Atlanta's Hospital Accessibility:

A case study using E2SFCA

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Background

- The most ideal location principle for healthcare facilities is to provide equal access (Lovett et al., 2002).
- Healthcare facilities are essential to human life and have a more significant impact than any other public facility.
- It should be not only accessible, but also equally accessible anywhere.

(reuters.com, 2021)

- Accessibility to a hospital is affected by distance and time. Supply and demand should also be considered when analyzing these factors. (Kanuganti et al., 2016).

Purpose

- Visualize the results to see the differences in hospital accessibility by region.
- This study provides data for policymakers to see differences in accessibility to hospitals and refer to policy decisions.

Methodology

- Analysis Area: Atlanta Metropolitan Area (County: Fulton, De kalb, Gwinnett, Cobb)
- Analysis Unit: Census tract
- Methodology: E2SFCA (Enhanced Two-Step Floating Catchment Area)
- Tools: Python, ArcGIS Pro

Method: 2SFCA

1) First step

$$R_j = \frac{S_j}{\sum_{k \subset \{d_{kj} \le d_0\}} P_k}$$

where

R_j: the supply-to-demand ratio of location j.
S_j: the degree of supply (e.g., number of doctors) at location j.
P_k: the degree of demand (e.g., population) at location k.
d_{kj}: the travel cost between locations k and j.
d_0: the threshold travel cost of the analysis.

(github.com/jparkgeo, 2022)

- j: Hospital
- R_j: the supply-to-demand ratio of hospital
- S_j: the degree of supply at the hospital – the number of beds
- P_k: the degree of demand at the hospital – Population
- d_{kj}: the distance between the hospital and the center point of the area
- d_0: Maximum distance access to the hospital

2) Second Step

$$A_i = \sum_{j \subset \{d_{ij} \le d_0\}} R_j$$

where

A_i: the accessibility measures at location i.
R_j: the supply-to-demand ratio of location j.

(github.com/jparkgeo, 2022)

- i: center point of the area
- j: Hospital
- A_i: the accessibility to hospital j area i
- R_j: the supply-to-demand ratio Hospital j

Enhanced Method: E2SFCA

1) First Step

$$R_j = \frac{S_j}{\sum_{k \in \{t_{kj} \leq t_0\}} P_k W_k}$$

where

R_j: the supply-to-demand ratio of location j.

S_j: the degree of supply (e.g., number of doctors) at location j.

P_k: the degree of demand (e.g., population) at location k.

t_{kj}: the travel time between locations k and j.

t_0: the threshold travel time of the analysis.

W_k: Weight based on a distance decay function

$$R_j = \frac{S_j}{\sum_{k \in \{t_{kj} < t_1\}} P_k W_1 + \sum_{k \in \{t_1 < t_{kj} < t_2\}} P_k W_2 + \sum_{k \in \{t_2 < t_{kj} < t_3\}} P_k W_3}$$

(github.com/jparkgeo, 2022)

- R_j: the supply-to-demand ratio of hospital
- S_j: the degree of supply at the hospital - the number of beds
- P_k: the degree of demand at the hospital - Population
- t_{kj}: the travel time between locations k and j
- t_0: maximum time available to access the hospital
- W_k: Weight based on a distance decay function

- Apply weigths differently over time

2) Second Step

$$A_i = \sum_{j \in \{t_{ij} \leq t_0\}} R_j W_j$$

where

A_i: the accessibility measures at location i.

R_j: the supply-to-demand ratio of location j.

W_j: Weight based on a distance decay function

$$A_i^M = \sum_{j \in \{t_{ij} < t_1\}} R_j W_1 + \sum_{j \in \{t_1 < t_{ij} < t_2\}} R_j W_2 + \sum_{j \in \{t_2 < t_{ij} < t_3\}} R_j W_3$$

(github.com/jparkgeo, 2022)

- i: center point of the area
- j: Hospital
- A_i: the accessibility to hospital j from area i.
- R_j: the supply-to-demand ratio Hospital j.
- W_j: Weight based on a distance decay function

3) Data

- Population data obtained from census 2020 Atlanta tracts as ".csv" format
- Image files obtained from census Atlanta tracts as ".shp" fomat
- GA hospital data involved the number of staffed beds and their location [coordinate(X,Y)]
- geocoded hospitals shape file using Google earth pro
- Age range of Atlanta population
- Age range of hospital utilization in the United States

*The coordinate system uses EPSG: 26967 (NAD83 / Georgia West)
(Area of use: United States (USA) - Georgia - county of Cobb, De Kalb, Fulton, Gwinnett etc.)

Population in Atlanta

census, 2020

https://data.census.gov/cedsci/

Census tracts

shapefile in Atlanta

https://www.census.gov/programs-surveys/geography.html

Atlanta Hospitals

staffed beds, coordinate(X,Y) data

https://www.officialusa.com/stateguides/health/hospitals/georgia.html

Google Earth Pro

geocoded hospitals shape file

https://www.google.com/intl/ko/earth/versions/

Atlanta Population by age

census, 2020

https://data.census.gov/cedsci/

Hospital utilizantion

by age in United States

https://www.cdc.gov/nchs/hus/contents2019.htm
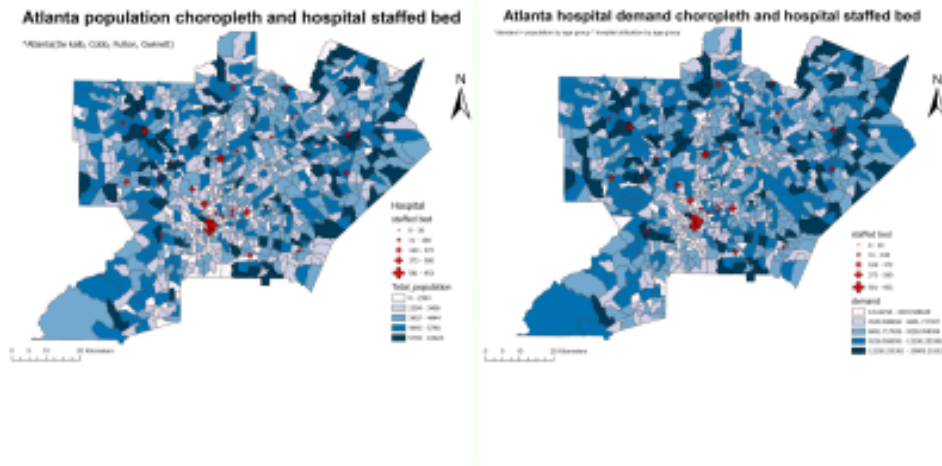
Data Analysis

1) Workflow

2) weights

Atlanta population choropleth and hospital staffed bed
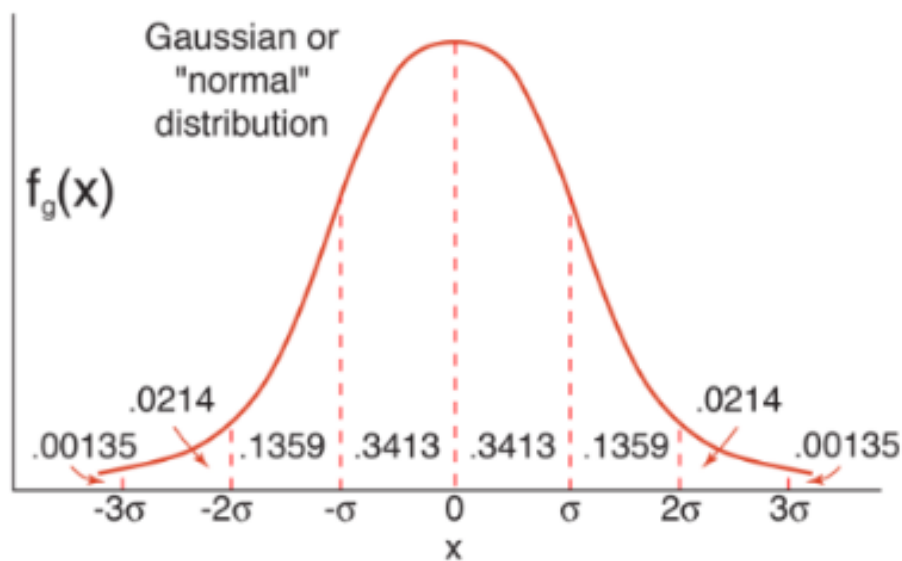
Atlanta hospital demand choropleth and hospital staffed bed
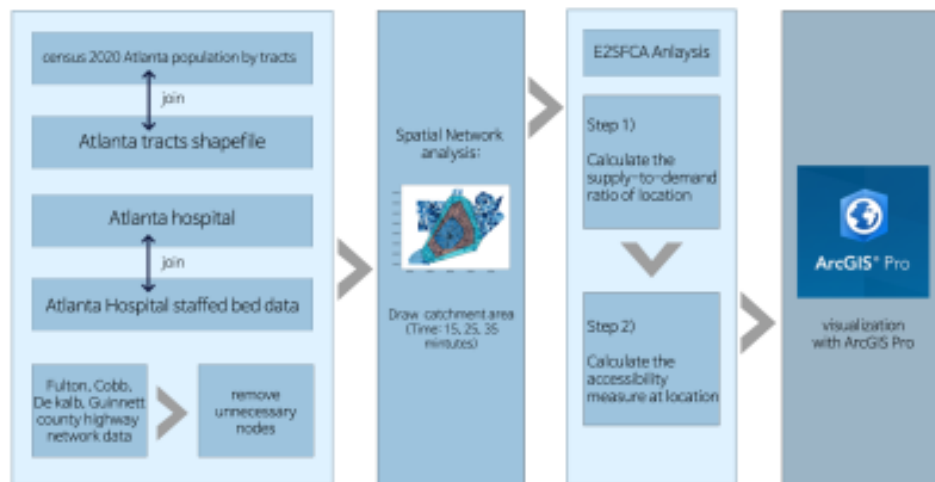
- Left : Atlanta Population Choropleth and Hospitals.
- Right : Atlanta Hospital Demand Choropleth and Hospital Staffed bed. (*Demand = population by age group * hospital utilization ratio by age group)

For Weight based on a distance decay function….(E2SFCA)

Gaussian or "normal" distribution

$f_g(x)$

.00135   .0214   .1359   .3413   .3413   .1359   .0214   .00135

-3σ   -2σ   -σ   0   σ   2σ   3σ

X

- The average time spend on the road when an American go to hospital is 35 minutes.
- Set the threshold time to travel up to 35 minutes, 25 minutes, and 15 minutes respectively.
- Set the weight to 1, 0.68, 0.22 for each catchment area Weight is defined by Gaussian function

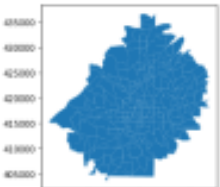- The closer the distance, the higher the weighting (area under slope).

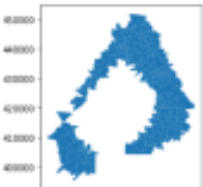| Minute	15min	25min	35min
Weights	1	0.68	0.22

3) Network analysis
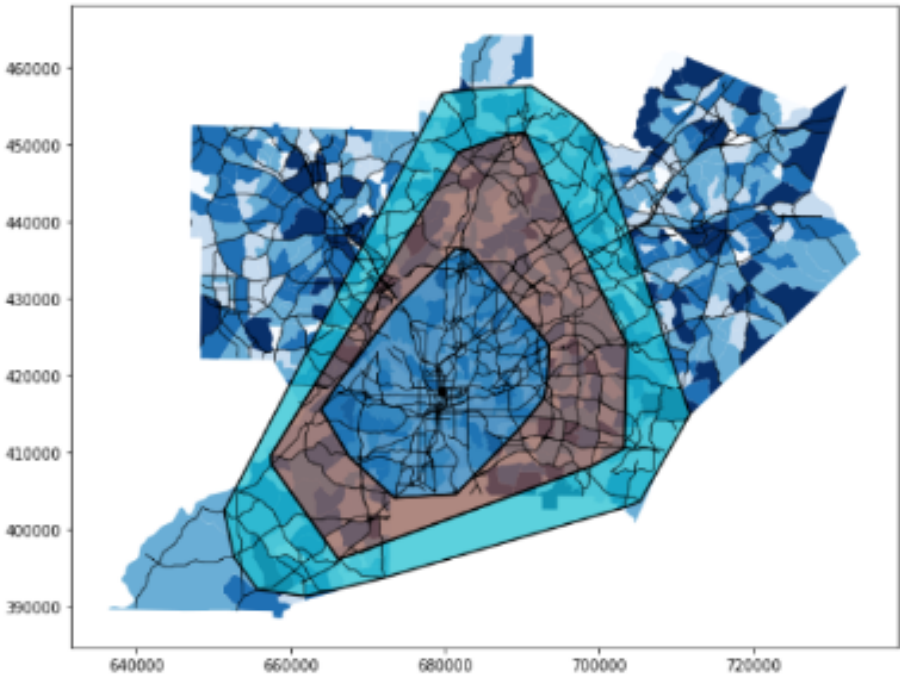
- The accessible ranges of 15, 25, and 35 minutes from hospital. (Dark Blue : 15 minutes, Brown : 25 minutes, Light Blue : 35 minutes)
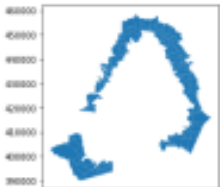
4) E2SFCA - Step 1

catchment area within 15 minutes has 1692994.490 people and its weight is 1

catchment area within 25 minutes has 1814122.121 people and its weight is 0.68

catchment area within 35 minutes has 1377746.734 people and its weight is 0.22
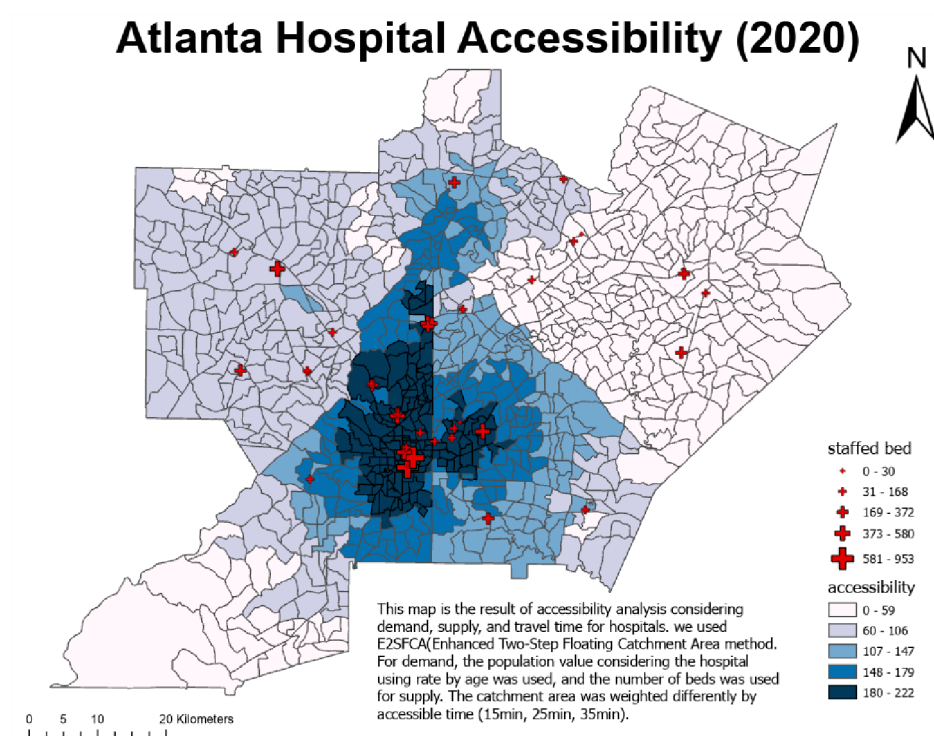
- We aim to divide supply factor to demand factor with weight value.
- Using convex hull, we extract catchment area with 15, 25, 35 threshold time. These tracts have a weight based on gaussian distribution distance decay.
- Divide the number of staffed beds to* weight population by tracts.

5) E2SFCA - Step 2

- Set an catchment area based on the centeroid of each region.
- Sum all R-values(the supply-to-demand ratio of hospital location) within the catchment area and apply a distance decay function.
- Repeat this process in all regions'centeroid to measure an A-value, which means accessibility to hospital.

Result

1) Results Map

Atlanta Hospital Accessibility Top 5 and Bottom 5 (2020)

The five areas with the highest hospital accessibility were located in the downtown of Atlanta. On the other hand, the five least accessible areas were located in the southwestern part of Atlanta

- **Top 5 tracts (Blues)**: [Census code 92.02, Fulton], [Census code 2.02, Fulton], [Census code 2.01, Fulton], [Census code 11.01, Fulton], [Census code 5.01, Fulton]

- **Lowest 5 tracts (Reds)** : [Census code 104.02, Fulton], [Census code 104.01, Fulton], [Census code 105.40, Fulton], [Census code 105.2, Fulton], [Census code 103.1, Fulton]

2) Difference in accessibility

- Good accessibility : good network, many staffed beds nearby.

- Poor accessibility : poor network, hospitals are far from tracts.

3) Direction of development

- The purpose of this study is to visualize differences in hospital accessibility in Atlanta.
- Further studies will find variables that affect medical accessibility and analyze more realistic medical accessibility.

Reference

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OUR BEST TEAM!

(left) MINSOO KIM, HYUNWOO NAM, MINJUNG SONG, SEUL LEE

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