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# Service Quality Improvements in Hospitals by Reducing Response Time: Operational Statistics and IT Solutions

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## ABSTRACT

*In this study we develop a Decision Support System tool to monitor and understand the characteristics of emergency departments of NSW Hospitals management systems in detail to find cost effective solutions to service quality improvements. In the past researchers have used statistical, operational research or simulation techniques in finding solutions to improve management systems. In contrast to these procedures, we introduce a new way of integrating operations research and statistics to build an operations statistics model and simulate the system for forecasting. Statistical and data mining techniques are used to analyse data. Further computing and IT skills are used to create and integrate various functional modules in developing the Decision Support System tool. Finally the capabilities of the developed DSS tool will be illustrated by using several studies to improve efficiency of the Campbelltown Hospital emergency service facility.*

## INTRODUCTION

Providing emergency services has become one of the primary responsibilities of governments in order to improve the level and perception of safety in the community. In this paper we consider the emergency medical services and in particular focus on the hospital emergency service. The performance of any hospital emergency service department is measured along two dimensions: first, the speed in which the system can respond to emergencies (Keeney, 1973); and second, the ability of the responding personnel to handle the situation. This paper is concerned with response time or waiting time with means of reducing it, and not with techniques for improving the service quality once the doctors and nurses commence providing the service. However, we recognise that the two performance dimensions are related (Eaton et., 1985). We identify that the waiting time of patients, play a crucial role in patient satisfaction and hence by reducing waiting time we can improve efficiency of the management system. Further this will lead to reducing doctor/nurse idle time and hence will become cost effective.

In recent years the levels of service has declined drastically due to lack of funds, resources and increasing costs for medical care. This situation has become very critical and health care agencies around the world all share the urgency and the need to improve health services in order to provide quality health care. Hence, there is an internationally recognised need and urgency to monitor and understand the characteristics of hospital management systems in detail to find cost effective solutions to service quality improvements.

## REVIEW OF RELATED LITERATURE

During the last decade many researches have worked on this issue with a view to improve National Health Services. Much of the literature relates to, either developing simulation models, operations research models such as queuing models, stochastic models and linear programming models, using statistical tools or developing IT solutions. Summary of these past works under these headings are listed as follows.

Simulation Models:

- Davies (1985a and 1985b) used discrete event simulation in the planning of renal care.
- Wright (1987) developed a simulation model for inpatient general surgery and urology care
- Ceric (1990) developed a simulation study of an automated guided-vehicle system in a Yugoslav hospital.
- Gupta (1991) developed a simulation model of a maternity division designed to assist in increasing capacity and providing optimum occupancy of the maternity unit
- Davis (1994) developed a simulation model to predict the resources used and the costs arising from the treatment of patients.
- McAleer, Turner,Lismore and Naqvi (1995) developed a simulation model for a hospital theatre suite.
- Lehaney and Ray (1996) used systems methodology in developing a simulation of out-patient services at Watford general hospital.
- Huanrng and Lee (1996) used simulation in out-patient queues.

Operations Research/ Statistics/Mathematics Models:

- Brahimi and Worthington (1991) studied the trade off between patients waiting time and doctors idle time in out-patients clinics using queuing models.
- Gupta (1991) used simulation techniques in maternity care analysis
- Lennon (1992) showed that emerging technology could be used to refocus complex operational and staffing issues to create optimum efficiency without necessarily adding space or tab.
- Butler et al (1992) used simulation, stochastic modelling, linear programming with chance constraints and marginal analysis for addressing facility layout issues in hospital systems

- Siferd and Benton (1994) used statistical tools in the mathematical modelling of the number of nurses in a hospital
- Liyanage and Gale (1995) used theory of queuing models to minimise patients waiting times while controlling the associated running costs.

Computing/Information Technology Solutions:

- Gabaeff and Lennon (1991) used computerised technology for the design and planning of emergency departments

Operations Management Strategies:

- Sahney and Rupp (1988) used industrial engineering methodology for the management of the Henry Ford Hospital in Detroit.
- Weiss (1990) identified the similarities between manufacturing management and hospital management
- Gabaeff and Lennon (1991) highlighted deficiencies in a number of key areas at Stanford University Hospital by suggesting a four-pronged methodology.
- Ramani, Chapman, Chandy, and Aruldas (1998) a comparative study of hospital management in different countries

## RESEARCH FOCUS

In spite of many attempts, which have been made in the past to improve several individual units of hospitals, the outcomes are not been satisfactory. The waiting times have increased significantly during the past few years to a point of becoming a major national concern.

This paper considers an integrated approach to hospital management by combining techniques of the three disciplines operations research, statistics and computing/IT technology together. In contrast to the traditional way of setting a stochastic model assuming a certain distributional form and using statistics in estimating the parameters, we first take real data and use statistics and operations research techniques to build the model based on the real data and then use the same data to demonstrate that it will do better under revised conditions and then also to extend this model to forecast future behaviour. Statistical part is mainly intended to predict what will happen in the future and show that if the same statistical nature was to continue or persists, to show the future behaviour and the improvement we expect under revised conditions. This will provide an Operational Statistics Model and Forecast giving a snapshot of what would have happened. In this model we are estimating the output distribution based on statistics rather than the input distribution as traditionally done. Finally using this model and computer technology, an effective Decision Support System has been developed to assist management in their decision making process to improve efficiency of the operations of the emergency services department.

This process and it's effectiveness has been illustrated by a case study based on Campbelltown Hospital Emergency Service Facility, Campbelltown, Australia. This particular example focuses on finding a cost effective approach to improve service quality by selecting appropriate scheduling patterns and service disciplines to reduce overall waiting times in outpatient services.

## BACKGROUND

The emergency service facility at Campbelltown hospital provides medical care for emergency patients as well as those visiting as out patients. Hospital has been experiencing a continuing increase number of patient visits each year and as a result it has become common for patients arriving during peak hours having to wait long hours before they are treated by a doctor.

On arrival at the hospital, the patient first reports to the nurse at the counter to register the visit. Then the patient will enter the system and will be placed in a queue to be assessed by the Triage nurse. When the patient arrives at the Triage nurse they will be categorised according to their urgency based on the severity of their medical conditions. They will be placed in one of five categories according to the degree of emergency (Resuscitation, Emergency, Urgent, Semi-Urgent and Non-Urgent) and hence be placed in one of five parallel queues. Patients fall into Emergency and Urgent categories will attempted to be seen, within 10mins and 30mins respectively. This process creates customer dissatisfaction as the patients who are relatively less urgent may fall backward in their position in the overall queue while waiting in line. Once the patients are categorised, patients will wait in the queue until a doctor is available.

Phase1: Building the model and finding system characteristics at the initial point in time. Following gives the steps taken in this initial phase.

- As a function of the Decision Support System (DSS) a data entry module has been developed to collect the data needed in order to build the queuing model, which will describe the characteristics of the system of the emergency department. The data entry will be an ongoing process and incoming patient distributions and associated functional parameters will continuously be updated. Essentially the data entry interface is form-like and contains a series of fields, which needs to be entered for each patient entering the system.
- For every patient who enters the system the arrival time, time arrived at the Triage nurse, time completing the preliminary check up by the Triage nurse, time starting doctors' consultation, time completing the consultation etc is recorded.
- This information listed above together with other information such as degree of urgency, number of doctors available, number of nurses available, number of examination rooms operating, waiting room capacity, total number of beds available, number of beds occupied, date, time and service discipline are used to simulate the queuing system.
- Once the data is entered to the data entry module, the captured data will be stored in a database and it will serve as the primary source of information in building the model. It is also set up in such away for it to automatically generate the simulation model representing the queuing system of the emergency department assuming the same statistical nature was to continue or persists. This is on contrast to the normal procedure of assuming or estimating the input distributions based on the input data.
- However this will also has the capacity to generate the inter-arrival time distribution, service time distribution, arrival rate and service rate, overall or for a given time period of your choice. This information describes the statistical nature of the system under consideration at the initial point in time. If these distributions can be proved to assume standard distributional form then the available standard results can also be used in the predictions and making better decisions.
- Further a data manipulation module is set up to generate the distribution of the queue length, waiting time distribution, service time distribution, idle time distribution and their corresponding means. These represent the output characteristics highlighting the degree of efficiency or inefficiency also at the initial point in time. For each day and for each queue the inter-arrival time, waiting time and service time distributions are modelled and shown that they assume an exponential distribution. The estimates of the mean for each variable are calculated separately for each day of the week giving the distributional parameter.

Phase2: Improving system parameters in order to improve the efficiency. Following gives the steps taken in this intermediate phase.

- Degree of urgency, which is used to categorise the severity of the emergency is usually made with a predetermined codes defined by an adult codes and paediatric codes. However the accuracy of this parameter is subject to question and it plays a major role in waiting times and particularly increase waiting times of patients who are categorised as not urgent. In order to improve the accuracy of this parameter another function within the data entry module is set up to enter and store data such as diagnosis of the patient, presentation of patient to triage nurse and assigned triage code. This data can be analysed in the data manipulation module in order to test the accuracy of the classification of the triage nurse with a view to improve this parameter. Data-mining techniques are appropriate in this classification module and hence will be included in the Statistical Library mentioned in Phase5. The following table giving proportion of urgent patients suggests that it has a tendency to increase during less busy days.

- Doctors Schedule and predetermined Shifts is another system parameter we explored with a view to improve system efficiency. The distribution of inter-arrival time is used to identify busy periods and it is observed that the three days Saturday Sunday and Monday are busy compared to the rest of the week. Further data mining techniques are suitable in classifying or identifying the busy periods. This information are intern used to forecast performance subject to shift changes in order to identify more suitable shift arrangements in improving efficiency of the system and measure the degree of improvement subject to this change.
- Expected service times for standard treatments is another valuable statistical summary measure which will be useful in understanding the system efficiency. This can be calculated using the data manipulation module. The DSS tool developed can be used to provide many such statistical summaries to assist managers to make informed decisions regarding staff levels, shift arrangements etc.

Phase3: Forecasting output characteristics or performance indicators based on alternate shifts arrangements and doctors schedule

This will give a snap shot of what would have been and what it will be subject to the suggested changes. This will also give a relative measure of improvement.

Phase4: Forecasting output characteristics or performance indicators based on alternate service disciplines.

Similarly this also will give a snap shot of what would have been and what it will be subject to many different alternate service disciplines. This will also give a relative measure of improvement for each alternate arrangement and provide a tool in identifying the most appropriate service discipline for any given system.

Phase5: Statistical Library of charts and graphs and other tools needed for exploring alternate ways to find management processes leading to local optimum solutions.

As a future development we intent to provide in a separate module statistical and operational research tools used and those will be useful as a statistical library within the DSS Tool.

## CONCLUSION

In this study a decision support system has been developed using a new approach of using operational statistics, which integrates statistical and operations research techniques in a different way to what has been done in the past. It's effectiveness has been demonstrated by a case study in modelling Campbelltown hospital emergency services facility and finding alternate system parameters and service disciplines to improve the systems efficiency. It has also used in finding the expected improvement subject to these changes.

This system can be used by all hospitals in New South Wales who adopt a similar service facility to improve patient satisfaction and to improve efficiency of the system. By linking all hospital systems one can modify this system to extend this to other areas such as optimum utilisation of available beds etc.

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