



An alternative scheduling approach for improving emergency department performance

Amir Elalouf*, Guy Wachtel

The Department of Management, Bar-Ilan University, Israel

ARTICLE INFO

Article history:

Received 3 August 2014

Received in revised form

30 December 2015

Accepted 4 May 2016

Available online 5 May 2016

Keywords:

Emergency department

Approximation algorithm

Patients scheduling

Optimal stopping

ABSTRACT

Crowding in hospitals and its effects on emergency departments (ED) and on patients have received increasing attention in recent years. The objective of this paper is to propose an approach for optimizing the scheduling of patients' ED examinations. Referred to as the "floating patients" method, this approach entails sending patients, if possible, to receive treatment in other hospital departments (instead of in the ED) in order to reduce their waiting time for examinations and treatment. Specifically, we assume that the ED determines a maximal (fixed or dynamic) value for patients' length of stay, and that patients who cannot be evaluated in the ED in a timely fashion are redirected for treatment to other hospital departments. In order to demonstrate the use of this method we use an algorithmic approach. We first solve a basic problem in which the ED physician and the triage have full information on patients' conditions and on how long their evaluations are expected to take. We then extend this problem to incorporate real-life uncertainty; specifically, we assume that the physician carries out initial examinations to obtain information on patient attributes and, at each point in time, decides whether to continue to examine patients or to stop the process (halting rule) and "float" the remaining patients to other departments. Next, the physician determines the optimal schedule for the full evaluations of the examined patients. The proposed algorithms are demonstrated using a simulation with real-life data.

© 2016 Elsevier B.V.. All rights reserved.

1. Introduction

A hospital's emergency department (ED) is the place where new patients with acute ailments or injuries receive initial diagnosis and treatment. The ED is responsible for assigning incoming patients to appropriate departments in the hospital, or for referring them to general practitioners or to specialists for further treatment (Zink, 2006). Overcrowding in EDs is a serious problem in health-care systems around the world and in Israel in particular (see Haklai et al., 2014). A common solution for handling overcrowding is to determine a maximum level of occupancy for the ED and, once this level is exceeded, to turn away arriving patients and ambulances (by referring them to other EDs in the area) and reject non-urgent patients. These "turn-aways" and rejections not only create inconvenience for patients but also result in loss of income for hospitals and EDs. The current paper proposes an approach for optimizing the scheduling of patients' ED examinations, in order to mitigate the detrimental effects of overcrowding. Referred to as the "floating patients" method, this approach entails

sending patients, if possible, to receive treatment in other hospital departments (instead of in the ED) in order to reduce their waiting time for examinations and treatment.

Overcrowding in EDs is currently associated with patient mortality, transport delays, treatment delays, ambulance diversion, patient elopement, and financial effects (Hoot and Aronsky, 2008). Accordingly, ED overcrowding and patient length of stay are attractive subjects for studies on operations research in health care, and numerous approaches have been developed to improve ED work-flow. Most studies have focused on forecasting patient volume, scheduling physicians' and nurses' shifts, medical process chains, and resource planning and utilization. Numerous studies have used scheduling methods and computer simulations in order to identify means of increasing the efficiency of health care and reducing the amount of time patients spend in the process chain. Su and Shih (2003), for example, used computer simulations to model an emergency medical services system, focusing on pre-hospital care. Marmor and colleagues (Sinreich and Marmor, 2005; Marmor et al., 2012) built a simulation model, based on empirical data from five EDs in Israel, with the aim of identifying means of reducing the turnaround time and improving ED service quality. They identified several potentially effective approaches, including (i) reducing patients' "delay time" in the ED, i.e., time spent waiting and doing nothing; (ii) the use of a fast-track model, in which

* Corresponding author.

E-mail addresses: Amir.Elalouf@biu.ac.il (A. Elalouf), Guy.Wachtel@biu.ac.il (G. Wachtel).

URL: <http://www.biu.ac.il/faculty/alalouf/> (A. Elalouf).

“easier” patients are treated separately from others; and (when triage and fast-track methods are not feasible) (iii) the use of different lanes for ambulatory and acute patients. Today, many hospitals in Israel use these models. In a similar vein, a study by Connelly and Bair (2004) discusses the use of discrete-event simulation methods for advanced system-level investigation of ED operations. In their simulations, use of the fast-track approach decreased patients' length of stay in the ED by tens of percentage points. Duguay and Chetouane (2007) also discussed discrete-event simulation approaches.

Other papers analyzing patient length of stay are those of Rossille et al. (2008) and Harrison and Escobar (2010). They formulated multistage models describing the length-of-stay distribution for diverse patient groups, distinguished according to various factors such as diagnosis, severity of illness, age, or hospital. In a recent work, He et al. (2014) compared several ED workflow strategies: first-in-first-out (FIFO) with priority, fast-track, physician triage and team triage; they concluded that physician-triage and team-triage strategies provide the best ED performance. Further extending those results, we propose an approach to help the decision-maker in the triage to further improve ED performance. Ashour and Kremer (2014) recently proposed the use of a dynamic grouping and prioritization (DGP) algorithm in order to identify appropriate patient groups and prioritize them according to the benefits to patients and to the system. The results, which are based on discrete event simulation (DES), provide statistical evidence that the DGP system outperforms alternative prioritization methods in terms of all performance measures, yet it does not improve patient throughput.

Another stream of literature uses algorithmic approaches to derive recommendations for improving the quality of care provided by EDs. Most of the papers in this stream address the problem of increasing the accuracy of triage examination. Berman et al. (1989) demonstrated the effectiveness of a computerized algorithm for characterizing patients in the triage in order to improve the examination and treatments assigned to the patients. Chonde et al. (2013) and Fields et al. (2013) offered a prediction method for estimating patients' Emergency Severity Index (ESI) and urgency. Ballard et al. (2010) validated a similar algorithm for categorizing the severity of patients' conditions in the New York University ED. Other works in this stream include those of Claudio and Okudan (2010), Ashour and Okudan (2010) and Ashour and Kremer (2013). These studies addressed triage algorithms that use the Fuzzy Analytic Hierarchy Process (FAHP) and Multi-Attribute Utility Theory (MAUT) to rank patients according to their characteristics. The algorithms proposed in those studies were better able to balance (simulated) patients' length of stay and time-to-bed, as compared with the typical ESI-based prioritization method. Claudio et al. (2014) also studied the FAHP-MAUT method as a decision support model in combination with the use of new technology. The latter approach was able to aid triage nurses in prioritizing patients waiting in the ED.

Lowe and Fu (2008), from another angle, tested the ability of ED algorithms to detect changes in ED use. They found that even if an algorithm can efficiently identify the severity of different patients' conditions and various patient characteristics, it is less useful than other methods in predicting differences in patients' access to care (length of stay).

In this paper we suggest a dynamic programming (DP) algorithm and corresponding FPTAS (Fully Polynomial Time Approximation Scheme) to help the physician in the triage to schedule patients' examinations and treatment in the ED while taking into account uncertainty regarding patients' actual medical requirements during their stay in the ED. Our work is based on the premise that appropriate scheduling and programming approaches can speed up patient handling procedures, thereby reducing the

amount of time that patients spend in the ED, improving service quality, increasing patient throughput and, correspondingly, increasing the ED's revenue and financial profit.

Our approach incorporates the “floating patients” method: In January 2014, the CEO of the Israel Ministry of Health released guidelines (Efrati, 2014) promoting partial implementation of this method. Specifically, these guidelines state that patients whose ailments suggest that they should be hospitalized in internal departments, and who have been waiting for several hours in the ED, should be moved to internal medicine departments as “floating patients”. Generally, the triage nurses – or the triage physician in the case of the “Physician in Triage” (PIT) method – are those who decide, based on their professional judgment, which patients will “float” to other departments. A “floating patient” policy can take pressure off ED physicians and lower the work rate in the ED, balancing it with work rates in other departments. This can reduce delays for examinations and treatments, thereby reducing patients' length of stay and their uncertainty about their conditions, and improving service quality overall. To develop an effective scheduling and control approach that will speed up patient handling procedures and reduce crowding in the ED, it is first necessary to identify the dominant factors that the ED decision maker needs to address. We begin by modeling a basic problem in which we show that it is possible to reduce patient length of stay by adopting an appropriate scheduling approach that assumes that the maintenance of proper service quality that results from giving full and fast treatment to all patients (jobs) is related to patients' length of stay in the ED (time of job in the system), in addition to the potential of making mistakes when handling patients in the ED. We then extend this problem to more closely resemble real-life by taking into account stochastic factors, time-flow and uncertainty regarding patients' medical requirements. In contrast to the online knapsack method (Buchbinder and Naor, 2005; Babaioff et al., 2007), we adopt a halting condition in which the ED decision-maker's (e.g., triage physician's) work with a given subset of patients, according to the algorithm, stops after reaching predetermined “profit” constraints (from giving high service quality). At this point, the decision maker chooses which patients will receive full treatment in the ED, and which will be dealt with as “floating patients”.

To demonstrate an application of our approach, we carry out simulations using data collected from actual observations in an ED and show its efficiency when crowding in the hospitalization departments is not high. We will build our algorithm gradually: First, we provide a formal presentation of the basic problem, and then we expand it to fit to the real-life scenario. We note that patients who are sent to hospital departments as “floating patients” without undergoing an ED evaluation run a greater risk of being mis-handled, particularly if there is a high level of uncertainty regarding their actual medical requirements. Likewise, there is no technological or medical means of completely avoiding uncertainty regarding patients' conditions. Thus, the “floating patients” method is expected to be fully effective only when applied to a small proportion of patients. Nevertheless, obtaining even a small improvement in ED work-flow efficiency without increasing expenditures is important.

2. Basic problem

2.1. Problem description

The first problem we address (referred to as P1) is a case-study of an ED triage station or physician who is required to schedule evaluations (diagnoses) of patients who arrive at the ED. The ED management decides to assign a limit for a patient's length of stay

Download English Version:

<https://daneshyari.com/en/article/5079298>

Download Persian Version:

<https://daneshyari.com/article/5079298>

[Daneshyari.com](https://daneshyari.com)