded that it was difficult to defend a large-scale hospital information processing system on the grounds that the cost of patient care would be reduced (201).

Singer reported that in his survey he had been given figures of $2 to $7 per patient day as direct operating costs for hospital computer systems. Developmental costs ranged from $500,000 to over $1,000,000.

But he found little information to support these assertions or to identify any offsetting cost reductions that resulted from automation (354). Saunders estimated that a comprehensive system of computer controlled remote terminals throughout a hospital would likely increase costs by $3 to $4 per patient day.[14] Yet he found no adequate evidence that this increase in cost would be offset by savings in other areas or by an increase in productivity of staff (342).

National Data Corporation requires a hospital to sign a five-year contract for its hospital information system. Depending on the size of the installation the monthly rental runs from $64,000 to $103,000. For this sum National Data Corporation furnishes the equipment, personnel to run and maintain it, all programming, and the tie-in to their central computer (361).

Costs and benefits of computer-based information systems may be summed up by saying that the costs are real and immediate, the benefits less evident. The benefits usually mentioned but rarely documented are salary savings due to reduction of paperwork, freeing of technically trained persons from clerical tasks, possible reduction in number of employees, more timely information for use in current operations and in planning, availability of data for research, reduction of errors in recording and transmitting data, additional revenue created by reduction in the number of lost charges, quick access to records, and so forth.

However, for an administrator to take advantage of such an information system and to get full benefit from it some costs must be

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[14]The article in which these cost figures appear was published in 1969. They appear to be low by current standards (1970-71). Informal figures given to the authors estimated such costs at $7 to $9 per patient day. Of course, breakthroughs in computer technology could reduce these costs.

incurred beyond those for the purchase or rental of the equipment and software package. Published reports (38, 267) and the authors' conversations with administrators of hospitals where such systems are installed indicate that additional personnel must be added to the payroll even if a shared computer system is used and the vendor provides the software. A continuing training program for all employees involved with the information system appears necessary. In addition, some employees would have to be retrained (e.g., the nurses who would be expected to spend time saved from clerical duties on direct patient care).

Lack of evaluation notwithstanding, more and more hospitals are using computers. Major pilot projects involving computers need to continue. We do not want to commit what Thring called "the fallacy of premature economic assessment" (392) by judging computers in hospital administration uneconomic before adequate information is available. Pilot projects may well lead to breakthroughs in cost reduction, software and hardware development, and even medical practice and education. Flagle has made some interesting suggestions on what projects might be carried out, how they could be financed, and where they might be done (151). Only with knowledge gained from projects such as those suggested by Flagle can the role of the computer in hospital operations be appraised.

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In summary, the literature cited in this section has dealt with specific computer applications, computer based information systems, or general statements about computers, automation, and information systems. The emphasis has not been on systems analysis. Many of the studies assumed that it was obvious that use of sophisticated technology to improve existing communications within the hospital would result in

reduced costs and better patient care. For a variety of reasons this assumption has been hard to prove. The total hospital information system while useful as a concept in which to view various subsystems of the hospital does not appear to be obtainable now given the present state of knowledge about decision making, patient care, disease diagnosis and treatment, and hospital operations (342).

A good ending for this section is provided by a quotation from West Churchman:

> Just because certain functions in a hospital are connected by an information system that is handled in part by a computer does not mean that the hospital has taken a systems approach to its problems (88, pp. 104-5).

Models of Hospitals

Operations researchers have made a few attempts to build models of hospitals which go beyond the analogue models of data flow found in the studies of hospital information systems. Fetter and Thompson proposed a model of an entire general hospital (146). One purpose of their study was to understand the influences of the increased number of special care units within the hospital (e.g., intensive care unit, coronary care unit) upon the operation of the entire hospital. Fetter and Thompson restated their purpose to make it more operational. They asked whether the hospital administrator can use patient-flow information for deciding the number of beds to be allocated to each care zone in a hospital organized along progressive patient care lines in accordance with the characteristics of the anticipated patient load?

To answer this question the authors used a two-stage approach of computer simulation and linear programming. Paths followed by patients through a hospital, the frequencies and conditional probabilities for

each path, and the means and standard deviations of time spent in the various care zones were the basic data for the simulation.

One output of the simulation, the probability of bed utilization in each care zone, was an input to a linear programming model which maximized overall bed utilization subject to budgetary constraints on the investment and operating costs of beds. Weights were used which reflected the subjective valuation of the relative desirability of beds in different care zones.

The remaining articles will be mentioned more briefly because the models presented or concepts proposed are not as well defined or developed as those of Fetter and Thompson.

Baligh and Laughhunn (33) proposed a linear programming model of a hospital that is quite different from that of Fetter and Thompson. Patients are assigned to one of a set of classes upon admission. Assignment is based on the "value" of a patient to the hospital and upon the patient's requirements for hospital resources. Value is defined in terms of the importance the hospital places on various illnesses which bring patients to hospitals. There is no flow from one care zone to another within the hospital. The output of a hospital is the "value" of each class multiplied by the number of patients in that class summed over all classes. The objective is to maximize this output subject to constraints of hospital resources, technology, and a maximum number of patients for each class. The model is left in notational form; no numerical example is given. As the authors state, "A cursory examination shows that the task of data collection and parameter estimation necessary to make the model operational as a planning tool is likely to be difficult" (33, pp. 301-2).

Jelinek discussed briefly and in general terms a patient care system for a community hospital as an input-output model with corrective feedback (228).

Howland has written extensively of his concept of a hospital system model. Influenced by cybernetics and the concept of homeostasis, he views the hospital as a goal-directed system which provides patient care by the regulation and control of patient condition defined in terms of patient states. Patients by definition need the help of doctors, nurses, and hospital resources to regain their "balance." Hence the nurse-patient-physician triad, seen as a self-regulating mechanism, becomes the focus of investigation (213, 214, 215, 216, 217).

Flagle discussed a model of the health services system in which the hospital is but one element. He recognized the cybernetic nature of health services but he also emphasized that conscious decisions were taken in the system (152).

Two economists have developed models of hospitals. Although the economic component outweighs the health component, the articles are interesting attempts to model a complex organization.

Ro drew upon the economics of consumption to build a model in which the consumption of hospital services results from the interaction of physicians, patients, and the hospital. To make the regression model operational most of the dynamics of hospital operations and physician diagnosis and treatment are eliminated. Because of the difficulty in measuring hospital output, three input measures (number of days hospitalized, weighted number of services received, and amount of the hospital bill) are used as proxy variables for output (330).

Newhouse uses his model of the hospital as an example in his work to develop a theory for nonprofit institutions. The model is not developed very far and no example based on empirical data is given. Differences of opinion among the board of trustees, the medical staff, and the administrator are assumed to have been resolved somehow so that for purposes of analysis one may speak of a single hospital decision maker. Definitional problems of the quality and quantity of hospital output are discussed (297).

This brief survey shows the preliminary and tentative nature of hospital models. At the present time the applicability of such work to hospital administration is extremely limited. The urgent need for advances in model development in the hospital field will be discussed in the final section of this monograph.

REASONS FOR DIFFICULTIES IN IMPLEMENTING OPERATIONS RESEARCH STUDIES

In a paper presented at a meeting of health professionals and operations researchers in 1969, Young referred to an earlier remark that operations research had generally failed the health services. Young stated that his first reaction was to protest this statement, but that upon reflection he was hard pressed to name a single instance where the application of operations research had initiated or led to a major decision in the health services (433).[15] This is a damaging admission, coming as it does some twenty years after operations research studies were formally undertaken in the health field with the study of outpatient clinics at hospitals (25, 26, 410, 411, 413).

Why have the results of operations research studies been so little used by hospital administrators? From the viewpoint of the administrator the studies have often had various shortcomings.

1. Omission of Some Problems Deemed Important by Administrators
2. Tendency to View Hospitals as Separable Systems
3. Omission of the Medical Staff from Hospital Studies

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[15] Young suggests the following reasons to explain the lack of influence of operations research on major decisions or significant developments in the health field: the lack of high quality operations researchers working in the health field, the lack of understanding and acceptance of operations research by the medical profession, the refusal of the medical profession to admit they have major problems and their refusal to admit that they cannot solve their own problems, and the relatively poor identification of problems and objectives in the health field as compared to industry and the military.

4. Overlooking Dysfunctional Consequences of Introducing Computer-Based Technology in the Hospital
5. Omission of Difficult-to-Quantify Variables
6. Influence of the Academic Setting on University-Based Operations Research in Hospitals
7. Lack of Detailed Information in the Studies of the Costs and Benefits of Proposed Changes
8. Failure to Recognize Limitations on the Power of the Administrator
9. Neglect of the Literature on Implementation

Omission of Some Problems Deemed Important by Administrators

Implicitly at least the literature just surveyed assumes that the hospital administrator has certain goals, certain motivations, and certain key problems. What is the picture of the hospital administrator which emerges from these studies? It is that of an individual primarily concerned with having a high percentage of beds occupied, minimizing the fluctuations of this percentage, efficiently assigning staff (primarily nursing personnel) to their tacks, minimizing the idle time of physicians, reducing inventories and food preparation costs, and rapidly collecting and accurately transmitting data. Certainly the hospital administrator wants the smooth, efficient operation which the studies imply. However, the hospital administrator often sees his major problems arising in some of the following areas and his important goal as providing leadership to solve these problems:

-- Cost allocation problems brought into prominence by federal regulations governing Medicare and Medicaid reimbursements and the new thrust of reimbursement plans to give incentives to cut operating costs. How will the administrator get funds to be creative, improve care, mount

new programs, and try out what seems to him to be innovative ideas?

-- Problems in maintaining financial stability. What are the ways of ensuring financial solvency in the face of rapidly rising costs of operation? How can the administrator influence third party payers to set reasonable reimbursement rates?

-- Quality of care problems recently highlighted by court decisions holding hospitals liable for actions by private physicians on their staffs. How can peer group control be made to work within the hospital's medical staff?

-- Continuity of care problems. For example, what should the hospital's discharge planning program be? Should the hospital provide preventive care? Should it operate an extended care facility, undertake a home care program, expand vastly its outpatient clinic into the community? If the hospital does not directly operate such programs, then what should its relationship be to such facilities and programs?

-- Problems involving the relationship of the hospital with the surrounding community, especially in ghetto areas. For example, should the hospital have a training program for "hard core" unemployed? Should the hospital have a program to recruit physicians from minority groups for its staff and should this effort include programs to upgrade minority physicians if they do not now meet qualifications for staff privileges?

-- Manpower and personnel administration problems brought about by low pay scales, blocked upward mobility, increase in unionization, and proliferation in number of different jobs performed. How does one recruit, train, and retain good employees for the many professional and sub-professional jobs in hospitals? How should the hospital deal with the increasing professionalization in medical care? What should be done about

the high turnover in the hospital where the employees are predominantly women?

-- Problems in dealing with the governing board which has legal control of the hospital and has the power to hire and fire the hospital administrator. How should the administrator educate board members about the problems of operating a hospital? Board members usually are community leaders with little initial knowledge of hospitals. Should the administrator encourage community participation in policy making at the board level?

-- Problems in dealing with medical staff. How can the administrator work effectively with private physicians some of whom may hold the view that a hospital administrator's main functions are to keep the building heated and to have facilities and personnel available in order not to waste the valuable time of physicians? Is it desirable to have full-time, salaried chiefs for each key medical department? What administrative action is required to achieve and maintain high quality patient care? How can the administrator make physicians more aware of the impact of their decisions and orders on hospital costs? How can he get them to assume more responsibility for keeping costs in line?

-- Problems of planning for the future.[16] Is expansion necessary? What services should the hospital provide for its community? How will

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[16] Much work has been done to analyze internal hospital operations in order to provide planners and architects with better information upon which to base their decisions. The first use of operations research in hospital planning and design probably occurred in England shortly after World War II (29,301). Souder, Clark, Elkind, and Brown present a systems approach to hospital design which builds on these earlier studies and expands their scope considerably with the use of computer aided techniques (368). A further discussion of the use of computers in hospital design is given by Souder (367). An issue of Health Services Research was devoted to health facilities design (188).

the administrator reconcile the interests of his hospital and its medical staff with the requirements of governmental or quasi-governmental health planning agencies?

-- Problems concerning relationships with other hospitals in the community vis-a-vis possible consolidation of medical services (e.g., maternity units), pooling of service department (e.g., laundry), and even merger.

-- Problems arising from the demand that the overall delivery of health services be made more effective, probably through some kind of reorganization. Should the hospital administrator attempt to influence the changes occurring in our health care system? If so, how? Will his role and responsibilities be reduced if his hospital becomes just one cog in a much larger organization?

Even if it could be argued that the operations research studies previously cited would help solve some of the above problems, the connection between the findings of the studies and solutions to these problems has not been set out explicitly.

The situation in the hospital field where there are many differences between the problems studied by the operations researchers and the problems deemed important by hospital administrators is similar to that which existed some years ago in the business world. For several reasons many early operations research studies in business firms dealt with inventory problems. Reading the early literature might lead one to conclude that businessmen spent most of their time worrying about the size of their inventories. In fact, inventory problems were and are usually of minor concern compared with other problems facing executives.

Tendency to View
Hospitals as Separable Systems

Many operations researchers have tended to study the hospital as if it were made up of many small pieces more or less isolated from each other. The hospital administrator, however, is forced to consider the interrelatedness of the parts of his organization. This difference in perspective may be a reason why some operations research studies have not been implemented.

Probably the engineering background of many operations researchers leads them to study little pieces of an organization without first considering the overall system within which each piece is embedded. Churchman has contrasted this "housekeeping" approach -- when you see a mess, clean it up -- with the "whole system" approach -- study the entire system before you change part of it (85). Those who favor the "housekeeping" approach assume a system may be separated into parts in such a way that an improvement in the performance of a part of the system will result in the improvement in the performance of the overall system.[17]

Several writers have warned about possible adverse consequences of adopting the "housekeeping" approach. In the early operations research literature Hitch discussed some of these consequences under the heading of suboptimization (198). Churchman made an extensive analysis of what the assumption of separability means in terms of systems design and what may occur if this assumption is made when in fact the system is not separable (86). Referring to the complex problems of human life, Dubos thought it a

[17]Adam Smith assumed the economy of a nation was a separable system when he made his famous statement that an "invisible hand" worked to ensure that individual pursuit of selfish ends promoted the general good (360).

strange assumption that knowledge of complex systems will inevitably emerge from studies of much simpler ones. He saw that this reductionist approach could lead a scientist to become so involved intellectually and emotionally in the elementary fragments of the system that he would lose interest in the phenomena or the organisms which had been his first concern (123).

Separability and reductionism may arise in the construction of computer simulation models. Those who build such models tend to select a subsystem of the hospital and proceed to write a computer program for it. Because such programs require considerable work and ingenuity (e.g., 332) there may be a tendency for the investigators to get so involved in the simulation that they forget the very problems they intended to solve.

Ingbar questioned whether the assumption of separability was applicable in the field of medical care.

> It seems to me we have implicitly assumed that we will be able to improve the health system of this country by improving its segments. We postulate a tautology between the whole and its parts that may be more appropriate to mathematics than to medical care (220, p. 17).

The interdependent nature of hospital activities makes the "housekeeping" approach inappropriate. Where subsystems are interdependent it is not necessarily true that what is good for one part of a system is good for the whole. With the possible exception of a few subsystems such as the laundry it would appear that considerable knowledge of how the parts of the hospital relate to one another is needed before improvement is attempted in any of the parts. Even the laundry could not be improved without some knowledge of the rest of the system.

In practice a compromise may be reached between the "whole system" approach and the "housekeeping" approach. The researcher looks at the overall functioning of the organization before selecting a part for further study. He is constantly aware of the relation of the part to the whole.

As his study of the part proceeds he continually checks what effect changes in the part might have on the rest of the system. However, there is little indication in most of the operations research studies that such a procedure was followed.

One possible result of using the "housekeeping" approach is given in the often cited case study of Bavelas and Strauss about a toy manufacturing company. Here a change in procedures was effected in a part of the system without regard for the impact the change would have on the whole system. The result was failure. The change was cancelled and most of the persons involved quit (50).

Omission of the Medical Staff from Hospital Studies

The physicians on the staff have been largely ignored in operations research studies in hospitals.[18] Although the relationships among the three main internal power groups, medical staff, governing board, and hospital administration, influence almost all areas of hospital activity, one would never know this from the operations research studies.

The demand upon the resources under the control of the hospital administrator is generated largely by physicians who are not employees of the hospital. Patients are admitted to hospitals on order of physicians, the treatment they receive is prescribed by physicians, and their time of discharge is in most cases controlled by physicians. Therefore, many of the activities of hospital employees are dictated by doctors' orders.

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[18] There may be good reasons for omitting the physicians. Perrow reports that working with doctors was the biggest single problem encountered by medical sociologists (313). No doubt, operations researchers could make the same statement.

The physician's goals may differ markedly from those of the hospital administrator and the conflict in goals creates administrative problems (103, 230). If we assume that a physician wishes to minimize the amount of his unproductive time and to maintain a large degree of convenience and freedom from bureaucratic constraints, and if we further assume that the hospital adapts itself to help physicians achieve their goals (and it appears that most hospitals do adapt), then certain administrative problems are inevitable. For example, most physicians find it more convenient and saving of their time to visit or to operate on their hospitalized patients in the morning. The resulting concentration of doctors' orders produces peak loads in demands for hospital services which are costly for hospitals just as peak loads are costly for electric utilities. Were the doctors' orders spread out more evenly over the day the costs of operating hospitals would be less. In addition, the behavior of surgeons (and others) results in reduced work loads for the hospitals on weekends.

Another example of a difference in goals concerns the occupancy rate. The physician would like to have a bed available whenever he wants to admit a patient. In effect, this natural desire on the part of the physician means he wants an occupancy rate somewhat lower than that wanted by the administrator. The administrator is trying to maintain a steady and relatively high occupancy rate so the hospital's per diem costs will be within the allowable range under the various arrangements for reimbursement by government and insurance carriers. The physician and the administrator both act rationally, but they are pursuing different goals. The problem of occupancy rates can also result in additional conflict. In order to reduce fluctuations in the rate the administrator often tries to

get the physicians to give one or two days' notice on admissions and one or two days' notice on discharges. Such a request may be seen by the physicians as interfering with their practice of medicine.

A third example was given by Levy and Cammarn in their discussion of information processing in medicine. Hospital administrators find that standard forms are required to use computers effectively and that physicians often resist the use of such forms. Three reasons for this resistance suggested by Levy and Cammarn point to other goals considered important by physicians: (1) self-image as an individualist; (2) concern for the patient rather than the written record; and (3) in some cases the knowledge that standardized data input facilitates quality control over medical practice (255).

Another illustration of problems arising from differences in goals was provided the authors by an administrator who described how little real control he has over certain subsystems within the hospital. He stated that the scheduling of the operating suite was done with the convenience and desires of the anesthesiologists and the surgeons in mind with little consideration given to the overall operation of the hospital. He thought it would be extremely difficult, if not impossible, to administer the operating suite to optimize the efficiency of the total hospital. Another example of a hard to change hospital practice concerns the established pattern of reduced weekend use of hospital beds. A Blue Cross official spoke of the problems involved in increasing the occupancy of a hospital and thus the workload on Saturdays and Sundays:

> Great difficulties have been experienced in attempting to change this pattern, since it involves the work habits of many thousands of hospital employees and physicians already in short supply (299).

Certainly it would be difficult for the operations researcher to handle problems such as those just cited. However, until operations research studies deal with the very real administrative problems caused by physicians and others pursuing their own goals the administrator may think the operations researcher just doesn't understand the situation.

Overlooking Dysfunctional Consequences of Introducing Computer-Based Technology in the Hospital

In their eagerness to use computer-based technology to solve hospital problems many operations researchers and systems analysts overlook the potentially dangerous effects that automation might have on the basic nature of the hospital. McDermott pointed out in his analysis of the effects of advanced technological systems in the military field that the introduction of a technological system influenced every area it touched. He argued that a "Gresham's Law of Technology" operates in which higher levels of technology drive out the lower with the result that the need to keep the advanced technological system functioning forces the rest of the organization to adapt to it.[19] This, in turn, he contended, would lead to controls designed to minimize the incidence of personal or social behavior which is erratic or otherwise not easily classified and to reduce unresponsiveness to central management (266).

Another person, thoroughly familiar with advanced technological systems, supports McDermott's conclusions. Boguslaw stated that one result of computer technology's pervading an organization is:

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[19] Mouzelis makes a similar argument in connection with industrial engineers. He points out that the effort of industrial engineers to "rationalize" the work of individual employees could not be confined to the workers but would, by the logic of the situation, spread upward and outward until it covered and controlled the whole organization (284, p. 82).

> . . . an insistence upon a uniformity of perspective, a standardization of language, and a consensus of values that is characteristic of highly authoritarian social structures. Nonconforming perspectives, language, and values can be and, indeed, must be excluded as system elements (63, p. 186).

Patients certainly might exhibit erratic personal or social behavior or might have nonconforming perspectives, language, and values which would have to be constrained and controlled. The cold and impersonal treatment of patients in hospitals as they are now organized is well documented.[20] A computerized hospital could make this worse, the glowing claims of those who sell the technology notwithstanding.[21]

Hospital information systems such as those proposed by Lockheed (261) and IBM (223) would cause changes throughout the hospital. All the supporting subsystems in the hospital which feed data into the computerized system would be under pressure to rationalize their systems and impose management controls to achieve greater efficiency and reliability. Maintenance of the computer system could become an end in itself and the consequences might or might not further hospital goals. At the very least those who propose automated hospital systems cannot ignore the spillover of the technology into other subsystems.

A computer system once installed might impose some undesirable features of its own upon the organization. A good overview of the experiences hospitals have had in installing computers was made by Humphrey (219).

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[20] Cherkasky states that the one thing that unites all patients, rich and poor alike, is their complaint about treatment in hospitals (402, p. 461). Other references confirm Cherkasky's observation (23, 69, 100, 124, 186).

[21] In the field of education, Oettinger's well documented study of the use of computer-based instructional devices showed that the claims made by the equipment manufacturers for this advanced technology were premature to say the least and could not be fulfilled in practice (307).

Singer argued that a computer system involves a certain degree of rigidity and resistance to change -- the more complex the system, the higher the cost of change, and therefore the more rigid and inflexible the system (354). He thought the impact on a hospital's operations of batch computer operations such as accounting and business office applications would be far-reaching and that the potential impact of a total hospital information system would be even more profound.

Others have written about the inflexibility of large-scale computer systems (110, 219, 342). Given the present-day nature of hospital operations this aspect may be a major obstacle to effective use of computers. The hospital problems to be solved have increased in complexity as health professionals have taken on new functions and as new methods of treating patients have been introduced. There seems to be more rather than less uncertainty. Professional groups within the hospital (e.g., nurses, dietitians, medical record librarians, and even to some extent physicians) are engaged in redefining their roles and functions. Physicians differ among themselves in matters of diagnosis and treatment. Situations such as these are inherently difficult for computerization. As Saunders concluded, "The computer is so dependent on humans for its use that it becomes unusable if the humans have not resolved their own problems" (342, p. 66).

Several writers have made insightful comments on why total hospital information systems have not flourished. Singer argues that such a hospital information system would be difficult to achieve because of the heterogenity of hospital activities (354). Hospitals contain a variety of activities which in many ways are only minimally related to each other.

Hence the recognition of the need for and value of a computer is likely to develop at different rates in different departments.

Saunders believes that only in a small unit such as an individual ward will one get the common terminology and ways of doing various procedures that are prerequisites for implementing a medical information system. That one could have such a system for an entire hospital he calls "a present fiction" (342).

Brown and Dickson believe that there has been a gross underestimation of the dimensions of the task at hand. A lack of communication between engineers and computer specialists on the one hand and medical and hospital operating personnel on the other has contributed to the lack of progress (71). Other writers have commented that these two groups speak different languages and tend to view the world differently (306, 342, 354). Therefore, computerization is quite apt to lead to conflicts between these groups.

Brown and Dickson also point out that a computerized hospital information system would require considerable reworking of present physician procedures, nursing procedures, record keeping, and information handling. Even if such a revised system were desirable, they argue that the theoretical base adequate for the conceptual advances needed to deal with hospital information systems is lacking. They also state that the studies which might demonstrate that hospital activities will be assisted and improved by computerization have not been conducted (71). Saunders also points to the lack of studies in this area (342).

Blain lists six errors that have been made in introducing computerized systems into hospitals. These include incomplete or misleading feasibility studies and the lack of psychological preparation

among the individuals whose work will be affected by the implementation of the automated system (59).

Barnett and Greenes give several reasons for the slow progress. Hospital and medical staffs greatly underestimate the magnitude of the problem and do insufficient advance planning. As a result, they fail to provide enough manpower and money and expect results far quicker than is possible. Also, the computer industry because of its tendency to overstate its ability to solve hospital problems is partially responsible for the misconceptions of the hospital and medical staffs (42).

An extensive survey of the literature on information processing in medicine by Levy and Cammarn called the difference between the proclaimed potential of various applications and actual data provided to validate claims a disturbing characteristic of many of the reports. Two strong deterrents to progress were suggested: over-enthusiasm for particular methods and failure to project realistically the cost and complexity of transferring experimental models to the bedside or the clinic (255).

Because of the long interest and involvement of the Kaiser Foundation Research Institute in applying automation to health care the statements of two of their top researchers are important. Collen (91) and Van Brunt (403) gave several reasons for the difficulty in implementing computerized information systems designed for other than routine administrative functions: high costs, long-term commitment required before results will show, level of operational sophistication demanded by physicians and nurses, scarcity of technical specialists needed to plan and install the system, and difficulties in defining and standardizing the medical care process.

In the foreward to a book on medical computer development in Scotland, McLachlan raised two points which administrators and researchers would do well to consider. First, he suggested that rather than determine which procedures could be computerized with some conceivable benefit, an administrator would be well advised first to satisfy himself that none of the new procedures could reasonably be introduced more cheaply without computer use.[22] Secondly, he suggested that before proceeding with a computerized system the administrator look at how in practice medical practitioners are going to utilize the complex and intricate elements which many of the systems entail. He thought an intensive study was needed of the way in which doctors and the system itself accumulate and use information both for medical and administrative purposes (305).

Indeed, the effectiveness of computer-based management information systems has not been proven in industry. A leading management consulting firm surveyed the computer operations of 36 large corporations and concluded that the routine clerical and accounting procedures had been automated successfully but that the economic payoff and operating feasibility of the highly touted total management information systems had not been demonstrated and that such systems were a long way from practical realization in business (193). Dearden discussed what he labeled the myths and fallacies of real-time management information systems. He argued that it is not practicable to operate a real-time management control system and that such a system would be at best of marginal value even if it could be implemented (109).

Of course, as Gouldner pointed out some years ago dysfunctional consequences are not necessarily bad (172). For example, Hertz warned

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[22] Shegog made the same point (348).

that the introduction of computers into an organization may upset traditional organizational ideas, traditional sources and repositories of information, and traditional decision making prerogatives (194). But this may be good -- hospitals may need to be shaken up. In fact, an astute hospital administrator may use the introduction of a computer as a vehicle to bring about changes he believes desirable. However, he should recognize that there are lessons to be learned from reports of those who have had experience with computers in hospitals and other organizations.

In retrospect, the attempt by some analysts and hospital administrators to move in one step from what was essentially a paper and pencil operation to a sophisticated, on-line, real-time computerized hospital information system may have been a serious mistake. However, it is worth repeating that computer applications of varying scope and complexity are in operation in many hospitals and some administrators report they are pleased with the results. Many of the small-scale computer applications may be cost-effective and some may improve patient care. The same may be said of those applications which begin with an overall view of the system and then proceed step-by-step to build effective, large-scale systems.

Omission of Difficult-to-Quantify Variables

In general, operations researchers have used models and conceptual frameworks which have worked well in industrial and military operations and have applied them to hospitals. Because these models handle price and quantity variables very well, it is understandable that operations research studies in hospitals have concentrated on variables which are

easily quantifiable (e.g., cost per patient day, number of visits to outpatient clinics, time spent in outpatient clinics, time spent in keeping records, length of patient stay, number of hospital beds occupied, and number of nursing hours), and have avoided difficult-to-define and difficult-to-quantify output variables such as the quality of patient care with which the hospital administrator is also concerned.

Not surprisingly, the researchers have tended to see the outputs of hospitals as much more difficult to measure than the inputs and the service statistics just listed. The relationship of measures of utilization of services, facilities, and personnel to the more important considerations such as quality of output or accessibility of service is not spelled out by the researchers.

Quality of care is such an important concept in hospitals that some attempts should be made to include this variable as well as other output variables in operations research studies. Persons in the medical care field such as Donabedian (117, 118, 119), Peterson (314), Sheps (349) and Goss (171) have written insightful articles on the measurement of quality of care which could be exploited by operations researchers.

Given the industrial engineering background of many operations researchers the imaginative use of quality control concepts would seem to be something they would stress. There are certain hospital operations in which the use of such concepts within a systems framework is desirable. Possible applications could be based upon Schimmel's work on the hazards of hospitalization (345) and the studies on errors in medication (200). However, the industrial engineers do not seem to emphasize studies such as these in their investigations of hospital operations (45, 357, 358).

Influence of the Academic Setting on University-Based Operations Research in Hospitals

For several reasons the academic setting in which much of the research on hospitals has been done influences the kinds of studies undertaken and hence influences the implementation of the findings of these studies.[23] The studies reported in the literature appear to have taken place for the most part in teaching hospitals associated with large university medical centers. Such teaching hospitals might be considered "captive audiences" for academic researchers. Certainly the acceptance of research as an important activity is probably much higher in teaching hospitals than in community hospitals. This difference alone would make it more difficult to carry out operations research studies in a community hospital than in a teaching hospital. In addition, the salaries of the researchers were probably not paid by the teaching hospital and the indirect costs of such research are probably easier to absorb in a teaching hospital budget than in a community hospital budget.

The intellectual interest of certain problems attracts the academician. Queueing theory, linear programming, and computer simulation are important topics in operations research. It is no wonder that studies in the hospital field have tended to use these techniques. However, carried to the extreme, this practice leads to studies in which a technique seeks a problem rather than to studies in which the analysis of a problem suggests a technique.

Several writers have commented on the effects of the need for academicians to publish a great deal in order to advance in their profession. Dubos expressed it this way:

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[23] Gue in his survey of the literature on operations research in health and hospital administration quotes an experienced consultant who said that he

> Scientists shy away from the problems posed by human life because these are not readily amenable to study by the orthodox methods of the natural sciences. For this reason, such problems are not likely to yield clear results and rapid professional advancement. The way to scientific success is often through substituting for important problems that appear overwhelmingly complex other far less important problems that can be solved within a relatively short time (123, p. 216).

In a discussion of studies of hospital costs, Kelman argued that consideration of professional advancement caused academicians to concentrate on the technical aspects of a question to the exclusion of other more important aspects. He concluded, "Hence, we find major social issues reduced, in professional journals, to irrelevant technical (albeit publishable) questions" (236, p. 57).

Perrow was referring to social scientists' studies of hospitals when he characterized their work as having "dealt with accessible trivia rather than significant and recalcitrant problems" (313, p. 966). Stringer suggested that operations researchers have looked upon hospitals as interesting places in which to test some general theories and have not tried to solve real, present, local problems (378). Gue in his survey of operations research in health and hospital administration stated that academicians wanted problems that were intellectually interesting and would yield publishable research. He believed that many problems of practical significance to the hospital did not satisfy either of these two requirements (177). This is, of course, unfortunate for the administrator.

Publication policies of professional journals may be another reason why some operations research studies are not used. Because many of

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could count on one hand the number of hospital research studies conducted at various universities in the United States that had actually been implemented (177). Dunn and Hindle reach a similar conclusion about the operations research studies done in English hospitals (126).

these studies are made by academicians who must publish, the studies are directed toward publishing criteria and not toward administrative usefulness. For example, instructions for authors in Health Services Research advise the authors that their manuscripts should be "scholarly and precise rather than descriptive and operational in concept." (Italics added.)

An interesting exchange took place in Operations Research about editorial policy on criteria for publication in that journal (134, 239, 265). King wrote the editor of Operations Research that the journal devoted too much emphasis to papers of a formal mathematical nature. He contended that the articles in the journal avoided the most difficult parts of a practicing operations researcher's task, namely, the "messy elements of problem formulation, model construction, testing and implementation." Machol replied for the journal by saying that the mix of articles was "about right" and went on to argue that in the best engineering journals the bulk of the papers were "highly mathematical and scientific." Eilon entered the controversy by stating that Machol confused "scientific" with "mathematical." "You can be as mathematical as you like without being at all scientific about it, and conversely you can be thoroughly scientific without resorting to a single mathematical equation." Eilon went on to say that most papers in the journal were "neat abstract expositions with elegant manipulations that delight the theorist, yet the models that are described in them are just figments of the imagination, with little or no relation to any real problems." There the exchange rested. However, there has been little discernible change in the kind of articles published in Operations Research. No wonder a hospital administrator might have difficulty in seeing how some of the operations research articles could be applied to his operations.

No doubt the academic setting of many researchers has been a factor in their lack of interest in implementation. Traditionally, scientists conduct their experiments and report their findings. It is up to someone else (e.g., the entrepreneur or the administrator) to carry out the often tedious and difficult task of implementing the findings. Implementation is simply not defined as a scientific task by many academicians. However, had the operations researchers tried to implement the findings of their hospital studies they might well have learned about such things as the internal politics of the hospital. In any event, without studies showing that findings were successfully used in hospitals the caution of an administrator in using the findings is understandable.

Lack of Detailed Information in the Studies of the Costs and Benefits of Proposed Changes

A major shortcoming of the 20 years or more of operations research studies in hospitals is that the hospital administrator cannot go to the literature and find out "What's in it for me?" in terms of reduced costs or increased operating efficiency if he were to go to the effort and expense of bringing in specialists in operations research.

The lack of specific data on costs and benefits of implementing and maintaining the new procedures suggested in the operations research studies is a barrier to their acceptance. Too often the "savings" promised by the studies are not a reduction in out-of-pocket costs. For example, some of the staffing and information system studies mentioned earlier claim, among other things, to relieve nurses of much clerical work. It is not suggested that the number of nurses be reduced. Rather, the studies imply that the nurses will now be able to spend more time in direct patient care. Such "savings" are typical in industrial engineering

studies. However, it is not at all clear that resources are transferred perfectly, i.e., that the nursing time that was "saved" will be transferred intact to direct care of the patient. Several studies suggest that this will not be the case (227, 293, 304).

At one hospital the authors were shown a detailed internal study of cost savings which could be realized by the introduction of a computerized hospital information system. The savings were calculated in the following way. For each activity of each class of employee (e.g., order follow-up and billing by pharmacy clerk, preparation of test results by medical secretary in radiology) the hours per day or week which could be saved by the proposed system were converted to hours saved per year. Multiplication by the hourly rate paid for that classification of employee gave the yearly savings. By summing the yearly savings for all activities of all classes of employees the total yearly savings attributable to the proposed system was obtained. The somewhat skeptical administrator remarked that it would take a great deal of management effort and ingenuity to realize such prospective savings. As these examples show, savings claimed by staffing and scheduling studies and savings attributed to the introduction of computerized information systems need to be scrutinized closely.

Automation in the hospital is an area in which sellers' brochures extoll the benefits of computerized operations but do not give cost figures. The lack of information on costs and benefits has been discussed in detail in the earlier sections on computer applications and hospital information systems. One further example will suffice here.

Feldman argued that before investing a considerable sum of money in computers and other technology one should have some idea of what

existing activities cost without the technology and what they would cost with it. His conclusion points to the lack of knowledge about how a hospital operates.

> We cannot judge the saving in the time of nurses, pharmacists, physicians, patients, or clerks, because we have not yet analyzed the operation of a hospital in terms of what processes are really carried on and how much they cost (138, p. 120).

The need for evaluation of operations research studies is as urgent in the hospital field as it is in the other fields of the public sector. For example, a recent study of nurse staffing said that recommended changes were currently being implemented with an anticipated savings of about $50,000 per year (422). It would be extremely interesting to read a follow-up article on this study after a year or two had passed. Was $50,000 saved and how were the savings calculated? Without casting any aspersions on this article, it seems likely that many of the articles previously cited would not have been published in their present form if the authors had had to implement their studies and report the results a year or two later.

Failure to Recognize Limitations on the Power of the Administrator

Operations researchers seem to assume that the hospital administrator has unlimited power to make changes and has many more resources available to carry out changes than he usually has. Undoubtedly some operations research studies have not been implemented for this reason. For example, one administrator told the authors that at his hospital an advance registration and bed utilization system was used for approximately one year but that the project failed in part because the physicians would not accept it.

The dual lines of authority within a hospital -- one running upward through the physicians to the chief of the medical staff and the other running upward through the non-physicians to the hospital administrator -- curtail the power of the administrator in many areas of hospital operation. The medical staff chain of command carries out many administrative duties which affect the operations and performance of the hospital. Medical staff committees influence administrative decisions in such matters as admissions, discharges, medical records, purchase of equipment, development of new patient care programs, and the like. Although sociologists and others have discussed the problems caused by this particular organizational structure (137, 234, 313), the influence of their work is not evident in the operations research studies. Only rarely does a study mention the relation of these different hierarchies to the hospital's performance (410).

In addition to the direct administrative functions exercised by the medical staff through their orders to hospital employees and through their peer group committees, members of the medical staff have an influence on hospital affairs through their relationships with and often membership on the governing board.

In accredited hospitals there must be a formal channel of communication between the governing board and the medical staff. The most frequently used mechanisms are membership on the governing board[24] and a joint committee composed of board and medical staff members. The administrator generally is an ex-officio member of this committee. Top-level policy recommendations are developed by this committee for final

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[24]Recently the American Medical Association began a nationwide campaign to get physicians appointed to the boards of directors of hospitals. The implication is that as board members they could exercise even more direct control over hospital operations (14).

action by the governing board. A strong hospital administrator is of course in a position to provide a key leadership function but he does not have the authority to determine on his own many important policy matters.

In addition, members of the medical staff may have considerable indirect influence on hospital affairs through their informal relationships with members of the governing board. For example, individuals from each group may belong to the same country clubs or civic organizations. Moreover, personal physicians of board members are usually on the hospital's medical staff. As Knowles pointed out in his testimony before a Senate committee, it is not easy for a member of the governing board to refuse a physician something when he is in the physician's examining room as a private patient (402, p. 694). Such charges are difficult to document. However, the American Medical Association has asked the personal physicians of legislators to speak to their legislators (who are also their patients) about pending health legislation (131, 394).

Finally the high prestige of the established profession of medicine provides a contrast to the prestige of the newly emerging profession of hospital administation. Because of the difference in prestige and influence and because of the organizational structure of the hospital the administrator is forced to exert leadership through persuasion if he wishes to influence the medical staff. As one administrator put it to the authors:

> All decisions made directly or indirectly affecting medical staff are made in a political environment. Use of administrative power can only be in the form of political power.

In a showdown, the governing board finds the hospital administrator, not the medical staff, expendable. As another hospital administrator remarked to the authors, "They fire the manager, not the ball team."

In summary, the position of the administrator in the hospital structure may deter him from implementing innovations proposed by an operations researcher who fails to take into account some of the complexities within the hospital organization.

Neglect of the Literature on Implementation

Churchman has argued that an operations research study not implemented is in some sense a failure (87).[25] One reason for failure to implement operations research studies in the hospital field is that the recommendations of these studies do not seem to consider the complicated process which characterizes implementation.

A survey of the literature on problems connected with the implementation of the results of research turned up several interesting points (376):

-- Rational exhortation doesn't seem to be an effective means of changing behavior (79, 99). Thus the great emphasis on rationality and efficiency in the operations research studies to the exclusion of other considerations limits the possibilities of implementation.

-- The implementation of the results of research seems to follow a well defined process over time. Lewin called these sequential stages of change: unfreezing, restructuring, and refreezing (258). (These

[25] Of course, Churchman doesn't mean all operations research should be implemented. His statement includes the case in which the operations research study is rightfully rejected because it is a poor study. Other writers in their discussion of implementation point to some of the complexities in the relationship between the manager and the operations researchers. Alderson suggests several reasons why a manager might wish an operations research study even though he has no intention of implementing the results of the study (10). Also, Arrow (21), Dorfman (120), and Little (260) point out that benefits may accrue to a manager just from participating in an operations research study even though he doesn't adopt the recommendations.

stages have also been labeled: awareness, interest, evaluation, trial, and adoption.) In addition, different persons are involved in the process of change at different times. For example, rural sociologists have found that farmers utilize different sources for different types of information at different stages in the process of adopting an innovation. A farmer may be unfrozen by the mass media, restructured by his county agent and the salesman of the innovation, and refrozen by confirmation from his neighbors (417). Operations researchers will have to consider the ways in which hospital administrators, physicians, and others obtain, evaluate, and verify information if they are to be successful in influencing hospital operations.

-- The extent to which the results of research are implemented is related directly to the degree to which existing relationships within the organization are disturbed; the speed of implementation is dependent upon the extent to which the administrator's and the physicians' goals will be furthered through the implementation of the research results. Certainly the implementation of the recommendations of operations research studies could challenge the institutionalized patterns of work and power in the hospital. Operations researchers seem to evaluate their findings in terms of their impact on the existing technical system but not in terms of their impact on the existing social system. Studies in other organizations show that changes which threaten the existing social relationships are strongly resisted (280, 335).

-- Recommendations may be ignored because of differences in values between analysts and clients. Two examples from the poverty field illustrate that what the professional investigators saw as good recommendations were not seen that way by the recipients of the advice and the

targets of the programs (97, 281). The result was that the investigators could not understand why the recipients of their advice did not follow their suggestions.[26] There may be a similar difference between the perceptions of the operations researcher and the hospital administrator or physician as to what are good recommendations.

Testimony and articles by leaders in the health field reveal that a great deal is known about deficiencies in hospitals and the health care system (114, 324, 402). It has been suggested that what we need to do is to implement what we already know about correcting some of these deficiencies. A real contribution could be made in applying the findings of the social change literature to the health field. Unfortunately, most operations research texts and journal articles stress techniques and neglect implementation.

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Stringer's assessment of the lack of use of operations research in the public sector is appropriate also to the hospital field. He ascribed the tardy development of operations research in the public sector vis-a-vis industry not to the slow adoption of new ideas by political bodies but to the slowness of operations research itself in adapting to the special nature of public problems (378). Indeed, operations research studies may tell us more about what industrial engineers and physical scientists are like than what hospitals are like.

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[26] Cooper tends to blame the researchers for the failure of their studies to be utilized. In referring to recommendations made by economists to help solve problems of poverty he found the advice given by the economists "to be so unrelated to the real situations that they approach a kind of autistic thinking that makes me wonder whether the fellows working on programs to meet these problems ever stepped out of their offices." (97, p. 522).

SUGGESTIONS AND SPECULATIONS

On the tomb of Karl Marx are inscribed the following words: "The philosophers have only interpreted the world in various ways. The point however is to change it." Describing the various approaches operations researchers have taken in studying hospitals is far easier than stating how hospitals should be studied in order to effect beneficial change. In this section suggestions to deal with some of the issues raised in this monograph are discussed under such diverse topics as the use of outside consultants, the desirability of model building, the organization of operations research teams, the relation of the hospital to the health care delivery system, and the need to emphasize planning.

No doubt many approaches to studying and solving hospital problems should and will be tried. As the work on the management of research and development has shown, in situations characterized by much uncertainty the pursuit of several approaches simultaneously may be a good strategy (290).

Consultants and Outside Services

Hospitals may be changed in many ways. One of these is through the use of consultants and outside services. Of course, biomedical researchers, architects, equipment manufacturers, third party payers, graduates of university programs in hospital administration, and changing expectations of the general public all have a great impact over time. Long-term trends in the economy and social structure affect hospitals through their effect on the supply and demand for health services.

Congressional legislation and procedural changes promulgated by federal agencies may induce more immediate changes in hospital operations. But hospital administrators have little or no control over these forces.

Hospital administrators frequently employ consultants to study their operations and to suggest changes. Administrators have told the authors they found consultants beneficial in certain ways. For example, one administrator thought the real benefit of consultants is that they force the administrative staff and the medical staff to re-examine their goals and their actions. In his opinion this was more important than any benefit derived from the consultant's report. Another administrator said he couldn't think of a better way to keep hospital management on its toes than through outside challenges provided by consultants, whether the substance of the challenge is useful or not.

The use of consultants would seem to be an excellent way for an administrator to introduce operations research without having to hire additional staff. From a national point of view also this would appear to be a good move. Flagle remarked that a mechanism is lacking to spread an idea from the hospital where the innovation occurred to other hospitals (153). Consulting firms would seem to provide a means for spreading new ideas.

There are however some possible disadvantages in the use of consultants. It is often difficult for an administrator to judge adequately the qualifications of a consulting firm. The cost of studies may be too high for an individual hospital. Moreover, if the relationship between the hospital and the consultant is episodic, undesirable consequences may result.

There are other factors which the administrator should consider in the use of consulting firms which advertise that they will undertake operations research and systems analysis studies for hospitals (e.g., Community Systems Foundation, Battelle-Northwest) and in the use of recently organized cooperative management engineering programs which operate on either a regional or statewide level (e.g., Hospital Management Engineering Program of the Western New York Hospital Association, Ohio Hospital Management Services). If descriptive brochures, statements of purpose, presentations at hospital meetings, and published papers are accurate indicators of what these and similar organizations are doing in hospitals, it appears that they rely primarily on the traditional industrial engineering approach to solve hospital problems. They seem to use the industrial firm as their frame of reference and in effect transfer to hospitals engineering techniques developed for management use in industry. The administrator needs to be aware that the variables and measurement techniques which worked satisfactorily in an industrial setting may or may not work satisfactorily in a situation in which there is a central concern for human life and in which the technology is not well known.

A promising avenue for the development of effective operations research in hospitals would be for a small number of hospitals (5 to 10) to form a group for the purpose of sharing the services of operations researchers. The concept of sharing among hospitals has already been developed in such areas as purchasing, laundry, and more recently computer systems (9, 62, 174).

A group of hospitals in a community could explore various ways to share the services of operations researchers, for example, by

establishing a nonprofit corporation to employ consultants or by signing an exclusive long-term contract with a group of consultants. Such sharing would result in several benefits. The individual hospitals would create and control the group. There would be relatively few hospitals in the group and they would be in close geographic proximity. This arrangement should facilitate acquisition of detailed knowledge of specific hospital problems and make for good working relationships between hospital personnel and consultants. A requirement that each hospital have one person on its staff to act as a full-time analyst and provide liaison with the consultants would be desirable. The financial cost appears to be within reason. For example, eight hospitals of 200-300 beds each could afford an annual budget of several hundred thousand dollars for such a group at a cost of less than $1.00 per patient day including the in-house staff person. Needless to say the operations research group should consist of persons with various backgrounds in addition to engineering. This kind of arrangement contrasts with an organization such as the Ohio Hospital Management Services in which six industrial engineers service 75 hospitals in Ohio (192).

Of course, the difficulties in setting up an effective operations research group for a few hospitals should not be overlooked. Some obvious ones are the recruitment of qualified personnel and the achievement of the necessary close cooperation among participating hospitals. It would perhaps be useful if a pilot project could be funded to evaluate the feasibility and desirability of such a consulting group.

An outside service to which a hospital administrator may subscribe is offered by organizations which provide reports and statistical summaries of hospital operations. The Commission on Administrative

Services for Hospitals (CASH) (128, 130),[27] Hospital Administrative Services (HAS) (15, 16), and the California Health Data Corporation (CHD) (253, 254) are well known. The services provided by nonprofit corporations such as these emphasize cost control, man-hour control, and productivity indicators. Uniform accounting procedures and records are the bases of their programs.

To take advantage of these services, the hospital completes standard forms each month and sends them to the service company. It should be noted that the validity and reliability of the data submitted for processing are not known (254). The company takes this input, runs it through its computer, and provides the hospital administrator with monthly reports on many indices of his hospital's performance. Comparisons are also provided. HAS furnishes the median performance on the same indices of a group of "similar" hospitals while CASH furnishes a "standard" for each indicator obtained from engineering studies of a sample of "similar" hospitals. A discrepancy between the hospital's performance and the group's performance is a signal for the administrator to ascertain the reasons for the discrepancy.

No doubt it is of interest to an administrator to have information on his performance and that of "similar" hospitals. However, a major shortcoming of all the service organizations is that they have no model of hospital operations to tell them which data are important, how they are generated, how accurate they should be, what programs they

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[27] CASH offers additional services to its member hospitals. It acts as a clearing house for ideas which it disseminates in newsletters, puts on training programs for hospital personnel, and develops operating standards and controls. If requested, CASH will do studies in individual hospitals. However, a list of its basic programs shows that traditional industrial engineering (e.g., work simplification, work measurement, work load scheduling, forms design and control) is its main approach to solving hospital management problems.

represent, and so forth. Without a model all data are potentially of equal value and one ends up collecting everything. Lacking a model which sets out the relations between the goals and the policy alternatives, these companies have concentrated on the measurement of inputs. The emphasis on inputs limits the usefulness of the monthly reports for managerial decision making because changes in input are difficult to relate to achievement of goals.[28] One gets the feeling when reading the reports that something was measured, but what?

Fleming has expressed skepticism that uniform reporting would contribute importantly to hospital effectiveness. He stated that significant benefits from uniform reporting were foreclosed by the elusive issues of quality of care and service and the formidable difficulty of meaningfully comparing inherently different methods of operation (396).

Nevertheless, statistical reporting services may become compulsory rather than discretionary. Reports compiled by organizations such as HAS (205) and CASH (343) have been seized upon by some third party payers and even by the Federal government as one means of controlling the rising cost of hospitalization. Trials now in progress in several states use data from such reports as a basis for incentive reimbursement payments to hospitals. For example, in Connecticut target budgets for hospitals are based largely on these statistical analyses. Hospitals which operate within the target budget are rewarded with the difference

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[28] However, one administrator who had recently taken over a hospital beset with financial problems which may have been caused by overstaffing told the authors he was pleased with a study CASH made in his hospital to set performance standards. He used the monthly comparison of actual performance to these standards as a basis for reviewing operating problems with his department heads. He thought the presentation of data in this format focused the discussion on specific problems and what to do about them.

between costs and the target budget. Those that operate over their budgets are paid only costs for Medicare patients while their reimbursement for care of Connecticut Blue Cross patients is reduced by two per cent (191).

One possible result of such reimbursement schemes is that the more creative hospitals with innovative programs will be penalized because their operating costs are higher than an engineering "standard" or the median of "similar" hospitals. Such hospitals could be forced to change but not necessarily in the right direction. In addition, these schemes emphasize certain activities and costs within the hospital and omit others. The classification of categories and the assignment of activities to them forces a certain view of the hospital which may be questioned. Thus activities which many would consider desirable such as time spent by a nurse in reassuring a patient and explaining certain procedures to him become in the HAS system simply increases in such indices as "Total Nursing Man-Hours per Bed per Day." Needless to say, "high" scores on such indices are not rewarded.

Discussion about various reimbursement mechanisms shows that the matter of reimbursement incentives is complex (183, 197, 274, 308, 352, 425). It is not certain that relatively easy to administer schemes such as the one described above will achieve their goal of containing costs with no lessening of quality of care. Moreover, such incentive reimbursement schemes focus primarily on the hospital and not on alternatives to the hospital. That is, they do not place enough emphasis on other elements of the system for delivery of health care. In an interdependent system savings at one point may impose costs at another.

The lack of models for nonprofit organizations in which output is difficult to measure makes it hard to argue against those who push for incentive reimbursement schemes tied to reporting services such as HAS, CASH, and CHD. Here is a challenge for the operations researcher. Stringer (378) and Newhouse (297) have made a start but much more work is needed.

Model Building

Models are constructed by operations researchers to attempt to capture the "essence" of the system being studied. Their values and world views are reflected in the models. Unfortunately, the operations research studies in hospitals pay little attention to explicit model building and contain little discussion about why a particular model was selected.

A hospital administrator without a quantitative background may feel himself at a disadvantage in dealing with persons who present solutions filled with mathematical formulas and computer programs. Without a clear understanding of the model and the assumptions underlying it the administrator could in actuality allow the real decision making power to pass to the analysts.[29]

In addition, the failure of operations researchers to spell out the assumptions and implications of their models may lead to disputes over their recommendations. As Boguslaw noted:

> Differences in system design may, in the last analysis, involve little more than different allocations of power and authority throughout the system. Indeed, alternate arguments about the merits of different system design formats may well

[29] Galbraith has argued that in large, complex organizations it is no longer the managers who decide. The decision making power resides in what he called the "technostructure," i.e., the technical, planning, and other specialized staff (165). A method by which managers might prevent this loss of control has been called "antithetics" by one writer (20) and "counterplanning" by another (88).

> involve little beyond implicit rationalizations for alternate modes of power distribution (63, p. 188).

Several writers have commented on the need for more emphasis on the construction of models. Lave criticized the studies on hospital costs for not putting enough work into building models which show the relationships among variables. As she pointed out, without some understanding of the underlying cost structure -- the relationship between cost and output within the hospital -- the arithmetic calculations are arbitrary (252). Feldstein argued that although quantitative methods in government management decisions may be extremely fruitful, the absence of an appropriate framework may result in empty algorithms which hide misleading advice in a mass of reassuring calculations (139). Ehrenberg was even more blunt about the need for knowledge of the process being modeled:

> The basic question in model-building remains as follows: Take away the mathematical language and what generalized factual knowledge of the process in question still remains? If the answer is none, the mathematical symbol for <u>that</u> is very simple (133, p. 435).

Unfortunately, the popularity of computer simulation may result in even less attention to model building and to understanding the hospital and health care systems under study. The lack of operational models of the hospital and the apparent ease of storing data for quick retrieval by the computer combine to create a situation where administrator and researcher alike want to collect everything. A basic assumption which seems to underlie the automation of hospital data handling is that "accuracy, efficiency, and rapidity of information processing play major roles in determining the quality of patient care." (201, p. 64.) But questions immediately arise: How accurate? How efficient? How rapid? What information? Must everything be "on-line, real-time?" Without better

models of hospital operations to indicate which data are important and should be collected and which are not and may be ignored, the present emphasis on faster computers with greater memories to store ever more data will probably dominate the thinking.

Cross and Robert came to a similar conclusion based on their experience in England. They argued that because the means of collection, storage and retrieval of vast amounts of data had progressed faster than the practical development of management science the result had been the application of sophisticated techniques to increasingly large files of information with little attention to how the information could be usefully applied to the problems which confront the managers of the facilities from which the information was derived (101).

Others have voiced their concern. Beer and Ackoff pointed out that because computers can handle large numbers of variables simultaneously they may be used as a substitute for thought and creativity. They went on to argue that although a simulation may reproduce history with some accuracy, it does not by itself establish a correspondence of structure between the model and reality (52). Hertz has also warned against the view that computer programming can somehow fill in or supplement sketchy or incomplete models (194).

Two other points should be mentioned in connection with model building.

Apparently many operations research studies were conceived and carried through without much consideration of the problem of implementation of the results of the research. The models were constructed without sufficient thought about whether the persons for whom the study was done could influence the variables used in the model. As a consequence, the

findings of such a study often ignore the question of how or where the persons who commissioned the study might intervene to effect change.

The second point is that hospital data could stand additional scrutiny. Alper, et al. criticized some data used in operations research models of the educational process (13). They stated that the data available represented the flows which resulted after all the conflicts in the system had been resolved. Further they thought the knowledge of the demand and supply mechanism behind the flows was very limited. Data in the health field may be subject to the same criticisms.

For example, hospital data (e.g., average number of daily admissions, occupancy rate, average length of patient stay, nursing hours per patient day, number of meals served per day) merely reflect the outcome of complex processes. By themselves these data give little insight into the dynamics of the system. In addition, there are errors in recording and transcribing such data. (See 122, 406.) Higgins presented a detailed and insightful discussion of reasons an investigator may encounter problems in using existing medical records (196).

A study in Monroe County, New York, concerning the need for health services for the elderly illustrates the desirability of questioning how data are generated. The traditional method of projecting needs by taking the present use pattern and adjusting it for population growth was rejected in favor of a more sophisticated approach. A survey of over 15,000 elderly persons living at home or in institutions was made to determine if they were in the right place given their physical and mental health care needs. The survey concluded that 40.9% of these persons were not placed in the appropriate facility (414). Thus in this case the uncritical use of historical data to plan for health care for the elderly would have been a

serious mistake. Cristo made a similar point in a discussion of regional health planning (402, p. 805).

Possible interaction of supply and demand need to be kept in mind in interpreting hospital data. In an interesting analysis Brotherston reviewed studies in England which showed that the availability of hospital beds apparently affected physicians' decisions on the utilization of these beds (67). An analysis of United States data by Roemer and Shain led them to the same conclusion (336). A later study by Feldstein confirmed this finding (140).

Without much more attention to understanding the purposes for which data are collected (which in turn determine the accuracy required), the mechanisms by which data are generated, and the accuracy with which data are recorded, models of hospitals will remain in their present unsatisfactory state.

Organization of Operations Research Teams

Interdisciplinary research has become an article of faith in operations research. The usual argument (e.g., 6) goes that complex problems cannot be solved within the boundaries of a single discipline. Because no one person can be an expert in all disciplines, the practical way to proceed is to form an interdisciplinary team in which each member is an expert in at least one of the needed disciplines. Although a few persons who have worked in interdisciplinary teams have pointed to difficulties which they experienced in such groups, their criticisms apparently have had little effect (12, 81, 264).

It might be profitable for persons working in the health field to consider a suggestion by William Alonso, an urban planner. His experience

with interdisciplinary teams in urban and regional planning led him to suggest that what is needed is the creation of what he named a meta-discipline rather than an interdisciplinary team (12). The basic distinction between the meta-discipline approach and the interdisciplinary team approach is that the former emphasizes bringing persons together because of their common interest in a particular subject while the latter emphasizes bringing them together because of the diversity of disciplines they represent.

Alonso cited the development of regional science as an example of the creation of a meta-discipline:

> Every year several hundred scholars gather at the Regional Science Association Conference and present and discuss papers. The participants may be economists, geographers, planners, political scientists, sociologists, systems analysts, and the like, but at these meetings they present and receive papers which share a defined range of topics, a body of techniques, and certain standards of validation. These men share to a large degree a common technical language, common competences, and they read much of the same literature. I suggest that these meetings are not interdisciplinary but rather meta-disciplinary, since they are gathered not because of their diversity but because of their commonality (12, pp. 9-10).

In reading the above one is very much aware that the creation of a meta-discipline devoted to problems of the delivery of health care will require much time and effort. On this point it is instructive to recall Hitch's comment on the effort which preceded the introduction of systems analysis into the Department of Defense:

> In Defense we had several hundred analysts at the RAND Corporation alone, many others elsewhere, developing programming and system-analysis techniques for a decade before Defense attempted any large-scale application (199, p. xxv).

The health field is at least as complex as the military field. Moreover, as Flagle noted, there is a shortage of trained analysts in the health field (153). In addition, the fragmentation of the health field

and the accompanying lack of agreement on values, topics, techniques, and standards of validation are notorious.

Several new societies have been formed to deal with some of the fragmentation of the health field, the impact of technological change, and the need to bring various disciplines closer together. Examples are the Hospital Management Systems Society, the Society for Advanced Medical Systems, and the Biomedical Engineering Society. Several journals which deal with parts of the health care system came into existence in the 1960's. Among these are Computers and Biomedical Research, Health Services Research, Inquiry, and Medical Care. Because of its broad scope Health Services Research could evolve into the journal of the new meta-discipline.

In the operations research field the Health Applications Section of the Operations Research Society of America has been formed. Sessions devoted to reports of original research in the health field are presented at the semi-annual meetings of the Society. The Section sponsored a Symposium on Health in 1969 which brought together operations researchers, lawmakers, government officials, and academicians to discuss the efforts of two Presidential commissions, the National Advisory Commission on Health Manpower and the National Advisory Commission on Health Facilities (82). Another operations research oriented group is also active. The Hospital and Health Services Division of the American Institute of Industrial Engineers held its first national conference in 1970 (66).

At the present time the membership of these two groups appears to consist mainly of persons with backgrounds in engineering and the physical sciences. Among the disciplines which need far greater representation are the behavioral sciences and the various health

professions.[30] Gue (177) and Flagle and Young (154) have called for collaboration with other profesional groups to tackle the difficult administrative problems in the health care field.

But even with the addition of persons from a variety of disciplines the resulting group would still be essentially an elitist, academically oriented group considering the problems of the delivery of health care for all individuals. How will consumers, government officials, lawmakers, paramedical personnel, and employees of health facilities be included in the planning and operation of the programs for effective delivery of health care?

The inclusion of non-professionals in the decision making process may not be easily accomplished as illustrated by recent attempts at effective community participation in comprehensive health planning groups (17), on hospital boards (231), and in local Office of Economic Opportunity programs (53, 75, 339). Nevertheless, the active involvement of persons outside academic disciplines is essential to the creation of an effective meta-discipline. Certainly there would be many exciting possibilities if the health field could be opened to a variety of viewpoints. Putting more money into the same old system hasn't seemed to work too well.

The attitudes of the several professions in the health field present obstacles to change. To use the most obvious example, no doubt most physicians would resent anything which could restrict their professional independence (158).

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[30] Starr, Editor-in-Chief of Management Science, has said that his review of papers submitted for publication in that journal has led him to conclude that operations research sidesteps the behavioral issues and concentrates on technological product and process decisions (371).

When testifying before Senator Ribicoff's Subcommittee on Executive Reorganization Cherkasky was asked what he thought the reaction would be if Social Security authorities or Blue Cross officials handed down rules and regulations as to which hospitals would receive reimbursement for certain types of care. Cherkasky answered:

> The hospitals would scream to high heaven and many of the doctors who have vested interests in these programs would scream, but that doesn't make any difference. You know, medical care is too serious to entrust to administrators and doctors (402, p. 14).

Even operations researchers might have to change. For example, Revans' view of communication in hospitals derives from the behavioral sciences and is quite different from that of electronic data processors (325, 326). As Horvath pointed out in his review of Revans' book, if Revans' analysis is correct the traditional "bag of tricks" of the operations researcher will not suffice to solve hospital problems (207).

However, the pressures for change in the health field are so great that some changes are inevitable, and indeed are occurring. The questions really are: In what directions? Who will make the decisions?

To paraphrase a remark by Thomas Cowan: The answer to the question of "What is operations research in hospital administration up to?" is "It's up for grabs." If the industrial engineers and the physical scientists alone grab it, a promising opportunity will have been lost.

The Hospital in the Health Care Delivery System

Operations researchers in their emphasis on efficiency and cost reduction in hospitals may not have asked the right questions. They have concentrated on a few areas while ignoring many important problems.

Thompson believes that hospital studies concern themselves too much with the essentially limited area of costs. He wants to change the focus of the studies and to broaden them. Specifically he suggests that two basic questions must be considered. Is the right patient in the right bed for the right period of time? Is he receiving the correct kind of care while he occupies that bed (384)?

It is not that studies of internal operations of individual hospitals at the level discussed in the first part of this paper should not be done. With the demand for hospital services almost sure to increase (362, 363) improvements in internal hospital management processes and structure will be required if substantially larger numbers of persons are going to be accommodated without a breakdown in the system. But these studies need to be carried out with full awareness of the overall objectives of the hospital and with recognition of the larger system within which the particular hospital activity is embedded. Some of the theoretical problems of designing and modeling these larger hospital systems are discussed by Teitz (393).

Studies of larger systems have great potential. An individual hospital and its community, hospital chains, and health care delivery systems are examples of larger systems which could be analyzed. Beyond these lies the intriguing possibility of focusing on health itself rather than on ways of coping with disease.

At the level of the individual hospital, the governing board, medical staff, and hospital administrator need to consider the relation of their hospital to a larger system which includes other hospitals in the community, ambulatory care programs, extended care facilities, nursing homes, rehabilitation centers, and the like. It is at this level that

opportunities for specialization in medical services (e.g., maternity care, open heart surgery, emergency care) and joint operation of supporting services (e.g., data processing, laundry) occur. Also at this level the responsibility of the hospital to its geographical community becomes a proper subject for study. For example, what kinds of health care programs should be provided to serve that community? How accessible is medical care to all segments of the community? What training programs should be developed for potential employees from the community?

In Arizona, Morris, who started as the administrator of a single hospital, now heads a nonprofit corporation which operates a chain of ten hospitals. To cope with this growth he has introduced a corporate form of management (282, 373). This interesting experiment will be closely watched to see what effect the use of modern management techniques in such an organizational structure has on hospital costs, quality and accessibility of care, and ability to respond to changing demands.

It may well be that in the future the big payoffs in the health field will not lie in studies designed to make hospitals more efficient in doing what they are already doing. Various authorities have testified that the significant savings will come from having an efficient system for the delivery of health care in which hospitals are only one element (402). For example, Flagle used his model of patient flow into and through the health care system to identify and classify problems which could be thought of as projects ready for development (152). Task force reports (e.g., 398) specify the enormous complexity and vast range of issues involved in health care and stress the urgent need for studies which take into account the interdependencies among the elements of such a large system.

Some authorities look beyond the health care system for ways to improve health. Ginzberg suggests that funds spent outside the health field might do more to improve health than more money spent on health facilities and biomedical research.

> The therapeutic margins, that is, what can be done by better hospitals, better physicians, and so on, is much more limited than people realize . . . . There are many ways of influencing for better the health of the American public that have nothing to do with spending money on biomedical research (401, p. 242).

Cross and Roberts seem to agree with Ginzberg. Drawing upon their work in England they argue that the major causes of ill health are inadequate environment, debilitating personal and social habits, and old age. Clinical treatment is of marginal importance in dealing with these causes (101).

McNerney believes that both the public and the health professions have defined health and health care in very restricted and distorted terms. The result has been that the health care system does not support many measures that might have greater impact on health. McNerney concludes, "if our society's concern were truly with health (that is, postponement of death and preservation of maximum function), we could achieve gains much more effectively than by pouring more money into the health-care system" (273).

Millis lists several important contributors to morbidity and mortality about which physicians and hospitals can do little. These include accidents, obesity, smoking, abuse of alcohol and drugs, environmental pollution, and a life style that leads to organic and psychosomatic disease and disability (278).

Winkelstein and French argue that relatively little that is done at the preclinical and clinical levels has a real effect on health. Their thesis is that ecology, defined as the general interaction of man and his environment, is the primary determinant of the health status of the population. Data from epidemiological studies indicate that poverty and air pollution are key factors in determining the pattern of mortality in the urban eco-system (420).

No one argues that sick and injured persons should not have ready access to high quality medical care, as Winkelstein and French are careful to state. Their point is that we need to study health as well as disease.

Roemer and Shain argue that important determinants of hospital admissions and length of hospital stay lie in our whole social fabric. Because such things as poverty and associated poor housing create needs for prolonged hospitalization the remedy requires action on a wide social front (336). There would appear to be great opportunities here for systems analysts interested in the broad field of health to collaborate with ecologists and epidemiologists as well as to utilize work done by many persons in such fields as poverty, housing, and environmental pollution.

Importance of Planning

Most operations research studies discussed in this monograph have concentrated on hospital operating problems. However, Flagle and Young have stated that the long-term planning of new health care systems is the greatest present challenge to operations research (154). There is some evidence that operations research and systems analysis have something to offer in planning at the hospital level and also in planning the larger systems of which the hospital is an important element.

There have been some operations research studies useful in planning. Fetter and Thompson emphasized planning within the hospital (146) and planning for hospital services at the regional and state levels (387, 388). Flagle discussed simulation of the flow of patients within health facilities and among health services (152, 153.5). Beer placed the hospital within the totality of the health system and argued that " . . . we can learn more about health services by structural systemic study than by contemplating statistics" (51, p. 482). Smallwood, Sondik, and Offensend suggested a methodology for analyzing health care systems (359.5). A planning model for the health care sector was outlined by Feldstein (141). The prospects for the application of operations research to long-range mental health planning were analyzed by Hunter and Schnee (219.5). Horvath discussed the organizational and management problems in the delivery of medical care which could be studied by the operations researcher and systems analyst (208.5).

Planning studies within an organization may well have a greater payoff than studies of current operations. Operating studies often attempt to improve marginally situations caused by prior poor planning or lack of planning. Instead of simply coping with such problems it may be better strategy to intervene so that the problems do not arise. The experience of one of the authors in the petroleum and petro-chemical fields proved to him the value of operations research studies in planning. Studies to assist in decision making about future allocations of resources helped eliminate problems by indicating far enough in advance where difficulties might occur so that corrective action could be taken before serious problems arose. Moreover, planning is not seen as a direct threat by operating personnel and thus the results of planning studies

may be easier to implement. Planning studies also provide a relatively easy way for members of an organization to become familiar with operations research and computers. The experience of one of the authors was that the interest of operating personnel in computer simulation models developed for planning purposes provided an entry for the study of operating problems.

As more and more public funds flow into the health field policy decisions at the regional, state, and federal levels become even more important. Research on health policy could help provide information upon which to base these decisions. The arguments given by the proponents of various schemes for national health insurance indicate how much information is lacking to support these arguments. Yet crucial decisions are being made which will have an almost irreversible effect upon health care in the United States. Certainly the experience of Medicare and Medicaid should be sufficient to indicate that planning studies are needed.

There appears to be a great need for health policy research. Certainly it is difficult to formulate national health policy without knowing the impact which past health policies have had on hospitals, their employees, medical staff, and patients, and on the other elements in the health care delivery system. Operations research and systems analysis should play a part in providing methodology, techniques, and tools to study health problems. As considerations of quality become as important as those of quantity and as the concept of easy access to quality health care as a basic right gains ground, operations researchers and systems analysts need to reexamine their past activities and decide what part they should play in the changing health care system.

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