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Scenario-based analysis of fast track strategy optimization on emergency department using integrated safety simulation

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ABSTRACT

Although discrete event simulation models are known as classic cost-effective tools for analysis of healthcare systems, they are barely suited to represent a strategic level of emergency department (ED). This study applies discrete-event simulation combined with the system dynamics approach to present a comprehensive integrated safety simulation investigation of fast track and ED improvement strategies. By embedding a fast track process logic in the base model of ED discrete event simulation, different strategies have been proposed to evaluate the impact of each scenario. Integration of the base simulation model with system dynamics simulation approaches can articulate the main interconnected and sensitive variables affecting ED key performance index. The integrated model presents the impact of sensitive policy parameters for evaluation of fast track strategy optimization including human resources adjustment, ED resources modification and environmental modification strategies. The main contribution of the proposed integrated safety simulation paradigm is to couple the macroscopic level of safety dynamics analysis with the microscopic discrete level simulation. The results comprise the main model with the scenarios tested by the suggested approach to investigate the ED optimized performance levels. The research results have been validated and indicated that the fast track strategy optimization using the integrated safety simulation could play a significant role in facilitating patient flow without requiring any additional resources.

1. Introduction

1.1. Problem Definition

In response to an increasing demand for emergency department services, different investigations have so far been conducted to achieve process reform of ED. In recent years, healthcare engineering has been developing in the world to help improve ED productivity. Moreover, different improvement strategies have been proposed in an effort to reduce crowd in ED. The ED overcrowding problem can result in long waiting times, patient dissatisfaction, increase in the rate of patients who leave without being seen (LWBS), delay of care and increase in the patient length of stay, and decrease in patients' health outcomes (Lidal et al., 2013; Lin et al., 2013; Kaushal et al., 2015). Hence, improvement of ED productivity by mitigation of overcrowding can help achieve a significant impact on ED performance.

Every ED consists of two main units: (1) urgent care and (2) cardiopulmonary resuscitation (CPR). Fast track area is a parallel service with main units of ED (Fig. 1) to facilitate patient flow and improve the treatment process (Banks et al., 2005; Clarey and Cooke, 2012). This service has the potential to work as a rapid care system treating low-acuity patients by either a nurse or doctor (Lidal et al., 2013; Ashour and Okudan, 2010). As shown in Fig. 1, area A is called CPR, area B is urgent care and area C is used as fast track proposed to reduce ED waiting time and improve other KPIs.

This paper focuses on the implementation of the fast track system in ED and addresses the following question: what impact does fast track strategy optimization have on ED's key sensitive policy parameters?

During last decade different approaches were used in different engineering disciplines including integrated safety management (Benjaoran and Bhokha, 2010) but this research has deployed a novel approach using a comprehensive integrated safety simulation paradigm for evaluating ED optimized performance levels.

1.2. Integrated safety simulation for ED

Even though discrete event simulation has been used vastly in healthcare problems as classic cost-effective tools, they are not well suited to represent a strategic level of ED. In this paper, an integrated safety simulation (ISS) model is developed based on ED discrete event

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Nomenclature

Identifier	definition
DES	discrete event simulation
SD	system dynamics
ISS	integrated safety simulation
ED	emergency department
FT	fast track
ESI	emergency severity index
KPI	key performance index
WT	waiting time
LOS	length of stay
LWBS	leave without being seen
CPR	cardiopulmonary resuscitation
IAT	inter-arrival time

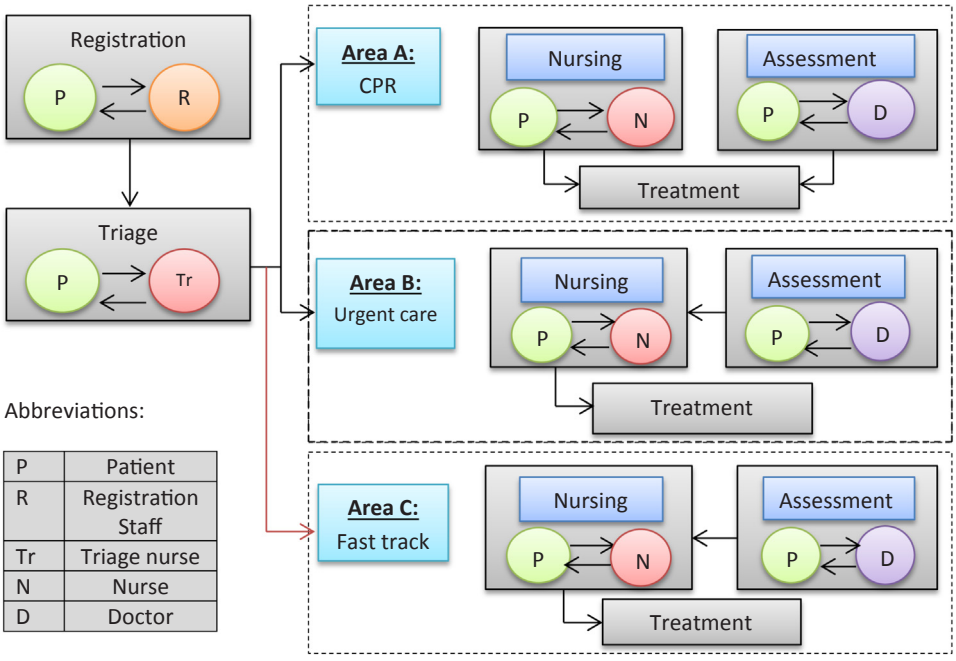

Fig. 1. Fast track interactions with other ED care units (CPR and Urgent Care).

simulation (DES) coupling with system dynamics (SD) scenario-based analysis. Integration of the base ED discrete simulation model with SD approaches can articulate the ED key performance index (KPIs). The ISS is an integrated method to collaborate system dynamics simulation (macroscopic level) with discrete event simulation (microscopic level). Since healthcare problems are highly complex, the ISS method could be used to evaluate different aspects of the ED improvement strategies.

To classify the ED discrete event simulation regarding ED overcrowding causes, scenario building should be performed through the output of DES model. The DES models capture the details of ED's individual behavior levels over time without leaving any causal implications. On the other hand, the SD model has been used to explore how the ED structures and process internally affect the system behavior with "what-if scenario analysis". Fig. 2 shows the integrated safety simulation paradigm.

The output from DES model has been analyzed and designed into different safety scenarios. Due to the size and complexity of the safety problem, a detailed level of ISS model has been employed in healthcare studies. The ISS methodology can describe the effectiveness of introducing FT into the ED before implementation. Although there is a considerable variation in the ED improvement by implementation of FT system using simulation, most studies have focused on FT strategy without considering other ED optimized strategies.

This paper proposes different scenarios to evaluate ED's strategic KPIs before and after implementation of FT. The ISS designates the impact of sensitive policy parameters to evaluate the ED optimized strategies including human resources adjustment, ED resources modification and environmental modification strategies.

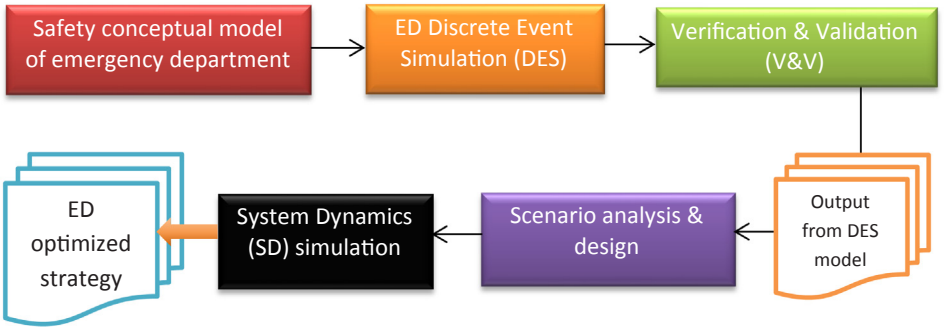

Fig. 2. Integrated safety simulation for ED.