International Seminar on Geospatial Modelling and Operations Research in Emergencies

Prof Marcus Ong

Senior Consultant, Clinician Scientist, Singapore General Hospital

Vice Chair of Research, Emergency Medicine Academic Clinical Program

Professor, Director Health Services and Systems Research, Duke-NUS Medical School

Director Health Services Research Institute

Director Health Services Research Center, Singhealth

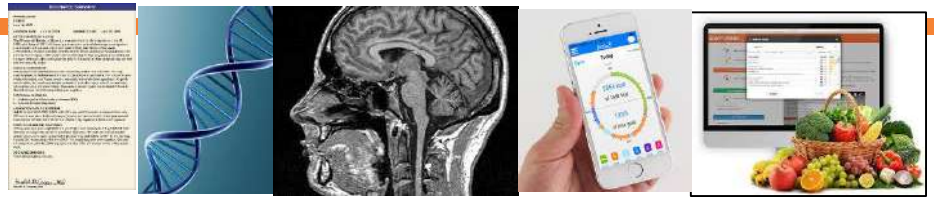
Senior Consultant, Ministry of Health

Director, Unit for Prehospital Emergency Care

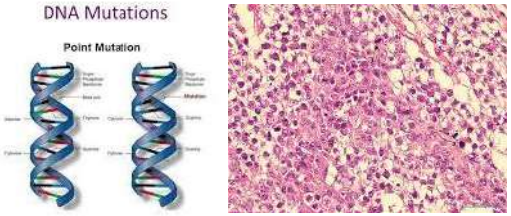
care
education
research

Data is the New Oil of Healthcare and Biomedicine

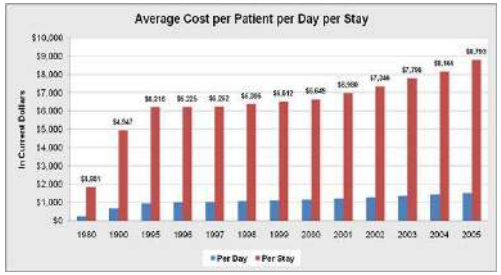
Data Generation



Harnessing and Using the Data



Disease and Biological Insights



Improve Hospital Efficiencies and Processes

New Tools for Healthcare

Improve Patient Outcomes and Experiences

Lower Healthcare Costs

SingHealth DukeNUS ACADEMIC MEDICAL CENTRE

Geographic Data?...

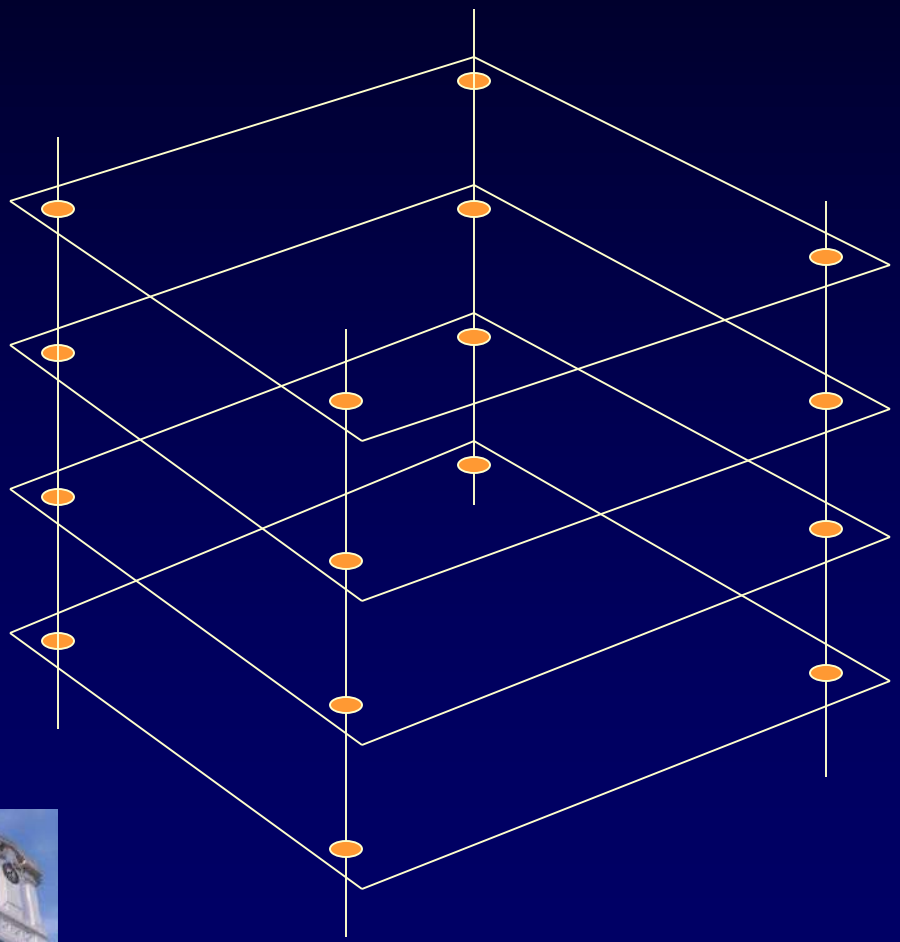
- "Geographic data" are spatial data that result from observation and measurement of earth phenomena referenced to their locations on the earth's surface.

- Examples of reference locations: longitude/latitude, street address, G-pins, census tracts, city/county/state borders, zip codes, known neighborhoods, polygons…

What is GIS?…

- **GIS** = ***G****eographical* ***I****nformation* ***S****ystems*
- Computer-based systems for the integration and analysis of geographic data.
- May be several usages of the term “GIS”
  - As a technology (GPS, etc.)
  - As a research field
  - As a “community”

In GIS, Data Layers (or themes)…



- Can be overlapped using a common geographic reference system.
- There is almost no limit to the number and type of layers (themes) which can be spatially represented on maps with data from underlying databases.
- Interesting items can be lead the observer to open the underlying database—even editing the databases if necessary while still in the GIS program.

Examples of Data Themes/Layers

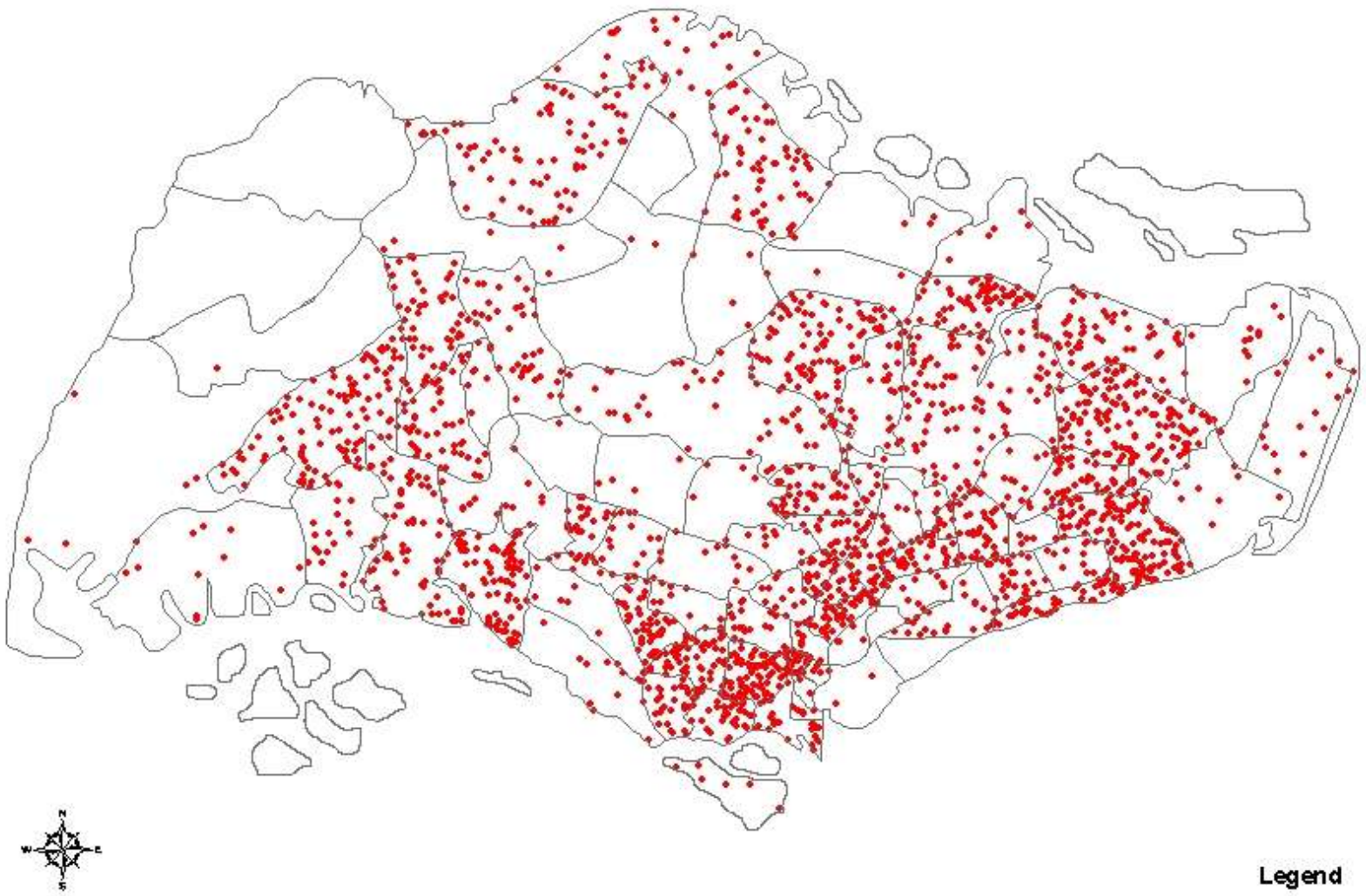
- Streets, alleys
- Lakes, rivers
- City limits, zones
- Railroads
- Parcels of land
- Building footprints
- Events (EMS runs)
- Hospitals, clinics
- Fire, EMS, PD stations

- Demographics
- Elevation, land use
- Crime statistics
- Census tracts. blocks, block groups
- Sets of data by graduated color and symbols, unique values, labels, etc.
- Utilities (pipes, lines, cable, zoning, etc.)

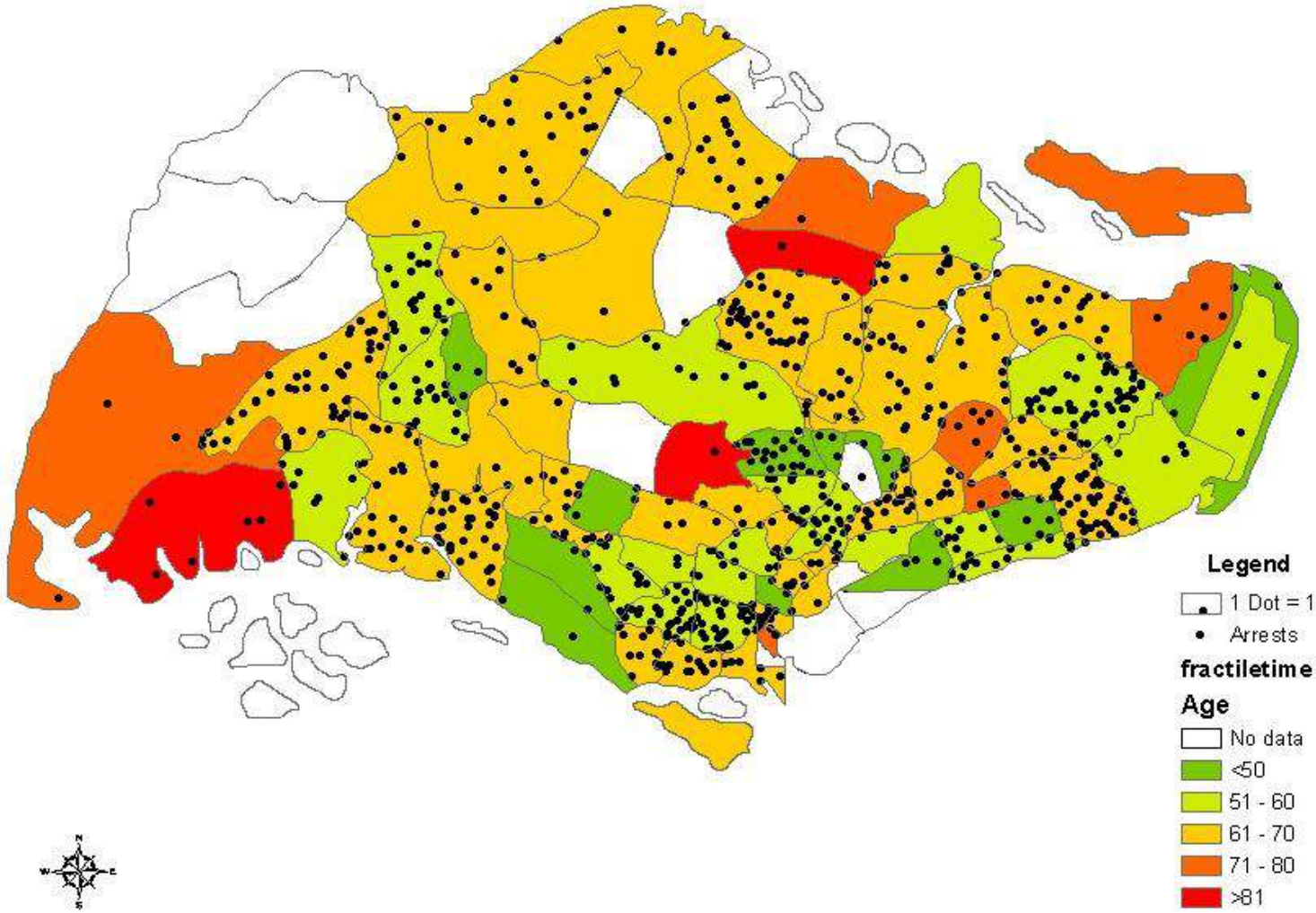
What Advantage Does GIS Offer?

- Visualization—the human eye…
- Somehow it is easier to discern patterns by looking at spatial representations (maps) and graphs rather than columns of figures in tables.
- Large amounts of data can be represented at one time, and in a variety of contexts.

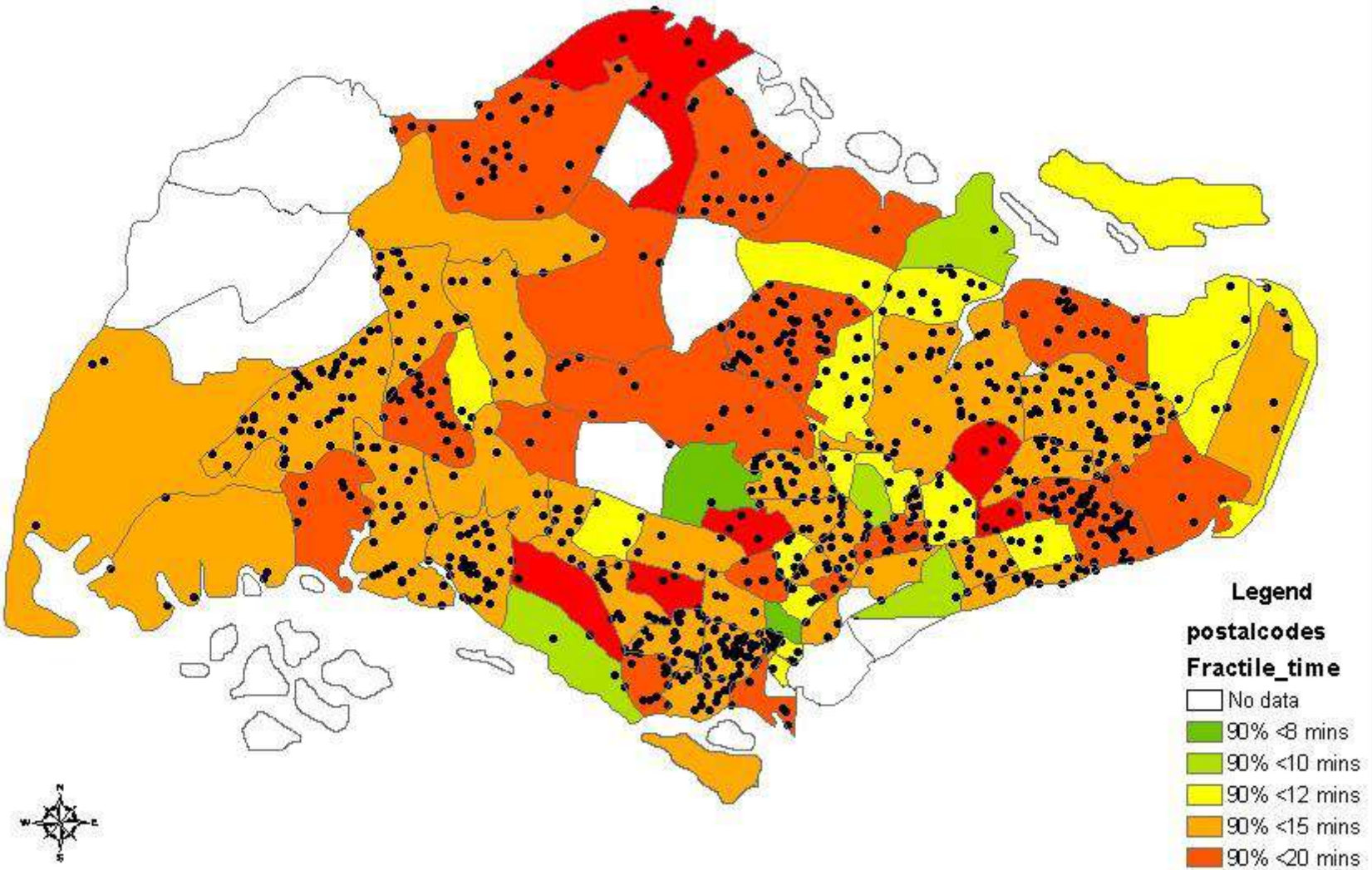
Geographical distribution of cardiac arrests



Mean age of cardiac arrest by geography



Fractile response times for cardiac arrest



Spatial Variation and Geographic-Demographic Determinants of Out-of-Hospital Cardiac Arrests in the City-State of Singapore

Marcus Eng Hock Ong, MBBS (S'pore), FRCS Ed (A&E), MPH, Arul Earnest, MSc, PhD, Nur Shahidah, Wen Min Ng, BSc (Hons) Statistics, Chuanyang Foo, BSc (Hons) Statistics, David John Nott, PhD

From the Department of Emergency Medicine, Singapore General Hospital, Singapore (Ong, Shahidah); the Clinical Research Unit, Tan Tock Seng Hospital, Center of Quantitative Biology & Medicine, Duke-NUS Graduate Medical School, Singapore (Earnest); and the Department of Statistics and Applied Probability, National University of Singapore, Singapore (Ng, Foo, Nott).

Study objective: Our primary objective is to calculate the relative risk of cardiac arrests at the development guide plan (DGP) (equivalent to census tract) level in a city-state, Singapore, and examine its relationship with key area-level population characteristics.

Methods: This was an observational ecological study design. We calculated the relative risk as the ratio of the observed and population standardized expected counts of out-of-hospital cardiac arrests in Singapore, aggregated at DGP level. Data were collected from October 2001 to October 2004. We used conditional autoregressive spatial models to examine the predictors of increased risk at the DGP level.

Results: We found a spatial distribution of cardiac arrests, with an unexpected cluster caused by nonresident arrests occurring at the international airport. The risk of out-of-hospital cardiac arrest more than doubled, 2.35 (95% confidence interval [CI] 1.28 to 4.48), for each 5-point increase in the proportion of people aged 65 years and older. For each 5-point increase in the proportion of Chinese individuals living in a DGP, the risk of out-of-hospital cardiac arrest was reduced by a factor of 0.8 (95% CI 0.7 to 0.9). The risk of out-of-hospital cardiac arrest increased by 1.49-fold (95% CI 1.18 to 1.82) for every 5-point increase in the proportion of households with no family nucleus (live alone). When restricted to residential cases of out-of-hospital cardiac arrest, none of the variables remained significant, possibly because of small sample size.

Conclusion: The risk of cardiac arrests could be related to the age and racial and family structure of DGPs in Singapore. This article models how such data can help to direct public health education, cardiopulmonary resuscitation training, and public access defibrillation programs in other health systems. [Ann Emerg Med. 2011;xx:xxx.]

Please see page XX for the Editor's Capsule Summary of this article.

0196-0644/$-see front matter

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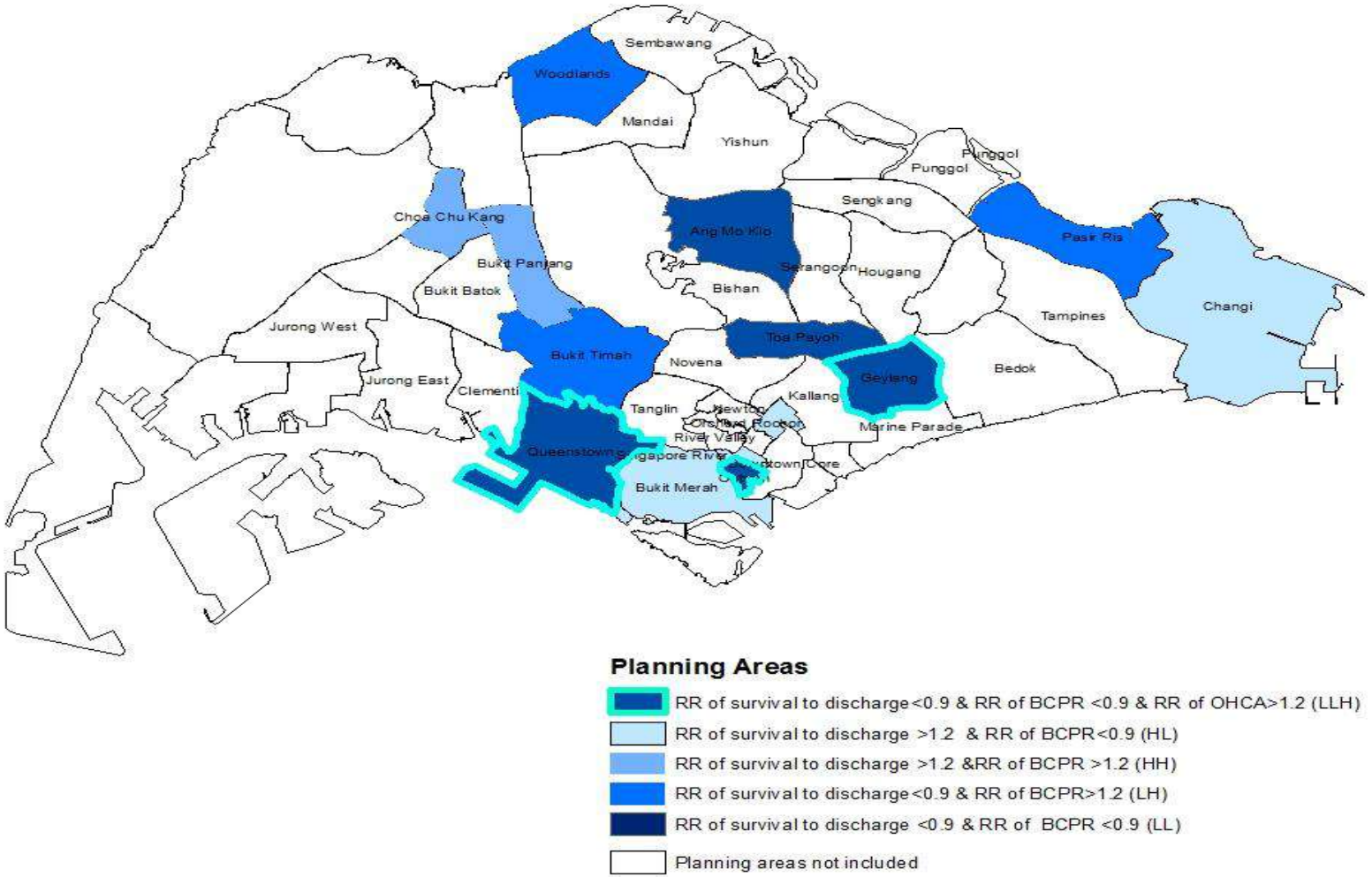
Clinical Paper

Geographic factors are associated with increased risk for out-of hospital cardiac arrests and provision of bystander cardio-pulmonary resuscitation in Singapore☆

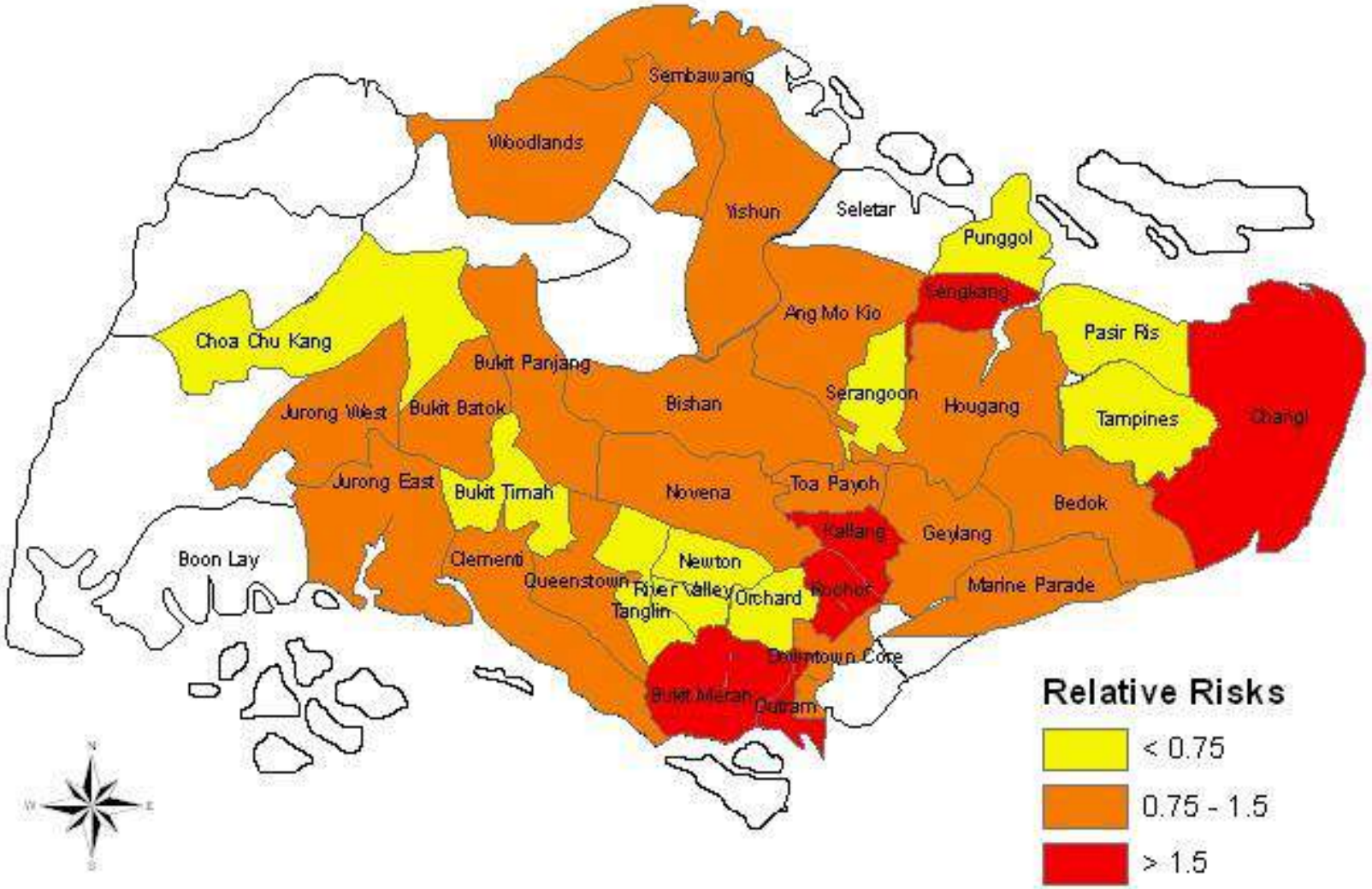
Marcus Eng Hock Ong[a,*], Win Wah[b], Li Yang Hsu[b], Yih Ying Ng[c], Benjamin Siew Hon Leong[d], E. Shaun Goh[e], Han Nee Gan[f], Lai Peng Tham[g], Rabind Antony Charles[h], David Chee Guan Foo[i], Arul Earnest[j]

[a] Department of Emergency Medicine, Singapore General Hospital, Singapore Office of Clinical Sciences, Duke-NUS Graduate Medical School, Singapore
[b] Centre for Infectious Disease Epidemiology and Research, Saw Swee Hock School of Public Health, National University of Singapore, Singapore
[c] Medical Department, Singapore Civil Defence Force, Singapore
[d] Emergency Medicine Department, National University Hospital, Singapore
[e] Department of Emergency Medicine, Khoo Teck Puat Hospital, Singapore
[f] Accident and Emergency Department, Changi General Hospital, Singapore
[g] Department of Emergency Medicine, KK Women's and Children's Hospital, Singapore
[h] Emergency Medicine Department, Alexandra Hospital, Singapore
[i] Department of Cardiology, Tan Tock Seng Hospital, Singapore
[j] Centre for Quantitative Medicine, Office of Clinical Sciences, Duke-NUS Graduate Medical School, Singapore

Geographic factors and OHCA survival



GEOGRAPHICAL VARIATION IN AMBULANCE CALLS IN SINGAPORE IS EXPLAINED BY SOCIO-ECONOMIC STATUS

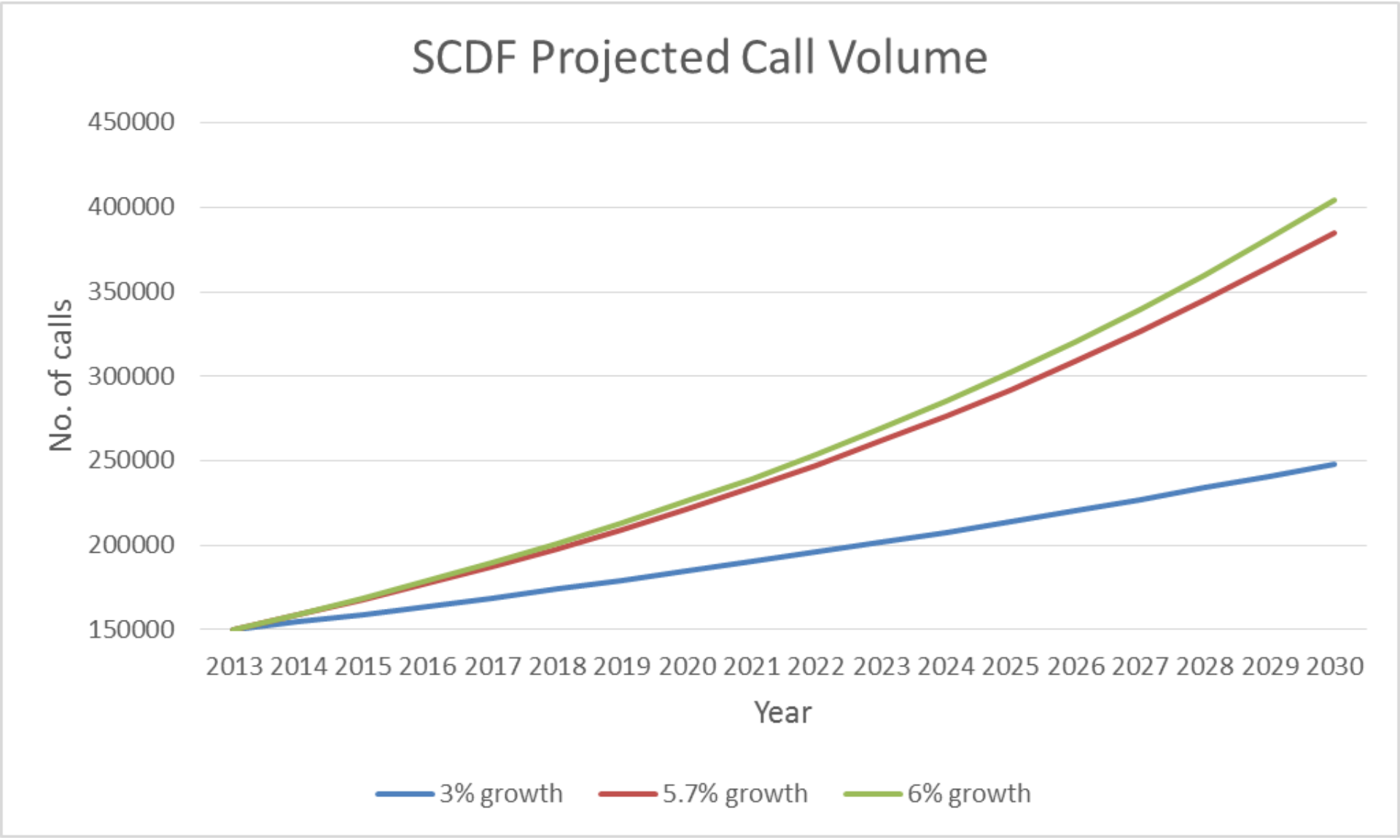


What is Operations Research?

- **Operations Research, or Operational Research (OR), is a discipline that deals with the application of advanced analytical methods to help better decisions**
- **‘management science’, ‘decision science’**

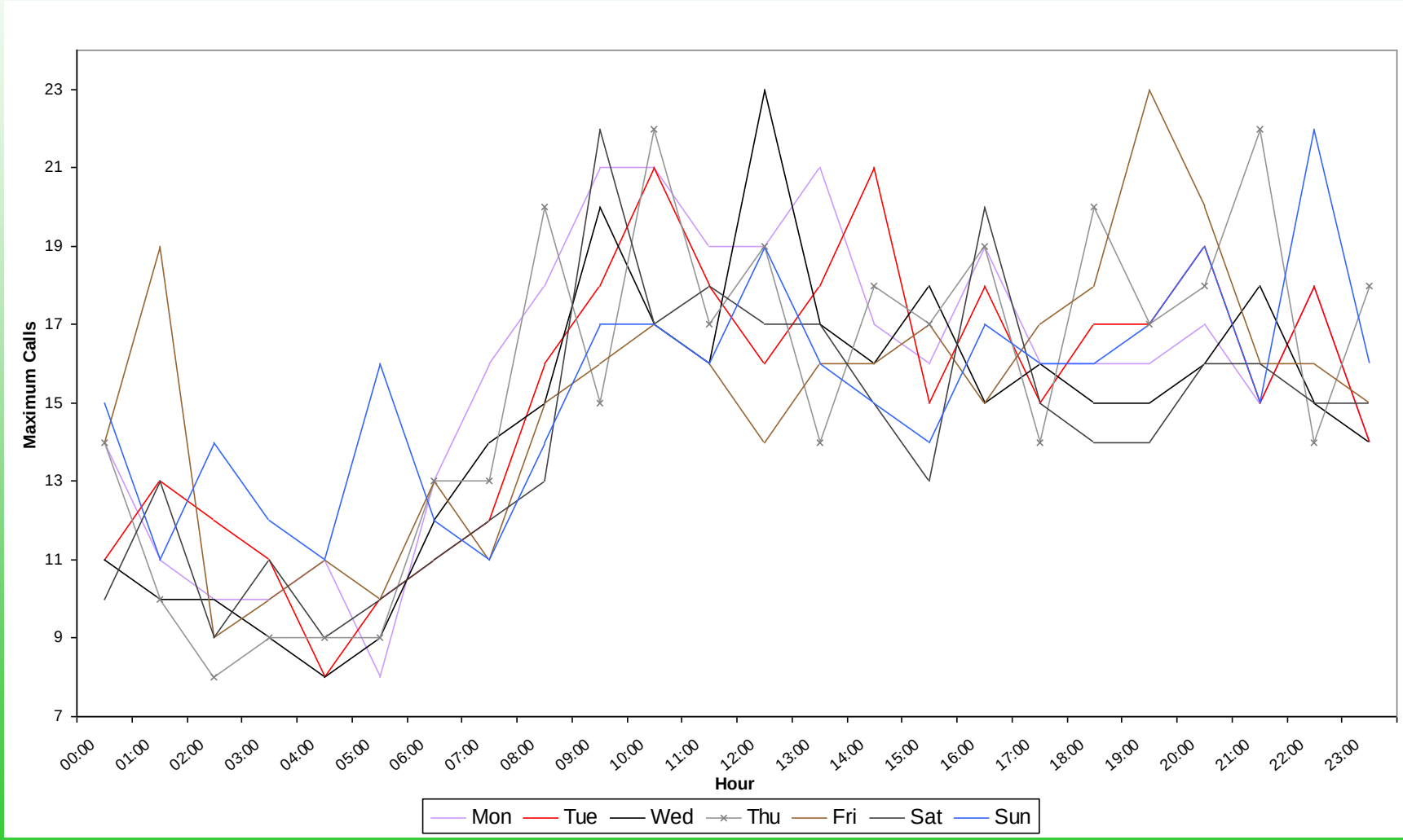
What is Operations Research?

- Simulation
- Mathematical optimization
- Queueing theory
- Stochastic-process models
- Markov decision processes
- Econometric methods
- Data envelopment analysis
- Neural networks
- Expert systems
- Decision analysis
- Analytic hierarchy process

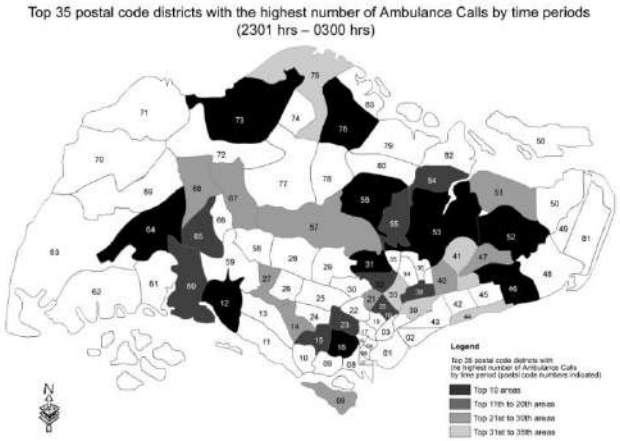


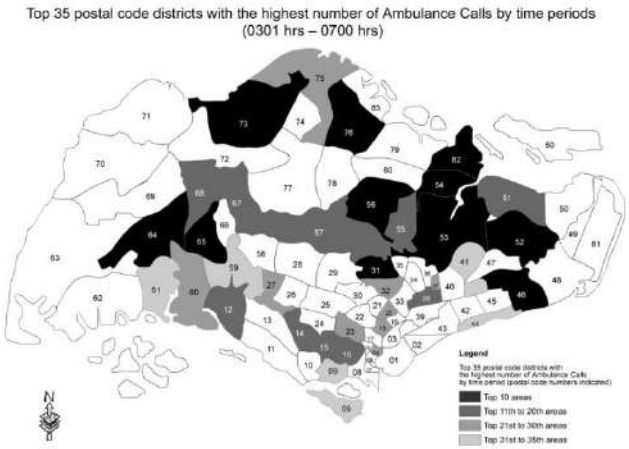
Factoring for aging population- 10% elderly (Age >65 years) accounted for 35% of usage in 2011

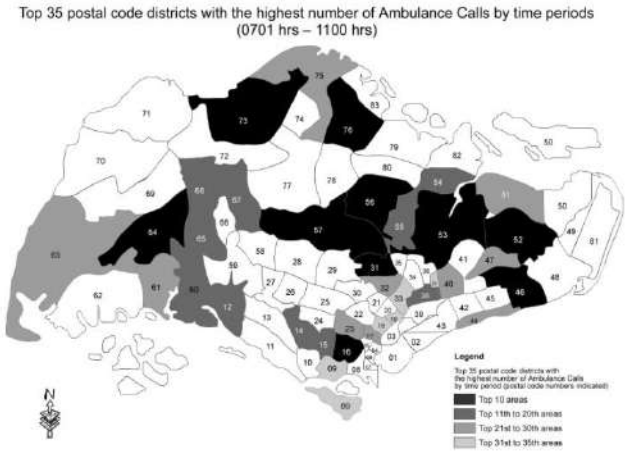
Distribution of ambulance calls by hour of the day

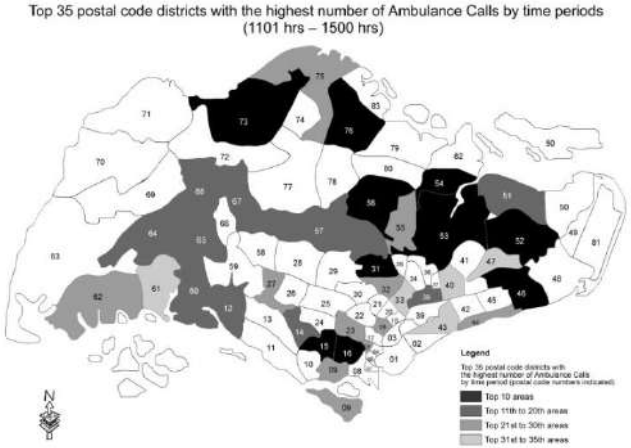


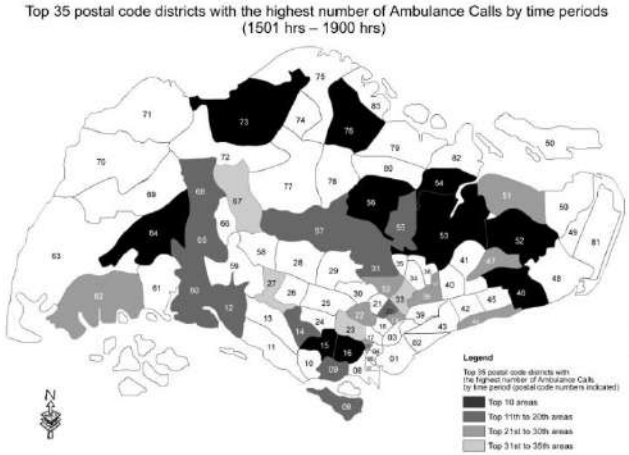
Top 35 postal code districts with the highest number of Ambulance Calls by time periods

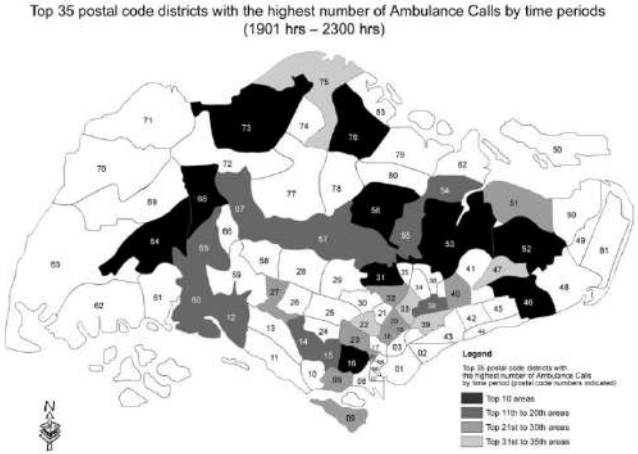










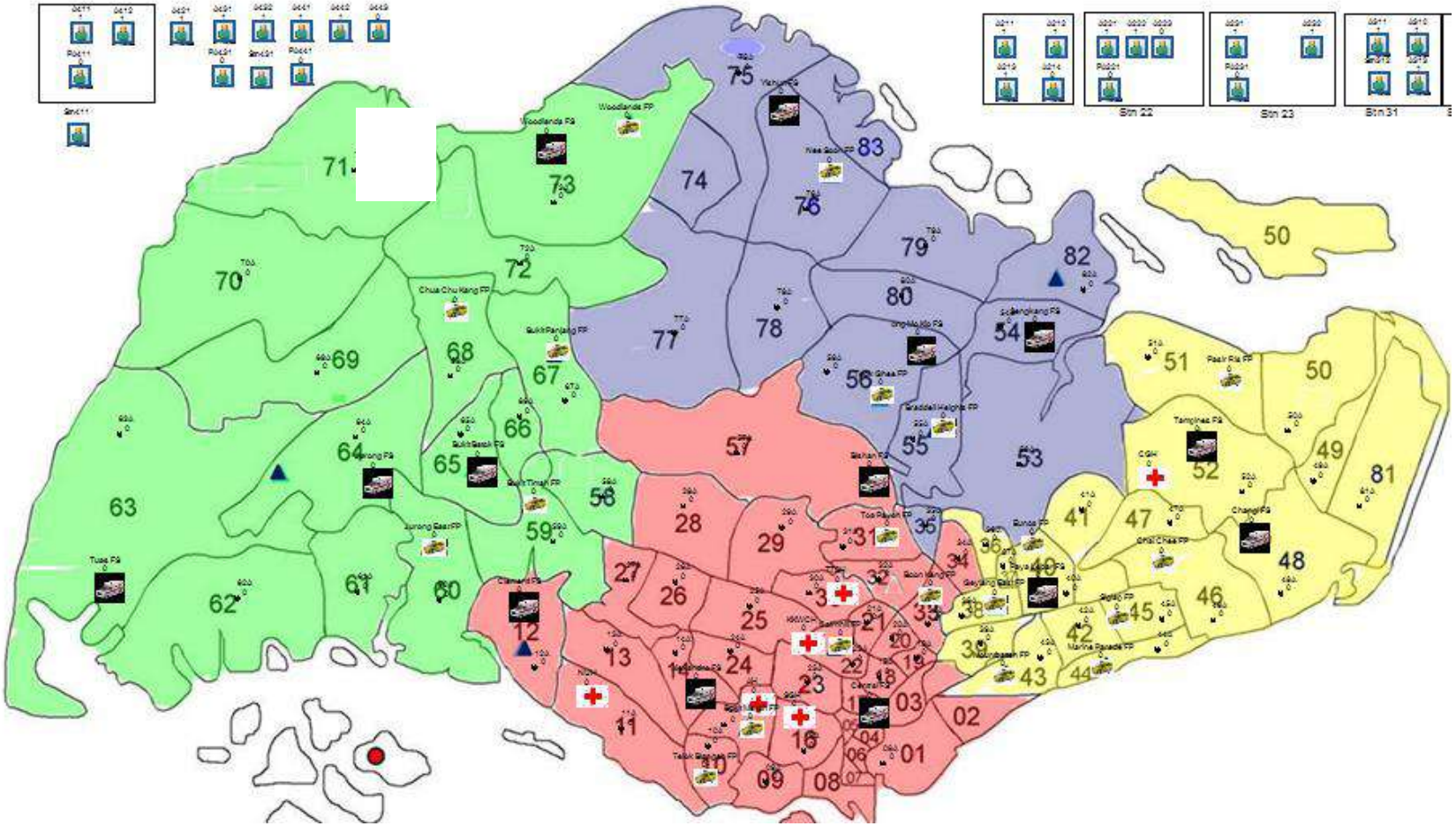


Reducing Ambulance Response Times Using Geospatial–Time Analysis of Ambulance Deployment

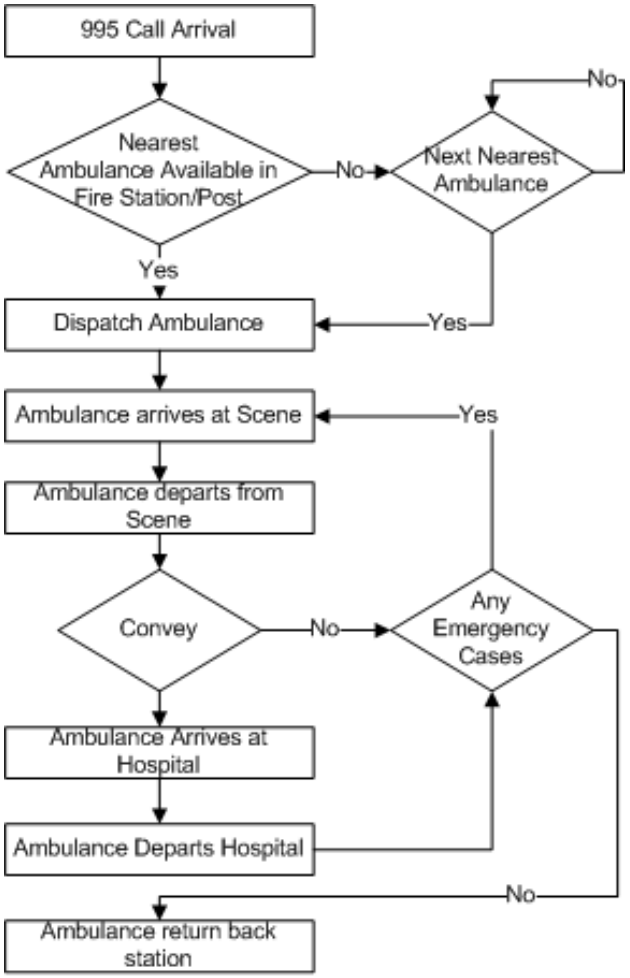
Marcus Eng Hock Ong, MBBS (S'pore), MPH, Tut Fu Chiam, MBBS (S'pore), MMed, Faith Suan Peng Ng, MApp Stat, Papia Sultana, PhD, Swee Han Lim, MBBS (S'pore), FRCS Ed (A&E), Benjamin Sieu-Hon Leong, MBBS (S'pore), MRCS Ed (A&E), Victor Yeok Kein Ong, MBBS (S'pore), FRCS Ed (A&E), Elaine Ching Ching Tan, MBBS (S'pore), MRCS Ed (A&E), Lai Peng Tham, MBBS (S'pore), MMed, Susan Yap, RN, and V. Anantharaman, MBBS (S'pore), FRCS Ed (A&E), on behalf of the Cardiac Arrest Resuscitation Epidemiology (CARE) Study Group:

ACADEMIC EMERGENCY MEDICINE 2010; 17:951–957 . 2010 by the Society for Academic Emergency Medicine

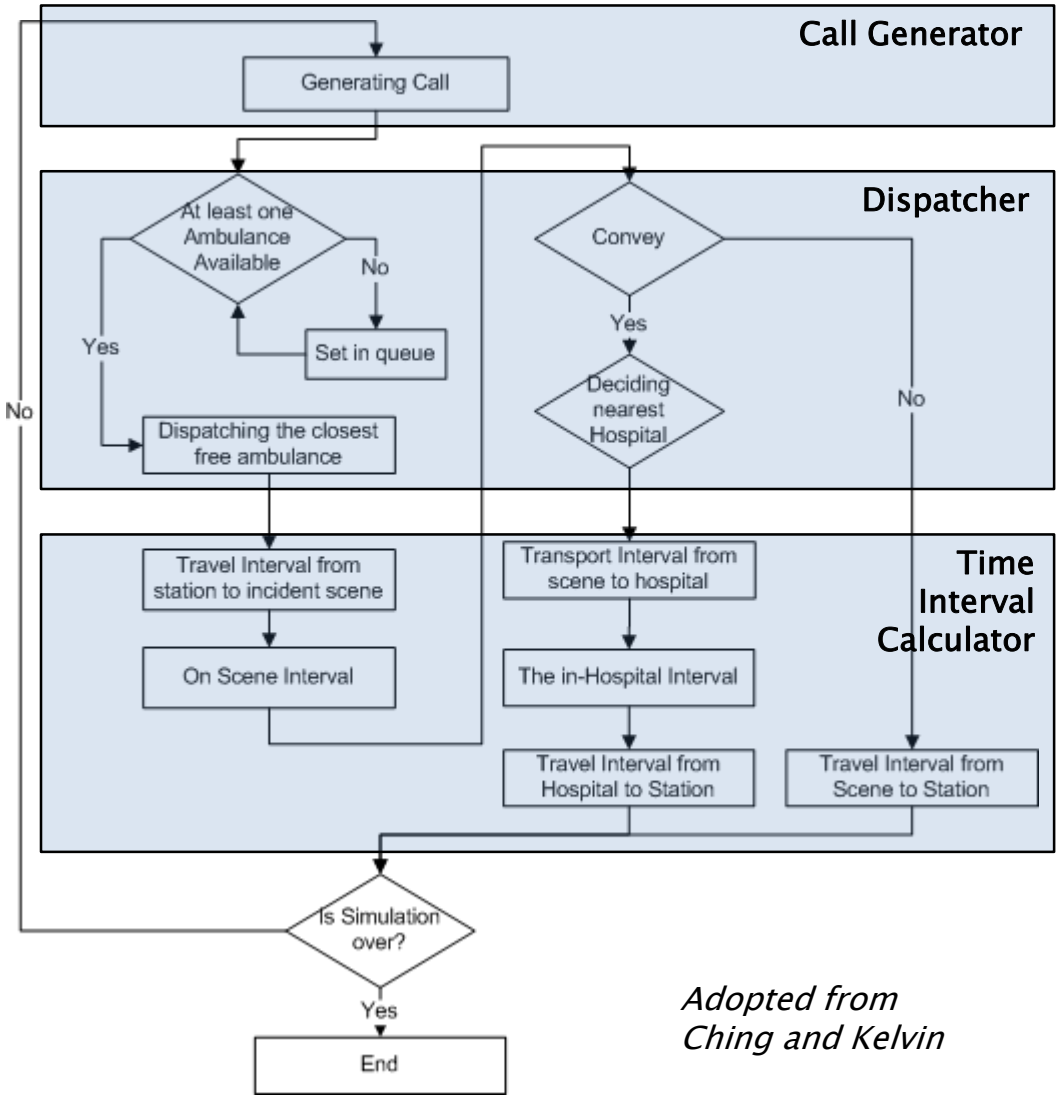
Ambulance Discrete Events Simulation



Singapore EMS Process

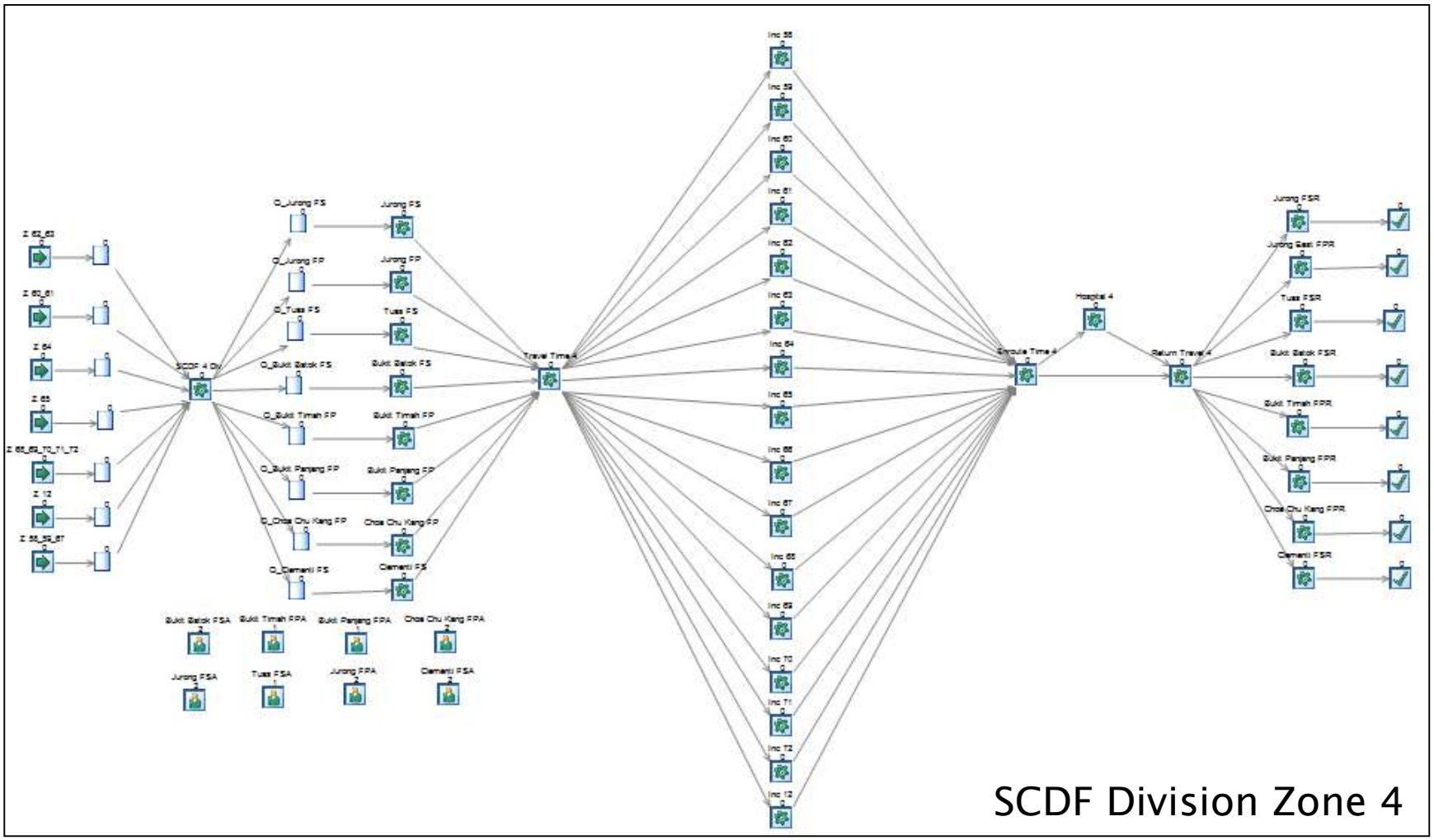


Simulation Process



Adopted from Ching and Kelvin

Simulation Model



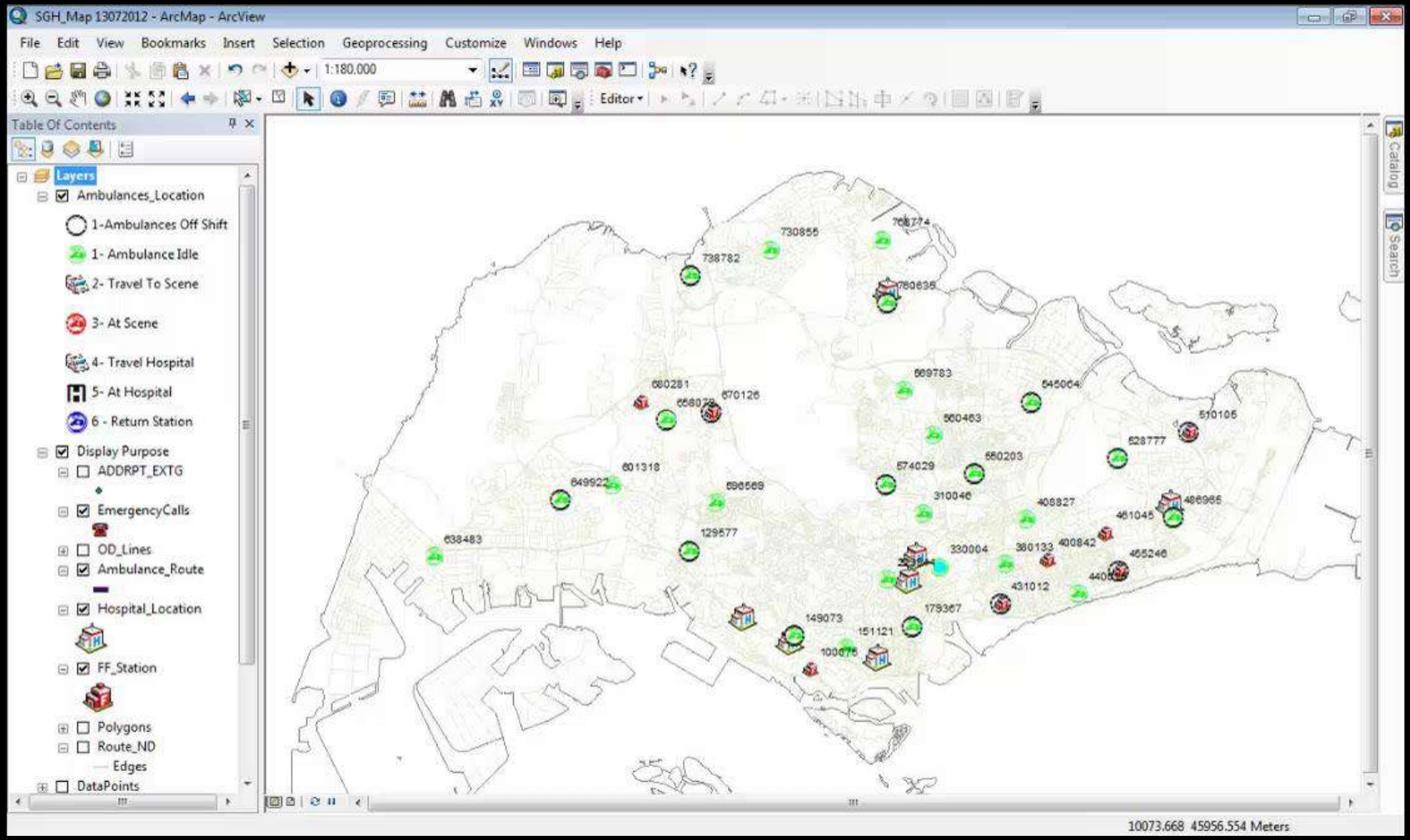

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Table Of Contents
Layers
Ambulances_Location
1-Ambulances Off Shift
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2- Travel To Scene
3- At Scene
4- Travel Hospital
5- At Hospital
6 - Return Station
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ADDRPT_EXTG
EmergencyCalls
OD_Lines
Ambulance_Route
Hospital_Location
FF_Station
Polygons
Route_ND
Edges
DataPoints
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680281
658078
670126
669783
645004
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The CARE Study

Singapore General Hospital
SingHealth

Cardiac Arrest & Resuscitation Epidemiology (CARE) in Singapore: Comparison of Outcomes with Implementation of System Status Plan

Marcus Ong[1], Poon Beng Hoong[2], David Matchar[3], Wang Qinan[4], Zhang Zhong Cheng[1], Oh Hong Choon[5]

[1]Singapore General Hospital
[2]Singapore Civil Defence Force
[3]Duke-NUS Graduate Medical School
[4]Nanyang Technological University
[5]Singapore Health Services Pte Ltd

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7 JUNE 2011

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PATIENTS. AT THE HEART OF ALL WE DO.

Members of the SingHealth Group

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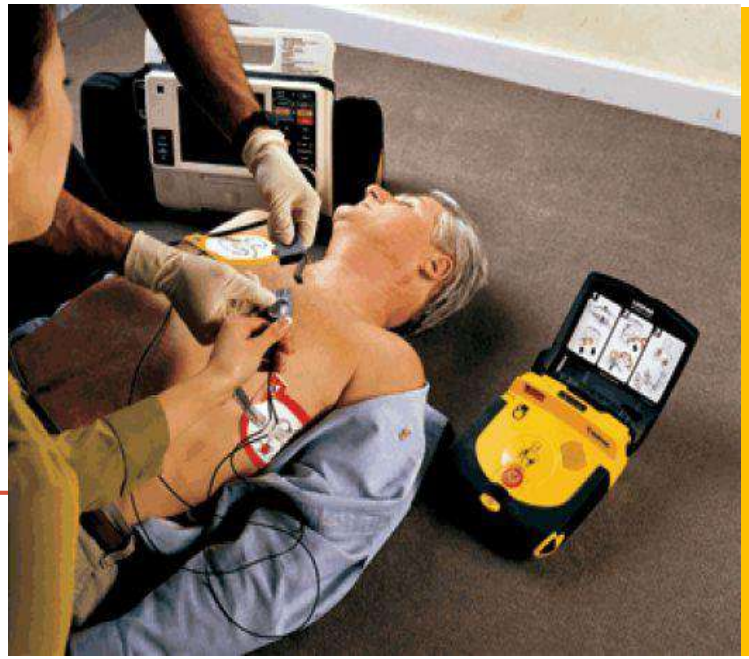
What is the Optimum Number of Emergency Ambulances Needed in Singapore? A Discrete Events Simulation Modeling Study

Zhang Zhong Cheng
Supervisors
A/Prof Huang Boray
A/Prof Marcus Ong



IT'S ABOUT UNDERSTANDING AND IMPROVING THE SYSTEM!

The problem of response times in Out of Hospital Cardiac Arrest

This is the power of crowdsourcing!

https://medium.com/invisible-balloons/uber-911-5d28d7428de6

The SCDF myResponder App

1

Dial 995 and send your geo-location at the same time

myResponder

SCDF

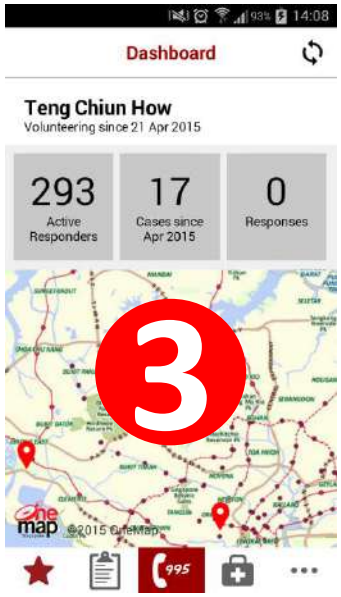
The Life Saving Force

2

Know where the nearest AED is located

ANDROID APP ON Google play

Available on the App Store



3

Sign up as a volunteer responder

UNIT FOR PRE-HOSPITAL EMERGENCY CARE
UPEC
SINGAPORE

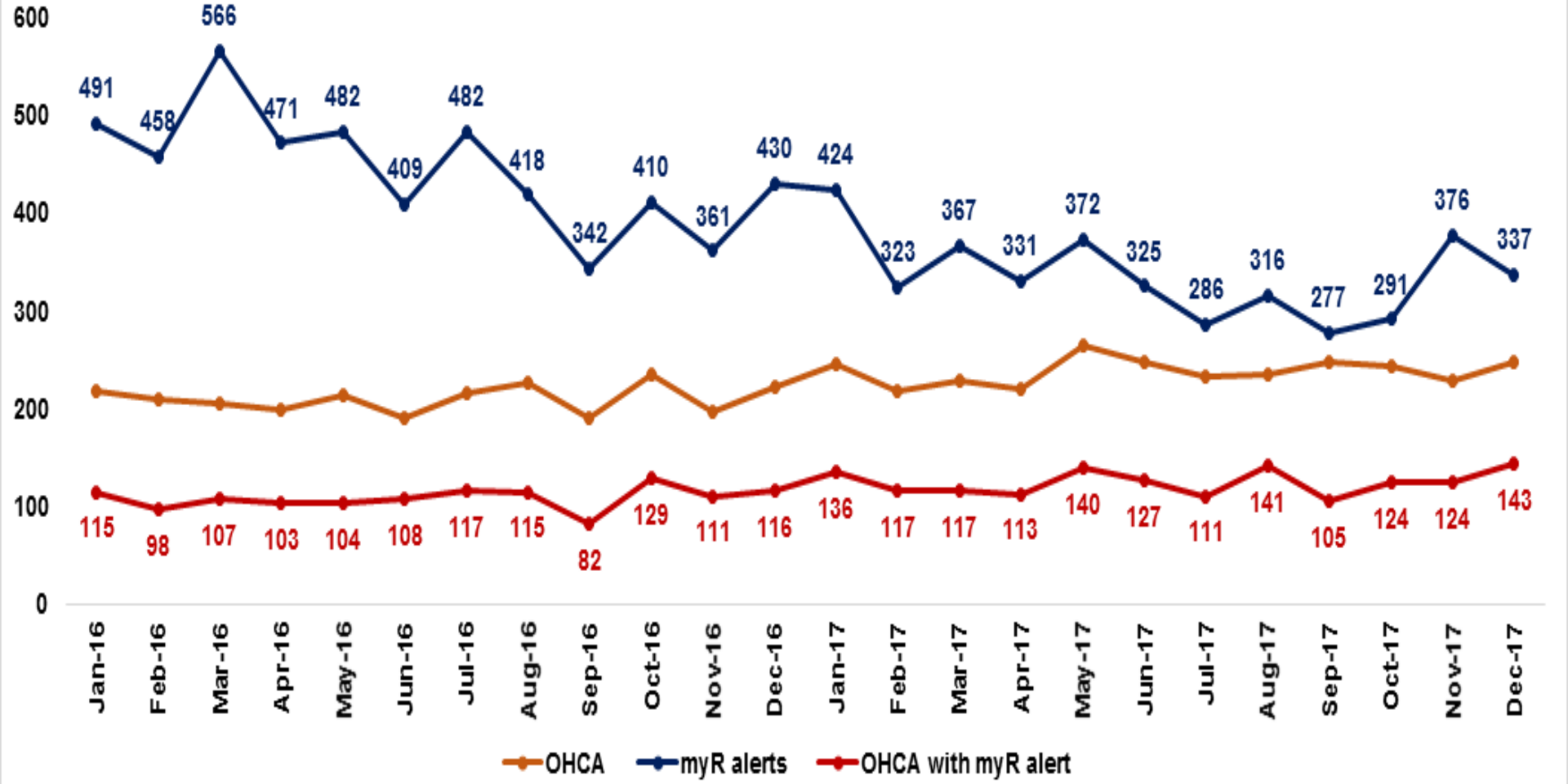
Leverage on existing I.T.

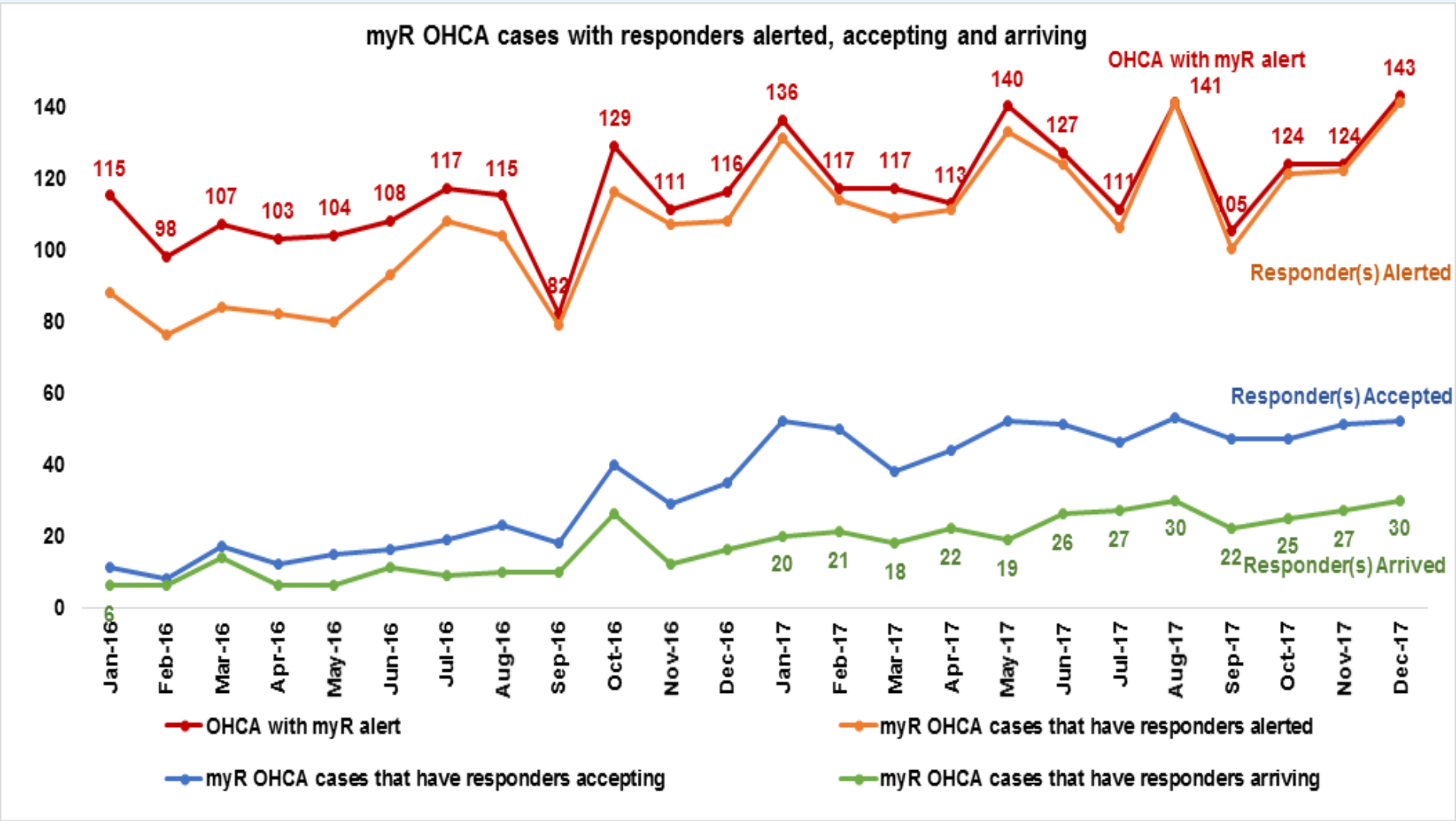
- 9-9-5 Dispatch System
- National authentication system: ***SingPass***
- OneMap for detailed map layers
- Govt Cloud Services

myResponder
SCDF
The Life Saving Force

SCDF
The Life Saving Force

Proportion of myResponder alerts that were OHCAs vs OHCAs attended by SCDF




myR OHCA cases with responders alerted, accepting and arriving
OHCA with myR alert
Responder(s) Alerted
Responder(s) Accepted
Responder(s) Arrived
115
98
107
103
104
108
117
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Dec-17
OHCA with myR alert
myR OHCA cases that have responders alerted
myR OHCA cases that have responders accepting
myR OHCA cases that have responders arriving

sph A SINGAPORE PRESS HOLDINGS PUBLICATION

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» 国人对新加坡社会看法改善

咨询公司对新加坡公民和永久居民展开调查，让他们选最能形容新加坡社会的词汇。结果显示，与3年前相比，国人眼中的新加坡社会较正面，是享有“救育机会”、“和平”及“安全”的国家。**本地新闻B2**

» 希腊第2轮纾困投票通过

希腊国会从前晚就新纾困方案的第2轮投票进行辩论，一直讨论到昨天凌晨，终于以大比数顺利通过。当国会就纾困方案进行辩论时，约9000民众在国会外聚集，反对进一步财政紧缩。**世界新闻B4**

» 金秀贤同父异母妹妹沾光被批

韩国歌手金珠娜发行为韩剧献唱的插曲，自爆是“金秀贤同父异母妹妹”搏版面，间接曝光金秀贤歌手老爸金忠勋23年前疑“偷吃”往事，被网友狠批。**娱乐B12**

协助更多心脏病发者 救命App使用率待提高

苏文琪

通知公众就近协助疑似心脏病发者的手机应用软件，已推出超过3个月，用户使用率仍有待提高，以帮助更多患者，增加对方的存活机会。

民防部队于今年4月17日推出的“myResponder”应用软件，至今的下载量约2500次。该软件可指出设有自动心脏除颤器（AED）最靠近的地点，也可用于通知用户附近有心脏病发者。

当局接获疑似心脏骤停个案的通报后，会立刻用软件通知在事发地点400公尺内的用户。只有已注册为“社区急救员”的700多名用户才会接到通知。

过去3个月，民防部队共发出约1000则急救通知，当中六成确为心脏骤停个案。不过，仅不到5%的通知获公众回应。45起获回应个案中，有15起确为心脏骤停个案。

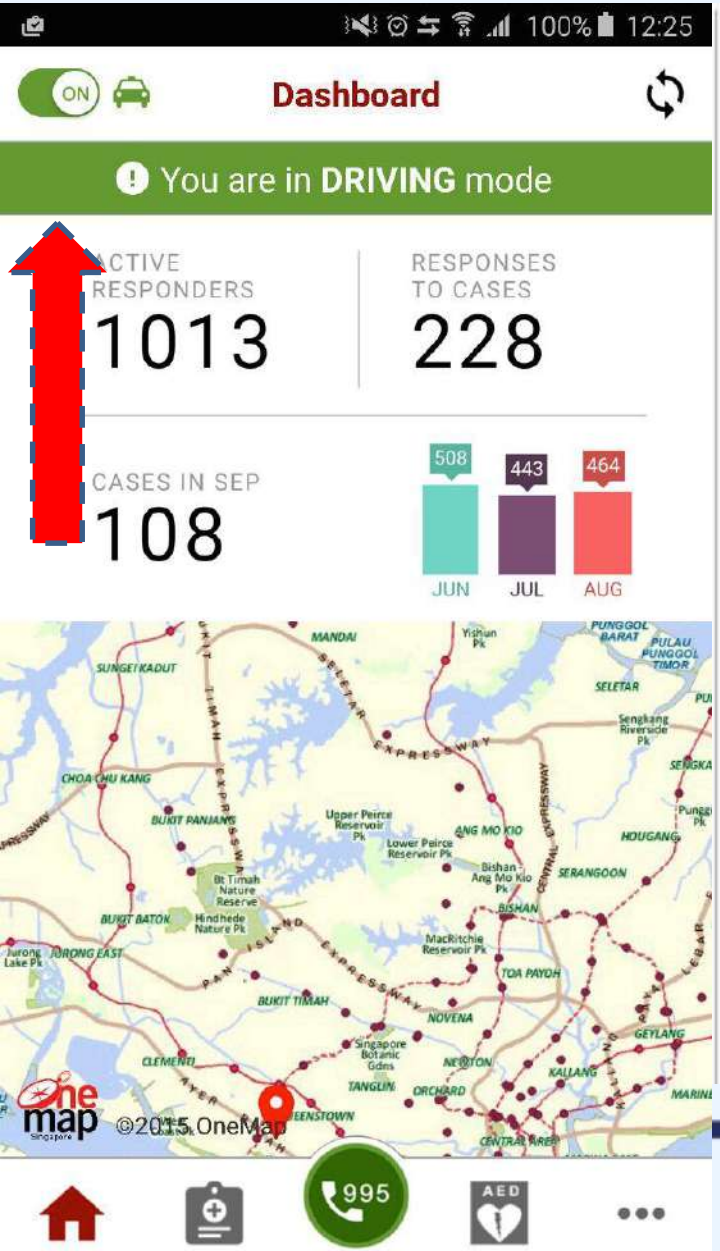
民防部队总医务官黄毅宝医生上校说，即使没有接受过急救训练，公众还是可以注册为急救员。接获通知时，他们可帮忙取来最靠近的自动心脏除颤器，或在民防接线员的指导下为患者进行心外按摩，或协助指引救护人员到事发地点。

他说：“心脏骤停的情况下，每一秒都非常重要，有人及时介入帮忙，将增加患者的存活机会。”

另外，软件现虽以处理心脏骤停个案为主，用户仍可借由软件通知民防部队其他紧急事故，当局会通过定位技术得知通报者的位置。

目前获回应个案中，未有心脏骤停者成功存活，但获援助的其他患者都从中受益。

邻里主动应急计划志愿者彭秀翠（左）和拉詹在接获“myResponder”应用软件的通知后，能赶在救护车之前到场，及时为患者提供援助。（周柏荣摄）



SINGAPORE

Automated External Defibrillators installed on 100 SMRT taxis

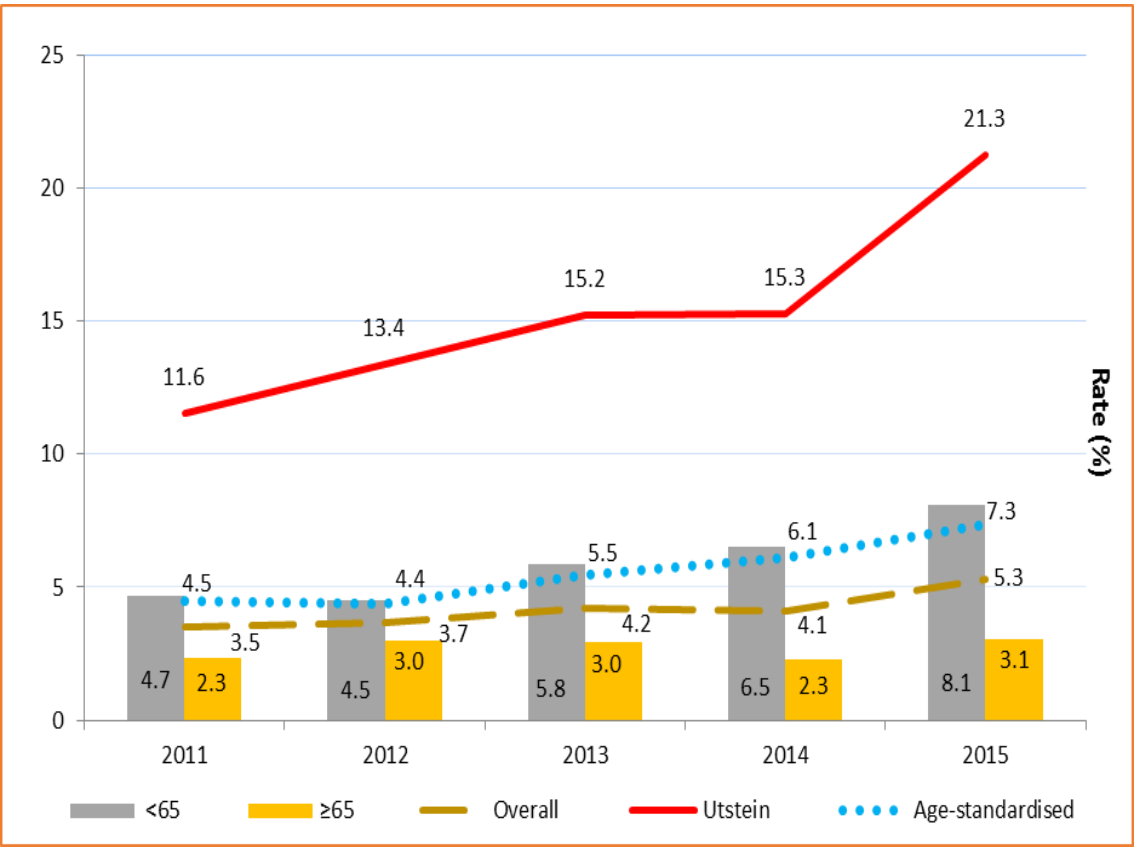
The initiative is part of a three-year pilot programme called SMRT-Temasek Cares AED on Wheels, which aims to increase the availability of AEDs within the community.

POSTED: 27 Nov 2015 21:43 **UPDATED:** 27 Nov 2015 23:59

VIDEOS PHOTOS

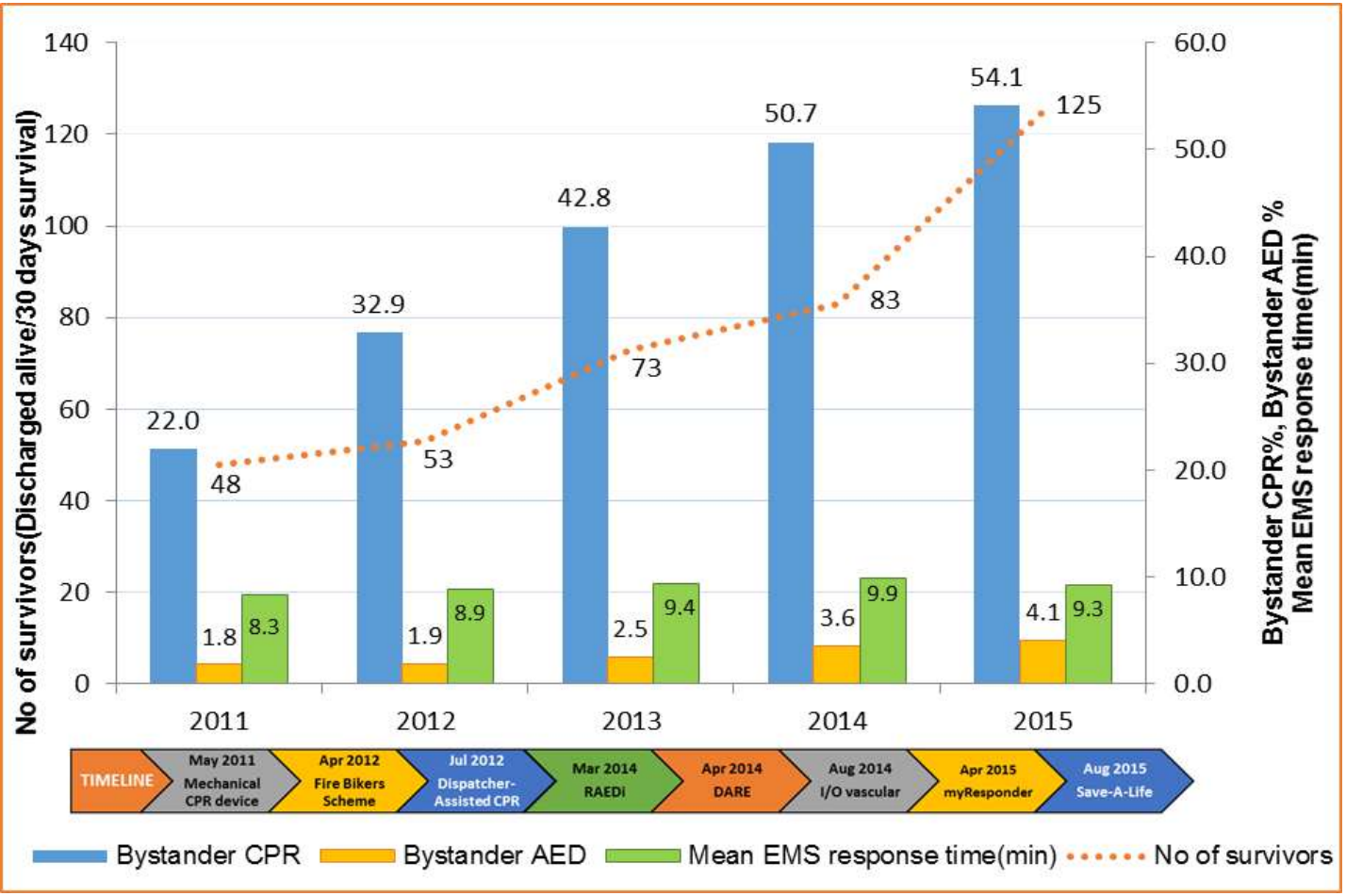
SMRT taxi driver Simon Ngiam Shu Leng with the AED which will be installed in his taxi. (Photo: SMRT)

Survival Rates: Overall, Utstein, <65 and >65



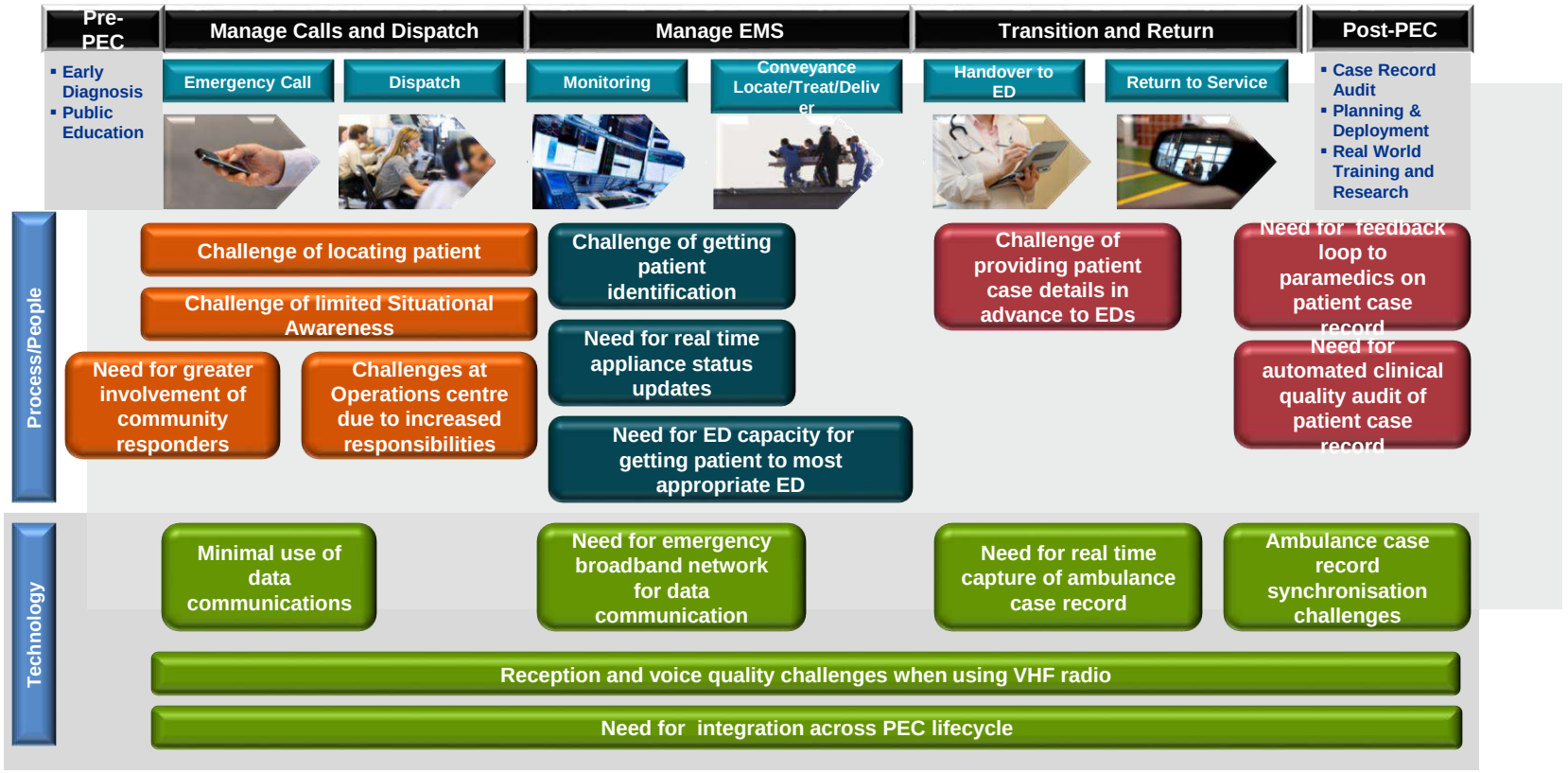
- W***itnessed cardiac arrest survival rates*** have ***doubled*** from 11.6 to 21.3%
- ***Overall survival rates*** have gone up from 3.5 to 5.3%
- Younger patients (<65) are 2.6 times more likely to survive than older patients (>65)

Timeline of Interventions

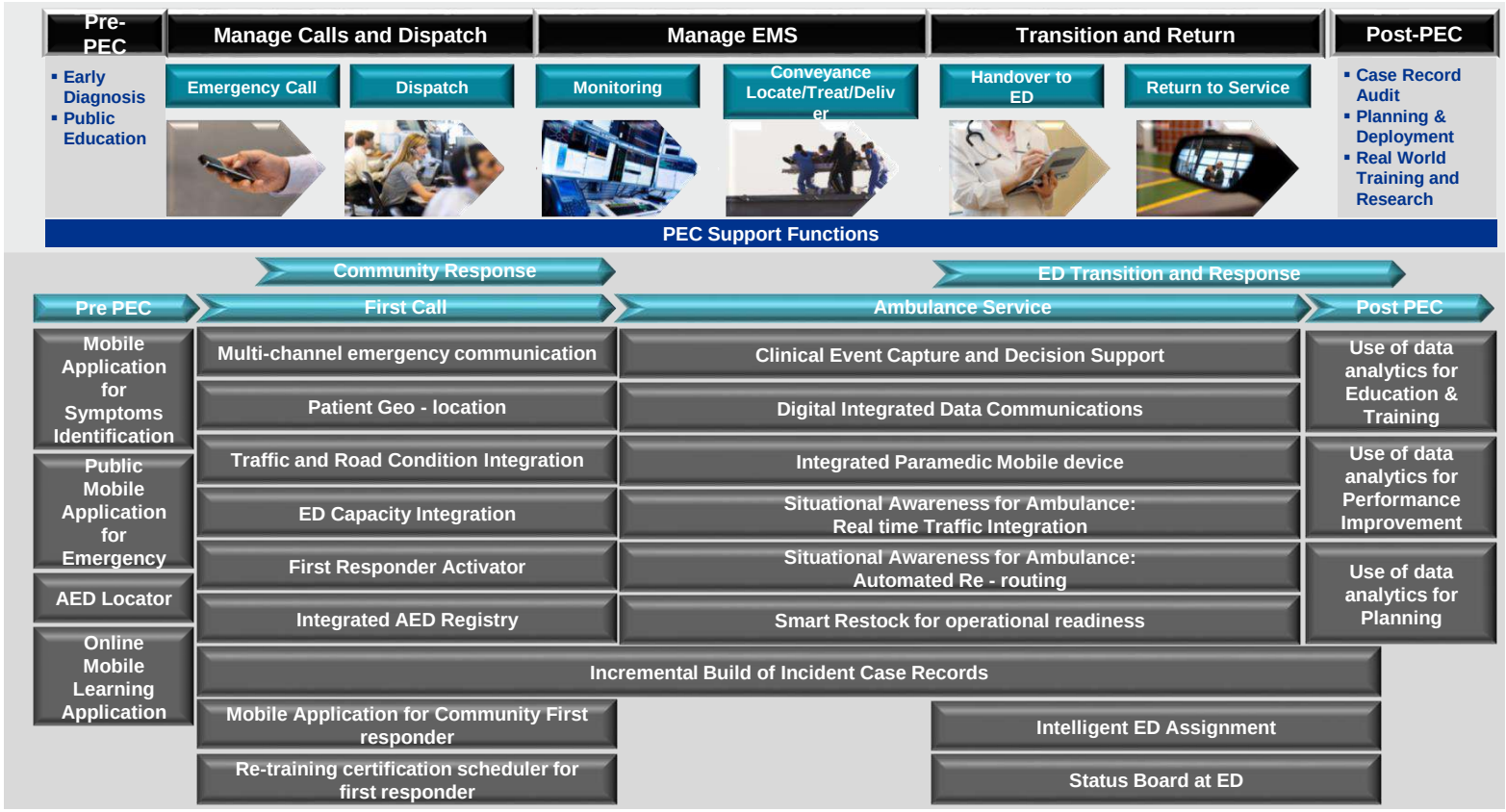


- Total survivors increased from 48 to 125.
- Bystander CPR rates increase from 22% to 54%
- AED use 1.8% to 4.1%
- EMS response time gradually increasing 8.3mins→9.3mins

Pre-hospital Emergency Care National IT Blueprint



PEC Potential Solution Capabilities



PEC IT Blueprint and Analytics

Manage Calls and Dispatch | **Manage EMS** | **Transition and Return**

Emergency Call | **Dispatch** | **Monitoring** | **Conveyance** Locate/Treat/Deliver | **Handover to ED** | **Return to Service**






Operations Centre

Smart Ambulance Device

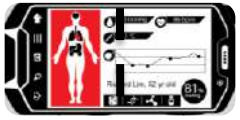
Mobile Devices

Participating EDs (SGH, KTPH and TTSH)

995 call/ situational data

Incident Details on IBCR

Clinical Data Capture



Electronic Case Record

My Responder

Dispatch Tape Review

Comms between Paramedics and ED

ePCR NEHR

Heartsave forms

IBCR

MHA Firewall

Extract, Transform, Load

Hospital Firewall

Data Warehouse ⇔ **HDG (MOHH)**

Reporting and Analytics Services

Potential Area of Analytics

- Research on OHCA, Trauma, Stroke and STEMI

Project OMNI

Emergency Medicine

- Unique domain of medicine that encompasses the acute care of medical, surgical, paediatric, obstetric/gynaecological and other emergencies
- It has also developed sub-specialty niches in:
  - Pre-hospital Emergency Care
  - Paediatric emergency medicine
  - Toxicology
  - Emergency Trauma Care
  - Emergency Airway Management
  - Emergency cardiac care
  - Emergency imaging
  - Observation Medicine
  - Critical Emergency Care
  - Resuscitation
  - Disaster Medicine

Health Services Research Institute

Develop infrastructure and resources in SingHealth in support of the vision and mission for HSR in SingHealth Duke-NUS AMC

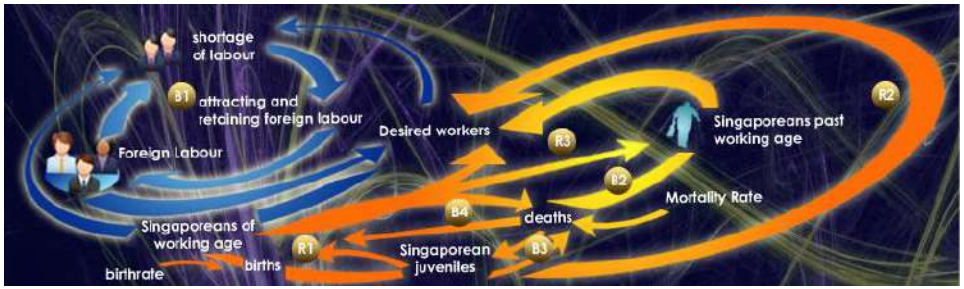
Enhance HSR capability in each SingHealth institution to address operational and implementation issues

Nurture promising HSR Researchers

Encourage cluster-wide and national dissemination and implementation of the results of HSR

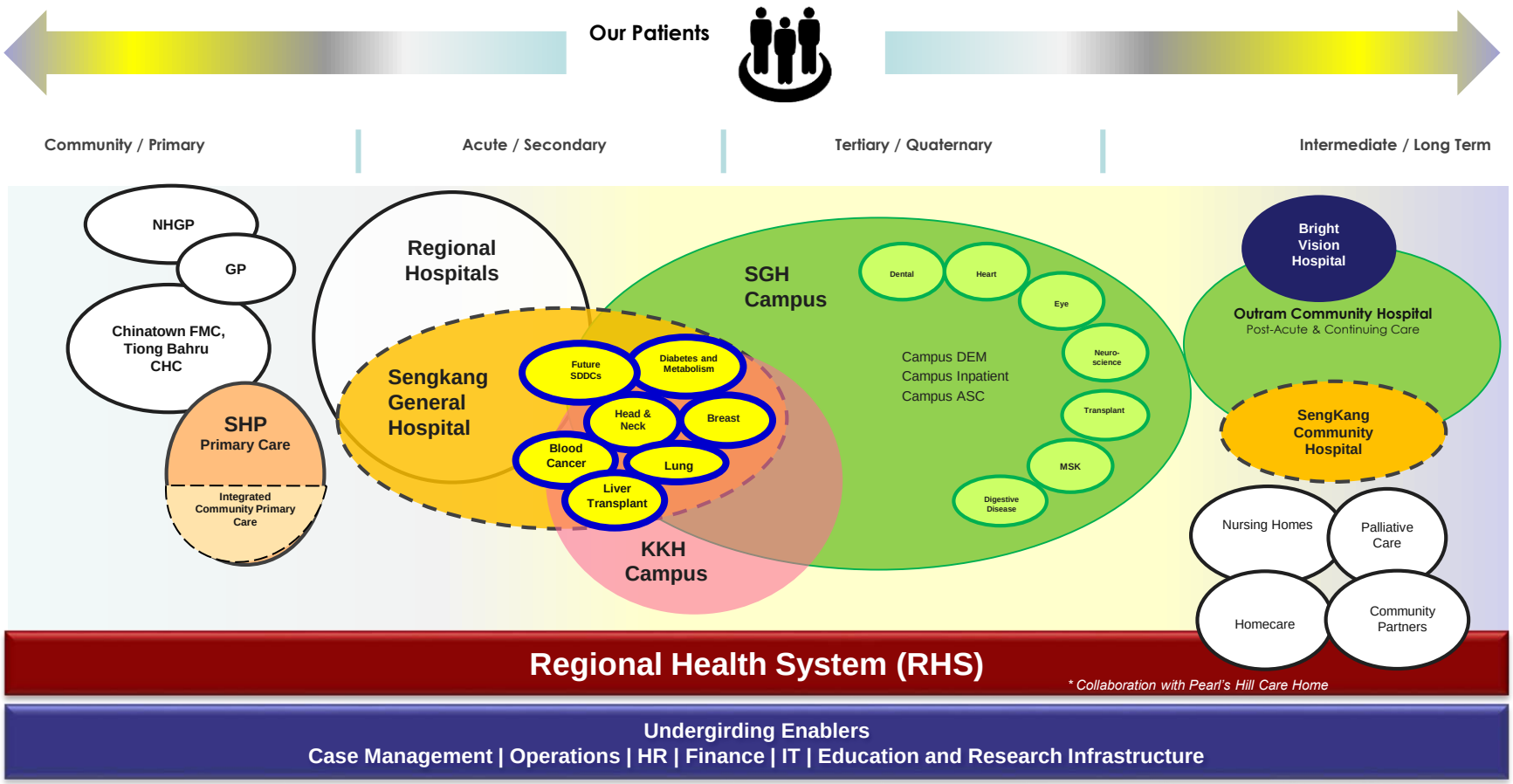
HSSR

SingHealth RESEARCH Health Service Research Centre



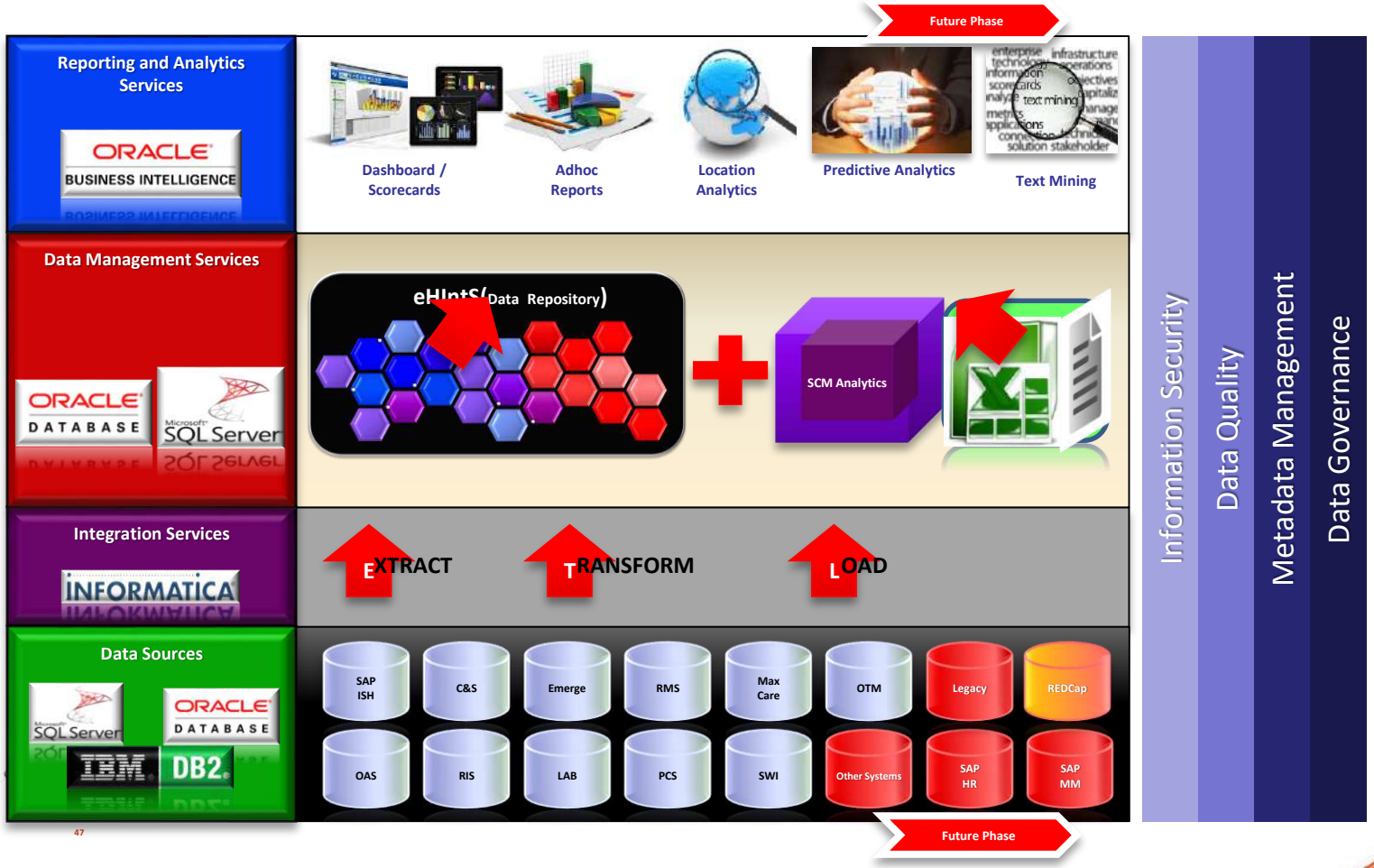
SingHealth DukeNUS ACADEMIC MEDICAL CENTRE

Availability of Data across the spectrum of healthcare



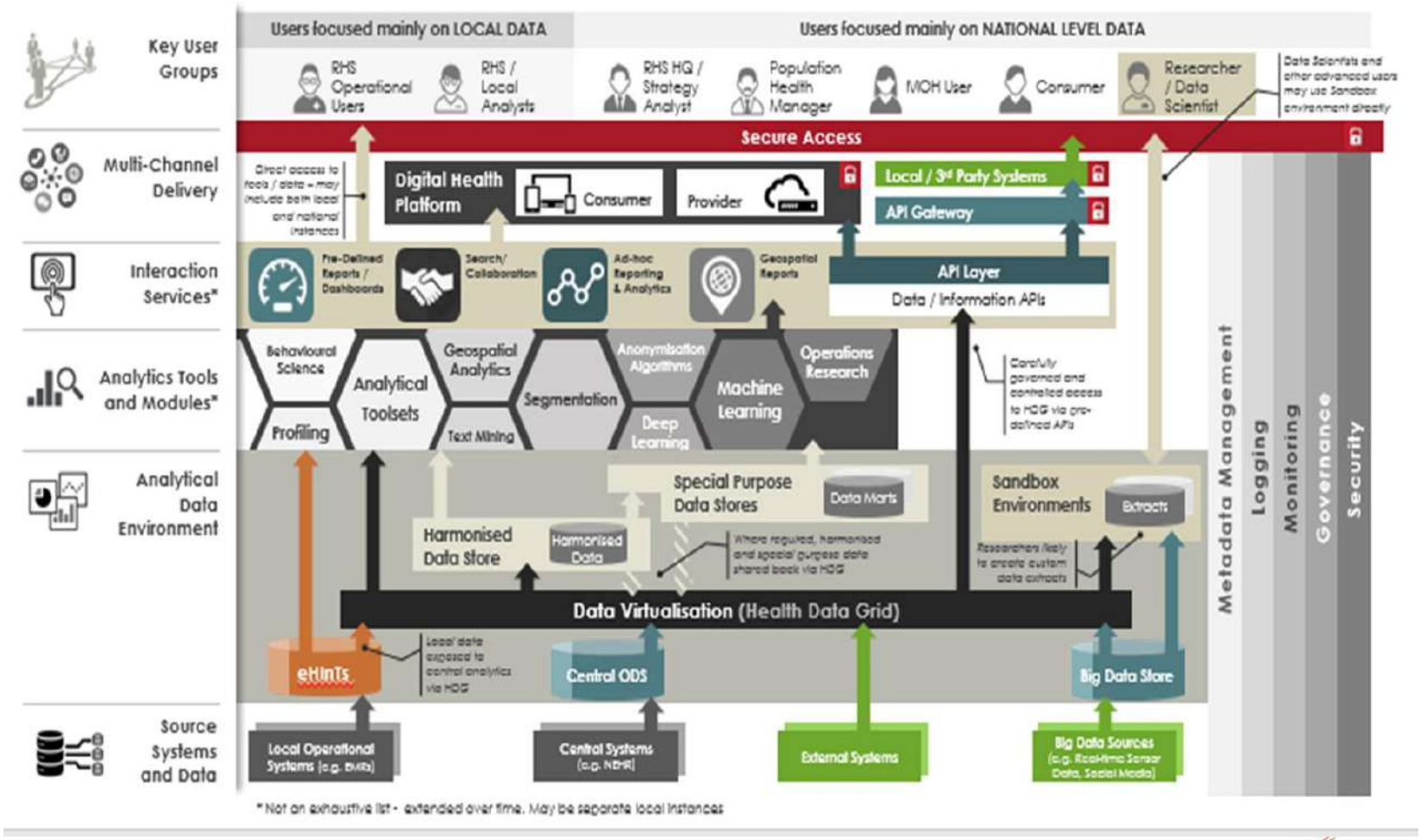
Singapore General Hospital

Supporting Analytics Infrastructure in SingHealth – Duke NUS AMC



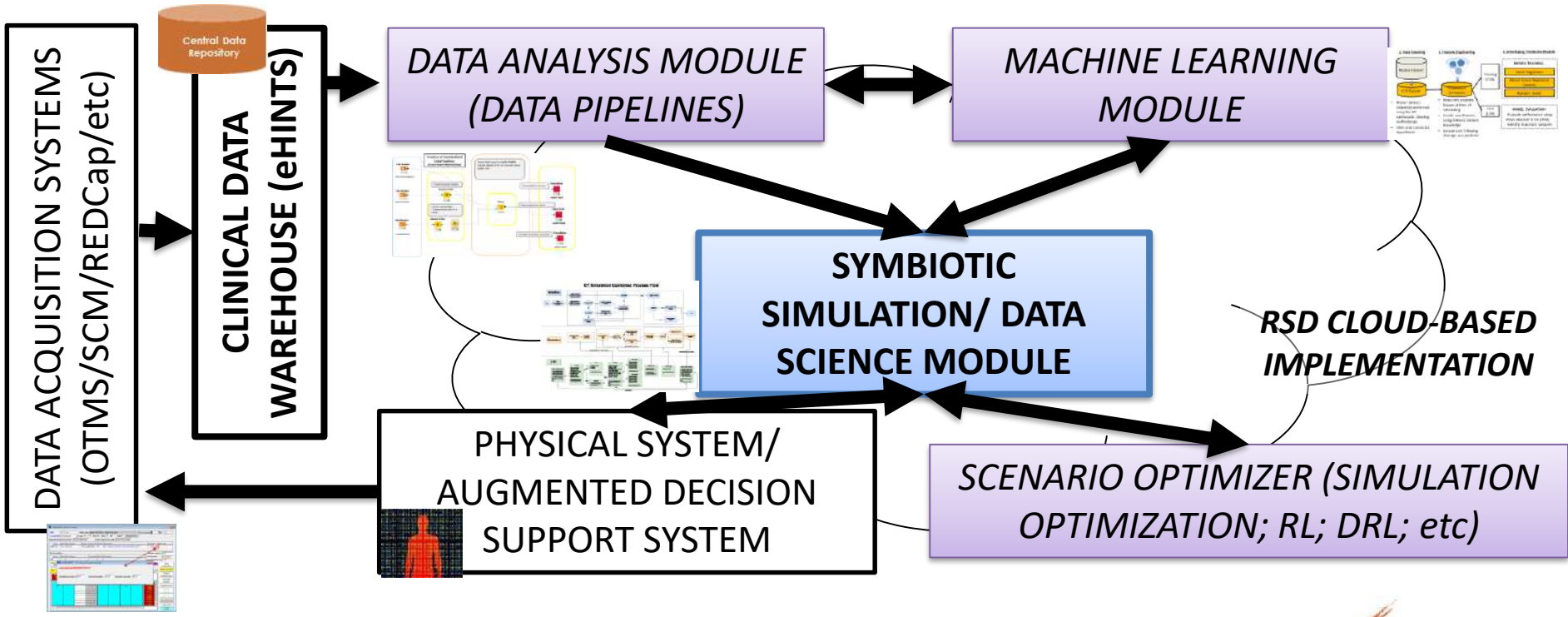
SingHealth DukeNUS ACADEMIC MEDICAL CENTRE

SingHealth Analytics Infrastructure



Research Standing Database

Healthcare Digital Twin Integration Framework



AI/ Data Science models need to go beyond validation to IMPLEMENTATION

Research | **Implementation**

Development	Internal validation	Assessing incremental value of new (bio)marker	External validation	Model updating	Impact assessment	Test-bedding	Scale up

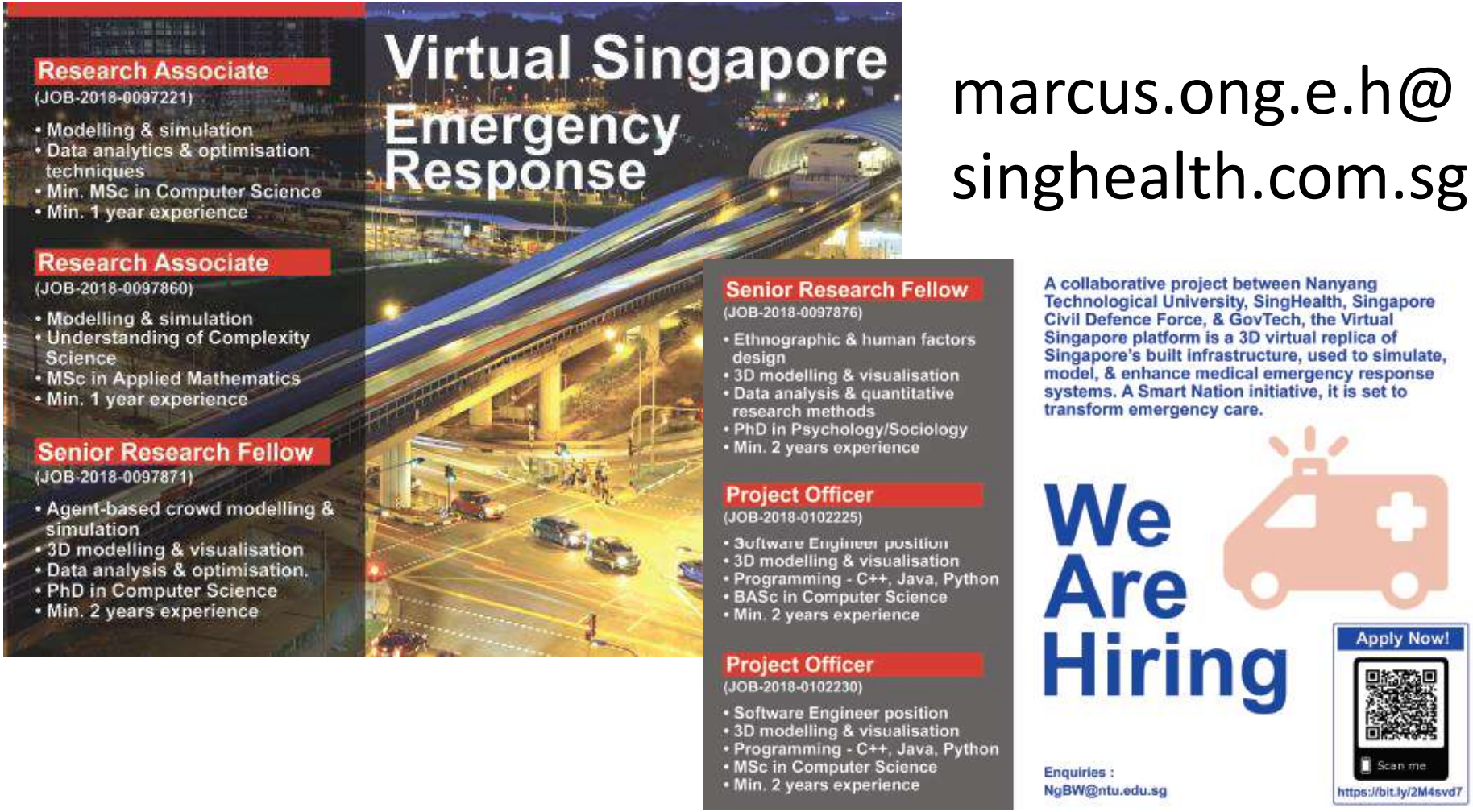
• Data source
  • Quality
  • Missing data
• Variable selection
	• From same sample
	  • Random split
	  • Bootstrapping
		• C-statistic
		• Net reclassification improvement
			• Temporal
			• Geographical
			• Domain (different population)
				• To adjust/improve performance for other settings or populations
				• Need to undergo further external validation
					• Quantify impact on behaviour and decision making, health outcomes & cost-effectiveness
					• Comparative designs
						• Explore context
						• Adoption
							• Implement
							• Sustain

Our Goal is Implementation!

Data Rich with INformation and Knowledge (DRINK!)

1. Moons *et al*. *Heart*. 2012;98(9):691-698
2. Moons *et al*. *Heart*. 2012;98(9):683-690
3. Amarasingham *et al*. Health affairs 2014;33(7):1148-54

SingHealth DukeNUS ACADEMIC MEDICAL CENTRE



marcus.ong.e.h@singhealth.com.sg