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A simulation-based decision support system to prevent and predict strain situations in emergency department systems

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ABSTRACT

The management of patient flow, especially the flow resulting from health crises in emergency departments (ED), is one of the most important problems managed by ED managers. To handle this influx of patients, emergency departments require significant human and material resources, but these are limited. Under these conditions, the medical and paramedical staff are often confronted with strain situations. To deal with these situations, emergency departments have no choice but to adapt. The main purpose of this article is to develop a simulation-based decision support system (DSS) to prevent and predict strain situations in an ED in order to improve their management by the hospital system. A discrete-event simulation model was constructed in order to visualize the strain situations, examine the relationship between the strain situations and propose corrective actions. A simulation experiment is presented with the results, identifying several important aspects of the strain situations and corrective actions in ED systems. The results have proven the importance of anticipation and management of strain situations in emergency departments.

1. Introduction

Today, many researchers are interested in hospital systems and are trying to provide managers of such establishments with new organization and management strategies. In response to events and/or exceptional situations (e.g. health threats related to epidemics, seasonal flux, heat waves, and cold waves), hospitals, and in particular emergency departments, must be able to receive patients for medical and surgical treatments whatever the extent of the patient flow. The conventional medical resources are often outdated and ineffective in absorbing a large influx of patients, which often leads to strain situations. Hence it has become essential to strengthen the organization of emergency departments so they can manage such situations.

Current dysfunctions observed in EDs are mainly due to the mismanagement of patient flows. ED managers must control problems related to process flow (patients and information), as well as internal restructuring reflected by resource pooling, including technical platforms. However, health personnel are neither prepared nor trained to solve such problems. It appears that they are deprived of methodologies, decision support systems and management solutions adapted to anticipate and manage these strain situations.

To manage patient flow (often very significant), the ED requires major resources and a high degree of coordination among human and material elements [1]. However, these resources are limited for handling this large influx of patients thus leading

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to very lengthy waits for patients, or patients leaving the ED without being treated, and overloaded staff. In these conditions, the medical staff are frequently confronted with strain situations. To cope with these situations, the ED has no choice but to adapt.

Our current work aims to develop a decision support system (DSS) to:

(a) Prevent and predict strain situations with a predictive model for: (i) identifying and characterizing strain situations, (ii) developing a system of indicators: relevant indicators and combinations of indicators that portend a pending strain situation, and (iii) working out suitable strategies (relevant corrective actions) to anticipate and/or limit these situations.
(b) Ensure the best management of undetected and/or non-detectable strain situations (reactive mode): so, it is necessary to define the management rules (actions, means) of the strain situations to be implemented and integrated within the decision support system with feedback on strain situations.
(c) Consider the human behavior in the modeling of strain situations in hospital emergency department. The successful development of the DSS to anticipate and manage the strain situations in an emergency department requires an in-depth understanding of the social, cultural, and organizational process of the healthcare system. The human centered methodologies are useful for the improvement of efficiency of the care process and robustness of an emergency department [2,3].

This paper focuses on the first part of DSS and shows how simulation is the best tool to build the appropriate predictive model. It is organized in five sections. Section 2 summarizes and characterizes the strain situations in a hospital emergency department. Section 3 presents the simulation-based decision support system based on the strain indicators and the corrective actions in the case of an emergency department. Section 4 presents the pediatric emergency department at the hospital in Lille (France); the simulation model to validate the selected strain indicators is described. The fifth section uses a case study to show the results. The last section provides concluding comments and future prospects.

2. Strain situations in emergency departments

2.1. Literature review

Nowadays, many researchers are trying to provide hospital managers with new organization and management strategies, and improve performance and/or efficiency. Hospital performances are strongly linked to the performance of all its departments, in particular the emergency department (ED). Efficiency and effectiveness are often used as quality indicators for emergency departments [4]. The objectives of most of the papers reviewed are centered around 3 points:

(1) Improve the quality of care in hospital emergency departments and help hospital managers make decisions and manage hospital operations better: Gonzalez [5] examined how to improve the quality of service in the emergency room by applying total quality management concepts. Beaulieu [6] used a mathematical programming approach to plan doctors' tasks. Cabrera [7,8] proposed a model to design a decision support system for running an ED. The aim was to use the model as a tool to help ED managers set up strategies and management guidelines to optimize and improve the running of EDs.
(2) Reduce patients' waiting time before receiving care and maximize patient throughput: Samaha [9] presented a simulation model of the operations in the ED at Cooper Health System in order to create a model which depicts the current operation and evaluates possible alternatives to reduce the length of stay in the hospital system. Ruohonen [10] presented a model which described the special health care operations in the ED at Jyvaskyla Central Hospital, Finland. The objective of this model is to test the impact of a new triage approach on patient waiting times and especially patient throughput time. Dawson [11] developed a theoretical model of the effect of greater patient choice on waiting times. Duguay [12] described a discrete-event simulation study of an ED in Moncton (Canada). The objective of the study is to reduce patient waiting times and to improve overall service delivery and system throughput. Laskowski [13] presented two modeling methods: an agent-based model, and queuing model techniques applied to the study of patient flow in an emergency department. The objective of these methods is to reduce waiting times in an ED.
(3) Study the complexity of the hospital systems, in particular EDs, using simulation and optimization models: Rossetti [14] developed an ED simulation model for the Virginia Medical Centre to test the impact of alternative attending physician schedules on patient throughput and resource utilization. Komashie [15] developed a discrete event simulation model for modeling the operations in an ED in the London area in order to determine the impact of key resources on key performances. Ahmed [16] integrated simulation and optimization to design a decision support tool for the running of an emergency department at the governmental hospital in Kuwait. Zeng [17] presented a simulation model of the ED at a community hospital. The aim of this simulation model is to emulate patient flow in the emergency department.