DEVELOPING A DECISION SUPPORT FRAMEWORK: AN ANALYSIS OF RESOURCE UTILISATION AND EFFECTIVENESS OF CARDIAC ARREST CENTRES IN SINGAPORE

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IE3100R Systems Design Project | Group 7 - SingHealth 1
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BACKGOUND

Established in 2000, Singapore Health Services, also known as **SingHealth**, is an academic medical hub integrating clinical care, education and research to innovate and improve healthcare quality.

Missions: Care to Heal, Educate to Empower and Innovate to Advance

This project focuses on **Cardiac Arrest Centres** (CACs) in **Singapore**.

PROBLEM DESCRIPTION

In Singapore, the annual number of sudden cardiac arrest (CA) cases is **on the rise**, with 3432 cases reported in 2020. To address this, Singapore has established three Cardiac Arrest Centres (CACs) that offer comprehensive treatment for OHCA patients. However, it is important to also consider **resource utilisation**, including transportation of OHCA individuals, alongside specialized treatment to effectively address patient outcomes.

PROBLEM OBJECTIVE

To analyse the effectiveness of Singapore's CACs in treating OHCA patients and resource utilisation by developing a **Decision Support Framework**.

This helps healthcare management make informed decisions on the transportation of OHCA individuals to improve clinical outcomes, particularly survival rates.

PROBLEM IMPACTS

- Mismatch of supply and demand due to the limited number of CACs.
- Delayed recovery of OHCA individuals due to inadequate and delayed care.
- Loss of life or unfavourable clinical outcomes due to allocation errors, transportation delays and reduced survival probabilities.

METHODOLOGY

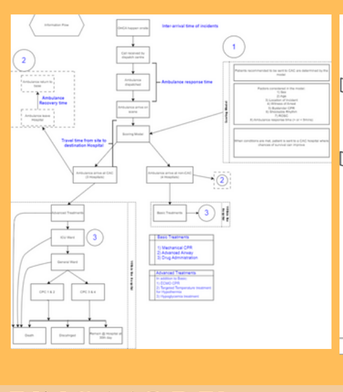
Information and Material Flow diagrams to provide an overview of the movement of patients and ambulances → **Scoring Model** simplifies decision-making process of diversion to CACs → **Ambulance DES** to examine policy options to improve response time and fleet utilisation → **Hospital DES** to model EMS conveyance to hospitals and limited ICU ward capacity

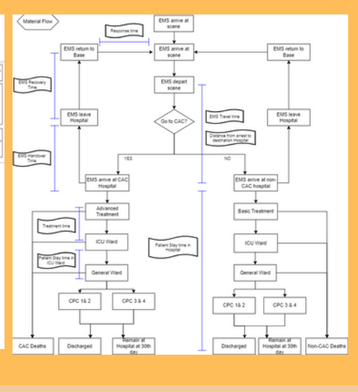
CAC VS NON-CAC

CACs: SGH, NUH and TTSH
Treatments: Emergency Percutaneous Coronary Intervention (PCI), Emergency Coronary Artery Bypass surgery (CABG), Hypothermia Therapy and Extracorporeal Membrane Oxygenation (ECMO)
Non-CACs: SKH, KTPH, NTFGH and CGH
Treatments: Mechanical CPR, Advanced Airway and Drug Administration

INFORMATION AND MATERIAL FLOW DIAGRAM

Overview of movement of OHCA individuals from scene of the arrest to hospital, including the steps for transport decisions.





SCORING MODEL

Provides guidance and **simplify decision-making** process on whether an OHCA patient should be diverted to a CAC.

Base Scoring Model		
1.	Gender	Male/Female
2.	Age	<31/31-64/≥65
3.	Location of Arrest	Home/ In Public/ Healthcare Facility
4.	Witness of Arrest	Yes/No
5.	Bystander CPR	Yes/No
6.	Shockable Rhythm	Yes/No
7.	Prehospital ROSC	Yes/No
8.	EMS Response Time	<8 mins / >8 mins

Further Suggestions		
9.	Respiratory Rate, breaths/min	<12/12-23/24-35/≥36
10.	Systolic Blood Pressure, mm Hg	≤90/90-140/141-180/>180
11.	Heart Rate, beats/min	≤60/61-99/100-119/≥120
12.	Pulse Oximetry, %	≥93/88-92/80-87/<80
13.	Glasgow Coma Scale Score	15/12-14/8-11/<8
14.	Aetiology/Other Illness	Hypertension, Diabetes, Chronic Lung Disease, Cancer, Congestive Heart Failure
15.	Race	Chinese/ Eurasian/ Indian/ Malay/ Others

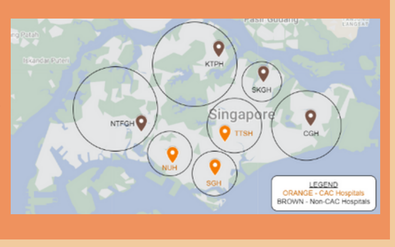
AMBULANCE DES

Simulates the operations and processes of an ambulance service, **improving ambulance response times** and clinical outcomes.

Data Required for Ambulance DES	
1.	Time call received by dispatch centre
2.	Time ambulance dispatched
3.	Time ambulance arrived at scene
4.	Time ambulance left scene
5.	Time ambulance arrived at the hospital
6.	Time ambulance left hospital
7.	Time ambulance returned to base location

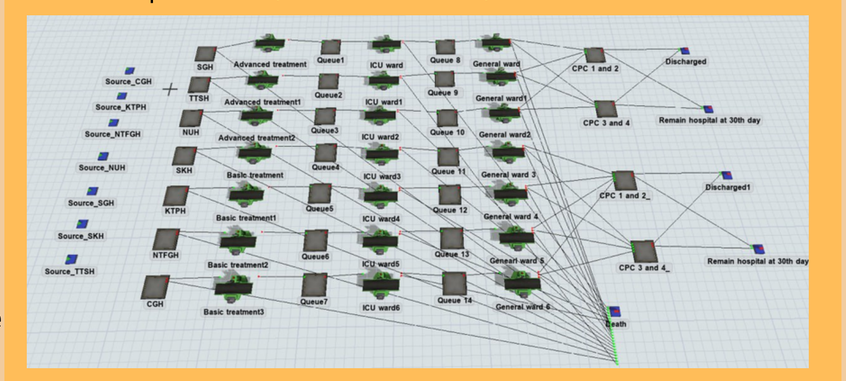
OHCA SOURCE LOCATIONS

Seven OHCA source locations, grouped by their actualized destination hospitals, with individual interarrival time, dispatch time, response time, treatment time and conveyance time distributions.



HOSPITAL DES

Enables scenario analysis to investigate interactions between components → Improve overall clinical outcomes of OHCA patients (FlexSim Model)



DATA COLLECTION

Data from the Pan-Asian Resuscitation Outcomes Study (PAROS) is used. The final dataset included **15171** records starting from 1 January 2015 of non-trauma OHCA cases in Singapore of individuals aged 18 years and above.

Age: Mean **69.5** years; Gender: **63.3%** Male; Race: **68.9%** Chinese
Bystander CPR = 'Yes': **59.9%**; Witness of Arrest = 'Yes': **56.3%**
Shockable Rhythm = 'Yes': **15.3%**; Prehospital ROSC = 'Yes': **12.1%**
Location of Arrest: **70.2%** Home, **12.7%** Public Places
EMS Response Time < 8 mins: **70.7%**
Ambulance Conveyance Time < 9 mins: **69.7%**

% of OHCA Patients to CACs: **38.7%**
Survived = 'Yes': **4.80%**

SCENARIO ANALYSIS

Scenario analysis was done to evaluate survival rates of OHCA patients (%) when parameters in Hospital DES are changed.

Scenarios 1 and 2: 3 CAC hospitals, 4 Non-CAC hospitals

Scenario 1: Change in ICU Ward Capacity and Diversion Rates to CACs

Percentage of Patients Diverted to CAC (%)	0	25	50	75	100
+2 ICU Beds	5.3	5.1	5.8	5	5.2
+1 ICU Bed	5	4.9	5	4.8	5.1
Base ICU Bed	4.4	4.3	4.9	4.4	4.6

Scenario 2: Scenario 1 with **increased rates of OHCA occurrences by 1.1** (10% more OHCA occurrences)

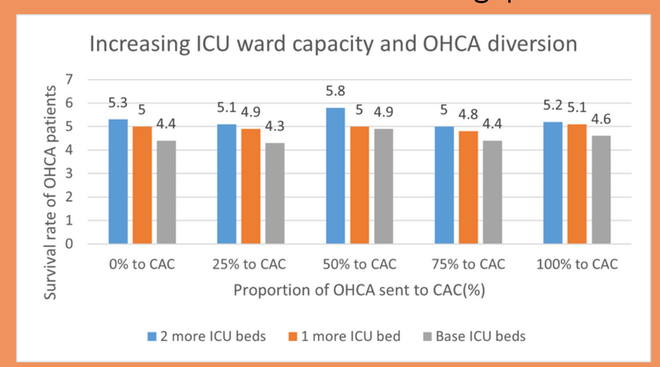
Percentage of Patients Diverted to CAC (%)	0	25	50	75	100
+2 ICU Beds	4.4	4.8	4.6	4.8	4.8
+1 ICU Bed	4.5	4.3	4	3.9	4.6
Base ICU Bed	3.9	3.8	4.2	4.4	4.3

Scenario 3: Have **CGH or KTPH as a new CAC hospital** (4 CAC, 3 Non-CAC)

Hospital	CGH	CGH	KTPH	KTPH
Percentage of Patients Diverted to CAC (%)	50	100	50	100
Base Arrival Rate	4.5	5.2	4.2	4.6
1.05 times Arrival Rate	5.5	5.1	4.7	4.3
1.1 times Arrival Rate	4.6	4.5	5.2	4.4

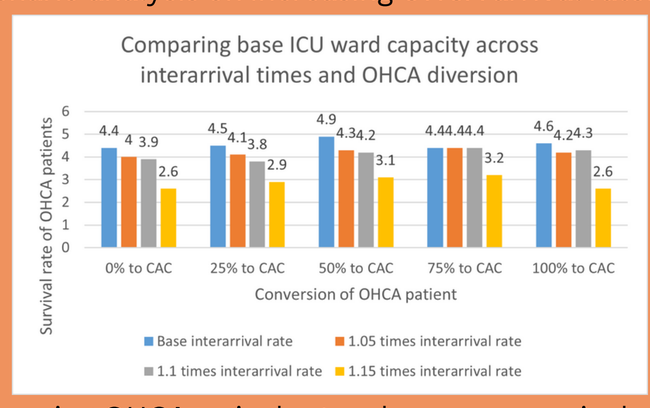
RESULTS

The following visualizations illustrate the results of scenario analysis regarding the increase in the number of ICU beds and additional CACs in Singapore.



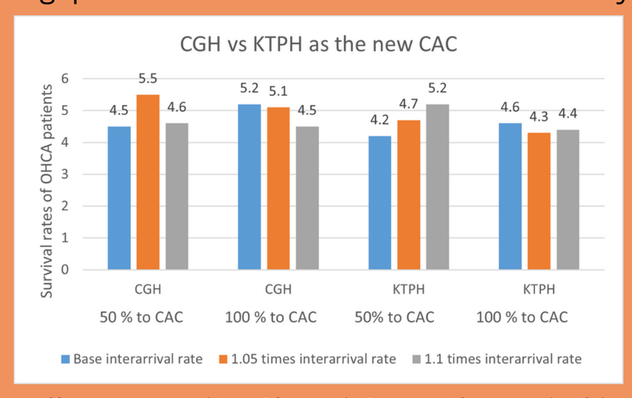
Increasing ICU ward capacity for OHCA patients is positively associated with in-hospital survival rates. The best results would be 2 more ICU beds when 50% of OHCA patients are diverted to CACs.

Scenario analysis on increasing OHCA arrival rates:



Increasing OHCA arrival rates decreases survival rate across the diversion of OHCA patients to CACs.

If Singapore would increase number of CACs by 1,



Generally, converting Changi General Hospital into a new CAC would be **more beneficial** for survival rates.

SKILL SETS

Data Management
- Extract, Filter, Transform, Load, Validate

Software Proficiency
- FlexSim
- Python
- Excel
- R
- Miro

Project Management
- Project Scheduling
- Time Management
- Teamwork

Statistical Knowledge
- Odds Ratio
- Threshold
- Bayes' Theorem
- Logistic Regression