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EVALUATION OF PERFORMANCE AND RESPONSE CAPACITY IN EMERGENCY DEPARMENTS

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ABSTRACT

The saturation of Emergency Departments, due to the increasing demand of the service, is a current problem in the healthcare system. We propose an analytical model to obtain information from data obtained through the simulation of a Hospital Emergency Department. The model defines how to calculate the theoretical throughput of a particular sanitary staff configuration, that is, the number of patients it can attend per unit time given its composition. This index is a reference to measure indicators concerning to performance and emergency response capacity of the system. The data for the analysis will be generated by the simulation of any possible scenario of the real system, taking into account all valid sanitary staff configurations and different number of patients entering into the emergency service.

1 EMERGENGY DEPARTMENT AGENT BASED SIMULATOR AS SOURCE OF DATA

The growing demand of emergency medical care in Emergency Departments (ED) is one of the most important problems for the management of the system worldwide, because it requires a substantial amount of human and material resources, which unfortunately are often too limited (Kadri, Chaabane and Tahon 2014). A sudden increase in the entrance of patients is an extraordinary, but possible situation, which most likely cause the collapse of the service. The response capacity of the system in anticipation of such situations is directly related to the leeway of the sanitary staff configuration to absorb an extra demand of the service, and it will depend on its composition. Even though computerized systems in hospitals provide more and more real data, there are no real data available concerning this kind of situations, which cannot be tested in the real system. This limitation can be overcome through computer simulation, using as main source of data an ED simulator, based on an Agent-Based Modeling design of the system, which has been already developed, verified and validated. The simulator includes patients, admissions staff, triage nurses, assistant nurses, doctors and radiology technicians as agents. For sanitary staff agents (all except patients), we consider two levels of experience (junior/senior) and all of them can work in parallel on each phase. The actions and interactions between the involved agents at each process step result in changes of state of the agents, which ultimately result in the global operation of the system (Taboada, Cabrera and Luque 2013). Once the patient enters the service, the simulation runs according to patient flow shown in Figure 1.

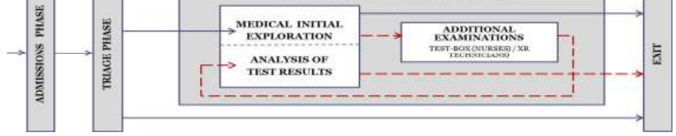

Figure 1: Patient flow in the emergency department

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The admission and triage phases are common to all patients entering the service. In the diagnostic and treatment phase, all patients go through an initial medical exploration phase. Some of them are discharged and leave the ED. The rest remain in the ED and they go through a phase of complementary examinations. After this, they return again with the doctor who analyzes the test results and, finally, they are discharged from the service. Each simulated scenario is identified by a sanitary staff configuration and a specific input of patients into the service, and the output of the simulation brings data concerning the number of attended patients, attention time, and waiting time for each patient in all phases in the service.

2 ANALYTICAL MODEL

In order to transform this raw data generated by the simulation and to visualize the potential information which they contain, we have defined a set of indexes that characterize numerically each scenario. Given the values of an index called *Patient attention Time* (PaT_i), which is the time a patient is receiving attention in each stage in the service for a given configuration, the *Equivalent Patient attention Time* for the stage *i* ($EpaT_i$) is defined as the attention time of a patient taking into account the possibility of working in parallel for the agents in that stage. The equivalent time of the slowest phase will determine the number of patients that a given configuration can treat per unit of time, given its composition. We call this index *Theoretical Throughput (T_ThP)* and is an indicator of patients' attention capacity of the configuration:

$$T\_ThP = \frac{1}{Max\ EPaT_i} \quad (1)$$

It is also defined the *Real Throughput (R_THP)* index as the number of patients treated per unit time, which values are direct output data from simulation or provided from the hospital. The ratio between the real throughput and theoretical throughput is defined as an indicator of *Performance (PeR)* of a given configuration for a specific scenario. Moreover, we define the *Emergency Response Capacity (ERC)* as the capacity of a given configuration to provide extraordinary service to patients in an exceptional situation related with an unexpected increase in the number of patients requiring urgent attention. We can decide the percentage of patients p_e that the current configuration should be able to absorb in expectation of a possible emergency, what we call the leeway of the configuration. This would establish a maximum throughput (ThP_{max}) and the *ERC* for the considered configuration, which are

$$ThP_{máx} = T\_ThP \times \frac{100-p_e}{100} \quad \text{and} \quad ERC = T\_ThP \times \frac{p_e}{100}. \quad (2)$$

The analysis of these indexes, should lead us to identify the characteristics of the most suitable configurations facing an increase in the number of input patients.

3 CONCLUSIONS AND FUTURE WORK

The *Theoretical Throughput (T_ThP)* for the diagnosis and treatment phase it's much more difficult to calculate than for other phases in the process, due to its nonlinearity. In fact, it depends not only in the type of doctor, also in the kind of care they are doing, either in the first step of initial exploration, or in the second, analyzing the results of a requested supplementary examination. We are currently working to complete the analytical model, trying to get the equations for calculating the *T_ThP* for this phase for any possible configuration of doctors. The ultimate goal of this work is to be able to anticipate the best mix of sanitary staff to ensure the established emergency response capacity.

REFERENCES

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