Proceedings of the 2013 Winter Simulation Conference
R. Pasupathy, S.-H. Kim, A. Tolk, R. Hill, and M. E. Kuhl, eds

SIMULATION OF PATIENT DISCHARGE PROCESS AND ITS IMPROVEMENT

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ABSTRACT

This paper presents results of a study conducted jointly with a regional hospital and concerned with inpatient discharge process. In an effort to see what the hospital can do to reduce alternative level of care (ALC) days (or length of stay, LOS), a simulation model of the discharge planning path was created and validated. The model was used to explore the effects of standardizing parts of the discharge process. The results showed a potential for 4.5 day reduction in the median of LOS. Obtained results indicate that organizational changes (e.g., early involvement of social workers, improved information flow, close collaboration with external facilities accepting patients, etc.) will lead to process improvement and substantial economic benefits.

1 INTRODUCTION

In Canada, the publicly funded healthcare system reflects the national beliefs of equality and complete accessibility. Canadian national health insurance program (Medicare) is responsible for that universal access to healthcare services across the country (Pearson et al. 2004).

Canadians seek primary care as a first step in trying to solve their immediate health problems. Very often, individuals receive their proper diagnosis and treatment (or intervention) and have their medical or health concern taken care of. While they come at the front line of the system, this step also includes; doctors, nurses, pharmacists, and therapists among many others. When it is found necessary, patients are passed on to specialized hospitals, long term care facilities or home care services (Health Canada 2005).

The Canadian healthcare system is not immune to immense pressure due to changes in the way services are delivered, fiscal constraints, demographics and the cost of new technology (Health Canada 2005); factors that will not recede anytime soon. Growing spending (currently over 10.5% of the GDP) and difficulties of meeting the public expectations of satisfactory care are driving interest in improving patient flows and healthcare performance. A number of studies have focused on non-value adding activities, such delays and waiting in care delivery process (for example, Selker et al. 1989; Sanmartin et al. 2000) and have shown that most delays occurred most frequently is related to the following:

- Scheduling of tests (31%).
- Unavailability of post-discharge facilities (21%).
- Physician decision-making (13%).
- Discharge planning (12%).
- Scheduling of surgery (12%).

However, when defined in terms of delay days, and due to the length of the delays, awaiting post-discharge facilities was found to cause 41% of them (thus becoming the most important problem).

Very often when examining efforts to improve patient flow, rather special attention is given to the discharge process, in some cases, by clearly mentioning it among other issues when discussing bed management, communication of information or even most importantly, delays. By focusing on lengthy patient episodes it was found that "...four types of system obstacles prevented timely discharge; patient care issues, financial and legal issues, administrative issues and deficiencies in coordination between hospital and community personnel. Such nonmedical reasons for delayed discharges suggest that better planning may be beneficial." (Health Canada 2004).

Discharge planning is suffering from a lack of information, poor communication and synchronization between acute and long-term care. Consequently, it results in disrupted flow, blocked beds, frustrated patients and distressed unit staff. Even though the process is nevertheless always completed, it can be described as "unsuccessful" in some literature. Unsuccessful discharges can either be unplanned readmissions within an unexpected short period of time, or delays in length of stay causing it to be greater than what is set by standards for particular patient groups (Pearson et al. 2004).

2 THE DISCHARGE PLANNING PROCESS

The discharge planning process is currently extending beyond the acute care days of patients resulting in Alternate Level of Care days and an increased length of stay. Even though the reasons of ALC days mainly lie outside the hospital due to unavailability of resources to accommodate those transitioning patients, the question worth asking here is; what can the hospital do in terms of discharge planning to reduce length of stay. This question cannot be answered unless the following question is answered first: how exactly is the discharge planning process currently performing to generate the historically observed LOS. Only when this is understood, certain recommendations can be laid out.

Simulation modeling can be a tool for comparison between the current situation and the recommended one in this case. Analyses of the discharge planning activities should be done in order to create the closest possible model to reality. Afterwards, the recommendation will be modeled accordingly.

3 DATA COLLECTION AND MODEL STRUCTURE

3.1 The Hospital

The hospital, where the data were collected is the region's premier tertiary acute care hospital, providing services in diagnostic imaging technology, and leading in areas of complex trauma, neural diagnosis, acute mental health, cardiac care, stroke and neurosurgical, and the broad foundation of medical and surgical services required to support these areas.

Working with 412 physicians, the hospital operates 305 patient beds; 128 in Medicine, 84 in Surgery, 20 in Intensive Care Unit, 9 in Cardiac Care Unit, and 64 in Mental Health Unit. All units provide care to an average of 120,000 patients per year, conducting 158,960 diagnostic exams and 8,705 nuclear medicine tests per year.

Inpatient units at the hospital consist of 5 medical and 3 surgical units. Surgical patients are sent either to 6-East, 6-West - which specialize in orthopedic and general surgery respectively - or to the Neurosurgical Unit. The medical units and their specialties are:

- 2 – North (2N): general medicine
- Telemetry (TEL) : biotelemetry (i.e., people with the risk of abnormal heart activity)
- 7 – East (7E): renal
- 7 – West (7W): general medicine
- Neurology (NEU).

3.2 Patient Flows

The regression analysis performed on the 1,744 patient data (Khurma 2009) indicated that the most persistent category of patients contributing to ALC days were the ones requiring placement in long term care (LTC), accounting for almost half of the patients awaiting ALC days and leaving the rest for the 6 remaining institutions. The top ranked medical units sending most patients (69.1%) to LTC were:

- 7 East (7E - Renal) – 31.9%
- 2 North (2N - General Medicine) – 23.4%
- 7 West (7W - General Medicine) – 13.8%.

Therefore, from the same population of patients used in the previous analyses of ALC days (Khurma 2009), the sample of data collection was chosen from institution type LTC, and units 2N, 7E and 7W.

The model was structured in a way similar to the sequence of events of discharge planning that are illustrated in the flow chart in Figure 1. The complex path of discharge planning (Khurma and Pasek 2010) was simplified since the data collection process was tedious in that it required painstakingly pulling out relevant data manually from rather complicated patient charts (paper documents). The structure of the model is shown in the patient episode with the considered time stamps illustrated in Figure 2.

Figure 1: Simulation Model Path

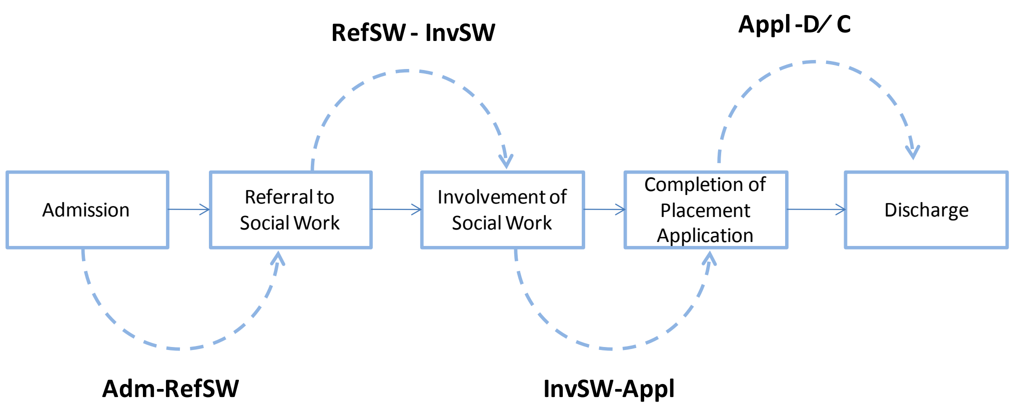

Figure 2: Path of Discharge Planning with Milestones

A number of activities take place between each of those time milestones. The abbreviations that will be used in this section for each of the intervals and the most important activities that occur in them are as follows:

- Admission to Referral to social work (**Adm-RefSW**): the start of acute care and the functional assessment resulting in referral to social work.
- Referral to social work to Involvement of social work (**RefSW-InvSW**): wait time (while still receiving acute care) between the referral and the actual acknowledgement of it by social work to follow up with the patient for discharge planning
- Involvement of social work to Sending LTC placement application (**InvSW-Appl**): time taken to decide on the best course of action to fulfill patient needs in terms of discharge destination. This period includes a series of meetings with the patient to reach to an agreeable destination (LTC in this case). The importance of the "Application sending" milestone lies in the fact that the patient will not be placed on the waiting list of the chosen LTC facility until the application is completed and sent.
- Sending Application to Discharge (**Appl-D/C**): this phase is technically the placement application processing time. At a point in time in between, the patient stops receiving acute care and is given

the ALC status. Social work would be in close contact with the mediator; Community Care Access Center CCAC to continuously for availability in the chosen LTC facility.

4 CURRENT STATE MODEL

In order to identify the nature of phases of the model, the date for each milestone was recorded and the number of days between each of the dates was calculated. A total sample of 152 patients charts were reviewed and for each phase. ProModel (Ver.7) was used as the simulation tool, and in order to identify the inputs of the model, a probability distribution for each of the intervals had to be identified.

The data did not resemble a normal distribution under any of them due to high kurtosis and skewness, therefore further testing was necessary. Minitab (v.15) was chosen for this task as it has the option of running tests of all possible continuous variable distributions at once. The software uses an Anderson Darling test (checking fit of the data to the tested distribution). A P-value > 0.05, indicates that the test is significant. The AD statistic allows the comparison between several matching distributions, with the lowest value being the best. It is worth remembering here that the main target is to achieve a model that is close enough to reality to allow a valid comparison; that is results that resemble the actual LOS distribution.

The results of the distribution identification tests are summarized in Table 1. Bolded values are ones that indicate that the corresponding distribution matched the data. ProModel has built in functions for all those functions except for logistic distribution; the user would only need to enter the parameters. The most appropriate option was selected based on the AD value and the availability of the function in ProModel. The shaded values in Table 1 resemble the selected distributions.

The results show that no probability distribution matched data from the intervals; Ad- RefSW, RefSW - InvSW for any of the units. Some options were identified for InvSW - Appl for only unit 7W. Assuming the character of any of the distributions incorrectly would create a discrepancy in the results. Therefore, to deal with this issue - the lack of representative probability distribution - it was decided to embed a function in the model that allows it to literally "read" data from a spreadsheet containing the actual historical data. Three spreadsheets were prepared for the three types of intervals for each of the units (including InvSW - Appl from 7W for consistency), and a READ (File, <name>) function was installed in the model to enable accurate input. As for the interval Appl-D/C, the following probability distributions were used:

- 2N : W(1.198, 21.4)
- 7E: L(19.61, 18.74)
- 7W: L(18.26, 17.94).

Other important inputs to the model are the probabilities of sending each patient to each unit, since in reality the three are not equal in sending patient to LTC. From the sample it has been deduced that 32.9% were from 2N, 49.3% and 17.8% were from 7E and 7W respectively. An illustration of the model with its inputs and outputs is shown in Figure 3. The goal to be achieved here is to get outputs that are similar to the actual (historical) lengths of stay of patients from the different units, and for LOS of all together as a group. Table 1 also has the distribution identification results of the LOS variables.

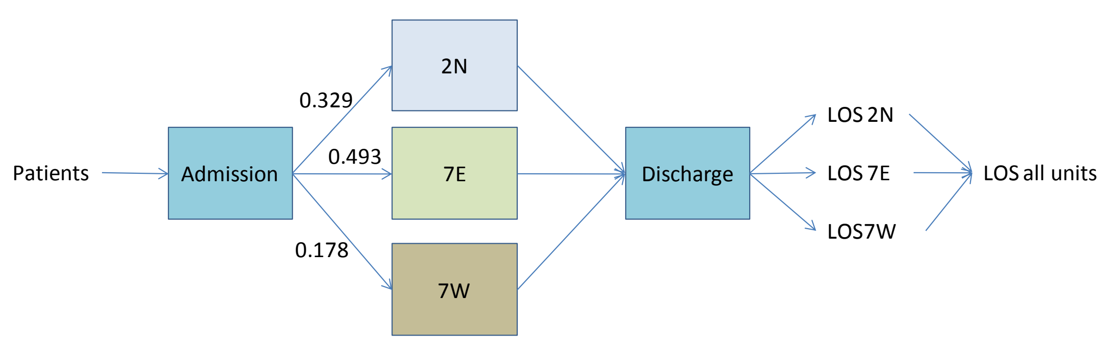

Figure 3: Simulation Model Inputs and Outputs

Table 1: Distribution Identification Results for Intervals

Unit	Interval	Possible Distributions													
		Logistic		**S.E.V.***		**L.E.V. ****		**Gamma**		**Exponential**		**Weibull**		**Lognormal**	
		AD	P-value	AD	P-value	AD	P-value	AD	P-value	AD	P-value	AD	P-value	AD	P-value
2N	Ad-refSW	3.18	<0.005	7.19	<0.01	2.47	<0.01	-	-	-	-	-	-	-	-
	refSW-InvSW	4.65	<0.005	11.70	<0.01	4.20	<0.01	-	-	-	-	-	-	-	-
	InvSW-Appl	1.35	<0.005	4.40	<0.01	**0.70**	**0.065**	-	-	-	-	-	-	-	-
	Appl-D/C	1.30	<0.005	6.96	<0.01	**0.61**	**0.108**	**0.48**	**>0.25**	**1.19**	**0.07**	**0.47**	**0.239**	**0.56**	**0.134**
	LOS	1.28	<0.005	4.97	<0.01	**0.48**	**0.23**	**0.60**	**0.14**	5.85	<0.003	1.19	<0.01	**0.30**	**0.58**
7E	Ad-refSW	5.98	<0.005	10.56	<0.01	5.04	<0.01	-	-	-	-	-	-	-	-
	refSW-InvSW	6.99	<0.005	13.62	<0.01	6.85	<0.01	-	-	-	-	-	-	-	-
	InvSW-Appl	2.47	<0.005	12.08	<0.01	1.52	<0.01	-	-	-	-	-	-	-	-
	Appl-D/C	3.64	<0.005	9.20	<0.01	2.46	<0.01	1.35	<0.005	2.21	0.005	1.54	<0.01	**0.57**	**0.13**
	LOS	1.52	<0.005	5.71	<0.01	**0.47**	**0.24**	**0.46**	**>0.25**	7.42	<0.003	0.99	0.01	**0.36**	**0.45**
7W	Ad-refSW	0.81	<0.005	2.34	<0.01	**0.70**	**0.06**	-	-	-	-	-	-	-	-
	refSW-InvSW	1.99	<0.005	4.55	<0.01	1.76	<0.01	-	-	-	-	-	-	-	-
	InvSW-Appl	1.21	<0.005	1.65	<0.01	**0.89**	**0.20**	**0.44**	**>0.25**	**0.76**	**0.22**	**0.48**	**0.23**	**0.42**	**0.32**
	Appl-D/C	1.13	<0.005	3.79	<0.01	**0.66**	**0.08**	**0.38**	**>0.25**	**0.79**	**0.20**	**0.48**	**0.23**	**0.14**	**0.90**
	LOS	0.99	0.006	2.31	<0.01	**0.59**	**0.12**	**.601**	**0.132**	3.47	<0.003	0.85	0.03	**0.35**	**0.45**
LOS all units		3.43	<0.005	12.65	<0.01	1.06	<0.01	1.18	<0.005	16.49	<0.003	2.62	<0.01	**0.49**	**0.22**

* Smallest Extreme Value Distribution **Largest Extreme Value distribution

The lack of understanding (or specific distribution identification) of data under the process intervals Ad- RefSW and RefSW - InvSW, implies that there is inconsistency in the time taken to complete the tasks within these phases. The time between the referral of social work to the involvement of social work is practically and theoretically a delay in the discharge process, and efforts should be expanded to minimize this delay as much as possible.

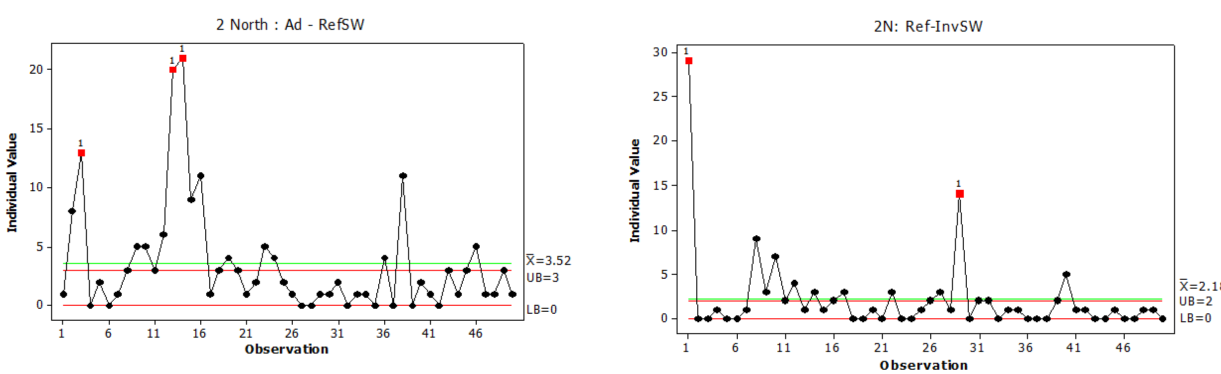

Figure 4: Process Control Charts for unit 2N

As for the time between admission and referral to social work: it is a matter that has already been addressed in literature and discharge planning books. They all call for early planning and suggest it should start as early as admission. The performance of both processes Ad - RefSW and RefSW - InvSW was examined using control charts generated by Minitab, by setting the specification limits to 0-3 days for referral to social work, and 0-2 days for involvement of social work after referral.

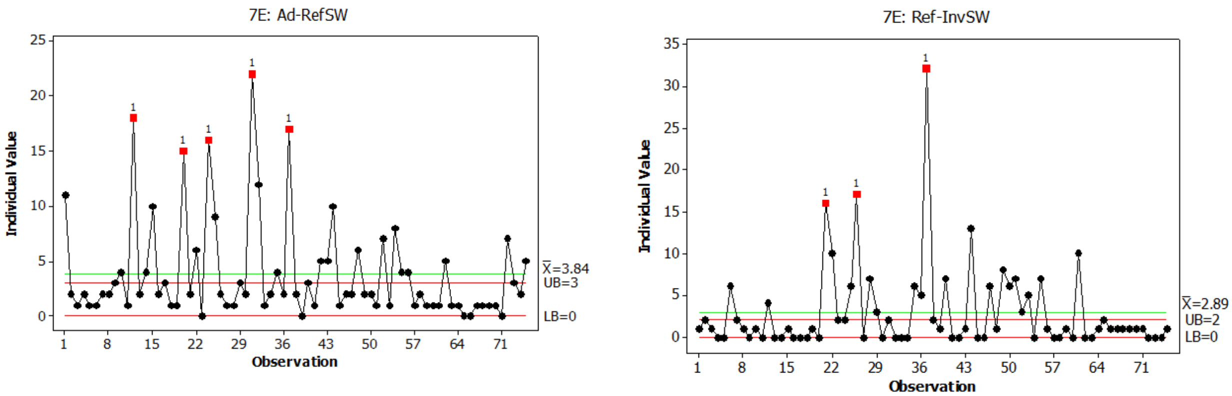

Figure 5: Process Control Charts for unit 7E

The control charts for 2N in Figure 4 showed little deviation from the upper limits of 2 and 3 days, however for some patients they did exist. In the charts from 7E and 7W the deviations are radical (Fig. 5).

5 MODEL VALIDATION

The model was run for a sample of patients equal in volume to the sample size of 152. The results showed a significant resemblance to the distribution of actual LOS. However, to check that the model is able to perform well on any number of patients, replications of quadruple size (608) was used and the performance of the model did not change. A comparison between the distributions is shown in Figs 6 and 7.

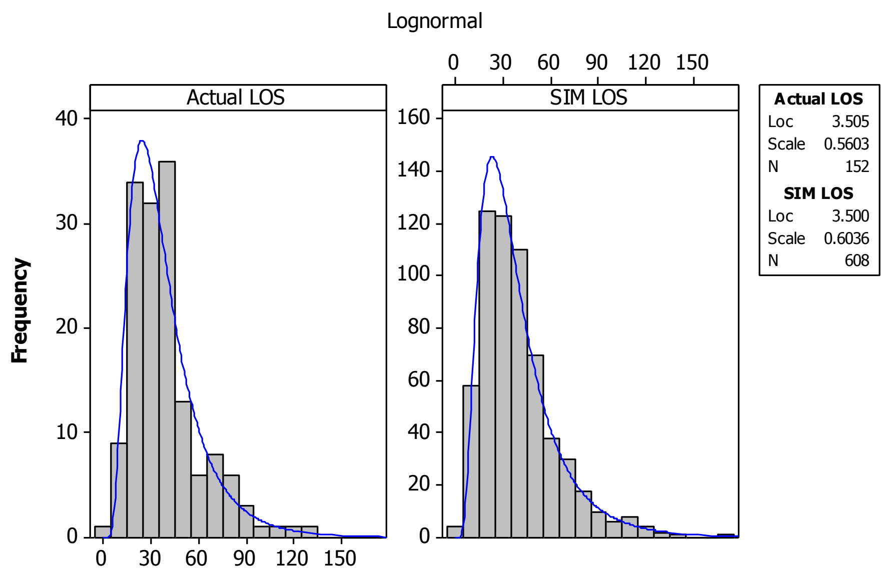

Figure 6: Comparison Between Actual LOS and Simulated LOS for All Patients

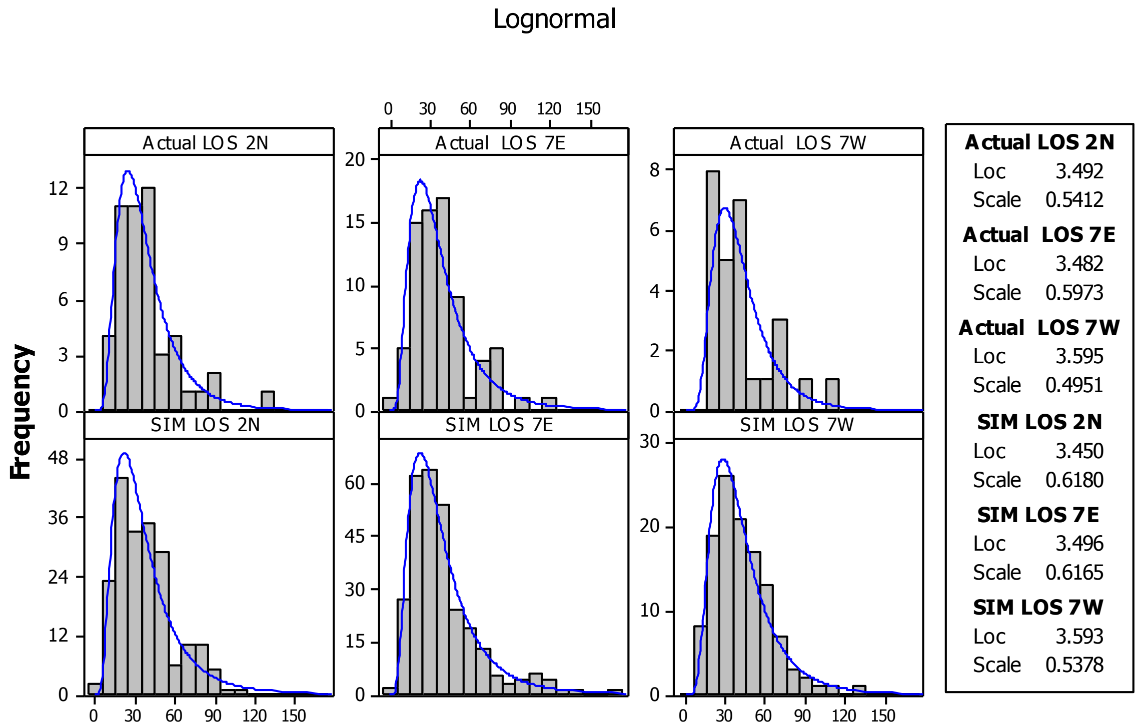

Figure 7: Comparison between Actual LOS and Simulated LOS for the separate units

6 FUTURE STATE MODEL

Previous section mentioned that the time between the referral of social work and the actual start of discharge planning is in itself a delay. For the patient it is a non value added time that might not be effective at that moment (since the patient would be receiving acute care), however it can add to the delay in discharge and cause more ALC days. The same can be said for the first interval, Adm - RefSW. In order to be able to detect the need for planning, many efforts have been put to create accurate checklists and questionnaires that when answered, provide a score indicating the necessity of referral. The hospital itself has early planning process (starting at admission) emphasized in the responsible resources' job descriptions. This implies that this interval should be zero days.

Since the hospital is running at high capacities, it is sensible to assume that there is quite a lot on the nurses and social worker's hands that a drastic improvement from the current performance to zero or 1 day intervals might be unrealistic. However, as almost already being done in 2N, it is worth testing the effect of a what-if scenario saying; what if the time between admission and referral to social work was between 0 and 3 days, and the time between the referral of social work and the actual start of discharge planning was between 0 and 2 days?

In order to answer that question, the current state model has to be modified. The way this can be done is by creating two new spreadsheets of values for both intervals, and having the model read those new values as opposed to the ones that showed the current state. To keep a random effect on the model the new files were prepared in such a way that:

- Integer numbers between 0 and 3 inclusive are randomly generated and listed for the time to referral according to a 0.25 probability of occurrence of each number.

- Integer numbers between 0 and 2 inclusive are randomly generated and listed for the time to involvement of social work after referral according to a 0.333 probability of occurrence of each number.

The new model with the aforementioned characteristics was run keeping the InvSW-App and Appl-D/C characteristics the same as in the current state model. Those last two intervals are shaped by many variables that might need a separate project by itself for the ability of making valid interventions. Some of those factors can be:

- InvSW - Appl. incorporates ongoing series of discussions that might be complicated by the nature of the patients illness and social status such that the decision making process of discharge destination can be largely influenced. Another impact is the patient's personality and judgement ability in cooperating with the social workers.
- Appl - D/C is - as has been said before- the application processing time, which is mainly shaped by the performance of CCAC alongside the status of availability in LTC facilities.

Both reasons indicate that adjusting what happens within those two intervals is a challenge by itself and is out of this project's scope, and can be addressed in future work. Also, it is worth mentioning that the model assumes that processing times for LTC placement have not changed.

7 RESULTING IMPROVEMENTS

After running the what-if scenario, the results showed promising improvement in length of stay. As shown in Figures 8 through 10, the slight shift (dashed line) - to the left - of all the distributions indicates that more people are staying for less time at the hospital. The slight difference in improvement between unit 2N and both 7E and 7W is due to the fact that efforts are already in place to help early discharge planning in 2N; an effect also visible in the control charts of section (Figures 4 and 5) when comparing 2N to the other units.

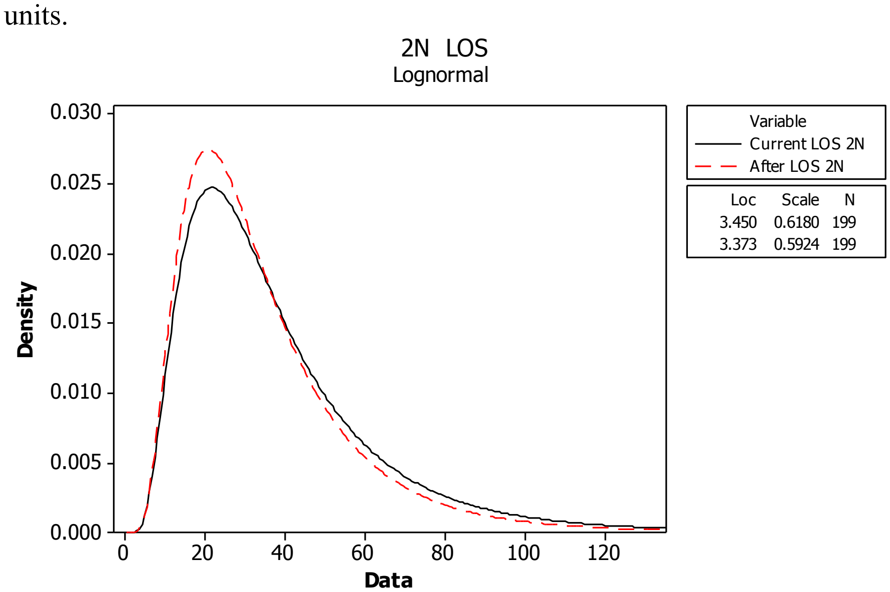

Figure 8: Improvement on LOS in 2N

In order to quantify this improvement, a test was conducted to see whether the before and after (current vs. after 'what-if' scenario) data (from combined units) are statistically significantly different. Since the distributions resemble nonparametric data, Mann Whitney U was used to test for the difference in medians. The test results are shown in Table 2, demonstrating that the difference between the samples is not due to chance, and an improvement or 4.5 days can be deduced. Translated into dollar values, the savings were \$3,146,400 - \$2,736,000 = \$410,400 (13%) for the 152 LTC patients. On average, it accounts for savings of \$214,121 per year (\$17,843 per month).

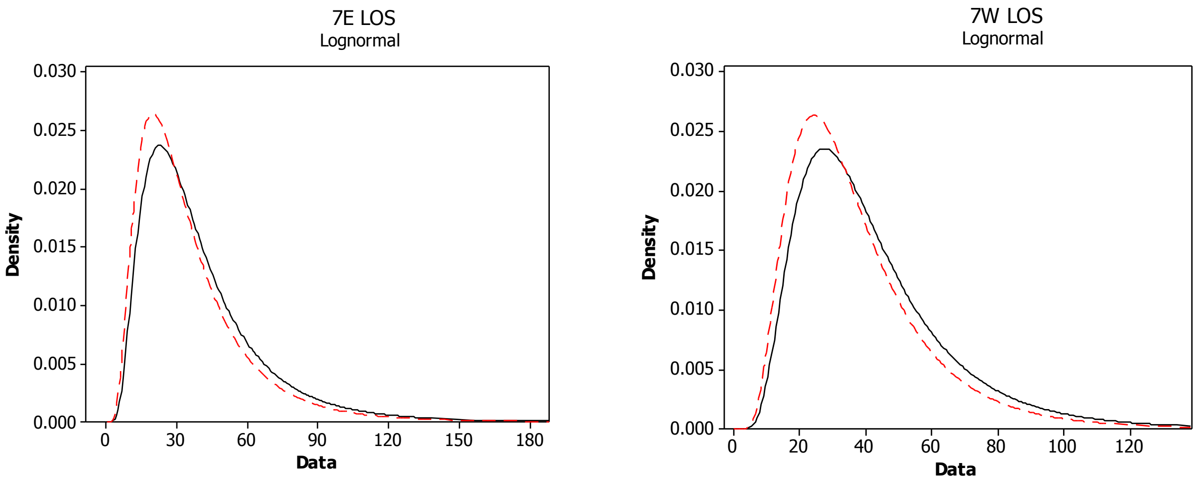

Figure 9: Improvements on LOS in 7E and 7W

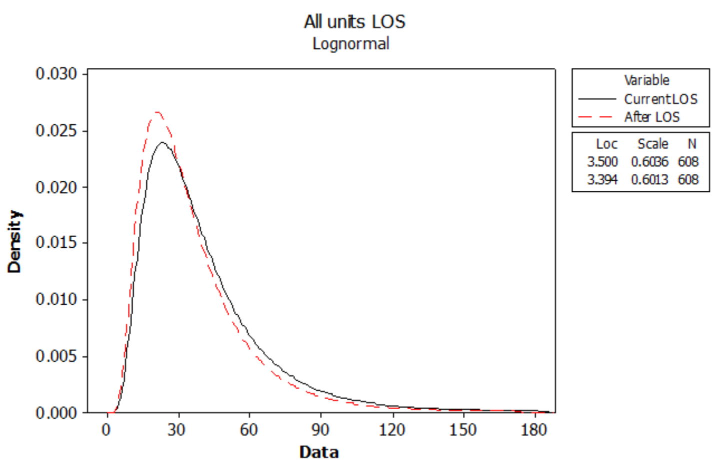

Figure 10: Improvements of LOS (Three Units Combined)

Table 2: Man Whitney Test Results for Before and After Improvement

Variable: LOS	**Mean**	**Std. Dev.**	**Median**	**Man Whitney Test**	
				Z	**P-Value**
Before	38.73	22.52	34.5	-2.194	0.028*
After	35.27	22.39	30.0		

* Using a two-tailed $\alpha = 0.05$

8 SUMMARY

Long term Care facilities and complex continuing care facilities cause more persistent ALC cases and longer ALC days. This might lead to the conclusion that the hospital cannot do anything about it. Not that it can solve the problem completely, it can either look into what it can do to minimize that delay, or look into quantifying that delay accurately to help with the discharge predictions, and hence help the admission process synchronize incoming cases.

The case of ALC patients going to long term care was used to see whether in fact there is something that the hospital can do to minimize LOS or not. The simulation model that resembled the reality of the situation was compared against one that proposed that the time of admission to referral to social work and the time for involvement of social work be strictly set to a maximum of 3 and 2 days respectively. The improvement was evident with a median decrease of about 5 days (from 35 to 30 days) in length of stay of patients who wait ALC days.

ACKNOWLEDGMENTS

Authors gratefully acknowledge support and collaboration with staff of the Hotel Dieu Grace Hospital in Windsor, ON. Insightful feedback from Dr. Maher El-Masri from the Faculty of Nursing at University of Windsor is also acknowledged.

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