Ambulance Rezoning: Possible future directions

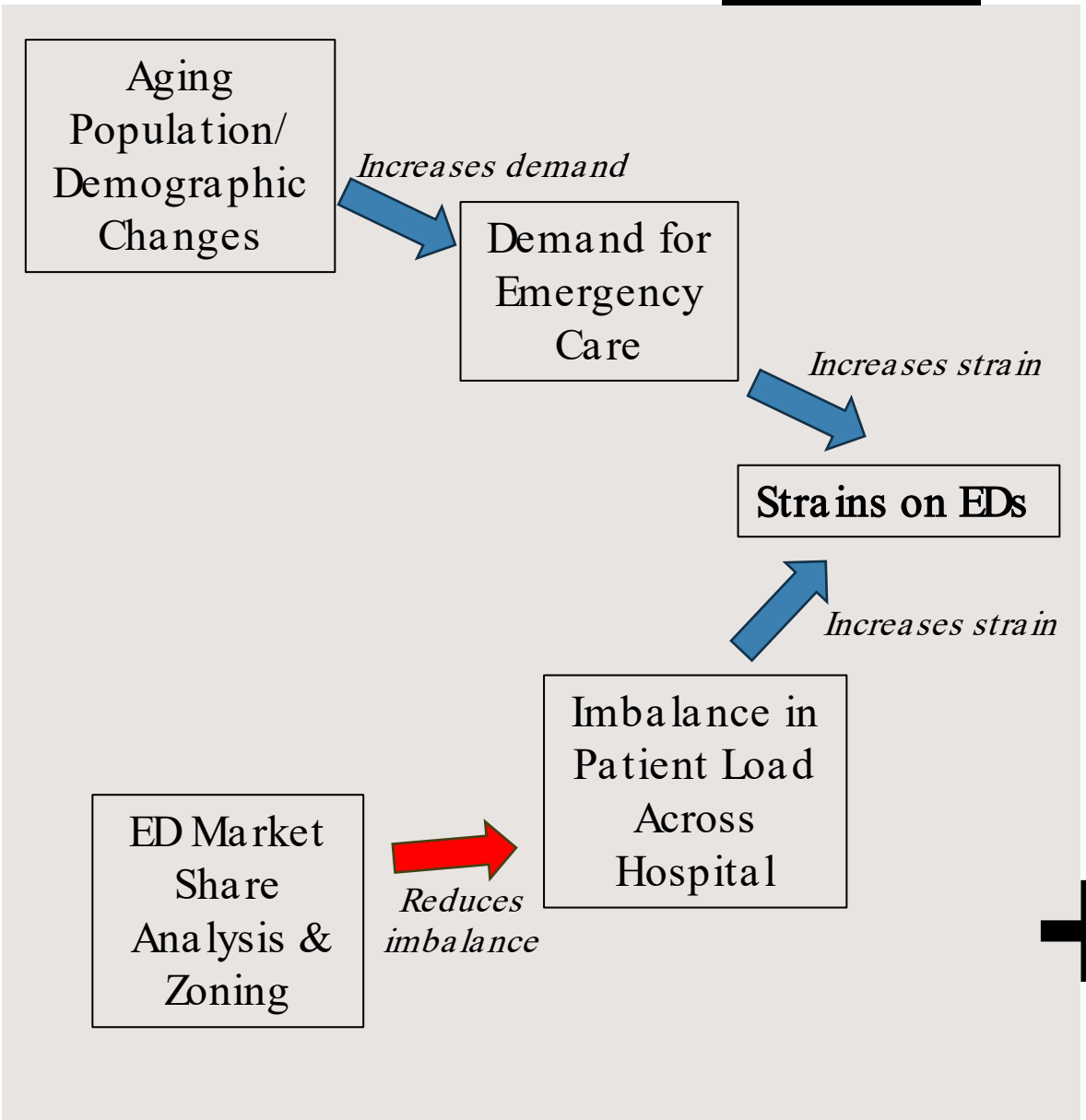
7 March 2025

Presenter: Adriel Rao

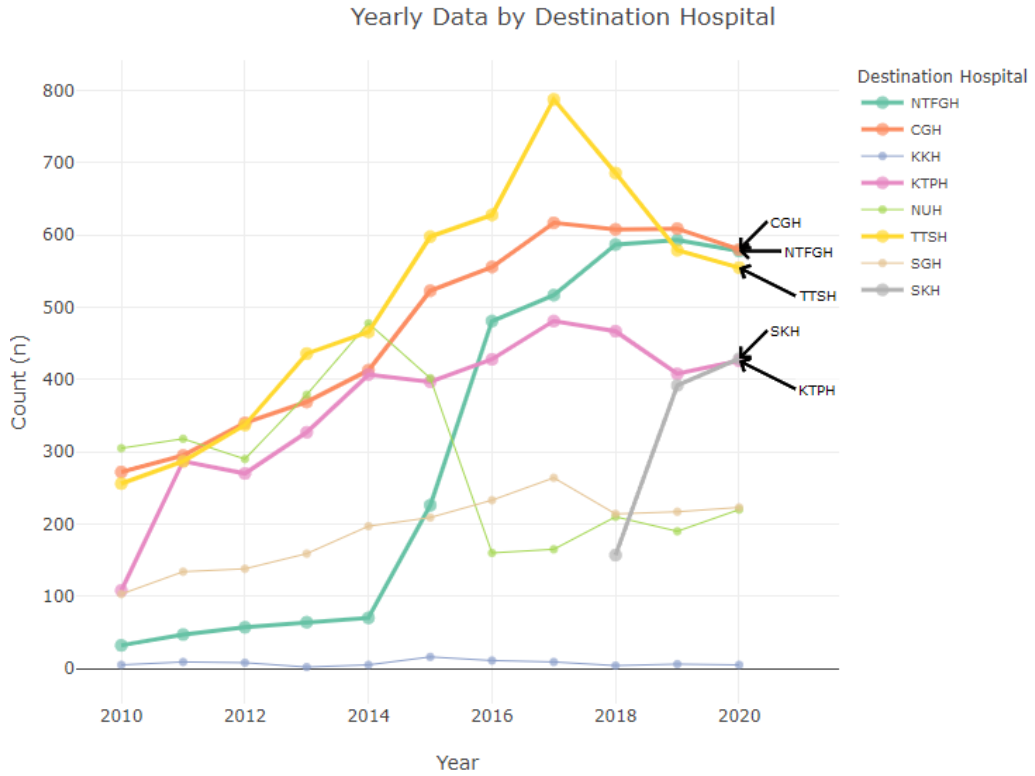
Team: Yohei Okada, Adam Quek, Ge Yao, Sean Lam, Ashish Kumar, Marcus Ong

Background

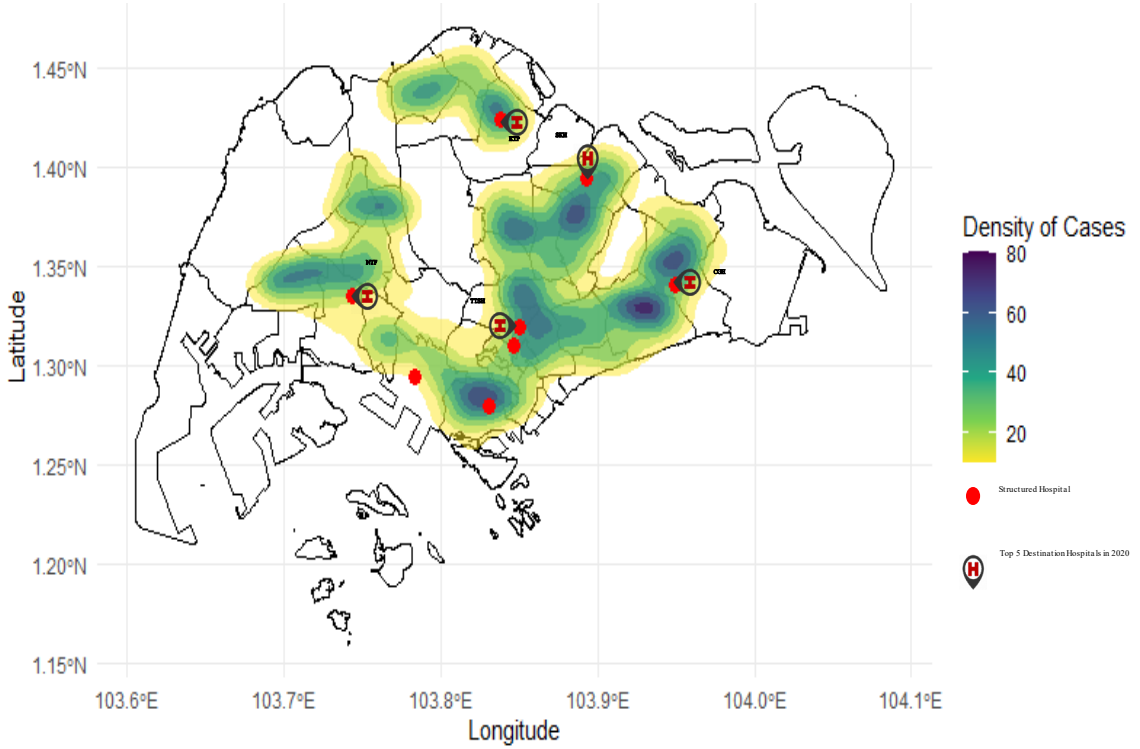
- **Growing Strain on EDs**
  - Increased demand for emergency care due to aging population and demographic changes
- **Current SCDF Ambulance Protocol**
  - Patients transported to the nearest hospital based on real-time traffic conditions.
  - Exceptions: severe trauma, STEMI, or pediatric emergencies.
- **Challenges with Current Practice**
  - Imbalance in patient load across hospitals.
  - Longer ambulance turnaround time in some regions.
  - Delays in patient care.
- **Need for a Systemic Solution**
  - Optimize ambulance services through load distribution.
  - Leverage historical demand and zoning via ED market share analysis.



Imbalance in Emergency Workload (2010 – 2020): Trends and Spatial Distribution



In 2020, the top 5 destination hospitals—CGH, NTFGH, TTSH, SKH, and KTPH—accounted for 75%of all cases (n = 2,568 out of 3,016)



Hotspots of ED cardiac incidents are concentrated in the north, north-eastern and eastern regions of Singapore

Note: Figures based on 23,151 cases of OHCA conveyed incidents from 2010 to 2020. A total of 1,171 cases were excluded due to missing geospatial data.

Study Aim

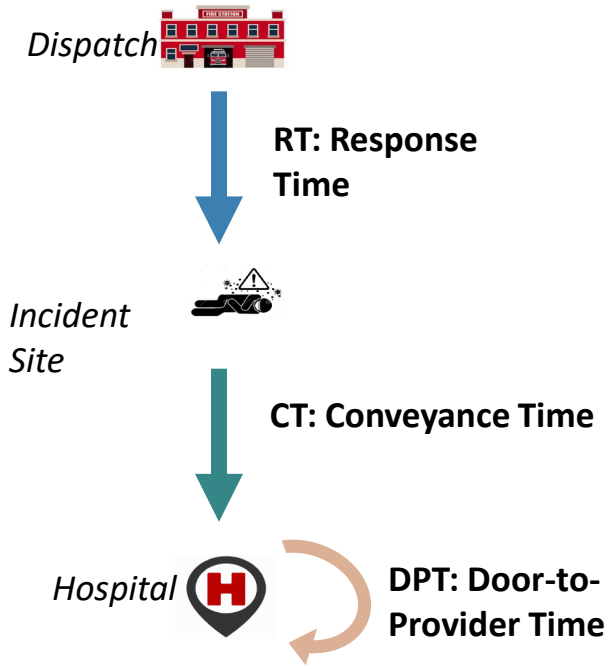
Primary Objective

Assess the impact of adjusting ambulance destinations using load balancing based on ED market share analysis.

Key Goals

- Optimize ambulance turnaround times.
- Enhance patient outcomes through a simulation-approach.

Study Approach



Time Components

This simulation models the total time to attend to an ED case, from dispatch to hospital for evaluation and treatment.

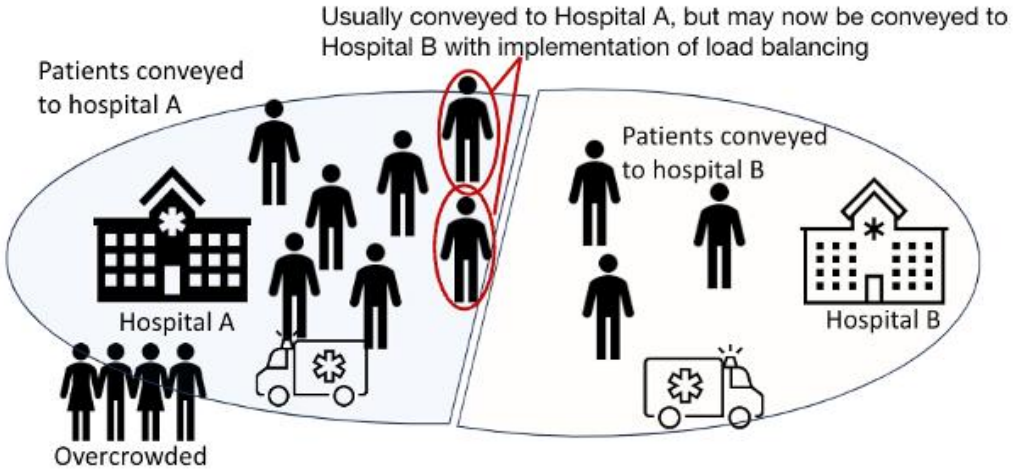
- **RT: Ambulance Response Time** – Time taken to reach the incident site.
- **CT: Conveyance Time** – Time to transport the casualty to the hospital.
- **DPT: Door-to-Provider Time** – Time from arrival at ED until the first contact with a provider (e.g. triage or assessment).

Calculation

- **Total Case Time = RT + CT + DPT**

Simulation Goal

This simulation assesses whether redirecting non-critical patients to less crowded hospitals (e.g., Hospital B) can achieve comparable or reduced total case time compared to the current policy of always routing to the nearest hospital (e.g., Hospital A).



Insights on Response Time (RT) and Conveyance Time (CT)

- **Response Time:**
  - Mean RT remains consistent across years, suggesting stable ambulance deployment efficiency.
- **Conveyance Time:**
  - SGH and SKH have the shortest mean CT (~ 5 min), likely due to proximity to high-density areas.
- **Trend Over Time:**
  - Mean CT has improved steadily from 2010 (10.6 min) to 2020 (6.07 min) reflecting enhanced transportation network and increase in EDs.

Table 1: CT by Site

Site	CT (min)
NTFGH	7.25 (0 - 36.52)
CGH	7.67 (0 - 61.7)
KKH	8.64 (0.1 - 25.85)
KTPH	8.14 (0 - 54.12)
NUH	10.74 (0 - 41.25)
TTSH	8.69 (0.02 - 48.72)
SGH	5.26 (0 - 42.83)
SKH	4.08 (0 - 27.27)

(Mean and Range in Minutes)

Table 2: RT &CT by Year

Year	RT (min)	CT (min)
2010	8.56 (0.5 - 29.28)	10.6 (0.22 - 41.23)
2011	8.54 (0.03 - 27.38)	10.41 (0 - 54.12)
2012	9.02 (0.48 - 40.7)	10.29 (0.12 - 29.93)
2013	9.4 (0.8 - 29.53)	10.69 (0.23 - 41.25)
2014	9.91 (0 - 29.52)	9.61 (0.37 - 39.53)
2015	9.45 (2.08 - 77.45)	9.04 (0.02 - 31.37)
2016	9.01 (1.25 - 28.27)	7.93 (0 - 61.7)
2017	9.52 (1.28 - 61.32)	7.06 (0 - 41.65)
2018	9.05 (1.78 - 93.08)	6.5 (0 - 32.42)
2019	8.65 (1.72 - 80.53)	5.97 (0 - 27.27)
2020	8.88 (1.7 - 27.87)	6.07 (0.02 - 48.72)

Note: Descriptive statistics based on 23,151 cases of OHCA conveyed incidents from 2010 to 2020.

Simulated Conveyance Time (CT)

- **Conveyance Time Simulation:** Travel times to all hospitals can be simulated for each case to assess potential conveyance durations.
- **Travel Time Source:** Travel times were retrieved using the OneMap API, which provides accurate local driving time estimates.
- **Policy Evaluation Component:** Simulated CT highlights the trade-offs in Total Case Time when redirecting patients to alternate hospitals.

Example: Simulated travel times (in minutes) from a single case location to various hospitals

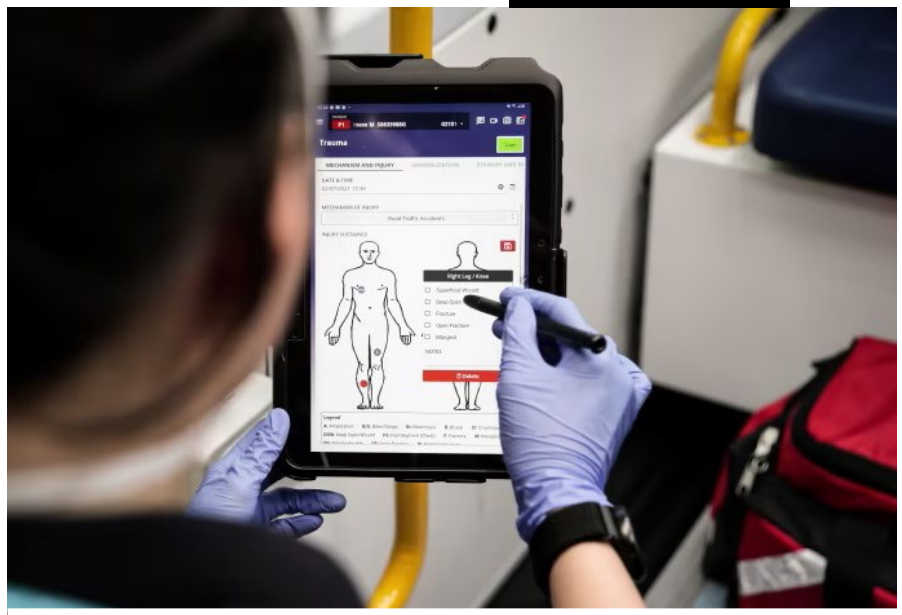
Case No	Postal	Driving Time (Min)									
		AH	CGH	KKH	KTPH	NTFGH	NUH	SGH	SKH	TTSH	WH
SGSIN0130073	650117	19.6	36.3	25.9	35.5	6.1	18.0	24.2	39.1	24.4	27.9

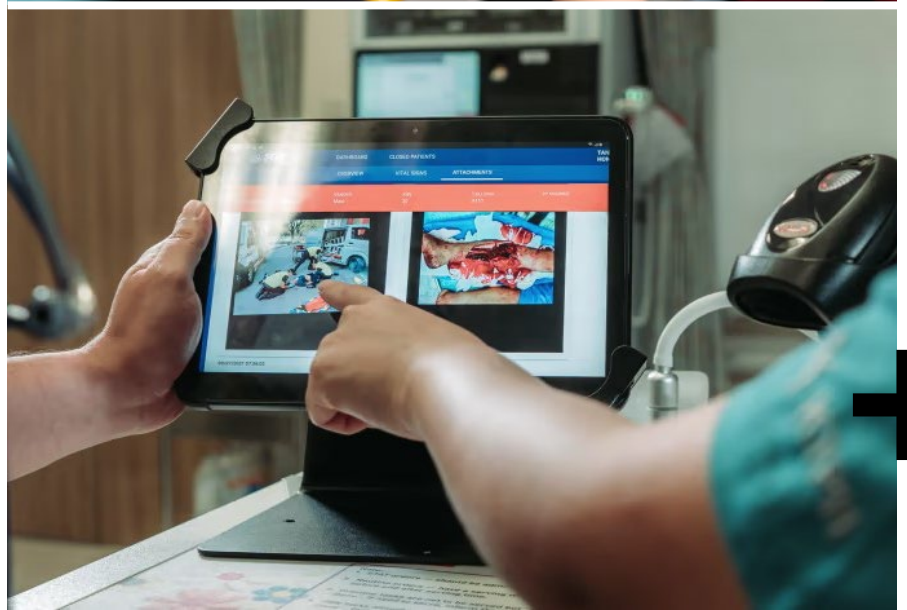
Closest ED

Furthest ED

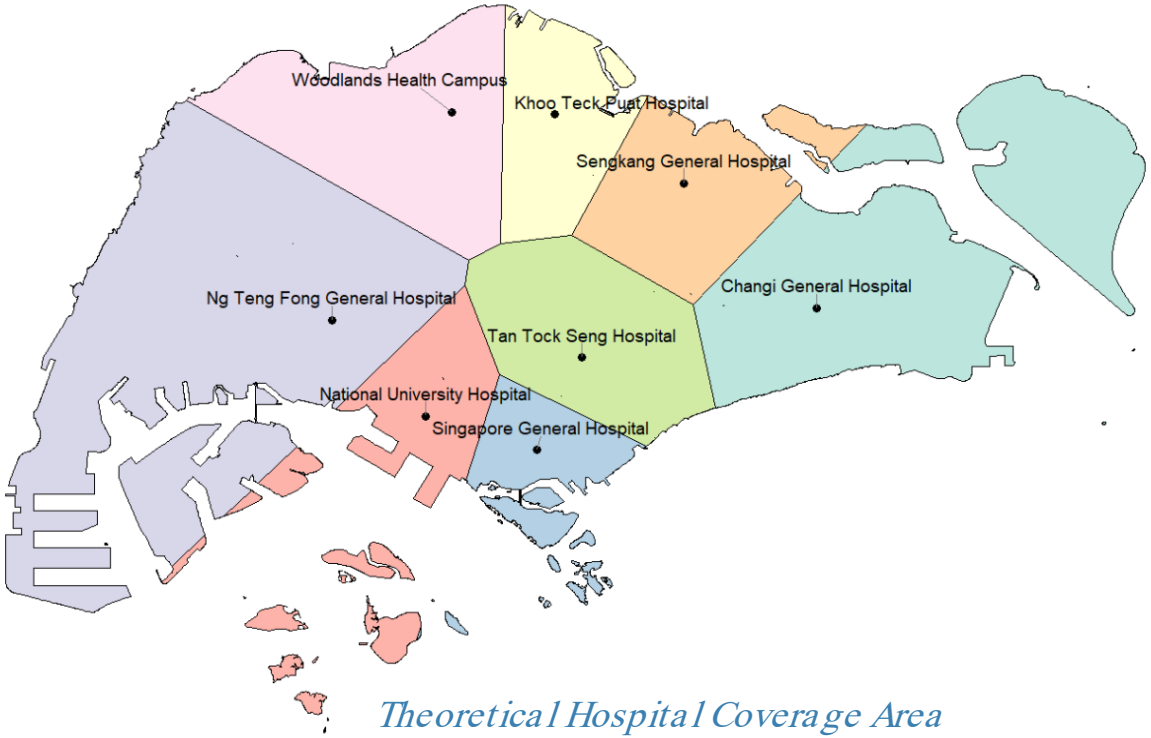
Door-to-Provider Time (DPT)

- DPT reflects ED efficiency, with high values indicating potential delays in initial care due to overcrowding.
- Historical DPT will be derived from **Operational Medical Networks Informatics Integrator (OMNII)** system.
- Based on one-year ambulance ED cases to **simulate workload imbalance** across the ED.

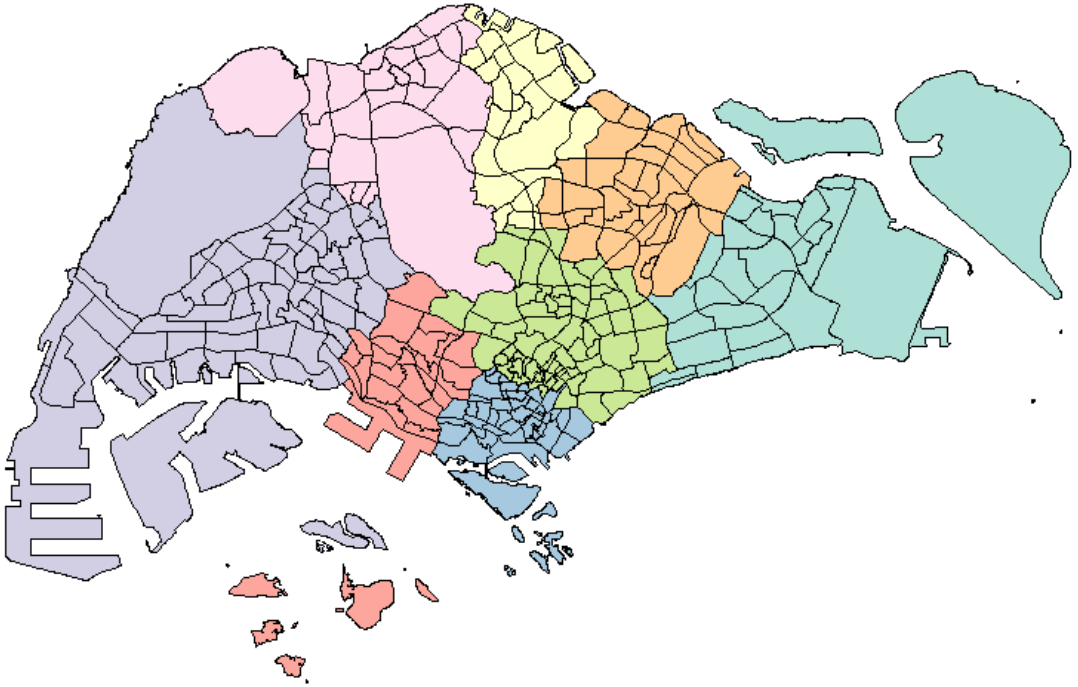




Identifying Operational Zones for Case Time Analysis



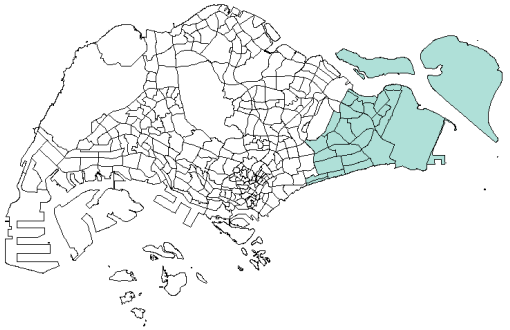
Theoretical Hospital Coverage Area
(tessellation based on purely geography and distance)



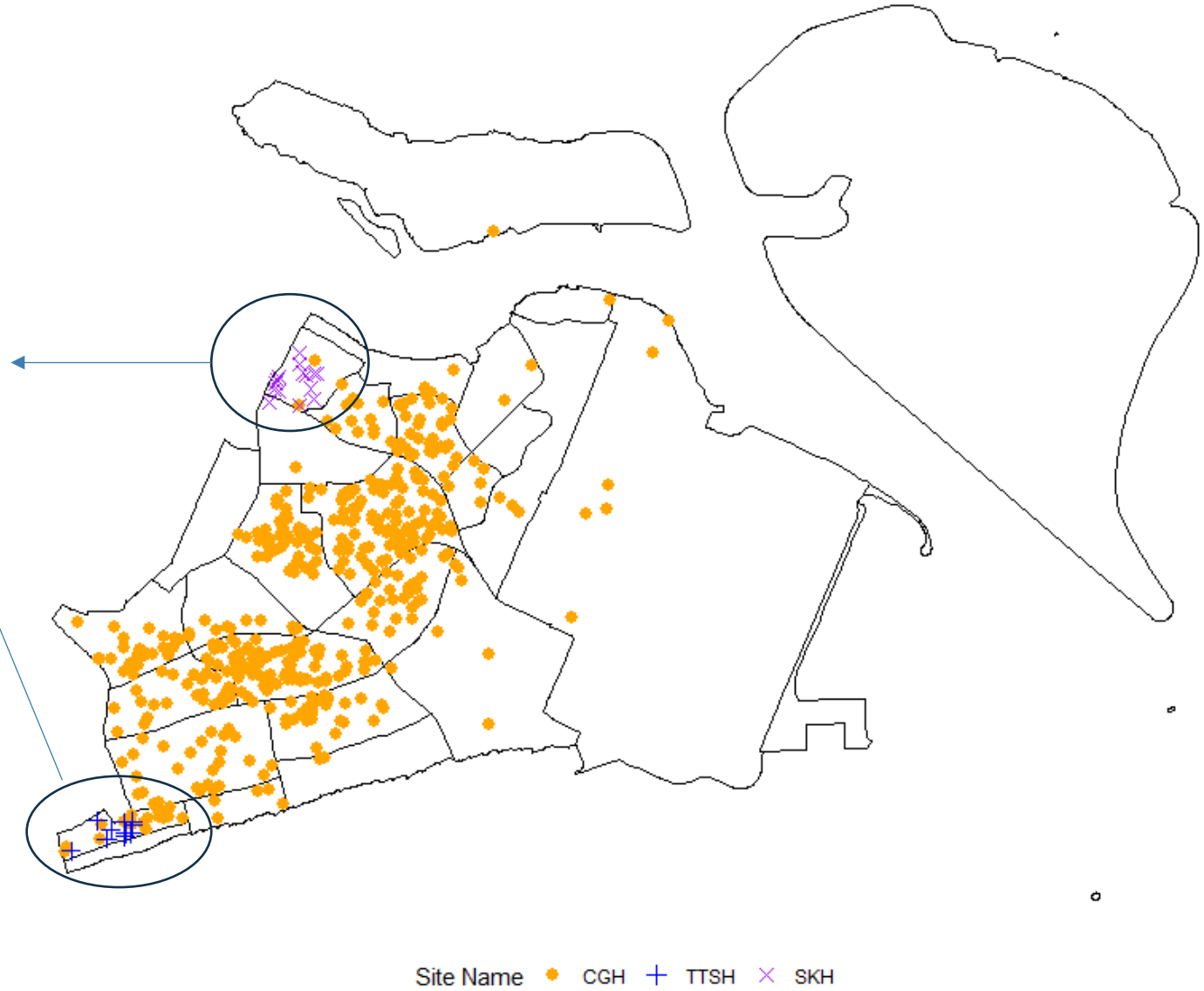
Subzones for Policy Implementation

- Singapore is divided into 332 subzones (URA), we assigned each to a specific hospital based on its geographical location (via Voronoi polygons through nearest neighbor analysis).
- The current actual coverage by each hospital can be larger/smaller than this illustrated zoning.
- This operational zoning approach simplifies the management of ambulance re-directions.
- Objective: Streamline decision-making by focusing on subzones instead of individual cases, ensuring a balanced workload across hospital.

CGH Theoretical Zone Coverage

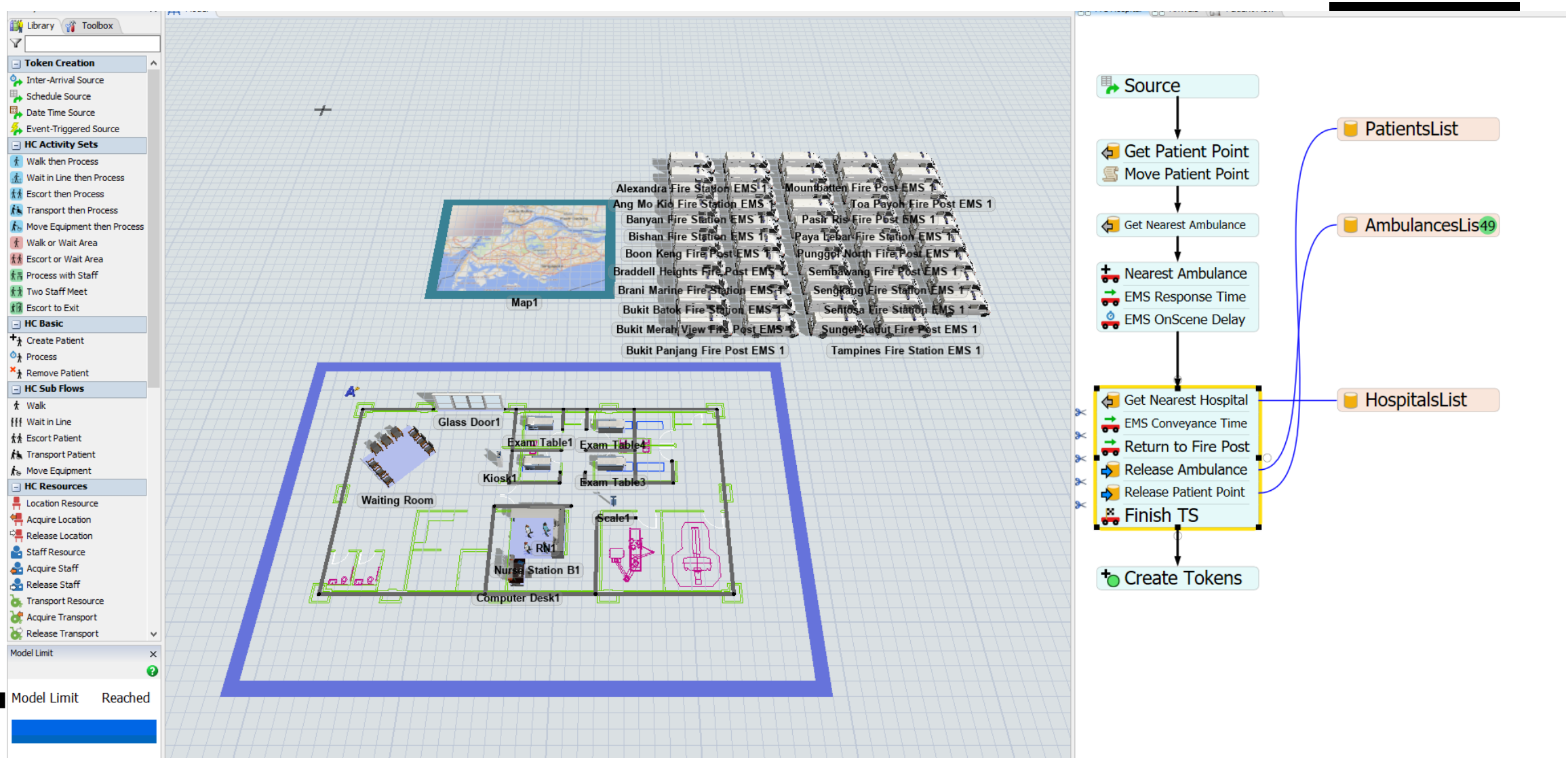


Determine if existing border/ overlapping zones can be assigned to another hospital based on Total Case Time (RT + CT + DPT). Essentially trying to identify potential cases that can benefit from re-direction to another hospital.



Note: Location base on ambulance conveyed OHCA cases in 2019.

FlexSim Platform



Example of another Flex Sim project

SingHealth RESEARCH | Health Services Research Centre

Optimising Transport Policies to Specialised Cardiac Arrest Centers using Discrete Event Simulation

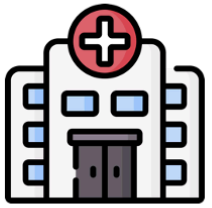
Data

SingHealth RESEARCH | Health Services Research Centre

1. List of **postal codes** in Singapore from 00000 to 999999
   a. Serve as sample space for potential OHCA

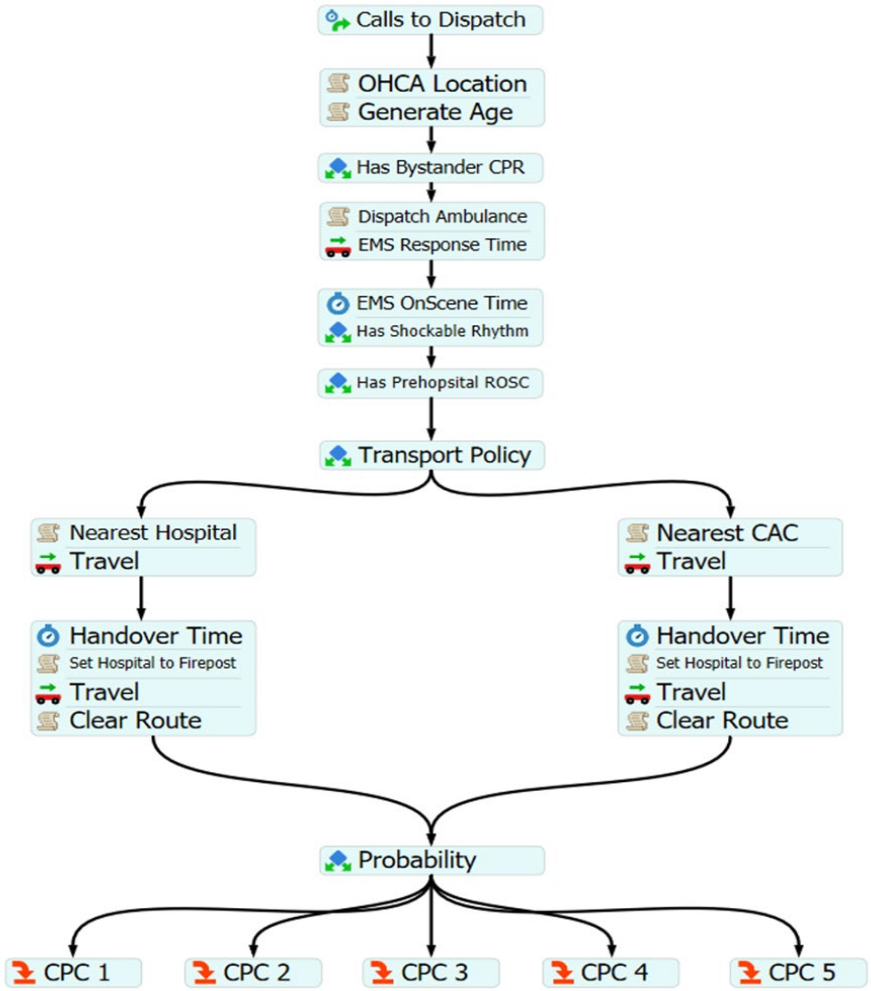
1. Location of **fire posts and fire stations**
   a. EMS ambulance will be stationed here

1. Location of **hospitals**
   a. 3 CACs and 4 non-CACs



1. Pan-Asian Resuscitation Outcomes Study **(PAROS)** 2010 to 2020
   a. Retrospective data on OHCA patients

Discrete Event Simulation Model

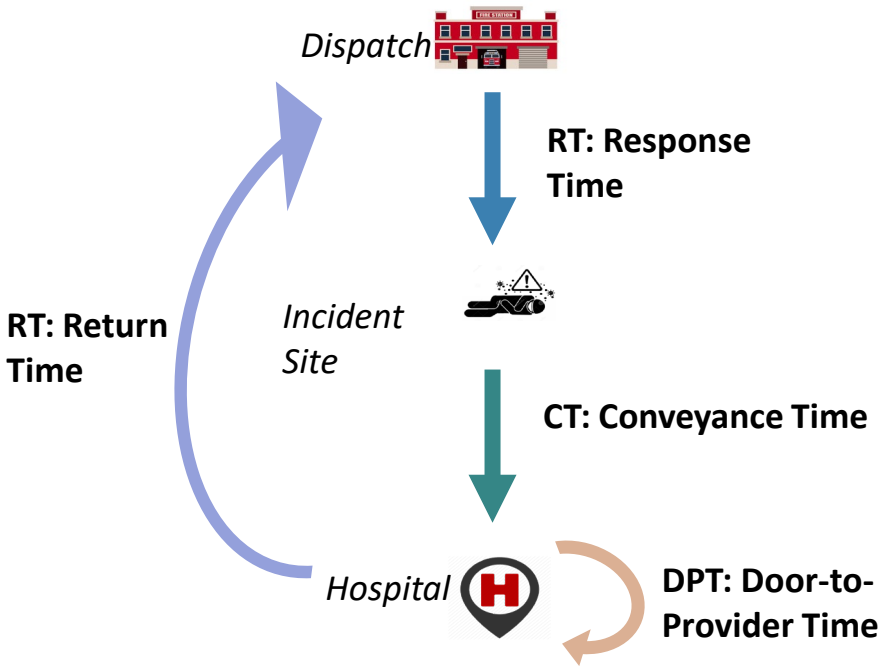


Model Logic

1. Choose random OHCA location
2. Generate Utstein variables
3. Dispatch ambulance from nearest fire post
4. Travel to patient
5. Perform OnScene treatment
6. Decide CAC or non-CAC
7. Travel to hospital
8. Handover patient to hospital
9. Return to fire post
10. Patient final CPC score

Next Steps

- **Data Acquisition**
  - Collaborating with SCDF & MOH to access historical data for simulation model validation.
- **Assess Impact on Ambulance Return Time**
  - Evaluate how sending ambulances to slightly further hospitals impact return times and subsequent deployments.
- **Establish ED Workload Metrics**
  - Determine if there are other metrics or models to understand the ED workload
- **Address Confounders**
  - Time of day; traffic condition; weather condition
  - Severity of patient condition



Thank you!