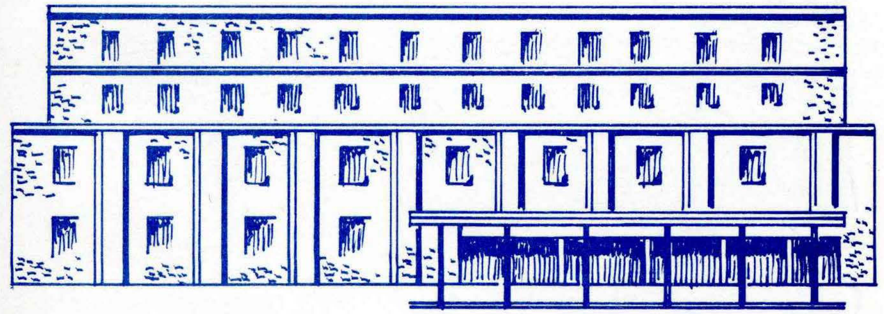
A Programming Model for Analysis of Nonmetropolitan Hospital Services Systems and Application of the Model



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A PROGRAMMING MODEL FOR ANALYSIS OF NONMETROPOLITAN HOSPITAL SERVICES SYSTEMS AND APPLICATION OF THE MODEL

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FOREWORD

This publication is written to meet the needs of two different audiences--health planners and health researchers. For health planners at county, multicounty, or state levels, it describes the use of a quantitative technique for analyzing a common problem how best to plan for the delivery of hospital services in a multicounty, nonmetropolitan setting. Most useful to the planner will be the study problem and objectives, nontechnical discussion of the research model and data needs, and the discussion of policy implications. The research method will be useful to the researcher regardless of whether he is employed by a university or a health planning agency. Of prime interest to him will be the application of the modeling technique in the analysis of a practical problem. Careful reading of this publication will enable a researcher who has appropriate training in quantitative methods and some familiarity with health planning to apply the described analytical technique to a similar problem setting. The model is operational with modest data requirements and is relatively inexpensive to use. Ideally, cooperation between a health planner and an economist skilled in quantitative methods and with access to computer capability is needed for maximum effectiveness in applying the modeling technique. Economists at most universities would have the required research skills and access to computer services.

The research model is applied to multicounty hospital services planning. It is recognized that health care encompasses far more than hospital services. Physician care, emergency transportation, mental health care, a general emphasis on preventive care, and acute care also are important aspects of the total health care picture. This model and its application, however, provide an instructive and highly useful application of quantitative methods to a real problem, and though limited here to hospital services, the model is flexible enough that it could be applied to the other facets of health care planning. Relatively straightforward modifications and extensions of the model by a skilled researcher are all that would be required.

It is assumed that those who might use this model will further refine its capability in specialized problem settings. As described, however, the model is a readily operational quantitative tool that has been very useful in the analysis of commonly encountered health planning questions. As such, we suggest both quantitative researchers and health planners will find the model and its application interesting, informative, and useful.

The Authors

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

Health care costs are of major concern to Americans. The health care industry is experiencing rapid cost escalation relative to the increases for other goods included in the Consumer Price Index. For example, hospital per diem costs rose at an annual rate of 13.9 percent from 1966 to 1970 [17].

Health care providers agree that hospitals will continue to play a key role in the delivery of health care [19]. However, hospitals in nonmetropolitan America are experiencing underutilization resulting from excess capacity and investment in increased service capability [24]. The high fixed costs for hospitals with underutilization is driving many close to insolvency [13]. Third-party payers are pressuring hospitals to exercise stringent cost containment.[1] Federal legislation is attempting to restrict hospital expansion and excess utilization of such services through health planning legislation [20].

Health planning councils and multicounty decision-making groups need an analytical decision framework to effectively implement newly legislated authority. This report discusses such a framework and its application to a problem setting.

II. THE STUDY PROBLEM AND OBJECTIVES

The North Iowa Health Planning Council is the client group to which this research report relates. The area represented by this council includes

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[1] Personal communication with Iowa Blue Cross-Blue Shield, 1974.

Butler, Cerro Gordo, Floyd, Franklin, Hancock, Kossuth, Mitchell, Winnebago, Worth, and Wright counties. These 10 north central Iowa counties are contiguous and largely rural counties.

The North Iowa Health Planning Council requested professional support for data identification, collection, and analysis from the Center for Agricultural and Rural Development at Iowa State University. The council was interested in decision making for acute care services delivery, and thus the analysis concentrates on that dimension of health care.[2] The Center agreed to support a research project that would provide data and data analysis to support the Council's decision-making process.

Planning Council Authority

Planning councils are composed of consumer and interest group selected participants. Such councils do have responsibility under federal law such as in section 1122 of the Social Security Amendment of 1972 and subsequent amendments in 1973 (Public Law 89-749). These sharply strengthened the review authority of state and substate level health planning councils. Councils created by such legislation receive joint federal and state funding; three quarter federal and one quarter state.

Planning councils are to review and make recommendations on most provider capital-expenditure projects. Federal legislation states, including Hill Burton applications, that all capital expenditures planned

[2] The modeling framework developed is flexible enough to include preventive and rehabilitative care if a researcher so desired.

by health providers involving (1) $100,000 or more, (2) changed bed capacity, or (3) substantial changes in service requiring federal reimbursements (e.g., medicare, medicaid, maternal and child health payments, and depreciation and interest on provider facility investment) fall under such review procedures. Councils (including physicians, hospital administrators, nursing home administrators, and consumer representatives) act on such proposals and function as a planning body. Councils review projects within the context of long range plans for delivery of health care services within the planning area.

The Problem Setting

The North Iowa Health Planning Council lacked professional manpower and data to provide its own analysis of alternatives. It had to make important decisions without an adequate understanding of the effects of those decisions. Therefore, CARD agreed to help build (1) a health data base for the area, and (2) an analytical tool to be used in evaluation of proposals for changes in capacity and capability of the hospitals in the planning area. The model constructed was to be used in an analysis of the impacts of proposed changes in the hospital services delivery system.

While MacQueen and Eldridge [16] suggested a conceptual framework for hospital and physician service delivery, this research involves an analysis of a series of specific questions raised by the Health Planning Council. A programming model is constructed using quantitative data, permitting explicit analysis of the trade-offs resulting from selected policy choices. As such, this type of analysis framework is supportive of efforts at a multicounty and state level to develop a comprehensive health plan for Iowa. Indeed, Iowa health planners have viewed it in this way. The analytical framework used in this project builds on and extends earlier work by a number of health researchers.

Flagle has discussed the value of system analysis in planning health services delivery, noting its value in describing how systems not yet built would behave [9]. Morrill and Erickson noted the importance of creating simulation models to test the effects of relating the decision control of the system [18]. They noted that patient demand and service supply in hospital modeling is differentiated by the kind of care sought. Feldstein applied linear programming to case mix planning within a hospital [8]. Luke [15], Holland [12], and Carr [3] have used distance and time as variables in transportation cost functions when modeling health delivery systems. Wennberg and Gittelsohn have noted the importance of population-based data on small areas for responsible decision making by area health planners [25]. And finally, Dodge and Nadler have pointed out the importance of developing a research framework that can be applied to any hospital situation [7].

The ten-county planning area had an estimated population in 1970 of 187,927 people [23]. The largest city is Mason City with a 1970 population of 30,491. The second largest city is Charles City with a 1970 population of 9,268. The area, predominantly rural, has limited concentrations of industrial activity in Mason City, Charles City, Forest City, Hampton, and Algona. Table 1 contains county and area

population data in 1970. Eleven hospitals are located in the area. Two each are in Winnebago, Wright, and Cerro Gordo counties. Table 2 contains names and locations of planning area hospitals.

One hospital is owned by a religious order (nontax supported), one is a proprietary hospital, and eight are nonprofit tax supported. One hospital is nonprofit charitable and nontax supported. Seven are approved by the Joint Commission on Hospital Accreditation of the American Hospital Association and the American Medical Association.

Hospitals range from 17 to 213 beds, and all provide medical-surgical services. One does not provide obstetric services. One provides extended and long-term care services in addition to the usual acute care services. St. Joseph Mercy and Memorial Hospitals deliver both primary and secondary care hospital services. All other hospitals deliver only primary care services.[3] In 1972 utilization in the area hospitals ranged from a low of 41.4 percent to a high of 82.5 percent in 1972 (Table 3). The smaller hospitals generally had lower utilization levels than the larger hospitals.

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[3] Primary care services are generally considered to include basic acute care services of limited complexity; such procedures as tonsilectomies, appendectomies, normal child birth, and setting of simple fractures.

Secondary care services are of a greater level of complexity requiring higher skill levels by the medical and support personnel and more complex support equipment than is required in primary care; such as gall bladder surgery, many types of thoracic and abdominal surgery, many orthapedic surgery procedures, and simpler plastic surgery procedures. Tertiary care services are those of high level of complexity requiring very high skill levels of the medical and support personnel and extensive supporting equipment. Examples of such procedures would include heart surgery, neurosurgery, organ transplant, and complex restroative procedures.

Table 1. North Iowa health planning area population (1970).

County	Population
Butler	16,953
Cerro Gordo	49,335
Floyd	19,860
Franklin	13,255
Hancock	13,227
Kossuth	22,937
Mitchell	13,108
Winnebago	12,990
Worth	8,968
Wright	17,294
Ten County Population	187,927

Source: Bureau of the Census [23;211-212].

Table 2. Hospitals surveyed.

Name	County
Community Memorial Hospital, Clarion	Wright
Belmond Community Hospital, Belmond	Wright
Memorial Hospital, Mason City	Cerro Gordo
St. Joseph Mercy Hospital, Mason City	Cerro Gordo
Floyd County Memorial Hospital, Charles City	Floyd
Franklin General Hospital, Hampton	Franklin
Hancock County Memorial Hospital, Britt	Hancock
Kossuth County Hospital, Algona	Kossuth
Mitchell County Memorial Hospital, Osage	Mitchell
Buffalo Center Hospital, Buffalo Center	Winnebago
Forest City Municipal Hospital, Forest City	Winnebago

Table 3. Hospital utilization.

	Belmond Comm.	St. Joseph Mercy	Memorial Hospital	Floyd Co.
Total patient days[a]	5,998	81,828	18,939	22,203
Ave. length of stay[b]	7.8	7.5	9.8	6.7
Patients discharged	774	10,876	2,089	3,321
Patient discharge days	5,984	81,867	18,363	15,609
Persons admitted	781	10,881	2,114	2,214
Percent occupancy ratio[c]	54.8	71.6	82.5	68.2
Medical-Surgical[d]	57.8	77.8	82.5	73.6
Obstetrics[d]	35.4	58.4		38.8
Pediatric[d,e]		45.9		75.2
Psychiatric[d]		65.9		
Rehabilitation-P.T.[d]				
Extended care[d]				
Long-term care[d]				

[a] Does not include newborn.

[b] $\text{Average length of stay} = \dfrac{\text{Total patient days}}{\text{Patients discharged}}$.

[c] $\text{Occupancy ratio} = \dfrac{\text{Total patient days}}{\text{Number of beds} \times 365}$.

[d] Occupancy ratio for service categories

$$= \frac{\text{Total patient days for service}}{\text{Number of beds in service category} \times 365}.$$

[e] When not listed separately, pediatric days are included in Medical-Surgical.

Table 3 (cont'd.)

Franklin Gen.	Hancock Co.	Kossuth Co.	Mitchell Co.	Forest City	Buffalo Center	Clarion Comm.
19,371	6,440	7,986	15,291	3,795	3,087	6,645
17.4	4.9	6.9	6.1	5.5	5.2	6.2
1,110	1,302	1,164	2,647	696	593	1,066
19,345	6,905	9,233	16,019	3,828	3,084	6,396
1,110	1,157	1,155	2,647	690	603	1,068
57.6	55.1	54.6	67.6	52.0	49.7	41.4
39.4	59.9	57.1	75.9	53.1	58.1	
32.5	34.4	34.5	35.7	42.1	22.7	
		76.6				
114.0						
71.3						

All the planning area hospitals originated 50 percent or more of their patient demand from the county in which the hospital was located. The proportion of patients originating in the county where the hospital is located increases to 66 percent or more, except in the case of Belmond when the two Mason City hospitals are not considered. All hospitals originated 83.6 percent of their patients from the planning area. Appendix Table 1 presents the patient origin patterns for area hospitals by county.

Despite proposals by hospitals to increase capacity, 800 hospital beds were utilized at 65 percent occupancy during 1972, well below the "rule of thumb" 75-86+ percent occupancy for hospitals in an area [10]. Ninety additional acute care beds have been planned or added since 1972. Patient origin data for the area indicate such beds could only be filled from within the area.[4]

Such hospital expansion has not been in response to patient demand. Stimuli such as community pride, edifice complex, and less than realistic or responsible demands by physicians on hospital staffs are responsible [14]. Optimistic and unrealistic bed-day demands are often developed by hospital administrators and their consultants to justify expansion planned without regard to need. Johnson considered 1972 new hospital bed construction costs to average $54,000. The minimum acceptable occupancy rates needed to amortize such investment with reasonable room rates was calculated at 80 percent [13].

[4] Patient origin data indicated approximately as many persons left the ten-county area for hospital care as came into the area for hospital care.

Decision Making in Planning Framework

The North Iowa Health Planning Council faces numerous proposals for building and remodeling projects. Each proposal is stated in terms most favorable to it. A microanalysis, if any, is related to the effects of such projected changes on the institution presenting the proposal only. Further, potential service areas and effective demand for the services of such a proposal are frequently overstated. Conflicting proposals by competing institutions are often presented to the health planning councils.

The Council must make decisions in a planning framework. The objective function they wish to maximize is multivariate. Council decisions must be acceptable to health care providers and tax payers as well as to consumers and third party payers (insurance firms). Not only political reality but access, utilization levels, and cost are considered [10]. The effect of changes in one part of the hospital care system within the area on other hospitals in the area and on accessibility of services needs to be weighed. Councils cannot decide where to approve new services as though none presently existed. Rather, substantial previous capital investment has taken place in health care facilities. Service patterns and health consumer habits have adapted to the existing facility capabilities. These facilities will not disappear because a new facility is approved or even built. Unneeded facilities can only be phased out over a long planning horizon.

Capital recapture and physical, use, and locational obsolescence must occur before such facilities, though severely underutilized, can be phased out of use entirely.

Analytical Tool for Decision Makers

The construction of an analytical tool to aid planning council decision makers in assessing the relative merits and system impacts of proposals by health care providers and testing its usefulness in the North Iowa Health Planning area were the major objectives of this study. Such a model should be of practical use in planning a health care delivery system. A linear programming model, a technique well suited to answering questions posed in this study, is constructed.

To cope with the data limitations encountered, a linear programming model that is relatively parsimonious in data requirements was constructed. It uses data readily identified and generated from secondary sources or from primary sources within the planning area.

The programming model was used to answer the following questions raised by the Health Planning Council.[5]

1. What effect will decreasing manpower resources in the hospital system have on utilization in any hospital or subset of hospitals in the planning area?

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5 A number of other questions could have been answered for the Council. For example, the question posed could have been that of maximizing utilization of a hospital, individually within a region. The cost of providing a single service could have been minimized in the area without regard to capacity or resource constraints. The optimal service areas for hospitals could have been identified. However, the Council, which needed to make decisions on specific proposals for increases in services capability and capacity expansion, limited the scope of its questions to those directly useful in the required decision making.

2. What level of service utilization in the area's hospitals can be expected in the future, and what will be the utilization pattern?

3. What effect will changes in service capability in one hospital have on the utilization of that and other facilities?

4. What effect will these changes have on the patient day cost of care in the area (transportation included)?

5. What changes can be made in existing facility service utilization patterns to minimize the model cost?

III. THE PROGRAMMING MODEL

The model develops a cost-minimizing solution by allocating patient days of service demand to the hospitals so that the summation of patient day service costs and transportation costs is minimized. Trade-offs in patient allocation, resource use, and cost levels are explored. The model deals with marginal redistribution of service utilization among five major services extended by hospitals in a geographic planning area. These five services are: (1) medical-surgical, (2) obstetrics, (3) pediatrics, (4) intensive care, and (5) psychiatric. Not every hospital would necessarily have all five services. In north Iowa, only one hospital, Mercy in Mason City, extended all five services. All hospitals, with the exception of Memorial in Mason City, extended both medical-surgical and obstetrics. Three hospitals extended pediatric services as a separate service.[6] Five hospitals extended intensive care services.

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[6] Hospitals without pediatric services do treat children, of course. They simply do not have a defined pediatric department.

Service demands by patients are viewed as service specific. Patients enter a hospital for a specific service such as medical-surgical or obstetric. Further, demand is categorized by population age cohort. Figure 1 illustrates the model's linkages among hospitals, services, and planning area population.

The model constructed is useful in supporting multicounty planning processes of variable size and able to be generalized to many nonmetropolitan geographic settings. The model is adaptable to a variety of public and quasi-public service analysis settings.

The federal and state governments place increasing importance on cost effectiveness in health care delivery. It is important, consequently, to be able to weigh the costs and benefits of various alternatives for providing health care. Further, is is desirable to weigh these costs and benefits before public funds are committed to fixed investments.

Model Components

The model is composed of a set of production activities and patient day demand-generating activities linked by a network of transportation activities; all column vectors in the model. For maximum usefulness to planning councils, it is necessary to develop a technique, parsimonious in data requirements, that uses available data. This model assumes the adequacy of cross section data. Data requirements are limited to those available from hospital administrators and public sources.

The model has a set of production activities; model activities that provide hospital services. There is an activity for each hospital

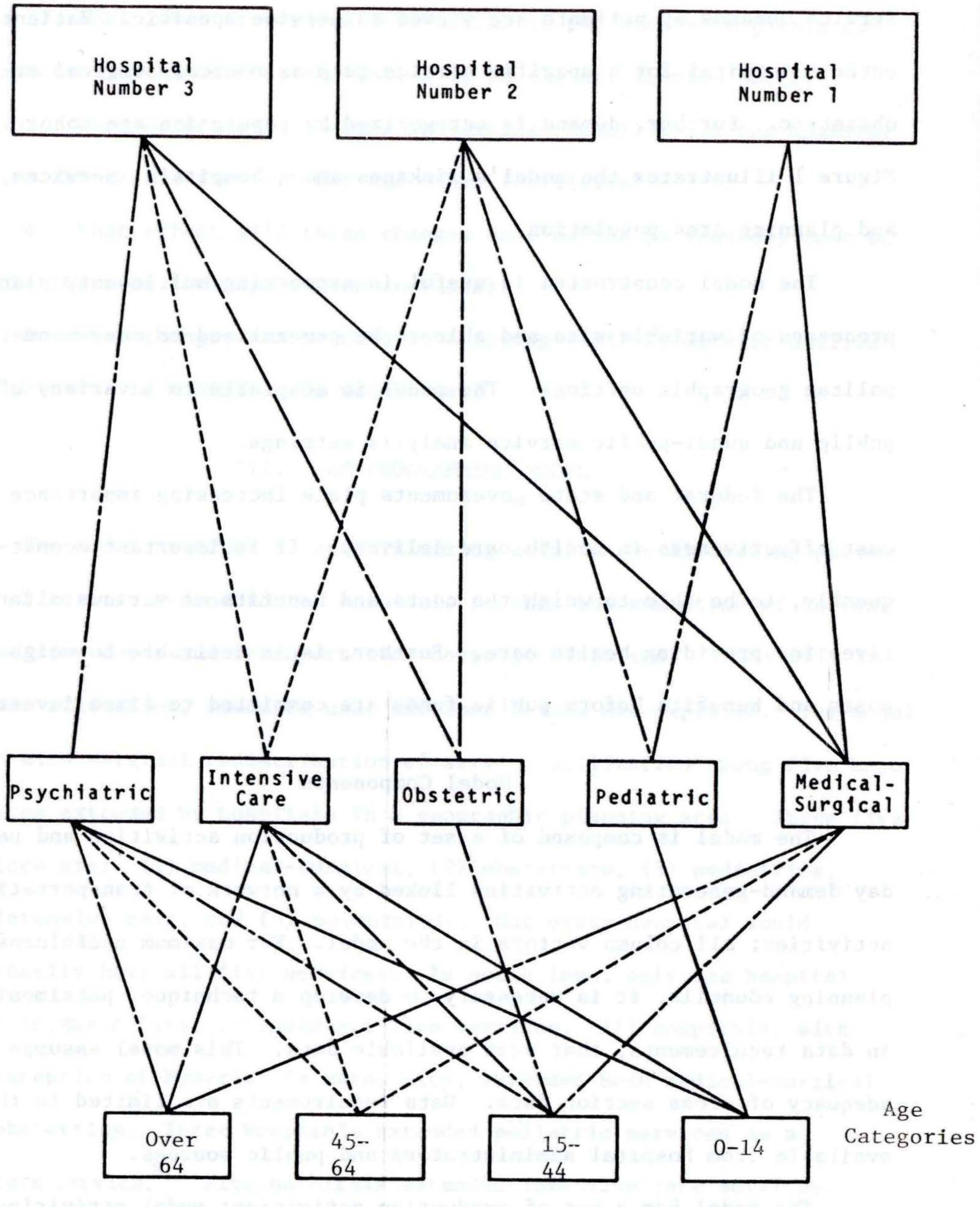

Figure 1. Model linkages

service delivered by any hospital in the ten-county area. For example, a hospital delivering medical-surgical, pediatrics, and obstetric services would be represented in the model by an activity for each of these three. When a hospital does not deliver pediatric care as a separate service, pediatric demand is provided in its medical-surgical service. Thus, the model has 38 service activities, one for each hospital service provided by area hospitals. Seven of these are used to transfer pediatric demand to medical-surgical services by linkages in the programming matrix.

The model has 35 patient day demand-generating sectors that generate service demand from geographic areas within the planning area. Each demand-generating sector has four demand-generating activities categorized by age of population. These activities generate patient days of demand for hospital services based on the number of persons in the geographic area and historical service demand rates. The model has 551 transportation activities; column vectors in the model. These activities link the demand-generating activities to the hospital service activities. Patient days of demand can move from demand-generating activities to the services demanded in each hospital which the demand sector has historically (or would logically have) related to. Each demand sector is linked by the transportation network to at least three hospitals. Figure 3 illustrates the relationship of the types of activities to each other in a linear programming table.

Data Needs

The 1972 data for input in the programming model were collected by survey form from each hospital in the planning region. Data requested were readily available in hospital records and financial reports. Two major classes of data are developed. One relates to the utilization of hospital services and the origin of patients utilizing those services. The other relates to the service capability, resource base, and the cost of providing that service.

Utilization data, measured by patient days of service extended in each of the five service categories for a fiscal year, were collected. Utilization was classified within each service by these age categories: (1) 0-14; (2) 15-44; (3) 45-64; and (4) over 64. These categories coincide with age cohorts used in both population projection work and hospital utilization data. Average lengths of stay in each service for each hospital and maximum potential patient days of each service (beds in service times 365) were collected.

Patient origin data were collected from each hospital, indicating the town from which each patient had come and the number of patients originated from each town. Data were available from admittance records or community relations departments of hospitals. Appendix 1 summarizes patient origin data by county.

Service-related data

Resource base. Categories of human resources used in delivering hospital services were identified. Data on full-time human resources equivalents available to each hospital were collected by these categories: (1) General practitioners (including family practice specialty); (2) Specialists (medical doctors and doctors of osteopathy having a recognized

medical specialty, either board qualified or board approved). These two categories of human resources include all physicians having active staff relationships to hospitals. Consultants are not included. (3) Registered nurses (includes all staff personnel who are RNs); (4) an LPN category (includes licensed practical nurses, nurses aides, and orderlies); (5) Specialized medical personnel (this category includes all persons not previously categorized having medically-oriented specialties, such as anesthetist, pharmacist, radiologic technologist, medical technologist, speech pathologist, etc.); and (6) Other personnel (this category includes all other employees of each hospital, such as clerical, housekeeping, janitorial, administrative personnel, etc.).

Appendix Table 2 presents human resources by category available to each hospital.

Service cost. A survey form was developed to collect hospital cost data in which data were categorized by service subcategories, assigned wholly or on a proportionate-use basis to one of the five major service categories. Service subcategory expense is disaggregated by salaries, supplies, fees, and miscellaneous or other. Thirty-two service subcategories were identified.[7] These include operating room, anesthesiology, laboratory, etc. Fiscal services expenses, including administrative, depreciation, debt servicing, and equipment rentals, are identified and allocated to services on a utilization basis as fixed and administrative expenses. Each major service category total cost is divided by the total

[7] See Appendix Table 3 for financial data survey instrument.

patient days' utilization of that service. This defines the patient day cost for each service in each hospital. Costs are developed unadjusted and adjusted for utilization.

Certain administrative and fixed charges are allocated to service categories on the basis of historic utilization in unadjusted cost. The formula is:

$$\frac{\text{Total cost of service}}{\text{Actual patient days of utilization}} = \text{Cost per patient day} \quad (1)$$

The adjusted cost has administrative and fixed charges allocated on a service capacity basis (possible bed days). The formulas are:

$$\frac{\text{Total cost of service}}{\text{Total possible bed days in service}} = \text{Cost per bed day} \quad (2)$$

$$\text{Cost per bed day} \times \text{Number of beds per service} = \text{Total cost of service} \quad (3)$$

$$\frac{\text{Total cost of service}}{\text{Actual patient days of utilization}} = \text{Cost per patient day} \quad (4)$$

Experience in data gathering with this format is that hospital administrators are able to provide data in the form requested. They can indicate the service cost subcategories attributable to delivery of a service. Thus, within the data set developed, reliable cross comparability of data among hospitals is achieved.

Model Assumptions

Certain assumptions are made in the model. They are: (1) Cross section data adequately represent patient origin patterns and utilization rates for each hospital. (2) The cost data represent both absolute

patient day costs for a hospital service and a hospital's cost relative to other hospitals in the area. Care was used in compiling costs so that data would be comparable across the hospitals. (3) The patient day cost is composed of the hospital cost and a transportation cost (a function of distance and elapsed travel time for the patient and family and friends visiting patients). The function used is discussed more fully in the discussion on transportation cost. The function used builds on earlier work by Carr (3), Luke (15), and Holland (12) in the specification and use of transportation cost in modeling hospital demand. (4) Individuals select the hospital service that minimizes the summation of hospital-incurred cost per patient day and transportation costs. Certain institutional constraints to reallocation of service demand are recognized. (5) The resource demand coefficients for hospital service production do not change within broad service utilization ranges. This is reasonable since manpower numbers are adjusted to permit efficient utilization of that resource. (6) Average services demand coefficients by age cohort for the planning area also represent patient services demand by age cohorts within each demand sector. (7) Travel distance to a hospital service is calculated from a central point in the demand sector (a central city). (8) The planning area, for modeling purposes, is essentially a closed system. That means as many persons leave the area as come into the area for hospital service. Therefore, a hospital's excess capacity in the model can only be filled by patient demand presently serviced at another area hospital. A set of service activities representing a composite of all out-of-region hospital services could be added to relax this assumption. Demand sectors could be created for out-of-region areas generating patient demand for in-region hospital services.

Model Formulation

The linear programming model developed for a multicounty health planning council in north Iowa could easily be adapted to more hospital services, more or fewer demand sectors, and a different sized transportation matrix. The model incorporates an interhospital service comparative advantage production sector,[8] a transportation network, and 35 service demand sectors subdivided by age grouping into 140 service demand activities generating hospital services demand. 1972 production costs, transportation costs, and hospital services demand are used.

Cost minimization

The programming model minimizes the cost of satisfying hospital service demand and transporting that demand from a demand sector[9] to the hospital service at which the demand is satisfied (where the patient receives care). This model has 38 hospital service activities linked with service demand-generating activities[10] by 551 transportation activites.

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[8] The model can satisfy hospital services demand from a given demand sector in the least costly hospital service to which the demand sector relates; subject to cost of transportation and hospital capacity constraints.

[9] The demand sectors are geographic units constructed from subcounty census reporting districts.

(footnotes continued on page 21)

Hospital services

Each hospital service is linked with three to six demand sector activities. Each demand sector is linked via a transportation activity to every hospital service it has related to or might logically relate to.

Hospital service demand is service specific. This means patients do not go to a hospital for services that the hospital does not deliver. Patients may demand medical-surgical services from a hospital that does not deliver obstetrics service and demand from another hospital obstetrics services. A further refinement might result in services being defined as primary, secondary, or tertiary care level. For example, a given hospital might deliver primary level care and secondary level care medical-surgical services. Thus, that hospital could have two medical-surgical services activities differentiated as to service level. Lack of data needed to differentiate patient demand by level of care required prevents use of this refinement.

Patient demand sectors

Patient demand sectors are composed of subcounty census reporting districts. These contain only one township in Iowa. They may contain from two to several townships in many other states. Demand sectors are built of subcounty census reporting districts with these characteristics: (1) residents uniformly related to one or more hospitals to satisfy

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Footnote 10 continued from page 20

[10] Service demand-generating activities are column vectors that create patient days of service demand, based on both the population of the age category in the activity and the coefficients that indicate patient days of each service demanded per person in the age category.

hospital services demand, (2) residents have access to a common transportation network, and (3) a district contains one central city. Based on these criteria, demand sectors can be of different geographic and population size. Figure 2 illustrates demand sectors identified for the north Iowa model.

Demand activities

Each demand sector generates four service demand activities.[11] These are segmented by age: activity (1) the 0-14 age population; activity (2), the 15-44 age population; activity (3), the 45-64 age population; and activity (4), the over 64 age population of that demand sector. Each demand activity has a fixed bound at that age category's population level in the demand sector. Patient days of demand for each of the five hospital services are derived out of demand activities. The volume of patient days of demand is determined by demand-generating coefficients in the demand activity.

Demand coefficients

Coefficients are developed for each of the services demanded. The model uses coefficients defined by dividing the patient days of a service utilized by an age category by the planning area's total population of that age.

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[11] It is important to remember that the hospital service activities provide service to patients, and service demand activities generate patient days of demand that utilize those hospital services.

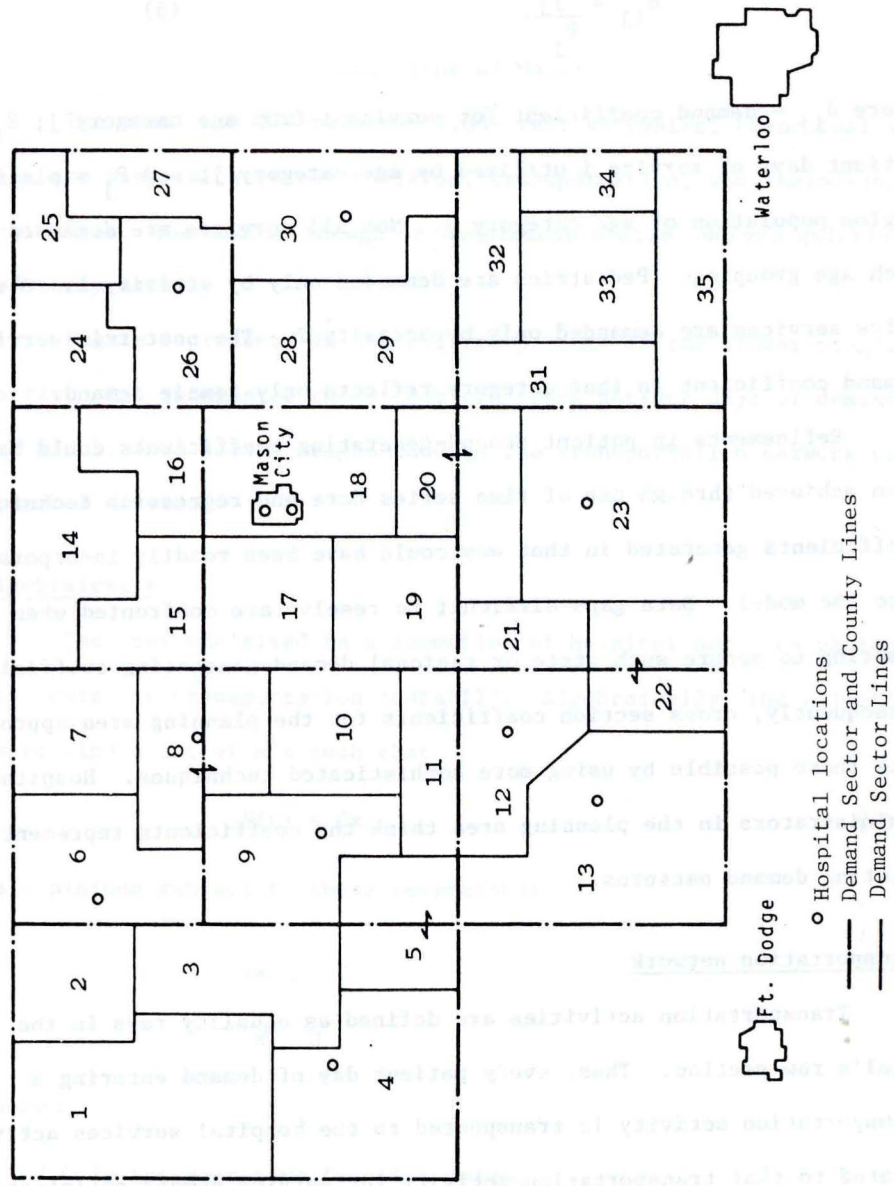

Figure 2. Service demand sectors

Algebraically,

$$d_{ij} = \frac{S_{ij}}{P_j} \qquad (5)$$

where d_{ij} = demand coefficient for service i from age category j; S_{ij} = patient days of service i utilized by age category j; and P_j = planning region population of age category j. Not all services are demanded by each age grouping. Pediatrics are demanded only by activity 1. Obstetrics services are demanded only by activity 2. The obstetric services demand coefficient in that category reflects only female demand.

Refinements in patient demand-generating coefficients could have been achieved through use of time series data and regression techniques. Coefficients generated in that way could have been readily incorporated into the model. Data gaps difficult to resolve are confronted when attempting to secure such state or regional demand-generating coefficients. Consequently, cross section coefficients for the planning area approximate those possible by using more sophisticated techniques. Hospital administrators in the planning area think the coefficients represent existing demand patterns.

<u>Transportation network</u>

Transportation activities are defined as equality rows in the model's row section. Thus, every patient day of demand entering a transportation activity is transported to the hospital services activity related to that transportation activity for service demand satisfaction. The hospital service activities and the demand-generating activities

are linked together in such a way that the value of the objective function (cost of service delivery and transportation) is minimized.

Statement of Model

The model has 279 rows and 1,089 real variables; these real variables are hospital service provision, transportation, and demand-generating activities. The model, though of considerable size, solves quickly and inexpensively.

Figure 3 presents an abbreviated picture of the linear programming matrix. The interested researcher can trace patient days of demand through the model, from demand origin through the transportation network to a hospital service.

<u>Algebraically</u>

The cost minimized is a summation of hospital services patient day costs and transportation costs [1]. Algebraically, the objective is to find a set of x's such that

$$F(C) = Cx \qquad (6)$$

is a minimum subject to these restraints:

$$Ax \leq b$$

$$x \geq 0$$

where:

C is the objective function value;

x is a column vector of production of hospital service activities, transfer activities, and demand sector activities;

	Hospital Services Activities								Transportation Activities								Demand-Generating Activities								
	MS0001	PED001	OB0001	MS0010	PED010	OB0010	IC0010	PSYC10	MS00101	PED0101	OB00101	MS00110	PED0110	OB00110	IC00110	PSYC110	0101 AGE	0201 AGE	0301 AGE	0401 AGE					
GP001	X	X	X																						≤ b
SP001	X	X	X																						≤ b
RN001	X	X	X																						≤ b
LPN01	X	X	X																						≤ b
MPS01	X	X	X																						≤ b
OPS01	X	X	X																						≤ b
GP010				X	X	X	X	X																	≤ b
SP010				X	X	X	X	X																	≤ b
RN010				X	X	X	X	X																	≤ b
LPN10				X	X	X	X	X																	≤ b
MPS10				X	X	X	X	X																	≤ b
OPS10				X	X	X	X	X																	≤ b
MS0001	-1								1																=
PED001		-1								1															=
OB0001			-1								1														=
MS0010				-1								1													=
PED010					-1								1												=
OB0010						-1								1											=
IC0010							-1								1										=
PSYC10								-1								1									=
MS00R01									-1			-1						X	X	X					=
PEDOR01										-1			-1				X								=
OBOOR01											-1			-1				X							=
ICOOR01															-1		X	X	X	X					=
PSYCR01																-1	X	X	X	X					=
Bounds	Up	Up	Up	Up	Up	Up	Up	Up									Fx	Fx	Fx	Fx					
Obj. fctn.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X									N

Figure 3. Linear programming tableau[a]

Figure 3 cont'd.

[a]The columns in the tableau represent model activities: hospital services-, transportation-, and demand-generating functions (MS, medical-surgical; PED, pediatric; OB, obstetric; IC, intensive care; PSYC, psychiatric).

Service activities from two hospitals are represented in this figure. For example, MS0001 is medical-surgical from hospital 1, and MS0010 is from hospital 10. Transportation activities transfer patient days of service demand from demand-generating activities to hospital services. For example, MS00101 transfers demand from demand sector 1 to hospital 1. Each demand sector has four demand-generating activities categorized by age. AGE0101 generates demand from the 0-14 age group for pediatrics, intensive care, and psychiatric services, for example. Rows GP001 through OPS01 are human resources available to hospital 1. GP010 through OPS10 are human resources available to hospital 10. Resources are in terms of man-years (GP, general practitioners; SP, medical specialists; RN, registered nurses; LPN, licensed practical nurses, nurses aides, and orderlies; MPS, medically oriented specialties such as laboratory technicians; and OPS, all other personnel ranging from housekeeping to administrative duties). Rows MS001 through PSYC10 are transfer rows related to hospital services activities. Rows MSOOR01 through PSYCR01 are transfer rows related to demand-generating activities in demand sector 1.

A is a matrix of transformation coefficients; and

b is a column vector of resource restraints.

Transformation coefficients

The constraining resources used to produce hospital services are those human resources previously identified. The transformation coefficients for a hospital are defined by resources used in that hospital to produce hospital services.[12] Transformation coefficients are developed by dividing full-time equivalents (40 hours x 52 weeks) of each manpower category by the total patient days of service delivered by the hospital during 1972. Competition is among services of different hospitals, not within a hospital. Characteristically then, each hospital service competing for a patient day of demand would have a different set of transformation coefficients. Engineering coefficients could be used if a new facility is contemplated. Hospital service activities are upper bounded at the service's maximum patient day capacity.

Objective Function

Patient day cost

A hospital service's objective function is the patient day cost of delivering that service at the level of service utilization during the relevant data period. Patient day cost is a summation of professional salaries, supplies, fees, miscellaneous and other, and administrative and

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[12] Lack of data needed to develop service-unique transformation coefficients within a hospital necessitated the use of hospital-unique coefficients.

fixed expense used to deliver the historic level of service utilization divided by historic patient days.

Cost subcategories are assigned wholly to a service or prorated among services based on utilization. The patient day cost is based on utilization during the data period. Those hospital administrators consulted support this methodology for determining patient day costs by service. Assuming constant patient day costs over a limited range of utilization are reasonable, the model is primarily concerned with marginal utilization changes.

Transportation cost

Transportation activities contribute to the objective function whenever the level of movement in activity is greater than zero. Transportation cost is a function of time and distance for the patient demanding hospital services and for those persons who visit the patient in the hospital. Transportation cost is:

$$TC = F_1(T_1) + F_2(D_1) + F_3(T_2) + F_4(D_2)^{13} \qquad (7)$$

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[13] $F_1(T_1)$ is the round-trip distance to the hospital service used divided by an average speed of travel times a time charge (federal minimum wage) and divided by average length of stay in the hospital service.

$F_3(T_2)$ is the round-trip distance to the hospital being visited divided by an average speed of travel times number of visits per day times number of visitors per visit times a time charge (federal minimum wage).

$F_2(D_1)$ is the round-trip distance times a mileage charge and divided by the average length of stay in the hospital service.

$F_4(D_2)$ is round-trip distance times number of visits per inpatient day times a mileage charge.

where:

TC = transportation cost;

T_1 = time expended by hospital patient in round trip to hospital;

D_1 = distance traveled by hospital patient in round trip to hospital;

T_2 = time expended by visitors traveling round trip to visit hospital patient; and

D_2 = distance traveled by those visiting hospital patient.

The equation used to determine transportation costs for each transportation activity is:

$$T.C. = \frac{\left(\frac{2 \times D}{45}\right) \times 2.10}{ALS} + \frac{(2 \times C \times D)}{ALS} + \left(\left(\frac{2 \times D}{45}\right) \times 1.79 \times E \times 2.10\right) + (1.79 \times 2 \times C \times D) \quad (8)$$

where:

T.C. = transportation cost, objective function for the activity;

ALS = average length of stay, in particular hospital service;

D = miles from demand sector to hospital service;

E = number of visitors per visitor trip;

45 = miles per hour speed (assumed to be reasonable for the planning area);

1.79 = patient visits per inpatient day verified by delphi techniques;

C = cost per mile for transportation (15¢); and

\$2.10 = federal minimum wage.

Institutional Constraints

Certain institutional constraints inhibit the movement of patient demand to the service offering least-cost satisfaction. Such constraints

include the hospital service preference of the admitting physician (based on his preference function and very important in determining utilization patterns), the patient's subjective evaluation of service quality in a hospital, and trade patterns for other goods and services. Recognizing an inability to accurately specify such institutional constraints, the service activity levels are constrained to range within 70 to 130 percent of historic utilization patterns.[14] Planning area physicians, hospital administrators, and health planners indicated utilization patterns could reasonably shift within this range over a five to ten year period. Historic utilization patterns are assumed to reflect institutional constraints as well as patient day cost of the service and transportation.

Model Output

The programming model's output identifies cost-minimizing, hospital service utilization patterns. Several changes in service capacity, manpower constraints, demand sector population, and demand coefficients are imposed on the model to determine the costs of provision of hospital services in a planning region under different utilization patterns. Tradeoffs in utilization levels among hospital services are determined. Shadow prices on limiting resources and capacities are developed.

Policy Decisions

The model is useful in answering a number of questions. It is used in north Iowa to determine the impact on the area's hospital utilization

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[14] Specific model solutions not so constrained are indicated in each case. Constraints are not used when they would have no bearing on model solutions or when their use would lead to an infeasible solution.

patterns of consecutive decreases in hospital manpower availability. The redistribution of patient days of service demand among hospitals with resources is determined. Area hospitals' utilization pattern changes, resulting from deletion of a hospital-service capability or an entire hospital, are tested. Population projections are incorporated into the model. Planners can then determine probable utilization patterns in area hospitals at some future time. Changes in patient day cost as a result of new construction and changes in transportation costs are incorporated into the model objective function.

The complete model can be used to simulate the effects on the hospital services system of changes in costs, resource use coefficients, resource and capacity constraints, population changes, and demand coefficient changes. Planners can adjust demand coefficients to reflect a lack of transportation or inability to pay for health care services. Thus, questions of access can be addressed.

IV. MODEL SOLUTIONS

Nine models of the North Iowa Health Planning Area service demand satisfaction were constructed. The models were solved under several levels of utilization, population change, manpower availability, service capacity, and cost. Each model is discussed individually. Table 4 presents the historic utilization patterns in the north Iowa area. Model solution discussions use historical utilization patterns as a bench mark.

Table 4. Historic utilization patterns.

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Belmond Comm.	5,481	0	517	0	0
Buffalo Center	2,346	409	332	0	0
Clarion Comm.	6,261	0	384	0	0
Floyd Co.	18,229	1,646	1,133	1,195	0
Forest City Mun.	3,488	0	307	0	0
Franklin Gen.	6,818	0	475	110	0
Hancock Co.	5,687	0	753	0	0
Kossuth Co.	6,672	559	755	0	0
Memorial	17,847	0	0	1,092	0
St. Joseph Mercy	64,017	7,227	3,200	1,611	5,774
Mitchell Co.	13,883	0	1,042	366	0

Model 1: Population Projections and Iterative Costs

Model 1 uses the hospital service costs developed with an iteration technique.[15] These costs then cause an unconstrained model solution to approach historic utilization patterns. These hospital patient day costs are used in a solution with future population projections. The model solution then reflects probable utilization patterns under unchanged patients' preferences for hospitals.

Two population projections for 1985 are used. Projection A assumes that net out-migration from the planning area is 75 percent of the 1950-60 experience and the completed fertility rate is 2.45 children.[16] That fertility rate is now the United States Bureau of the Census' high fertility rate projection track. Projection B assumes that net out-migration from the area is 50 percent of the 1950-60 experience, and the completed fertility rate is 2.110 children. That fertility rate is now the United States Bureau of the Census' mid-level fertility rate projection track and has been called the zero population growth level of fertility. The county level projection data for 1985 are reduced to demand sector level by proportionate allocation with 1970 population determining the base proportions.[17] Table 5 presents historic and projected

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[15] Hospital patient day costs are adjusted over a series of solutions until approximate conformity with historic utilization patterns is achieved. Magnitude of cost adjustments is determined by comparison of activity dual values in bounded and unbounded solutions. Patient day costs in each iteration are adjusted by the difference in dual values.

[16] Completed fertility rate refers to the average number of offspring by a female who has completed the procreative years.

[17] County level projection data for 1985 are from population projection studies done by Dr. H. C. Chang at Iowa State University [4]. Such projections, on the basis of 1950-60 experience, are the most recent available.

Table 5. Patient days of demand generated by population projections.

	Medical-Surgical	Pediatrics	Obstetrics	Intensive Care	Psychiatric	Total
1970 population	148,396	12,071	8,898	4,470	5,776	179,611
1985 population Track A	151,516	10,729	10,083	4,545	5,801	182,674
1985 population Track B	159,420	10,731	10,791	4,778	6,138	191,858
1972 historic utilization	150,729	9,840	8,898	4,374	5,774	179,615

utilization through 1985. Table 6 presents hospital-service utilization data for both Model 1.1 and Model 1.2.

Model 1.1: Population Projection A

Total patient days of service used in 1985 are 3,059 days higher than in 1972. There are 182,674 patient days of demand generated as compared to 179,615 in 1972. Medical-surgical service demand increases 787 patient days; pediatrics decreases 889 patient days. Obstetrics increases 1,185 patient days. Intensive care increases 171 patient days, psychiatric care increases only 27 patient days.

The model 1.1 solution is constrained to range between 70 and 130 percent of historic utilization patterns. All models, unless otherwise indicated, are similarly constrained. Patient days of service demand do not exceed the present capacity of any hospital, except in the case of Memorial Hospital. As increases occur in some hospital services use, others decrease below the 1972 level. Differential population level changes[18] across the planning area and patient demand shifts to satisfaction in the lowest cost location account in part for the utilization shifts. Though Memorial Hospital falls 5.5 beds short of demand, Mercy Hospital in the same city has ample unused capacity delivering the same level and type of services.

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[18] As out-migration occurs and as fertility rates change, the age mix of each demand sector changes. For example, out-migration occurs primarily among those in the 16 to 44 age cohort. Thus, the proportion of this cohort to the total demand sector population changes between 1970 and 1985. As completed fertility rates decrease, the proportion of the population in the 15 years and under age cohort decreases from 1970 to 1985.

Table 6. Model 1: Population projections using hospital patient day cost developed by iteration.[a]

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 1.1: Population projection A					
Belmond Comm.	4,656	-[b]	520	-[c]	-[c]
Buffalo Center	3,050[d]	286[e]	374	-[c]	-[c]
Clarion Comm.	8,139[d]	-[b]	499[d]	-[c]	-[c]
Floyd Co.	20,537	1,479	1,209	921	-[c]
Forest City Mun.	4,534[d]	-[b]	399[d]	-[c]	-[c]
Franklin Gen.	4,773[e]	-[b]	540	77[e]	-[c]
Hancock Co.	7,393[d]	-[b]	800	-[c]	-[c]
Kossuth Co.	4,670[e]	727[d]	882	-[c]	-[c]
Memorial	23,201	-[b]	-[c]	1,420[d]	-[c]
St. Joseph Mercy	57,784	8,238	3,507	1,848	5,801
Mitchell Co.	12,779	-[b]	1,355[d]	279	-[c]

[a]Model results constrained to be within 70-130 percent of historic utilization patterns.

[b]Service provided by medical-surgical service.

[c]Service not available at hospital.

[d]Upper constraint level.

[e]Lower constraint level.

Table 6. (cont'd.)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 1.2: Population projection B					
Belmond Comm.	5,381	-[b]	602	-[c]	-[c]
Buffalo Center	3,050[d]	288	432[d]	-[c]	-[c]
Clarion Comm.	8,139	-[b]	499	-[c]	-[c]
Floyd Co.	21,571	1,352	1,172	966	-[c]
Forest City Mun.	4,534	-[b]	399[d]	-[c]	-[c]
Franklin Gen.	6,063	-[b]	595	77[e]	-[c]
Hancock Co.	7,393[d]	-[b]	875	-[c]	-[c]
Kossuth Co.	4,670[e]	727[d]	961	-[c]	-[c]
Memorial	23,201[d]	-[b]	-[c]	1,420[d]	-[c]
St. Joseph Mercy	62,143	8,365	3,902	2,025	6,138
Mitchell Co.	13,275	-[b]	1,355[d]	290	-[c]

Model 1.2: Population Projection B

The Model 1.2 solution uses population Projection B. This projection is regarded as the most realistic one for the North Iowa Planning Area. Medical-surgical demand increases 8,691 patient days over 1972. Pediatrics demand increases 891 days. Obstetric demand increases 1,893 patient days. Intensive care demand increases 404 patient days. Psychiatric care demand increases 364 patient days. Total patient days of demand increases 12,243 patient days. Present hospital capacities in the area can accommodate the increased demand. Some demand shifts occur in the cost-minimizing procedure.

If patient preferences do not substantially change (thus changing inputed patient day costs), ample capacity exists in each of the present hospitals, except Memorial Hospital through 1985. Though Memorial Hospital capacity is exceeded, Mercy Hospital can absorb the excess demand. Demand for certain services changes as the age mix of planning area residents change. This is particularly true with obstetrics and pediatrics. Significant increases in per capita demand for medical-surgical and intensive care services occur as the population cohort over 64 increases.

Model 2: Population Projections and
Actual Patient Day Costs

The Model 2 uses both a standard hospital patient day cost and a patient day cost adjusted for utilization.[19] The standard patient day

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[19] In the unadjusted cost, certain administrative and fixed charges are allocated on the basis of historic utilization by this formulation:

$$\frac{\text{Total cost/service}}{\text{Actual patient days}} = \text{Cost per patient day.}$$

(Footnote continued on page 42)

Table 7. Model 2: Utilization with 1985 population projection B.

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 2B.3: Four-variable transportation cost function and standard patient day cost					
Belmond Comm.	7,125[c]	-[a]	672[c]	-[b]	-[b]
Buffalo Center	3,050[c]	532[c]	432[c]	-[b]	-[b]
Clarion Comm.	8,139[c]	-[a]	499[c]	-[b]	-[b]
Floyd Co.	23,698[c]	1,921	1,367	966	-[b]
Forest City Mun.	4,534[c]	-[a]	399[c]	-[b]	-[b]
Franklin Gen.	8,863[c]	-[a]	618[c]	143[c]	-[b]
Hancock Co.	7,393[c]	-[a]	979[c]	-[b]	-[b]
Kossuth Co.	8,674[c]	727[c]	970	-[b]	-[b]
Memorial	12,493[d]	-[a]	-[b]	1,420[c]	-[b]
St. Joseph Mercy	57,403	7,551	3,500	1,773	6,138
Mitchell Co.	18,048[c]	-[a]	1,355[c]	476[c]	-[b]

[a]Model results constrained to be within 70-130 percent of historic utilization patterns.

[b]Service provided by medical-surgical service.

[c]Service not available at hospital.

[d]Upper constraint level.

[e]Lower constraint level.

Table 7. (continued)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 2B.4: Four variable-transportation cost function and patient day cost adjusted for utilization					
Belmond Comm.	7,125[c]	-[a]	672[c]	-[b]	-[b]
Buffalo Center	3,050[c]	532[c]	432[c]	-[b]	-[b]
Clarion Comm.	8,139[c]	-[a]	499[c]	-[b]	-[b]
Floyd Co.	23,698[c]	1,921	1,367	966	-[b]
Forest City Mun.	4,534[c]	-[a]	399[c]	-[b]	-[b]
Franklin Gen.	8,863[c]	-[a]	618[c]	143[c]	-[b]
Hancock Co.	7,393[c]	-[a]	679[c]	-[b]	-[b]
Kossuth Co.	8,674[c]	727[c]	970	-[b]	-[b]
Memorial	12,493[d]	-[a]	-[b]	1,420[c]	-[b]
St. Joseph Mercy	57,403	7,551	3,719	1,773	6,138
Mitchell Co.	18,048[c]	-[a]	1,137	476[c]	-[b]

cost sums variable costs associated with a particular service and adds to this the proportional amount of administrative and fixed charges. The total service cost is divided by the patient days of that service extended to arrive at a patient day cost.[20]

The adjusted patient day cost allocates variable costs associated with a service to that service. Additionally, certain administrative and fixed charges are allocated to a service on the basis of service capacity (possible bed days). This raises the per patient day cost in a hospital service with lower-than-average utilization. Population Projection B is used for 1985, since demographers consider it the more realistic projection. Note that the model cost incurred is a summation of patient day costs in each hospital and transportation costs incurred by patients and visitors.

Model 2B.3

The model uses the four-variable transportation cost function and standard patient day hospital cost. Though population Projection B

(footnote continued from page 39)

[19] In the adjusted cost, these same charges are allocated on the basis of service capacity (possible bed days) by this formulation:

$$\frac{\text{Total cost of service}}{\text{Total possible bed days in service}} = \text{Cost/bed day.}$$

Cost/bed x Number of beds per service = Total cost of service.

$$\frac{\text{Total cost per service}}{\text{Actual patient days}} = \text{Cost per patient day.}$$

[20] See Appendix 3 for the survey instrument used to collect data and an example of the computation used.

develops 12,243 more patient days of hospital services demand than 1972 historic use, no hospital service capacity is exceeded. A shift in utilization patterns occurs at the expense of larger hospitals. The service utilization level in all but the two largest hospitals is at 130 percent of historic utilization level for medical-surgical services. Obstetric services demand is at the 130 percent level in all hospitals, except Mercy, Kossuth County, and Floyd County Hospitals. Three hospitals delivering intensive care are at the 130 percent level also (Franklin General, Memorial, and Mitchell County Hospitals).

Model 2B.4

The model uses the four-variable transportation cost function and the patient day hospital cost adjusted for utilization. The solution is identical to Model 2B.3, except that 218 patient days of obstetric service demand shift from Mitchell County Hospital to Mercy Hospital. Present capacities of hospital services are not exceeded, except for Memorial Hospital's intensive care service.[21] That hospital has ample excess capacity in its other service to shift capacity to intensive care. Also, Mercy Hospital's intensive care service can accommodate the excess demand experienced by Memorial Hospital.

Since only small, marginal changes in utilization patterns occur when adjusted patient day hospital costs are used, only the standard patient day hospital costs are used in models subsequent to Model 2. Marginal shifts in pediatric and obstetric services demand do occur.

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[21] See Appendix Table 5 for hospital services capacities.

Demand shifts to services with higher utilization rates. The formula is used in Model 2 to demonstrate its effect on utilization patterns. Hospital administrators, however, rarely use an adjusted formula.

The four-variable transportation function accounts for the value of a visitor's time. Such a function affects utilization patterns, particularly in hospital services characterized by short average lengths of stay. Planners are interested in model solutions minimizing total cost to the planning area. The four-variable transportation function more adequately accounts for this total cost than would one in which a visitor's time has no value.

Model 3: Reductions in Physician Manpower

Health planners ask, what happens to hospital services utilization patterns when manpower resources are reduced? If manpower resources are reduced in one hospital, where are the hospital services demands satisfied? Model 3 addresses that question by reducing physician services 25 percent, consecutively, in area hospitals. Such a reduction in manpower might occur if a town was to lose a physician.

Each model uses standard patient day hospital costs and the four-variable transportation cost function. Utilization reallocation is constrained to within 70 percent of historic utilization and service capacity. Table 8 presents the utilization reallocation that occurs. Model solutions are compared to the cost-minimizing solution in which the solution is constrained within 70 to 130 percent of the historic utilization pattern.

Table 8. Model 3: Reallocation of utilization under manpower decrease.[a]

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 3.1: Reallocation of service utilization under 25 percent decrease in Belmond Community physician service manpower					
(Model cost: $12,812,484.00)					
Belmond Comm.	4,167	-[b]	558	-[c]	-[c]
Buffalo Center	4,015[d]	730[d]	770	-[c]	-[c]
Clarion Comm.	13,130	-[b]	1,114	-[c]	-[c]
Floyd Co.	13,373	2,190[d]	793[e]	837[e]	-[c]
Forest City Mun.	5,585	-[b]	429	-[c]	-[c]
Franklin Gen.	16,790[d]	-[b]	663	703[d]	-[c]
Hancock Co.	9,490[d]	-[b]	902	-[c]	-[c]
Kossuth Co.	11,680[d]	730[d]	529[e]	-[c]	-[c]
Memorial	12,493[e]	-[b]	-[c]	1,044	-[c]
St. Joseph Mercy	44,812[e]	8,422[e]	2,240[e]	1,128[e]	5,776
Mitchell Co.	12,863	-[b]	900	730[d]	-[c]

[a]Model results constrained to be within 70 percent of historic utilization and hospital service capacity.

[b]Service provided by medical-surgical service.

[c]Service not available at hospital.

[d]Upper constraint level.

[e]Lower constraint level.

Table 8. (continued)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 3.2: Reallocation of service utilization under 25 percent decrease in Buffalo Center physician service manpower					
		(Model cost: $12,879,561.00)			
Belmond Comm.	9,490[d]	-[b]	1,460[d]	-[c]	-[c]
Buffalo Center	1,642	361	428	-[c]	-[c]
Clarion Comm.	12,727	-[b]	876	-[c]	-[c]
Floyd Co.	13,373	2,190[d]	793[e]	837[e]	-[c]
Forest City Mun.	3,037	-[b]	429	-[c]	-[c]
Franklin Gen.	16,790[d]	-[b]	663	730[d]	-[c]
Hancock Co.	9,490[d]	-[b]	580	-[c]	-[c]
Kossuth Co.	11,680[d]	730[d]	529[e]	-[c]	-[c]
Memorial	12,493[e]	-[b]	-[c]	1,044	-[c]
St. Joseph Mercy	44,812[e]	8,791	2,240[e]	1,128[e]	5,776
Mitchell Co.	12,863	-[b]	900	730[d]	-[c]

Table 8. (continued)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 3.3: Reallocation of service utilization under 25 percent decrease in Clarion Community physician service manpower					
		(Model cost: $13,017,173.00)			
Belmond Comm.	4,134	-[b]	591	-[c]	-[c]
Buffalo Center	4,015[d]	730[d]	770	-[c]	-[c]
Clarion Comm.	4,726	-[b]	507	-[c]	-[c]
Floyd Co.	15,617	2,190[d]	793[e]	837[e]	-[c]
Forest City Munn.	5,659	-[b]	429	-[c]	-[c]
Franklin Gen.	16,790[d]	-[b]	1,152	730[d]	-[c]
Hancock Co.	9,490[d]	-[b]	985	-[c]	-[c]
Kossuth Co.	11,680[d]	730[d]	529[e]	-[c]	-[c]
Memorial	12,493[e]	-[b]	-[c]	1,044	-[c]
St. Joseph Mercy	44,812[e]	8,422	2,240[e]	1,128[e]	5,776
Mitchell Co.	18,980[d]	-[b]	900	730[d]	-[c]

Table 8. (continued)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 3.4: Reallocation of service utilization under 25 percent decrease in Floyd County physician service manpower					
(Model cost: $12,812,506.00)					
Belmond Comm.	4,167	-[b]	558	-[c]	-[c]
Buffalo Center	4,015[d]	730[d]	770	-[c]	-[c]
Clarion Comm.	13,130	-[b]	1,114	-[c]	-[c]
Floyd Co.	13,321	2,190[d]	793[e]	837[e]	-[c]
Forest City Mun.	5,636	-[b]	429	-[c]	-[c]
Franklin Gen.	16,790[d]	-[b]	663	730[d]	-[c]
Hancock Co.	9,490[d]	-[b]	902	-[c]	-[c]
Kossuth Co.	11,680[d]	730[d]	529[e]	-[c]	-[c]
Memorial	12,493[e]	-[b]	-[c]	1,044	-[c]
St. Joseph Mercy	44,812[e]	8,422	2,240[e]	1,128[e]	5,776
Mitchell Co.	12,863	-[b]	900	730[d]	-[c]

Table 8. (continued)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 3.5: Reallocation of patient demand under 25 percent decrease in Forest City physician service manpower					
(Model cost: $12,813,132.00)					
Belmond Comm.	4,167	-[b]	558	-[c]	-[c]
Buffalo Center	4,015[d]	730[d]	770	-[c]	-[c]
Clarion Comm.	13,130	-[b]	1,114	-[c]	-[c]
Floyd Co.	13,373	2,190[d]	793[e]	837[e]	-[c]
Forest City Mun.	2,773	-[b]	215[e]	-[c]	-[c]
Franklin Gen.	16,790[d]	-[b]	663	730[d]	-[c]
Hancock Co.	9,490[d]	-[b]	902	-[c]	-[c]
Kossuth Co.	11,680[d]	730[d]	529[e]	-[c]	-[c]
Memorial	12,493[e]	-[b]	-[b]	1,044	-[c]
St. Joseph Mercy	44,812[e]	8,422	2,240[e]	1,128	5,776
Mitchell Co.	15,674	-[b]	1,114	730[d]	-[c]

Table 8. (continued)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 3.6: Reallocation of patient demand under 25 percent decrease in Franklin General physician service manpower					
(Model cost: $13,018,291.00)					
Belmond Comm.	4,363	-^{b}	362^{e}	-^{c}	-^{c}
Buffalo Center	4,015^{d}	730^{d}	770	-^{c}	-^{c}
Clarion Comm.	13,870^{d}	-^{b}	1,310	-^{c}	-^{c}
Floyd Co.	20,133	2,190^{d}	969	837^{e}	-^{c}
Forest City Mun.	5,659	-^{b}	429	-^{c}	-^{c}
Franklin Gen.	4,773^{e}	-^{b}	333^{e}	725	-^{c}
Hancock Co.	9,490^{d}	-^{b}	902	-^{c}	-^{c}
Kossuth Co.	11,680^{d}	730^{d}	529^{e}	-^{c}	-^{c}
Memorial	12,493^{e}	-^{b}	-^{c}	1,049	-^{c}
St. Joseph Mercy	44,812	8,422	2,240^{e}	1,128^{e}	5,776
Mitchell Co.	17,109	-^{b}	1,054	730^{d}	-^{c}

Table 8. (continued)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 3.7: Reallocation of patient demand under 25 percent decrease in Hancock County physician service manpower					
(Model cost: $12,863,030.00)					
Belmond Comm.	4,363	-^{b}	362^{e}	-^{c}	-^{c}
Buffalo Center	4,015^{d}	730^{d}	770	-^{c}	-^{c}
Clarion Comm.	13,870^{d}	-^{b}	1,335	-^{c}	-^{c}
Floyd Co.	13,373	2,190^{d}	793^{e}	837^{e}	-^{c}
Forest City Mun.	5,659	-^{b}	541	-^{c}	-^{c}
Franklin Gen.	16,790^{d}	-^{b}	663	730^{d}	-^{c}
Hancock Co.	4,546	-^{b}	527^{e}	-^{c}	-^{c}
Kossuth Co.	11,680^{d}	730^{d}	767	-^{c}	-^{c}
Memorial	12,493^{e}	-^{b}	-^{c}	1,044	-^{c}
St. Joseph Mercy	44,812^{e}	8,422	2,240^{e}	1,128^{e}	5,776
Mitchell Co.	16,796	-^{b}	900	730^{d}	-^{c}

Table 8. (continued)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 3.8: Reallocation of patient demand under 25 percent decrease in Kossuth County physician service manpower					
(Model cost: $12,933,669.00)					
Belmond Comm.	4,363	-[b]	362[e]	-[c]	-[c]
Buffalo Center	4,015[d]	730[d]	770	-[c]	-[c]
Clarion Comm.	13,870[d]	-[b]	1,310	-[c]	-[c]
Floyd Co.	13,373	2,190[d]	793[e]	837[e]	-[c]
Forest City Mun.	5,659	-[b]	429	-[c]	-[c]
Franklin Gen.	16,790[d]	-[b]	663	730[d]	-[c]
Hancock Co.	9,490[d]	-[b]	902	-[c]	-[c]
Kossuth Co.	5,369	391[e]	529[e]	-[c]	-[c]
Memorial	12,493[e]	-[b]	1,044	-[c]	-[c]
St. Joseph Mercy	44,812[e]	8,761	2,240[e]	1,128[e]	5,776
Mitchell Co.	18,163	-[b]	900	730[d]	-[c]

Table 8. (continued)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 3.9: Reallocation of patient demand under 25 percent decrease in Memorial physician service manpower					
(Model cost: $12,812,484.00)					
Belmond Comm.	4,167	-[b]	558	-[c]	-[c]
Buffalo Center	4,015[d]	730[d]	770	-[c]	-[c]
Clarion Comm.	13,130	-[b]	1,114	-[c]	-[c]
Floyd Co.	13,373	2,190[d]	793[e]	837[e]	-[c]
Forest City Mun.	5,585	-[b]	429	-[c]	-[c]
Franklin Gen.	16,790	-[b]	663	730[d]	-[c]
Hancock Co.	9,490[d]	-[b]	902	-[c]	-[c]
Kossuth Co.	11,690[d]	730[d]	529[e]	-[c]	-[c]
Memorial	12,493[e]	-[b]	-[c]	1,044	-[c]
St. Joseph Mercy	44,812[e]	8,422	2,240[e]	1,128[e]	5,776
Mitchell Co.	12,863	-[b]	900	730[d]	-[c]

Table 8. (continued)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 3.10: Reallocation of patient demand under 25 percent decrease in Mitchell County physician service manpower					
		(Model cost: $12,794,897.00)			
Belmond Comm.	9,490[d]	-[b]	1,460[d]	-[c]	-[c]
Buffalo Center	4,015[d]	730[d]	578	-[c]	-[c]
Clarion Comm.	11,556	-[b]	779	-[c]	-[c]
Floyd Co.	15,054[e]	2,190[d]	793[e]	837[e]	-[c]
Forest City Mun.	2,442[e]	-[b]	545	-[c]	-[c]
Franklin Gen.	16,790[d]	-[b]	718	730[d]	-[c]
Hancock Co.	9,490[d]	-[b]	527[e]	-[c]	-[c]
Kossuth Co.	11,680[d]	730[d]	529[e]	-[c]	-[c]
Memorial	12,493[e]	-[b]	-[c]	1,044	-[c]
St. Joseph Mercy	44,812[e]	8,422	2,240[e]	1,128[e]	5,776
Mitchell Co.	10,575	-[b]	729[e]	730[d]	-[c]

Model 3.1

The model imposes a reduction in physician services on the Belmond Community Hospital. The medical-surgical services activity level decreases 2,958 patient days. A 114-patient days' decrease occurs in obstetric services demand. The hospital services increasing utilization at the expense of Belmond Community's service utilization, are Buffalo Center, Clarion Community, Forest City, Hancock County, and Franklin County--hospitals best located to service patient demand not satisfied at Belmond Community Hospital. This is expected since the smallest hospitals derive most patient demand from the same county or contiguous areas.

Removing the 130 percent capacity bound does result in some readjustment of hospital services demand from the more expensive to the less expensive hospitals. This is true for all services, except psychiatric. Note that in this submodel solution, as in all Model 3 solutions, utilization of medical-surgical services in Mercy and Memorial Hospitals, as well as intensive care and obstetric services in Mercy and Floyd County Hospitals, declines to the 70 percent constraint level. The model cost is $12,812,484.00

Model 3.2

The model imposes a reduction in physician services on the Buffalo Center Hospital. Medical-surgical demand decreases 1,308 patient days, pediatric demand 171 patient days, and obstetric demand 4 patient days for that hospital. The hospitals realizing increased patient day demand are the contiguous hospitals including Belmond Community, Clarion Community, Kossuth County, and Hancock County Hospitals. Forest City's medical-surgical service utilization decreases while its obstetric service utilization increases (almost doubling to 429 patient days). The model cost is $12,879,561.00.

Model 3.3

The model imposes a reduction in physician services on the Clarion Community Hospital. While medical-surgical services utilization at Clarion Community decreases substantially (3,413 patient days), obstetric service utilization increases slightly. Belmond Community Hospital experiences a shift in services demand to other surrounding hospitals. Kossuth County, Hancock County, Franklin County Hospitals, and, to a much smaller extent, Forest City Hospital, experience services utilization increases. The model cost is $13,017,173.00. This increase over previous submodel costs reflects the reduction of capacity in a relatively inexpensive hospital and servicing of that demand by more expensive hospitals.

Model 3.4

The model imposes a reduction in physician services on the Floyd County Hospital. The medical-surgical service utilization decreases 10,000 patient days. Obstetric service utilization decreases 304 patient days, intensive care decreasing marginally. Pediatrics service demand actually increases (50 patient days). Clarion Community and Franklin General Hospitals experience substantial increases in services utilization. Kossuth County, Hancock County, and Forest City Hospitals are marginal gainers. The model cost is $12,812,506.00

Model 3.5

The model imposes a reduction in physician services on the Forest City Hospital. The medical-surgical services demand decreases 1,761 patient days, but obstetric service demand is the same. Hancock County, Kossuth County, and Buffalo Center Hospitals experience major increases in services utilization. Franklin General Hospital also experiences substantial increases (7,927 patient days in medical-surgical and 587 patient days in intensive care), due in large part to service shifts from Mercy and Floyd County Hospitals. The model cost is $12,813,132.00.

Model 3.6

The model imposes a reduction in physician services on Franklin General Hospital. Medical-surgical services utilization decreases 4,090 patient days, and obstetric services utilization decreases 1,285 patient days. Intensive care increases to a capacity level (730 patient days) as a result of removing the 130 percent constraint. Floyd County, Forest City,Kossuth County, Hancock County, and Clarion Community Hospitals experience major increases in services utilization. Mitchell County and Buffalo Center Hospitals experience marginal increases. The model cost is $13,018,291.00.

Model 3.7

The model imposes a reduction in physician services on Hancock County Hospital. Medical-surgical utilization decreases 2,847 patient days, and obstetric utilization is reduced to the 70 percent constraint (527 patient days). Kossuth County, Franklin General, Forest City, Clarion Community, and Buffalo Center Hospitals experience major increases in service utilization. The model cost is $12,863,030.00.

Model 3.8

The model imposes a reduction in physician services on Kossuth County Hospital. Medical-surgical utilization decreases 3,305 patient days, pediatrics utilization decreases to the 70 percent constraint (391 patient days) as does obstetric services demand (529 patient days). This pattern reflects the higher costs of these two services in that hospital relative to other hospitals. Hancock County, Franklin General, Forest City, Buffalo Center, and Clarion Community Hospitals experience major increases in services utilization. The model cost is $12,933,669.00.

Model 3.9

The model imposes a reduction in physician services on Memorial Hospital. Medical-surgical services utilization does not decrease, since it previously was at the 70 percent constraint. Intensive care services utilization decreases 376 patient days. Franklin General and Mitchell County Hospitals receive the intensive care service utilization that Memorial Hospital loses. The minimal reallocation of hospital services utilization reflects the weak competitive position of Memorial Hospital. The model cost is $12,812,484.00.

Model 3.10

The model imposes a reduction in physician services on Mitchell County Hospital. Medical-surgical services utilization decreases 7,473 patient days. Obstetric services utilization decreases to the 70 percent of historic use lower constraint (729 patient days). Intensive care services utilization increases 254 patient days to the 130 percent constraint. Kossuth County, Hancock County, Franklin General, Floyd County, Clarion Community, and Belmond Community Hospitals experience major increases in services utilization. Forest City Hospital experiences decreased patient days of medical-surgical services utilization and increased obstetric services utilization. The model cost is $12,794,897.00.

Model 4: Deletion of Hospital Services

Health planners ask, what reallocation of hospital services utilization patterns would occur if a hospital were to go out of business? Model 4 answers that question by consecutively deleting the smaller hospital in each county having two hospitals. Clarion Community Hospital is also deleted since its utilization rate is only 41.4 percent.

The standard patient day hospital cost and the four-variable transportation cost function are used in the model. Utilization levels are constrained to fall between 70 and 130 percent of historic utilization. Both 1970 population and the population projection track B for 1985 are used. Table 9 presents the utilization patterns for both 1970 and 1985 populations. Psychiatric care is delivered only at Mercy Hospital for

Table 9. Model 4: Reallocation of utilization under service deletion.[a,b]

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 4.1: With service deleted at Belmond Community, four-argument cost function, and 1970 population					
(Model cost: $14,381,621.00)					
Belmond Comm.	0	0	0	0	0
Buffalo Center	3,050[e]	532[e]	432[e]	-[d]	-[d]
Clarion Comm.	8,139[e]	-[c]	499[e]	-[d]	-[d]
Floyd Co.	23,698[e]	2,140[e]	1,206	910	-[d]
Forest City Mun.	4,534[e]	-[c]	215[f]	-[d]	-[d]
Franklin Gen.	8,863[e]	-[c]	618[e]	143[e]	-[d]
Hancock Co.	7,393[e]	-[c]	979[e]	-[d]	-[d]
Kossuth Co.	8,674[e]	727[e]	767	-[d]	-[d]
Memorial	12,493[f]	-[c]	-[d]	1,420[e]	-[d]
St. Joseph Mercy	53,505	8,673	3,128	1,520	5,776
Mitchell Co.	18,048[e]	-[c]	1,054	476	-[d]

[a]Model results constrained to be within 70-130 percent of historic utilization patterns.

[b]Four-variable cost function.

[c]Service provided by medical-surgical service.

[d]Service not available at hospital.

[e]Upper constraint level.

[f]Lower constraint level.

Table 9. (continued)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 4.2: With service deleted at Belmond Community, four-argument cost function, and 1985 track B population					
(Model cost: $15,469,130.00)					
Belmond Comm.	0	0	0	0	0
Buffalo Center	3,050[e]	532[e]	432[e]	-[d]	-[d]
Clarion Comm.	8,139[e]	-[c]	499[e]	-[d]	-[d]
Floyd Co.	23,698[e]	1,921	1,390	966	-[d]
Forest City Mun.	4,534[e]	-[c]	399[e]	-[d]	-[d]
Franklin Gen.	8,863[e]	-[c]	618[e]	143[e]	-[d]
Hancock Co.	7,393[e]	-[c]	979[e]	-[d]	-[d]
Kossuth Co.	8,674[e]	727[e]	970	-[d]	-[d]
Memorial	12,493[f]	-[c]	-[d]	1,420[e]	-[d]
St. Joseph Mercy	64,528	7,551	4,149	1,773	6,138
Mitchell Co.	18,048[e]	-[c]	1,355[e]	476[e]	-[d]

Table 9. (continued)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 4.3: With service deleted at Buffalo Center, four-argument cost function, and 1970 population					
(Model cost: $14,274,495.00)					
Belmond Comm.	7,125[e]	-[c]	672[e]	-[d]	-[d]
Buffalo Center	0	0	0	0	0
Clarion Comm.	8,139[e]	-[c]	499[e]	-[d]	-[d]
Floyd Co.	23,698[e]	2,140[e]	1,079	910	-[d]
Forest City Mun.	4,534[e]	-[c]	399[e]	-[d]	-[d]
Franklin Gen.	8,863[e]	-[c]	618[e]	143[e]	-[d]
Hancock Co.	7,393[e]	-[c]	979[e]	-[d]	-[d]
Kossuth Co.	8,674[e]	727[e]	878	-[d]	-[d]
Memorial	12,493[f]	-[c]	-[d]	1,420[e]	-[d]
St. Joseph Mercy	49,430	9,205	2,702	1,520	5,776
Mitchell Co.	18,048[e]	-[c]	1,054	476[e]	-[d]

Table 9. (continued)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 4.4: With service deleted at Buffalo Center, four-argument cost function, and 1985 track B population					
(Model cost: $15,353,488.00)					
Belmond Comm.	7,125[e]	-[c]	672	-[d]	-[d]
Buffalo Center	0	0	0	0	0
Clarion Comm.	8,139[e]	-[c]	499[e]	-[d]	-[d]
Floyd Co.	23,698[e]	1,921	1,367	966	-[d]
Forest City Mun.	4,534[e]	-[c]	399[e]	-[d]	-[d]
Franklin Gen.	8,863[e]	-[c]	618[e]	143[e]	-[d]
Hancock Co.	7,393[e]	-[c]	979[e]	-[d]	-[d]
Kossuth Co.	8,674[e]	727[e]	982[e]	-[d]	-[d]
Memorial	12,493[f]	-[c]	-[d]	1,420[e]	-[d]
St. Joseph Mercy	60,453	8,083	3,902	1,773	6,138
Mitchell Co.	18,048[e]	-[c]	1,355[e]	476[e]	-[d]

Table 9. (continued)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric

Model 4.5: With service deleted at Clarion Community, four-argument cost function, and 1970 population

(Model cost: $14,522,862.00)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Belmond Comm.	7,125[e]	-[c]	675	-[d]	-[d]
Buffalo Center	3,050[e]	532[e]	432[e]	-[d]	-[d]
Clarion Comm.	0	0	0	0	0
Floyd Co.	23,698[e]	2,140[e]	1,206	910	-[d]
Forest City Mun.	4,534[e]	-[c]	215[f]	-[d]	-[d]
Franklin Gen.	8,863[e]	-[c]	618[e]	143[e]	-[d]
Hancock Co.	7,393[e]	-[c]	979[e]	-[d]	-[d]
Kossuth Co.	8,674[e]	727[e]	767	-[d]	-[d]
Memorial	12,493[f]	-[c]	-[d]	1,420[e]	-[d]
St. Joseph Mercy	54,519	8,673	2,955	1,520	5,776
Mitchell Co.	18,048[e]	-[c]	1,054	476[e]	-[d]

Table 9. (continued)

Model 4.6: With service deleted at Clarion Community, four-argument cost function, and 1985 track B population

(Model cost: $15,610,174.00)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Belmond Comm.	7,125[e]	-[c]	672[e]	-[d]	-[d]
Buffalo Center	3,050[e]	532[e]	432[e]	-[d]	-[d]
Clarion Comm.	0	0	0	0	0
Floyd Co.	23,698[e]	1,921	1,390	966	-[d]
Forest City Mun.	4,534[e]	-[c]	399[e]	-[d]	-[d]
Franklin Gen.	8,863[e]	-[c]	618[e]	143[e]	-[d]
Hancock Co.	7,393[e]	-[c]	979[e]	-[d]	-[d]
Kossuth Co.	8,674[e]	727	970[e]	-[d]	-[d]
Memorial	12,493[f]	-[c]	-[d]	1,420[e]	-[d]
St. Joseph Mercy	65,542	7,551	3,976	1,773	6,138
Mitchell Co.	18,048[e]	-[c]	1,355[e]	476[e]	-[d]

Table 9. (continued)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 4.7: With service deleted at Memorial, four-argument cost function, and 1970 population					
	(Model cost: $13,996,146.00)				
Belmond Comm.	7,125^{e}	-^{c}	672^{e}	-^{d}	-^{d}
Buffalo Center	3,050^{e}	532^{e}	432^{e}	-^{d}	-^{d}
Clarion Comm.	8,139^{e}	-^{c}	499^{e}	-^{d}	-^{d}
Floyd Co.	23,698^{e}	2,140^{e}	1,097	910	-^{d}
Forest City Mun.	4,534^{e}	-^{c}	215^{f}	-^{d}	-^{d}
Franklin Gen.	8,863^{e}	-^{c}	618^{e}	143^{e}	-^{d}
Hancock Co.	7,393^{e}	-^{c}	979^{e}	-^{d}	-^{d}
Kossuth Co.	8,674^{e}	727^{e}	767	-^{d}	-^{d}
Memorial	0	0	0	0	0
St. Joseph Mercy	58,873	8,673	2,565	2,940	5,776
Mitchell Co.	18,048^{e}	-^{c}	1,054	476^{e}	-^{d}

Table 9. (continued)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 4.8: With service deleted at Memorial, four-argument cost function, and 1985 track B population					
	(Model cost: $15,065,307.00)				
Belmond Comm.	7,125^{e}	-^{c}	672^{e}	-^{d}	-^{d}
Buffalo Center	3,050^{e}	532^{e}	432^{e}	-^{d}	-^{d}
Clarion Comm.	8,139^{e}	-^{c}	499^{e}	-^{d}	-^{d}
Floyd Co.	23,698^{e}	1,921	1,367	966	-^{d}
Forest City Mun.	4,534^{e}	-^{c}	399^{e}	-^{d}	-^{d}
Franklin Gen.	8,863^{e}	-^{c}	618^{e}	143^{e}	-^{d}
Hancock Co.	7,393^{e}	-^{c}	979^{e}	-^{d}	-^{d}
Kossuth Co.	8,674^{e}	727^{e}	970	-^{d}	-^{d}
Memorial	0	0	0	0	0
St. Joseph Mercy	69,896	7,551	3,500	3,193	6,138
Mitchell Co.	18,048^{e}	-^{c}	1,355^{e}	476^{e}	-^{d}

the entire planning area. Thus, no reallocation of utilization for that service can occur.

Model 4.1: 1970 population

The model is solved with Belmond Community Hospital's capacity deleted (Table 9). Medical-surgical and pediatric utilization in all hospitals, except Mercy and Memorial, is at the 130 percent of historical utilization constraint. Memorial Hospital's utilization is at the 70 percent constraint. Obstetric services utilization is at the upper constraint in four hospitals (Buffalo Center, Clarion Community, Franklin General, and Hancock County). Floyd County, Forest City, Kossuth County, Mercy, and Mitchell County Hospitals experience obstetric services demand at less than the 130 percent constraint. Intensive care services utilization is at the upper constraint level in Franklin General, Memorial, and Mitchell County Hospitals and below that in Floyd County and Mercy Hospitals. Though Memorial Hospital's intensive care utilization exceeds the service capacity, it does not exceed the hospital capacity. The model cost is $14,381,621.00.

Model 4.2: 1985 population

The model is solved with Belmond Community Hospital's capacity deleted. The model solution results in upper constraint level medical-surgical services utilization in all hospitals, except Mercy and Memorial. Memorial Hospital's utilization is at the 70 percent constraint. Buffalo Center and Kossuth County Hospitals' pediatric services are utilized at

upper constraint levels. Buffalo Center, Clarion Community, Forest City, Franklin General, Hancock County, and Mitchell County Hospitals experience obstetric services utilization at upper constraint levels. Hospitals with upper constraint levels of intensive care utilization are the same as in Model 4.1. The 1985 hospital services demand does not exceed present hospital services capacity, except in the case of Memorial Hospital's intensive care. Neither total Memorial capacity nor intensive care capacity in Mason City are violated, however. The model cost is $15,469,130.00.

Model 4.3: 1970 population

The model is solved with Buffalo Center Hospital's capacity deleted. Medical-surgical utilization at Belmond Community Hospital increases to the 130 percent constraint (7,125 patient days). At Mercy Hospital, the increase is to 49,430 patient days. Pediatric use at Mercy Hospital increases to 9,205 patient days. Mercy, Kossuth County, and Forest City Hospitals provide the obstetric services demand formerly provided by the Buffalo Center Hospital. Floyd County Hospital's obstetric services utilization decreases, compared to Model 4.1. The model cost is $14,274,495.00.

Model 4.4: 1985 population

The model is solved with Buffalo Center Hospital's capacity deleted. Mercy Hospital increases in medical-surgical services demand over Model 4.3 (11,023 patient days), though pediatric demand decreases 1,120 patient days. Increases in demand for obstetric services, compared to the Model 4.3 solution, occur in Floyd County, Mercy, and Mitchell County Hospitals. Floyd County and Mitchell County Hospitals experience increases in intensive care demand. Services demand does not exceed the capacity of any hospital's market area. The model cost is $15,353,488.00.

Model 4.5: 1970 population

The model is solved with Clarion Community Hospital's capacity deleted. Only Mercy and Memorial Hospitals' medical-surgical and pediatric services utilization are not at the 130 percent constraint, Mercy Hospital's being at the 70 percent constraint. Floyd County, Kossuth County, Mercy, and Mitchell County Hospitals' obstetric services demands are not at upper constraint. Floyd County and Mercy Hospitals' utilization of intensive care services are not at upper capacity constraint. Mercy Hospital's medical-surgical and obstetric services experience the largest net increase among all hospitals from the deletion of Clarion Community Hospital services. Floyd County Hospital's obstetric service experiences 109 patient days of increased utilization. The model cost is $14,522,862.00.

Model 4.6: 1985 population

The model is solved with Clarion Community Hospital's capacity deleted. Mercy Hospital experiences increases in medical-surgical services utilization and decreases in pediatric services utilization as compared to Model 4.5 (11,023 patient days and 1,122 patient days, respectively). Memorial Hospital's medical-surgical utilization remains at the 70 percent constraint. Floyd County, Forest City, Mercy, and Mitchell County Hospitals experience obstetric services utilization

increases. Floyd County and Mercy Hospitals experience intensive care utilization increases. The model cost is $15,610,174.00.

Model 4.7: 1970 population

The model is solved with Memorial Hospital's capacity deleted. Only Mercy Hospital's medical-surgical service is not at the 130 percent constraint. Mercy Hospital's medical-surgical and pediatric services utilization are, respectively, 58,873 and 8,673 patient days. Mercy Hospital satisfies its own and Memorial Hospital's intensive care services demand (2,940 patient days). Memorial Hospital's services demand is satisfied by Mercy Hospital. A ripple effect is observed as utilization in other hospitals' obstetric services shifts. Deleting Memorial Hospital's capacity presents no problem in satisfaction of all hospital services demand generated by the model. The model cost of $13,996,146.00 indicates that substantial savings accrue to the planning area as a result.

Model 4.8: 1985 population

The model is solved with Memorial Hospital's capacity deleted. Mercy Hospital services both its and Memorial Hospital's medical-surgical, pediatric, and intensive care services demand. Obstetric service utilization decreases in this solution as compared to Models 4.2, 4.4, and 4.6 solutions. Ample hospital services capacity exists in the planning area through 1985. Again, the lowest cost model solution deletes Memorial Hospital's capacity. The model cost is $15,065,307.00.

Model 5: Increases in Service Capacity

Health planners ask the effect on other hospitals' utilization patterns of one area hospital increasing its services capacity. Model 5 addresses this question, looking at the implications of capacity increases in Forest City, Memorial, and Mercy Hospitals. These hospitals are considered because of proposed expansion plans at each of them. Standard patient day hospital costs, the four-variable transportation cost function, and 1970 population data are used in the model.

The cost per bed of additional hospital construction is estimated at $38,800.00.[22] The construction cost is assumed to be paid by hospital revenue bonds issued on the corporation itself amortized over 40 years. The current yield on such bonds, 7 percent, is used in calculating the yearly charge needed to retire hospital revenue bonds.[23]

Increased capacity is assumed to be utilized at one-half the rate of present capacity. Demonstrated inability to attract additional patients from outside the planning area and the higher patient day cost of amortizing new construction make this assumption reasonable. Patient demand for new capacity can only be attracted from other hospitals within the planning area. The planning area has no shortage of hospital

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[22] Average per bed cost of hospitals from Building Construction Cost Data. The range in bed cost of hospitals in 1974 was from a low of $8,780 to a high of $90,600 [2].

[23] $(P/a)\ {}^{.07}_{.40}$ = annual charge needed to retire hospital bonds. Information from personal communication with office of Merrill, Lynch, Pierce, Tenner, and Smith, Des Moines, Iowa, 1975.

capacity. Utilization patterns are constrained to range between 70 to 130 percent of historic use patterns, except for the hospital experiencing capacity change, in which case the constraints are zero to capacity.[24] Table 10 presents the utilization patterns resulting from capacity increases in the three hospitals. Reduced costs associated with marginal changes from the solution results are discussed.

Model 5.1: Forest City Hospital

Forest City Hospital's capacity is increased 100 percent. The model solution indicates the hospital's medical-surgical services utilization increases 6,968 patient days over a similar solution with no increase in Forest City Hospital's capacity. Obstetric services utilization decreases 24 patient days. The model cost is $13,933,298.00. No cost savings can be achieved by marginal (one more patient day) changes in the hospital's utilization.

Releasing the lower capacity constraint allows Forest City Hospital to service patient demand previously services by Memorial Hospital. Mercy Hospital then experiences utilization increases at Memorial Hospital's expense also. Forest City Hospital is unable to attract service demand from other area hospitals. Without lower capacity constraints and with adequate capacity elsewhere in the system, Memorial

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[24] In model solutions 5.1 and 5.2, Memorial Hospital has a lower capacity constraint of zero. This allows a test of Memorial Hospital's competitiveness in the face of service expansion in the planning area. In solution 5.3, Memorial Hospital's service utilization is constrained within 70 to 130 percent of historic utilization patterns. Earlier model solutions determined that Memorial Hospital's medical-surgical service was not competitive with that of Mercy Hospital.

Table 10. Model 5: Capacity increases in selected hospitals.[a,b]

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 5.1: Increase hospital capacity in Forest City 100 percent with one-half original utilization rate in new capacity					
(Model cost: $13,933,298.00)					
Belmond Comm.	7,125[f]	-[c]	672[f]	-[d]	-[d]
Buffalo Center	3,050[f]	532[f]	432[f]	-[d]	-[d]
Clarion Comm.	8,139[f]	-[c]	499[f]	-[d]	-[d]
Floyd Co.	23,698[f]	2,140[f]	1,097	910	-[d]
Forest City Mun.[e]	11,502	-[c]	191	-[d]	-[d]
Franklin Gen.	8,863[f]	-[c]	618[f]	143[f]	-[d]
Hancock Co.	7,393[f]	-[c]	979[f]	-[d]	-[d]
Kossuth Co.	8,674[f]	727[f]	767	-[d]	-[d]
Memorial	0	-[c]	-[d]	1,420[f]	-[d]
St. Joseph Mercy	51,904	8,673	2,588	1,520	5,776
Mitchell Co.	18,048	-[c]	1,054	476[f]	-[d]

[a]Model results constrained to be within 70-130 percent of historic utilization patterns, except in case of a hospital with increased capacity, in which case the constraints are zero to capacity.
[b]Four-variable cost function.
[c]Service provided by medical-surgical service.
[d]Service not available at hospital.
[e]Upper constraint at hospital service capacity.
[f]Upper constraint level.
[g]Lower constraint level.
[h]Utilization between zero and 130 percent of historic utilization.

Table 10. (continued)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 5.2: Increase hospital capacity in Memorial 50 percent with one-half original utilization in new section					
(Model cost: $13,965,076.00)					
Belmond Comm.	7,125[f]	-[c]	672[f]	-[d]	-[d]
Buffalo Center	3,050[f]	532[f]	432[f]	-[d]	-[d]
Clarion Comm.	8,139[f]	-[c]	499[f]	-[d]	-[d]
Floyd Co.	23,698[f]	2,140[f]	1,097	910	-[d]
Forest City Mun.	4,534[f]	-[c]	215[g]	-[d]	-[d]
Franklin Gen.	8,863[f]	-[c]	618[f]	143[f]	-[d]
Hancock Co.	7,393[f]	-[c]	979[f]	-[d]	-[d]
Kossuth Co.	8,674[f]	727[f]	767	-[d]	-[d]
Memorial[e]	0	-[c]	-[d]	1,812	-[d]
St. Joseph Mercy	58,873	8,673	2,565	1,128[g]	5,776
Mitchell Co.	18,048[f]	-[c]	1,054	476[f]	-[d]

Table 10. (continued)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Model 5.3: Increase hospital capacity in St. Joseph Mercy 20 percent with one-half original utilization in new section					
(Model cost: $14,066,822.00)					
Belmond Comm.	7,125[f]	-[c]	672[f]	-[d]	-[d]
Buffalo Center	3,050[f]	532[f]	432[f]	-[d]	-[d]
Clarion Comm.	8,139[f]	-[c]	499[f]	-[d]	-[d]
Floyd Co.	23,698[f]	2,140[f]	1,097	910	-[d]
Forest City Mun.	4,534[f]	-[c]	215[g]	-[d]	-[d]
Franklin Gen.	8,863[f]	-[c]	618[f]	143[f]	-[d]
Hancock Co.	7,393[f]	-[c]	979[f]	-[d]	-[d]
Kossuth Co.	8,674[f]	727[f]	767	-[d]	-[d]
Memorial	12,493[g]	-[c]	-[d]	1,420[f]	-[d]
St. Joseph Mercy[e]	46,380	8,673	2,448	1,520	5,776
Mitchell Co.	18,048[f]	-[c]	1,171	476[f]	-[d]

Hospital experiences the loss of its medical-surgical services utilization. Indeed, treating another patient in that service at Memorial Hospital would add $6.99 to the value of the model cost.

Model 5.2: Memorial Hospital

The capacity of Memorial Hospital is increased 50 percent. Memorial Hospital experiences the loss of all its medical-surgical services utilization to Mercy Hospital. Its intensive care services utilization does, however, increase 394 patient days, reflecting an increase in the capacity of that service. Intensive care service is less costly at Memorial Hospital than at Mercy Hospital. The solution results in Mercy Hospital's intensive care unit being utilized at the 70 percent constraint.

The model cost is $13,965,076.00. One more patient day of treatment in Mercy Hospital's intensive care unit would add $16.89, and one more patient day of treatment in Forest City Hospital's obstetric service would add $1.43 to the program cost. Model costs would be unchanged by a marginal change in Memorial Hospital's intensive care services utilization.

Model 5.3: Mercy Hospital

The capacity of Mercy Hospital is increased 20 percent. Absolutely no change occurs in medical-surgical, pediatric, intensive care, and psychiatric services utilization in the hospital, compared to a similar solution in which capacity was not increased. Only in the obstetric service is there a marginal utilization shift out of Mercy Hospital (117 patient days) to Mitchell County Hospital.

The model cost is $14,066,822.00. Model costs would increase by relaxing the utilization constraint on the services and utilizing an additional unit of either Memorial Hospital's medical-surgical or Forest City Hospital's obstetric services but would be unchanged or reduced by relaxing other utilization constraints.

Model 6: Unbounded Cost Minimization

Planners think substantial savings to a planning area would result if decisions to select hospital services were made entirely on the basis of cost minimization. Federal and state level governmental agencies relating to health care delivery place increasing emphasis on cost effectiveness and least-cost service delivery configurations. The theoretically acceptable transportation cost is a function of patient and visitor distance traveled and of patient and visitor elapsed time.[25] This is particularly true when total service and transportation costs to an area are to be minimized. Model solutions are compared to historic utilization patterns in the discussion of results. Table 11 presents minimum cost utilization patterns for area hospitals.

Model cost data indicates such an unbounded model solution would cost $13,245,665.00, compared with $14,637,011.00 for a solution in which utilization patterns are within 5 percent of historic patterns. The model solution constrained 70 to 130 percent of historic utilization

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[25] See the section on transportation cost for a more complete discussion.

Table 11. Model 6: Optimal unbounded solution.[a]

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Unbounded utilization patterns with four-variable transportation cost function and a standard hospital cost					
Belmond Comm.	9,490[d]	-[b]	1,054	-[c]	-[c]
Buffalo Center	4,015[d]	730[d]	564	-[c]	-[c]
Clarion Comm.	12,727	-	617	-[c]	-[c]
Floyd Co.	20,791[d]	2,190[d]	639	858	-[c]
Forest City Mun.	6,570[d]	-	85	-[c]	-[c]
Franklin Gen.	16,790[d]	-	663	730[d]	-[c]
Hancock Co.	9,490[d]	-	870	-[c]	-[c]
Kossuth Co.	11,680[d]	730[d]	767	-[c]	-[c]
Memorial	0	-	-	1,095	-[c]
St. Joseph Mercy	37,863	8,422	2,584	1,056	5,776
Mitchell Co.	18,980[d]	-	1,054	730[d]	-[c]

[a] Model results constrained to be within 0 and capacity levels of utilization.

[b] Service provided by medical-surgical service.

[c] Service not available at hospital.

[d] Upper constraint level.

patterns costs $14,003,297.00. Thus, substantial yearly savings can accrue as a result of shifting toward cost-minimizing utilization patterns.

Belmond Community, Buffalo Center, Forest City, Franklin General, Hancock County, Kossuth County, and Mitchell County Hospitals' medical-surgical services are utilized at capacity. Clarion Community Hospital's utilization increases substantially, more than doubling its medical-surgical services utilization to 12,727 patient days. Floyd County Hospital's medical-surgical services utilization decreases 2,562 patient days, though its pediatric services utilization increases to capacity (2,190 patient days). Memorial Hospital experiences the loss of all its medical-surgical services utilization. Mercy Hospital experiences the loss of 26,154 patient days of its medical-surgical utilization and an increase in pediatric services utilization of 1,196 patient days. Pediatric services in other hospitals offering that service are utilized at capacity. Obstetric and intensive care services utilization shift substantially to lower cost services. Belmond Community Hospital's obstetric services utilization increases more than two times (to 1,054 patient days). Buffalo Center, Clarion Community, Franklin General, and Hancock County Hospitals experience a marked increase in obstetric services utilization. Floyd County, Forest City, and Mercy Hospitals experience a marked decrease. Intensive care utilization at Mitchell County Hospital more than doubles (to 730 patient days) and at Franklin General Hospital increases over six times (to 730

patient days). Floyd County and Mercy Hospitals' intensive care utilization decreases substantially (by 337 and 555 patient days, respectively). Other utilization levels change marginally or remain the same.

Model 7: High Transportation Cost

What utilization patterns for hospital services would exist in a planning area if transportation costs increase substantially or if emergency transportation vehicles are used to transport patients to hospitals? This question is a particularly valid one in light of increasing energy costs and the rural nature of the planning area being studied. Model 7 addresses the question using a solution constrained to within 70 to 130 percent of historic use patterns and the standard hospital cost. The four-variable transportation cost function is altered by inclusion of a 65¢ per mile distance to hospital cost charge for the patient. Such a charge approximates emergency transportation charges to the hospital and private vehicle charges home from the hospital.

Table 12 presents the hospital services utilization patterns in this solution.

Substantial shifts in utilization, compared to historic utilization patterns, do occur. Medical-surgical and pediatric utilization in all hospitals, except Mercy and Memorial, are at the 130 percent constraint. Memorial Hospital's medical-surgical services utilization is at the 70 percent constraint. Belmond Community, Buffalo Center, Clarion Community, and Franklin General Hospitals' obstetric service

Table 12. Model 7: High mileage cost model solution.[a]

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Four-variable high mile cost transportation cost function (65¢ x D)					
		(Model cost: $14,152,413.00)			
Belmond Comm.	7,125[d]	-[b]	672[d]	-[c]	-[c]
Buffalo Center	3,050[d]	532[d]	432[d]	-[c]	-[c]
Clarion Comm.	8,139[d]	-[b]	499[d]	-[c]	-[c]
Floyd Co.	23,698[d]	2,140[d]	1,097	910	-[c]
Forest City Mun.	4,534[d]	-[b]	215[e]	-[c]	-[c]
Franklin Gen.	8,863[d]	-[b]	618[d]	143[d]	-[c]
Hancock Co.	7,393[d]	-[b]	955	-[c]	-[c]
Kossuth Co.	8,674[d]	727[d]	767	-[c]	-[c]
Memorial	12,493[e]	-[b]	-[c]	1,420[d]	-[c]
St. Joseph Mercy	46,380[e]	8,673	2,588	1,520	5,776
Mitchell Co.	18,048[d]	-[b]	1,054	476[d]	-[c]

[a]Model results constrained to be within 70-130 percent of historic utilization patterns.

[b]Service provided by medical-surgical service.

[c]Service not available at hospital.

[d]Upper constraint level.

[e]Lower constraint level.

utilization is at the 130 percent constraint. Forest City Hospital's utilization is at the 70 percent constraint. Utilization of the service in other hospitals ranges between the constraints. Intensive care services in Floyd County, Memorial, and Mitchell County Hospitals are utilized at the 130 percent constraint; this includes psychiatric service.

When this model solution (Model 7) is compared to a cost-minimizing solution using standard hospital patient day cost and the four-variable transportation cost function, also constrained to fall within the 70 to 130 percent constraints, almost no change in utilization patterns occurs. Only one marginal change in the utilization patterns occurs when the higher cost transportation function is used--a shift of obstetric services utilization from Hancock County Hospital to Mercy Hospital. Utilization patterns can be assumed relatively insensitive to changes in round-trip transportation costs within the ranges of the standard 15¢ per mile charge to 65¢ per mile distance to hospital. Thus, an emergency transportation network could be established without seriously affecting the continued existence of any hospital in the planning area.[26]

Model 8: Historic Utilization

The Model 8 solution is constrained within 5 percent of historic use patterns in the planning area.[27] An upward adjustment of 105 patient

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[26] It must be noted that Memorial Hospital fares poorly in competition with the other area hospital, regardless of the transportation cost function used.

[27] See Table 3.

days in Memorial Hospital's intensive care capacity was needed to correct an infeasibility (no solution was possible because of inadequate capacity) in the model solution. The model cost of $14,637,011.00 came as close to representing actual hospital care delivery costs (as defined in this study) as the programming technique allows.

Hospital and service codes are used in Models 8 and 9. The first two to four letters of the code in the range analysis table refer to the service; the last two numbers refer to a hospital.[28] The first two to three letters of the code in the resource shadow price table refer to the type of human resource; the last two numbers refer to the hospital number.[29]

Resource shadow prices (values imputed to resources in the model solution) are developed only for those resources that limit the effective capacity of each hospital. The shadow price, Table 13, presents the value to the program of one more unit of the resource. As might be expected, general practitioners have the highest value at $63,338.59. The same resource is not at the same price in different hospitals. The LPN004 value of $11,284.40 is the value imputed to one full-time equivalent

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[28] 1 - Belmond Community
2 - Buffalo Center
3 - Clarion Community
4 - Floyd County
5 - Forest City Municipal
6 - Franklin General
7 - Hancock County
8 - Kossuth County
9 - Memorial
10 - Mercy Hospital (St. Joseph)
11 - Mitchell County
MS - medical-surgical
PED - pediatric
OB - obstetric
IC - intensive care
PSYCH - psychiatric

[29] SP = specialist; GP = general practitioner; RN = registered nurse; LPN = LPN, nurses' aides and orderlies; MPS = specialized medical personnel; OPS = other personnel.

Table 13. Model 8: Resource shadow price.

Code	Per Unit of Resource
GP001	$63,338.59
RN002	32,429.57
LPN003	22,868.64
LPN004	11,284.40
MPS005	31,617.68
RN006	20,987.79
RN007	27,219.39
LPN008	20,805.92
LPN010	1,107.56
LPN011	6,356.71

of licensed practical nursing in hospital number 4 by the model solution. But, the value imputed to one full-time equivalent of the same resource varies from $22,868.64 in hospital 3 to $1,107.56 in hospital 10.

The resource shadow prices presented in Table 13 can only generally indicate the magnitude and range of resource valuation prices in the Model 8 solution.[30] They, nonetheless,are quite revealing. The imputed values for physician resources are in a reasonable relationship to the values for

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[30] Imputed resource prices have no necessary relationship to actual market prices of resources. They are imputed values within the context of a specific model solution. In a cost minimization model such as the one used, the imputed prices are dual values. As such, they represent the marginal value of the resource to the model solution. The value of resources used in the model solution is maximized, subject to the model solution cost being minimized [11].

other human resources. The most skilled resources are valued highest, and the least skilled resources are valued lowest. An additional unit of a human resource has a higher imputed value for a hospital with lower patient day costs than for one with higher patient day costs. Consider an LPN unit at Clarion Community Hospital (LPN003) at $22,868.64, compared to an LPN unit at Mercy Hospital (LPN010) at $1,107.56.

Model 9: Within 70 to 130 Percent of Historic Utilization

The model reflects the cost-minimizing hospital services utilization pattern, subject to the 70 to 130 percent constraints. Table 14 presents the utilization patterns of the Model 9 solution. Reduced costs available when utilization constraints are relaxed are indicated.

Substantial utilization shifts occur compared to historic utilization patterns. All hospitals' medical-surgical and pediatric services are utilized at the 130 percent constraint, except for Mercy and Memorial Hospitals. Memorial Hospital's medical-surgical services are utilized at the 70 percent constraint (12,493 patient days). Mercy Hospital's medical-surgical and pediatric services are utilized at 46,380 and 8,673 patient days, respectively, a decrease of 17,737 patient days in medical-surgical services utilization and an increase of 1,447 patient days in pediatric services utilization. Mercy Hospital services some pediatric patients historically serviced at Memorial Hospital.

Belmond Community, Buffalo Center, Clarion Community, Franklin General, and Hancock County Hospitals' obstetric services are utilized at the 130 percent constraint. Forest City Hospital's obstetric

services are utilized at the 70 percent constraint. Floyd County and Mercy Hospitals' obstetric services utilization decrease from historic levels (36 and 635 patient days, respectively). Utilization of Mitchell County and Kossuth County Hospitals' obstetric services increase slightly (12 patient days).

Intensive care services in Franklin General, Memorial, and Mitchell County Hospitals are utilized at the 130 percent constraint. Floyd County and Mercy Hospitals' intensive care services utilization decreases 285 and 91 patient days, respectively, from historic utilization patterns (to 910 and 1,520 patient days).

Also presented in Table 14 are reduced costs possible when hospital services constraints are relaxed one unit. Utilization shifts increase the solution cost only with Memorial Hospital's medical-surgical and Forest City Hospital's obstetrics services. The solution cost is unchanged or reduced in other situations.

Mercy and Memorial Hospitals each experience substantial services utilization loss to smaller, less expensive hospitals. These two hospitals have serviced approximately one-third of their historic utilization levels at a secondary care level. Secondary level care utilization accounts for less than 50 percent of total services utilized at the two hospitals in the Model 9 solution.

Appendix 4 presents the range analysis results of the Model 9 solution.

Table 14. Model 9: Hospital service utilization.[a,b,c]

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Belmond Comm.	7,125[f]	-[d]	672	-[e]	-[e]
Buffalo Center	3,050[f]	532[f]	432[f]	-[e]	-[e]
Clarion Comm.	8,139[f]	-[d]	499[f]	-[e]	-[e]
Floyd Co.	23,698[f]	2,140[f]	1,097	910	-[e]
Forest City Mun.	4,534[f]	-[d]	215[g]	-[e]	-[e]
Franklin Gen.	8,863[f]	-[d]	618[f]	143[f]	-[e]
Hancock Co.	7,393[f]	-[d]	979[f]	-[e]	-[e]
Kossuth Co.	8,674[f]	727[f]	767	-[e]	-[e]
Memorial	12,493[g]	-[d]	-[e]	1,420[f]	-[e]
St. Joseph Mercy	46,380	8,673	2,565	1,520	5,776
Mitchell Co.	18,048[f]	-[d]	1,054	476[f]	-[e]

[a]Model results constrained to be within 70-130 percent of historic utilization patterns.

[b]Four-variable transportation cost function.

[c]Standard hospital cost.

[d]Service provided by medical-surgical service.

[e]Service not available at hospital.

[f]Upper constraint level.

[g]Lower constraint level.

Table 14. (continued)

Hospital	Medical-Surgical	Pediatric	Obstetric	Intensive Care	Psychiatric
Reduced total cost to model from relaxing utilization constraints by one unit of service					
Belmond Comm.	39.41	0	41.49	0	0
Buffalo Center	62.96	39.53	30.54	0	0
Clarion Comm.	52.00	0	54.64	0	0
Floyd Co.	3.96	9.09	0	0	0
Forest City Mun.	22.30	0	+1.43	0	0
Franklin Gen.	39.25	0	23.82	106.69	0
Hancock Co.	35.34	0	2.47	0	0
Kossuth Co.	49.41	38.18	0	0	0
Memorial	+2.70	0	0	0	0
St. Joseph Mercy	0	0	0	0	0
Mitchell Co.	0	0	0	0	0

Six pieces of information are presented in the range analysis for each hospital service. Hospital services are identified by code.[31] The activity level indicates the level of utilization of a particular service in the model solution. Input cost indicates the patient day hospital cost of a day of that service. The lower activity and higher activity levels indicate the range within which utilization of a service can vary, and the per patient day cost penalties for varying (the last two columns) the utilization level from the model solution level are constant. The cost penalties indicate the amount by which the model solution cost increases or decreases as utilization varies. If utilization varies beyond that range, cost penalties change.

The range within which the per unit cost penalty is constant is proportionately much narrower for medical-surgical services than for intensive care or obstetric service. The only hospitals in which medical-surgical utilization can be varied by 620 patient days or less with invariant cost penalties for deviation from the optimal solution are Floyd County and Franklin General. Other hospitals' medical-surgical utilization can be varied up to as much as 2,794 patient days with constant per unit cost penalties. Obstetric services utilization generally can change by 130 patient days or more in each hospital without causing the size of cost penalties to change, except in the Buffalo Center Hospital where it can change 110 patient days. Pediatric services can change by at least 163 patient days. Intensive care services can change from 57 to 178 patient days in different hospitals.

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[31] See earlier Model 8 discussion related to hospital codes.

Cost penalties range from $106.90 to a low of 22 cents with highest cost penalties associated with lowest cost hospital services.

V. POLICY IMPLICATIONS

Unlimited resources are never available in a public or quasi-public decision setting to do everything the decision maker would like to do. Schools, roads, public transportation, law enforcement, etc. all complete with health care for a limited quantity of available public resources. Bonding capacity used on road building cannot be used to build hospitals and vice versa. It is incumbent, then, upon decision makers to carefully weigh the relative merits of publically funded or controlled projects [22]. Once decisions have been made to accomplish certain goals in an area of need, funds and resources must be committed wisely. Delivery of the maximum number of units of service supply for a given cost should be a prime decision criterion. Such a criterion is not pursued single-mindedly but in combination with other well thought-out criteria.

The quantitative results discussed in the model results do speak to a number of policy issues. The issues of adequate capacity in the present and future are among them. Emerging utilization patterns, compared to those perceived as optimal, is an issue. Expansion of hospital services, both in terms of quantity and quality, is an issue facing each community.

Capacity Questions

Based on minimum occupancy levels[32] developed by the Office of Comprehensive Health Planning, 115+ excess (unneeded) hospital beds existed in the planning area [12, Appendix C, Iowa Operating Procedures]. The excess capacity exists in each hospital in the planning area, except Memorial Hospital. However, each hospital market area has excess hospital services capacity. Indeed, Mason City has in both hospitals (Memorial and Mercy) an excess capacity of over 50 beds. Only Memorial Hospital has an acceptable occupancy ratio.

Many hospital financial management experts contend 85-90 percent occupancy is needed to operate reasonably priced hospital services at "break-even" income-expense levels. If this is true, an even larger amount of excess capacity exists in the planning area. For example, if 90 percent occupancy is the desired level, only 547 general acute care hospital beds are required rather than the 760 beds presently in place (1972).

It is possible to completely delete any one of four different area hospitals and still adequately service the patients in the remaining hospitals (Model 4).[33] Indeed, it is possible to delete Memorial Hospital

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[32] Minimum acceptable occupancy is derived using a Poisson probability distribution that takes into account the occurrence of a sudden sharp increase in service demand resulting from a natural disaster or disease epidemic.

[33] This would include smaller hospitals in counties with two hospitals (Belmond Community, Buffalo Center, and Memorial Hospitals) as well as Clarion Community Hospital, the hospital with the lowest utilization level in the planning area.

and satisfy service demand at slightly lower cost than with Memorial Hospital in the model solution (at 70 percent of historic utilization).

When hospital use preferences in the model are similar to actual preferences (Model 1), adequate capacity still exists in the system under both population Projections A and B. Projected utilization for 1985 increases slightly over 12,200 patient days with Projection B. Adequate capacity exists through 1985 with utilization constrained within 70-130 percent of historic levels. When hospital services are deleted (Model 4), using population Projection B,[34] ample capacity exists to satisfy services demanded.

Excess hospital services capacity would be 29,913 patient days in 1985 with Projection B. That is higher than the acceptable level.[35] The excess patient days convert to 82 excess beds. If a 90 percent utilization rate is required, 176 excess beds would exist in 1985.

No shortage of capacity for secondary level care is experienced if Mercy and Memorial Hospitals are the only hospitals providing that care. Model 4 solutions indicate Mercy Hospital has adequate capacity to service both hospitals' expected demand through 1985 for both primary and secondary care level services. Hospital services demand can be met without Memorial Hospital; and done at a lower cost than when Memorial Hospital is used. Capacity constraints in the hospital services capacity

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[34] B is the most likely population projection, with three-fourths decline in the 1950-60 migration rate and 2.110 completed fertility rate.

[35] Using Iowa of Comprehensive Health Planning formula [5].

would not be violated if Belmond Community, Buffalo Center, and Memorial Hospitals were to all cease operation.[36]

Utilization

The more expensive hospitals experience losses in service utilization compared with the smaller, less expensive hospitals. Utilization of at least medical-surgical services and often obstetric and pediatric services in the less expensive hospitals increases to the 130 percent constraint. That is assumed to be the greatest proportional shift that tastes and preferences of patients and hospital employees (primarily physicians' preferences) would allow (in the short or midterm planning horizon). The two Mason City hospitals are successful in retaining their intensive care service utilization. In the Model 6 solution, Mercy Hospital's utilization of services decreases substantially from historic levels, while no medical-surgical services are utilized at Memorial Hospital. On the other hand, Floyd County Hospital increases service utilization levels marginally, and the other hospitals increase substantially, many to their service capacity levels.

Service utilization patterns do shift substantially. In general, service demand is satisfied as close to the point of origin as possible. Primary care level providers (all hospitals, except Mercy and Memorial Hospitals) would thus experience increased utilization levels. The secondary care level hospitals would experience substantial decreases in

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[36] These are the smaller hospitals in each county with two hospitals. By 1976, Forest City will have a 15-bed capacity expansion in service. Capacity is adequate, however, without the expansion.

utilization levels. They would retain adequate utilization levels to service secondary care level demands and most of the demand for primary care services originating in Mason City.

Utilization shifts have implications for employment opportunities in planning area hospitals. Employment would decline in Mason City, remain approximately constant in Mitchell County and Floyd County Hospitals, and increase substantially in the remainder of the hospitals. Presumably, general practitioners would increase absolutely in numbers in all communities with hospitals, except Mason City. Their absolute numbers and the proportion of general practitioners might decline as utilization of hospital services in Mason City shifts proportionately toward secondary care level of service demand.

Possible savings

Yearly savings of $633.714.00 are realized by using the cost-minimizing solution constrained between 70 and 130 percent of historic utilization (the Model 9 solution) rather than the solution constrained within 5 percent of historic utilization (Model 8). If institutional barriers to utilization are removed and the solution can reflect unconstrained cost minimization (Model 6), an additional $757,632.00 yearly in savings can be achieved.

Patient day costs used in the models are based on historic occupancy levels. If a hospital moves down its average cost curve as occupancy increases, the shift toward utilizing that hospital's service is actually greater than the model solution indicates. The converse is also true. As a hospital loses utilization, its fixed costs are spread over fewer patient days of service, thus placing it at a greater competitive disadvantage.

Institutional constraint, such as physician and patient preferences and manpower availability, are in the short run. In the long run, over decades rather than years, preference functions of both physicians and patients can be expected to shift. Manpower and facility components of the hospital services delivery system are capable of moving toward a least-cost utilization configuration.

Further, care of patients demanding primary care level service by general or family practitioners (rather than specialists) could be expected to contribute further to savings.

Primary level hospital services care can be supplied as competently in one of the smaller planning area hospitals as in Mercy or Memorial Hospitals.[37] It is less expensive for the planning area to service such demand in local hospitals.

The model solutions question the idea that large hospitals must get larger and small hospitals must go out of existence. Dr. MacQueen has suggested small hospitals have a useful role in the future delivering primary level hospital care.[38] This research indicates that greater use of small hospitals may, in fact, reduce total hospital care cost and related expense for a planning area such as north Iowa.

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[37] This can reasonably be implied by JCAH accreditation of such hospitals.

[38] Personal communication with Dr. John MacQueen, Associate Dean, College of Medicine, University of Iowa, Iowa City, 1974.

The concept of supplying service at the lowest access level[39] consistent with quality and competence of care is at issue. A systems approach is implied with primary care level hospitals referring to secondary care level hospitals' patients, requiring a more sophisticated level of care than they can deliver.

An emergency transportation and communication network connecting the hospitals is a logical deduction, and useful extension, from the foregoing analysis. Hospitals at a primary care level in such a system would not need to possess capability to deliver seldom-used procedures. Such service demand could be delivered at a secondary care level hospital where equipment and human skills needed would be used more fully and thus more efficiently (and, as many health care providers feel, more competently).

Larger hospitals are more expensive, in part, because of the more sophisticated service capability they have. Usually, hospitals spread the cost of such capability over all patients. Thus, persons using Memorial or Mercy Hospitals for services that could have been delivered by Kossuth County or Franklin General Hospitals help to pay for the secondary care level services required by someone who needs very sophisticated treatment. The study results support the need for a mix of both kinds of hospital services. But the mix suggested is not that which appears to be emerging.

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[39] Meaning in this context, closest to the patient demanding the service.

Considerable pressure exists to build into every hospital the most sophisticated capability that hospital can acquire. For larger and smaller hospitals to continue expansion well beyond demonstrated need is both destructive to an integrated systems approach to health care and more expensive to public and private supporters and users of the hospital services than is necessary. Such activity constitutes an open invitation to closer federal and state regulation and procedure review of hospitals and physicians.

Capacity and Capability Expansion

Actual need for more room in a hospital is only one reason for planning expansion. When those who pay for hospital services also decide on the capacity and level of hospital services delivered, efficiency in producing those services can be achieved. Frequently, those who make such decisions are not the same people who use the service and pay the cost. The cost of such decisions is added to all patients' hospital bills as well as to the health insurance premiums of everyone within the hospital's market area.

To the extent that decision makers and service users are not composed of the same people, an economic externalities[40] is created. Those who add to service capability or capacity are implicitly driving the marginal benefit of such expansion to equality with the perceived marginal cost of the expansion. But since decision makers do not bear

[40] An externality is said to exist when marginal social cost is not equal to marginal social value.

the full cost, the expansion continues past the true marginal equality of benefit and cost. Only those costs explicit to the decision makers, an incomplete accounting of costs, are considered. Thus, excess capacity and capability frequently result. The solution to this problem is to consider all benefits and costs deriving from and accruing to the expansion when making the decision. Including consumer representation in the decision process and making information of costs and benefits available to participants allows more responsible decision making. Thus, efficiency of resource use and product distribution is facilitated.

Imputed resource value data supports the assertion that savings are available to the planning area. An additional man-year of health care provider's time is more valuable in the smaller, outlying hospitals in the area than in a Mason City or Charles City hospitals. An additional worker in the LPN category in Belmond Community or Franklin General Hospital adds more to minimum cost satisfaction of services demand than one in Mercy or Memorial Hospitals. One additional physician practicing in the Franklin General Hospital is a more valuable human resource to the planning area than one additional physician practicing in Mercy Hospital. This is not to suggest that each small community should have its own physician on grounds of efficiency of resource use. Rather, model solutions infer support for a policy encouraging the location of physicians and other skilled health care workers in communities with hospitals (or continguous communities).

Such a location policy implies, again, a systems approach to hospital services delivery and a broad range of health care services.

Continuing education opportunities must be available to physicians and other health care workers in smaller communities and hospitals. Emergency transportation networks are implicitly necessary. Health planning councils or like groups have an important planning and implementation role in such a policy setting.

Physicians and hospital administrators may have incentives to upgrade the level of capacity of a hospital not associated with actual need. Community leaders know a hospital brings business to town. The local hospital often generates the largest payroll in the community. Hospital facilities are sometimes expanded or upgraded to place an institution or community in a better competitive or survival position. Strong pressures often develop within a community to expand or upgrade its hospital services capability. These institution too seldom view themselves as part of an integrated system. Rather, the common view is to expand quickly to get the jump on another hospital or community. The result of independent expansion is an excess of hospital services capacity and capability. Care is then delivered at a higher-than-necessary cost. When hospital expansion is used to spur economic development, a community must decide whether there are more efficient or less costly means of achieving that development; or whether, indeed, the investment will spur development.

Not all institutions have to be judged by the same criteria. A community may have two hospitals that provide complementary rather than competitive services. Sometimes a community desires excess capacity in

hospital services as an implicit safety net. The question to be answered is whether that safety net could be provided less expensively by an integrated emergency transportation system.

Communities opting for higher-than-necessary costs in delivery of public or quasi-public services should do so consciously. A project should not be justified on spurious grounds. An honest dialogue among the medical community, community decision makers, and consumers, both at the community and area health planning levels, is called for. Those affected by decisions, and expected to finance plans and programs, should have input into the process whereby decisions are made. This contention is based on the premise that such an "open" decision process leads to the best policy decisions.

Sound decisions require good information. The pros and cons of possible alternatives must be weighed. Quantitative as well as more subjective types of data are needed. Sociocultural as well as economic evaluations must be made. Constructive decision making requires the creative balancing of both quantitative and qualitative criteria.

Usefulness of Model

The methodology developed in this report has usefulness in many specific problem settings as does the mathematical programming model developed here. The methodology provides a solid foundation upon which health planners can conduct data gathering and analysis in hospital services planning. The mathematical programming model built for this project is readily generalized to other settings. It can be used almost entirely intact in other multicounty hospital services planning projects in nonmetropolitan settings. The basic model size can be easily expanded to encompass a larger geographic area, even an entire state. Additional hospital services activities, demand-generating activities, and transportation activities can readily be identified and added to the model. The model format for identifying activities is also suitable for adding more activities. The demand-generating coefficients are readily adjusted to account for unmet needs and changes in demand patterns.

The mathematical programming model is readily adapted to analysis of other health services delivery systems in a planning framework. Little model adaptation is required to analyze delivery of nursing home services. The model could readily be adapted for use in planning locations of physician assistants' outposts and location of emergency transportation vehicles and crews. The methodology developed provides a logical framework for analyzing a number of public and quasi-public service problems. Law enforcement problems are amenable to analysis using this methodology. For example, patrol car locations could be activities and possible targets of criminal activity demand-generating activities. Planning the locations of educational facilities could also be facilitated using this methodology. The programming model can be adapted to an educational enterprise setting.

VI. SUMMARY

Study Problem and Objectives

The North Iowa Health Planning Council has authority within certain guidelines to approve or reject proposals for health care service capacity or capability change [5]. The Council is composed of health care providers, governmental units, and consumer representatives. It is empowered to draw a comprehensive long-range plan for health care delivery in that planning area. The Planning Area is largely rural, 10 counties in size, and under 190,000 population. Professional assistance was needed to identify, collect, and analyze data supportive of the Council's decision process.

Questions are being asked about the adequacy of hospital services capacity in the future: If a hospital expanded its services or ceased to function, what impact would that have on the area hospital services system? What would happen to area utilization patterns if physician manpower decreased in a community? What effect would high transportation cost or cost minimization have on utilization patterns? How large would potential savings be from least-cost satisfaction of hospital services demand? A linear programming model was constructed to answer these questions in a simulation frame of reference. The model constructed can be generalized to answer similar questions in other health planning area.

The Programming Model

The model develops an optimal cost-minimizing solution allocating patient days of service demand to hospital services so that the summation of patient day service costs and transportation costs is minimized. The model deals with the marginal redistribution of service utilization among five major services extended by hospitals in a geographic planning area. The services are: (1) medical-surgical; (2) obstetrics; (3) pediatrics; (4) intensive care; and (5) psychiatric. The model has a set of 38 production activities supplying hospital services. A set of 35 services demand sectors is geographically defined. Each demand sector contains four service demand activities categorized by age cohort. The production activities and the service demand activities are linked by a network of 551 transportation activities.

Data needs of two types are experienced: utilization and origin data; and service capability, resource, and cost data. These data are developed by survey of the 11 hospitals in the ten-county area and from secondary data sources.

The model is a cost-minimization model. Demand-generating coefficients and transformation coefficients developed are specific to the geographic area and planning area hospitals. Patient day services costs are developed from cost data collected by survey instrument. Transportation costs are a summation of patient and visitor time cost and mileage cost.

Certain institutional and attitudinal constraints confine the movement of patient demand to least-cost services. These include

preference functions of admitting physicians and their patients. Recognizing the inability to accurately specify such constraints, model solutions are constrained to range within 70 to 130 percent of historic utilization patterns. Solutions constrained only by hospital service capacity are also run.

Model Results

Nine models of the North Iowa Health Planning Area hospital services system are constructed. The models are solved under a variety of constraints related to levels of utilization, population change, manpower availability, service capacity, and cost.

Hospital services capacities are adequate to accommodate, within 70 to 130 percent of historic utilization, anticipated demand through 1985. Marked shifts in utilization patterns do occur. Small hospitals delivering primary care level services gain substantially in utilization at the expense of large hospitals delivering both primary and secondary care levels of service. Patients seek hospital services closer to home. Shifts in manpower demands occur. Additional manpower resources in smaller, outlying hospitals (those delivering primary care level services) contribute more to cost minimization for the planning area than additional manpower resources in Mason City and Charles City hospitals. Yearly savings approaching $1,400,000.00 are conceptually possible with cost-minimizing utilization patterns.

Policy Implications

Model solution results do have important implications for policy makers. Excess hospital services capacity of 115+ beds exists in the North Iowa Health Planning Area. Excess capacity exists into 1985 in all hospital trade areas within the health planning area. Substantial utilization shifts toward less costly smaller primary care level hospitals occur in all model solutions. Such shifts have important implications for planners considering system capability and capacity, recruitment of physicians and skilled health care professionals, emergency transportation and communication, and health care professionals' training and continuing education programs. Federal and state governments as well as third-party payers are increasingly concerned about cost effectiveness and cost minimization in health care delivery.

Smaller hospitals delivering primary care level services have an important role in a systems approach to delivering hospital services. The need to develop service capability in response to demand within an integrated systems framework is emphasized. Hospitals and communities competing with each other by excessive expansion or facilities investment assure patients of higher cost service than is necessary and invite further government regulation and control.

Decision makers deciding on expansion programs are frequently not the same persons who pay the cost of the expansion. Consumers may be paying for higher cost health care, particularly hospital services, than they want to. Health planning councils can bring effective consumer representation into the decision-making process.

This research methodology has value as a model for hospital services and health services analysis in other multicounty health planning areas. The linear programming model can directly be used in other planning areas to analyze the effects of changes in hospital services systems. Minor adaptation allows the model to be used when studying other health services delivery systems. Analysis of changes in law enforcement or educational systems are possible. The major use of this methodology and model is expected to be in nonmetropolitan areas.

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Appendix Table 1. Percentage origin of hospital patients by county

Origin of patients	Mason City Mercy	Mason City Mem.	Floyd Co.	Franklin Co.	Hancock Co.	Kossuth Co.	Mitchell Co.	Buffalo City	Forest City	Belmond Comm.	Clarion Comm.
Butler County	1.1	0.4	5.0	19.0			0.1				
Cerro Gordo County	59.7	58.7		1.2			2.5		2.0	4.2	
Floyd County	4.7	3.6	89.0	0.2			10.3				
Franklin County	5.0	3.2		66.1						6.2	0.8
Hancock County	5.1	2.8		0.3	75.0	3.0	0.1	5.0	5.1	30.3	0.4
Kossuth County	2.1	8.5		0.1	19.0	92.0		15.0		1.4	2.3
Mitchell County	1.0	1.2	2.0				68.2				
Winnebago County	4.9	5.0		0.1	4.0		0.3	75.0	83.2	0.5	
Worth County	7.3	7.6					2.1		5.4		
Wright County	2.6	2.3		4.6						50.4	82.8
Total ten-county area	93.5	93.2	96.0	91.5	98.0	95.0	83.6	95.0	95.8	93.2	86.3
Counties contiguous to area	4.2	5.1	4.0	6.5	2.0		6.0			5.0	10.0
Rest of Iowa	0.8	0.8		1.2		5.0	0.4		2.3	1.0	2.3
Minnesota contiguous counties	0.2	0.3					8.7	5.0	1.2		
Rest of Minnesota	0.7	0.1					0.7				
Other states	0.6	0.4		0.8			0.6		0.7	0.8	0.4
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Appendix Table 2. Manpower resources available.

Hospital	Physicians: General Practitioners	Physicians: Specialists	Registered Nurse	Licensed Practical Nurse	Medical Specialized Personnel	Other Specialized Personnel
Belmond Comm.	5	1	7	11	5.5	2
Buffalo Center	2	2	6.25	6	2	0
Clarion Comm.	6	1	11.4	19	5	2.7
Floyd Co.	14	7	30	46.8	7.5	5.4
Forest City Mun.	2	1	6.4	8	3	1.7
Franklin Gen.	4	3	15	13	3.85	3.03
Hancock Co.	5	0.1	9	16.8	2.0	0.4
Kossuth Co.	5	1	15	20	5	2
Memorial	0	19	28.5	38.5	2	3
St. Joseph Mercy	19	48	119	197.1	52	13
Mitchell Co.	7	2	18.5	37.5	4	3.8

Note for Appendix Table 3

The hospital revenue and expense form in Appendix Table 3 is used to collect necessary data for calculating hospital service patient day costs. For this purpose, revenue is not considered. Cost data is available on a fiscal or calendar year basis. Utilization data should be collected on as close to the same basis as possible. This data is converted to patient day costs using the aggregations and allocations described below.

The following listing of items to include are completely allocated to the service indicated:

Service	Items to Include
Medical-Surgical	1,2,3
Pediatric	9
Obstetric	6,7,8
Intensive Care	4,5,12,17
Psychiatric	19

Items 13 and 14 are allocated to medical-surgical, pediatric, and obstetric services on a utilization proportion basis.

Items 11, 16, and 20 are allocated to medical-surgical, pediatric, obstetric, and intensive care services on a utilization proportion basis.

The following listing of items is allocated to medical-surgical, pediatric, obstetric, intensive care, and psychiatric services on a utilization proportional basis: 18, 21, 22, 24-25, 33-38, 41, 43, 47, 48.

Item 45 is allocated to the proper service categories on the same basis that all other salary-related costs are allocated.

Cost items in each service category are summed. Total service costs are then divided by patient days' utilization of each service to arrive at patient day costs for each service.

The critical concern in collecting such data is that each data category is interpreted the same way in each hospital from which data are collected. Thus, cross comparability among data sets is achieved. The programming technique makes use of the relative magnitudes of patient day costs for the utilization being allocated rather than the absolute magnitudes.

Appendix Table 3. Hospital revenue and expense statement (for most recent fiscal year).

Service Category	Revenue	Operating Expense				Other (Specify)	Total
		Salary	Supplies	Fees	Misc.		
1. Medical	___	___	___	___	___	___	___
2. Surgical	___	___	___	___	___	___	___
3. Operating room	___	___	___	___	___	___	___
4. Intensive care	___	___	___	___	___	___	___
5. Coronary care unit	___	___	___	___	___	___	___
6. Obstetrical	___	___	___	___	___	___	___
7. Delivery room	___	___	___	___	___	___	___
8. Labor rooms	___	___	___	___	___	___	___
9. Pediatric	___	___	___	___	___	___	___
10. Outpatient clinic	___	___	___	___	___	___	___
11. Emergency room	___	___	___	___	___	___	___
12. Intravenous therapy	___	___	___	___	___	___	___
13. Anesthesiology	___	___	___	___	___	___	___

Appendix Table 3. (continued)

Service Category	Revenue	Operating Expense				Other (Specify)	Total
		Salary	Supplies	Fees	Misc.		
26. Long-term care	___	___	___	___	___	___	___
27. Gross patient services revenue	___						
28. Gross patient services expense		___	___	___	___	___	___
29. Deduction from revenue							___
A. Adjustment for bad debts							___
B. Contractual adjustments							___
C. Other adjustments							___
30. Total deductions							___
31. Other operating revenue							___
32. Subtract total of Line 28 from total of Line 27; subtract Line 30; then add Line 31 to the result. This equals total adjusted operating revenue.							___

Appendix Table 3. (continued)

Service Category	Revenue	Operating Expense					
		Salary	Supplies	Fees	Misc.	Other (Specify)	Total
14. Inhalation therapy							
15. Renal dialysis							
16. Whole blood							
17. Electrocardiology							
18. Lab. - Pathology							
19. Psychiatric							
20. Radiology-Diagnostic							
21. Pharmacy							
22. Nursing services administration							
23. Ambulance							
24. Medical records							
25. Central services administration							

Appendix Table 3. (continued)

Service Category	General Services Expense					
	Salary	Supplies	Fees	Misc.	Other (Specify)	Total
33. Dietary food services						
34. Plant engineering and maintenance						
35. Buildings and grounds						
36. Housekeeping						
37. Laundry and linen						
38. Credits and collections						
39. Total general services expenses (sum of Lines 33-38)						

Appendix Table 3. (continued)

Fiscal services expense

40. Administrative and general--

A. Salary ________
B. Fees ________
C. Supplies and office expense ________
D. Telephone and telegraph ________
E. Dues and memberships ________
F. Travel ________
G. Insurance ________
H. Miscellaneous ________

41. Total administrative and general expense ________

42. Depreciation--

A. Major moveable equipment ________
B. Provision for replacement of lessor's equipment ________
C. Building depreciation ________

43. Total depreciation ________

Appendix Table 3. (continued)

Fiscal services expense (cont.)

44. Employee's benefits--

A. Social security ________
B. Group life and health ________
C. Workmen's compensation ________
D. Other ________

45. Total employee's benefits ________

46. Rent

A. Equipment rentals ________
B. Building rentals ________

47. Total rent ________

48. Interest on notes and bonds ________

49. Total fiscal services expense ________

Appendix Table 4. Model 9: Range analysis: Hospital services activities.

Hospital	Activity	Input Activity	Lower Activity	Upper Activity	Cost Penalty for Decreasing Activity Level	Cost Penalty for Increasing Activity Level
MS00S01	7,125	$ 54.74	6,837	8,466	$ +39.41	$ -39.41
OB00S01	672	48.50	497	676	+41.49	-41.49
MS00S02	3,050	54.25	1,824	4,590	+62.96	-62.96
PED0S02	532	54.25	361	578	+39.53	-39.53
OB00S02	432	37.64	428	538	+30.54	-30.54
MS00S03	8,139	54.74	7,851	8,938	+52.00	-52.00
OB00S03	499	48.50	324	503	+54.64	-54.64
MS00S04	23,698	63.15	23,395	24,015	+3.96	-3.96
PED9S04	2,140	49.94	1,977	2,213	+9.09	-9.09
OB00S04	1,097	98.71	796	1,272	+5.53	+4.44
IC00S04	910	104.00	853	910	+30.61	-[a]
MS00S05	4,534	74.30	3,308	6,102	+22.30	-22.30
OB00S05	215	80.20	191	540	-1.43	+1.43
MS00S06	8,863	53.11	8,560	9,180	+39.25	-39.25
OB00S06	618	84.32	510	764	+23.82	-23.82
IC00S06	143	63.04	64	237	+106.69	-106.69
MS00S07	7,393	61.25	6,167	8,806	+35.34	-35.34
OB00S07	979	56.39	955	1,085	+2.47	-2.47

[a]Figures are meaningless since activity level is at both upper and lower activity level associated with constant change in cost.

Appendix Table 4. (continued)

Hospital	Activity	Input Activity	Lower Activity	Upper Activity	Cost Penalty for Decreasing Activity Level	Cost Penalty for Increasing Activity Level
MS00S08	8,674	$ 67.35	7,448	10,242	$ +49.41	$ -49.41
PED0S08	727	67.37	311	1,226	+38.18	-38.18
OB00S08	767	73.50	743	873	+7.26	+11.09
MS00S09	12,493	70.94	11,061	14,061	-2.70	+2.70
IC00S09	1,419	125.81	1,363	1,541	+17.99	-17.99
MS00S10	46,380	68.17	43,912	46,683	+2.70	+3.96
PED0S10	8,673	54.15	8,673	8,836	-[a]	+9.09
OB00S10	2,565	95.29	2,448	2,755	+0.22	+1.76
IC00S10	1,520	143.55	1,520	1,578	-[a]	+17.99
PSYCS10	5,776	61.94	5,776	5,776	-[a]	-[a]
MS00S11	18,048	53.68	16,286	18,365	+5.08	-5.08
OB00S11	1,054	85.89	863	1,171	+1.76	+0.22
IC00S11	476	96.88	419	545	+36.61	-36.61

Appendix Table 5. Planning Area Hospital Capacities

	Belmond Comm.	St. Joseph Mercy	Memorial Hospital	Floyd Mem.	Franklin Gen.	Hancock Co.	Kossuth Co.	Mitchell Co.	Forest City	Buffalo Center	Clarion Comm. Mem.
Medical	26	102[a]	62	69	48	26	32	34	18	11	38
Surgical	-[b]	136	-[b]	-[b]	-[b]	-[b]	-[b]	20	-[b]	-[b]	-[b]
Obstetrical	4	15		8	4	6	6	8	2	4	6
Pediatrics		35		6			2			2	
Psychiatric		24									
Rehab/Phys. ther.											
Extended care					10						
Long term care					30						
Other	30	312		6							
Total			62	89	92	32	40	62	20	17	44

[a]Included in ICU/CCU.

[b]Included in medical beds.

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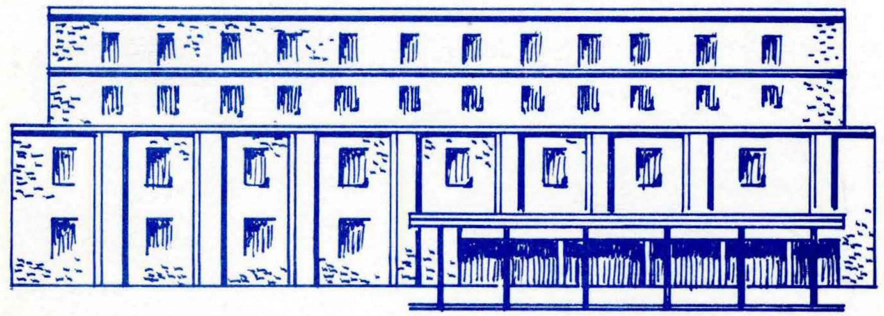

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