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A decision support system to improve the efficiency of resource allocation in healthcare management

Emel Aktaş[a], Füsun Ülengin[b,*], Şule Önsel Şahin[b]

[a]*Istanbul Technical University, Faculty of Management, Industrial Engineering Department, Macka, 34357 Istanbul, Turkey*
[b]*Dogus University, Engineering Faculty, Industrial Engineering Department, 34722 Kadikoy, Istanbul, Turkey*

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Abstract

Limitations in healthcare funding require hospitals to find more effective ways to utilize resources. An effective patient management system is critically dependent on the accurate analysis of individual patient outcomes and resource utilization. In the current paper, a management-oriented decision support model is thus proposed to assist health system managers in improving the efficiency of their systems. In the first stage of the model, the key variables affecting system efficiency, as well as their causal relationships, are identified through causal maps. Efficiency is measured by the total time spent in the system. In the second stage, a Bayesian Belief Network (BBN) is employed to represent both the conditional dependencies and uncertainties of the key variables. In the third stage, a sensitivity analysis is performed using a BBN to determine the most critical variable(s) in terms of impact on the system. Finally, strategies to improve system efficiency are proposed. The suggested decision support system is applied to the tomography section in the radiology department of a private hospital in Turkey.

Keywords: Healthcare management; Decision support system; Bayesian belief network

1. Introduction

Effective utilization of limited resources is a vital problem for healthcare management [1,2]. The scarcity of healthcare resources is particularly important in developing countries where poor health conditions is one of the most important obstacles in the fight for economic development and welfare [3]. However, healthcare systems are complex and depend on a variety of economic, structural, and organizational factors, and their interdependencies. For example, a change in a clinical action may affect treatment cost, while a change in activity scheduling may influence treatment procedure.

Additionally, many of the factors that influence healthcare system efficiency are uncertain. In order to increase such efficiency, we thus seek insight into the system by highlighting its most critical variables [4].

Although, efficiency is often measured by the cost of providing a given level of service, generally, quality of service and the desire to not wait in queues are of critical importance to the users of health services [5,6]. In this

*Corresponding author. Fax: +902122407260.
E-mail address: fulengin@dogus.edu.tr (F. Ülengin).

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paper, efficiency is thus measured by the total time spent in the system. In fact, length of stay (LOS) in hospitals is a challenging task and essential to operational success in terms of reducing costs while maintaining high quality of care [2].

Having to wait is caused by a scarcity of resources while more effective use of existing resources can help reduce LOS in the system.

This paper thus aims:

1. To provide insight into the complexity of the healthcare system by analyzing interactions of key variables affecting time spent in the system.
2. To provide a useful guide for healthcare managers in improving the efficiency of their systems by evaluating the consequences of selected strategies.

To these ends, we propose a management-oriented decision support system (DSS) based on (for reasons noted below) a Bayesian Belief Network (BBN). In the first stage, the key variables affecting system efficiency are identified and their causal relationships revealed through causal maps.

In the second stage, a BBN is used to represent the conditional dependencies as well as the uncertainties of these variables. In the third stage, a sensitivity analysis is performed using the BBN to determine impacts of the most critical variables affecting system efficiency. The proposed model is then applied to the case of a tomography section in the radiology department of a private hospital in Turkey.

In the following section, a literature review helps identify basic advantages of the proposed DSS model. Section 3 discusses major stages of the proposed model in some detail. Results of the model application to our case study facility are given in the fourth section, where important strategies are revealed through selected analyses of earlier results. Finally, conclusions and suggestions for further research are presented to generalize use of the proposed model on a nationwide basis.

2. State of the art

2.1. General considerations

The approaches available to evaluate the efficiency of resource utilization in a healthcare facility are varied [7]. If the interaction effects of multiple variables on resource requirements are to be investigated, a simulation model is generally seen as desirable [8]. Simulation may be used to mimic the behavior of a healthcare system in order to evaluate its performance and analyze the outcomes of various scenarios [9]. For example, simulation-based applications are well-suited to estimate and evaluate the potential effects of changes to a facility's environment [6].

There has been substantial research using discrete event simulation to describe and analyze the behavior of healthcare systems, e.g., asking what-if questions in providing guidance for the design of management policies. In [10] and [11], such simulation was used to analyze waiting lists and resource utilization in a hospital. Côté [6], for example, considered the relationship between examining room capacity and patient flow across four clinic-based performance measures. Blake and Carter [12] investigated the impact of surgical schedule on resources throughout the hospital. Zaki et al. [2] developed a simulation model which is easy to understand and employ by system administrators in the allocation and management of resources for emergency services.

Another approach to evaluating the efficiency of resource utilization in healthcare systems involves mathematical optimization models [40]. These explicitly represent the functioning of the system, generally resulting in large linear/nonlinear and integer models with significant numbers of variables and constraints [13,14]. Optimization applications in health care address a variety of issues such as the efficient use of resources [15], the cost-effectiveness of selected interventions [15,16], portfolio analysis for policy/decision-making [17], and nursing home and hospital in-patient expenditures on heart failure [18].

A significant number of papers involving the optimization of healthcare management activities deal with economic aspects of the subject. Ferri et al. [19], for example, discuss selected issues of healthcare resource allocation in developing countries. They propose an object-oriented system, and illustrate its implemented