Designing Service Coverage and Measuring Accessibility and Serviceability

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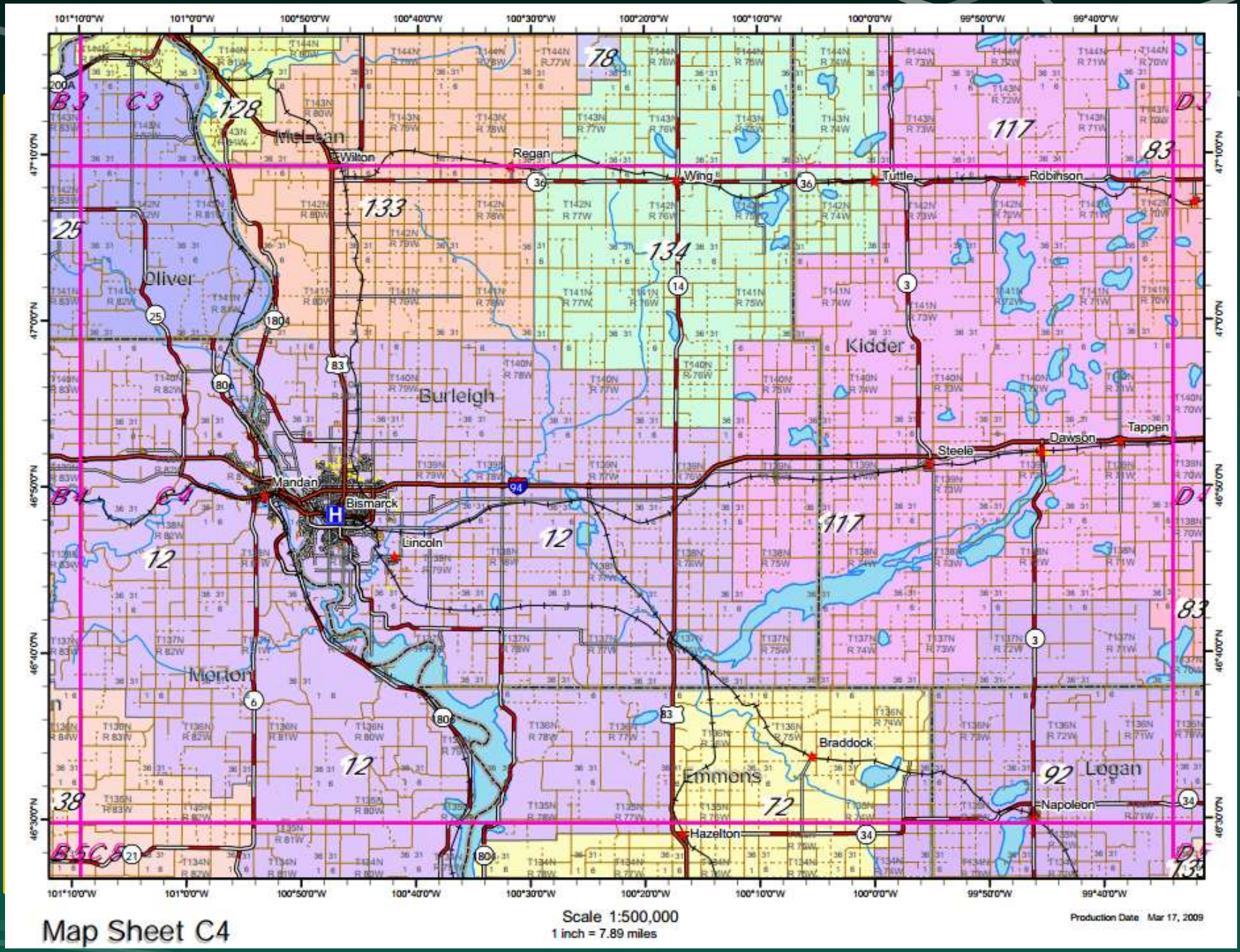
Agenda

- Introduction
- Objectives
- Previous Studies
- Model Development
  - Potential Accessibility
  - Potential Serviceability'
  - Service Coverage
- Conclusions
- Q & A

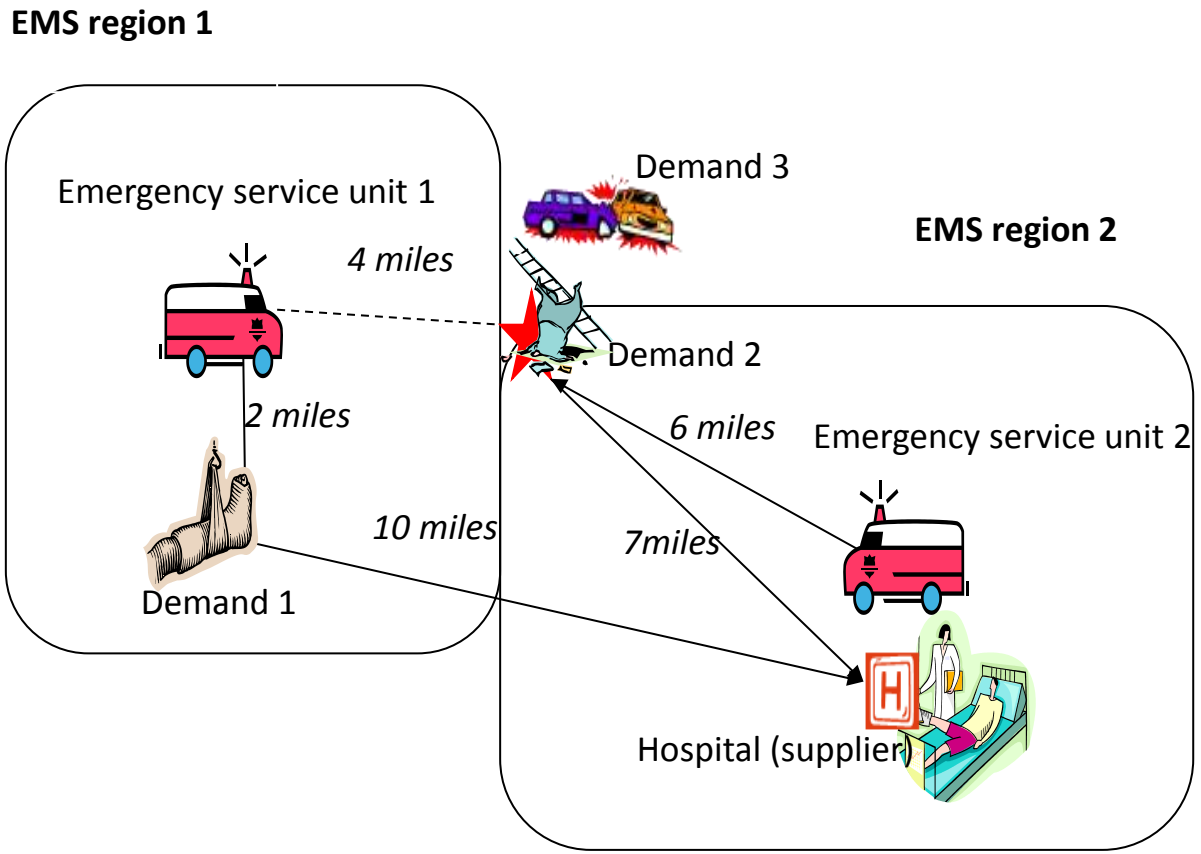
Introduction

- Planning of Emergency Medical Service (EMS)
  - Urban Area
    - Congestion
  - Rural Area
    - Road condition
    - Service distance
- Equality and Quality of Life



Source of the map: https://www.ndhealth.gov/EMS/pdfs/Map_Book/Map%20Book%20Web%20Version2.pdf

Introduction



Introduction

- Challenges of rural EMS
  - Insufficient revenue
  - Difficulty in recruiting ambulance service employees and volunteers
  - Natural barriers
  - Changing demographics
- In need of collaboration and efficient operations

Introduction

- Unlikely to provide equal service and response time throughout heterogeneous service areas
- Needs of Scientific planning
  - Rationalizing service coverage plans and response prediction
  - Providing effective public service
  - Ensuring disadvantaged groups and impaired individuals receive appropriate emergency responses

Objectives

- Designing service coverage
  - GIS-based spatial analysis
  - Analytical models to measure
    - Potential accessibility with demand-covered-ratio
    - Potential serviceability with ambulance-covering-ratio
- Location planner and service designer to assess and provide rational service coverage
  - Continuous improvement

Objectives

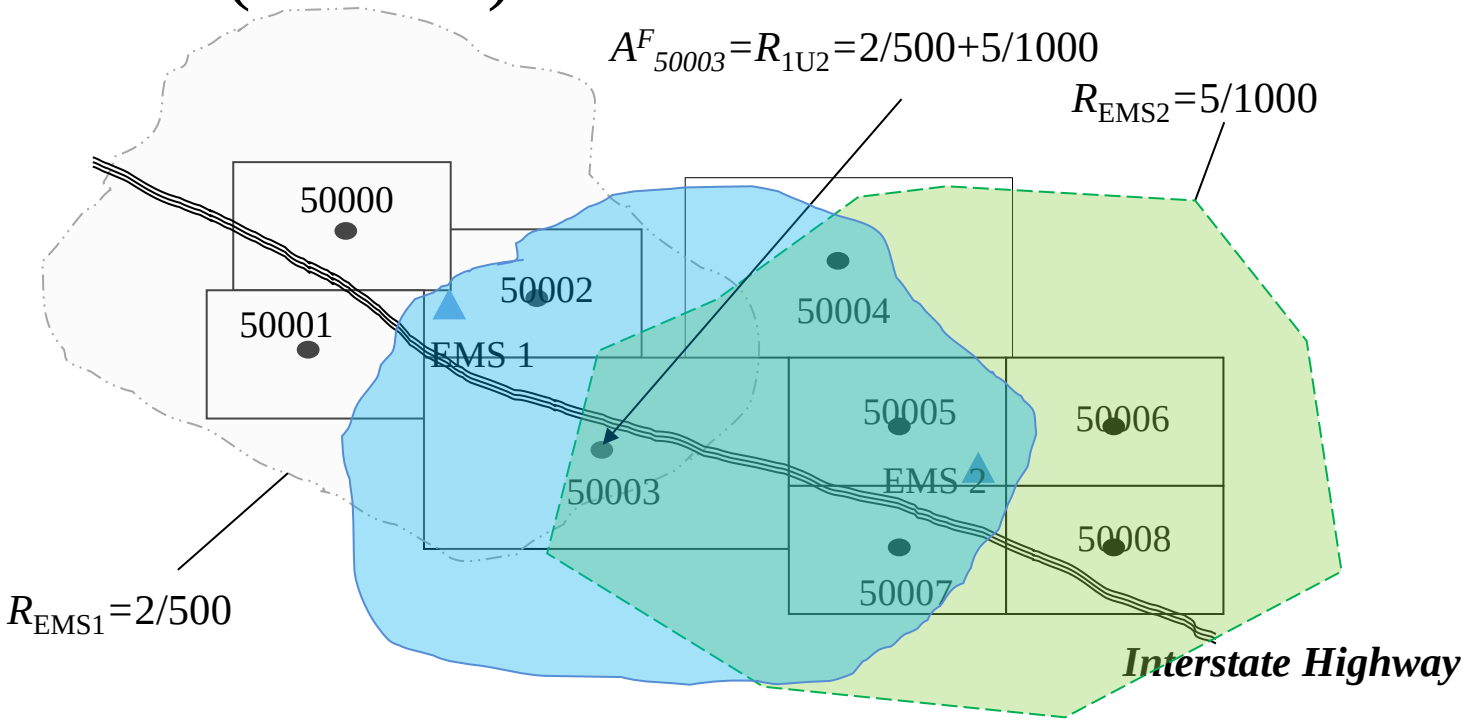
- how well the coverage matches the population distribution
- how quickly the ambulances serve the demands
- to provide maximum coverage with a fixed number of facilities.

Previous Studies

- Finding shortest path from emergency service units to crash locations
- searching service coverage based on the population of zip codes
- minimizing the required number of facilities and EMS regions using a location set covering model
- maximum coverage with a fixed number of facilities.

Previous Studies

- Illustration of the two-step floating catchment method (2SFCM).

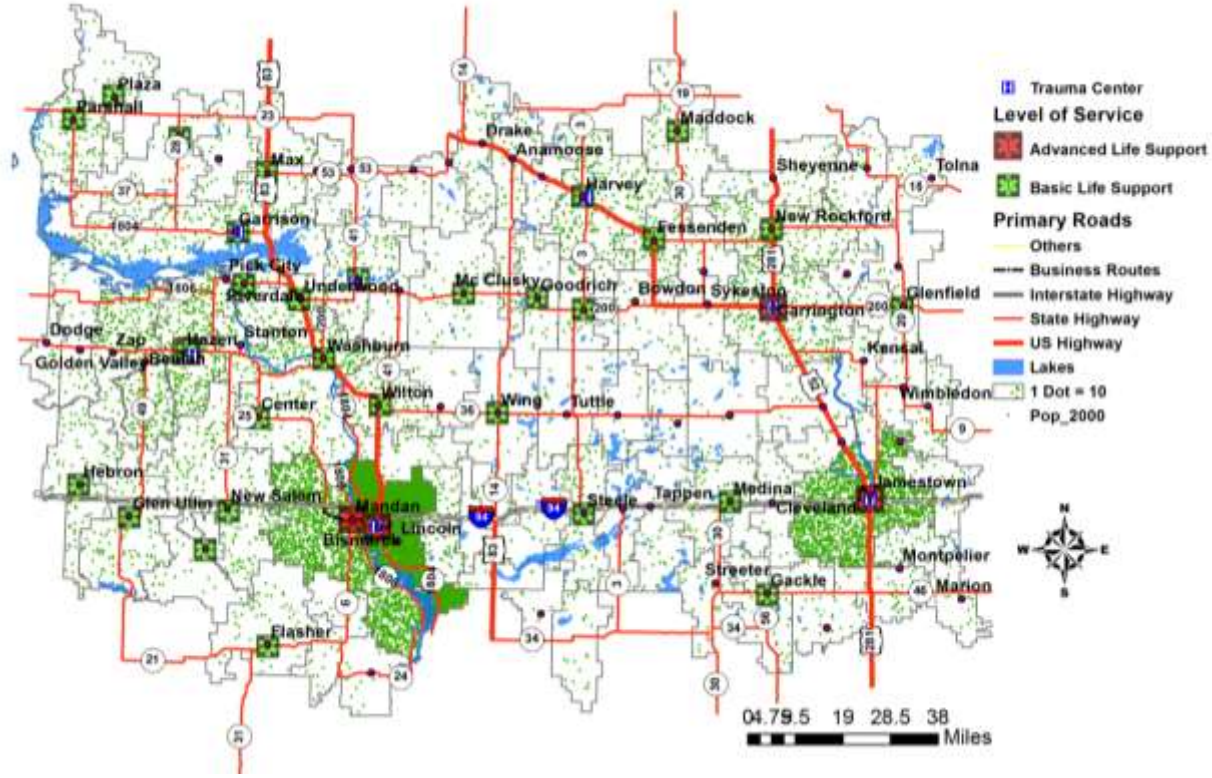


Model Development

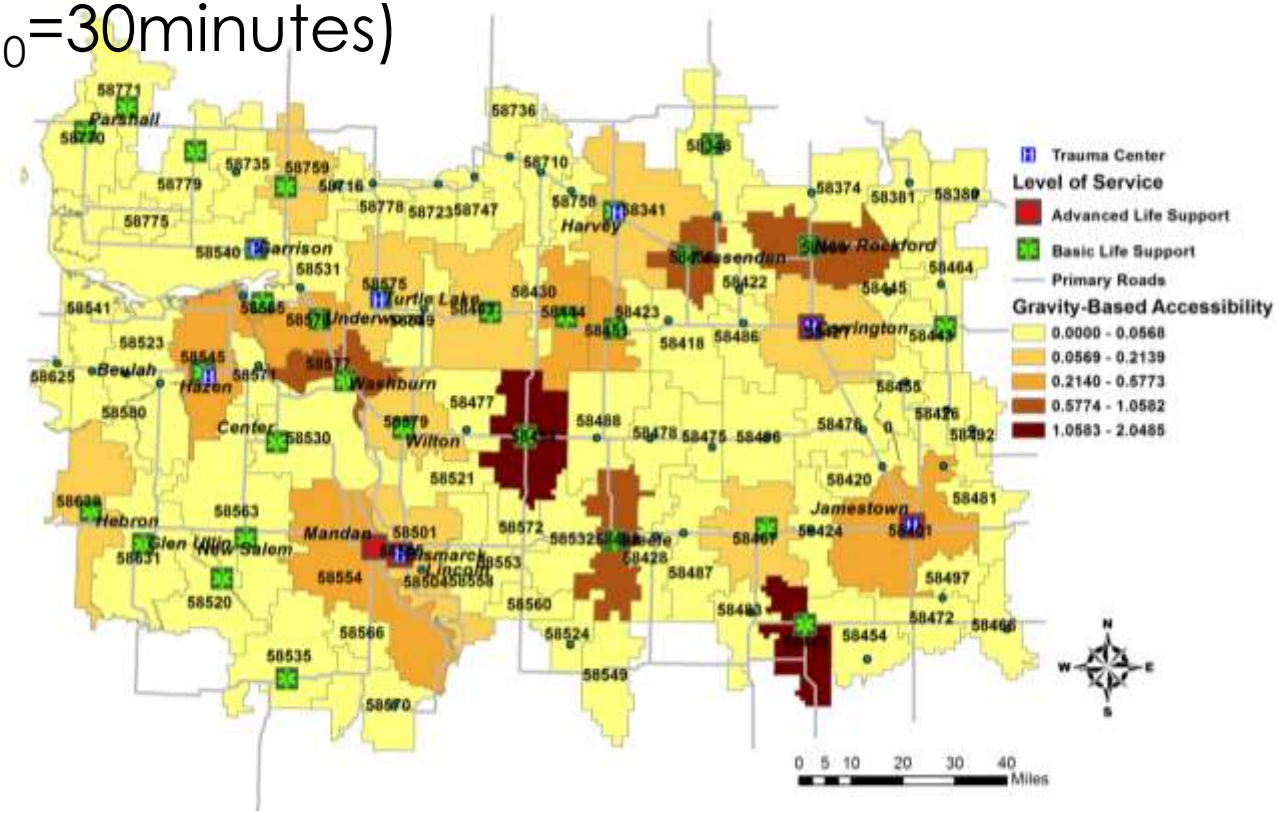
- Data Sources
  - Roads Network
  - Population Data
  - Zip codes Polygons
  - EMS Locations
    - Advanced Life Support
    - Basic Life Support

Model Development

- Population density and roads

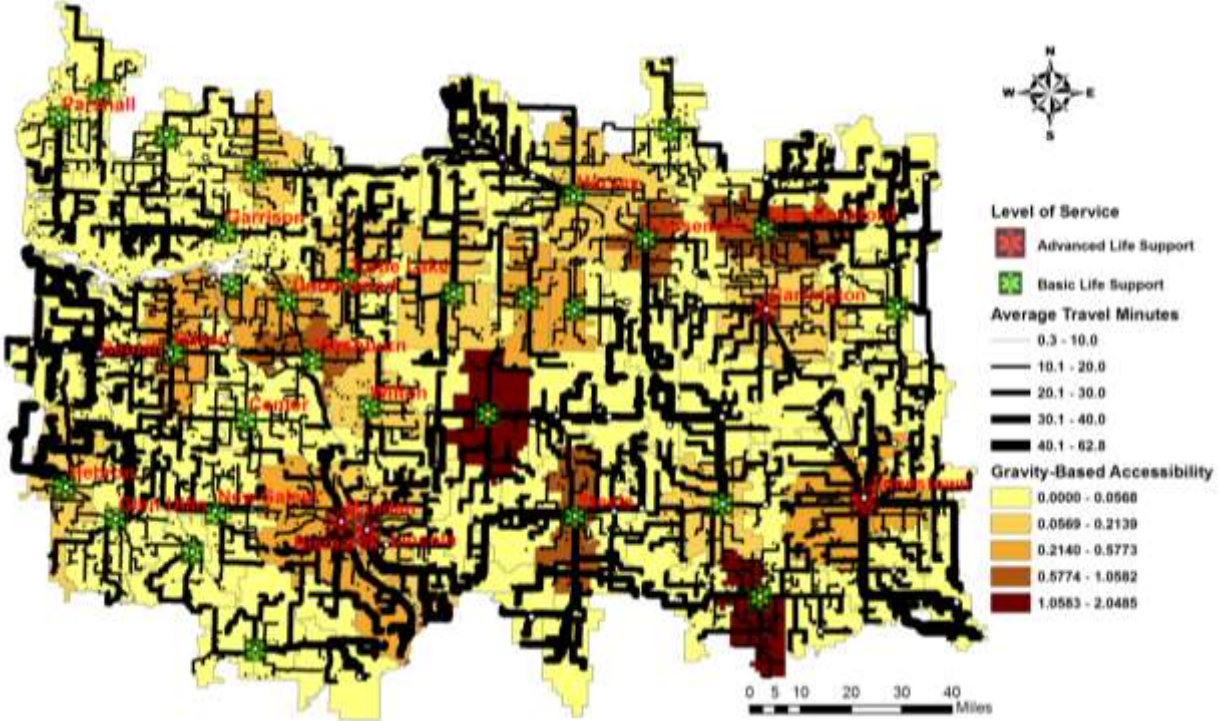


- Gravity-Based Accessibility 2SFCA (d_0=30minutes)



Response Time

- Fastest Routes from Ambulance to random Incidents



Note: Some regions will show bias from the real practices due to unconnected roads links used in the study

Potential Accessibility

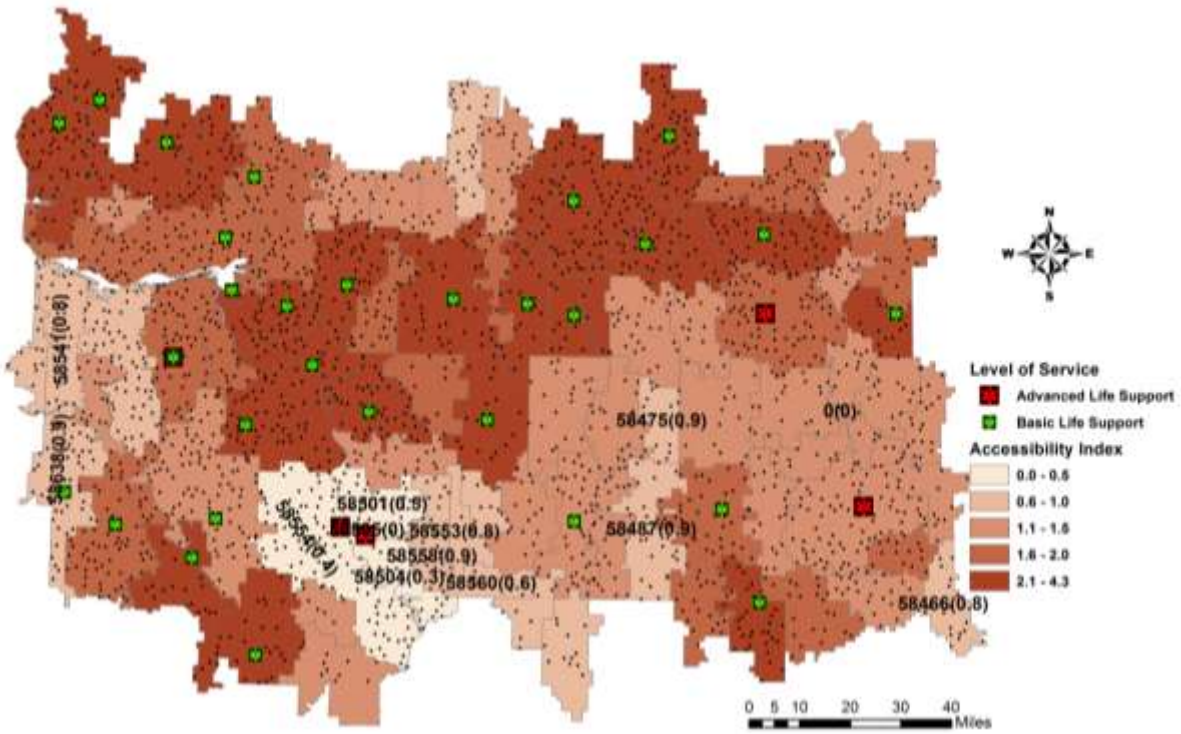
- Average response time to a zip code

$$\overline{T}_z = \frac{\sum t_{ji}}{N_{i \in z}} \qquad i \in z, j \in w_i \qquad \forall i \in M$$

- Potential Accessibility

$$A_z = t_0^z / \overline{T}_z$$

- Potential Accessibility Index



Potential Accessibility

- Demand-covered-ratio

$$C_z(\%) = \frac{N(t_{ji} \le t_0^z)}{N_i} \times 100 \qquad \forall i \in z, i \in M, j \in W_i$$

Potential Accessibility

- Accessibility and Coverage Ratio

ZIP code	Required service time (t_o^z)	# of Random events	# of events within t_o^z	Travel Distance (miles)			Response Time (minutes)			Accessibility (A_z)	Demand–Covered-Ratio (C_z)
				Mean	Min	Max	Mean	Min	Max		
58504	9	26	4	18.2	2	37.7	20	2.2	46.7	0.4	15.38%
58554	9	97	17	15.4	0.9	35.5	17	0.9	36.1	0.5	17.53%
58501	9	28	5	12.4	0.8	19.7	13.6	0.8	22.3	0.7	17.86%
58560	20	7	4	30.8	25.1	36.1	31	26.6	38.8	0.6	57.14%
58541	30	24	6	40.1	24.3	51.4	44.2	26.5	52.3	0.8	25.00%
58466	30	20	3	37.2	25.5	47.9	36.8	24.4	48	0.8	15.00%
58553	20	6	1	25.9	14.4	35.7	26.3	12.1	38.4	0.8	16.67%
58625	30	13	2	38.4	33	48.3	46.4	40.5	50.4	0.9	15.38%
58475	30	11	5	29.2	20.9	38.9	32.5	25.1	42.1	0.9	45.45%
58638	20	55	28	17	2.9	44.9	22.9	3.2	58.9	0.9	50.91%
58487	20	23	9	21.3	13.6	30.1	22.8	12.7	33.8	0.9	39.13%

Potential Serviceability

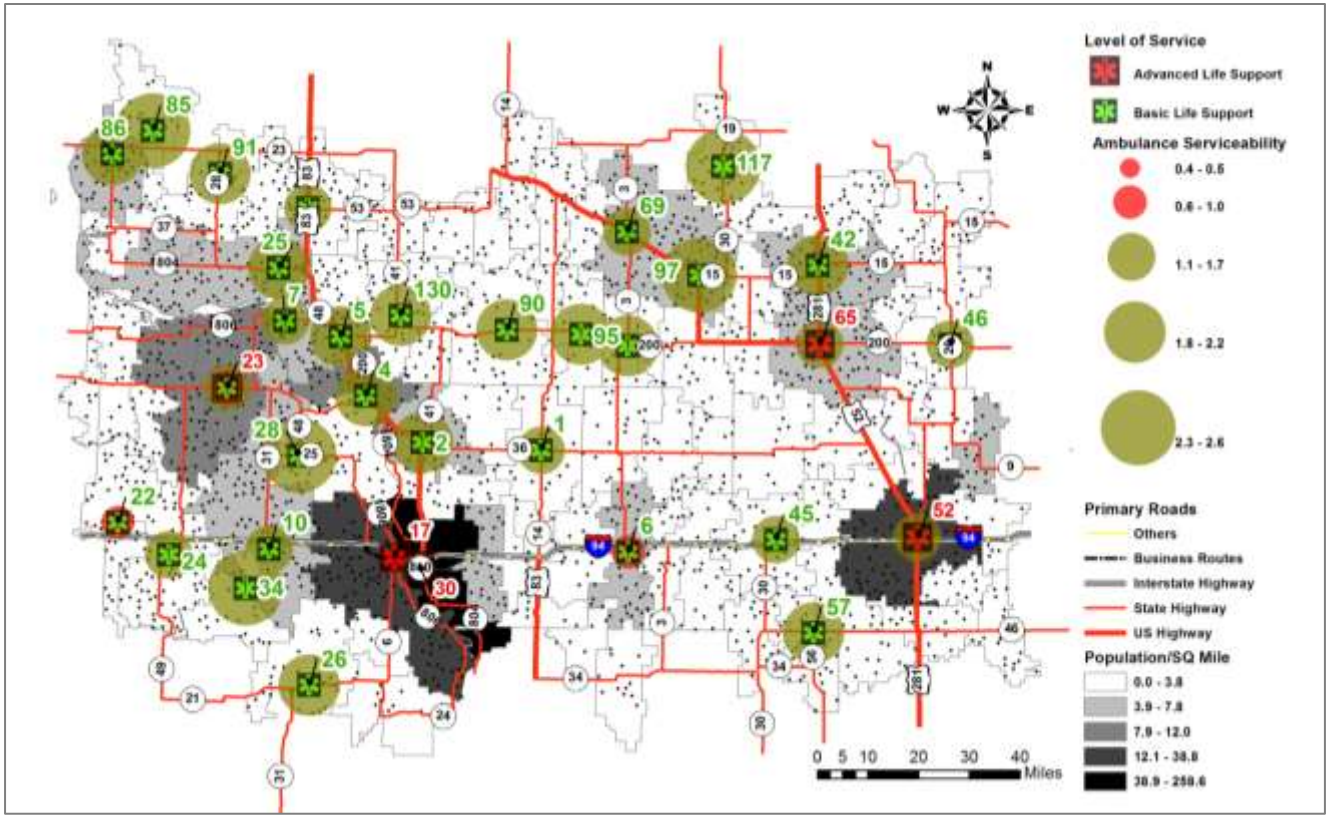
- Ambulance's average response time to serve the community without restrictions by the service boundary

$$\overline{T}_j = \frac{\sum_{i \in M_j} t_{ji}}{N_{i \in M_j}}$$

- Serviceability index for a location

$$S_j = \frac{t_o^j}{\overline{T}_j}$$

Potential Serviceability



Potential Serviceability

- Ambulance-Covering-Ratio

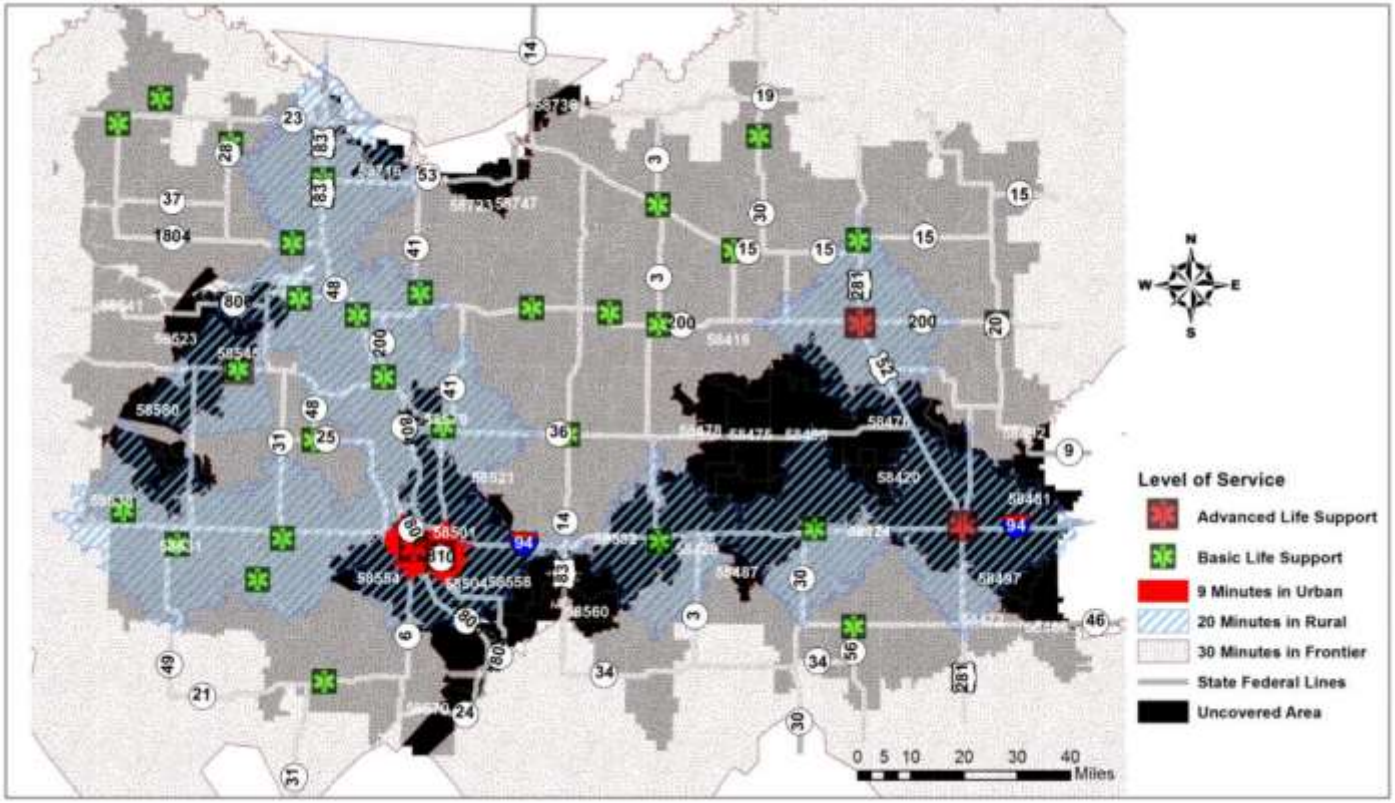
$$C_j(\%) = \frac{N_{(i \in M_j, t_{ji} < t_0^j)}}{N_{i \in M_j}} \times 100$$

Potential Serviceability

Ambulance Location	Required service time (t_o^j)	# of Random events	# of events within t_o^j	Travel Distance (miles)			Response Time (minutes)			Serviceability (S_j)	Ambulance-Covering-Ratio (C_j)
				Mean	Min	Max	Mean	Min	Max		
30	9	83	19	17.4	0.8	37.7	18.8	0.8	46.7	0.5	22.89%
17	9	93	29	15.6	0.9	35.5	17.1	0.9	36	0.5	31.18%
31	20	146	82	20.3	3.3	50.4	22.4	3.3	62.8	0.9	56.16%
22	20	45	28	14.7	2.9	33	19.9	3.2	47.1	1	62.22%
6	20	133	77	18.2	3.1	35.1	19.7	3.6	37.4	1	57.89%
52	20	175	143	18.4	0.7	47.9	18.9	0.7	48	1.1	81.71%
45	20	87	71	15.9	0.5	38.9	17.5	0.6	42.1	1.1	81.61%
24	20	89	66	13.7	0.7	34	16.5	0.7	52.4	1.2	74.16%
137	20	78	75	13.5	3.6	33.8	14.5	3.6	36.7	1.4	96.15%
23	20	15	15	12.1	2.2	17.6	14.4	2.2	23.9	1.4	100.00%
65	20	93	93	13.5	3.3	28.3	14.4	3.7	29.2	1.4	100.00%
1	30	73	54	18.2	1.2	38.1	20.6	1.2	38.8	1.5	73.97%
46	30	102	92	19.1	2.7	36.2	20.6	4.1	37.7	1.5	90.20%
10	20	63	47	11.5	0.3	23.6	12.9	0.3	24.6	1.5	74.60%
69	30	117	103	16.8	0.7	39.9	17.7	0.8	39.7	1.7	88.03%
7	20	16	16	9.6	0.9	13.6	11.9	0.9	17.6	1.7	100.00%

Service Coverage

- Service Coverage Estimated



Conclusions

- Developed Public Communications tool
  - for Residents
    - Potential accessibility with Relative demand-covered-ratio
  - for Ambulance Service Provider
    - Potential serviceability with Relative ambulance-covering-ratio
- Created Service coverage
  - For Continuous improvement

Future Research

- Transportation
  - Finer Traffic Analysis Zone
    - Using the Census Block 2010
  - Utilize Navigable Roads Network
- Statewide analysis
- Dynamic impacts
  - considering seasonal effects
  - Considering first respondents response time to reach ambulance in rural area

Q & A

- Reference and contact information

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Article

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