Budget Allocation for Hospital Administration by an AHP through Goal Programming Model

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ABSTRACT:

This study presented Goal programming model based on Analytic Hierarchy Process (AHP) for budget allocation planning in hospital administration. This model acts as a long-range planning for the hospital. This work is limited to one year; however, this will helps in clear representation of the model development. After completion of one year, the basic model can be used for further planning by expanding parameter changes. In this work considered Nursing Division, Emergency Ward, General Services, Administration of large health care system in Bangalore. The problem was solved using the proposed model and results are discussed.

Keywords: Analytic Hierarchy Process, Goal Programming, Health care, Resources

1. INTRODUCTION

In modern medical sciences, the process of administering in hospitals has become complex and challenging. There is huge scope for caring process in hospitals. This is because of scope for protection in institutions for health, increase in population etc. To add with, rapid increase of salaries given to employees is one of the causes for cost increase in hospitals. Also, due to complexity in operations has made available facilities as ineffective. Therefore administration is a challenging problem for management to be addressed. It becomes difficult for common man to find hospitals providing uniform facilities. A suitable model is required to be designed in uniform for all hospitals. It is observed that many hospitals follow common procedures so that a common allocation model can be developed and applied uniformly.

Various models have been developed and improved over the past 35 years. They can aid in improving the effectiveness of the decision-making process in an organization. Arthur [1] gave a multiple objective nurse scheduling model. An application of linear programming in hospital resource allocation was given by Grant and Henden [2]. Stinnett and Pattiel [4] have given a mathematical model for the efficient allocation resources in health-care. In this work, a GPM

has been used to allocate resources in the hospital. GP is a variation of Linear Programming Model. Charnes and Cooper [6] conceptualized the name Goal Programming. It was applied to an analytical process that solved multiple, conflicting and non-commensurate problems. An objective which is not totally accomplished has an under- achievement or over- achievement of the objective. Objective function contains only negative deviational variable provided, the objective exceeds the stated goals and contains the positive deviational variables provided and the objective function is under the stated goal. There are two stages in this study main first we prioritize the goals by using Analytic Hierarchy Process and second stage we solve the problem by using goal programming model.

2. ANALYTIC HIERARCHY PROCESS

Goal Programming model does not provide ranking for goals. Analytic Hierarchy Process (AHP) offers ranking for goals based on multiple conditions. The AHP was introduced by Saaty[14] which is practical method to solve Multi criteria decision problems. In the Analytic Hierarchy Process method pair wise comparisons are used to get the weights of importance of decision criterion and relative importance measure of the alternatives corresponding to each individual criterion.

3. FORMULATION OF THE PROBLEM

To design the model, we consider a hospital by name Shushrutha located in Bangalore. Here patients are treated by physicians in person or considered as emergency and admitted. The rooms for emergency are in charge of local doctors working in rotation as per agreement. There are 125 beds and 86 employees for smooth conduction of the process. The information needed for the study is tabulated in 3 and 2. The salaries mentioned are in personnel and is average. The classifications made are in relation with various designations. Considering all the aspects, a AHP model is developed in an attempt to minimize the above said aspects.

The faculty groupings were made in connection to the task of staff costs inside the different bookkeeping assignments used by the emergency clinic. In spite of the fact that various split assignments are conceivable and regularly rehearsed, an endeavour is made here to limit these for the model structure.

category	Budget (Rs. 00000)	Unit cost (Rs. 000)
Nursing Division	1000	various
Emergency Ward	1800	various
General Services	1000	500
Administration	2500	various
Total	6300	

Table – 1. Expenditure

	Nursing Division	Miscellaneous	Emergency Ward	General Services	Administration	Total	Target
Personnel Requisite	8	5	6	6	7	32	40
Latest Equipment	5	3	4	7	8	27	35
Hike in Employee Salary	7	4	3	6	9	29	40
Funds for Expenses	6	4	4	3	7	24	30

Table – 2. Increase rate

	Category	Variable	Frequency	unit cost (Rs 000)
Nursing Division	Nursing Service Management	X_1	10	30
	Medical and Surgical Nurse	X_2	6	32
	Paediatric Nurse	X_3	10	21
	Obstetric Nurse	X_4	08	20
	Operating and Recovery room Nurse	X_5	10	15
	Service and Supply Room Nurse	X_6	11	13
	Pathologist	X_7	10	15
	Cardiologist	X_8	8	12

Emergency Ward	Radiologist	X_9	5	8
	Dietician	X_{10}	9	10
General Services	Emergency Room Nurse	X_{11}	20	10
	Intensive Care Nurse	X_{12}	30	12
	Laboratory Technician	X_{13}	40	8
	Laboratory Room Nurse	X_{14}	25	9
Administration	Plant Operation and Maintenance	X_{15}	10	40
	House Keeping	X_{16}	15	30
	Laundry and Linen	X_{17}	8	25
	Administrative Service	X_{18}	12	45

Table – 3. Allocation in various category

4. MODEL DEVELOPMENT

1. Variables:

There are two types of variables:

$x_j{}^1$= Expenses in different category.

$x_1{}^1$= Numbers in Nursing Division

$x_2{}^1$= Numbers in Miscellaneous

$x_3{}^1$= Numbers in Emergency Ward

$x_4{}^1$= Numbers in Emergency Ward

$x_5{}^1$= Numbers in Administration

x_j = Number of category presence in various types of Nursing Division, Emergency Ward, General Services, Administration 1,2,3,…….18, 19.

2. Goals and Their Priorities:

To accomplish the resources allocated in optimum manner, the Goal priorities must be found by the administrator. In this process, the decision should be taken in group by high profile authorities of the hospital. These goals determined by administrator are:

- To provide services in adequate through suitable manpower for the patients. In view of the administrator, it is sufficient with the existing manpower to provide services for the future.
- To provide services, it is required to purchase new or replace old equipment's.
- To provide hike in salary keeping in mind the market and the current economy.
- To provide required fund
- To distribute the category for each person
- Minimizing the operation breakdown and costs

In this study the goals, increase rate (P_1) , expected presence in the various category(P_2), expected frequency in nurse division(P_3), minimum resources in the Emergency ward(P_4), expected frequency of nurse division(P_5), increase brand awareness(P_6), total expense in administration(P_7), total expense in various Emergency(P_8), nurse division cost within the budget(P_9), total budget(P_{10}) are prioritized under the resource allocation condition, customer relation condition by using AHP. The overall importance of the 10 goals are 1) 0.286, 2) 0.242, 3) 0.132, 4) 0.085, 5) 0.081, 6) 0.060, 7) 0.033, 8) 0.031, 9) 0.030, 10) 0.020 (total 1) respectively

3. Goal Constraints:

Using Table-1, Table – 2, Table – 3 the resource allocation criterion, customer relation criterion formed by using AHP model.

Priority-1: the expected resources increase rate for each category of the four division in table-2

$$8{x_1}^1 + 5{x_2}^1 + 6{x_3}^1 + 6{x_4}^1 + 7{x_5}^1 + {d_1}^- - {d_1}^+ = 40$$

$$5{x_1}^1 + 3{x_2}^1 + 4{x_3}^1 + 7{x_4}^1 + 8{x_5}^1 + {d_2}^- - {d_2}^+ = 35$$

$$7{x_1}^1 + 4{x_2}^1 + 3{x_3}^1 + 6{x_4}^1 + 9{x_5}^1 + {d_3}^- - {d_3}^+ = 40$$

$$6{x_1}^1 + 4{x_2}^1 + 4{x_3}^1 + 3{x_4}^1 + 7{x_5}^1 + {d_4}^- - {d_4}^+ = 30$$

Priority-2: the expected presence in the various category given in table-3

$$x_{15} + {d_5}^- - {d_5}^+ = 10$$

$$x_{16} + {d_6}^- - {d_6}^+ = 15$$

$$x_{17} + {d_7}^- - {d_7}^+ = 08$$

$$x_{18} + {d_8}^- - {d_8}^+ = 12$$

Priority-3: the expected frequency in nurse division given in table-3

$$x_{11} + {d_9}^- - {d_9}^+ = 20$$

$$x_{12} + {d_{10}}^- - {d_{10}}^+ = 30$$

$$x_{13} + {d_{11}}^- - {d_{11}}^+ = 40$$

$$x_{14} + {d_{12}}^- - {d_{12}}^+ = 25$$

Priority-4: Maintain the minimum resources in the Emergency ward in table-3

$$x_{07} + {d_{13}}^- - {d_{13}}^+ = 10$$

$$x_{08} + {d_{14}}^- - {d_{14}}^+ = 08$$

$$x_{09} + {d_{15}}^- - {d_{15}}^+ = 05$$

$$x_{10} + {d_{16}}^- - {d_{16}}^+ = 09$$

Priority-5: the expected frequency of nurse division given in table-3

$$x_1 + {d_{17}}^- - {d_{17}}^+ = 10$$

$$x_2 + {d_{18}}^- - {d_{18}}^+ = 06$$

$$x_3 + {d_{19}}^- - {d_{19}}^+ = 10$$

$$x_4 + {d_{20}}^- - {d_{20}}^+ = 08$$

$$x_5 + {d_{21}}^- - {d_{21}}^+ = 10$$

$$x_6 + {d_{22}}^- - {d_{22}}^+ = 11$$

Priority-6: the marketing team wants to increase brand awareness and company re-organization through general services bill board advertising (x_{19}). this will be well versed by arranging a contract with an agent for general services bill board analysis that can be bought within the company budget Rs: – 1000 the budget has been divided into 200 equal units of Rs: - 0.5 (000)

$$x_{19} + {d_{23}}^- - {d_{23}}^+ = 20$$

Priority-7: The total expense in administration of Rs. 2500

$$40x_{15} + 30x_{16} + 25x_{17} + 45x_{18} + {d_{24}}^- - {d_{24}}^+ = 2500$$

Priority-8: The total expense in various Emergency Ward of Rs. 1800

$$10x_{11} + 12x_{12} + 08x_{13} + 09x_{14} + {d_{25}}^- - {d_{25}}^+ = 1800$$

Priority-9: The nurse division cost within the budget Rs - 1000

$$30x_1 + 32x_2 + 21x_3 + 20x_4 + 15x_5 + 13x_6 + 15x_7 + 12x_8 + 8x_9 + 10x_{10} + {d_{26}}^- - {d_{26}}^+ = 1000$$

Priotity-10: the total budget Rs. - 6300

$$30x_1 + 32x_2 + 21x_3 + 20x_4 + 15x_5 + 13x_6 + 15x_7 + 12x_8 + 8x_9 + 10x_{10} + 40x_{15} + 30x_{16} + 25x_{17} + 45x_{18} + 0.5x_{19} + {d_{27}}^- - {d_{27}}^+ = 6300$$

5. GENERAL GOAL PROGRAMMING MODEL

The general GP Model is formulated as follows

$$\text{Minimize } Z = \sum_{k=1}^{m} \sum_{i=1}^{n} W_{ki} P_k ({d_i}^- - {d_i}^+)$$

Subject to constraints

$$\sum_{i=1}^{m} a_{ij} x_j + {d_i}^- - {d_i}^+ = c_i$$

where $x_j, {d_i}^-, {d_i}^+ = non\ gegative\ variables$

6. OBJECTIVE FUNCTION

$$Z = P_1 \sum_{i=1}^{4} \left(d_i^- + d_i^+\right) + P_2 \sum_{i=5}^{8} \left(d_i^- + d_i^+\right) + P_3 \sum_{i=9}^{12} \left(d_i^- + d_i^+\right) + P_4 \sum_{i=13}^{16} \left(d_i^- + d_i^+\right)$$
$$+ P_5 \sum_{i=17}^{22} \left(d_i^- + d_i^+\right) + P_6\left(d_{23}^- + d_{23}^+\right) + P_7\left(d_{24}^- + d_{24}^+\right)$$
$$+ P_8\left(d_{25}^- + d_{25}^+\right) + P_9\left(d_{26}^- + d_{26}^+\right) + P_{10}\left(d_{27}^- + d_{27}^+\right)$$

7. SOLUTION

The model contains 19 variables and 27 constraints. The model was solved by QM for WINDOWS.Table4 shows the goal achievement. Table -5 shows the values of deviational variables. All the goals except four goals namely P_7, P_8, P_9, P_{10} are achieved. We can observe that the negative deviational variable $d_{24}^- = 910$, this means the total budget in Hospital can be decreased 910 (Rs. 000). The goal P_8 is not achieved, because the negative deviational variable $d_{25}^- = 695$ .This indicates that the total budget in Emergency Ward can be decreased 695 (Rs. 000).The goal P_9 is not achieved, because the positive deviational variable $d_{26}^+ = 531$.This shows that the total budget in hospital can be increased 531 (Rs. 000). Finally, the total budget goal P_{10} also not achieved, because the negative deviational variable $d_{27}^- = 2064$ .That is the total budget can be decreased 2064 (Rs. 000).

Goal Attainment	**Achieved/ Not achieved**
P_1	Achieved
P_2	Achieved
P_3	Achieved
P_4	Achieved
P_5	Achieved
P_6	Achieved
P_7	Not Achieved
P_8	Not Achieved
P_9	Not Achieved
P_{10}	Not Achieved

Table -4

Priority	Deviational Variable d_i^+	Deviational Variable d_i^-
P_1	0	0
P_2	0	0
P_3	0	0
P_4	0	0
P_5	0	0
P_6	0	0
P_7	0	910
P_8	0	695
P_9	531	0
P_{10}	0	2064

Table – 5

8. CONCLUSIONS:

The solution of the work is obtained by using QM for windows and result are discussed. The purpose of this work is to develop and analyse GP model to allocate budget for various categories. The model can be extended and applied in other fields where the same condition occurs.

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