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SMOOTHING TO IMPROVE PATIENT FLOW: CASE STUDY

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ABSTRACT

Patient flow represents one of the largest opportunities for improvement in healthcare systems. An effective approach to improve patient flow is identifying and eliminating artificial variability. The most significant artificial variability is dysfunctional scheduled admissions which can be decreased or eliminated by load-smoothing. In this study, we develop a discrete-event simulation model using 12 months of data from a hospital database and obstetric unit logbooks in order to examine the relationship between the impact of load-smoothing for scheduled admissions on the patient flow performance metrics of the unit and patient volume of unscheduled admissions. The results show load-smoothing leads to lower patient waiting times but it does not affect bed occupancy rates considerably. Moreover, reducing the patient volume of unscheduled admissions increases the reduction in the patient waiting time by load-smoothing while increasing the patient volume of unscheduled admissions decreases the reduction in the patient waiting time by load-smoothing.

1 METHODOLOGY

We use 12 months of data (March 2014 to February 2015), from the hospital database and obstetric unit logbooks, to extract arrival rate, arrival time patterns of patients, branching probabilities for patients moving to each ward, patients' LOS in every ward, bed distribution, and occupancy rate. Next, as inputs for the simulation model, we determine probability distributions for arrivals and LOS for each patient type. We also use information about the hospital operations and policies obtained by interviewing hospital staff including administration, physicians, and nurses to develop the simulation model. Then, we create and run the simulation model, which represents the hospital's operations and policies, using the simulation software Arena. We run 50 replications of 12 months in length with a 30-day warm-up period in order to evaluate steady state unit performance. Monitoring the instantaneous and cumulative average occupancy rate of each type of beds as starting in an empty state, we find a warm-up period of 30 days after which the average occupancy rate of beds is stable with slight variability. We also choose the run length large enough to reduce the impact of any bias from the initial on the final performance. To create tight confidence intervals on the metrics of interest, we determine the number of replication in a way that the half-width is within 15% of the averages. Furthermore, we validate the simulation model by comparing its results with actual operating data from the unit that is from a holdout sample. Since the simulated results are very close to the actual data, we can use the simulation model as a reliable representative of the unit to study the patient flow of the unit (see Table1).

Afterward, to identify artificial variability through the patient flow of the unit, we analyze the current scheduled deliveries procedures of the unit. Our focus is only on scheduled C-section deliveries because the demand for scheduled vaginal deliveries is insignificant. Using the "schedule" feature of Arena, we implement the new setup (load-smoothed) in the model and run the model under the load-smoothed setup. Then, we change the initial patient volume of unscheduled deliveries (unscheduled admissions) by different percentages and run the model under both the current and load-smoothed setups to compare the results of the simulation model before and after implementing load-smoothing.

As Table 1 shows the ward with the highest occupancy rate is the postpartum unit so the number of postpartum beds is the bottleneck of the unit. Therefore, we monitor PP bed occupancy rate and patient waiting time as two critical patient flow performance metrics of the unit to study how load-smoothing can affect patient flow performance metrics considering different patient volumes of unscheduled admissions. We run the simulation model under both current and load-smoothed setup while we decrease and increase the initial patient volume of unscheduled admissions by 5, 10, 15, 20 and 25 percent.

Table 1: Comparison simulated and the actual bed occupancy rate.

Ward	Simulated bed occupancy rate	Actual bed occupancy rate
AP/IPP	61.71%	60.01%
LDR	49.25%	47.11%
OR	9.18%	9.52%
PACU	14.32%	14.73%
PP	79.34%	78.04%

2 RESULTS

As Table 2 suggests, the load-smoothed setup outperforms the current setup in terms of patient waiting time. The results show that by implementing the load-smoothed setup, patient waiting time decreases in all cases, but the bed occupancy rate does not change considerably. Moreover, reducing patient volume of unscheduled admissions increases the reduction in the patient waiting time by load-smoothing while increasing patient volume of unscheduled admissions decreases the reduction in the patient waiting time by load-smoothing. For instance, decreasing the initial patient volume by 25% reduces ratio of unscheduled admissions to scheduled admissions from 77.66% to 58.25% and increases the reduction in waiting time by load-smoothing from 49.49% to 66.26%. This indicates that the significance of implementing load-smoothing increases when the ratio of unscheduled admissions to scheduled admissions decreases.

Table 2: Comparison of the simulation result of the current setup and load-smoothed setup considering different patient volumes of unscheduled admissions.

Case	Changes in the patient volume of unscheduled admissions	Ratio of unscheduled admissions to scheduled admissions	Bed occupancy rate	Waiting time (hr)	Bed occupancy rate	Waiting time (hr)	Reduction in waiting time by load-smoothing
			Current setup		Load-smoothed setup		
Decrease in the patient volume of unscheduled admissions	25%	58.25%	73.51%	2.12	73.53%	0.71	66.26%
	20%	62.13%	74.56%	2.13	74.66%	0.84	60.55%
	15%	66.01%	75.99%	2.46	76.00%	0.99	59.78%
	10%	69.90%	76.91%	2.60	77.32%	1.11	57.43%
	5%	73.78%	78.27%	2.86	78.40%	1.28	55.36%
Initial patient volume	0	77.66%	79.34%	2.97	79.75%	1.50	49.49%
Increase in the patient volume of unscheduled admissions	5%	81.55%	80.85%	3.37	80.86%	1.71	49.45%
	10%	85.43%	82.24%	3.67	82.31%	1.86	49.14%
	15%	89.31%	83.19%	3.86	83.45%	2.22	42.61%
	20%	93.20%	84.62%	4.16	84.67%	2.40	42.33%
	25%	97.08%	86.11%	4.64	86.18%	2.69	42.06%