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Using an Agent-Based Simulation for predicting the effects of patients derivation policies in Emergency Departments

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Abstract

The increasing demand of urgent care, overcrowding of hospital emergency departments (ED) and limited economic resources are phenomena shared by health systems around the world. It is estimated that up to 50% of patients that are attended in ED have non complex conditions that could be resolved in ambulatory care services. The derivation of less complex cases from the ED to other health care devices seems an essential measure to allocate properly the demand of care service between the different care units. This paper presents the results of an experiment carried out with the objective of analyzing the effects on the ED (patients' Length of Stay, the number of patients attended and the level of activity of ED Staff) of different derivation policies. The experiment has been done with data of the Hospital of Sabadell (a big hospital, one of the most important in Catalonia, Spain), making use of an Agent-Based model and simulation formed entirely of the rules governing the behaviour of the individual agents which populate the ED, and due to the great amount of data that should be computed, using High Performance Computing.

Keywords: Healthcare operational management, agent-based modelling, individual oriented simulation, emergency department, decision support systems.

1. Introduction

Hospital emergency departments (EDs) are a primary healthcare unit, usually the main entrance to the hospital and a key component of the whole healthcare system. The increasing demand of urgent care, the overcrowding of ED and limited economic resources are phenomena shared by health systems around the world [1-5], giving place to the delay in the first attention of patients who attend ED.

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Between 70 and 80% of patients visit the ED on their own initiative [3,4,6,7], and it is estimated that up to 50% of patients that are attended in ED have non complex conditions that could be solved in ambulatory care services [7]. In addition several Spanish authors have established that a variable percentage of these patients for up to 80% visit the ED inappropriately.

The derivation of less complex cases from the ED to other health care devices seems an essential measure to allocate properly the demand of care service between the different care units. Such derivation should be decided once the triage process is completed, the ED process in which nurses or physicians identify the priority level of patients. This has been borne out by the results of studies conducted in Spanish hospitals of large size like Hospital Clinic of Barcelona or Hospital Mutua de Terrassa [5].

Salmeron et al. [5] try to identify ways for achieving safety and efficacy of discharging from a hospital emergency department with referral to another point of care based on the application of an Algorithmic Aid to Triage (AAT) by nurses without physician evaluation of the patient. They carried out the study with data of the ED of the Hospital Clinic of Barcelona, considering a total of 102,063 visits, and concluding that the referral done by nurses accredited using the AAT is safe and effective. Gomez et al. [8] conclude that structured emergency department triage scales can be used to develop patient referral strategies from the ED to primary care, and specifically that non urgent patients that attend ED may be discharged. In fact in Spain several hospitals redirect to more appropriate levels of care (without being visited) those patients that go to the ED with minor illnesses [9].

There are no standard models to describe complex systems like ED, but simulation becomes an important tool for their modeling. Simulation modeling approach started to be used for solving healthcare problems in the US and UK more than three decades ago. In 1979 computer simulation was applied to hospital systems for improving the scheduling of staff members [10], and in Saunders et al. [11] the aim was to quantify the impact that the amount of staff members and beds had on patient throughput time. Especially over the last decade there have been fruitful efforts in developing simulation-optimization models for solving healthcare management problems [12, 13].

Discrete event simulation (DES), system dynamics (SD) and agent-based modeling and simulation (ABMS) are the main three approaches used in simulation of healthcare systems. Healthcare systems are based on human actions and interactions, and the ability of ABMS to represent this makes it an appealing approach, while DES is not well suited to model them [14]. The potential of the use of agent-based modeling and simulations techniques in emergency departments modeling is clearly illustrated and shown in Kanagarajah et al. [15], Günal [16] and Staindsby et al. [17].

In 2008 Hutzschenreuter et al. [18] present an agent-based simulation and evaluation tool for patient admission scheduling, with the aim of achieving an efficient use of the hospital resources through the combination of different profiles of resource use. The work carried out by Jones et al [19] is a specific example of simulation applied to Hospital Emergency Departments. Authors present an agent based simulation tool, developed with NetLogo, and designed to evaluate the impact of various physician staffing configurations on patient waiting times. Brenner et al. [20] use simulation, conducted in the emergency department at the University of Kentucky Chandler Hospital, for identifying bottlenecks and investigate the optimal numbers of human and equipment resources (eg, nurses, physicians, and radiology technology). In the case of Holmes and Dahl [21] simulation is used for evaluating the influence of a 45% increase in patient volume on the ED of Akershus University Hospital

This paper presents the results of an experiment carried out by the “High Performance Computing for Efficient Applications and Simulation” Research Group of the University Autonoma of Barcelona (UAB), with the participation of the ED Staff Team of the Hospital of Sabadell (one of the most important Hospitals in Spain, that gives care service to an influence area of 500,000 people, and attends 160,000 patients/year in the ED). Its general objective is to analyze the effects over the ED of different derivation policies, using for that an ABM model and simulation designed and developed by the Research Group, with the purpose of aiding the