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OPTIMIZATION OF THE EMERGENCY DEPARTMENT IN HOSPITALS USING SIMULATION AND EXPERIMENTAL DESIGN: CASE STUDY

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ABSTRACT

This case study aims at evaluating the impact of different scenario policies drawn from a hospital emergency department committee of experts, using the Delphi method and a literature review, on the Emergency Department (ED) performance. The purpose is to improve Length of Stay (LOS) of patients. Simulation and a Design of Experiment (DOE) were used in order to assess the LOS sensitivities to the selected improving scenarios: Fast Tracking, addition of stretchers for patients under observation, improvement of the waiting times for a consultation with a specialist, improvement of the waiting times for admission, and improvement of the treatment times for patients under observation.

1 INTRODUCTION

Emergency departments are under strict governmental and hospital regulations, and they present a very complex structure, involve continuous mode of operation, and require significant investments. Managers obviously need to have a high level of certainty regarding substantial improvements before implementing any changes. The purpose of this paper is to evaluate the impact of certain improvement scenarios on the patients LOS using simulation and a DOE plan based on a real emergency department case. The results will help select and prioritize actions needed to improve the LOS of patients, and consequently reduce waiting times and overcrowding in the ED.

2 METHODOLOGY

The case study is carried out at the Centre Hospitalier de l'Université de Sherbrooke (CHUS), which receives more than 40,000 patients in its emergency department each year. The model results from many observations made within the ED and a collaboration with the CHUS' Lean team. The numerical modeling was developed using the Arena (Version 14.50.0002). The final validation of the model is conducted according to Stewart Robinson's Technics (1997). The improving scenarios used in this study were selected by a committee of experts from the ED using the Delphi method. The committee included nurses, physicians and administrative staff who were involved in the improvement of LOS in the ED and a Lean project. The DOE plan was established according to the Taguchi method, a method that was used in conjunction with the simulation (Ramberg, John S. et al. 1991). A L27 Taguchi table is used with 5 variables at 3 levels each (Table 1).

Aroua et al. (2015) established that the frequency of pathologies that show patients (grouped into Major Diagnostic Categories (MDC)) varies during the year, giving place to a seasonal trend. Also, in the same work, it was shown that the admission rate varies from one MDC to another. In light of these facts, the simulations will be carried out over 3 different periods of the year: period 1 [May, June, July, and August], period 2 [September, October, November, and December], and period 3 [January, February, March, and April]. Analyzing simulation data for 3 different periods of the year will allow to evaluate the interaction between the periods of the year and the selected scenarios.

Table 1: Selected improvement scenarios and levels

Fast Track	Observation strechers	Waiting times for a consultation with a specialist	Waiting times for admission	Patients under observation
1 –Current	1- Current	1- Current	1- Current	1- Current
2- With internal Fast Track	2- With 6 strechers	2- With 20% decrease	2- With 20% decrease	2- With 30% decrease
3- With external Fast Track	3- With 12 strechers	3- With 40% decrease	3- With 40% decrease	3- With observation unit

3 RESULTS AND DISCUSSION

In total, 27 simulations were conducted according to the L27 Taguchi method. For each simulation and each period of the year, the average LOS for admitted and non-admitted patients were calculated. The tests of significance below are conducted with the null hypothesis H_0: no changes on the LOS. The significance level considered is $\alpha=0.05$.

For non-admitted patients, this work highlights the sensitivity of the LOS to waiting times for patients under observation, the implementation of Fast Tracking, and the number of stretchers in the emergency department. This influence is not the same for all periods, since the number of stretchers was not a statistically significant variable for the period 2. The waiting times for a consultation and the improved admission time do not represent influential variables for any of the periods (respectively, period 1: $p = 0.642$, $p = 0.994$; period 2: $p=0.995$, $p = 0.902$; period 3: $p = 0.760$, $p = 0.716$).

For admitted patients, this work highlights the sensitivity of the LOS to waiting times for admission, the implementation of Fast Tracking, and the waiting times for a consultation with a specialist. Neither the addition of strechers for patients under-observation nor the improvement in the observation process had a significant impact on the daily average LOS.

The problem related to the occupation of the stretchers by these patients could be treated through Lean projects or the creation of an external unit aiming at treating patients under observation. The simulation results demonstrate this fact with a reduction of 0.6 hours in LOS (8%) following a reduction of 30% in the processing time of these non-admitted patients, and a reduction of 1.41 hours (19%) following the implementation of an observation unit. This observation unit could accept patients admitted for short periods, and improve the waiting times for admission (Christopher W. Baugh et al. 2011).

The creation of an external walk-in clinic near the hospital, that would work independently of the emergency department, but with a vocation to accept patients referred by the ED (priorities 4 and 5 patients according to the Canadian Triage and Acuity Scale), is an attractive investment. This scenario allows a reduction of up to 1,188 hours for non-admitted patients (representing a reduction of 17.8% in LOS), and 0.8 hours for admitted patients (representing a reduction 6.56% in LOS). Regarding Fast Tracking with the same emergency department internal resources, the improvement is very low, with a reduction of 1.5%.

For the 3 periods of the year, the ranking of the influential variables did not change for admitted and non-admitted patients. Therefore, the temporal variable that can be considered as a noise variable has no influence on this order. Table 2 shows for these 3 periods the main effect plot of the LOS means.

The Analyze of Variance shows no interaction between Fast Tracking and the waiting times for a consultation or the waiting times for admission. This result can be justified with the assumption that the improvement ideas proposed in this work are independent and do not share the same resources.

Our model was designed with the assumption that the number of patients who leave without being seen remains constant while S. Goodacre (2005) shows that this number depends on waiting time.

Table 2: Main effect plot of means - LOS

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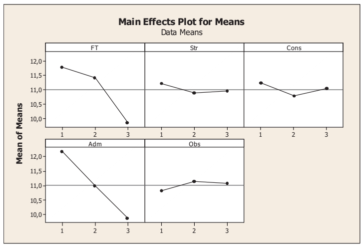
<td>LOS: admitted patients - Period 1

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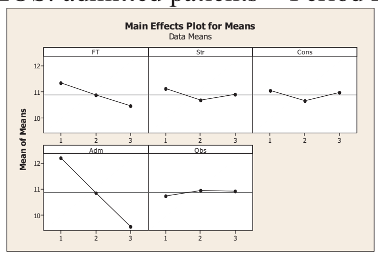
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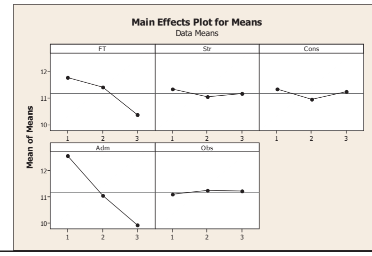
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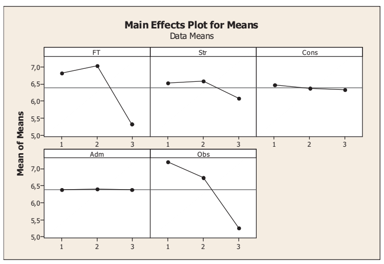
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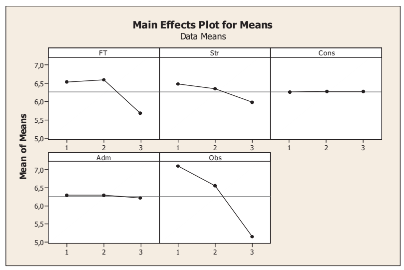
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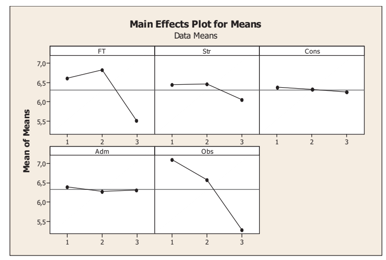
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4 CONCLUSION

In this study, two populations were considered: admitted and non-admitted patients. A simulation based on a DOE shows that for admitted patients, the hospital admission capacity is the most influential variable on the LOS. The improvement of this capacity could be addressed by increasing the number of beds or the creation of an independent unit for patients under observation and short-stay patients. For non-admitted patients, improving the treatment time for patients under observation consists in the improvement with the highest influence.

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