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Optimum Allocation Of Resources In Health Care Organization Through Fuzzy Goal Programming

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ABSTRACT-

In this paper, this study proposed a fuzzy mixed goal programming model addressing health care organization's resource allocation problem in a fuzzy environment. Compared to other deterministic techniques, the formulation can effectively handle the vagueness and imprecision in the statement of the objectives and ensure that the more importance of a fuzzy goal, the higher achievement degree it can obtain. Further, the formulation can easily be extended to other service organizations when the decision variables are vague and decision makers need to determine a desired achievement degree and preemptive priority for each of the fuzzy goals based on the relative importance of the goals. An example case with realistic data from the Turkeys health care organization structure showed the effectiveness and flexibility of our model to handle real world problems. With more information about the ser- vice structure and behaviors of healthcare organization, the system can set clear priority values as fuzzy weight (or importance) in future studies.

Key words: Fuzzy goal programming, Healthcare organization.

INTRODUCTION-

Access to health care may vary across countries, communities, and individuals, influenced by social and economic conditions as well as health policies. Providing health care services means "the timely use of personal health services to achieve the best possible health outcomes".[3] Factors to consider in terms of health care access include financial limitations (such as insurance coverage), geographical and logistical barriers (such as additional transportation costs and the possibility to take paid time off work to use such services), sociocultural expectations, and personal limitations (lack of ability to communicate with health care providers, poor health literacy, low income).[5] Limitations to health care services affect negatively the use of medical services, the efficacy of treatments, and overall outcome (well-being, mortality rates).

Health systems are organizations established to meet the health needs of targeted populations.[7]According to the World Health Organization (WHO), a well-functioning health care system requires a financing mechanism, a well-trained and adequately paid workforce, reliable information on which to base decisions and policies, and well-maintained health facilities to deliver quality medicines and technologies.

An efficient health care system can contribute to a significant part of a country's economy, development, and industrialization.[9] Health care is conventionally regarded as an important determinant in promoting the general physical and mental health and well-being of people around the world.[5] An example of this was the worldwide eradication of smallpox in 1980, declared by the WHO, as the first disease in human history to be eliminated by deliberate health care interventions.

Delivery

The delivery of modern health care depends on groups of trained professionals and paraprofessionals coming together as inter-disciplinary teams.[11] This includes professionals in medicine, psychology, physiotherapy, nursing, dentistry, midwifery and allied health, along with many others such as public health practitioners, community health workers and assistive

personnel, who systematically provide personal and population-based preventive, curative and rehabilitative care services.

While the definitions of the various types of health care vary depending on the different cultural, political, organizational, and disciplinary perspectives, there appears to be some consensus that primary care constitutes the first element of a continuing health care process and may also include the provision of secondary and tertiary levels of care.[8] Health care can be defined as either public or private.

Primary care

Primary care refers to the work of health professionals who act as a first point of consultation for all patients within the health care system. Such a professional would usually be a primary care physician, such as a general practitioner or family physician. Another professional would be a licensed independent practitioner such as a physiotherapist, or a non-physician primary care provider such as a physician assistant or nurse practitioner. Depending on the locality and health system organization, the patient may see another health care professional first, such as a pharmacist or nurse. Depending on the nature of the health condition, patients may be referred for secondary or tertiary care.

Primary care is often used as the term for the health care services that play a role in the local community.[15] It can be provided in different settings, such as Urgent care centers that provide same-day appointments or services on a walk-in basis.

Primary care involves the widest scope of health care, including all ages of patients, patients of all socioeconomic and geographic origins, patients seeking to maintain optimal health, and patients with all types of acute and chronic physical, mental and social health issues, including multiple chronic diseases. Consequently, a primary care practitioner must possess a wide breadth of knowledge in many areas. Continuity is a key characteristic of primary care, as patients usually prefer to consult the same practitioner for routine check-ups and preventive care, health education, and every time they require an initial consultation about a new health problem. The International Classification of Primary Care (ICPC) is a standardized tool for understanding and analyzing information on interventions in primary care based on the reason for the patient's visit.

In the United States, the 2013 National Health Interview Survey found that skin disorders (42.7%), osteoarthritis and joint disorders (33.6%), back problems (23.9%), disorders of lipid metabolism (22.4%), and upper respiratory tract disease (22.1%, excluding asthma) were the most common reasons for accessing a physician.[12]

In the United States, primary care physicians have begun to deliver primary care outside of the managed care (insurance-billing) system through direct primary care which is a subset of the more familiar concierge medicine. Physicians in this model bill patients directly for services, either on a pre-paid monthly, quarterly, or annual basis, or bill for each service in the office. Examples of direct primary care practices include Foundation Health in Colorado and Qliance in Washington.

Secondary care

Secondary care includes acute care: necessary treatment for a short period of time for a brief but serious illness, injury, or other health condition. This care is often found in a hospital emergency department. Secondary care also includes skilled attendance during childbirth, intensive care, and medical imaging services.

The term "secondary care" is sometimes used synonymously with "hospital care". However, many secondary care providers, such as psychiatrists, clinical psychologists, occupational therapists, most dental specialties or physiotherapists, do not necessarily work in hospitals. Some primary care services are delivered within hospitals. Depending on the organization and policies of the national health system, patients may be required to see a primary care provider for a referral before they can access secondary care.

In countries that operate under a mixed market health care system, some physicians limit their practice to secondary care by requiring patients to see a primary care provider first. This restriction may be imposed under the terms of the payment agreements in private or group health insurance plans. In other cases, medical specialists may see patients without a referral, and patients may decide whether self-referral is preferred.

In other countries patient self-referral to a medical specialist for secondary care is rare as prior referral from another physician (either a primary care physician or another specialist) is considered necessary, regardless of whether the

funding is from private insurance schemes or national health insurance.

Allied health professionals, such as physical therapists, respiratory therapists, occupational therapists, speech therapists, and dietitians, also generally work in secondary care, accessed through either patient self-referral or through physician referral.

DATA OF THE PROBLEM

NLEP

Although state has reached elimination of the disease, still large number of new cases is being detected every year indicating active transmission in the community. An in-depth situational analysis with steps to complete treatment etc be started.

IDSP

Delhi is a Phase-II state under IDSP. Data reporting for outbreaks have to be initiated from all the reporting units of the state.

NBCP

UCs for GIA released to State Blindness Control Society are not being received timely. SOE for Cash Grant are also not being received timely. Performance of School Eye Screening Programme needs to be improved.

NVBDCP

The Imported Kala Azar cases are reported from Delhi. In 2008, total of 1312 dengue cases and 2 deaths were reported. In the year 2008, 14 suspected Chikungunya fever cases were reported. In 2008, total of 1312 dengue cases and 2 deaths have been reported.

RNTCP

Delhi is one of the well performing States.

Summary of approvals

Financial Management under NRHM (Rs. in crore)					
Years	**Allocation**	**Release**	**Expenditure**	**% Release against Allocation**	**% Expenditure against Release**
2005-06	31.36	32.83	26.20	104.69	79.81
2006-07	57.25	54.40	38.10	95.03	70.03
2007-08	79.20	81.36	53.07	102.72	65.23
2008-09	85.21	118.47	84.98	139.04	71.73

2009-10	99.53			0.00	
Total	**352.55**	**287.07**	**202.36**	**81.43**	**70.49**

S. No.	**Timeline Activities**		**Achievement**	**%**
1	**ASHA**	**Selection**	2266	240
		Training	0	
2	**VHSC**		0	0
3	**24X7 PHCs**		1	13
4	**Mobile Medical Unit**		9	100
5	**Rogi Kalyan Samiti**		0	0

Budget Allocations (2005-09) (Amount in Crores)

Delhi

	Allocation	**Releases**	**Expenditure**
	RCH Flexipool		
2005-06	15.98	7.27	1.94
2006-07	22.34	13.38	4.97
2007-08	14.38	6.19	14.02
2008-09	27.29	20.13	16.73
2009-10	27.92		
Total (A)	**107.91**	**46.97**	**37.66**
	NRHM Flexipool		
2005-06		1.37	0.00
2006-07	18.70	4.54	0.32
2007-08	32.71	23.23	0.28
2008-09	23.77	27.02	11.29
2009-10	24.64		
Total (B)	**99.82**	**56.16**	**11.89**
	National Disease Control Programme		
2005-06	5.81	7.95	9.73
2006-07	6.55	12.22	9.56
2007-08	11.38	9.82	4.03
2008-09	9.70	9.29	3.97
2009-10	9.69	0.00	0.00
Total (C)	**43.15**	**39.28**	**27.30**
Grand Total (A + B + C)	250.88	142.41	76.85

Record of Proceedings (2005-2009) for Mission Flexible Pool

Approval for Infrastructure (Rs. in Crore)

S. No	**Health Facilities**	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**
1	Sub C	0.04		0.00	0.00	0.00
2	PHC			0.00	0.00	0.00
3	CHC	0.00		0.00	0.00	0.00
4	DH			0.00	0.00	0.00
5	Equipment			0.00	0.00	3.10
6	Transport			0.00		1.25
7	Others		0.33	8.93	9.99	45.49
	Total	**0.04**	**0.33**	**8.93**	**9.99**	**49.85**

Approval for Human Resources(Rs. in Crore)						
S. No	**Personnel**	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**
1	Doctors			0.63	0.00	5.46
2	Specialists			0.00	0.00	0.00
3	Staff Nurses			0.00	0.00	0.00
4	ANM			0.00	0.00	9.07
5	Others			0.00	0.00	10.56
	Total	**0.00**	**0.00**	**0.63**	**0.00**	**25.09**

Approval of other activities (2005-2009) in Rs. Lakh							
S.No	**Initiative**	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**Remarks**
		Released	Approved	Approved	Approved	Approved	
ASHAs							
1	ASHA				1471.53	1904.03	
	TOTAL				**1471.53**	**1904**	
	Untied Funds, Annual Maintainence Grants and RKS fundsrelated matters						
2	Rogi Kalyan Samiti			36	38	360	
3	Untied Fund				26.35	30.25	
4	Untied Fund-CHC			10.00			
5	Untied Fund for PHC		2				
6	Untied Fund for PUHC			12.5			
7	Untied Fund-SC	4		2			

8	Untied Fund for VHSC		16.5			16.5	
9	Annual Maintenance Grant				50.25	64.75	
10	Annual Maintenance Grant -mat Homes/CHC			5.00			
11	Annual Maintenance Grant -PUHC			25.00			
12	Annual Maintenance Grant -PHC		4				
13	Seed PUHCs				384.16	694	
14	Annual Maintenance Grant- SC			5			
	TOTAL	**4**	**22.5**	**95.5**	**498.76**	**1165.5**	
	Infrastructure related matters						
15	MMU		12.6	171			
	TOTAL		**12.6**	**171**			

Status of Infrastructure 2005-2010

	As per RHS 2008	**New Construction**	**Upgradation / Renovation**
Number of Sub Centre	41		
Number of PHC	8		
Number of CHC	0		
Number of DH	9 As per State Data Sheet, NRHM		

Status of NRHM as on 15.05.2009

1	**ASHA**	**Selection**	2266
		Training	0
2	**VHSC**		

3	**Joint A/C**		0
4	**24X7 Facility**		0
			35
5	**FRU**		20
6	**Contractual Manpower**	**Doctors & Specialist**	295
		AYUSH Doctors	0
		Staff Nurse	73
		Paramedics	155
		ANM	630
7	**JSY Beneficiaries (in Lakhs)**		0.31

FUZZY GOAL PROGRAMMING MODEL

Decision models are simply a means to an end. A decision model represents, to some degree, an existing problem. Analysis of the model then should yield results that indicate optimal or preferred courses of action to be taken in the solution of the actual problem. It seems intuitively obvious that, the "better" the model, the more likely it is that the results from such a model will determine the proper actions to be taken. One objective of this thesis is to furnish the ability to build a decision model that is, in general, hopefully better than those that have traditionally been taught. This is because the models with in this thesis will both acknowledge and deal with the fact that, in most real world problems, multiple conflicting objectives will exist. Unfortunately, with only a few exceptions, most works in the area of decision analysis (or mathematical programming optimization, etc.,) consider only models having a "single" objective. In fact, in most instances, the very existence of multiple objectives is completely ignored.

The multiple objective approaches, on the other hand, attempts to include all pertinent objectives. Such an approach recognizes that no all objectives can (or should) be optimized. However, one may establish aspired levels of achievement or goals for each of these objectives. Goal programming is then used to establish a solution that comes as "close as possible" to the satisfaction of all of these goals. Thus, while traditional approaches stress the optimization of single objectives, goal programming stresses the satisfaction of multiple objectives and one should recognize the significant differences between these two approaches.

Another, related, aspects of goal programming that is different from the traditional approach lies in the treatment of the so-called system "constraints". Such constraints are used to determine the design boundaries of a system and, with traditional methods, a solution must satisfy each and every constraint in order for it to be considered "feasible". Those employing goal programming, however, realize that is highly unlikely that all of these "constraints" are truly absolute. Consequently, for the no absolute "constraint", goal programming attempts to minimize the deviation from a pre specified level rather than to satisfy this level absolutely.

Although goal programming (GP) is itself a development of the 1950s, it has only been since the mid 1970's that GP has finally received truly substantial and wide spread attention. Much of the reason for such interest is due to GP's demonstrated ability to serve as an efficient and effective tool for the modeling, solution, and analysis of mathematical models that involve multiple and conflicting goals and objectives – the types of models that involve that most naturally represent real-world problems. Yet another reason for the interest in GP is a result of a growing recognition that conventional (i.e., single objective) mathematical programming methods (e.g., linear programming) do not always provide reasonable answers, not do they typically lead to a true understanding of and insight in to actual problem.

$$\min \sum_{i=1} P_i (w_i^- d_i^- + w_i^+ d_i^+)$$

$$\text{s.t. } c^1x + d_1^- - d_1^+ = t_1$$

$$c^kx + d_k^- - d_k^+ = t_k$$

$$x \varepsilon S$$

$$x, d_k^-, d_k^+ \geq 0$$

in which S is the feasible region, P_i is the priority of the i'th goal, c^ix is the i th goal criterion function, and the i th are the target values of the k goal criteria. The d_i^- and d_i^+ are deviational variables, which measure achievements below and above goal. The w_i^- and w_i^+ are relative importance weights attached to the underachievement and overachievement deviational variables.

The advantage of GP is that multiple criteria can be incorporated into a model that can be solved using conventional (single criterion) optimization software. GP's disadvantage is that information about the decision maker's preferences is required a priori in the form of priority levels, importance weights, and goal target values.

Min F=

$$\sum_i \sum_t \left\{ \alpha_i \left[l_i(0) + \sum_k p_i(k) - \sum_k d_i(k) \right]^+ + \beta_i \left[\sum_k d_i(k) - \sum_k p_i(k) - l_i(0) \right]^+ \right\}$$

[2.1] s.t. $\sum_i w_{i_j} p_i(t) \le c_j(t)$ for all j,t,

$p_i(t) \ge 0$ for all i,t,

Where $[x]^+ = \max\{0, x\}$

Note that the objective function [2.1] is not linear. Thus, the model cannot be solved by the efficient linear programming algorithms such as the simplex method and various interior-point methods. To deal with the non-linearity, **Wang [1995]** defined two sets of new variables, $x_i[t]$,$y_i[t]$:

$$x_i(t) = \max\left\{0, \left[l_i(0) + \sum_{k=1}^{t} p_i(k) - \sum_{k=1}^{t} d_i(k) \right]\right\}$$

$$y_i(t) = \max\left\{0, \left[\sum_{k=1}^{t} d_i(k) - \sum_{k=1}^{t} p_i(k) - l_i(0) \right]\right\}$$

And incorporated the recurrences,

$P_i[t]=x_i[t]-y_i[t]-x_i[t-1]+y_i[t-1]+d_i[t]$

Hence, the ETTP problem can be transformed into a LP model, [2.8] to [2.11]:

Min $F\left(x_i(t), y_i(t)\right) = \sum_i \sum_t \left\{ \alpha_i x_i(t) + \beta_i y_i(t) \right\}$

s.t.

$$\sum_i w_{i_j} \left[x_i(t) - y_i(t) - x_i(t-1) + y_i(t-1) \right] \le c_j(t) - \sum_i w_{i\,j} d_i(t)$$

for all j,t**,**

$x_i(t) - y_i(t) - x_i(t-1) + y_i(t-1) \ge -d_i(t)$ for all i,t,

[

$$x_i(t), y_i(t) \geq 0$$ for all i,t,

Wang also proved that the set of product terms, $x_i^*[t]y_i^*[t] = 0$, hold true at optimum for all i and t; and hence they are not required to be included in the model. After solving the LP model in terms of $x_i^*[t]$ and $y_i^*[t]$, the corresponding optimum production quantity, $p_i^*[t]$, can be obtained by [2.7].

RESULT ANALYSIS

The solution will be obtained by using LINDO package interpretated as follows:

Table I: Demographic, Socio-economic and Health profile of Delhi State as compared to India figures

S. No.	Item	Delhi	India
1	Total population (Census 2001) (in million)	13.85	1028.61
2	Decadal Growth (Census 2001) (%)	47.02	21.54
3	Crude Birth Rate (SRS 2007)	18.1	23.1
4	Crude Death Rate (SRS 2007)	4.8	7.4
5	Total Fertility Rate (SRS 2007)	2	2.7
6	Infant Mortality Rate (SRS 2007)	36	55
7	Maternal Mortality Ratio (SRS 2004 - 2006)	NA	254
8	Sex Ratio (Census 2001)	821	933
9	Population below Poverty line (%)	8.23	26.10
10	Schedule Caste population (in million)	2.34	166.64
11	Schedule Tribe population (in million)	0	84.33
12	Female Literacy Rate (Census 2001) (%)	74.7	53.7

Table II: Health Infrastructure of Delhi

Particulars	Required	In position	shortfall
Sub-centre	188	41	147
Primary Health Centre	31	8	23
Community Health Centre	7	0	7
Multipurpose worker (Female)/ANM at Sub Centres & PHCs	49	82	-
Health Worker (Male) MPW(M) at Sub Centres	41	0	41
Health Assistant (Female)/LHV at PHCs	8	28	-
Health Assistant (Male) at PHCs	8	4	4
Doctor at PHCs	8	18	-
Obstetricians & Gynaecologists at CHCs	0	0	0
Physicians at CHCs	0	0	0
Paediatricians at CHCs	0	0	0

Total specialists at CHCs	0	0	0
Radiographers	0	0	0
Pharmacist	8	3	5
Laboratory Technicians	8	6	2
Nurse/Midwife	8	0	8

(Source: RHS Bulletin, March 2008, M/O Health & F.W., GOI)

The other Health Institution in the State are detailed as under:

Health Institution	Number
Medical College	5
District Hospitals	9
Referral Hospitals	
City Family Welfare Centre	
Rural Dispensaries	
Ayurvedic Hospitals	10
Ayurvedic Dispensaries	148
Unani Hospitals	2
Unani Dispensaries	25
Homeopathic Hospitals	2
Homeopathic Dispensary	98

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