Impact of Novel Care Pathways on ED Operational Metrics

STERLING SIMULATION

Strategic Vision Through Simulation

Agenda

- Introduction
- Problem Statement
- Model Overview
- Experimentation
- Results
- Conclusion

Introduction

- Sterling Simulation was approached by a pharmaceutical client to evaluate the effectiveness of their new medication on emergency department (ED) operations.
- Their medication is used to treat a condition that occurs in a small percentage (~3%) of patients who present to the ED.
- However, as the client's treatment takes less time, ED efficiencies may be gained by using the client's treatment.

Introduction – Notes

- The client is currently pursuing publication of the model and its results in peer-reviewed journals.
- Therefore, the client's name, the treatment, and even the condition treated cannot be disclosed at this time.
- Once the information is in the public domain, this presentation may be updated with that information.

Problem Statement

- If EDs switch the treatment from the standard of care to the client's treatment, what operational gains are obtained for the ED, and at what cost?
  - This question applies to both just the segment of the population that presents with the condition to be treated, and also the general population presenting to the ED.

Model Overview – Method Selection

- The general method of choice for building a simulation model of an ED is discrete-event simulation (DES), and this was followed in this case.
  - A more agent-based modeling (ABM) approach was also considered, but the data was not available to substantiate this.
  - Nevertheless, in order to hold that capability in reserve, the AnyLogic software was selected given its multimethod focus as well as the modeler's familiarity with the software.

Model Overview – Model Elements

- Given the DES method selection, the model can be described neatly in three (3) parts: entities, resources, and the process.
  - The entities represent what moves through the process.
  - The resources represent what the entities need to move through the process.
  - The process represents what is happening in the model, overall.
- Additionally, the differences in the treatments also play a major part and will be discussed.

Model Overview – Model Assumptions

- Patient diagnosis was infallible.
- Clinical effectiveness of the treatments was the same.
- Standard DES assumptions surrounding entity volition.
- Patients could not develop the condition while in the ED.

Model Overview – Entities

- The entities in the model, as in most ED models, are the patients who present to the ED.
  - In this model, the patients have three (3) major parameters:
    - Condition status: Whether or not the patient had the given condition or not
    - Acute status: Whether or not the patient was acute.
    - Willingness to Wait: How long the patient would wait before leaving without being seen (LWBS).
  - These parameters mainly are considered statistically independent.

Model Overview – Resources

- The various resources and their default values in the model include:
  - Registration Clerks (2)
  - Triage Nurses (2)
  - ED Nurses (varies by shift; ~6–7)
  - Physicians (varies by shift; ~2)
  - ED Beds (21)
  - Observation Unit Beds (6)

Model Overview – Process

- There were three (3) main subunits in the process flow.
  - The Patient Creation process, which created the patients;
  - The Pretreatment process, which included registration, triage, and initial assessment by ED Nurses and Physicians;
  - And the Treatment process, which included both condition and non-condition treatments, and possible observation before final disposition.

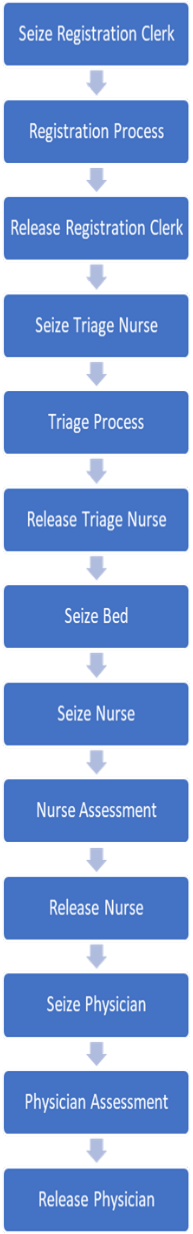
Model Overview – Patient Creation Subprocess

- Patients were created with the presentation rate given by a nonstationary Poisson process with an overall hourly average of about four (4) patients / hour.
  - 10% of patients were considered Acute.
  - Roughly 3% of patients presented with the condition treated by the client's treatment.
  - Patients were willing to wait a variable amount of time before being seen by a doctor, and this was set by data obtained by a literature review.
    - By that data, 32% of patients were willing to wait an unlimited amount of time.

Model Overview – Pretreatment Process

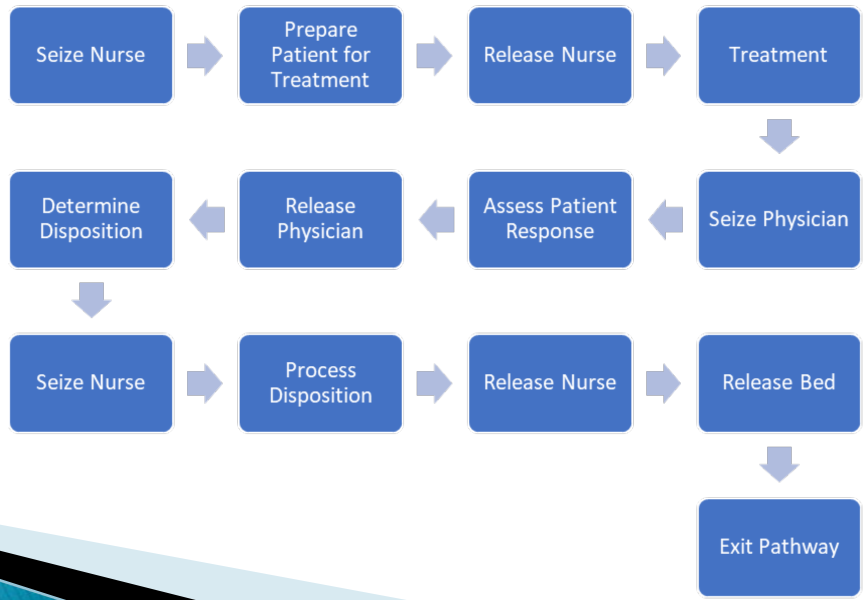
- The Pretreatment Process follows the
  - Registration
  - Triage
  - Assessment

  flow used in most EDs.
- Shown at right is the non-Acute process.
- Acute patients skip many of the steps.
  - Others are moved.
- Once the patient was assigned a bed, they would not leave before treatment was complete.



Model Overview – Treatment Process

- The Treatment Process follows the steps shown below.
- Patients without the condition were sent through a generic 'treatment' block. This was a large concern during validation.



Model Overview – Treatments

- The model considered three different treatments, and they primarily differed in the treatment time, disposition effects, and cost.
  - The standard of care has low cost, a moderate treatment time, and can lead to hospital admittance or the need for observation time.
  - The client’s treatment has high cost, a short treatment time, and is assumed to lead to discharge.
  - A competitor’s treatment has moderate cost, a long treatment time, and is assumed to lead to discharge.

Validation

- Once the model was completed, it was validated by an ED physician of 20+ years experience and passed internal review by the client.
  - The validation metrics were primarily Total LOS and LWBS Rate.
- The generic ‘non-condition’ process needed some calibration, but was otherwise fine for the validation output metrics of interest.

Experimentation

- After validation, production runs were done to gather data for statistical analysis of results.
  - Each run simulated a year of ED time.
  - As ED simulation models should be nonterminating, a one (1) month warmup period was created.
- As a variance reduction measure, each run considered two (2) treatments, and gave each treatment identical patient streams.

Results – Metrics

- The following metrics were gathered for every run, and for the patient population as a whole and also for the patient segment with the condition:
  - Throughput
  - Total LOS
  - Throughput Rate (Throughput / Total LOS)
  - Total Waiting Time
  - LWBS Rate
  - Admission (to Hospital) Rate
  - Resource Utilizations

Results – Condition Segment Metrics

- Throughput (Total Patients Treated) did not materially change by treatment. This was due to using 'reasonable' input factors for presentation (arrival) rate and therefore all patients were able to be treated under every treatment.
  - This led to developing the Throughput Rate metric.
- LOS was much lower with the client's treatment (and the competitor's), with Throughput Rate much higher.

Results – Total Patient Population Metrics

- Interestingly, it was found that providing the client's treatment to the condition segment reduced *all* patients' LOS in the ED by ~10%.
- It also improved admission rates to the hospital and reduced bed utilizations.
  - Other resource utilizations were similar under all treatments.
- The competitor's treatment had an issue with waiting time metrics (i.e., LWBS rate) as ED beds were tied up longer under their treatment.

Results – Cost / Benefit Analysis

- A cost / benefit analysis was also performed, given the wide difference in costs between the treatments.
  - The client's treatment outperformed the standard of care treatment *economically* in the Throughput Rate metric.
  - The competitor's treatment had a similar cost analysis profile to the client's treatment, except for the waiting time metrics.
- It should also be noted that costs modeled were reimbursable costs to the ED.

Results – Summary

- The client's treatment (which applies to ~3% of presenting patients) greatly improves ED operational metrics for that group, and also measurably improves the operational metrics for all presenting patients, compared to the standard of care treatment.
- The competitor's treatment shows lower improvements, and is measurably worse in waiting time metric calculations.

Conclusions

- Whether or not an ED should adopt the client's treatment depends on the likelihood of being reimbursed for the cost of the treatment and what metrics to which that ED is sensitive.
  - If the ED is likely to be reimbursed, the ED should adopt the client's treatment.
  - If the sensitive ED metrics include LOS or ED bed utilization, the ED should seriously consider the client's treatment.

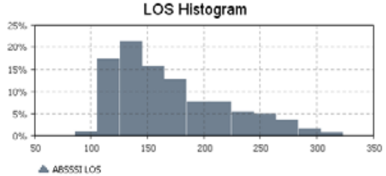
Model Screenshots

- Midrun overall metrics (client treatment on left, standard of care on right)

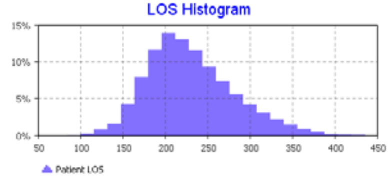
Scenario: 0% Drug Default / 100% Client

Condition Patient Metrics		Overall Patient Metrics	
ConditionThroughput:	439 Patients	Overall Throughput:	11677 Patients
Condition LWBS:	26 Patients	Overall LWBS:	625 Patients
Condition LWBS Rate:	5.591%	Overall LWBS Rate:	5.08%
Condition Wait Time (Avg / SD):	31.111 / 34.166 min.	Overall Wait Time (Avg / SD):	29.157 / 32.759 min.
Condition LOS (Avg / SD):	170.805 / 48.799 min.	Overall LOS (Avg / SD):	231.053 / 50.983 min.
Condition Admission Rate:	0%	Overall Admission Rate:	26.111%

LOS Histogram



LOS Histogram

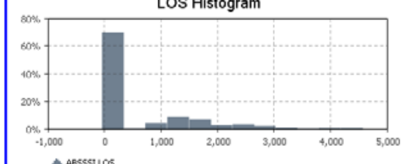


Condition Total Bed Time :	41.306 days	Overall Total Bed Time :	1,593.044 days
Condition Total Beds Occupied :	440 beds	Overall Total Beds Occupied :	11698 beds
Condition Total Reg. Clerk Time :	4.395 days	Overall Total Reg. Clerk Time :	118.079 days
Condition Total Triage Nurse Time :	3.688 days	Overall Total Triage Nurse Time :	98.409 days
Condition Total Nurse Time :	11.628 days	Overall Total Nurse Time :	361.716 days
Condition Total Physician Time :	7.091 days	Overall Total Physician Time :	186.181 days
Condition Total ED Bed Time :	41.306 days	Overall Total ED Bed Time :	1,593.044 days
Condition TP/LOSDays:	8.431	Nurse Utilization:	0.588
Condition Admitted:	0	Physician Utilization:	0.765
Condition Discharged:	8.431	Bed Utilization:	0.624
Condition Total Exit:	8.431	Overall TP/LOSDays:	6.232
Condition TP/Bed Time:	10.628	Overall Admitted:	1.627
		Overall Discharged:	4.605
		Overall Total Exit:	6.232
		Overall TP/Bed Time:	7.33

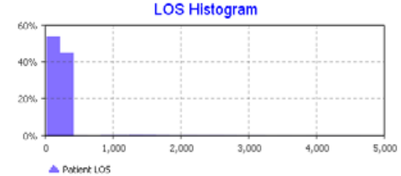
Scenario: 100% Drug Default / 0% Competitor

Condition Patient Metrics		Overall Patient Metrics	
ConditionThroughput:	444 Patients	Overall Throughput:	11648 Patients
Condition LWBS:	20 Patients	Overall LWBS:	654 Patients
Condition LWBS Rate:	4.31%	Overall LWBS Rate:	5.316%
Condition Wait Time (Avg / SD):	30.046 / 33.583 min.	Overall Wait Time (Avg / SD):	28.967 / 32.446 min.
Condition LOS (Avg / SD):	685.664 / 832.094 min.	Overall LOS (Avg / SD):	250.378 / 190.215 min.
Condition Admission Rate:	38.739%	Overall Admission Rate:	27.627%

LOS Histogram



LOS Histogram



Condition Total Bed Time :	200.422 days	Overall Total Bed Time :	1,745.725 days
Condition Total Beds Occupied :	446 beds	Overall Total Beds Occupied :	11670 beds
Condition Total Reg. Clerk Time :	4.447 days	Overall Total Reg. Clerk Time :	117.86 days
Condition Total Triage Nurse Time :	3.757 days	Overall Total Triage Nurse Time :	97.908 days
Condition Total Nurse Time :	17.714 days	Overall Total Nurse Time :	366.265 days
Condition Total Physician Time :	7.122 days	Overall Total Physician Time :	185.994 days
Condition Total ED Bed Time :	53.416 days	Overall Total ED Bed Time :	1,598.72 days
Condition TP/LOSDays:	2.1	Nurse Utilization:	0.589
Condition Admitted:	0.814	Physician Utilization:	0.764
Condition Discharged:	1.291	Bed Utilization:	0.626
Condition Total Exit:	2.1	Overall TP/LOSDays:	5.751
Condition TP/Bed Time:	2.215	Overall Admitted:	1.589
		Overall Discharged:	4.163
		Overall Total Exit:	5.751
		Overall TP/Bed Time:	6.672

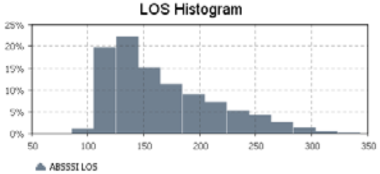
Model Screenshots

- End-of-run per-Patient metrics (client treatment on left, standard of care on right)

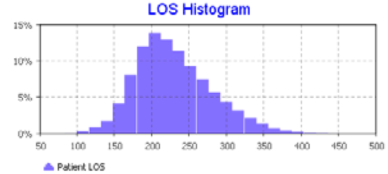
Scenario: 0% Drug Default / 100% Client

Condition Patient Metrics		Overall Patient Metrics	
ConditionThroughput:	1307 Patients	Overall Throughput:	34734 Patients
Condition LWBS:	70 Patients	Overall LWBS:	1792 Patients
Condition LWBS Rate:	5.084%	Overall LWBS Rate:	4.906%
Condition Wait Time (Avg / SD):	28.83 / 32.068 min.	Overall Wait Time (Avg / SD):	28.784 / 32.242 min.
Condition LOS (Avg / SD):	167.157 / 47.435 min.	Overall LOS (Avg / SD):	230.338 / 50.734 min.
Condition Admission Rate:	0%	Overall Admission Rate:	26.049%

LOS Histogram



LOS Histogram

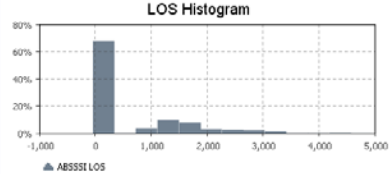


Condition Bed Time per Patient:	2.217 hours	Overall Bed Time per Patient:	3.266 hours
Condition Beds Occupied per Patient:	1 beds	Overall Beds Occupied per Patient:	1.001 beds
Condition Reg. Clerk Time per Patient:	0.243 hours	Overall Reg. Clerk Time per Patient:	0.243 hours
Condition Triage Nurse Time per Patient:	0.201 hours	Overall Triage Nurse Time per Patient:	0.202 hours
Condition Nurse Time per Patient:	0.631 hours	Overall Nurse Time per Patient:	0.743 hours
Condition Physician Time per Patient:	0.386 hours	Overall Physician Time per Patient:	0.383 hours
Condition ED Bed Time per Patient:	2.217 hours	Overall ED Bed Time per Patient:	3.266 hours
Condition TP/LOSDays:	8.615	Nurse Utilization:	0.589
Condition Admitted:	0	Physician Utilization:	0.76
Condition Discharged:	8.615	Bed Utilization:	0.617
Condition Total Exit:	8.615	Overall TP/LOSDays:	6.252
Condition TP/Bed Time:	10.825	Overall Admitted:	1.629
		Overall Discharged:	4.623
		Overall Total Exit:	6.252
		Overall TP/Bed Time:	7.349

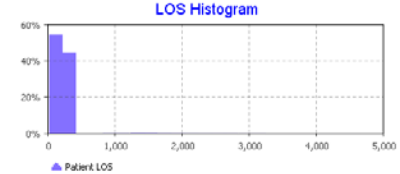
Scenario: 100% Drug Default / 0% Competitor

Condition Patient Metrics		Overall Patient Metrics	
ConditionThroughput:	1312 Patients	Overall Throughput:	34703 Patients
Condition LWBS:	65 Patients	Overall LWBS:	1822 Patients
Condition LWBS Rate:	4.72%	Overall LWBS Rate:	4.988%
Condition Wait Time (Avg / SD):	28.625 / 31.512 min.	Overall Wait Time (Avg / SD):	28.373 / 31.627 min.
Condition LOS (Avg / SD):	716.249 / 836.535 min.	Overall LOS (Avg / SD):	250.656 / 192.939 min.
Condition Admission Rate:	39.253%	Overall Admission Rate:	27.825%

LOS Histogram



LOS Histogram



Condition Bed Time per Patient:	11.37 hours	Overall Bed Time per Patient:	3.607 hours
Condition Beds Occupied per Patient:	1 beds	Overall Beds Occupied per Patient:	1.001 beds
Condition Reg. Clerk Time per Patient:	0.241 hours	Overall Reg. Clerk Time per Patient:	0.243 hours
Condition Triage Nurse Time per Patient:	0.199 hours	Overall Triage Nurse Time per Patient:	0.201 hours
Condition Nurse Time per Patient:	0.976 hours	Overall Nurse Time per Patient:	0.755 hours
Condition Physician Time per Patient:	0.384 hours	Overall Physician Time per Patient:	0.383 hours
Condition ED Bed Time per Patient:	2.872 hours	Overall ED Bed Time per Patient:	3.286 hours
Condition TP/LOSDays:	2.01	Nurse Utilization:	0.561
Condition Admitted:	0.789	Physician Utilization:	0.759
Condition Discharged:	1.221	Bed Utilization:	0.62
Condition Total Exit:	2.01	Overall TP/LOSDays:	5.745
Condition TP/Bed Time:	2.111	Overall Admitted:	1.599
		Overall Discharged:	4.146
		Overall Total Exit:	5.745
		Overall TP/Bed Time:	6.653

Thank you! Questions?