Analysis and prediction of emergency department scenarios from the reference model

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ABSTRACT

A reference model is a model of something that contains a goal or basic idea of something and that can be established as a reference for multiple purposes. In this research, we present an analysis of a set of scenarios based on a reference model following the document of standards and recommendations of the Spanish Ministry of Health [5] to achieve better care, efficiency, and uniformity in the emergency departments (ED). Following the document of standards and recommendations of the Spanish Ministry of Health and Social Policy on the hospital [5] ED, this standard outlines the guidelines and resources needed in hospital EDs to better care for patients. Adopting this standard should facilitate improved emergency care for patients of all ages and, when appropriate, timely transfer to a facility with a specialized ED. A standard is a type, model, norm, pattern, or reference.

Key performance indicators (KPI) refer to a series of metrics used to synthesize information on the effectiveness and productivity of the actions to make decisions and determine the most effective in meeting the set objectives. This general objective is specified through the following specific objectives: Characterization of the ED and its KPIs from a reference scenario. We verify the evolution of the KPIs (Length of stay (LOS) and occupation of resources).

Some studies carried out on standards in ED, whether for personnel calculations or waiting times, are as follows: The following study was conducted in the ED of a university hospital in Germany. This study aimed to measure the average doctor's time per patient (MPTPP) and its influencing factors [6]. Other studies focused on personnel estimation were in Canada and the US. Real-time measurement of MPTPP was provided in two studies in Canada [3, 1] and in one study in the US [2].

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CCS CONCEPTS

• **Computing methodologies** → **Modeling and simulation**; **Modeling and simulation**.

KEYWORDS

simulation, agent-based model, KPI

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1 EMERGENCY DEPARTMENT MODEL AND SIMULATION

There is an ED simulator, which has been developed as part of previous research work by the High-Performance Computing for Efficient Applications and Simulation (HPC4EAS) research group of the Autonomous University of Barcelona (UAB) [4].

The simulator is divided into zones A, where the patients with severity levels 1,2 and 3, with greater severity, and zone B, with severity levels 4 and 5. We carried out 100 simulations for the average patient arrival, which was 300 patients, compared to the peak arrival of 450 patients daily. As the number of patients increases to the peak of 450, the system degrades, as seen in Figure 1. In the case of nurse A, it can be seen that from approximately 85 percent occupancy, as the number of patients increases, it reaches almost 100 percent occupancy. This is because patients with severity levels 1, 2, and 3 are constantly taken care of by the nurses because they are more seriously ill patients and require constant care. For this reason, the nurses always supervise area A. The doctors in area B are 80 percent occupied, and the occupancy rate reaches almost 100 percent. This is due to the increase in patients and the fact that

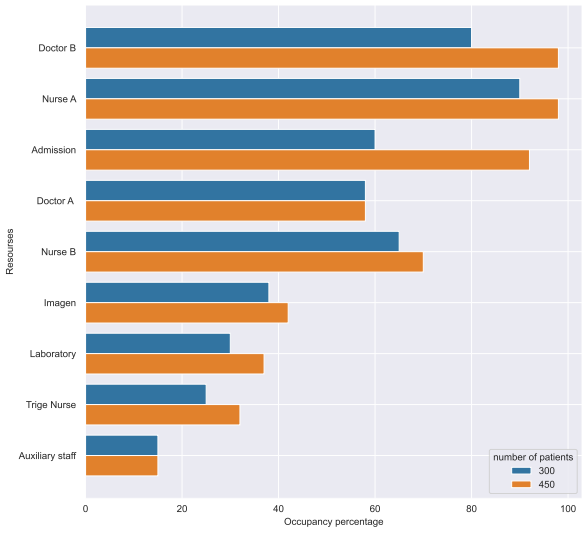

Figure 1: Percentage of patient occupancy comparing the average number of patients 300 with the peak 450

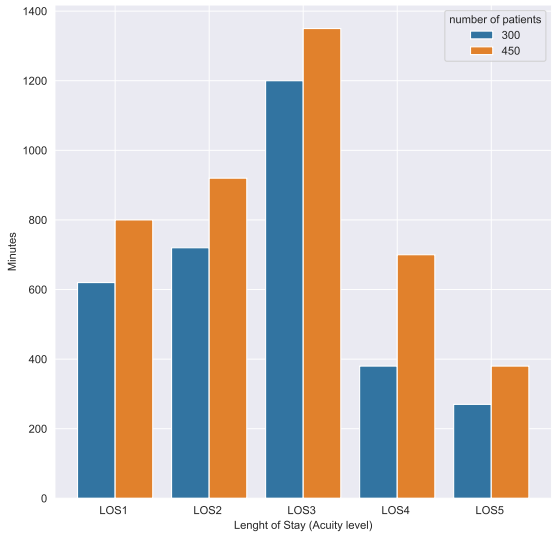

Figure 2: Comparison LOS according to severity level performing 100 simulations with 300 and 450 patients

doctors are constantly busy with diagnostic and treatment consultations for the mildest patients. The occupation of doctors in area A did not change much. This is because they only make their rounds to verify the most serious patients. They are not constantly with the patients, but the nurses are always looking for these patients. The nurse occupation in Area B increases due to the arrival of patients, but the nurses in Area B work less than those in Area A because the patients who arrive are milder. With the simulation, you can see which resources are less busy and redistribute them, such as doctors and nurses, to other areas.

The LOS of the patient is also observed according to the severity level. As the LOS increases as the number of patients increases, the LOS is classified according to the level of severity, which ranges from 1 to 5; LOS1 means patients with a severity level of 1, LOS2 with a 2, LOS3 with a 3, LOS4 with a 4, and LOS5 with a 5. With severity levels 1,2 and 3 are the most serious, and patients with severity levels 4 and 5 are the mildest. Figure 2 shows that patients with LOS1, LOS2, and LOS3 have the longest waiting time, and patients 4 and 5 have the shortest waiting time. Patients with severity level 3 have the longest waiting time because the most significant number of patients who enter the service are those with level 3.

The model presented can be applied to more countries, but this one is explicitly contextualized for Spain and adaptable to different environments; it was developed in collaboration with doctors from the Parc Taulí Hospital's ED in Spain. Many possible situations were included to fully capture ED complexity and unpredictability. The simulation methodology presented is novel because we apply the agent-based simulation methodology in this environment, and we can directly simulate the definition that a country makes of its ED. Trials can be carried out with larger patient situations and with different distributions of patients from area A or area B. This can help you verify where saturation of the ED occurs and whether more nurses, doctors, or redistributed resources within the hospital, such as doctors or nurses with less occupation in another area, will be needed. With simulations, you can analyze and predict different situations, such as the case of a pandemic.

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