Analysis and modeling of the key performance indicators in the emergency department

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Improving emergency department (ED) processes requires consideration of multiple variables and objectives. EDs are known as a highly dynamic and unpredictable environment, which makes decision making extremely difficult. The use of different methodologies and tools to support the decision-making process is therefore essential. Nevertheless, medical staff are not adequately trained or prepared to solve such problems. They are completely destitute in methodologies and tools for decision support and management adapted to their future activities. The management of emergency systems generally involves three issues: their conception, planning and control. Conception is the definition/prediction of the future characteristics of the hospital system. Planning involves identifying the various resources used to perform care operations and defining how and when these operations should be performed. Finally, the control aims at correct the inherent disturbances (deterioration in the patient's state of health, new patients to treat). These three key steps are performed according to the frequency of problems encountered during the execution of the scheduling. In this paper, we focus on the first point, which is a presentation of a prediction model and a modeling of the patient pathway in the adult ED (AED) of the Lille University Hospital Center (LUHC).

First, we present a statistical real data analysis. We use a real database of the AED provided by the LUHC, which is our partner. This Data collected over a period of four years, from June 2016 until June 2020, thanks to ResUrgence, a software implemented in LUHC. This analysis allows us to determine the most interesting aspects of the functioning of the AED.

1. The inflow of patients indicator : We can assume that a state of tension is directly related to a significant increase in the number of patient arrivals at the AED. Figure 1 provides a visualization of the AED attendance at different time scales (hour, day and month). The three curves show the average of patient attendance over the four years (2016-2020). Figure 1.(a) shows a day and night alternation with daily peaks at 11 am, 3 pm and 8 pm. Then we can see in figure 1.(b) that the attendance is globally stable throughout the year with an average of about 280 patients received each day in the service. Concerning patient inflow by month, Figure 1.(c) indicates that the critical period of patient arrival is generally during the winter period and a decline in attendance during the summer period.

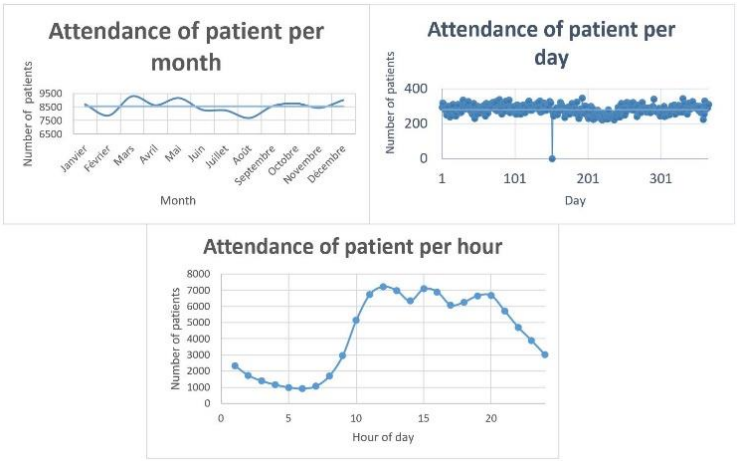

Figure 1. Results of the inflow of patient study

The study of the inflow of patient indicator is interesting because it allows us to identify the most critical arrival periods in the AED. Thus, these data can already serve as indicators to anticipate medical staff needs according to the time of day. This study also identifies variables that are useful for predicting the arrival of patients. Nevertheless, the use of the patient flow indicator alone cannot prove the existence of a situation of tension over a

period. Therefore, the study of other indicators to identify periods of overcrowding in the AED such as the waiting time is essential.

2. Primary Waiting Time (PWT) indicator : The PWT is the time of the patient waits from his arrival in the emergency department until his first care operation. Figure 2 shows that about 40% of patients wait one hour or less and 60% wait more than one hour to be managed. The average PWT was two hours. This study shows that the longer the PWT, the greater the risk that the patient's condition will worsen.

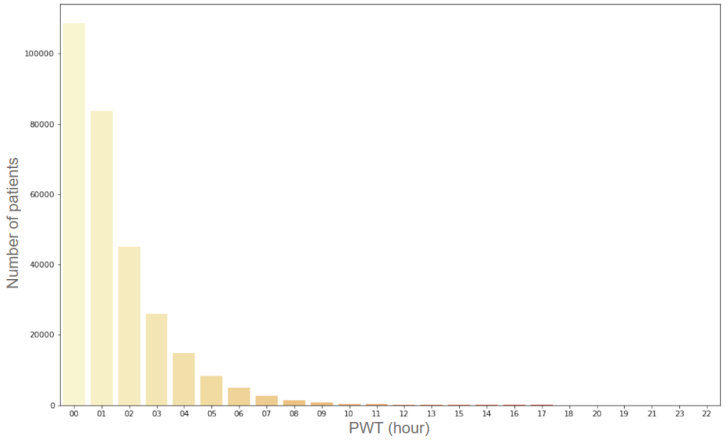

Figure 2. Primary Waiting Time

The PWT indicator is determined through detailed workflow modeling of the patient pathway into the AED. This model, represents the typical circuit of the patient pathway, this is divided into 3 parts (upstream, intra-emergency and downstream). It contains several decision points and two sub-processes corresponding respectively to the short circuit and long circuit. This decomposition into sub-processes aims to visually simplify the workflow while preserving the complexity of the connections between the different elements of the AED.

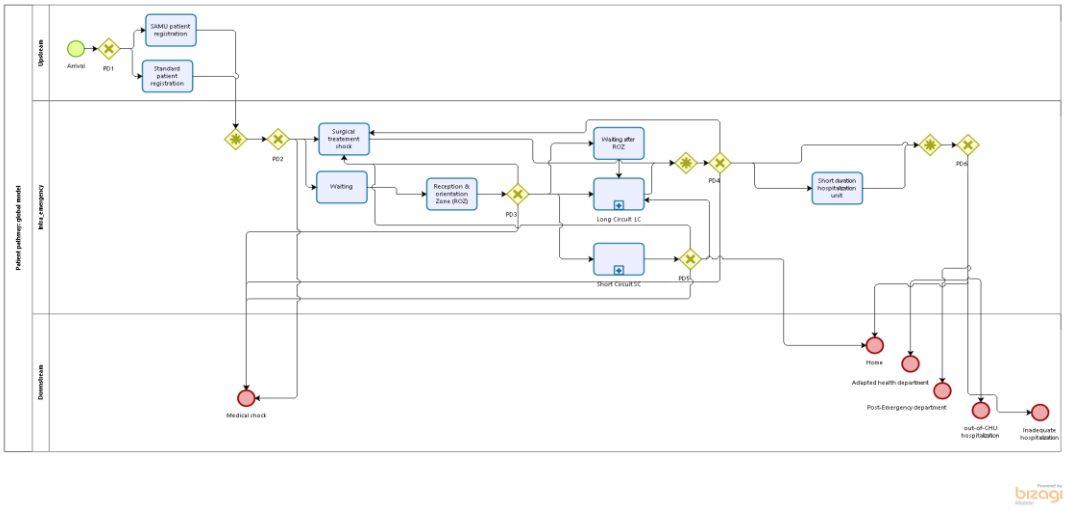

Figure 3. Global workflow for patient pathway model in the AED

This model allows visualizing the existence of several waiting times within the patient pathway. The PWT indicator is strongly correlated with the patient's state of patient. Indeed, for urgent patients, medical staff must act quickly in order to minimize the mortality rate, which is particularly related to the PWT. The PWT is therefore one of the most significant performance indicators for urgent patients, although it only determines part of the patient pathway in the AED, ignoring the various other stages of this complex pathway. To solve the indeterminacy at the different decision points of the workflow model, we will adopt a collaborative optimization method for scheduling multi-skilled care tasks.