



A STUDY ON STAFFING AS A TECHNIQUE OF OPERATIONS RESEARCH AND HUMAN RESOURCE MANAGEMENT IN HEALTHCARE ORGANIZATIONS

Dr. Maitreya N. Acharya

Assistant Professor, Department of Statistics, School of Sciences, Gujarat University, Ahmedabad, Gujarat, India.

Dr. Janhvi N. Upadhyay

Teaching Assistant, K.S. School of Business Management, Gujarat University, Ahmedabad, Gujarat, India.

ABSTRACT In present times, the health care systems are facing extreme pressures to obtain desired service level in spite of rapidly changing environment, scarce resources and financial challenges. The main task of operations research is to manage scarce resources in the best possible way. It mainly focuses on the application of analytical methods to facilitate the process of decision-making in the best possible way. Thus the application of operations research techniques can surely be very valuable for managing healthcare organizations in order to improve efficiency, achieve objectives and obtain desired service level. The main goal of this paper is to show how application of operational research models can improve decision making process, especially addressing efficient workforce allocation. The paper also presents the review of different groups of quantitative models which can be applied to various aspects of managing human resources in healthcare organizations. Ability to analyze and predict demand of health care services is of great importance. So at the beginning we present how time series analysis and various econometric models can be used to explore time and location dependent variations of the demand. Furthermore, queuing theory and optimization models can be applied in order to obtain the optimal allocation of human resources that leads to improvement in the satisfaction of the patients and employees satisfaction and thereby the economic efficiency of the entire healthcare system.

KEYWORDS : Human Resources Management, Operations Research, Healthcare Management

INTRODUCTION

In every society, organization and management are very complex, yet necessary tasks. Due to the unique nature of healthcare services, the management of healthcare system becomes more complex. Managing the operations in healthcare organizations is a question of extraordinary social relevance. Nowadays, health care systems are facing extreme pressures to obtain a desired service level in spite of the rapidly changing environment, scarce resources and financial challenges. Effective resource allocation is both a consequence and a solution for overcoming these challenges. Moreover, today's healthcare systems are characterized by multiple objectives, multiple evaluation criteria, and multiple decision-makers within the system, while resources and budget are extremely limited. Therefore, various quantitative methods are widely used to aid decision making process and improve overall efficiency. Optimal allocation of material, financial and human resources is extremely important in this sector and operations research models can be applied for different kinds of organizational issues. The World Health Organization stated that "One of the most important roles of the World Health Organization is to assist countries in making optimum use of scarce health resources." This is also the role of operations researchers. These public safety systems have received a great deal of attention in the operations research community, since they provide important services and the problems are amenable to mathematical modelling and solution.

Operations Research or Management Science exists as a scientific discipline since the 1930's and the first papers dealing with the health care problems date from 1950's. Despite the proliferation of papers in the academic literature, there are still major issues around getting quantitative models widely accepted and used as part of mainstream decision-making by clinicians, health managers and policy makers. Some possible reasons for this are as under:

- Low levels of managerial/mathematical background in the health care sector.
- Scientific papers are often written for operations research professionals, focusing on specialised and technical topics, and not reaching healthcare professionals.
- Lack of process-related data for modeling.
- Lack of in-house operations research expertise.
- High cost of engaging external operations research consultants.

Demand for medical services is increasing and the same trend is expected in the future. On the other side, due to serious financial difficulties in most of the countries, budgets became even more limited and reduced. Tighter budgets make efficient use of resources extremely important.

Scope and Importance

- The main objective of this paper is to present the review of various quantitative models, which can be applied to improve efficiency of human resources in healthcare organizations.
- Nowadays, when the demand for medical services is growing and the same trend is expected in the future, staff scheduling and rostering has become increasingly important area in every organization.
- These issues are characterized with complex constraints due to numerous legal and organizational regulations that should be satisfied together with personal preferences of employees.
- In this complex process of human resources modeling three main phases can be identified:
- Analysis and Forecasting of the demand for healthcare services.
- Determination of the optimal staffing level (the necessary number of employees needed to satisfy forecasted demand).
- Staff Scheduling and Rostering.
- The structure of this paper will follow the above mentioned phases on the basis of which we can introduce the major specifics of healthcare management. It will further explain how modeling of human resources in healthcare sector differs from the other types of organizations.
- It is very important to emphasise the necessity of coherence between all the phases in order to incorporate the stochastic nature of demand in staff scheduling and rostering process.

Need for the Study

There are several types of Operations Research Models dealing with optimal allocation of employees. One can study the concluding remarks and then prepare some guidelines for future research.

Objectives of the Study

- Effective and efficient nursing care.
- Increase productivity.
- Avoid role confusion, communication problems and wastage of time.
- Maintain stability in team work.

Literature Review

- Teow (2009) was of the opinion that there are still major issues

around getting quantitative models widely accepted and used as a part of mainstream decision-making by clinicians, health managers and policy makers. According to him, the major reasons behind it were found to be the low levels of managerial and mathematical background in the health care sector, lack of process-related data for modeling, lack of in-house operations research expertise. He opined about improving the same.

- Goldberg (2004) mentions that "ability to predict demand is of paramount importance", but this area has seen very little systematic study. The most challenging factor that influences the demand of healthcare services is randomness, specially when patients arrive without an appointment (which is the case of emergency especially in the radiology departments in hospitals, ambulance service, etc.).
- Baker and Fitzpatrick (1986) were the first who applied Winters Exponential Smoothing Model to obtain accurate forecasts of the daily volume of emergency and non-emergency calls at the ambulance service of South Carolina.
- Channouf et. al. (2007) used the Time-Series Models for the first time for the emergency medical service of the Canadian city Calgary. The estimated models were compared in terms of goodness of fit and forecasting accuracy.
- Zuidhof (2010) analysed the demand of ambulance services in Amsterdam. Holt Winters Exponential Smoothing Models, Seasonal Auto Regressive Integrated Moving Average (ARIMA) Models and Multiple Regression Models were used to forecast the daily demand. In this case, the best forecast has been obtained by multiple regression model.
- According to Setzler et. al. (2009), artificial neural network can also be designed to forecast the demand for healthcare services of specific areas during different times of the day along with various univariate and multivariate time series analysis methods.
- According to Bekker and DeBruin (2010), Yankovic and Green (2011), and Brahma (2012), the application of Queuing Theory in healthcare organizations might improve patients' and employees' satisfaction by reducing the time spent in waiting lines.
- B.S. Kumar, G. Nagalakshmi and S. Kumaraguru (2014) studied a shift sequence for nurse scheduling using Linear Programming Problem.
- C.M. DeRienzo, R.J. Shaw, P. Meanor, J. Ferranti and D. Tanaka (2016) developed a discrete event simulation tool to support and predict hospital and clinic staffing.

Characteristics of Healthcare Management

- The complexity of today's healthcare system and its high importance in every society imposes the conclusion that planning, organizing, leading and controlling of this sector is impossible without the proper implementation of management techniques.
- Contrary to the development of industrial management, healthcare management is characterized by different and slower path of development. Furthermore, we can conclude that the complete practical integration of healthcare and management techniques, which would result in the maximal synergistic effect, has not been achieved yet.
- Awareness of the importance and necessity of healthcare management exists, but its practical implementation is still at a relatively low level. The reasons for this are diverse and require a continual and systematic education about the possibilities and importance of managerial techniques and skills, which can contribute to the quality improvement of healthcare services and achievement of better financial results. Because of the basic similarities with the economic system, healthcare systems in the developed countries are treated as health industry, which is not led by doctors but the intellectuals with specialized knowledge and skills for the management and administration of healthcare organizations.
- Nowadays, implementation of modern management becomes

essential, not only at the central level but at all parts of a healthcare system. Attention is also focused on the development of an integral health information system and the application of mathematical modeling, in order to support decision making at strategic, tactical and operational level.

Salient Features of Healthcare Management

- Analysis and forecasting of the demand
- Determination of the optimal staffing level
- Staff scheduling and rostering

Analysis and Forecasting of the Demand

- In order to obtain efficient planning of various activities in healthcare organizations, it is very necessary to accurately predict the demand for medical services during the planning period. The demand patterns tend to be highly time and location dependent and the same can be concluded for the duration of medical interventions. Therefore, classical planning techniques, which assume the deterministic character of the demand, can not provide a relevant basis for decision making process.
- The adequate demand forecasting, which takes into account the stochastic nature of frequency and duration of medical interventions, allows better utilization of available resources that can enable improvements in quality of services, patients' and employees' satisfaction and costs reduction.
- One can assume that the level of demand for healthcare services varies over time and depends on the hour of the day, day of the week and month of the year. Taking into account these regularities, it is possible to predict future variations of the demand and consequently the number of personnel that should be available at the certain periods of time.
- For this purpose, it is necessary to perform various statistical analyses to examine whether it is possible to determine the daily, weekly or monthly patterns. Some of statistical techniques that are mainly used in this phase are: correlation analysis, numerous nonparametric tests and contingency tables. After detailed statistical analysis, it is also very important to choose the most suitable forecasting model. Based on an extensive literature review, the seasonal character of the demand for healthcare services can be assumed. Therefore, the forecasting methods that incorporate seasonality are most often the best choice.
- By applying the Winters Exponential Smoothing Model, we can obtain accurate forecasts of the daily volume of emergency and non-emergency calls at the ambulance service. To choose the exponential smoothing parameters, goal and quadratic programming were applied. The resulting forecasts were compared to those obtained by using a multiple linear-regression model and a single-objective Winters exponential smoothing model and the smoothing method yielded more accurate forecasts.

Determination of the Optimal Staffing Level

- It is important to embed observed regularities in the demand into human resources allocation process, by determining the optimal staffing level for different periods of time. In that way, the balance between demand and supply of medical services can be achieved, which consequently leads to the improvement of quality of services and increased satisfaction for both, patients and medical staff.
- The usual organizational problem of many healthcare organizations is that the number of available staff has been determined adhoc, regardless of the demand and system load, which might negatively influence the efficiency of the whole system. Waiting is a part of everyday activities in all segments of life, but people are even more sensitive when waiting for medical services to resolve their health problems.
- It is important to state that waiting to scheduled medical treatments is not a subject of queuing theory. Mathematical analysis of waiting lines is dealing with queues that occur when patients arrive without an appointment. In a long period of time, most of healthcare organizations have sufficient capacities to serve even

larger number of patients than the real demand, but the queues occur due to the unequal distribution of arrivals over time. Therefore, waiting lines are short term phenomena.

- The increase of a number of service providers (i.e. servers) leads to the greater quality and satisfaction, but also consequently to the higher costs. Those quantitative models are very applicative and suitable for determination of the most efficient way of the mass services system functioning. The overwhelming system capacity might cause the unnecessary costs, but on the other hand, insufficient number of servers could lead to the longer waiting times or other negative consequences, sometimes even with the fatal outcome.
- Queuing theory models ensure the achievement of balance between the available resources and quality of services at the one side and financial boundaries at the other side. Erlang'B' and Erlang'C'are queuing models that are most often applied in healthcare organizations.

Staff Scheduling and Rostering

- Employee scheduling in healthcare organizations is a very complex task due to the nature of vital medical services that must be provided 24x7 every day. Besides that, there are numerous legal and business regulations and agreements, which must be complied during this process.
- Compared to business organizations, determination of the optimal staffing level and scheduling employees is more complex in healthcare institutions, which are faced with very variable demand, chronic lack (or excess) of the workforce for certain profiles and limited budget.
- A great challenge for health care managers is also balancing between satisfaction of patients and satisfaction of employees. The application of quantitative models facilitates staff rostering process, by cost reduction and time saving. The great value of this schedule is that it links demand (through determinate staffing levels) and supply (available staff) which ensures better organization of work and higher level of satisfaction.
- Mainly, optimization models and simulation are developed and applied to aid staff scheduling and rostering. Usually it is difficult to transfer models from one organization to another one without significant changes, thus one of the future trends is to make a schedule more adaptable to constant changes and personal preferences.
- The method of linear programming solves the nursescheduling problem in hospitals. Nurses should benefit from this study by having higher quality schedules while the employees in charge of scheduling should enjoy the positive benefits of an optimization tool to solve problem related to healthcare.
- The use of linear goal programming is to assist and guide scheduling process in a hospital. The main purpose is to assign the personnel to the proper shift hours that enable management to meet the objective of minimizing the total payroll costs.
- The "Constraint Satisfaction Problem Approach" is used to solve human resource allocation problems in cooperative health services.
- A new tool is proposed for planning human resources utilization in hospital plants by using simulations for measuring the performance of the proposed heuristics.

Example

With the help of the example, we can understand the concept thoroughly well. Here, we shall study the yearly recruitment necessary to maintain the required strength of nurses in one of the private multi speciality corporate hospitals. There are 8 senior posts of nurses for which the length of service is the main criterion. We shall calculate the average length of service at the end of the year for the data obtained. The data shows the wastage of recruits which depends on their length of service. We shall also calculate the average length of service after which the new entrant expects promotion to one the senior posts.

TABLE 1

Year	1	2	3	4	5	6	7	8	9	10
Total % who have left by end of the year	5	36	55	63	68	73	79	87	97	100

The above table shows the wastage of recruits which depends on the length of service. The probability of nurse being in service at the end of the year can be calculated using the above data. Here, if 100 nurses are to be recruited every year, then the total number of nurses present at end of the year will be 436. Thus, to maintain the strength of 50 nurses in the hospital, a recruitment of 12 nurses has to be done each year. $[(100/436) \times 50 = 12]$. Further calculations are shown in the following table which shows the probability of nurses in service.

TABLE 2

Year	Number of nurses who left at the end of the year	Number of nurses in service at the end of the year	Probability of leaving at the end of the year	Probability of service at the end of the year
1	0	100	0.00	1.00
2	5	95	0.05	0.95
3	36	64	0.36	0.64
4	56	44	0.56	0.44
5	63	37	0.63	0.37
6	68	32	0.68	0.32
7	73	27	0.73	0.27
8	79	21	0.79	0.21
9	87	13	0.87	0.13
10	97	3	0.97	0.03
	100	0	1.00	0.00
		Total = 436		

We have already calculated that every year 12 new recruitments are done. Hence, the number of survivals where the nurses who will remain in service at the end of the year 'n' will be 12. The following table shows the calculation where the number of nurses in service at the end of each year.

TABLE 3

Year	0	1	2	3	4	5	6	7	8	9	10
Probability	1.00	0.95	0.64	0.44	0.37	0.32	0.27	0.21	0.13	0.03	0.00
Number of nurses	12	11	8	5	4	4	3	2	2	0	0

From the above table, we can say that there are 3, 2 and 2 nurses in service during 6th, 7th and 8th year respectively. The total of such nurses is less than the number of senior posts, i.e. 8. Hence, promotion of the new nurse must start by the end of the 5th year.

Conclusion and Suggestions

- The main goal of this paper was to show how application of operational research models can improve decision making process, especially addressing efficient workforce allocation.
- We presented the review of different groups of quantitative models which can be applied to various aspects of managing human resources in healthcare organizations. Ability to analyze and predict demand of health care services is of great importance, so we described how time series analysis and various econometric models can be used to explore time and location dependent variations of the demand.
- Important prerequisite for the comprehensive implementation of quantitative methods is the improvement and standardization of electronic records in healthcare organizations. It would provide an integral database for realization of scientific research projects, improve business organization throughout the healthcare system and facilitate the process of monitoring and evaluation.
- The application of mathematical models greatly accelerates and simplifies the process of human resources allocation, which is especially important in complex healthcare organizations.
- Integration of quantitative methods, management and health is

necessary in order to improve the overall healthcare system in today's rapidly changing environment.

REFERENCES

- [1] Baker, J. R. & Fitzpatrick, K. E. (1986). Determination of an optimal forecast model for ambulance demand using goal programming. *Journal of Operational Research Society*, 37 (11), 1047-1059.
- [2] Kwak, K. L., & Li, C. (1997). A linear goal programming model for human resource allocation in a health-care organization. *Journal of Medical Systems*, 21(3), 129-140.
- [3] Ernst, A.T., Jiang, H., Krishnamoorthy M. & Sier D. (2004). Staff scheduling and rostering: A review of applications, methods and models, *European Journal of Operational Research*, 153, 3-27.
- [4] Goldberg, J.B. (2004). Operations research models for the deployment of emergency services vehicles. *EMS Management Journal*, 1(1), 20-39.
- [5] Channouf, N., L'Ecuyer, P., Ingolfsson, A., & Avramidis, N. (2007). The application of forecasting techniques to modeling emergency medical system calls in Calgary, Alberta. *Health Care Management Science*, 10 (1), 25-45.
- [6] Setzler, H., Saydam, C. & Park, S. (2009). EMS call volume predictions: a comparative study. *Computers & Operations Research*, 36 (6), 1843-1851.
- [7] Teow, K.L. (2009). Practical operations research applications for healthcare managers. *Annals of the Academy of Medicine Singapore*. 38 (6), 564-566.
- [8] Zuidhof, G.M. (2010). Capacity Planning for Ambulance Services: Statistical Analysis, Forecasting and Staffing. Master thesis, Vrije Universiteit Amsterdam, Centrum Wiskunde en Informatica Amsterdam.
- [9] Bekker, R. & De Bruin, A. M. (2010). Time-dependent analysis for refused admissions in clinical wards. *Annals of Operations Research*, 178 (1), 45-65.
- [10] Yankovic, N. & Green, V.L., (2011). Identifying good nursing levels: a queuing approach. *Operations Research*, 59, 942-955.
- [11] Brahma, P.K. (2012). Application of queuing theory in hospital manpower planning. Saarbrücken, Germany. Lambert Academic Publishing.
- [12] Filho, C.F.F.C., Rocha, D.A.R., Costa, M.G.F. & Pereira, W.C.A. (2012). Using Constraint Satisfaction Problem Approach to Solve Human Resource Allocation Problems in Cooperative Health Services. *Expert Systems with Applications*, 39 (1), 385-394.
- [13] Kumar, B. S., Nagalakshmi, G. & Kumaraguru, S. (2014). A Shift Sequence for Nurse Scheduling Using Linear Programming Problem. *IOSR Journal of Nursing and Health Science*, 3(6), 24-28.
- [14] DeRienzo, C.M., Shaw, R.J., Meanor, P., Lada, E., Ferranti, J. & Tanaka D. (2016) A discrete event simulation tool to support and predict hospital and clinic staffing. *Health Informatic Journal*, pii: 1460458216628314