



Evaluation of fast track strategies using agent-based simulation modeling to reduce waiting time in a hospital emergency department

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ABSTRACT

Different strategies have been proposed to reduce patient waiting time in hospitals. Previous investigations indicate that up to 50% or more patients can be treated in a “fast track” process compared to the standard procedure in some emergency departments. However most studies on emergency department (ED) fast tracks were based on evidence without using an efficient decision tool to show applicability of the results. An agent-based simulation tool is proposed in this research to evaluate fast track treatment (FTT) in an ED. The tool can study the behavior change of entities and resources in a complex ED system. Static and dynamic FTT processes are evaluated. The static process uses a fixed duration in the daily ED operation. In the dynamic process, FTT is triggered based on the current patient waiting time and the state of ED operations. The simulation results provide details and information for the process of the FTT implementation at the ED to reduce patient waiting time.

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1. Introduction

The Canadian Institute for Health Information (CIHI) reported that Canadian total health care spending consumed 11.2% of Canada's GDP in 2013 [1]. In Manitoba health care costs have increased over 90% from 2001 to 2011 for only a 9% increase in the population [2]. A major problem is that the high expenditure has not necessarily led to better health care. CIHI admits that the long waiting time in emergency department (ED) remains a challenge to the health care system [3].

Long waiting times cause patient dissatisfaction and increase the probability of patients leaving the ED without treatment [4,5]. When studying waiting times in EDs, a commonly used term is ED overcrowding which is defined by Canadian Association of Emergency Medicine as a situation when the ED service cannot meet care demands within a reasonable time for quality care [6].

Different research and improvement strategies have been proposed to reduce ED overcrowding [7,8]. Previous studies indicate that ED patients spend the majority of their time waiting for treatment due to the mismatch of healthcare resources and demands [9]. Available improvement strategies include ED floorplan modifications, human resources adjustments, inner role adjustments, and changes in workflows and treatment procedures. ED crowding can also be reduced by improving the schedule of patient discharges from in-patient ward beds. Fast track is a method of changing ED workflows to treat low-acuity patients in a parallel service line with severe patients in EDs [10]. It is estimated that many EDs can treat up to 50% more patients in a fast track process compared to the normal procedure [11,12].

Unfortunately, most of those studies on the ED fast track process did not use an efficient decision tool to show applicability of the results. A decision tool to determine the application and limitations is required to examine these preliminary findings [10,13]. This research evaluates the fast track treatment (FTT) strategy proposed to reduce the waiting time at a hospital ED using agent-based simulation modeling. The ED is in a

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community hospital (Victoria General Hospital or VGH) located in south Winnipeg, Canada. The ED at the VGH (VGH-ED) provides comprehensive emergency services 24 h a day. More than 100 patients present to the VGH-ED each day. The VGH-ED was initially designed to treat 15,000 patients per year, however, this number has more than doubled by 2013 [14]. This has led to an increased pressure on the existing facility contributing to long patient waiting times. Different methods have been suggested to improve the VGH-ED operation. Among them, the FTT is considered as a cost-effective solution for the reduction of waiting time based on the reports of other ED practices. An effective method to evaluate the FTT at the VGH-ED is required before the implementation.

As the ED is a complex system due to random arrivals, uncertain service times of care, and randomness in human decision-making, it is difficult to examine ED performance by changing treatment procedures without disturbing the daily operation [15]. Simulation technology is therefore used to model patient flows of the VGH-ED. An agent-based system (ABS) is introduced in the simulation to model the human behavior in the ED operation. The integration of ABS and simulation can study the behavior change of entities and resources in a complex system based on the system state [16]. Patients, nurses, and doctors can be modeled as dynamic decision-making entities called agents [17].

A validated simulation model is used to evaluate the proposed FTT strategy in two processes. One is the static operation, the other is a dynamic process. The static operation considers a fixed duration in the daily ED operation. The dynamic process is that the FTT is triggered based on current patient waiting time and the state of the ED operation. The simulation results provide details to aid the FTT implementation at the VGH-ED to reduce waiting time.

This paper is organized as follows. Related research on ED improvement and simulation modeling are discussed in Section 2. The VGH-ED patient flow is introduced in Section 3. Simulation modeling and agent-based decision-making are introduced in Section 4. Section 5 describes the FTT strategy for ED improvement. The evaluation of the FTT strategy based on the simulation results is discussed in Section 6, followed by conclusions and further work discussions in Section 7.

2. Literature review

2.1. Measures for ED performance

ED performance can be evaluated using different measures such as patient waiting time, length of stay, resource utilization, and patient leaving without being seen [4,8,15,18,19]. Strategies and alternatives can then be designed based on these measures for performance improvement in patient flow, staff and treatment scheduling, facility floorplan, or assignment planning.

Green et al. used a queuing model in identifying ED staffing patterns to reduce the rate of patients who leave without being seen (LWBS) [4]. The authors compared results in a 39-week period before and after the staff scheduling changes. Their research concludes that the adjustment of staffing patterns to optimize the timely care of patients is necessary to reduce the LWBS. Pines raised a concern regarding the ED measure of LWBS rate as it has never shown to be associated with poor patient care outcomes. The resulting suggestion was to not look at the patients who leave but to focus on the patients who stay for the ED improvement measure [19].

This research evaluates ED performance for patients in the ED process using waiting to be seen (WTBS) and length of stay (LOS) in the ED as the two performance measures.

2.2. ED improvement strategies

Different strategies have been proposed for improvement of the ED patient flow including floorplan modification, improving the timing of in-patient discharges, human resources adjustments, inner role adjustment, and changing treatment procedures to reduce patient waiting time.

2.2.1. ED floorplan modification

Patient flow can be improved through floorplan modification by changing patient allocations to various resources. Using additional resources is a direct solution to release bottlenecks in ED operations. An ED floorplan can be modified with or without additional resources such as the changing the number of ED spaces and stretchers, or an additional short-stay area for observation of stabilized patients to unload these patients from acute-care ED [20,21]. A critical cause of bottlenecks in EDs is the availability of in-patient beds. A significant improvement to ED crowding can also be made by improving the schedule of patient discharges from in-patient ward beds [22].

2.2.2. Human resources adjustment

Although increasing stretchers or changing the ED floorplan can enhance the capacity of EDs, it may not be feasible in most EDs due to existing space restrictions and/or budget limitation. Alternative methods are to maximize staff utilization. Human resource adjustments consider planning medical staff working time for daily shifts and modifying the schedule over a longer period such as a month. Staff scheduling adjustments can better match the available human resources with the varying demands of fluctuating patient arrivals. The observed results show that the pattern of daily demand is persistently at a low level during the night, and grows to a peak at noon [23]. For example, physician coverage can be scheduled to ensure that peak physician coverage corresponds with peak demands, and staff break periods can be scheduled to prevent negative impact of patient throughput. The other method for medical staff rescheduling considers a longer period of arrangement for staff preferences [24].

2.2.3. Inner role adjustment

The “inner role” of medical staff can be adjusted to improve ED efficiency [25]. It is suggested that each medical staff should primarily be considered for the work only they can do, and that medical staff are assigned the jobs to match their abilities using a threshold. Only if the operating priority exceeds the threshold value are the corresponding tasks activated. Even for the same work, it has differential priority for medical staff with various skill levels and training backgrounds. For example, the priority list helps to ensure that senior physicians focus mainly on advanced problems and diagnoses rather than on basic procedures that other staff are able to perform.

2.2.4. Process improvement

Hospitals can improve their efficiency by improving the patient flow [26]. A concept called fast track strategy was initially introduced to accelerate the ED process for patients with non-urgent medical issues [26]. Five alternative scenarios show that the fast track application for patients who require minor care could notably reduce overall LOS. Research indicates that 85 percent of emergency demands are due to patients with minor or non-urgent illnesses [27]. Patient flow could be accelerated if the low-acuity patients can be discharged quickly.

Since then, many studies have reported that the establishment of a fast track service line can decrease patient waiting time [10]. A

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