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A Budget Planning Model for Health Care Hospitals

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ABSTRACT

This paper is devoted to the application of goal programming to Health care planning. More specifically, the paper presents the goal programming approach to the budget planning of health care Hospitals and drawing valid decisions for further improvement in future not only for healthcare but also for quality healthcare administration and resources.

Key Words: Financial Catastrophe, Business Manager, Optimization Techniques, Health Service

1. INTRODUCTION

The problems facing the hospital administrator in resource allocation and capital budgeting stem primarily from the unique decision environment in which he is placed. Capital budgeting in hospitals is uniquely complex due to funds limitations; the existence of multiple objectives encompassing both quality and quantity of hospital services; difficulties surrounding the measurement of output; and the necessity for setting priorities that satisfy the hospital's medical staff, board of trustees and administration. Moreover, rising medical costs make the need for better decision making within the hospital all the more urgent. As a reflection of the political, social and economic demand for more effective decision making.

This calls for better decision making techniques that can be justified a both the planning agency level and the hospital level. The pioneering work in analyzing investments in health was done by **Greene** [1] who proposed the use of cost-benefit analysis. However, this method has been criticized because of difficulties involved in determining the Rupee value of benefits associated with hospital investments and a number of other factors including the selection of an appropriate discount rate, project valuation in imperfect markets and associated shadow rates, the necessity for setting priorities and evaluating multiple hospital objectives, considering doctor-hospital relationships and spillover effects. Moreover, in the case of capital rationing and indivisibility of inputs, **Weingartner** [2] has shown that a ranking method such as cost-benefit analysis will not necessarily produce an optimal solution. **Kwak** [3] and later **Chatburn** [4] proposed the use of linear programming in order to deal with the problem of capital rationing common to the hospital setting. However, this solution does not deal adequately with the problem of indivisibility of inputs. Finally, the use of integer programming was suggested by **Bush** [5] in order to overcome this problem. While the

existence of multiple conflicting goals within the hospital is well documented, the precise goals and their priority rankings have been debated for over 60 years beginning with **Robinson** [6], who defined hospital goals as care of the sick, medical education, prevention of disease, and advancement of research. Other more recent studies have identified the hospital goal as being some combination of quality and output for all the various hospital "products," which are made conflicting by the limited resources available to the hospital. Thus, each hospital's goals will vary depending upon its particular teaching-research-product mix. In any case, the appropriate view of the hospital is one that recognizes the multiplicity and complexity of its products and goals, whether defined in terms of services, patients treated, end results, or health level contributions.

The situation is further complicated by limited resources. The objectives of the typical nonprofit organization are by their very nature designed to keep it constantly on the brink of financial catastrophe, for to such a group the quality of the services it provides becomes an end in itself. This is especially true in the hospital where these goals constitute bottomless receptacles into which limitless funds can be poured. As practicality dictates that funds cannot be limitlessly funneled into hospitals to improve quality or satisfy other goals, some binding capital constraint must be imposed. Thus, the hospital typically attempts to maximize a set of conflicting goals subject to some binding resource limitation. The purpose of this paper is to preset a model capable of dealing with the problems of multiple conflicting goals, indivisibility of projects, and capital rationing which characterize the unique decision environment of the hospital administrator.

2. DATA OF THE PROBLEM

The characteristics of the budget planning model for the clinic are based upon many factors, such as the type of clinic, the medical specialty, the location and size of the clinic, etc. Hence, it is difficult to design a general model that can be applied to all types of Hospitals. However, once a budget planning model is developed, it can be modified to fit many other types of Hospitals. This study was carried out to NIMS, Hyderabad. Some data was taken as hypothetical which was not obtained from the hospital records. The scope of this study is limited, however, to the planning horizon of one year. It is felt that this limited scope will allow a clearer presentation of the model development. Once it is completed for a year, the basic model can be expanded for a longer planning horizon by forecasting parameter changes. It is solely concerned with the treatment of patients in need of neuro car on an outpatient basis. Personnel employed by the clinic are:

12 Nuero Surgeons
8 Full-time and 8 Part-time Nurses
2 Full-time and 4 part-time Ultrasound Technicians
2 Full-time 4 Part-time CT scan Technicians
2 Business Manager
8 Secretaries
4 Receptionists
8 Office Personnel
10 Maintenance Personnel
2 Purchase personnel
4 EDP personnel
2 Patient Counselors

The doctors schedule their services in such a manner that they can treat their patients at the clinic. However, they are responsible for filling the neuro needs of two hospitals in the city.

The doctors billing is handled through the clinic for all their services and provide the sole income to the business itself.

Tables 1 and 2 outline the pertinent information needed for this study. The salaries given are an average of the salaries earned by each person in the individual category. The number of hours stated as being the physician's weekly hours is necessarily an average: however, the physicians are salaried, so the figure given by multiplying the hours/ week by the salary/hour will be an accurate average for twelve doctor's income. Figures given for machines, medical, and administrative & miscellaneous expenses are accurate. The total number of patients seen at the clinic is not a measure of individual patients, since it would be virtually impossible to determine this figure because of the number of patients who have more than one visit per year. This does not affect the accuracy of the model, however, since there is no contract or group plan billing system. The information found, in the tables is a compilation of operating revenues and expenses for the past year. In order to provide for the rising costs of the coming year. However, the average salary increase for the clinic's personnel is set at 10%.

Table1 : Clinic personnel, working hours and wages

Position	No. of employed	Hours/ Week	Total Hours/ Position/ Year	Salary/ Hour	Salary after 10% increase	Priority for wage increase
Neuro Surgeon	12	45 each	28080	600	660	12th
Full-time Nurse	8	35 each	14560	80	88	6th
Part-time Nurse	8	20 each	8320	65	72	7th
Full-time ultrasound Tech.	2	40	4160	65	72	1st
Part-time Ultrasound tech.	4	20 each	4160	65	72	8th
Full-time C.T. Scan Tech.	2	40	4160	80	88	2nd
Part-Time C.T. Scan Tech.	4	20 each	4160	80	88	9th
Business Manager	2	40	4160	220	222	14th
Secretary	8	40 each	16640	55	61	3rd
Business Office Personnel	4	40 each	8320	45	50	5th
Receptionist	4	40 each	8320	45	50	4th
Maintenance personnel/ House Keeping	10	14 each	7280	35	39	10th
Purchase Personnel	2	10 each	1040	40	44	15th
EDP personnel	4	45 each	9360	40	44	11th
Patient counselors	2	20 each	2080	300	330	13th

: 2 Patients, Expenses and Equipment Replacement

Patients

Total patients last year	=	49,200	
Expected increase for coming year (8%)	=	3,936	
Total expected patients for planning year	=	53,136	
Average charge per patient	=	979.02	(As Total Rs.4,81,67,818 last year)

Expenses	**Total for the Past Year**	**Average Per Patient**	**Average/ Patient After 8% Increase**
Ultra Sound	8,85,600	18	19.44
C.T. Scan	46,74,000	95	102.60
Medical Supplies	10,33,200	21	22.68
Administrative and Miscellaneous	42,31,200	86	92.88

Reserves for other Expenses

1 Ultra Sound replacement	Rs.	12,00,000	
8 Computer		1,60,000	
Retirement Fund		10% of total salaries	
Continuing Education of Doctors	Rs.	10,00,000	(Rs.8,00,000 last year)

3. GOAL PROGRAMMING MODEL

Goal programming is an extension and modification of linear programming which allows the business manager to more closely simulate real-life situations. Both linear and goal programming are optimization techniques which lend themselves to increasing the rationality of decision-making. The foremost value of goal programming is in its facility for solving problems with hierarchically arranged, conflicting goals. While there are presently certain limitations of goal programming which may slightly narrow the scope of its feasibile applications, it is believed that its potential for health care budget problem solving.

The basic goal programming problem is formulated as follows:

$$\textbf{Min } Z = \sum_{i=1}^{n} (d^-_i + di^+)$$

Such that $\bar{A}X + \bar{I}\,di^- - \bar{I}di^+ = \bar{B}$

and $X, d^-, d^+ \geq 0$

Where $\bar{A}$ is a *nxn* matrix, I is an *nxn* identity matrix and $\bar{B}$ is an component column vector.

Model formulation :
1) Define the variables and constraints
2) Formulate the constraint equations
3) Develop the objective function

3.1 Variables

x_1 = New hourly pay rate for physicians
x_2 = New hourly pay rate for full-time nurse
x_3 = New hourly pay rate for part-time nurse
x_4 = New hourly pay rate for full-time Ultrasound technician
x_5 = New hourly pay rate for part-time Ultrasound technician
x_6 = New hourly pay rate for full-time C.T. Scan Technician
x_7 = New hourly pay rate for pat-time C.T. Scan technician
x_8 = New hourly pay rate for business manager
x_9 = New hourly pay rate for secretaries
x_{10} = New hourly pay rate for office personnel
x_{11} = New hourly pay rate for receptionists
x_{12} = New hourly pay rate for maintenance personnel
x_{13} = New hourly pay rate for purchase personnel
x_{14} = New hourly pay rate EDP personnel
x_{15} = New hourly pay rate for patient counselors
x_{16} = Retirement fund
x_{17} = Fund for continuing education of physicians
x_{18} = Expenses for new Ultrasound machine
x_{19} = Expense for new computers
y_1 = Required No. of physicians' hours/year
y_2 = Required No. of full-time nurse hours/year
y_3 = Required No. of part-time nurse hours/ year
y_4 = Required No. of full-time Ultrasound technician hours/ year
y_5 = Required No. of part-time Ultrasound technician hours/year
y_6 = Required No. of full-time C.T. Scan technician hours/year
y_7 = Required No. of part-time C.T. Scan technician hours/year
y_8 = Required No. of business manager's hours/year
y_9 = Required No. of secretaries' hours/year
y_{10} = Required No. of business office personnel hours/ year
y_{11} = Required No. of maintenance personnel hours/year
y_{12} = Required No. of maintenance personnel hours/ year
y_{13} = Required No. of purchase personnel hours/year
y_{14} = Required No. of EDP personnel hour/year
y_{15} = Required No. of patient counselors hours/ year
z_1 = Ultra sound expenses per patient
z_2 = C.T. Scan expenses per patient
z_3 = Medical expenses per patient
z_4 = Administrative and miscellaneous expenses per patient
z_5 = Average charge per patient

3.2 Goals

The business manager must determine the economic goals of the clinic for the coming year in order to establish the budget planning model. The business manager lists the following goals in descending order of importance:

1. Provide job security to all personnel by avoiding underutilization of their regular working hours.

2.Provide an adequate (10%) wage increase to all personnel in keeping with the economic trend (see Table 1 for priority weights).
3.Provide funds for expense per patient.
4.Provide funds for equipment replacements.
5.Provide reserve for the retirement fund.
6.Provide funds for continuing education fund.
7.Achieve the break even goal in the operation.

3.3 Formulation of Goal Constraints

With the data defined in Table (1) & (2), the GP model constraints for budget planning are formulated as follows:

A. Wages It is desired that all personnel receive a 10% increase over the past year.

$x_1 + d^-_1 - d_1^+ = 660$ ……. (1)
$x_2 + d^-_2 - d_1^+ = 88$ …… (2)
$x_3 + d^-_3 – d_3^+ = 72$ …… (3)
$x_4 + d^-_4 – d_4^+ = 72$ …… (4)
$x_5 + d^-_5 – d_5^+ = 72$ …… (5)
$x_6 + d^-_6 – d_6^+ = 88$ …… (6)
$x_7 + d^-_7 – d_7^+ = 88$ …… (7)
$x_8 + d^-_8 – d_8^+ = 222$ …… (8)
$x_9 + d^-_9 – d_9^+ = 61$ …… (9)
$x_{10} + d^-_{10} - d_{10}^+ = 50$ …… (10)
$x_{11} + d^-_{11} - d_{11}^+ = 50$ …… (11)
$x_{12} + d^-_{12} - d_{12}^+ = 39$ …… (12)

B. Expenses

(i) Retirement Fund

The Retirement fund = 10% of the total yearly salaries

x_{16}– 0 .10[28080x_1+ 14560x_2 + 8320x_3 + 4160x_4 + 4160x_5 + 4160x_6 + 4160x_7 +4160x_8 + 16640x_9 + 8320x_{10} + 8320x_{11} + 7280x_{12} + 1040x_{13} +9360x_{14} + 2080 x_{15}]+$d^-_{16} – d^+_{16}$=0 …… (13)

(ii) Continuing Education Fund

$x_{17} + d^-_{17} – d^+_{17} = 10,00,000$ …… (14)

(iii) **Ultrasound Replacement Fund**
The estimated cost for a new machine is 13,50,000
The estimated salvage on old equipment Rs.1,50,000.00
$x_{18} + d^-_{18} – d^+_{18} = 12,00,000$ …… (15)

(iv) Computer Replacement Fund

Eight new computes are needed at the cost of Rs.30,000 each. The estimated total salvage on old equipment is 80,000.

$x_{19} + d^-_{19} – d^+_{19} = 1,60,000$ …… (16)

C. Personal Requirement:

It is determined that the present personnel manpower level will be adequate to provide satisfactory service to the patients.

$y_1 + d^-_{20} - d_{20}^+ = 28{,}080$ ..... (17)
$y_2 + d^-_{21} - d_{21}^+ = 14{,}560$ ..... (18)
$y_3 + d^-_{22} - d_{22}^+ = 8{,}320$ ..... (19)
$y_4 + d^-_{23} - d_{23}^+ = 4{,}160$ ..... (20)
$y_5 + d^-_{24} - d_{24}^+ = 4{,}160$ ..... (21)
$y_6 + d^-_{25} - d_{25}^+ = 4{,}160$ ..... (22)
$y_7 + d^-_{26} - d_{26}^+ = 4{,}160$ ..... (22)
$y_8 + d^-_{27} - d_{27}^+ = 4{,}160$ ..... (23)
$y_9 + d^-_{28} - d_{28}^+ = 16{,}640$ ..... (24)
$y_{10} + d^-_{29} - d_{29}^+ = 8{,}320$ ..... (25)
$y_{11} + d^-_{30} - d_{30}^+ = 8{,}320$ ..... (26)
$y_{12} + d^-_{31} - d_{31}^+ = 7{,}280$ ..... (28)
$y_{13} + d^-_{32} - d_{32}^+ = 1{,}040$ ..... (29)
$y_{14} + d^-_{33} - d_{33}^+ = 9{,}360$ ..... (30)
$y_{15} + d^-_{34} - d_{34}^+ = 2{,}080$ ..... (31)

D. Expenses per patient.

The expenses per patient are broken down into four classifications: Ultra sound expenses, C.T. scan expenses, medical expenses, and administrative & miscellaneous expenses.

(i) Ultrasound expenses per patient
$z_1 + d^-_{35} - d_{35}^+ = 16.67$ ..... (32)

(ii) C.T. Scan expenses per patient
$z_2 + d^-_{36} - d_{36}^+ = 87.96$ ..... (33)

(iii) Medical expenses per patient
$z_3 + d^-_{37} - d_{37}^+ = 19.44$ ..... (34)

(iv) Administrative and miscellaneous expenses per patient
$z_4 + d^-_{38} - d_{38}^+ = 79.63$ ..... (35)

E. Break – Even Constraint

In order to determine the reasonable charge (z_5) that will provide enough resources to achieve desired goals, a breakeven constraint must be introduced. This constraint can be used to determine the required charge per patient to achieve all the goals.

$53{,}136Z_5 - [28080x_1 + 14{,}560x_2 + 8320x_3 + 4{,}160x_4 + 4{,}160x_5 + 4160x_6 + 4160x_7 + 4160x_8 + 41640x_9 + 8{,}320x_{10} + 8320x_{11} + 7280x_{12} + 1040x_{13} + 9360x_{14}$

$+ 2080x_{15}] + (x_{16} + x_{17} + x_{18} + x_{19}) + [53, 136\ z_1 + 53{,}136\ z_2 + 53{,}136 z_3 + 53{,}136 z_4)] + d^-_{39} - d^+_{39} = 0$ ……(36)

3.4 Objective Function : The objective function for the model is

$$\text{Min } Z = P_1 \sum_{i=20}^{34} d^-_i + (15P_2d^-_4 + 14P_2d^-_6 + 13p_2\ d^-_9 + 12P_2d^-_{11} + 11P_2d^-_{10} + 10P_2d^-_2 + 9P_2d^-_3 + 8p_2d^-_5 + 7P_2d^-_7 + 6P_2d^-_{12} + 5P_2d^-_{14} + 4P_2d^-_1 + 3P_2d^-_{15} + 2P_2d^-_8 + P_2d^-_{13}) + P_3\ (d^-_{35} + d^-_{36} + d^-_{37} + d^-_{38}) + P_4\ (d^-_{18} + d^-_{19}) + P_5\ (d^-_{16}) + P_6\ (d^-_{17}) + P_7(d^-_{39}) \quad \ldots\ldots (37)$$

4. RESULT AND ANALYSIS

The above model is solved to determine the input requirements necessary to achieve all the goals presented by the business manager. Consequently, the break even goal is rated as the least important. The LGP problems used in the study contains 117 variables (decision and deviational), 39 constraints and 7 priorities (goals). The solution for the problem is in **Table 3.**

Table 3 - Analysis

Goal Attainment	Achieved/Not Achieved
Job security	Achieved
Wage Increase	Achieved
Patient Expenses	Achieved
Equipment Replacement	Achieved
Retirement Fund	Achieved
Continuing Education Fund	Achieved
Breakeven	Achieved

Variables

$x_1 = 660$	$x_{13} = 44$	$y_6 = 4160$	$z_1 = 19.44$
$x_2 = 88$	$x_{14} = 44$	$y_7 = 4160$	$z_2 = 102.60$
$x_3 = 72$	$x_{15} = 330$	$y_8 = 4160$	$z_3 = 22.68$
$x_4 = 72$	$x_{16} = 23{,}13{,}480$	$y_9 = 16{,}640$	$z_4 = 92.88$
$x_5 = 72$	$x_{17} = 10{,}00{,}000$	$y_{10} = 8{,}320$	$z_5 = 1055.09$
$x_6 = 88$	$x_{18} = 12{,}00{,}000$	$y_{11} = 8320$	
$x_7 = 88$	$x_{19} = 1{,}60{,}000$	$y_{12} = 7280$	
$x_8 = 222$	$y_1 = 28080$	$y_{13} = 1040$	
$x_9 = 61$	$y_2 = 14560$	$y_{14} = 9360$	
$x_{10} = 50$	$y_3 = 8320$	$y_{15} = 2080$	
$x_{11} = 50$	$y_4 = 4160$		
$x_{12} = 39$	$y_5 = 4160$		

5. CONCLUSION

The charge per patient (z_5) required to break even is Rs.1055.09. since the break even in the operation is treated as the goal with the lowest priority factor, the solution identities for input requirements necessary to attain all the goals. It is clear that the set of

goals defined by the business manager are quite realistic as they can be completely attained with a charge per patient is only 7.77% above the last year's figure.

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