Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 178 (2017) 368 – 376

Procedia Engineering

www.elsevier.com/locate/procedia

16th Conference on Reliability and Statistics in Transportation and Communication, RelStat'2016, 19-22 October, 2016, Riga, Latvia

Simulation and the Emergency Department Overcrowding Problem

Abdulrahman Nahhas[a,c,*], Ahmad Awaldi[a], Tobias Reggelin[b,c]

[a]*Otto-von-Guericke University, Department of Technical and Business Information Systems, Universitätsplatz 2, 39106 Magdeburg, Germany*
[b]*Otto-von-Guericke University, Institute of Logistics and Material Handling Systems, Universitätsplatz 2, 39106 Magdeburg, Germany*
[c]*Fraunhofer Instiute for Factory Operation and Automation IFF Magdeburg, Sandtorstraße 22, 39106 Magdeburg, Germany*

Abstract

In this paper, a brief review on the emergency department overcrowding problem and its associated solution methodologies is presented. In addition, a case study of an urgent care center is investigated that demonstrates different simulation-based solution strategies to deal with the Emergency Department overcrowding problem. More precisely, a simulation study is conducted to identify critical aspects and propose possible scenarios to configure an urgent care center. Based on statistical data supported from an international competition for simulation, several discrete-event simulation models have been built to study the behavior of a planned system and identify the required resources such as number of procedure and examination rooms, number of doctors, assistants and nurses. Each model contains a specific simulation scenario. The solution scenario has been developed based on combining key elements of the different previously developed scenarios. These elements have been observed carefully through a verification process combined with a heuristic optimization approach to identify their impact on the performance of the system. In particular, different patient arrival patterns with specific proportional critical level have been investigated. In addition, two main responses have been observed namely, the Leave Without Being Seen (LWBS) percentage and staffing and operational costs.

Peer-review under responsibility of the scientific committee of the International Conference on Reliability and Statistics in Transportation and Communication

Keywords: the emergency department overcrowding problem, urgent care center, Simulation based optimization, discrete-event simulation, stochastic systems

*Corresponding author.
E-mail address: abdulrahman.nahhas@ovgu.de

Peer-review under responsibility of the scientific committee of the International Conference on Reliability and Statistics in Transportation and Communication
doi:10.1016/j.proeng.2017.01.068

1. Introduction

In this paper, a brief overview on the emergency department overcrowding problem will be presented. This work was motivated by an international competition for simulation, which was organized by SIMIO LCC. A simulation study was conducted to evaluate and assess the configuration of a planned Urgent Care Center.

1.1. Simulation-based solutions for analyzing complex systems

Dimensioning any system taking into consideration the required equipment, resources and staffing capacity is a very tedious task. Normally such problems involve many obstacles, which require precise observations to obtain high quality solutions. Configuring a system involves stating scheduling policies, identifying staffing strategies and organizing resource allocation. In many instances, dealing with one of those tasks can be complex enough not to be solved using normal mathematical models. For instance, identifying the scheduling policies for the system is a very complex task, since the majority of scheduling problems are stated in the literature as NP-hard problems (Lenstra *et al.*, 1977; Pinedo, 2012). NP-hard class contains optimization problems, which are considered to be particularly hard to solve using an algorithm in polynomial time (Johnson, 2012). Therefore, analytical methods are often incapable of delivering optimal solution for such problems in reasonable time.

Simulation is a very powerful technique, which has been used to study the stochastic behavior of complex manufacturing and service systems (Paul *et al.*, 2010). Simulation models are often built to analyze modifications on a system. For instance, one of the most critical service sector is the health care, in which the level of service is an important issue that have been often analyzed based on simulation studies since the majority of such system are very complex. Moreover, the associated costs in the health care field is enormous, where many optimization opportunities can be investigated. Nowadays, operative as well as strategic decision making processes can rely on more precise forecasting, which can be obtained through simulation models. The results of these simulation studies allow the decision maker to obtain an insight into the behavior of the system towards different possible alternatives before committing resources and efforts (Bocciarelli *et al.*, 2014; Lajoie *et al.*, 2014). In this paper, a brief literature review on the Emergency Department (ED) overcrowding problem well be presented in the second section. Followed, in the third section, a case study of an Urgent Care Center (UCC) will be demonstrated, in which a simulation study is conducted to explore possible obstacles of the problem and present some solution scenarios. Finally, in the fourth section, conclusion and some recommendation will be presented.

2. The emergency department overcrowding problem

2.1. Background

Healthcare is a particular topic, which has been intensively analyzed in the past decades (Jun *et al.*, 1999; Richardson and Hwang, 2001). The major concern regarding healthcare systems is the problem of emergency department overcrowding, which has been extensively investigated specially in the United States (Richardson and Hwang, 2001; Trzeciak and Rivers, 2003). The ED overcrowding is considered to be a serious problem, which has a critical impact on the patient safety and could in some instance reduce the survival chances of severe patients because of long waiting time. Consequently, it endangers the entire national healthcare system and its capability to offer the minimal service in any country (Searle *et al.*, 2015; Trzeciak and Rivers, 2003). Urgent care centers have been reported to be one of the solutions towards reducing the impact of hospital ED overcrowding (Trzeciak and Rivers, 2003; Wang *et al.*, 2015) and accordingly saving enormous amounts of money (Weinick *et al.*, 2010). However, the problem has been actually shifted to the UCC (Wang *et al.*, 2015). The stream of research in this field has been focused on identifying special scores and estimation tools to measure and in some instances to predict the overcrowding level of an ED or UCC (Nathan R. Hoot *et al.*, 2007; Reeder *et al.*, 2003; Searle *et al.*, 2015; Wang *et al.*, 2015). For instance, the Length Of Stay (LOS); the percentage of the Leave Without Being Seen (LWBS); Severely overcrowded, Overcrowded and Not overcrowded Estimation Tool (SONET) (Wang *et al.*, 2015); and