### AED Locations Optimization Ivan Derevitskii, Wentong Cai

# Part 1. Ang Mo Kio Risk Map

#### Input Data

- Singapore subzones map (2014, https://data.gov.sg/)
- AED Locations
- Heart Attack Odd Ratio (Rakun A. D. U. et al.2017. Ethnic and neighbourhood socioeconomic differences in the incidence and survival of out-of-hospital cardiac arrest in Singapore )
- Singapore demography data with an ethnic group (2015, https://data.gov.sg/)



### AED per person

- Uneven AED distribution
- No demography data for Yio Chu Kang and Yio Chu Kang North subzones
- A lot of AED near MRT stations Yio Chu Kang and Ang Mo Kio



### Problem subzones



Sembwang Hills: AED – 0; people - 6890

Tagore: AED – 1; people - 8350



Category

6-0	0.04	0.18	0.19	0.47	0.058	0.11	0.2	0.47
10-19	0.034	0.025	0.061	0.29	0.055	0.11	0.093	0.34
20-29	0.043	0.099	0.12	1.3	0.1	0.62	0.19	2.8
30-39	0.071	0.13	0.17	2	0.22	1.1	0.39	5.7
40-49	0.12	0.33	0.33	1.6	0.49	1.3	0.98	7.2
50-59	0.26	0.63	0.75	2	1	2.4	1.9	8
69-09	0.62	1.7	1.8	5.2	1.9	4.4	4.2	14
70-79	2.1	4.8	3.8	8.3	4.1	6.8	5.8	18
80+	6.5	10	6.7	13	9.7	8.8	9.2	18
	Female Chinese	Female Indian	Female Malay	Female Other	Male_Chinese	Male Indian	Male Malay	Male Other

$$r_{gra} = (\frac{n_{gra}}{p_{gra}}) / (\frac{n_{ChineezeMale50}}{p_{ChineezeMale50}})$$

16

12

8

•  $r_{gra}$  - risk value for age gender race group

 n<sub>gra</sub>- number of ha cases in
Singapore with current age-genderrace patient

•  $p_{gra}$  - number of people in Singapore with current age-gender-race value

### Ang Mo Kio Age-Race-Gender HA Odd Ratio

TOWN CENTRE	177	196	245	272	225	249	241	267	366	406	273	303	225	249	132	147	48	53
CHENG SAN	854	917	926	994	1309	1406	1688	1813	1704	1831	1724	1852	1760	1891	938	1007	395	424
CHONG BOON	719	758	899	948	1258	1327	1498	1580	1522	1605	1682	1774	1682	1774	1095	1154	471	497
KEBUN BAHRU	601	660	811	891	1030	1131	1095	1202	1351	1484	1413	1551	1317	1446	804	883	371	407
3AWANG HILLS	214	243	359	407	433	491	251	285	400	454	458	519	355	402	210	238	119	135
SHANGRI-LA	433	451	536	558	746	777	772	803	871	907	1018	1060	893	930	555	578	257	267
TAGORE	249	275	393	433	567	625	355	391	457	503	584	643	499	550	207	228	131	144
TOWNSVILLE	690	763	697	772	948	1049	1195	1322	1274	1409	1250	1383	1289	1427	854	945	396	438
YIO CHU KANG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YIO CHU KANG HU KANG EAST	0 135	0 138	0 210	0 214	0 293	0 299	0 205	0 210	0 253	0 259	0 293	0 299	0 262	0 268	0 122	0 125	0 56	0 58
YIO CHU KANG HU KANG EAST J KANG NORTH	0 135 0	0 138 0	0 210 0	0 214 0	0 293 0	0 299 0	0 205 0	0 210 0	0 253 0	0 259 0	0 293 0	0 299 0	0 262 0	0 268 0	0 122 0	0 125 0	0 56 0	0 58 0
YIO CHU KANG HU KANG EAST J KANG NORTH HU KANG WEST	0 135 0 731	0 138 0 794	0 210 0 1073	0 214 0 1165	0 293 0 1201	0 299 0 1305	0 205 0 1225	0 210 0 1330	0 253 0 1501	0 259 0 1630	0 293 0 1544	0 299 0 1677	0 262 0 1466	0 268 0 1592	0 122 0 692	0 125 0 751	0 56 0 280	0 58 0 304

Ang Mo Kio Age-Race-Gender Distribution

1600

1200

800

400

0

### Risk Map Witout AED

- $R_s = \sum_{s,gra} r_{gra} * dem_{s,gra}$  ,
- $R_s$  risk value for subzone
- $r_{gra}$  risk value for age gender race group
- $dem_{s,gra}$  subzone number of people with current age-gender-race value



### AED/ODD value

AED/ODD value =

NumberAED

/(1 \* Total\_Chinese + 1.93\* Total Malay + 1.94\*Total Indian) 1;1.93;1.94 – Heart attack odd ratio for Chinese, Malay, Indian

- Subzone with high HA-odds ethnicity needs more AED
- Not take into account another ethnicity







Problem subzone Kebun Bahru only 9 AED, a lot of people, low AED/ODDS

Значение

**KEBUN BAHRU** 

**KEBUN BAHRU** 

1046417.00003

28700.16740 39496.50610 4288.19423

### Artificial Heart Attack Data Generation

- 1. Singapore Age-Race-Gender Odd Ratio with medical data
- 2. AMK population distribution with demography data
- 3. AMK subzones Risk Map with 1 and 2 results
- 4. AMK houses population with OneMap API
- 5. 386 artificial heart attack data



### HDB risk map

- $R_{hdb} = t_{min}(crd_{hdb})un_{hdb}R_s$ ,
- $R_{hdb}$  risk value for hdb subzone
- $R_s$  risk value for hdb subzone
- $t_{min}$  walking time to nearest AED
- $un_{hdb}$  number of dweling units
- $crd_{hdb}$  hdb geocoordinates







### Static Risk Map

- $R_{house} = t_{min}(crd_{house})un_{house}R_s$ ,
- *R<sub>house</sub>* risk value for house subzone
- $R_s$  risk value for house subzone
- $t_{min}$  walking time to nearest AED
- *un<sub>house</sub>* number of people
- crd<sub>house</sub> house geocoordinates





# Part 2. AED relocation methods

### Purpose of research task

**Goal**: Optimization AED locations for Ang Mo Kio;

**Methods**: Data analysis with QGIS, Genetic Algorithm optimization, Greedy optimization algorithm

**Task**: To maximize function  $|G|/|_{|H|} \rightarrow max$ ,  $G|G \subset H, \forall x \in G \ t_{min}(x) < 4 \ minutes)$ 

- $t_{min}$  walking time to nearest AED
- *x* heart attack place coordinates
- H set of artificial Heart Attack Data



### **Optimization Genetic Algorithm**

**Genetic Algorithm** 

#### **First population**

Generate set of random AED coordinates - population element (267 locations).

100 sets in start population

#### **Mutation**

Genes for change are selected on the basis of the probability distribution, depending on the number of artificial cardiac arrests that are only near this location (the dependence is inversely proportional).

#### **Fitness function**

$$|G|/|H| \to max$$



### Optimization results AED(green) heart attacks(red)



Current AED locations 87% ha <= 4 min

Optimal AED locations 100% ha <= 4 min

### Multicriterial optimization results: Genetic algorithm



Current - 267 AED , 87% ha <= 4 min

Optimal - 30 AED , 100% ha <= 4 min

### Set covering optimization: Greedy algorithm



Current - 267 AED , 87% ha <= 4 min

Optimal - 30 AED , 100% ha <= 4 min

## Part 3. AED relocation model

### AED relocation model



### 1. Heart attacks generation with Locations Type

#### **Problem:**

Worst effectiveness for optimal solution with real HA

**Reason:** take into account only home locations for artificial heart attacks generation

#### Solution:

Generate ha with different location's types

	Artificial Heart Attacks	Real Heart attacks
Current AED locations	87%, <=4 min	85%, <=4 min
Optimal solution	100%, <=4 min	70%, <=4 min

### 2. Bystander AED use probability with Location Type

- Dataset 1691 cases in 2016
- Bystander AED applied 63 cases 3,72%
- Home Residence 1286
- Bystander AED applied 0,87%

Bystander AED applied Probability



### 3. Bystander AED use probability with distance

# Factors for using AED probability:

- Signage
- People Knowleges
- Locations (family/street/other)
- Distance to nearest AED



### 3. Bystander AED use effectiveness with distance

- Died in ED or Died in the hospital 1540 cases
- Alive 105 cases
- Average distance to AED 183 meters
- AED applied, 63 cases, 16 applied, 25%
- Bystander AED not applied 1633, Alive 90, 5%



### Literature

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