DEVELOPMENT OF A DECISION SUPPORT SYSTEM FOR CARDIAC ARREST CENTRES (CAC) AND SIMULATION OF OUT-OF-HOSPITAL CARDIAC ARREST (OHCA) OCCURRENCE

IE3100R SYSTEMS DESIGN PROJECT AY23/24 | DEPARTMENT OF INDUSTRIAL AND SYSTEMS ENGINEERING

TEAM MEMBERS : NICHOLAS LIM JUN HENG | PER WONG XUE | KENN SEAH | HO SZE YANG ANDRE

DEPARTMENT SUPERVISOR : TANG LOON CHING

INDUSTRY SUPERVISOR : SEAN LAM | GE YAO | JUN TIAN

INTRODUCTION

Singhealth is a healthcare service group founded in 2000 by the Singapore government. They integrate education, research and clinical care to push for innovations to better serve their patients.

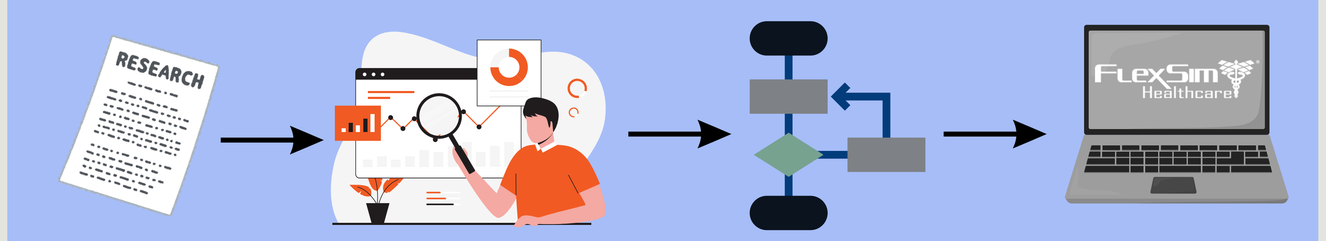
This project seeks to partner with the team of data scientist at Health Service Research Centre (HSRC) to optimse CAC hospital and OHCA patient care,

PROBLEM OBJECTIVE

Due to constrains of limited resources, informed decisions have to be made regarding OHCA patients and the use of CAC hospitals. We aim to do this by:

1. Creating a scoring model for OHCA patients, which will act as a decision framework on whether to send them to CAC or non-CAC hospitals
2. Developing a discrete event simulation (DES) to improve OHCA patient management

METHODOLOGY



Research on existing scoring models → Developing a Scoring Model to determine outcomes for OHCA patients → Understand and Develop Flowchart for Patient Flow in Hospital → Develop DES model using the Flowchart for Patient Flow

KEY SKILLS

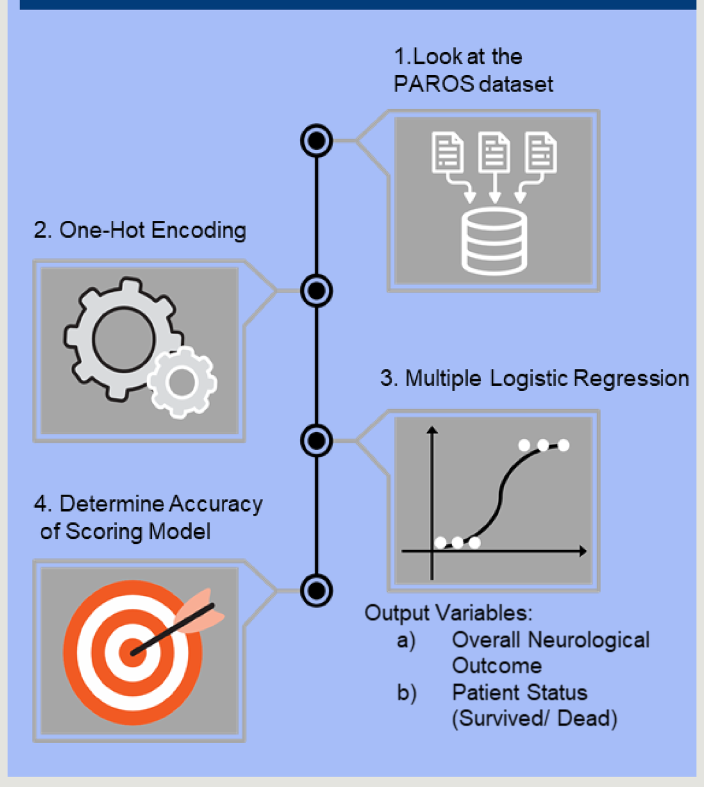
Simulation Modelling and Analytics (Flexsim Healthcare)

Machine Learning (Logistics Regression using Python)

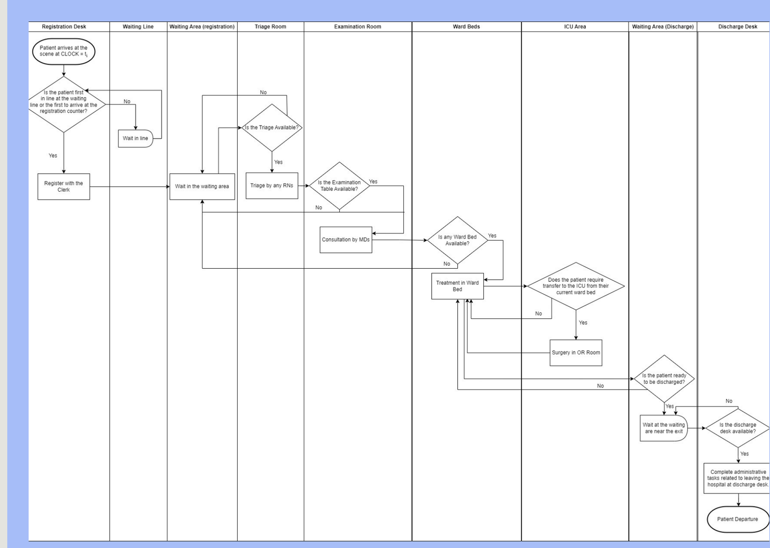
Clinical Workflow Analysis

Project Management

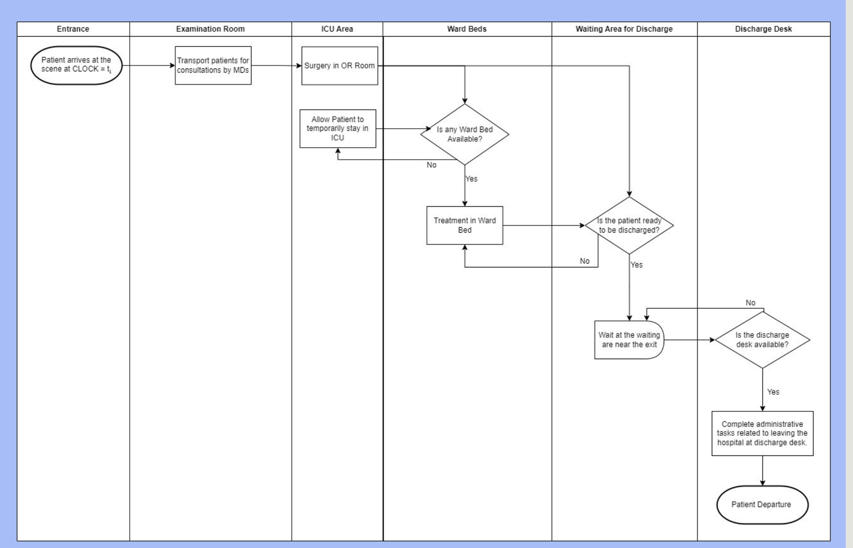
SCORING MODEL



PATIENT FLOW SWIMLANE DIAGRAM



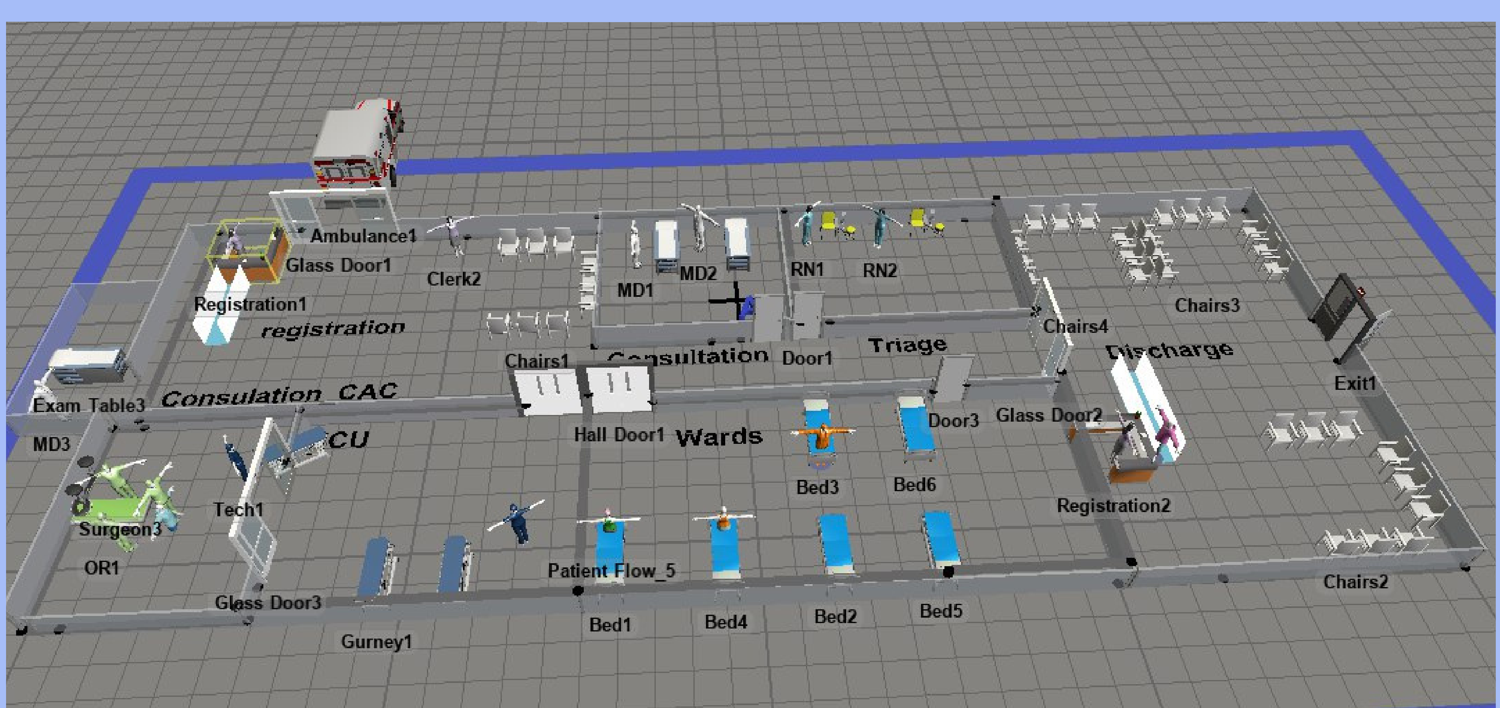
Walk-in Patients



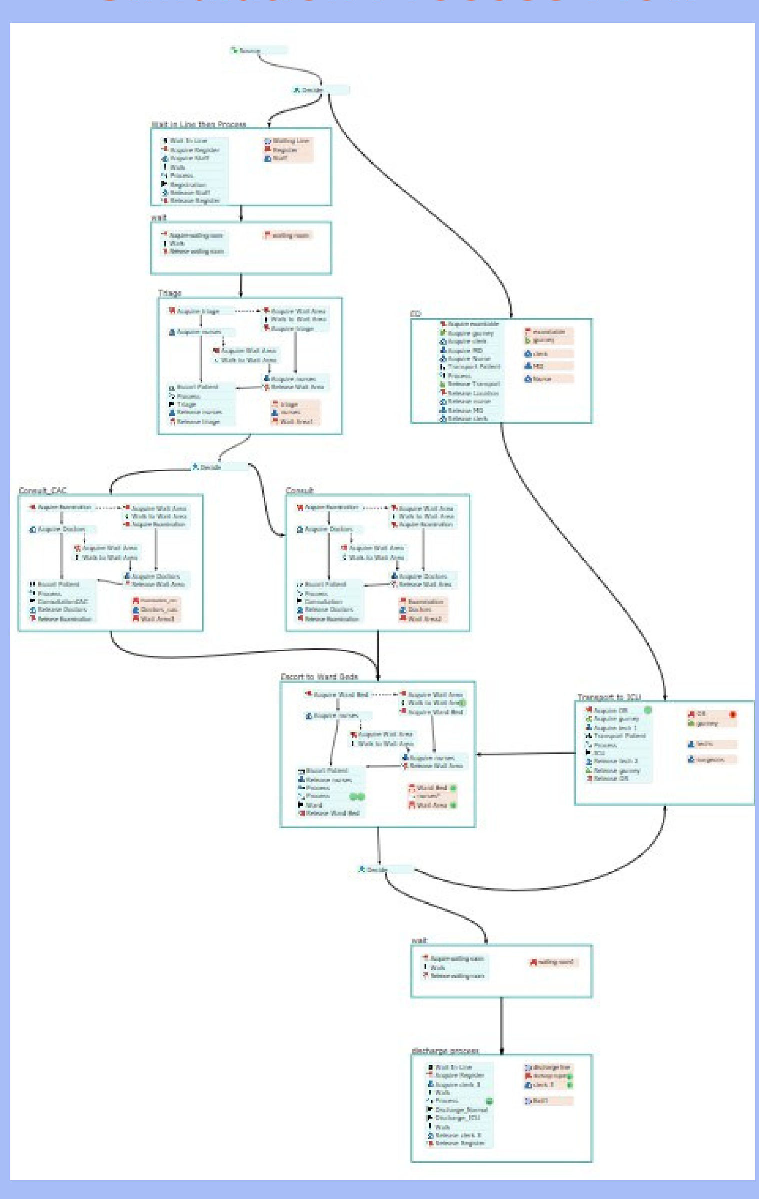
Acute Patients

FLEXSIM RESULTS

Flexsim Model



Simulation Process Flow



Process Flow 1: Standard Patient Journey

a. Patient Arrival to Registration: Patients arrive and register for a consultation, taking about 3.5 minutes.
b. Registration to Triage: Patients are assessed for urgency, taking approximately 3.2 minutes.
c. Triage to Consultation: Patients undergo consultation, the longest step at around 7.5 minutes.
d. Consultation to Warding: Patients are transferred to a bed, identifying areas for logistical improvements.

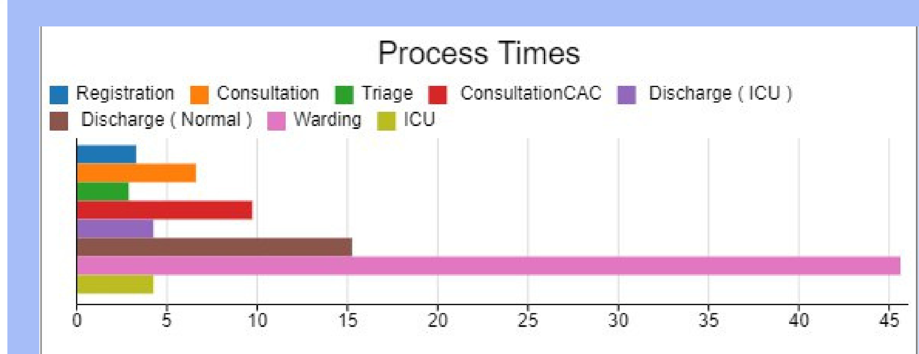
Process Flow 2: Normal Arrival with ICU Scenario After Warding

a. ICU Integration: Patients requiring intensive care move from warding to ICU, then back to warding before discharge, requiring high-level coordination.
b. Warding to Discharge: Efficient management of resources and bed availability is crucial for patients transitioning from ICU to wards.

Process Flow 3: ICU Arrival

a. Patient Arrival to ICU: Critical patients skip triage and consultation, moving directly to ICU, reducing wait times.
b. ICU to Warding: Optimized for critical cases, emphasizing prompt response and treatment, requiring efficient resource allocation in wards.

Simulation Results



The simulation shows that the bottleneck of the process comes in the warding procedure. The warding process took up significantly more time compared to the other processes as all 3 process flows require patients to enter or re-enter the wards, limiting to only 6 beds in the simulation. Efficiency here impacts bed availability and overall patient satisfaction with the overall service flow in the hospital. The

SCORING MODEL RESULTS

'Patient status' output variable

	precision	recall	f1-score	support
1	0.84	0.99	0.91	402
2	0.38	0.11	0.18	70
3	0.77	0.38	0.51	26
4	0.00	0.00	0.00	5
accuracy			0.82	503
macro avg	0.50	0.37	0.40	503
weighted avg	0.77	0.82	0.78	503

'Patient neurological status Overall' output variable

	precision	recall	f1-score	support
1	0.57	0.67	0.62	12
2	0.00	0.00	0.00	8
3	0.00	0.00	0.00	6
4	0.00	0.00	0.00	5
5	0.96	0.99	0.97	472
accuracy			0.95	503
macro avg	0.31	0.33	0.32	503
weighted avg	0.91	0.95	0.93	503

Comparison

ACCURACY

Accuracy is a measure of the overall correctness of your model's predictions. It calculates the ratio of correctly predicted instances to the total number of instances. With ' Patient neurological status' as the output variable, it has more correctly predicted instances as such greater accuracy compared to using 'patient status' as the output variable

PRECISION

Precision measures the proportion of true positive predictions out of all positive predictions made by the model. It tells you how many of the predicted positive instances were actually positive. High precision indicates that the model has a low rate of false positives.With ' Patient neurological status' as the output variable, it has more true positive predictions as such greater precision compared to using 'patient status' as the output variable

RECALL

Recall measures the proportion of true positive predictions out of all actual positive instances in the dataset. It tells you how many of the actual positive instances were correctly predicted as positive. High recall indicates that the model has a low rate of false negatives. With ' Patient neurological status' as the output variable, it has a higher proportion of true positive predictions as such greater recall compared to using 'patient status' as the output variable

F1-SCORE

The F1-score is the harmonic mean of precision and recall. It balances precision and recall, providing a single metric to assess a model's performance. The F1-score is particularly useful when you want to find a balance between minimizing false positives and false negatives.With ' Patient neurological status' as the output variable, it has a higher f1-score as such greater overall precision and recall compared to using 'patient status' as the output variable

RECOMMENDATIONS

IMPROVEMENT OF SCORING MODEL

The incorporation of machine learning algorithms (random forests/neural networks) could be used to capture complex non-linear relationships between the predictor variable and outcomes. The fine-tuning and re-evaluation of weighted variables based on their significance in predicting outcomes may uncover pattern that traditional regression analysis might overlook.

Since age is a significant predictor of outcomes in various medical conditions, accurate and complete data is essential to enhance the scoring model's generalizability and reliability when applied to new patient cohorts (new data group). As such, imputation methods may be utilized to account for missing data group (insufficient data for patients under the age of 18), thereby improving the utility of the scoring model

OUT-OF-HOSPITAL PROCESSES

Linkage of out-of-hospital process flow together with in-hospital processes would allow for a more targeted analysis of factors not limited to: triage protocols, treatment algorithms, and resource allocation strategies. It provides a comprehensive understanding of the entire continuum of care for patients from their arrival and departure from the facility. This linkage will help in optimizing the entire chain of survival for cardiac arrest patients, which could potentially lead to increased rate of survivability and improved outcomes.

ACCURACY OF SIMULATED FLOOR PLAN

The provision of the actual hospital facility floor plan would allow for a more detailed and accurate Flexsim simulation representation. The absence of the actual workflow process (e.g. patient registration, triage identification, treatment room, etc) may compromise the accuracy of spatial representation and hinder realistic modelling of patients' movements, resource allocation and overall workflow. The current simulation may not accurately capture bottlenecks, or provide realistic insights into OHCA patients' process flow in a hospital environment.