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Decision Support

Simulation-based framework to improve patient experience in an emergency department

Waleed Abo-Hamad *, Amr Arisha

3S Group, College of Business, Dublin Institute of Technology, Dublin, Ireland

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ABSTRACT

The global economic crisis has a significant impact on healthcare resource provision worldwide. The management of limited healthcare resources is further challenged by the high level of uncertainty in demand, which can lead to unbalanced utilization of the available resources and a potential deterioration of patient satisfaction in terms of longer waiting times and perceived reduced quality of services. Therefore, healthcare managers require timely and accurate tools to optimize resource utility in a complex and ever-changing patient care process. An interactive simulation-based decision support framework is presented in this paper for healthcare process improvement. Complexity and different levels of variability within the process are incorporated into the process modeling phase, followed by developing a simulation model to examine the impact of potential alternatives. As a performance management tool, balanced scorecard (BSC) is incorporated within the framework to support continual and sustainable improvement by using strategic-linked performance measures and actions. These actions are evaluated by the simulation model developed, whilst the trade-off between objectives, though somewhat conflicting, is analysed by a preference model. The preference model is designed in an interactive and iterative process considering decision makers preferences regarding the selected key performance indicators (KPIs). A detailed implementation of the framework is demonstrated on an emergency department (ED) of an adult teaching hospital in north Dublin, Ireland. The results show that the unblocking of ED outflows by in-patient bed management is more effective than increasing only the ED physical capacity or the ED workforce.

1. Introduction

Healthcare managers are constantly under pressure to control rapidly escalating expenses whilst simultaneously fulfilling the growing demand for healthcare services. As a result, they are continuously studying the efficiency of existing healthcare systems and exploring improvement opportunities. The evaluation of these proposed interventions is crucial prior to their actual implementation, though challenged by intrinsic uncertainty of demands and outcomes of healthcare systems; high level of human involvement at both patients level and resource level (doctor, nurses, etc.); limited budget and resources; and large number of variables (e.g., staff scheduling, number of beds, etc.). Patients, on the other hand, in addition to requiring a high service quality, are understandably no longer prepared to wait in queues for essential health services. Accordingly, the healthcare service concept has shifted from optimizing resources utilization to finding a balance between service for patients and efficiency for providers (Brailsford and Vissers, 2011). Dealing with these inevitable complexities within healthcare processes and services (e.g., hospitals, emergency departments, and bed management) and addressing the challenges in the decision making process is the focus of this paper.

Discrete-Event Simulation (DES) has proven to be an effective tool for process modeling and improvement (Benneyan, 1997; Jun et al., 1999). Healthcare managers can apply DES for assessing current performance, predicting the impact of operational changes, and examining the tradeoffs between system variables (Wierzbicki, 2007). Furthermore, DES has been used to identify areas of improvement of service through possible reorganization of existing resources, for example; reorganization of surgical and anesthesia care surrounding laparoscopic surgery (Stahl et al., 2004); and planning for the geographical locations of new healthcare services taking into account the demographics of the population and the location of the patients who need the services (Harper et al., 2005). Furthermore, DES is well-suited to tackle problems in emergency departments (EDs), where resources are scarce and patients arrive at irregular times (Jun et al., 1999), and effectively combine data mining (Ceglowski et al., 2006) for better results. Though a substantial body of work has appeared in the literature, most of these papers do not use strategy-linked performance measures and actions. The development and application of a decision support system that can coordinate diverse staff categories toward the

* Corresponding author. Tel.: +353 871653983.
E-mail address: waleed.abohamad@dit.ie (W. Abo-Hamad).

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strategy direction is becoming more pivotal for strategy implementation (Voelker et al., 2001). Moreover, the decision-maker preferences information is rarely considered in the process of alternative evaluation (Rosen et al., 2008).

The objective of this paper is to develop an interactive simulation-based decision support framework to improve planning and efficiency of healthcare processes. A real-world case study of an emergency department in one of the largest University Hospitals in Dublin is investigated in order to enhance patients' experience using the proposed framework.

2. Proposed integrated framework

2.1. Literature review

Efforts to develop DES models have been advancing since the late 1980s when Saunders et al. (1989) proposed a model to study the impact of key resources on waiting times and throughput. Since that time, DES models have been used to study the effect of a wide range of health interventions on healthcare processes' performance, for example; designing a new house staff work schedule (Dittus et al., 1996) and ambulance schedules (Ingolfsson et al., 2003); improving capacity utilization in intensive care units (Kim et al., 1999; Litvak et al., 2008); planning healthcare services (Oddoye et al., 2009); and evaluating different health interventions such as comparing the 'individual surgeons' strategy with the 'pooled lists' strategy for scheduling outpatient clinical appointments in surgical care (Vasilakis et al., 2006).

Recently, calls for improved performance have grown significantly. Therefore, applications for operational decision support are widespread and have become increasingly significant (Eldabi et al., 2006). Most of these undertakings have focussed on departmental operations; especially the more patient-intensive ones such as outpatient and emergency departments. For example, Samaha et al. (2003) analysed the effect of the physical expansion of ED on patient stay times. However, physician skills level was not considered in patients' service time. The impact of different patient triage methods on service times has been studied by Connelly and Bair (2004). Yet, variations in patients' arrival rate were not considered. The effect of staffing levels were investigated by Sinreich and Jabali (2007) to reduce patient's length of stay (LOS) and by Ahmed and Alkhamis (2009) to determine the optimal number of required staff (e.g., doctors, lab technicians and nurses) that maximize patient throughput and to reduce patient experience time. In Duguay and Chetouane (2007), a number of alternatives based on adding resources has been investigated with the objective to reduce patient waiting times and to improve overall service delivery and system throughput. Additionally, Thorwarth et al. (2009) examined the impact of staff scheduling on overall utilization and burnout issues related to over-utilized staff. The tradeoffs between different alternatives such as adding more beds or altering the admission rate has been evaluated by Khare et al. (2009), where patient length of stay is considered as the key performance indicator (KPI). However, aforementioned studies only consider a small number of KPIs (e.g., waiting time and LOS), while other performance measures such as resource utilization, productivity, and layout efficiency are rarely considered. Moreover, linking these KPIs to the international standard and national metrics is mostly neglected.

On the other hand, the balanced scorecard (BSC), pioneered by Kaplan and Norton (1992), is a systematic methodology that uses strategy-linked leading and lagging performance measures and actions for planning and implementing an organization's strategy (Kaplan and Norton, 2001). With many successful implementations at different organizations, BSC is considered as a popular model and effective means for performance management and strategy execution. Furthermore, the BSC concept has been modified and successfully developed at different types of healthcare organizations (Zelman et al., 2003; Ismail et al., 2010). The BSC usually has several perspectives (e.g., financial, internal operations, and patient) of the healthcare facility performance, with each perspective composed of main objectives and sub-objectives.

Yet, these objectives are interacting among themselves simultaneously, influencing each other in a complex relationship network, often under conditions that involve randomness, and requires the observation and evaluation of numerous decision criteria. Therefore, a structured technique is needed for dealing with problems with multiple and complex criteria influencing decision making (Dyer et al., 1992; Liberatore and Nydick, 2008; Saaty, 1990).

2.2. An interactive simulation-based decision support framework

An overview of the framework is given in Fig. 1 where a detailed description of each component is provided through the next sections. Further, the coordination between these components is explained in details along with highlighting their points of integration.

2.2.1. Formulation and understanding

Healthcare systems contain a high level of social interactions that are characterized by complexity and in particular at decision points. Therefore, problems associated with healthcare service delivery and managing patient flow are usually hard to define problems. Gaining a better understanding of the healthcare process is essential for making correct justifiable decisions and providing effective solutions. Therefore, it is necessary to formulate the underlined problem from the point of view of the individuals who are directly involved in the process of service delivery.

Accordingly, the data collection phase proceeds to gather relevant information of the underlying processes. This phase focuses on the retrieval of the data and also on the construction of a conceptual model (i.e., business process model). The quantitative data is either stored in databases, written on documents, or recorded on any type of storage medium where the qualitative data can be obtained *via* direct observation of the system and interviews from the experts. In the healthcare context, experts are those who work in the hospital – doctors, nurses, consultants, administrators and managers.

2.2.2. Conceptualizations and analysis

The data collection phase combines data from observations and interviews with experts and practitioners. This in return provided holistic insights for various system issues and aspects. The underlined business processes are then mapped into a conceptual process model using one of the well-developed modeling languages where sub-processes and activities are identified. The control flow definition is created by identifying the entities that flow through the system (e.g., patients, staff, and medical resources) and describing the connectors that link the different parts of the process. Finally, the resources are identified and assigned to the activities where necessary. The conceptual model is used in the simulation model for two purposes: first it is guidance for the actual simulation model, which contains and considers a higher degree of details, and second it is used as a communication platform in order to validate the model with the experts working within the real system. Once the conceptual model is completed, it is essential to validate it with the staff in the facility including senior managers. This is an essential step for the credibility of the simulation model and hence its output.

Interviews and observations have greatly contributed to a better understanding and an accurate modeling of work flow in the