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Health-Care Staff Decisions Goal Programming Approach

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Abstract: The main aim of this paper is to develop a staff planning model, which balances the expenditure and profit of staff task flexibility through cross training to healthcare industry using Goal programming approach.
Keywords: Cross Training, Goal programming, Health-care, Staff planning model

1. Introduction

Decision making is one of the important process in health care administration. Health care organizations are continuously updating in service area by recruiting highly experienced professionals and staff, so that the hospitals give higher level of quality services to the people so that they have a state of complete physical, mental and social well-beings in the society.

2. Data of the Problem

In this paper a mathematical model was developed to investigate the cost and benefits of the suggested model in a real health service which balances the expenditure and profit of staff task flexibility through cross training to healthcare organizations The model validation is realized using an example case of an AIDS prevention clinic located in Hyderabad. An AIDS prevention clinic has many health service characteristics common to general health clinics. The administrators of the AIDS prevention clinic studied suggested the factors and parameters used in the example case.
Research on AIDS can be divided into three areas:

i) Basic research in biomedical science, which develops and tests effective medicines for AIDS patients.
ii) Clinical research, which concerns providing treatment and care to those who are HIV (human immunodeficiency virus) positive patients.
iii) Epidemiological research concerned with the incidence and distribution of diseases and other factors relating to health for the prevention of AIDS.

In an AIDS prevention clinic, there were two major routine operations:

i) AIA-AIDS Initial Assessment
ii) AFA- AIDS Follow-Up Assessment

AIA is based on the sexual behavior and intake of drug of individual, the pervasiveness of HIV infection, and other risk factors to identify individuals at risk of AIDS and those needing immediate prevention services. AFA was designed for 3 months, 6 months or nine months to promote risk reduction behaviors of AIDS-risk individuals by welcoming their continuous contribution in an AIDS prevention clinic.

There are two kinds of demand encountered by an AIDs prevention clinic. One is scheduled demand – patients who make appointments with the health-care provider in advance. The other is un-scheduled demand – patients who walk in without appointments. Many patients are drug users, have a non-traditional sexual orientation, and are not reliable for keeping appointments. Sometimes, a health clinic may have difficulties in contacting patients for continuous prevention. Therefore, the professional staff of an AIDS clinic hopes to provide services when patients walk into the office.

An AIDS prevention assessment generally includes urine test, blood test, private counseling and head to head interview of each individual, though these procedures may vary among individuals. Before conducting blood and urine test Patients need to sign on agreement form. These tests should be done by a licensed phlebotomist, denoted as X_{33} in Table 3, the private counseling is provided by a licensed counselor, X_{22} and X_{42} in the following Table 3 and the head to head assessment interview is conducted by experienced interviewers, X_{11} in the Table 3

Table 1
Demand Information for the Annual planning Period

	Initial Assessment	Pre-blood Counseling	Blood Test	Post-Assessment Counseling	Urine Test
Time for each procedure in hours	2.00	0.35	0.35	1.25	0.35
AIA in hours	11833	1893	1893	378	1893
AFA-3 in hours	10650	1704	1704	3408	1704
AFA-6 in hours	10650	1704	1704	3408	1704
AFA-9 in hours	10650	1704	1704	3408	1704
Total Hours	43785	7005.35	7005.35	14011.25	7005.35

Administering urine test is not a specific requirement, it is considered to be a part of the phlebotomist's designated job [table 3]. The items in parentheses [Table 3] indicate task replacement. The term n/a means that task replacement is not allowed due to government licensing requirement.

This research area presents staff flexibility through cross training that a staff member can perform actions other than his/her designated job. For example, a counselor's allotted task is to conduct pre-blood test counseling and post-assessment counseling [Table 3]. However, he/she, after professional development and receiving on-the-job training on assessment interview, can also provide the assessment interview service. This reflects staff task flexibility and is expressed in [Table 3] as X_{12} in parentheses. Certain task substitutions required some legal requirements. For example, a counselor may not substitute for the task of performing blood tests since that task requires a license from the state government, not the skill from on-the-job training. The restrictions on job substitution reflect the sole nature of health service. These are indicated in Table 3 using n/a.

A regular demand with appointment and irregular demand without an appointment for dissimilar prevention procedures is presented in Table 1. But in original circumstances there will be demand uncertainty due to patients coming in without an appointment, or not showing up after arranging appointments.

A face-to-face assessment interview averages one and a half hours to complete, though it varies from one hour to two hours depending on the participant's responses and the interviewer's skill. Through the assessment interview, information is obtained on personal medical history, sexual orientation, number of intimate partners, drug use behavior, etc. pre-blood test counseling is given to inform the participants of the possible psychological consequences as reactions to the test. Post-assessment counseling is then designed to provide a tailor-made strategy for the high-risk individuals to reduce their AIDS risk level.

The demand level and the amount of time needed to perform each procedure are included in Table1.This table provides an information on the number of staff members at initial stage for each category, professional development hours for staff category, overtime cost, hiring cost ,dismissing cost and base salary for each staff category.

Table 2: Information of staff for The Planning Period

	Initial Assessment	Pre-blood Counseling	Blood Test
Initial Numbers	15	9	3
Annual Pay (Rs.)	15,20,800	10,87,500	5,84,375
Overtime Cost (Rs/Hour)	68.7	319.5	711.75
Hiring Cost (Rs.)	1,35,000	22,500	67,500
Dismissal Cost (Rs.)	2,02,500	33,750	1,01,250

Table 3: Tasks and Job Titles

Job Titles (j)	Type of Procedures(i)				
	Initial Assessmet	Pre-Blood Counseling	Blood Test	Post-Assessment counseling	Urine Test
Interviewer (1)	X_{11}	X_{21}	*n/a*	*n/a*	X_{51}
Counselor (2)	X_{12}	X_{22}	*n/a*	X_{42}	x_{52}
Phlebotomist (3)	*n/a*	X_{23}	X_{33}	*n/a*	X_{53}

3. Goal Programming Model

A manager for health care services desires to consider various objects in the health service facility. Figure1 provides a process of developing a personnel plan for a health-care facility. First, demand is predicted at the aggregate level. Then, demand for each staff category is assessed. Meanwhile, various objectives related to service delivery are considered and staff plan is evaluated. These objectives include the unique professional requirements, staff professional development, the customer service level, etc. If the model fits the overall objective and goals of a health provider and matches supply to time varying demand, the plan is accepted, otherwise, it must be revised. Figure 1 shows that health-care facility personnel planning is a multiple objective problem. Issues concerning health clinic managers during the personnel planning process include: do we have adequate resources (professional staff) to provide services to patients in satisfactory level? Is the system comfortable to meet the demands with respect to varying time? This study gives the solutions of these questions through goal programming personnel planning model. The GP model for the personnel planning system is described in detail, considering a number of objectives, which include staff task flexibility, staff professional development requirements, government licensing restriction on health service task substitution, etc.

Figure 1 Staff Flexibility Model

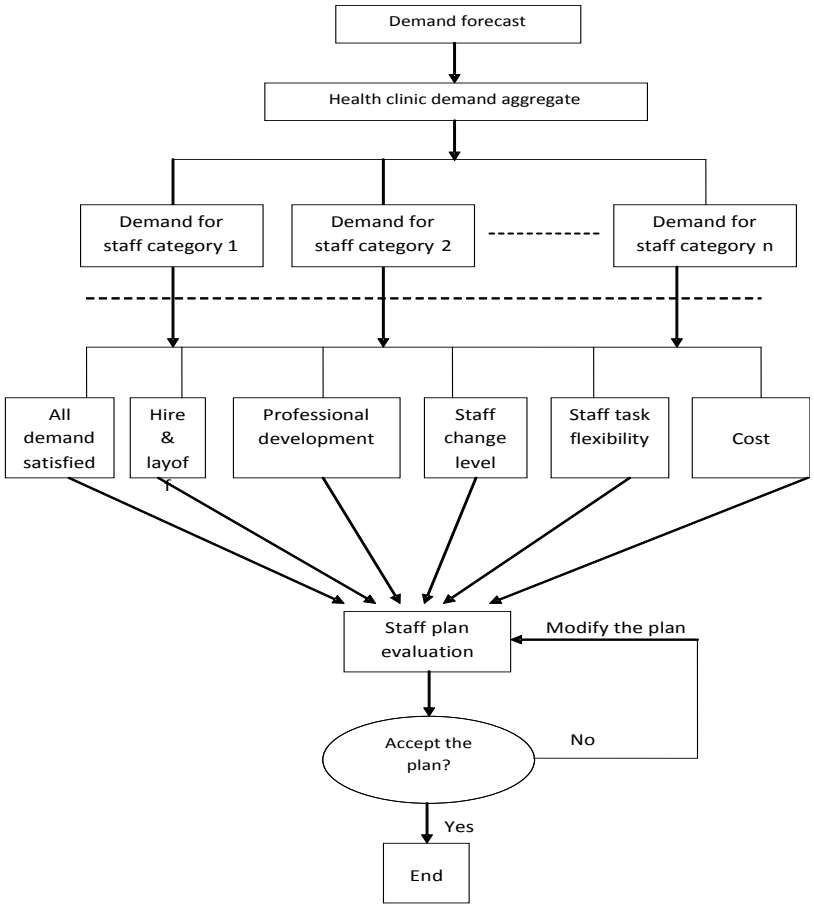

Figure1.2. A Flow Diagram for Staff Plan Development

Model Notations

In the model development process, the parameters and decision variables were

3.1 parameters:

3.1 PARAMETERS

X_1 = Demand from patients who have taken appointment in advance in staff hours This demand is called regular demand

X_2 = Demand from patients come directly without taking appointments. This demand is called irregular demand

X_{3ij} = Relative efficiency of staff category *j* performing procedure i. this variable is a non-negative real number, which is smaller than or equal to 1.0 for a substitute and equals 1.0 for a fully trained employee. This term does not illustrate in this model but is included into the following item.

X_{4j} = Productivity coefficient for staff task flexibility ; $X_{3ij}\ X_4 = 1$ for regular staff
$X_{4j} > 1$ for substitute staff

X_5 = Coefficient for a regular eight-hour working day.
X_{6i} = The fraction of i^{th} *procedure* that can be performed by substitute staff.
X_7 = Overtime limit of the employee. usually it is two hours of overtime, it is 25% industry overtime standard.
X_{8j} = The fraction of regular hours of staff category *j* planned for professional development.
X_{9j} = The cost of overtime as a multiplier of regular pay for staff category *j*
X_{10j} = Hiring cost of each employee in category *j*.
X_{11j} = Dismissing cost each employee from category *j*.
X_{12j} = Regular pay for staff category *j*.

3.2 DECISION VARIABLES

α_{ii} = Professional staff hours in category j conducting procedure *i*, (substitute staff is indicated using *f*)

.

β_{ti} = Number of staff in each staff category *j* for the planning period; ***i***
γ_{ij} = Planned professional development hours for staff category *j*
d_0^- = Negative deviation between the number of planned staff hours and the projected demand level.

d_1^+ = Over-achieved task substitution hours of professional staff (*j*)
d_1^- = Under-achieved task substitution hours of professional staff (*j)*
d_2^+ = Number of overtime hours for each staff category *j*
d_2^- = Number of idle hours for each staff category *j*
d_3^+ = Over-achieved professional development hours for staff category *j*
d_3^- = Under-achieved professional development hours for staff category j
d_4^+ = Number of employees to be hired in category *j* at the beginning of the planning period.

d_4^- = Number of employees to be dismissed in category *j* at the beginning of the Planning period.

3.3. MODEL CONSTARINTS

The health care clinics comprise the set of constraints based on demand and characteristics. The constraints are on projected demand, staff task flexibility, staff productivity, overtime, staff professional development and staff level change**.**

3.3.1. DEMAND CONSTARINT

In a health service clinic, demand has to be satisfied when patients are there. The first constraint is a demand constraint.

$\Sigma \alpha_{ij} + d^-_0 = x_1+x_2$ for $i= 1, 2\ldots n \forall j$ (1)

3.3.2 STAFF TASK FLEXIBILITY CONSTRAINT

There is a limit on task flexibility and the amount of procedure *i* performed by a substitute. The constraint for the staff task flexibility is given by

$\Sigma \alpha_{ij} + d^-_1 - d^+_1 = f_{1i} (x_1+x_2)$ for i= 1, 2… *n ,where* f_{1i} is a portion of procedure i
(2)

3.3.3 STAFF PRODUCTIVITY CONSTRAINT

Certain number of working hours are available for each staff member for the planning period. Regular time re-fleets allowance for vacations, sick hours, and holidays. Professional development time is planned. Overtime is allowed and is subject to in upper limit. Idle time may also exist. The staff productivity constraint is expressed as

$\Sigma x_4\alpha_{ij} + \gamma_{ij} + d^-_2 - d^+_2 = x_5\beta_{tj}$ for $i = 1, 2\ldots n$ (3)

3.3.4. OVER TIME CONSTRAINT

Generally there is a limit on the overtime hours of employee. The maximum boundary for overtime is expressed as

$\Sigma d_2^+ \leq f_2 x_5 tj$ for $j = 1,2 \ldots m$ (4)

Here f_2 is a portion of regular working hours of staff category j generally it is 25% of an eight hour working day.

3.3.5. PROFESSIONAL DEVELOPMENT CONSTRAINT

Staff professional development includes on-the-job training, job enlargement training, seminars, conferences, etc. With staff task flexibility as a system flexibility cushion, staff professional development and on-the-job training become even more important. The requirements for professional development may vary by staff category. This constraint is expressed

$\gamma_{ij} + d_3^+ - d_3^- = f_{3j}\beta_{tj}$ for $j = 1,2 \ldots m$

Where f_{3j} is a proportion of regular hours of staff category *j* (5)

3.3.6 STAFF LEVEL CHANGE CONSTRAINT

An initial number of persons at each category is assumed. Supplementary workforce may be hired if the available staff is not sufficient to reach the demand level. Some staff members may be dismissed in lower demand levels.

$\beta_{ij} + d_4^+ - d_4^- = \beta_{t-1j}$ for $j = 1,2 \ldots m$

Here β_{t-1j} indicates the number of employees at each staff category j in initial stage. (6)

3.4 GOALS

Various goals may be established that reflect the objective of a health care clinic. In health care clinic, the quality of service mainly depends on the ability and knowledge of the professional staff. Since the professional staff is a foremost resource to give valuable health care services, well designed staff plan should be established.

The administrators of the two clinics consulted for the study provided us with the objectives that they ranked as important to achieve a set of objectives.

The business manger set the following goals

(i) Reduce the negative deviation between the projected amount and amount demanded in each staff category.

$\text{Min } Z_1 = \Sigma d_0^-$ (7)

The purpose of this objective is to prevent the amount of demand planned from being lower than the projected level. This is to ensure that demand is satisfied. The objective is measured in hours.

(ii) Minimize the shortfall of professional development

$\text{Min } Z_2 = \Sigma d_3^-$ (8)

The objective seeks to minimize the under-achievement deviation between the desired staff professional development hours and the actual staff development hours. The term d_3 is the shortfall of staff professional development. Staff professional development keeps staff members current in the service area, assures a higher level of service quality, and allows job substitution and task flexibil*ity.*

(iii) Minimize the augmentation of regular staff:

$$\text{Min } Z_3 = \Sigma\, d_4^+ \quad (9)$$

The objective shows the undesirability of adding too many staff members for the period. The objective is measured in the number of employees, but is translated to hours when the model is solved.

(iv) Minimize staff task substitution:

$$\text{Min } Z_4 = \Sigma\, d_1^+ \quad (10)$$

The objective is to minimize task substitution. The clinic managers consulted for this project suggested constraining the task substitution level due to the effects of learning curve. The objective is measured in hours.

(v) Minimize overtime incurred:

$$\text{Min } Z_1 = \Sigma\, d_2^+ \quad (11)$$

The purpose of this objective is to minimize overtime incurred for each staff category j. The overtime is undesirable because long-hour working days could cause fatigue and affect service quality. The objective is measured in hours.

(vi) Minimize staffing cost:

A health service clinic is a non-profit organization, so maximizing profit is not a reasonable assumption. However, due to the prevailing cost containment efforts in the health-care industry, minimizing staffing cost is a serious concern of the clinic administrators.

$$\text{Min } z_5 = \Sigma_i\, x_{12}\, \beta_{ti} + \Sigma_i\, x_9\, d_2^+ + \Sigma_i\, x_{10}\, d_4^+ + \Sigma_i\, x_{11} d_4^- \quad (12)$$

Where x_{12} is the base salary for staff category *j* and x_9 is overtime rate per hour for staff category *j*. The terms $x_{10\ and}$ x_{11} are the hiring and lay-off costs per position of staff category *j* respectively. The objective is measured in rupees

4. Result and Analysis

The solution will be obtained by using LINGO software package interpreted as follows. A detailed representative staff plan was developed shown in Table 4. The staff model can specify the number of staff of each expertise class, satisfy the estimated customer demand, project staff professional development hours, and resolve the number of new employees to hire.

The result showed that 33 professional staff members were needed; among them six were newly hired employees. For the planning period, there would be 20 interviewers, 9 counselors, and 4 phlebotomists, 5 Interviewers and one phlebotomists would be hired for the planning horizon Table 4. No lay-offs would occur during the period.

TABLE 4: Example Case Considering Staff Flexibility Solution

	Interviewers	Counselors	Phlebotomists	Total
Number of Employees initial stage	15	9	3	27
New Hires (person) Procedures (hours):	5	0	1	6
Assessment	43,782			43,782
Pre-counseling	615	6,390	0	7,005
Blood test	-	-	7,005	7,005
Post counseling	-	14,010	-	14,010
Urine Test	0	0	7,005	7,005
Professional Development hours	1,800	1,200	300	3,300
Shortfall of Professional	0	0	0	0
Development Hours				
Overtime (hours)	9,252	4,320	2,862	16,434
Hiring cost (Rs)	4,05,000	0	2,70,000	6,75,000
Salary of employs	2,63,25,000	1,89,00,000	81,00,000	5,33,25,000
Overtime	8,87,22,200	55,22,918	27,44,783	1,71,39,600
Total				6,84,39,600

To assess the interviews the interviewers would spend a total of 43,782 hours and on pre-blood test counseling as task flexibility, they would spend 615 hours. The counselors would spend total of 14,010 hours on post-assessment counseling.. The phlebotomists would spend 7005 hours on blood tests and 7005 hours on urine tests Table 4

The interviewers, counselors, and phlebotomists would have the desired amount of time for professional development. The total cost for the suggested staff plan was Rs. 6,84,39,600. The hiring cost was Rs. 6,75,000 salary cost was Rs. 5,33,25,000, and overtime cost was Rs. 1,71,39,600. There were no lay-off costs incurred. The model was then run again without considering staff task flexibility (task substitution) to demonstrate the effects of staff task flexibility on the personnel plan. The same example case was employed. Test results are presented in Table 5

TABLE 5 Example Case without Considering Staff Flexibility Solution

	Interviewers	Counselors	Phlebotomists	Total
Initial Number of Employees	15	9	3	27
Extra staff (person) events (hours):	5	2	3	10
Evaluation	43,782			43,782
Pre-blood counseling		7005		7,005
Blood test			7,005	7,005
Post counseling		14,010		14,010
Urine Test			7,005	7,005
Professional Development (hours)	1800	1200	300	3,300
Shortfallof Professional	0	0	0	0
Development Hours				
Overtime (hours)	6,888	1,656	1,176	9,720
Hiring cost	4,05,000	1,35,000	2,70,000	8,10,000
Salary	2,63,25,000	1,89,00,000	81,00,000	5,33,25,00
Overtime	87,44,760	5680125	27,44,483	1,71,69,368
Total				7,13,04,368

Without staff task flexibility, the program would hire two more counselors and the total cost would be Rs. 7,13,04,368 about 4% more than the plan employing staff task flexibility. This result indicated the cost/benefit of staff task flexibility. However, if the substitute staffs productivity level is considerably lower than that of the non- substitute, the cost benefit could be reduced. The effects of staff cross training were further explored using five sets of demand data for each of the two scenarios. Table 8.5 shows the results. Demand will be satisfied. Professional development is assured. Total cost can be reduced when cross training is incorporated into the model. Additionally, the clinic can hire fewer new employees and use fewer overtime hours.

TABLE 6: **Comparison of Effects of Cross-Training**

Source	Means		
	Cross-training considered	No. cross-training	t-value
Cost	6,29,29,446.75	66,01,201.95	-61.74
No of Employees Newly Hired	6.6	7.5	-3.675
Overtime (hours)	15,844.8	15,835.2	3.21
Professional Development (hours)	3,300	3,300	No difference
Job Substitution (hours)	2,496	0	3.27

The model and the results of the example case were presented to the administrators of the AIDS prevention clinic for evaluation. The model- ensured an adequate professional staff level to serve patients and was flexible enough to handle demand uncertainty by introducing staff flexibility. The results from this have underscored the importance of professional development for staff members. As knowledge and technology rapidly progress in the healthcare industry, professional staff members need to update their skills constantly to continually provide quality service. The health-care administrators interviewed for the study also discussed obstacles in implementing staff task flexibility. One possible obstacle for task flexibility is staff members' unwillingness to perform tasks below his/her trained level.

5. Conclusion

The main objective of this paper is to develop a staff planning model, which balances the expenditure and profit of staff task flexibility through cross training to healthcare organizations using goal programming. This model can be used to balance the expenditure and profit in long range period for government and private hospitals.

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