AED Locations Optimization

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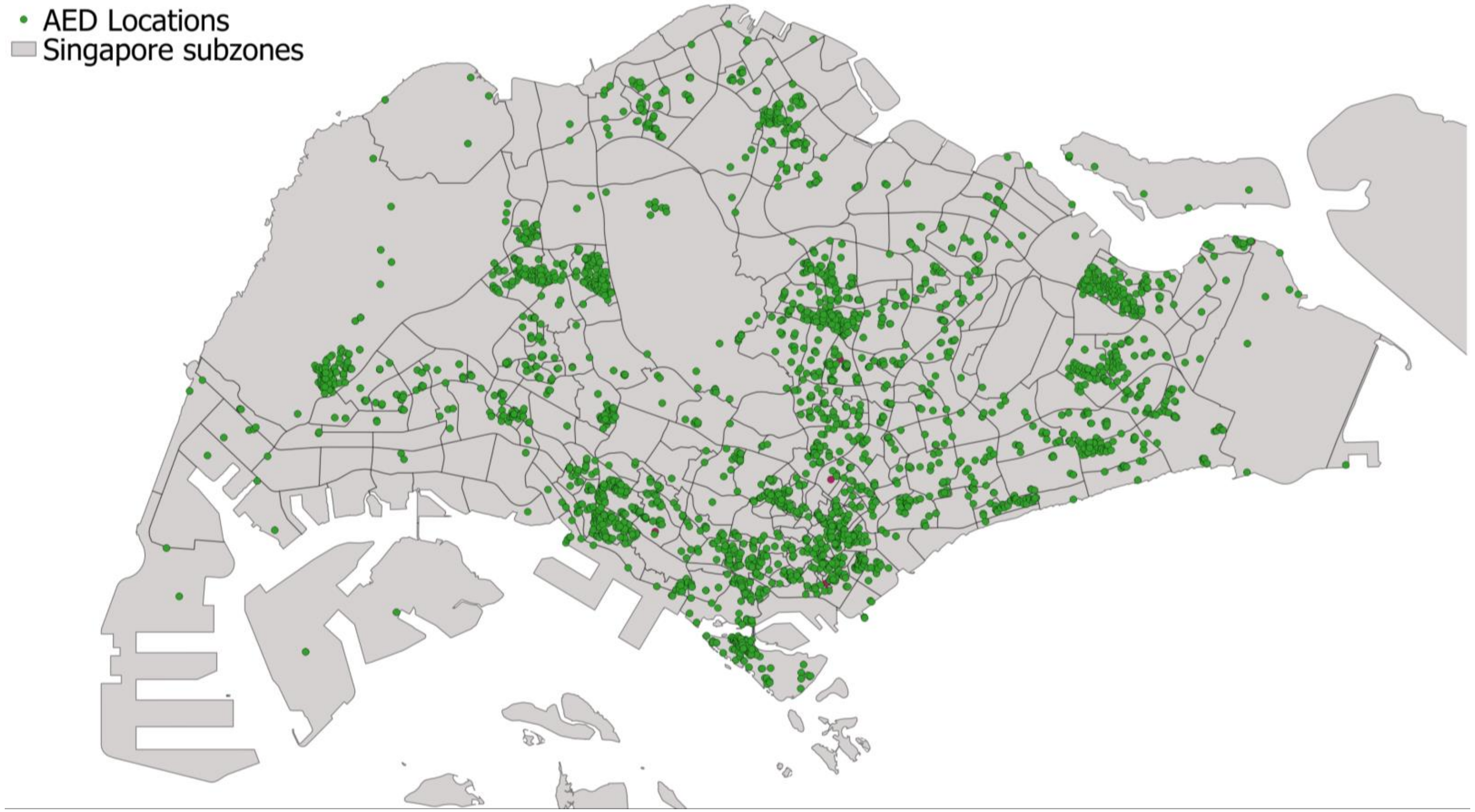
Part 1. Ang Mo Kio Risk Map

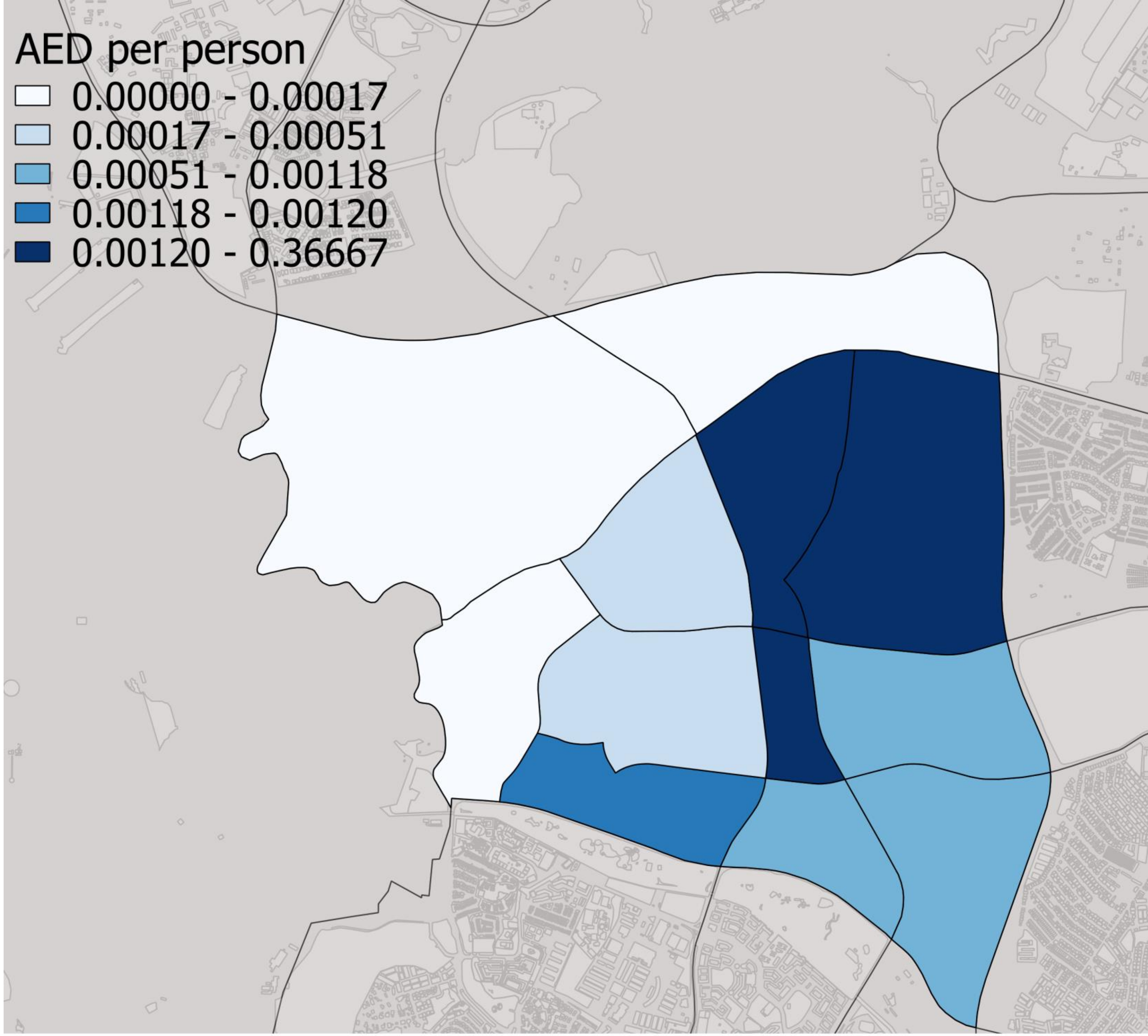
Input Data

- 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/)

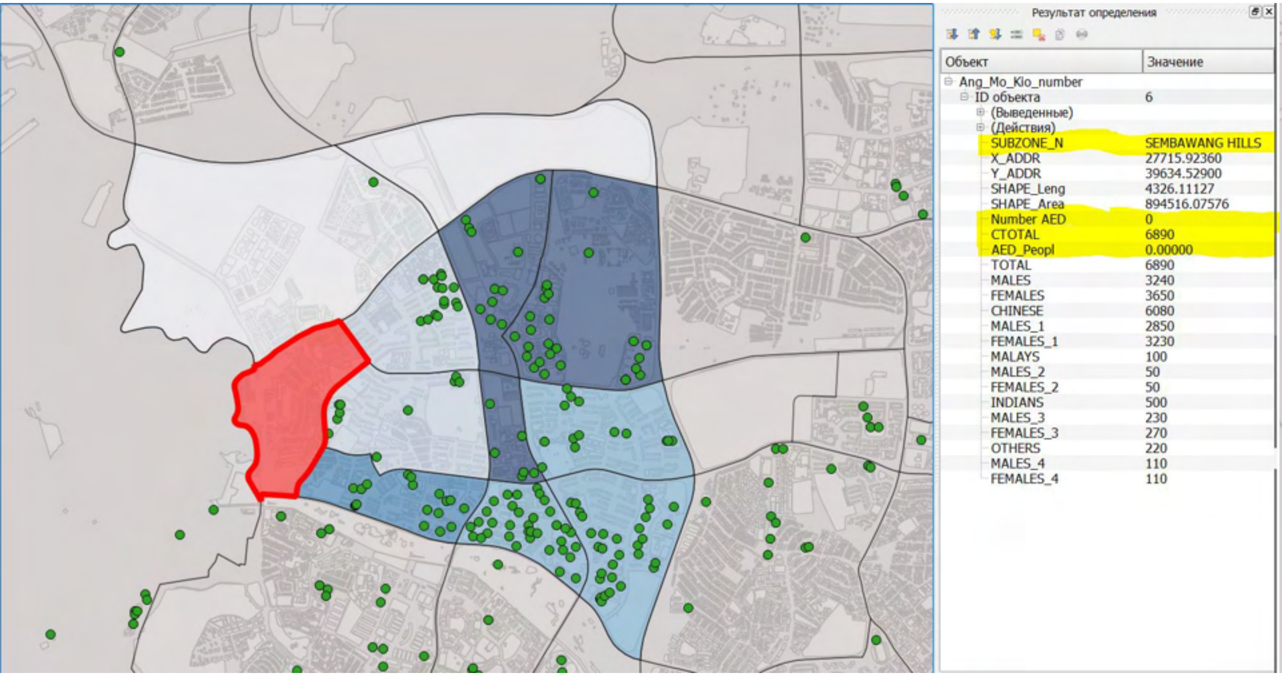


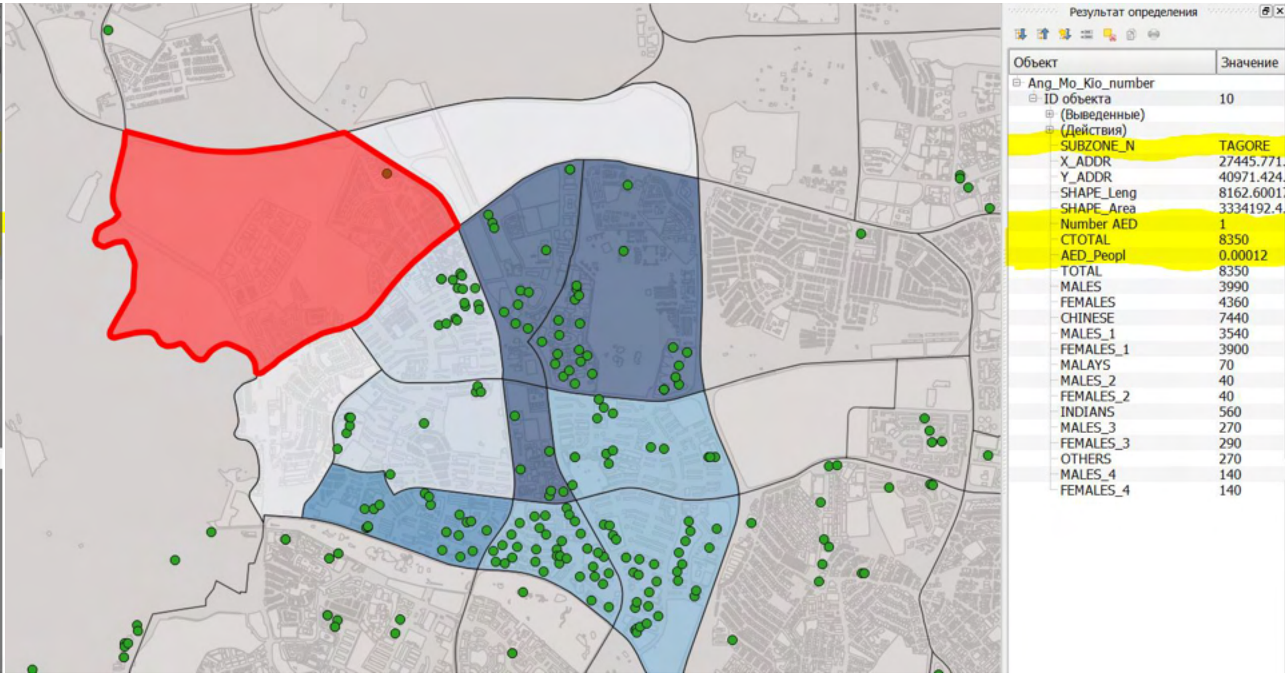
AED per person

- 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

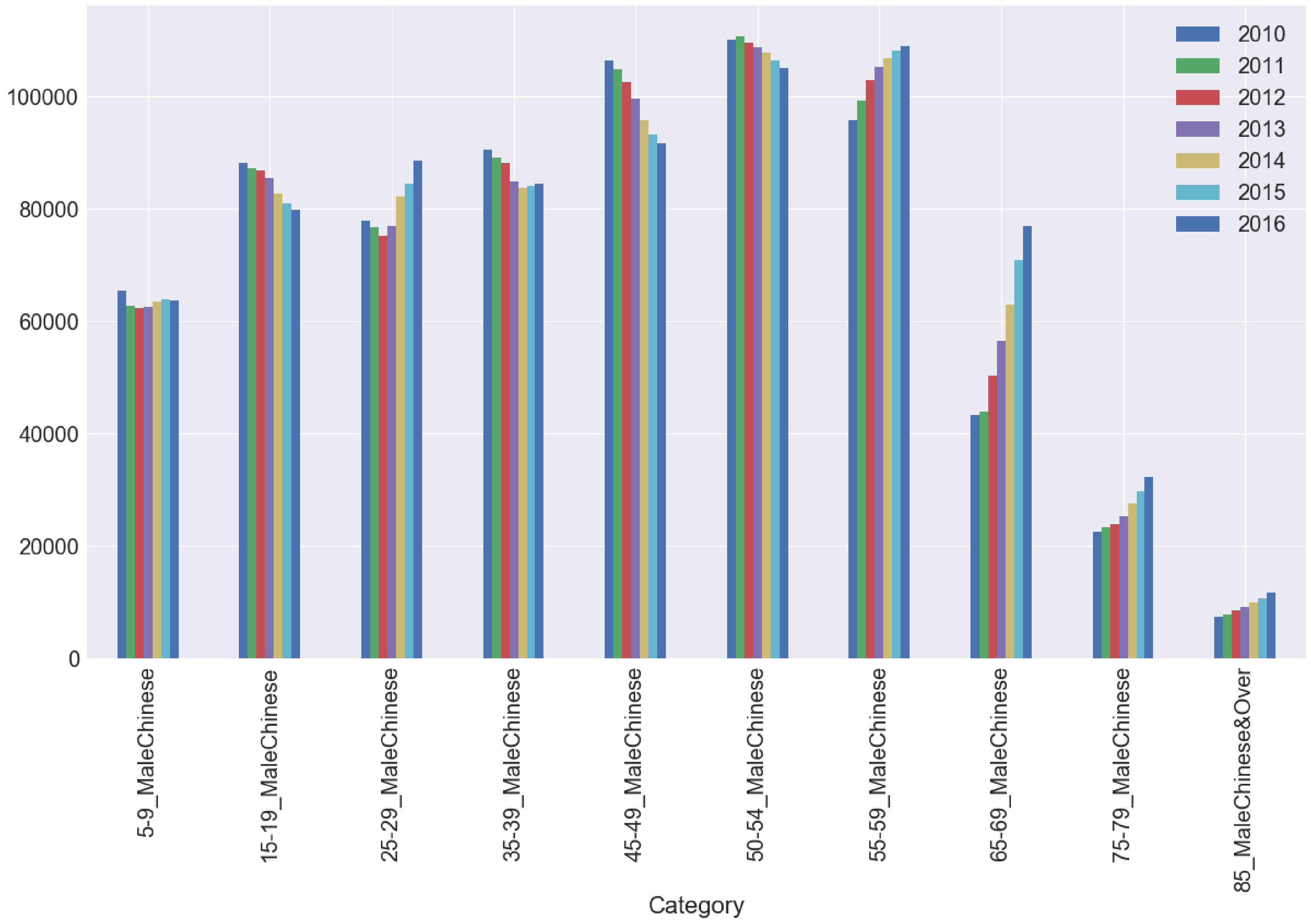


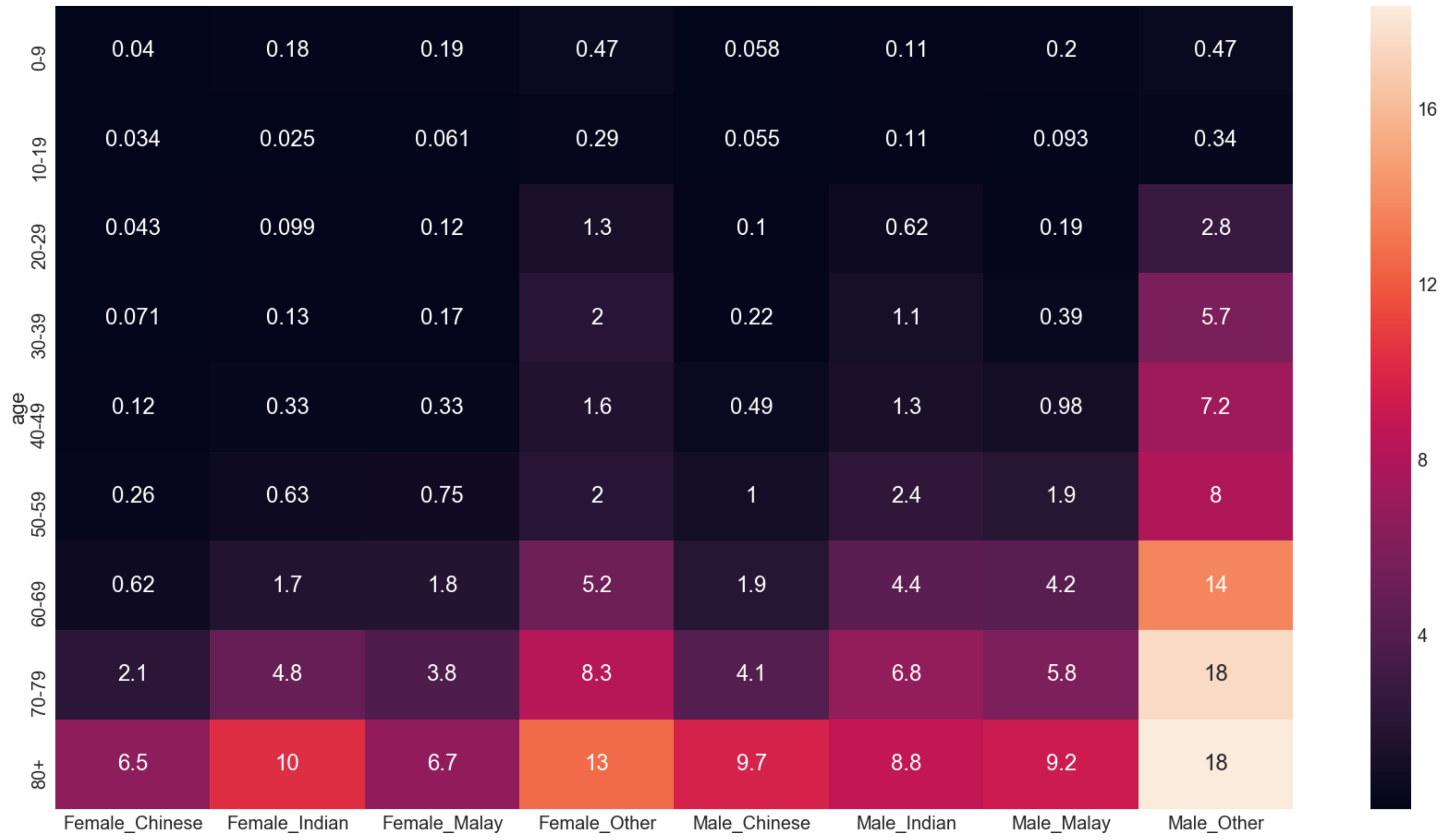


Sembwang Hills: AED – 0; people - 6890

Tagore: AED – 1; people - 8350

Singapore Demographic Data



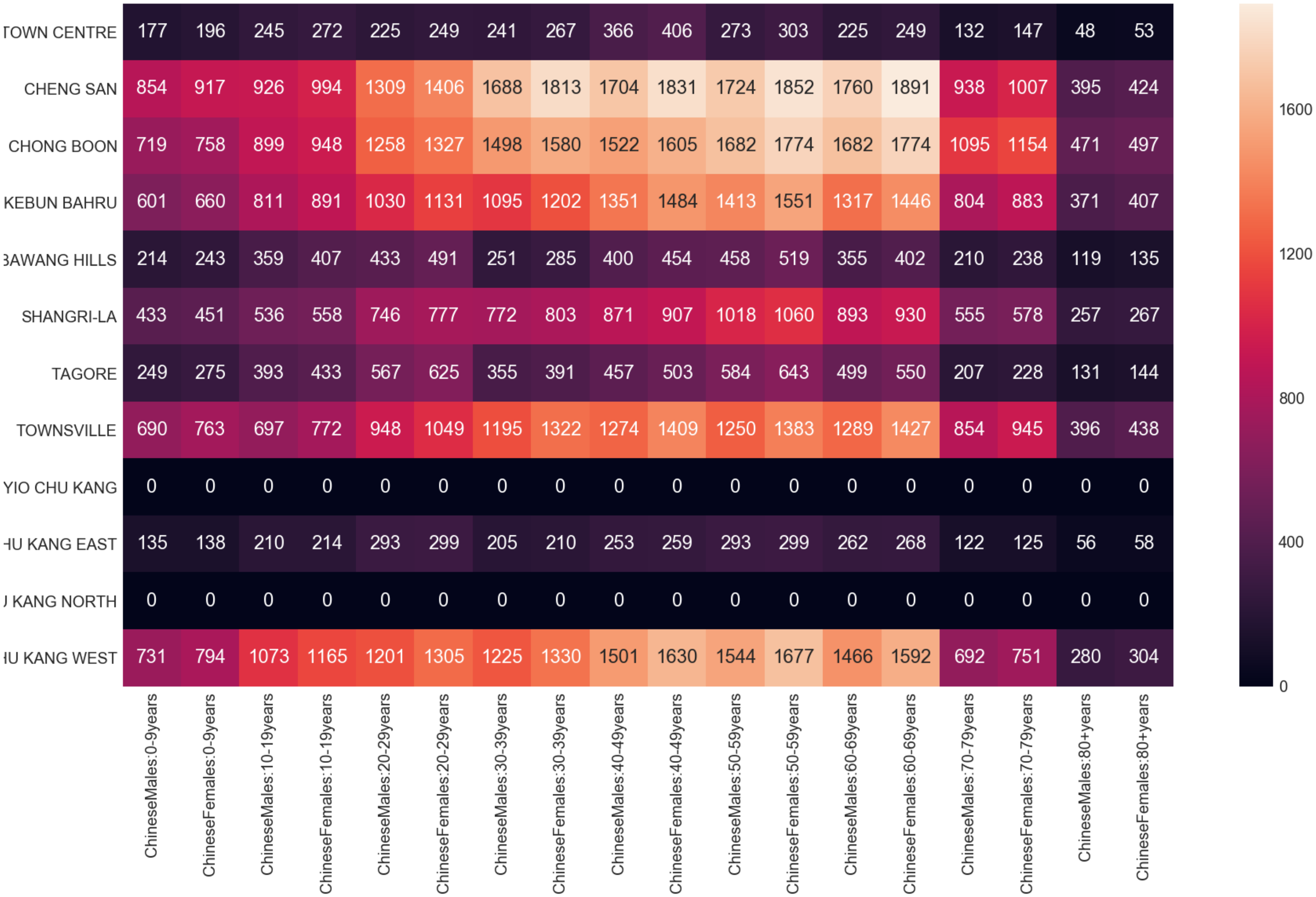


$$r_{gra} = \left(\frac{n_{gra}}{p_{gra}}\right) / \left(\frac{n_{ChineezeMale50}}{p_{ChineezeMale50}}\right)$$

- r_{gra} - risk value for age gender race group
- n_{gra}- number of ha cases in Singapore with current age-gender-race patient
- p_{gra} - number of people in Singapore with current age-gender-race value

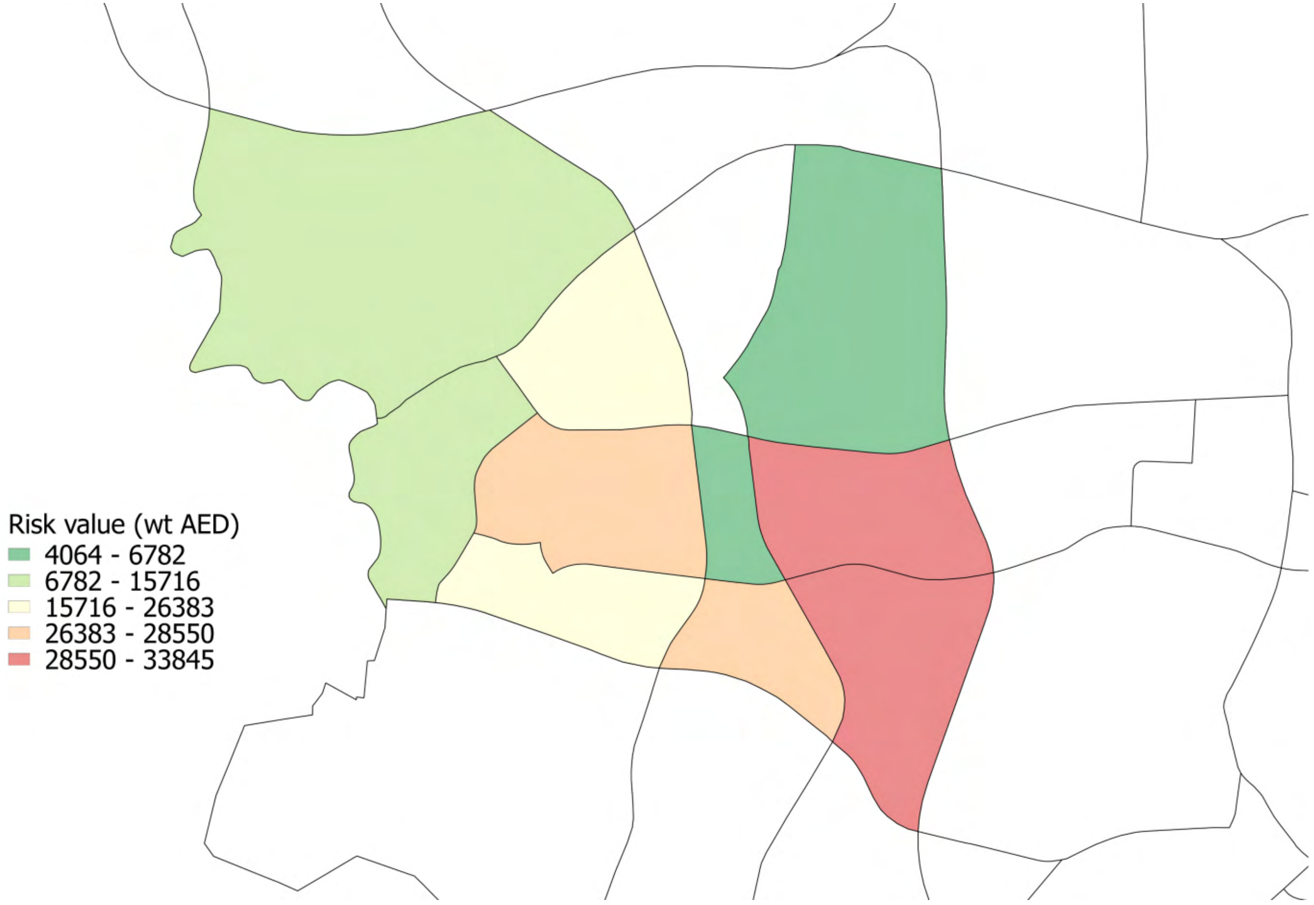
Ang Mo Kio Age-Race-Gender HA Odd Ratio

Ang Mo Kio Age-Race-Gender Distribution



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



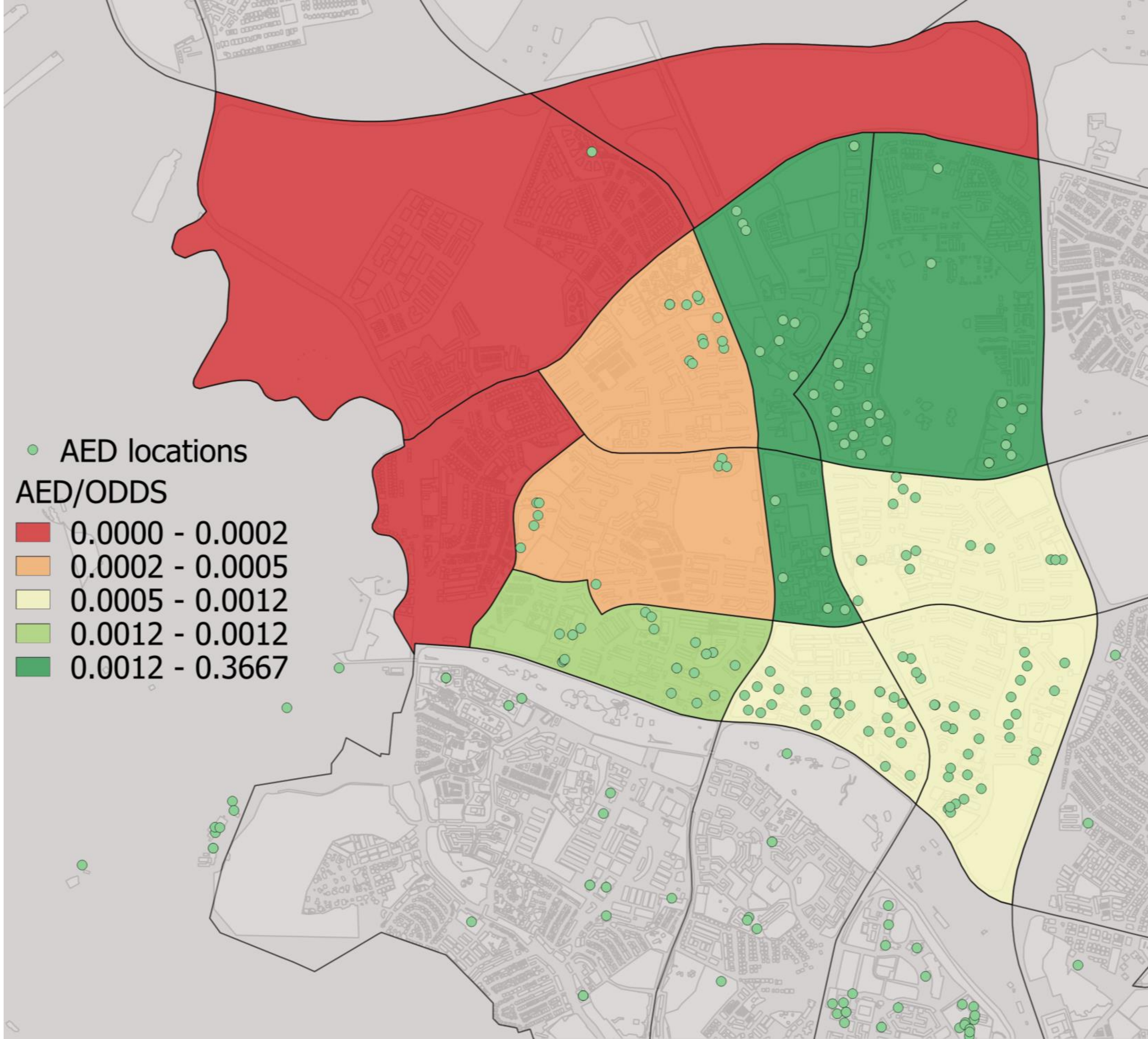
AED/ODD value

AED/ODD value =

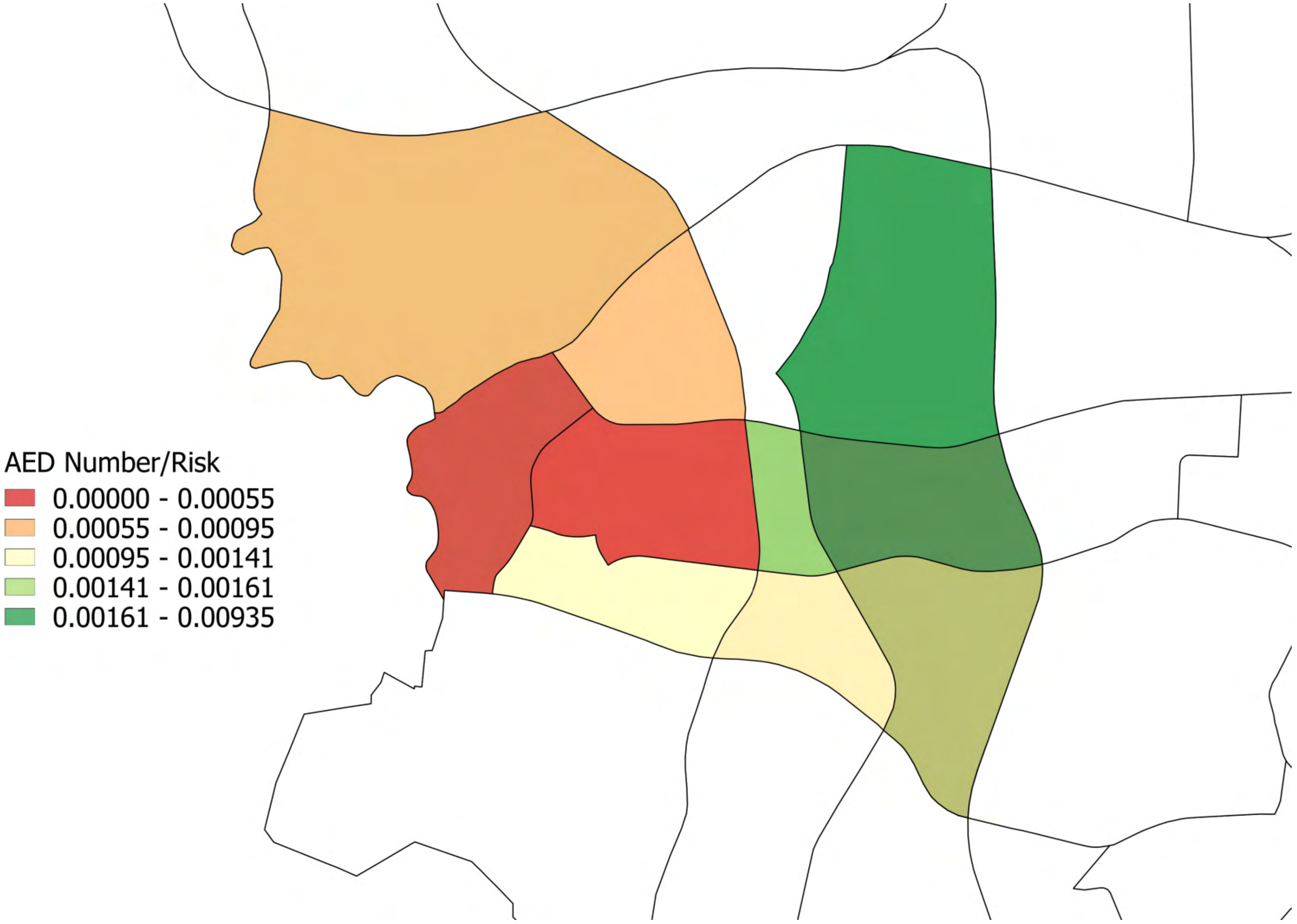
NumberAED

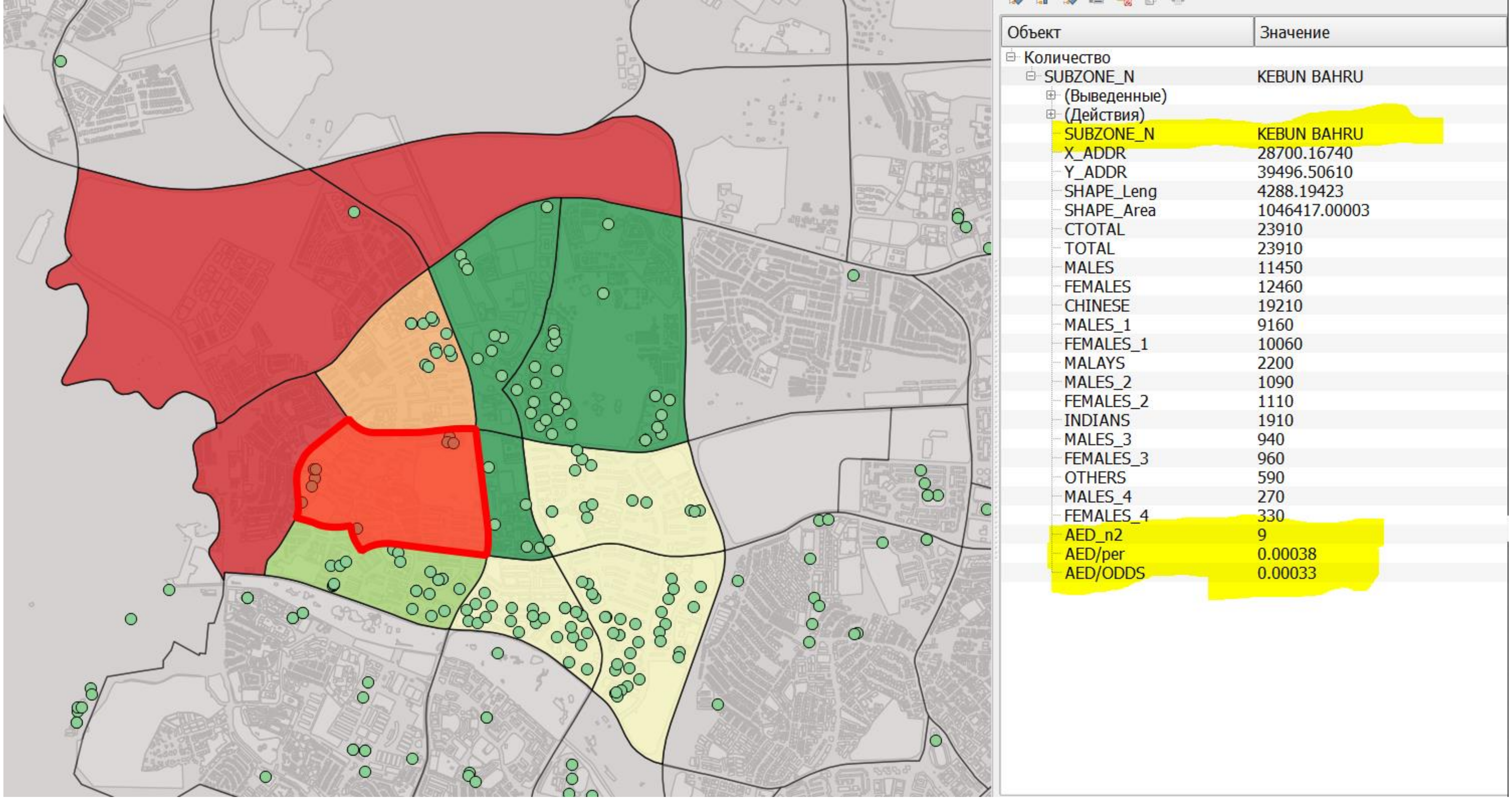
/(1 * Total_Chinese + 1.93* Total Malay + 1.94*Total Indian)
1;1.93;1.94 – Heart attack odd ratio for Chinese, Malay, Indian

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



AED/Risk value



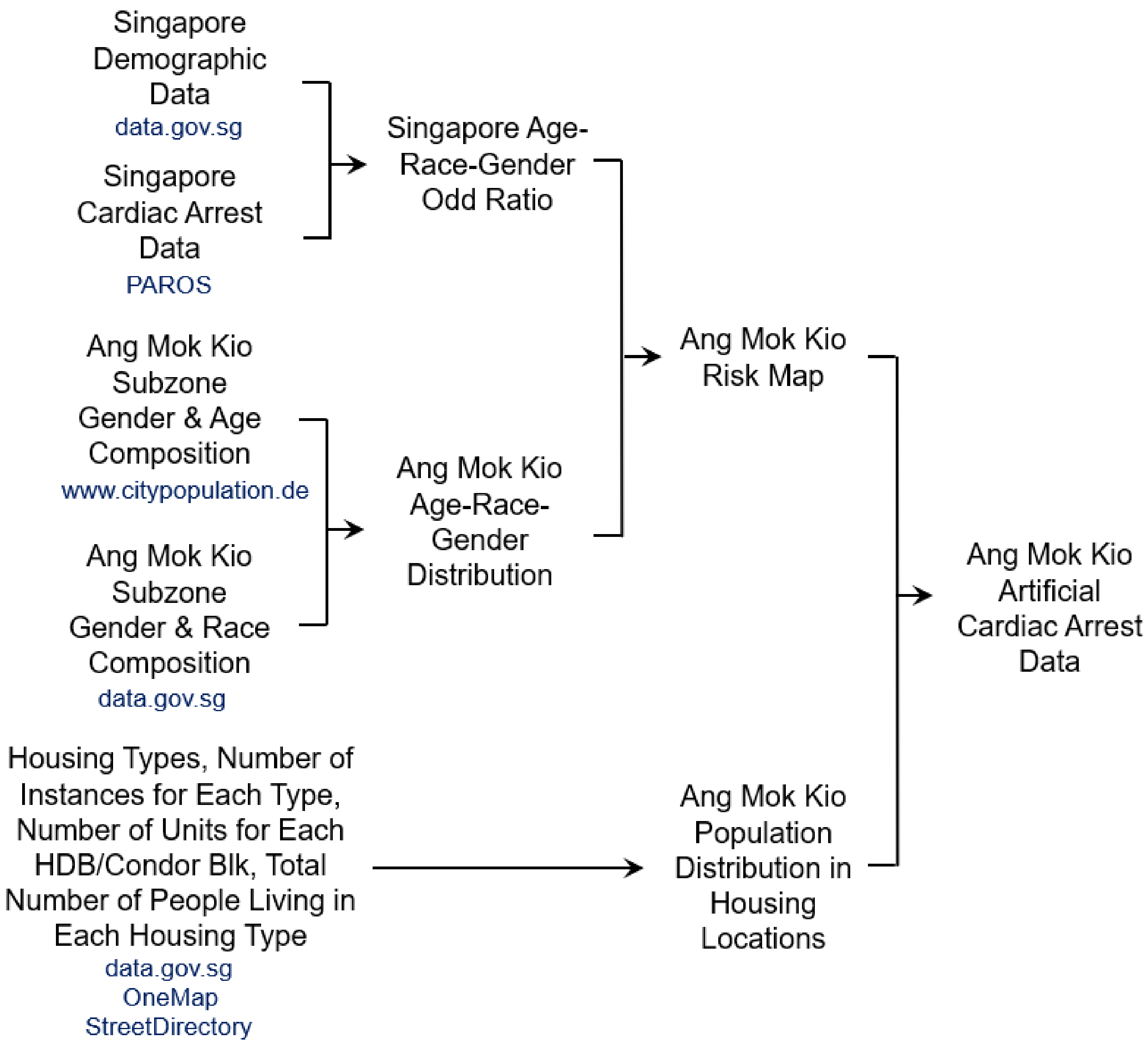


Problem subzone Kebun Bahru

only 9 AED, a lot of people, low AED/ODDS

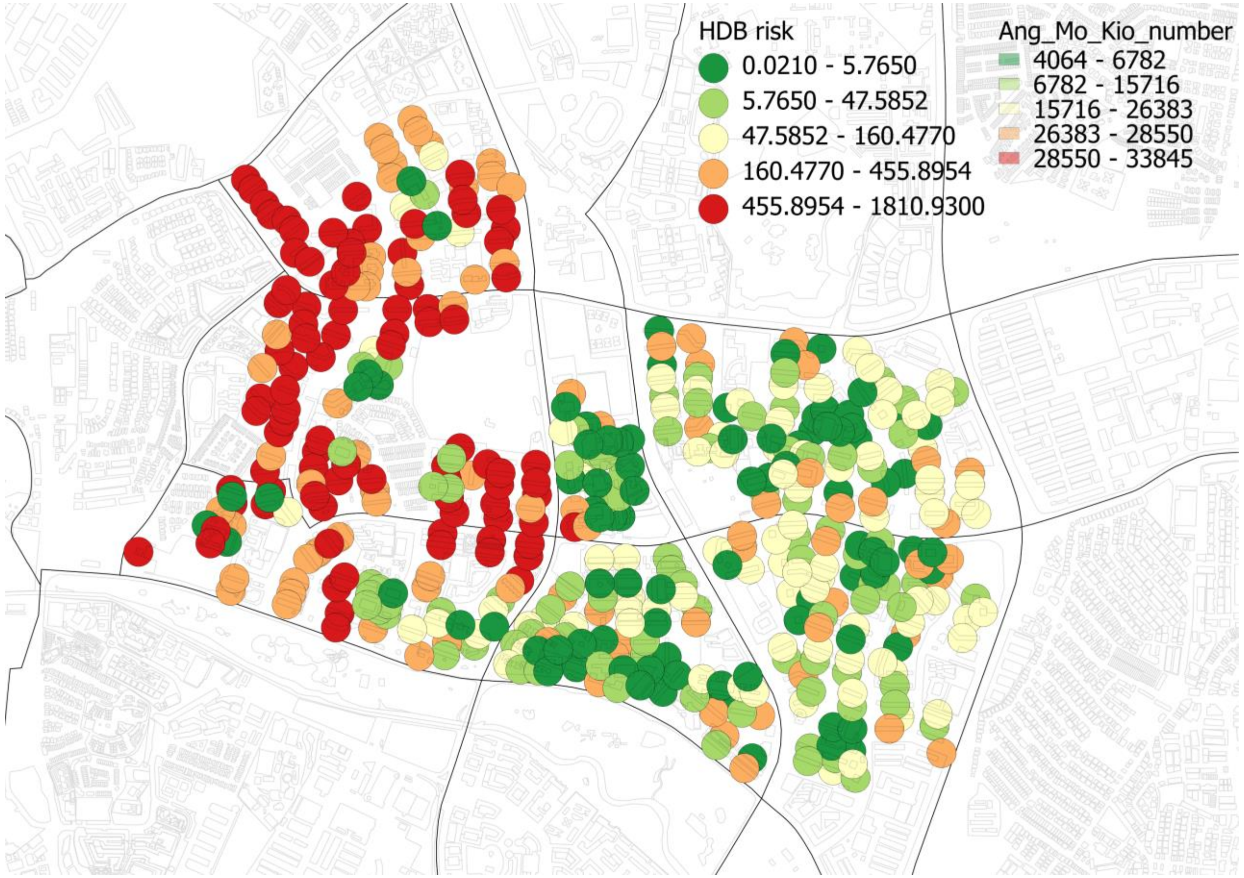
Artificial Heart Attack Data Generation

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



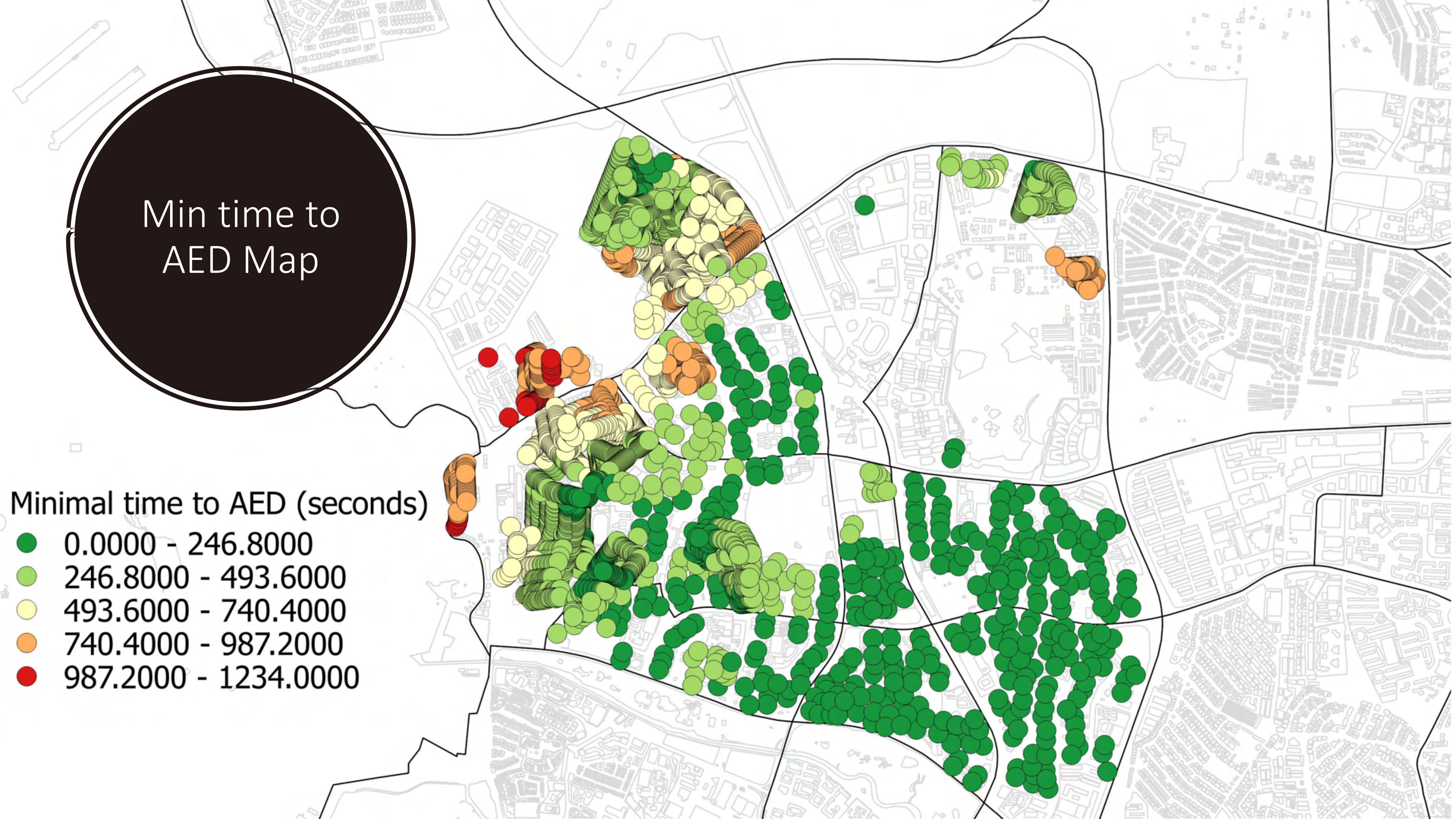
HDB risk map

- $R_{hdb} = t_{min}(crd_{hdb})un_{hdb}R_s,$
- 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



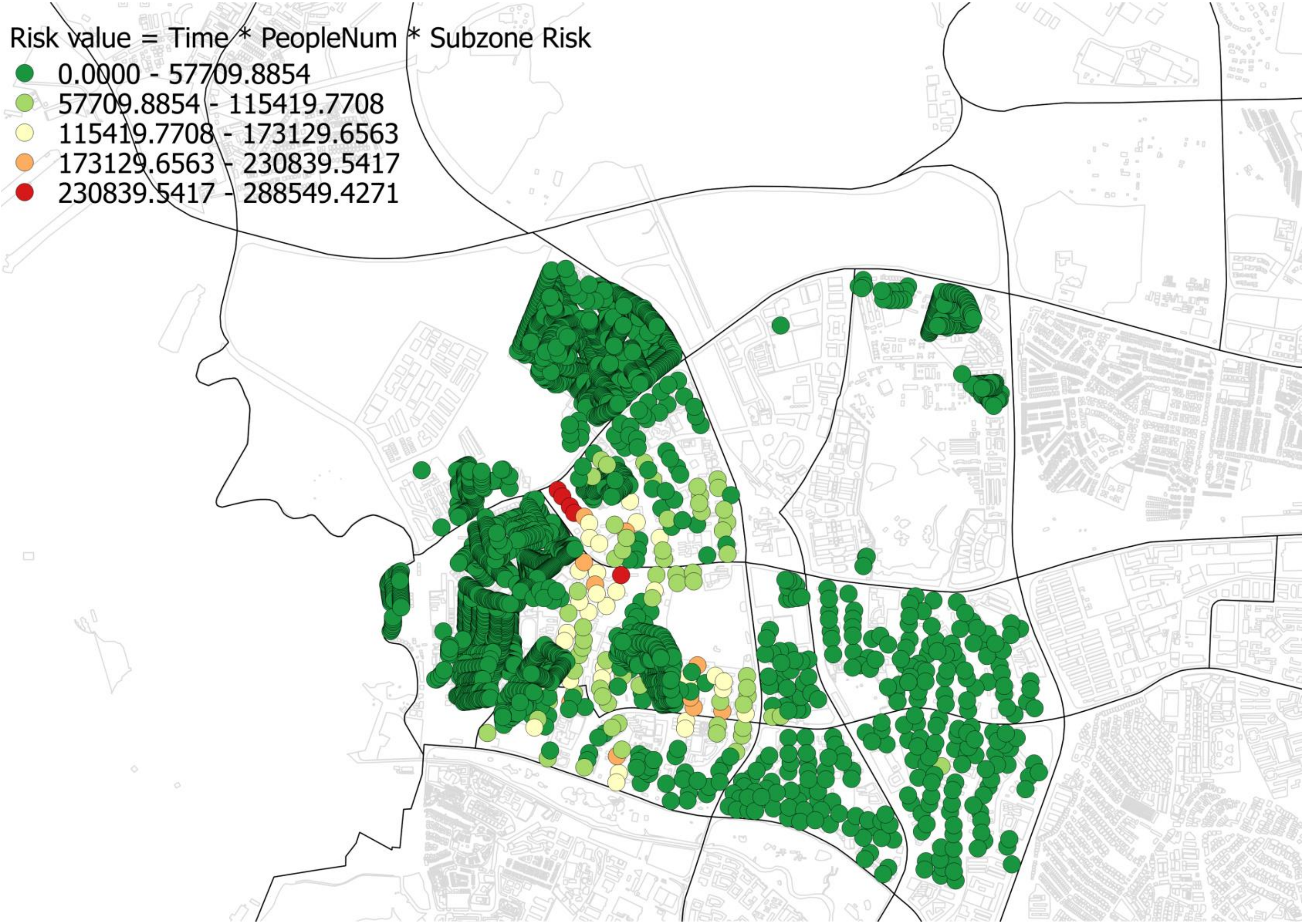

AMK
Houses
types Map
Condo
Landed
HDB
Singap_polygons

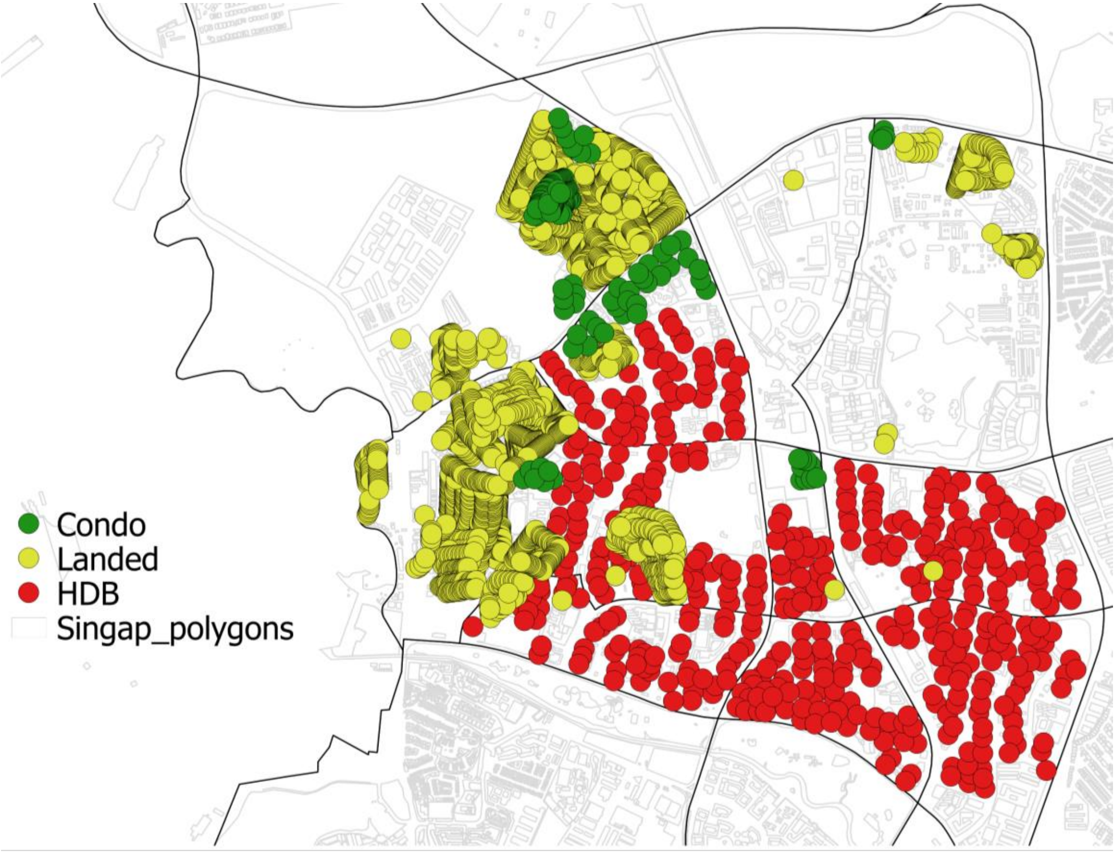
Min time to AED Map



Static Risk Map

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




Condo
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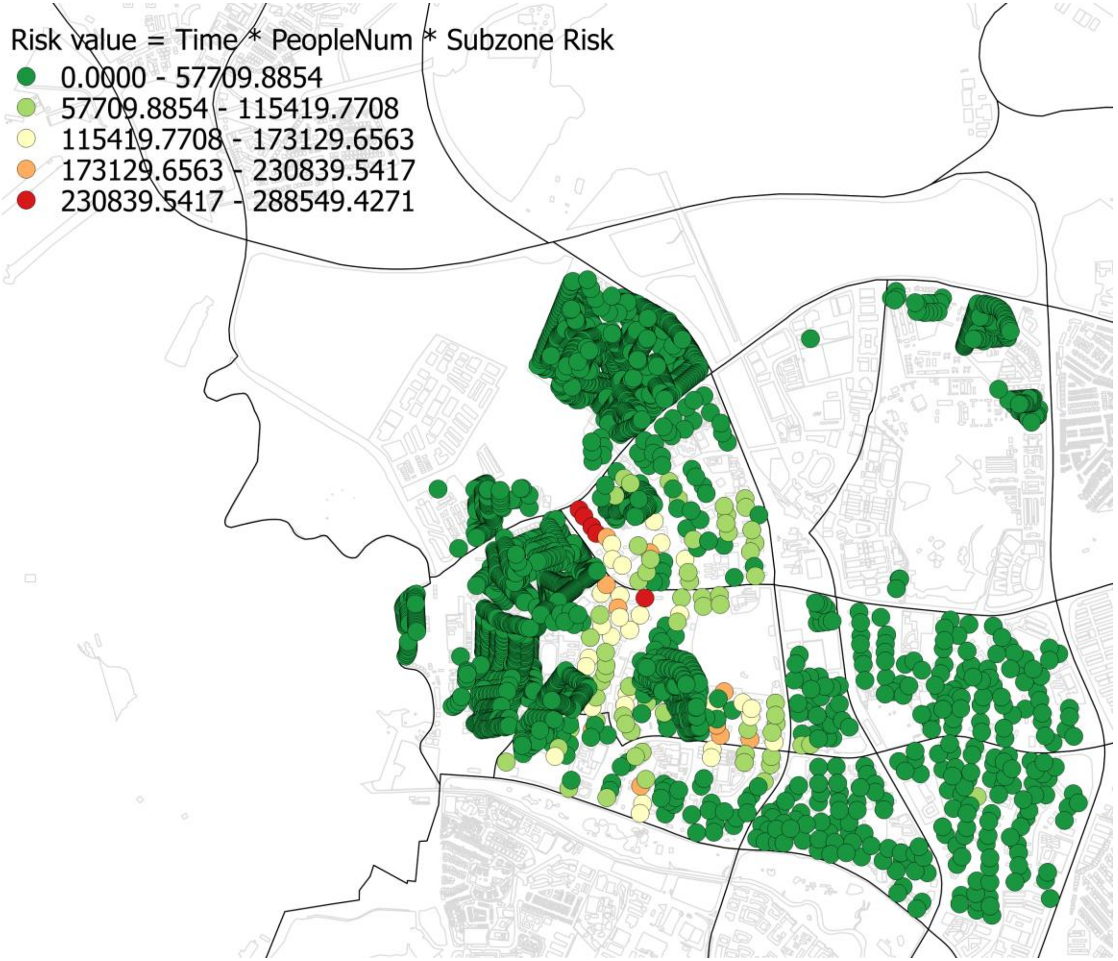

Risk value = Time * PeopleNum * Subzone Risk
0.0000 - 57709.8854
57709.8854 - 115419.7708
115419.7708 - 173129.6563
173129.6563 - 230839.5417
230839.5417 - 288549.4271

Part 2. AED relocation methods

Purpose of research task

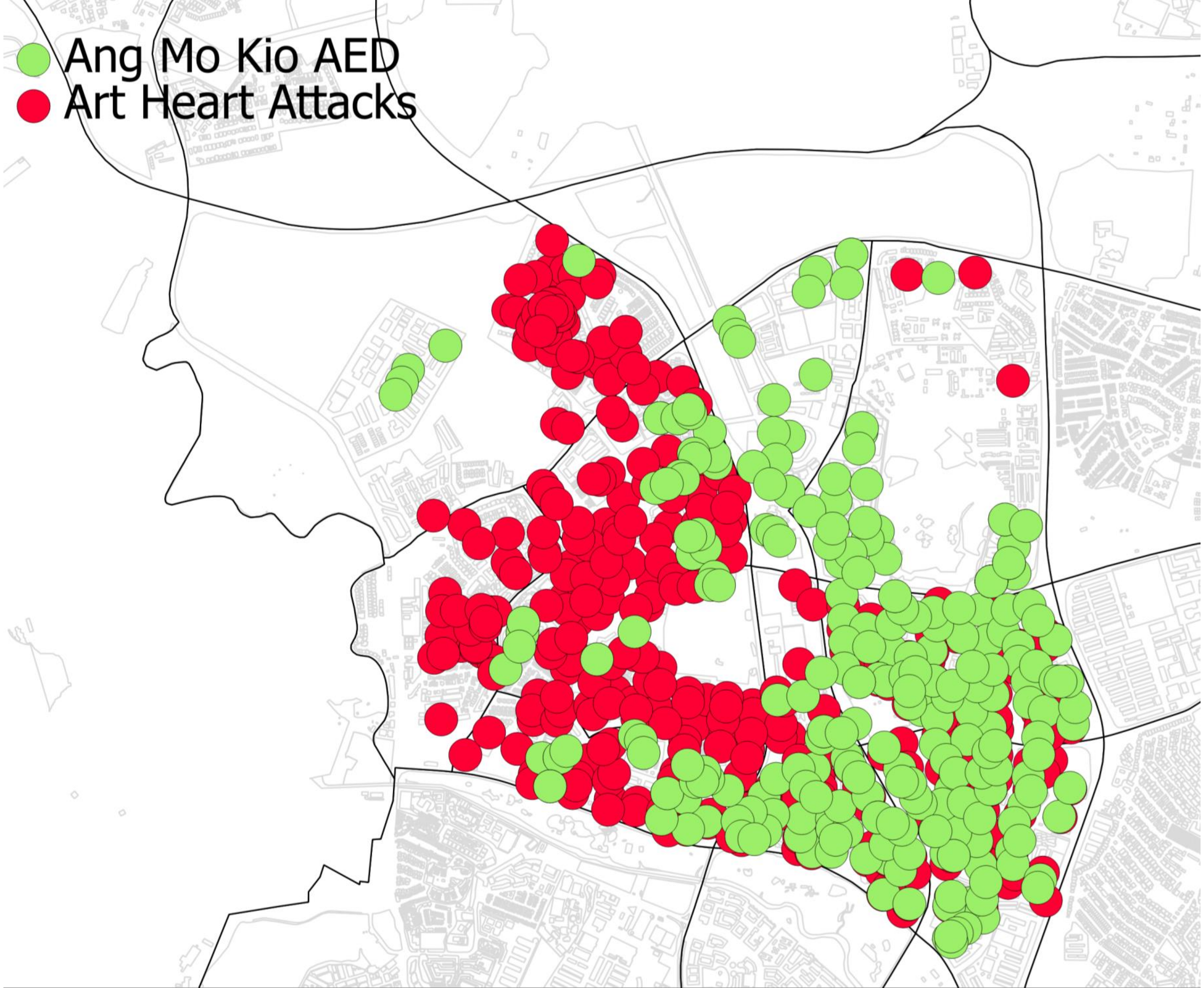
Goal: Optimization AED locations for Ang Mo Kio;

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

Artificial heart attacks data (386 ha)



Optimization Genetic Algorithm

Genetic Algorithm

First population

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

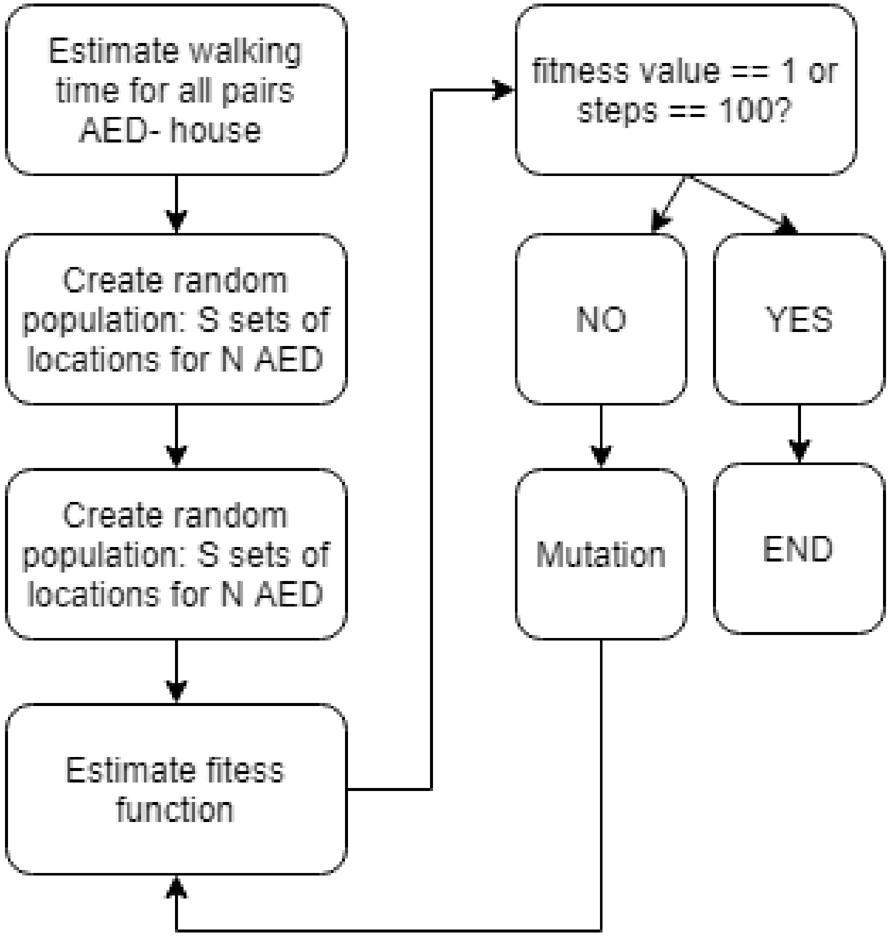
100 sets in start population

Mutation

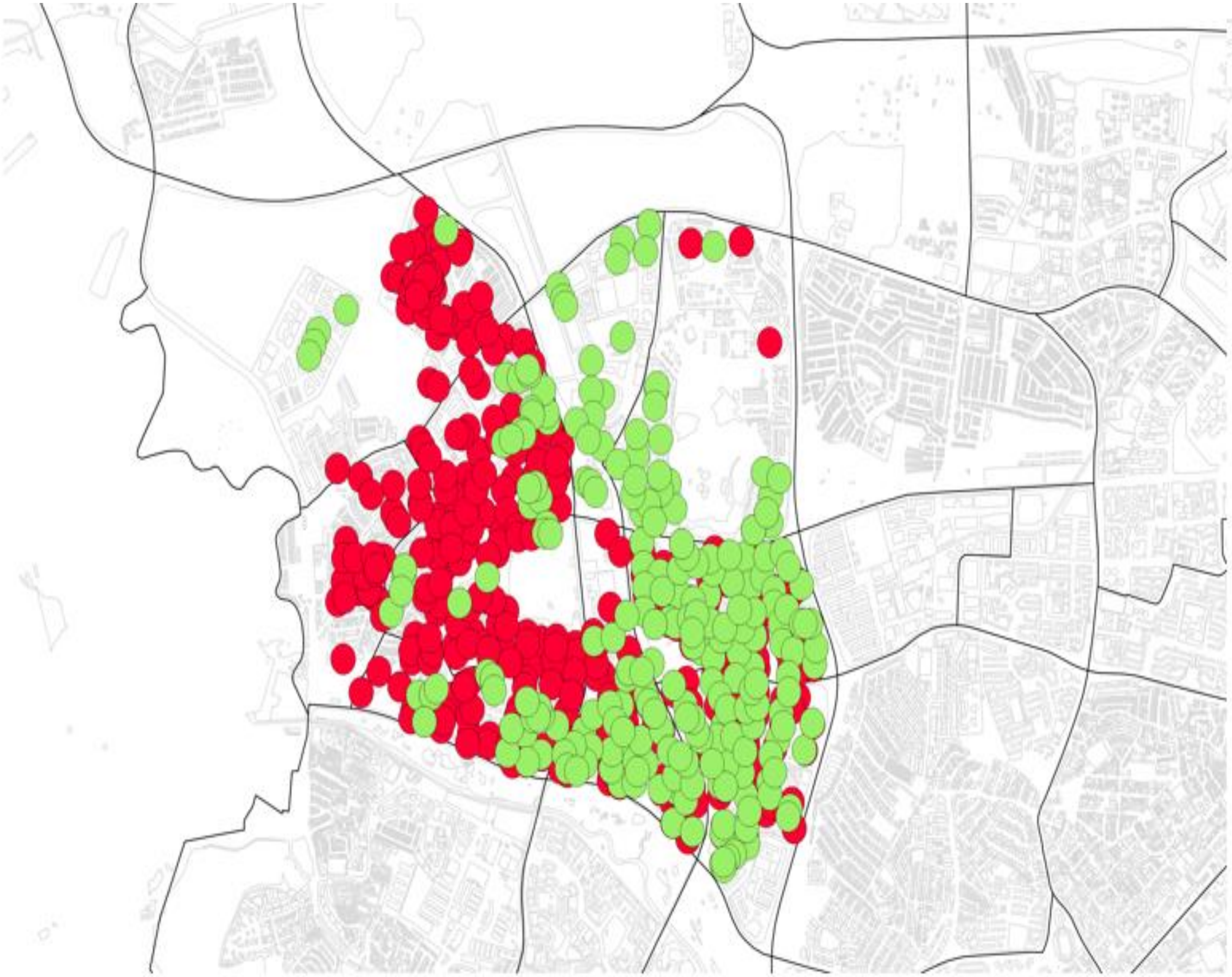
Genes for change are selected on the basis of the probability distribution, depending on the number of artificial cardiac arrests that are only near this location (the dependence is inversely proportional).

Fitness function

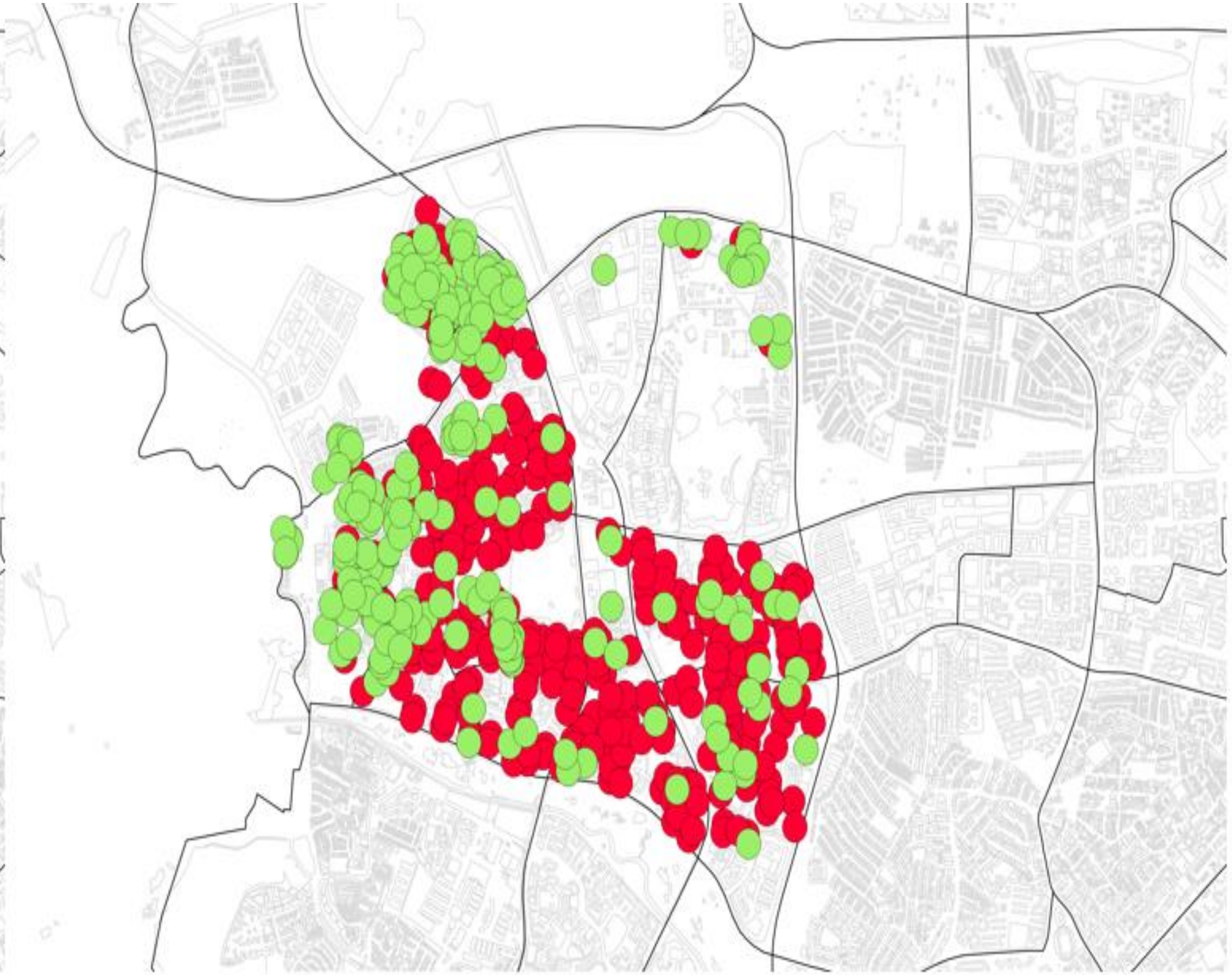
$$|G|/_{|H|} \rightarrow max$$



Optimization results AED(green) heart attacks(red)

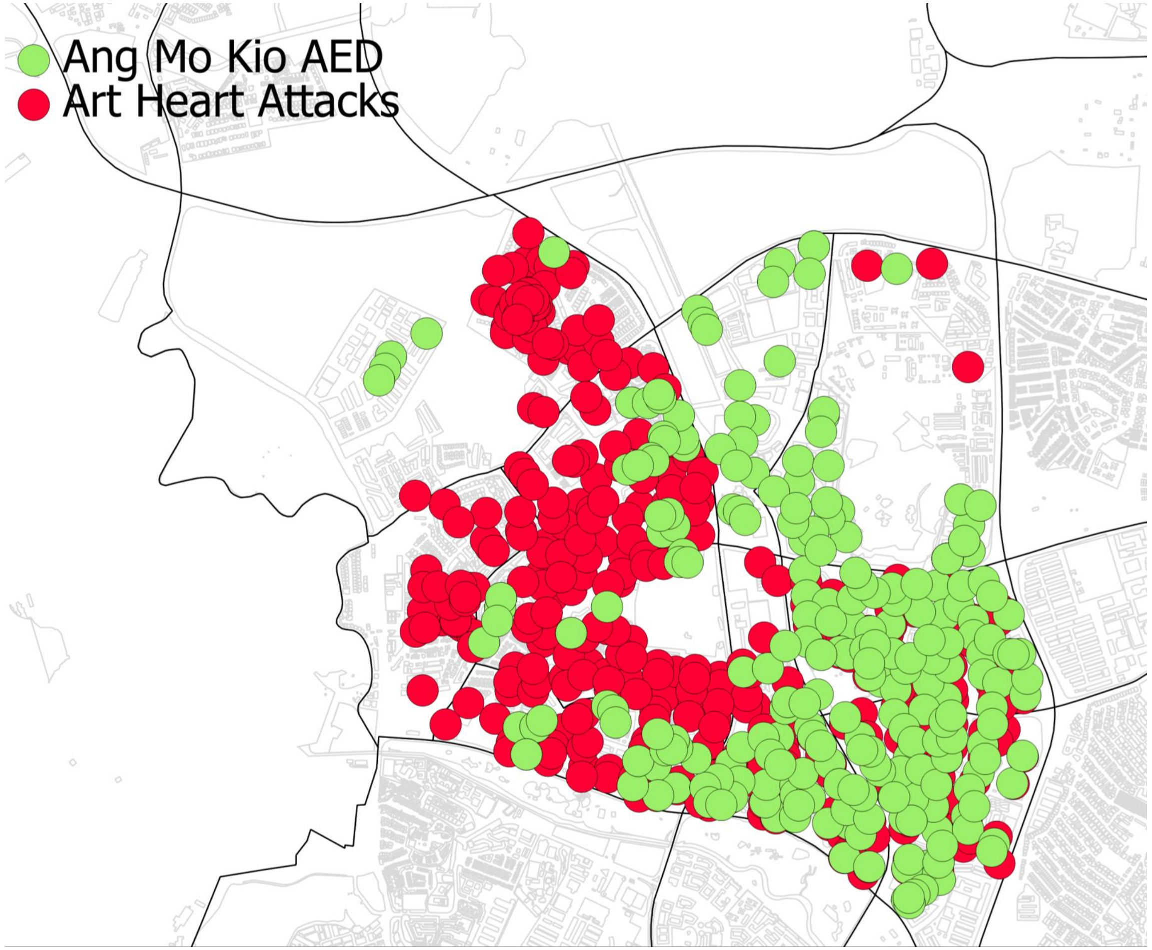


Current AED locations 87% ha <= 4 min

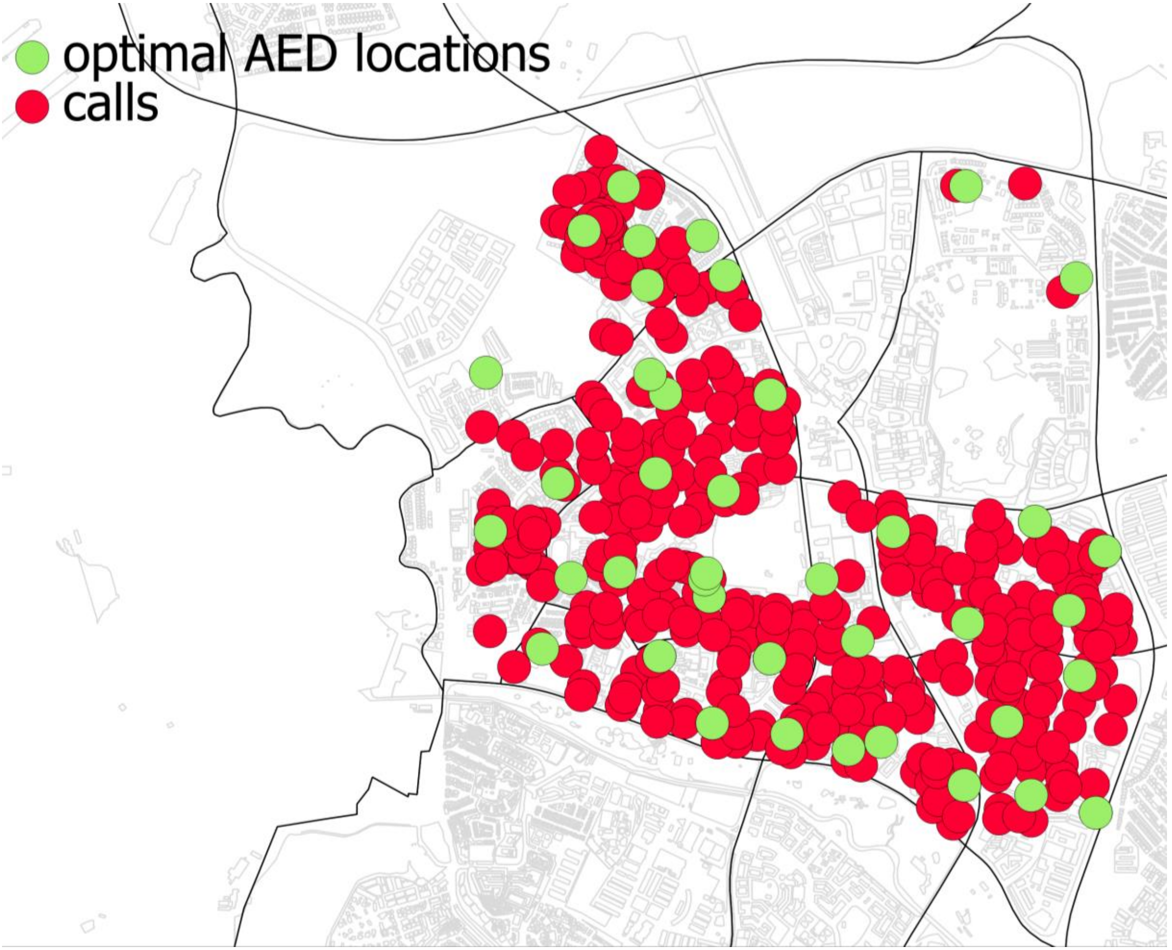


Optimal AED locations 100% ha <= 4 min

Multicriterial optimization results: Genetic algorithm

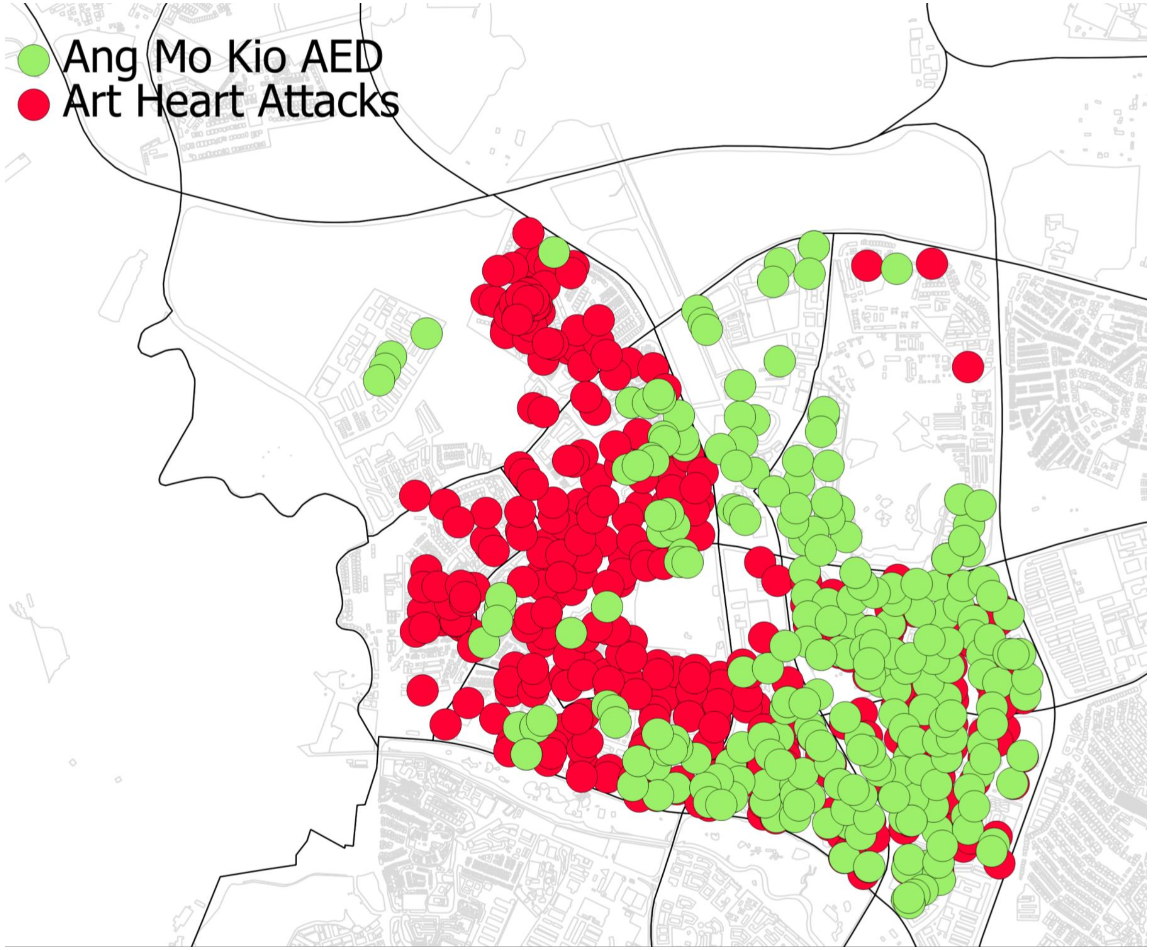


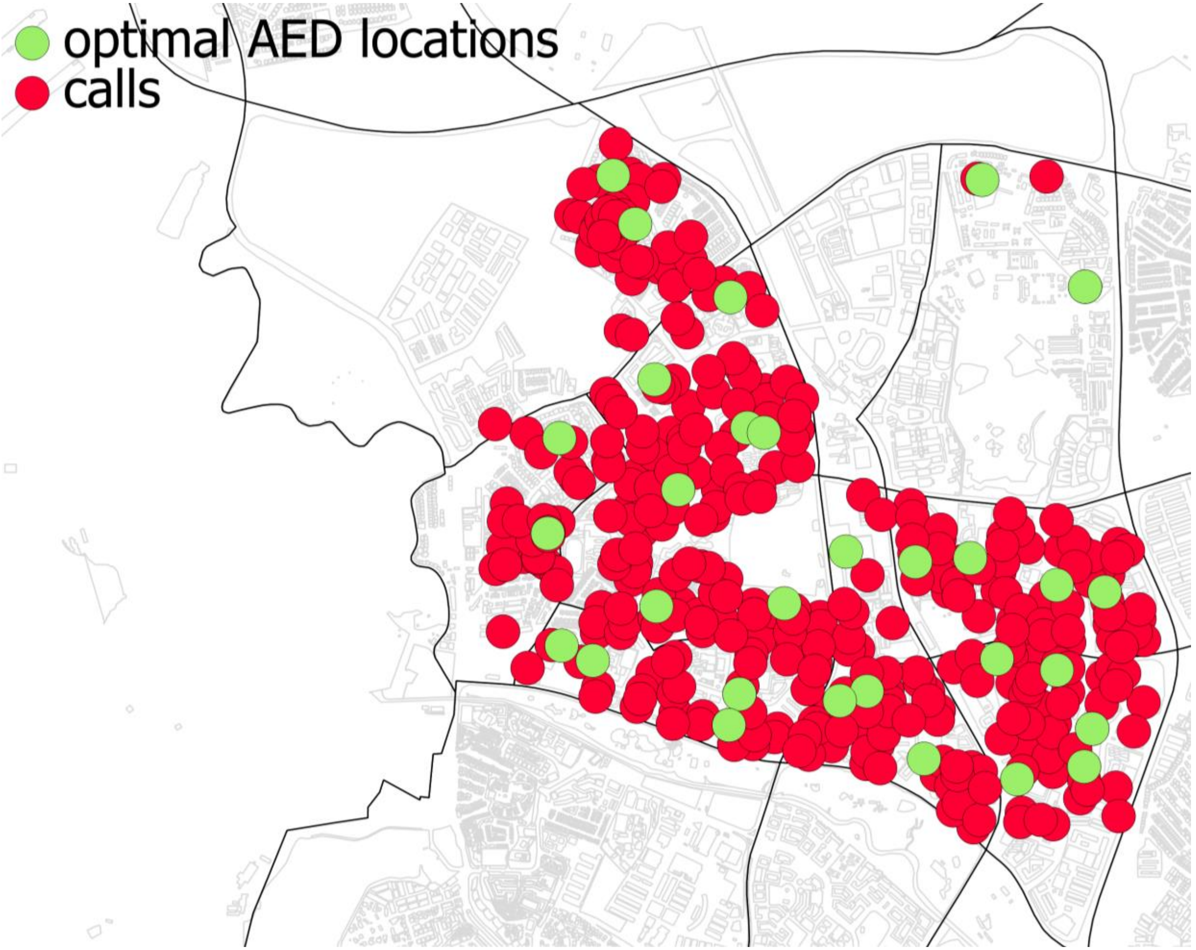
Current - 267 AED , 87% ha <= 4 min



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

Set covering optimization: Greedy algorithm



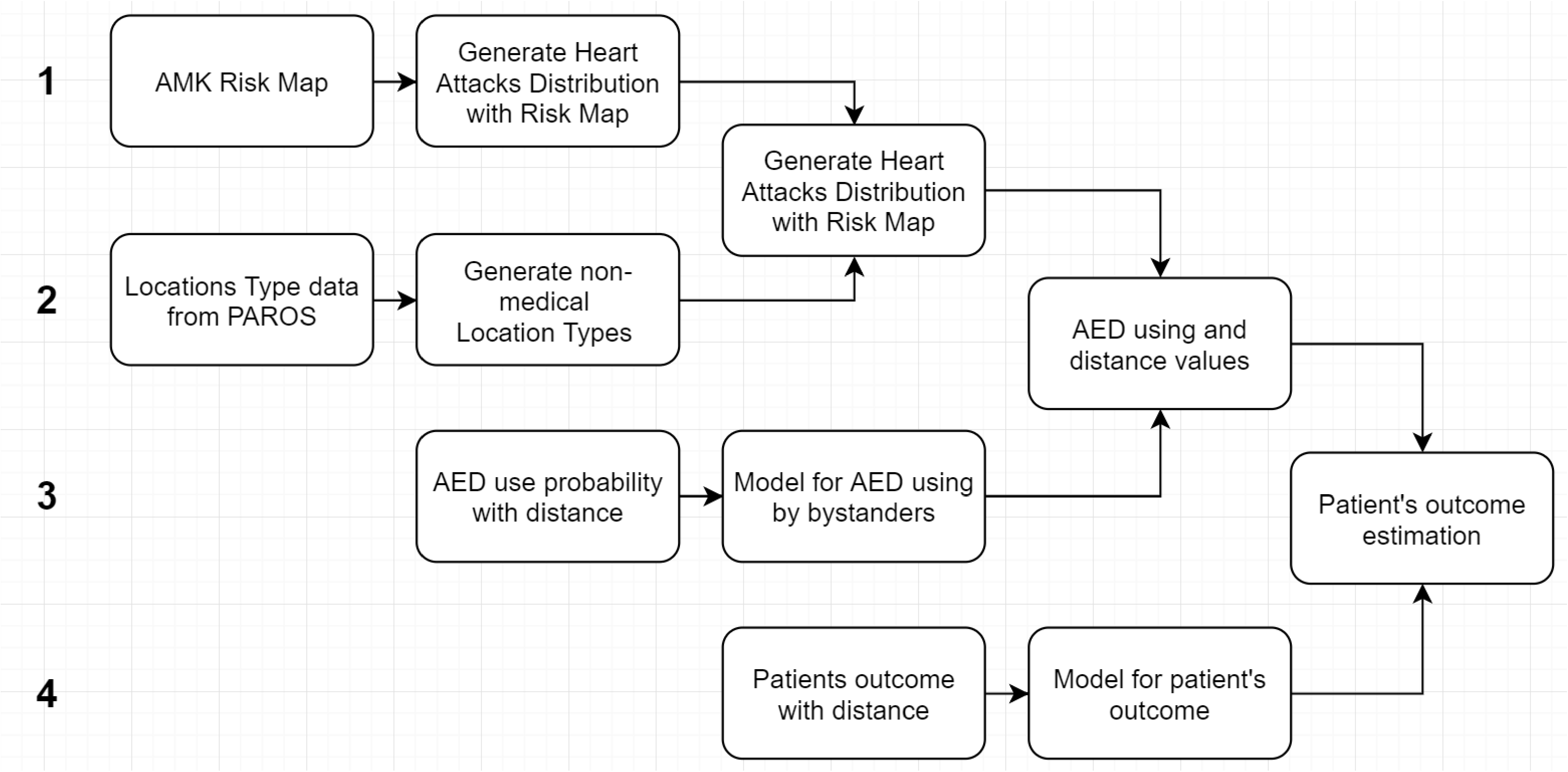


Current - 267 AED , 87% ha <= 4 min

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

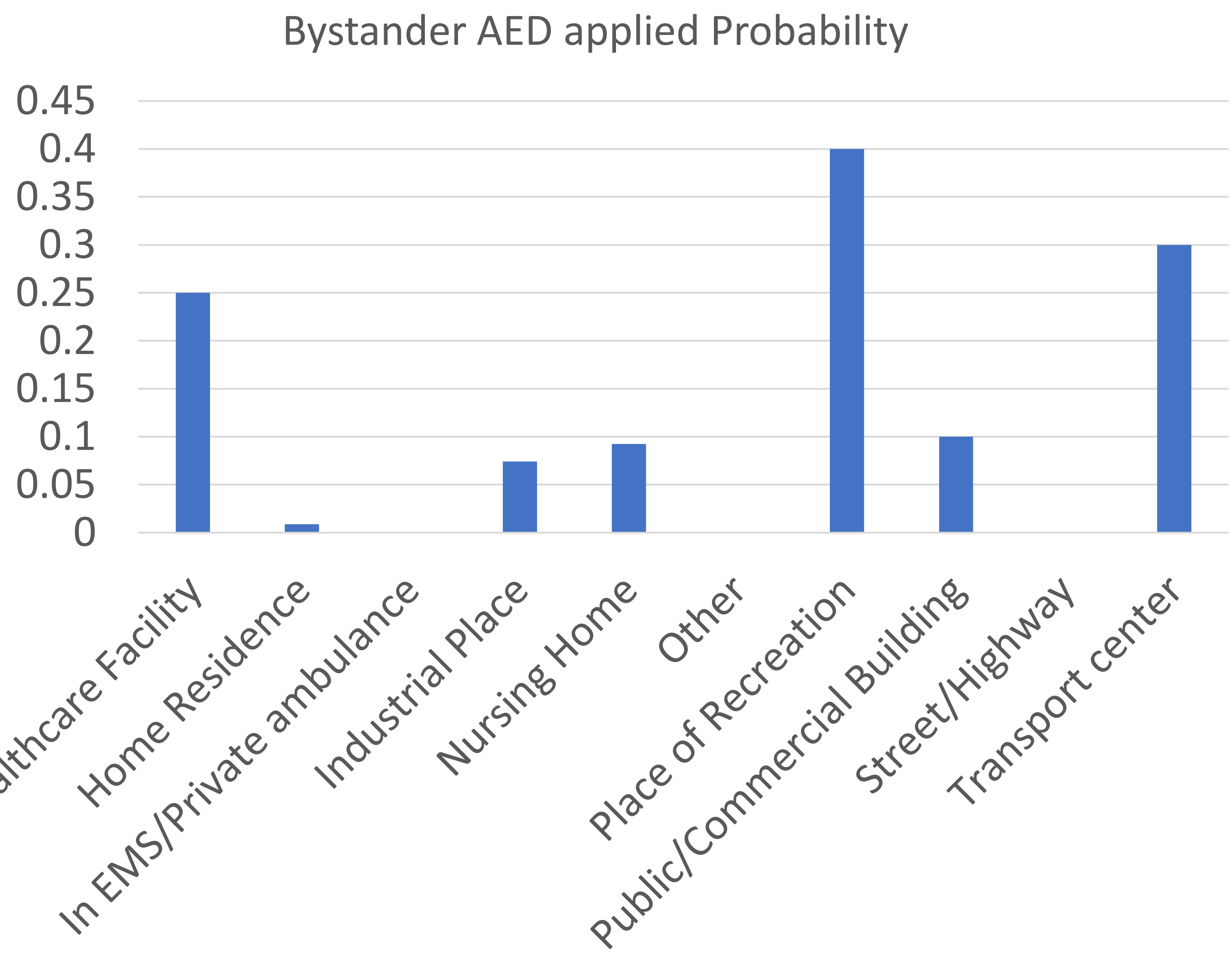
2. Bystander AED use probability with Location Type

Dataset 1691 cases in 2016

Bystander AED applied 63 cases – 3,72%

Home Residence – 1286

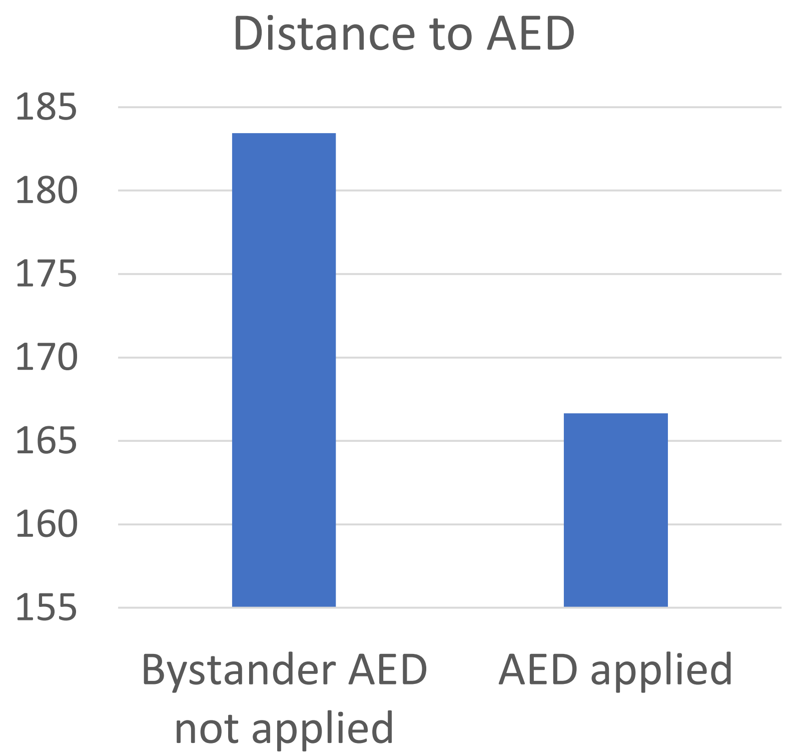
Bystander AED applied – 0,87%



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

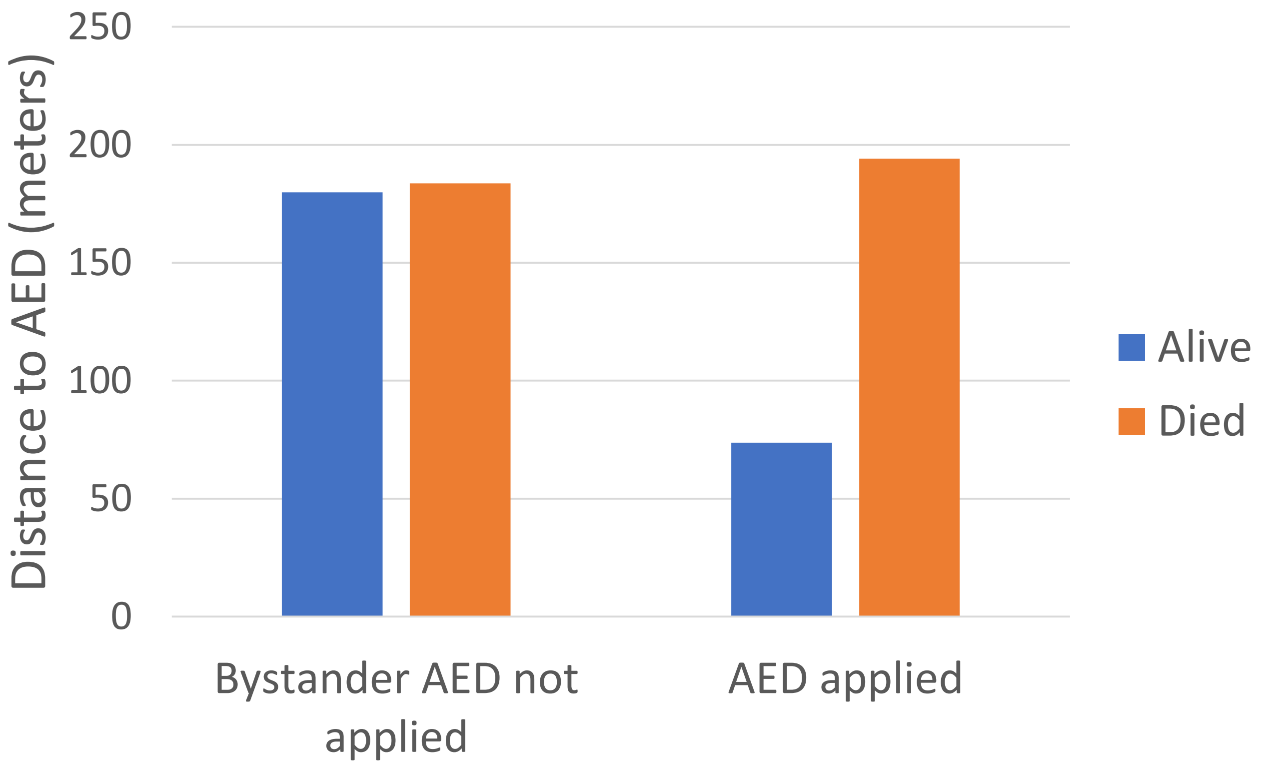
Died in ED or Died in the hospital – 1540 cases

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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