International Journal of Information Technology and Knowledge Management
January June 2009, Volume 2, No. 1, pp. 163-166

IMPLEMENTING A DECISION SUPPORT MODEL IN PRIMARY HEALTH CARE

Rajan Vohra*, Nripendra Narayan Das* & Gunjan Pahuja*

Delhi is the capital city of India but is administered by multiple government agencies. Each agency has its own network of health centers to cater to different segments of society. There is a need to define these health facilities in terms of a region or District, so that the facilities within the region are strengthened by facilitating collaboration, which can be achieved by load transfer between centers. There is also a need to decongest secondary care by shifting patient load to primary care and also to minimize referral of patients from primary care to secondary care.

At the primary level, all health centers of government have the same number of doctors, irrespective of the patient load on the center. This research paper describes a model driven Decision support system, that facilitates load balancing and decentralization. This model is then applied to the primary health care data of East district, one of the nine districts of Delhi and the results obtained are discussed in the paper. This model can be used by health care planners in strengthening primary health care services within a geographical region or district, and in manpower and equipment requirement planning, based on patient load, instead of fixed administrative guide lines.

***Keywords**: Model driven Decision support system; load balancing; primary health care services; health care planning.*

1. Background

A Decision support system is a system under the control of one or more decision makers that assists in the activity of decision making by providing an organized set of tools intended to impose structure on portions of the decision making situation and to improve the ultimate effectiveness of the decision outcome [1]. The culture of governance in India is has been characterized by secrecy, seniority and corruption [2]. An online DSS can remove this malady. All countries should progressively and continuously reorder health expenditure priorities, leading to the most cost effective actions relating to health centers [3]. The DSS can do this by redirecting patients to their nearest region, thereby improving accessibility of health centers.

Computerized Decision support systems are consultation systems that use techniques for encoding knowledge and solving problems with that knowledge [4]. The DSS uses Artificial Intelligence to convert a flat structure of health centers into a Hub and Spoke model, which is the functional basis of the model driven DSS. AI techniques can be used to search the health network for free capacity and overloaded centers. A rule based DSS is used for providing patient advice, during telephonic consultations, provided by a call center manned by nurses. This is similar to the NHS Direct service, that provides off hours counseling to patients [5]. In this model, rules can also direct patients to their nearest region – district, in the case of New Delhi.

The decentralization of out patient health services at the primary health care level can be achieved through the Hub and Spoke model, which facilitates dynamic load balancing and planning deployment of manpower and equipment [6]. The use of Call centers using this DSS, can redirect patient flow to the nearest region. A key reason for the failure of the public health care system in India, is because of a gap between expected and actual number of health centers, as also between expected and actual strength of doctors and consultants [7]. The DSS proposes to bridge this gap information. The shortage of medicines and specialists is responsible for the failure of the health care delivery system at the primary level [8]. A DSS can facilitate planning of doctors deployment, according to the health care needs of the region. Doctors and staff of a primary health centre are dissatisfied with the accessibility of health centers from their residence [9]. The DSS can improve accessibility for doctors by placing them in their nearest region. Collaborative advantages can be easier to obtain after competing participants first learn to collaborate [10]. The multiple service providers in the public sector in Delhi can learn to collaborate by transfer of patient load , as these service providers are unevenly loaded in terms of patients.

The WHO has promoted a decentralized approach based on the concept of a district as a self contained and geographical entity, to better integrate multiple health programs and providers [11]. In the model DSS, a district is treated as a single collective entity , to plan regionalizing

* Dept. of CSE & IT, Institute of Technology and Management, Gurgaon- 122017, India. *E-mail: rajanv12@yahoo.com, nripendradas@gmail.com, gunjanpahuja04@yahoo.com*

services within it .A hospital can administer its resources more effectively. WHO and UNICEF stressed the importance of primary health centers in Alma Ata declaration in 1978 [12], in which PHC is the first contact with the health system for an individual or family. The DSS aims to minimize referrals to secondary care and decentralize primary services through Hub and Spoke model.

A DSS can access data, process accessed data into information and provide recommendations to solve management problems [13]. A DSS using a rule based knowledge base was developed to assign patients to corresponding beds.

HYDRA is a grid based Decision support system that is being developed for the NHS in UK. It addresses the resource allocation problem. It includes finding the best health network for patients (optimization problem) and finding out alternate solutions (simulation)[14].

As such Delhi is administered by many government agencies. In this research paper, we apply a DSS model [15] to the primary health care data of East District, which is one of the nine districts of Delhi. The results obtained are discussed. East District is chosen by convenience sampling. Delhi is chosen for this study, as it is the capital city of India, and has multiple governing agencies in the public sector. The scope is restricted to the health agency of the state government of Delhi.

2. Research Methodology

The design of the model driven decision support system is causal in nature. The input data to this model consists of secondary data. The data is selected from East district of New Delhi, which is chosen by convenience sampling. East District is one out of nine districts of New Delhi, the capital city of India. The data is for the year 2005.

As seen in the table in the annexure, the data input to the model corresponds to:

Center name	*Patient load/ day*	*No of Doctors*

This corresponds to Columns 1,2 and 4 in the annexure table. The rest of the data is obtained by further computations on this input data. The results obtained by the application of this data to the decision support model are presented in this paper.

3. The Model Fitting : Results and Discussion

The Decision Support Algorithm described by Vohra *et al*. [15] can now be applied to the primary health care data of East District, New Delhi to get a analysis of how the Hub and Spoke model function, for real world data. The result of this are also discussed in this section.

In this section the results of applying the East district health care data to the Hub and spoke model are presented and discussed. The hub and spoke structure is obtained by applying the corresponding algorithm, described above.

Since the hub is chosen according to highest patient load, the center Trilokpuri, with the highest load of 389 is chosen as the hub. The remaining 24 centers are the spokes

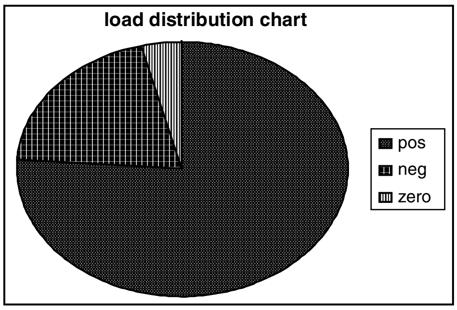

Figure 1: Chart Showing Excess Load Distribution in the Health Centers

It can be seen that 19 out of total 25 centers or 76 % centers have a positive excess load and are overloaded, while 5 out of 25 centers or 20% centers have a negative excess load and are under loaded. Also 1 out of 25 centers or 4% centers have zero excess load. In real world data, spoke centers can be under loaded and thus have free capacity available. The chosen hub has to decide how to service further patient requests for service. The requests can be satisfied by the hub itself, or by its spokes, if free capacity available in them. If no free capacity is available in the newly created hub and spoke network, further requests for service can be redirected to the nearest hub and spoke network.

The computation of capacity and excess load in the annexure table is done as per the decision support algorithm. The new load computations enable the spokes to be constrained to their capacity. While this results in 19 out of 24 spoke centers being constrained to their capacity, 5 spoke centers are under loaded and thus have free capacity available. The free capacity available at these spokes are as follows:

Table 1
Free Capacity Available at Spokes

Center Name	*Type(Hub/spoke)*	*Free capacity available*
I.P. Extension	Spoke	49
Karkardooma Court	Spoke	23
Mayur Vihar	Spoke	26
Mukesh Nagar	Spoke	14
Raghubirpura	Spoke	18

Therefore it can be seen that the total free capacity available at the spokes is 130. So 130 patients can be serviced at the spokes with the existing number of doctors.

Now, in order to calculate the free capacity available at the hub Trilokpuri, it must be noted that the new loads at all centers do not result in additional manpower, since the spokes are constrained to a maximum load of their capacity. However at the hub selected, total excess load in the network is transferred to the hub in addition to its capacity. Therefore, there is a need for greater manpower at the hub centre. The total new load at the hub selected Trilokpuri is 1240, which means according to our decision support model, a requirement of 1240/72, and rounding gives us a number of 18 doctors. Since 2 are already employed, there is a need to employ 16 more doctors at the hub centre. The free capacity at the hub is given by $72 \times 18 - 1240 = 1296 - 1240 = 56$. Thus the free capacity at the hub is 56. The total free capacity in the network = free capacity at hub + free capacity at spokes = 56 + 130 = 186. Therefore a total of 186 patients can be serviced by the newly created hub and spoke network. A request for service beyond this number will result in the request being redirected to the nearest hub and spoke network, where a similar search can be performed to determine free capacity.

In this case, we have chosen 1 hub for simulation. However 2 or more hubs can also be chosen. In the case of 2 hubs, the second hub is chosen according to the second highest patient load. In this case, the second hub after Trilokpuri, is Mandawali with 304 patients. If we select two hubs, then the total excess load can be divided equally between these two centers and added to their capacity. This means the total excess load of 1096 divided by 2 is 548. Both these centers have a capacity of 144. Therefore, the new loads at these centers is 692 each. The number of doctors required is now split and located between these two hubs. The loads and manpower at the spokes remains the same as before. We can see that 16 new doctors are split between these two centers and so eight doctors each are needed additionally at each of these centers. The free capacity computations can be done as before.

4. CONCLUSIONS

This research paper describes a health care management planning tool in the form of a model driven decision support system. This system can be used to implement decentralization of health care services, strengthening of primary health care services within a region or district, deployment of manpower and equipment. In this context, the Hub and spoke model was described. There after the model was used on input health care data of East District in New Delhi. The hub and spoke model algorithm was also written. The hub selection was done on the basis of patient load, with the health center having maximum patient load, within a district being selected as the hub. The philosophy of this model was to constrain spokes to their capacity, while simultaneously transferring al excess load from the spokes to the hub center.

In application on real world data of East district it was found that spokes can be under loaded and have free capacity available. The total free capacity in the hub and spoke network created was got by adding free capacity at spokes to the free capacity available at the hub center. The relationship between the hub and spokes was mainly of load transfer and load balancing. The hub selection and computation of new loads on centers, after creation of hub and spokes in East District was done by the algorithm

5. FUTURE WORK

In future extensions of this model, collaboration with another hub and spoke model in terms of load transfer between these two networks can be studied. In addition, spokes can be divided on some basis to be attached to multiple hubs. Also Data mining techniques can be applied to generate a decision tree, which partitions the set of input centers into overloaded and under loaded centers. This has implications for acquiring decision rules and machine learning applications. Finally, collaboration rules can be written for collaboration between two hub and spoke networks, belonging to different service providers, but located in the same region or district. The selection of the hub can be done by different criterion like Distance between the centers, services provided, population of a region etc. The hub and spoke network can be used to redirect patient flow to the nearest hub. This means primary health care facilities within a region are strengthened. Also it recommends deployment of Doctors and manpower/ equipment based on actual patient load at a center as opposed to fixed manpower recruitment and deployment norms. This will also strengthen regional budgetary planning and resource planning and allocation at the regional level. This model has research directions in Data communication, concurrency planning, distributed computing, Data mining, Artificial Intelligence, Expert systems and Machine learning. Also dynamic redirection of patient flow, in real time is possible, in further extensions of this model.

References

[1] Decision Support Systems, George Marakas, Pearson, (2005), 5.

[2] Sharma P. C. e Governance : The Next Chapter, *Proceedings of the Second Roundtable on IT in Governance*, March 12th, Hyatt Regency, New Delhi, (2002).

[3] Khan Akbar Ali M., Cost and Efficiency of Public Hospitals: *A Cross Sectional Analysis, South Asian Journal of Management*, **10**, (1), (2001), 33–53.

[4] Shortliffe, E. *Medical Expert Systems Knowledge Tools for Physicians*, **145**, (1986), 830–839.

ANNEXURE – I

East District Primary Health Care Data (Annexure)

Table 2
Hub and Spoke Model Application on East District Health Care Data

Center name	*Patient load/day*	*Capacity of center*	*Number of doctors*	*Excess load*	*New load*
Bhola Nath Nagar	132	72	1	60	72
Chander Nagar	162	144	2	18	144
Feroze Gandhi h c	132	72	1	60	72
Geeta Colony	226	144	2	82	144
Himmatpuri	234	144	2	90	144
I.P Extn	95	144	2	-49	95
Jagatpuri	84	72	1	12	72
Kalyanpuri	219	144	2	75	144
Kalyan Vas	191	144	2	47	144
Kanti Nagar	152	144	2	8	144
Karkardooma	190	144	2	46	144
Karkardooma Court	121	144	2	-23	121
Krishna Nagar	144	144	2	0	144
Laxmi Nagar	189	144	2	45	144
Mandawali	304	144	2	160	144
Mayur Vihar	118	144	2	-26	118
Mukesh nagar	130	144	2	-14	130
Raghubirpura	126	144	2	-18	126
Shashi Garden	180	72	1	108	72
Surajmal Vihar	195	144	2	51	144
Thokar8	105	72	1	33	72
Trilokpuri	389	144	2	245	1240
Vasundhra Enclave	229	144	2	85	144
Vishwas Nagar	154	144	2	10	144
Vivek Vihar	207	144	2	63	144

Source: Office of Chief District Medical Officer (CDMO), East District, Surajmal Vihar, New Delhi, India.

[5] Thornett A. M., Computer Decision Support Systems in General Practice, *International Journal of Information Management*, **21,** (2001), 39–47.

[6] Vohra Rajan, Empowering Primary Health Care Services through e Governance – A Case Study from Delhi Government, *Proceedings of Third International Conference on Web Information Systems and Technologies (WEBIST 2007)*, Barcelona, Spain, (March 3-6, 2007), 221–227.

[7] Singh J. P., Health for All in Rural India: Problems and Prospects, *Man & Development*, (Sept. 2002), 49–64.

[8] Planning Commission, Evaluation Study on Functioning of Primary Health Centers (PHCs), Assisted under Social Safety Net: *www.planningcommission.nic.in,* (2001).

[9] Rameshan P. & Singh S., Quality of Service of Primary Health Centers: Insights from a Field Study, *Vikalpa*, **29**, (3), (July-Sept 2004), 71–82.

[10] Ferratt *et al.*, 'Swords and Plowshares: Information Technology for Collaborative Advantage', *Information & Management*, **30,** (1996), 131–142.

[11] *www.who.int*

[12] WHO, UNICEF (1978), Declaration of Alma Ata, International Conference on Primary Health Care, Alma-Ata[on-line]. Available from http:// *www.who.int/chronic-conditions/primary-health care/en/almaata-declaration.pdf.*

[13] Fos Peter, A Decision Support System for Hospital Bed Assignment, *Journal of Health Care Services*, (1994), 386–400.

[14] *www.informatics.leeds.ac.uk/hydra*

[15] Designing a Model Driven Decision Support System for Primary Health Care Managers : Vohra *et al*., *International Journal of IT & KM*, **1**, (2), (July –Dec. 2008), 463–468.