

Chapter 15

A Simulation Decision Support System for the Healthcare Emergency Department Optimization

Manel Saad Saoud

University of Bordj Bou Arreridj, Algeria

Abdelhak Boubetra

University of Bordj Bou Arreridj, Algeria

Safa Attia

University of Bordj Bou Arreridj, Algeria

ABSTRACT

Agent-based modeling and simulation methods have demonstrated efficiency in modeling and analyzing the dynamics of the healthcare systems. Simulation has become a crucial tool that facilitates understanding these systems that involve different and heterogeneous components interacting in diverse and complex ways. However, during the dynamic evolutions of these societies, the agents involve a massive amount of data that contain non-explicit and unknown information. The analysis of these data to study and discover the hidden relationships and the emerging phenomena is a well-known difficulty in the simulation systems. The call for powerful tools such as the data mining techniques to support the simulations analysis is the best solution that can be used to tackle this issue. The aim of this chapter is to develop a decision support system based on the integration of simulation systems and knowledge extraction techniques, to design a decisive tool to help healthcare managers to improve the quality and the effectiveness of care provided to the emergency departments.

1. INTRODUCTION

Healthcare system is a sensitive and critical sector that has become a serious concern for most governments across the world. Accordingly, many researchers have become increasingly interested in modeling and improving the efficiency of such complex and dynamic systems. The efficiency of the healthcare systems has often been measured and related to the effectiveness of hospitals and their departments, more particularly the Emergency Department (ED), due to its complexity and variability compared to other hospital departments. Crowdedness, high demand (patient flow) for services, long waiting time and limited healthcare resources (doctors, nurses, equipment, space...) are the key problems that the emergency department managers must cope with. Furthermore, the emergency staff is required to adapt to those conditions and to provide a quick and appropriate care for all patients.

In order to improve the performance of the emergency department by reducing patients' waiting time, decreasing the patients' length of stay, optimizing the resources utilization, and increasing patients throughput (number of patient served), ED managers ought to have a good patient flow management and to find the optimal ED staff configurations. However, the unplanned and unpredictable nature of patients' arrival hinders the managers to achieve this task. Hence, developing decision support systems using computer simulation methods can be the best solution to anticipate and help ED managers choosing the adequate and efficient decision strategies and policies. (Saad Saoud, Boubetra, & Attia, 2016)

In recent years, simulation has profusely been used to model healthcare systems since it allows researchers to understand them better and analyze efficiently their functioning. Different simulation techniques have been presented in order to provide powerful systems that can help the managers to enhance the quality of services in the ED. A large portion of these studies have focused on the discrete event simulation (Evans, Gor, & Unger, 1996; Duguay & Chetouane, 2007; Konrad, et al., 2013) or the agent based modeling simulation (Cabrera, Taboada, Iglesias, Epelde, & Luque, 2012; Cabrera, Taboada, Iglesias, Epelde, & Luque, 2011; Jones & Evans, 2008).

Adopting simulation approaches facilitates the examination of different "what-if" scenarios and the evaluation of possible policies and changes in the system without making costly decisions and uncertain changes in the real one. Agent-based modeling is one of the most powerful simulation techniques that helps researchers to analyze a complex system such as the emergency department due to its ability to model systems close to the reality, to represent heterogeneous individuals and their interactions, to observe their behaviors and to understand their interrelations. In this paper, in addition to the choice of the multi-agent-based simulation model (programmable modeling environment Netlogo (Wilensky, 1999)), we used two data mining techniques (Pujari, 2001; Fayyad, Piatetsky-Shapiro, & Smyth, 1996; Hegland, 2001; Han, Kamber, & Pei, 2011) called respectively "preprocessing methods" and "linear regression", to design a decision support system for the improving operation of the emergency department in the public hospital Lakhdar Bouzidi in Bordj Bou Arreridj (Algeria) and help the ED managers to enhance the quality of care provided. The first technique was used to process the simulation inputs and the second one to investigate the relationship between the patients' arrival time and the acuity levels. Due to these latter techniques, we could find the optimal staff configurations and the simulation results showed that the average waiting time, the average length of stay and doctors' utilization have been consequently, improved considerably.

The remainder of this paper is organized as follows; Section two focus on the simulation within the healthcare. Section three describes how the emergency department is functioning. In Section four, the phases of design and development of the proposed simulation model using data mining techniques are

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