Understanding Spatial Distribution of Disease:

Clostridium difficile

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Objectives

- What is *C. difficile*?
- Why is Lehigh Valley Hospital concerned about an epidemic?
- What did we look at?
- What did we find out?
- Where do we go from here?

Ok, so… Clostridi-uh-what?

Clostridium difficile

C-Diff

CDAD

CDI

Characteristics

- Frequently found in the intestine of healthy individuals
- Imbalance in the intestinal flora leads to overabundance of *C. difficile*
- Risk factors:
  - Age, ≥ 60
  - Certain antibiotics
  - Immunosuppression
  - Use of Proton-pump Inhibitors

Why C-diff is *not* right for you:

- Outcomes:
  - Diarrhea, abdominal pain, fever
  - Pseudomembranous colitis
    - → Sepsis, bowl perforation, death
- Treatments:
  - Stronger, non-cephalosporin antibiotics
  - Bacterial replacement therapy
  - Colectomy

Why is this a hospital concern?

- Increasing incidence of CDAD nationally and statewide
- Stronger, more toxic strain has emerged
- Costly and difficult to treat
- Highly contagious
- Lehigh Valley population is aging

Methods: Overview

- Select all cases of community-acquired CDAD from FY 2007 admitted patients
  - Community Acquired Infection: positive toxin assay within 48 hours of admission
  - Nosocomial Infection: positive assay after 48 hours from admission
- Geocode billing addresses of patients using Census 2000 TIGER files
- Explore for clusters and spatial autocorrelation across study area

Methods: Variables & Analyses

Variables of interest:

- Cost and Length of Stay
- Gender
- Nursing Home
- Hospital Location
- Age and Age groups
- Mortality
- County

Statistics:

- Student's T-tests
- One-way ANOVA
- Linear Regression
- Directional Distribution
- Mean Center
- Average nearest-neighbor
- Moran's I

Statistical Results

	Median (Mean)
Cost	$10,885 ($18,838)
Length of Stay	8 days (11.5 days)
Age	74 years (70 years)

- Cost & Length of Stay:
  - Required log-transformation for appropriate analyses
  - NSD between males and females
  - NSD between nursing home and non-nursing home patients
  - NSD between age groups

Statistical Results

- Berks County had a significantly higher mean cost of stay than:
  - Lehigh County (+$18,288, p=0.016)
  - Northampton County (+$19,574, p=0.012)
- Why:
  - Outliers! Extreme values on cost and length of stay influenced the analysis.
  - When removed from the data set, this difference dissappeared
  - For hospital purposes, these observations were retained because they were informative of the processes in the patient population.

Statistical Results

- Average Cost & Length of Stay:
  - Highly correlated (r = 0.89), related with a 1-1 change in average percentage (p<0.001)

What that means:

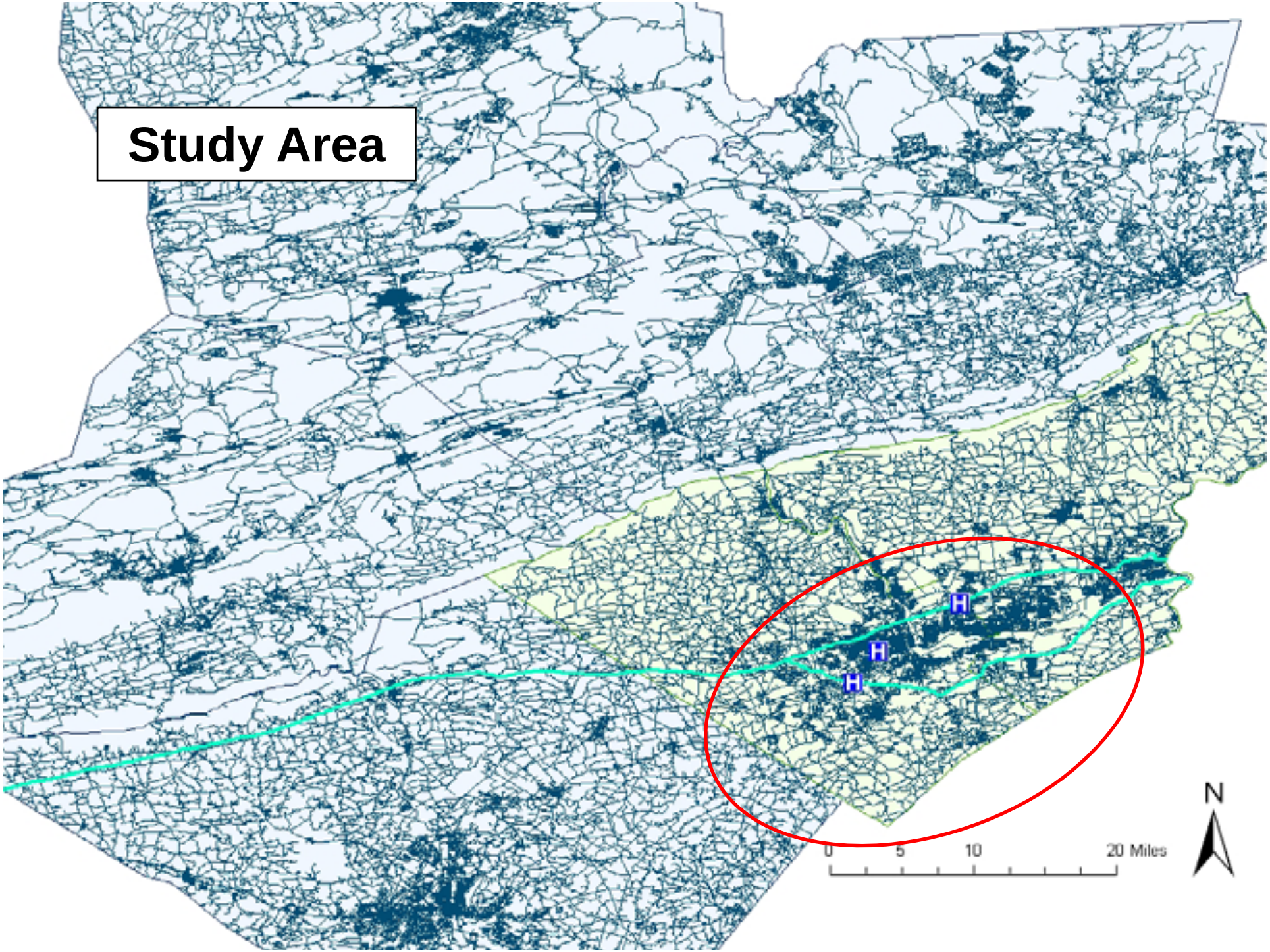
Estimates:	**Length of Stay (days)**	**Cost (Dollars)**
	11.5	$18,838.03
% increase	**Increase in Days**	**Increase in Cost**
1	0.1	$188.38
5	0.6	$941.90
10	1.1	$1,883.80
25	2.9	$4,709.51
50	5.7	$9,419.02
100	11.5	$18,838.03

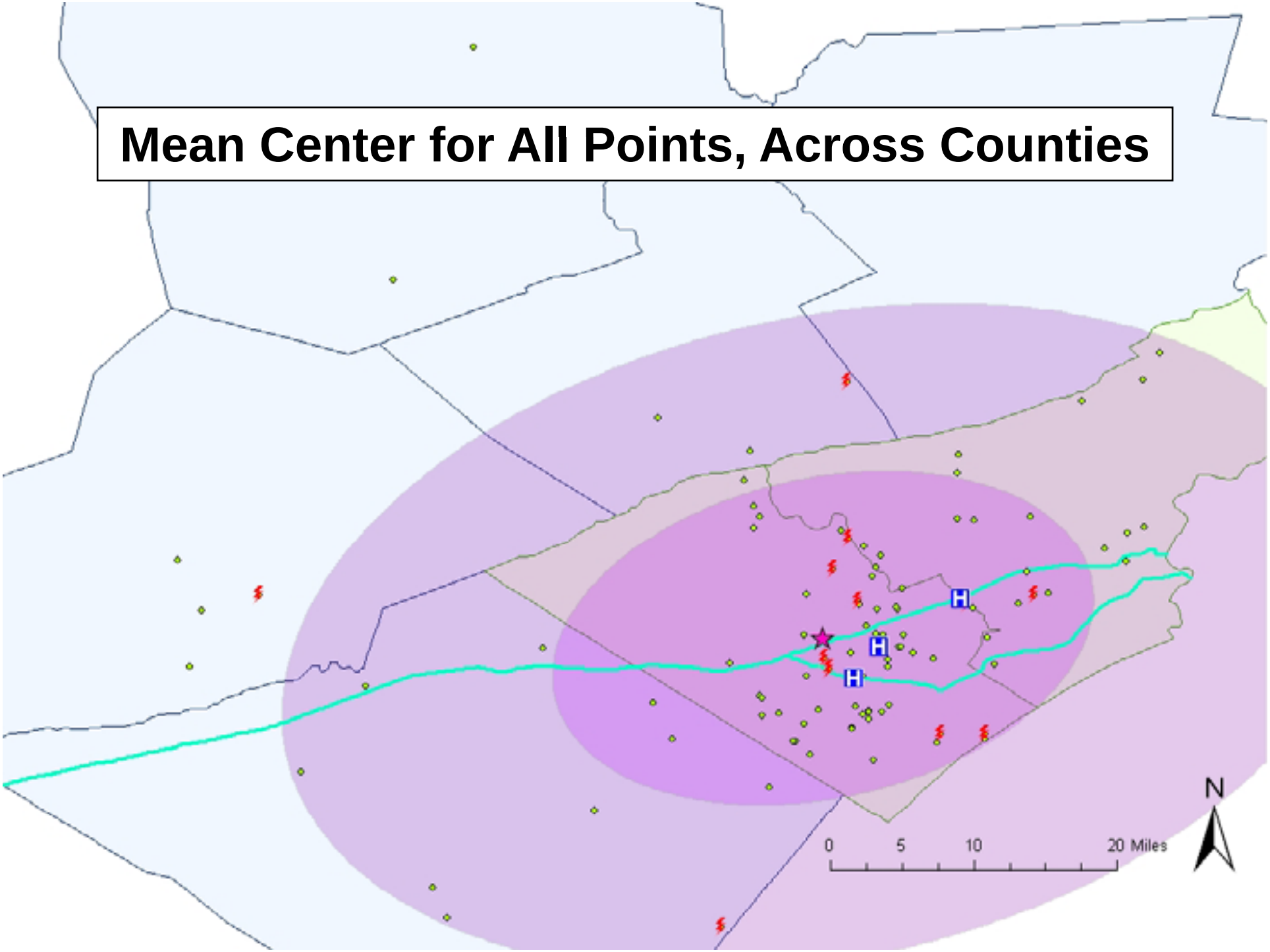
Geographic Results

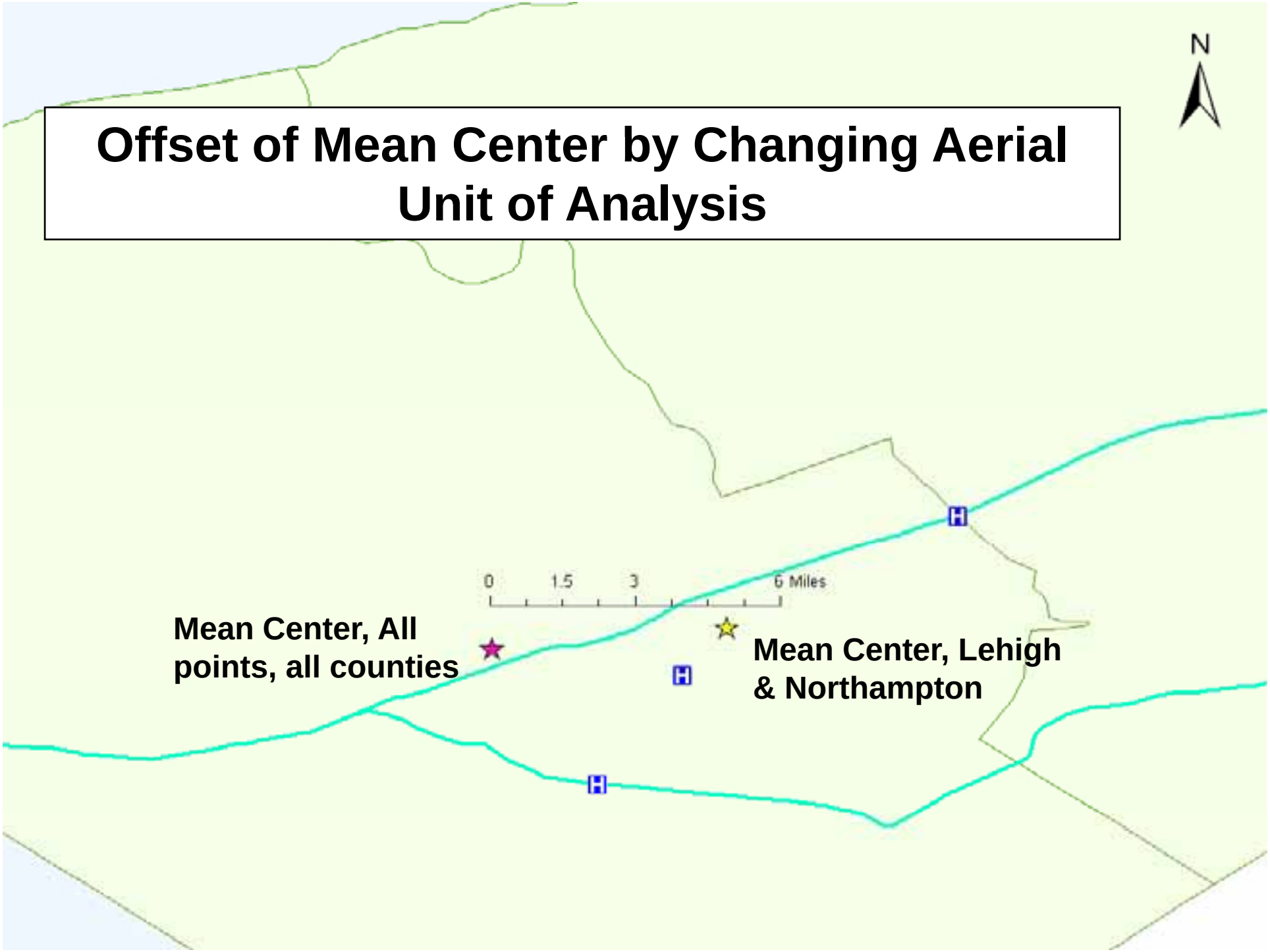
- Geocoding: 138 of 145 matched

- Patients originated from 7 counties
- 2 main contributors

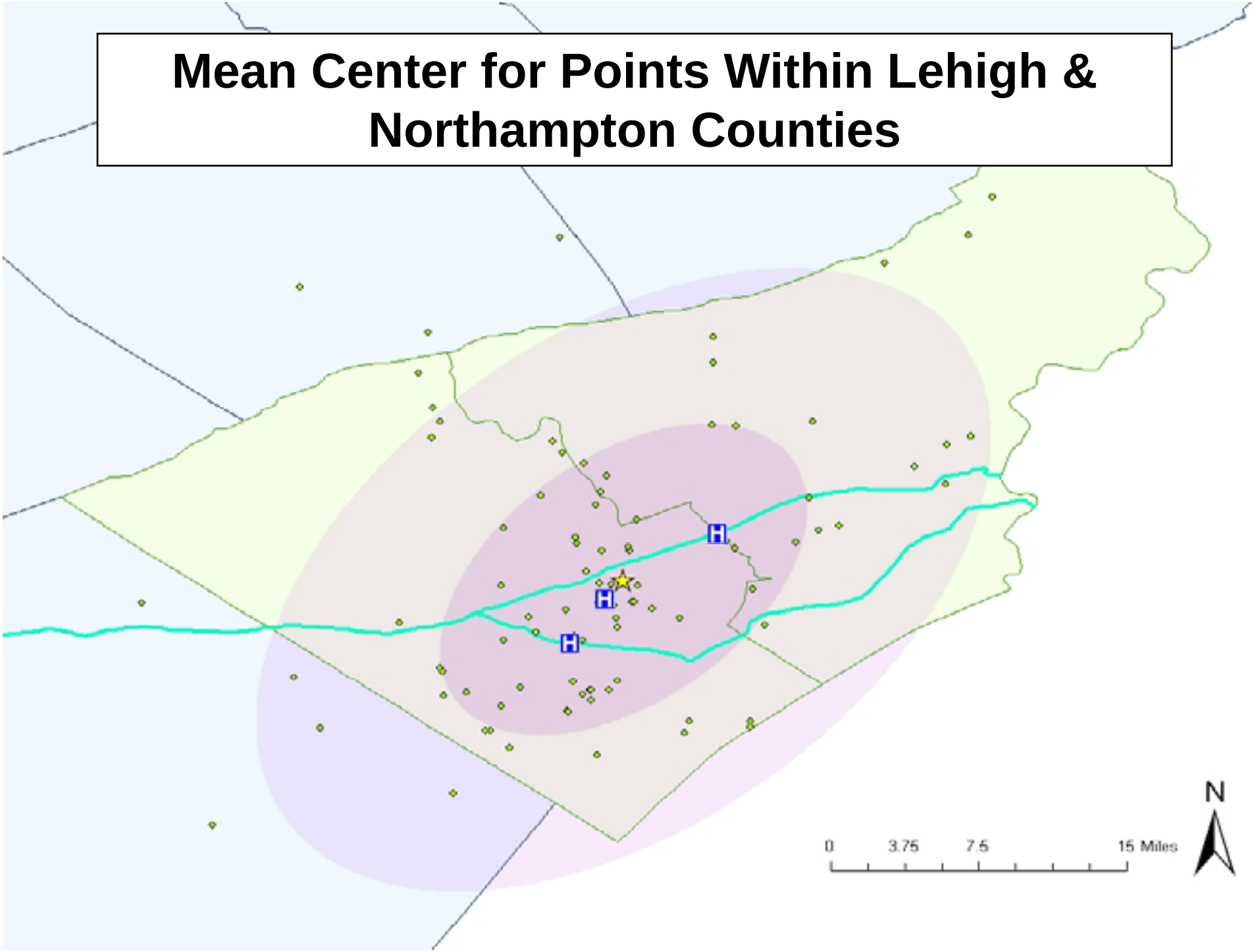
- **Visual Patterns**:
  - Cases clustered in the downtown Allentown region
  - Inverse relationship between distance and cost, length of stay

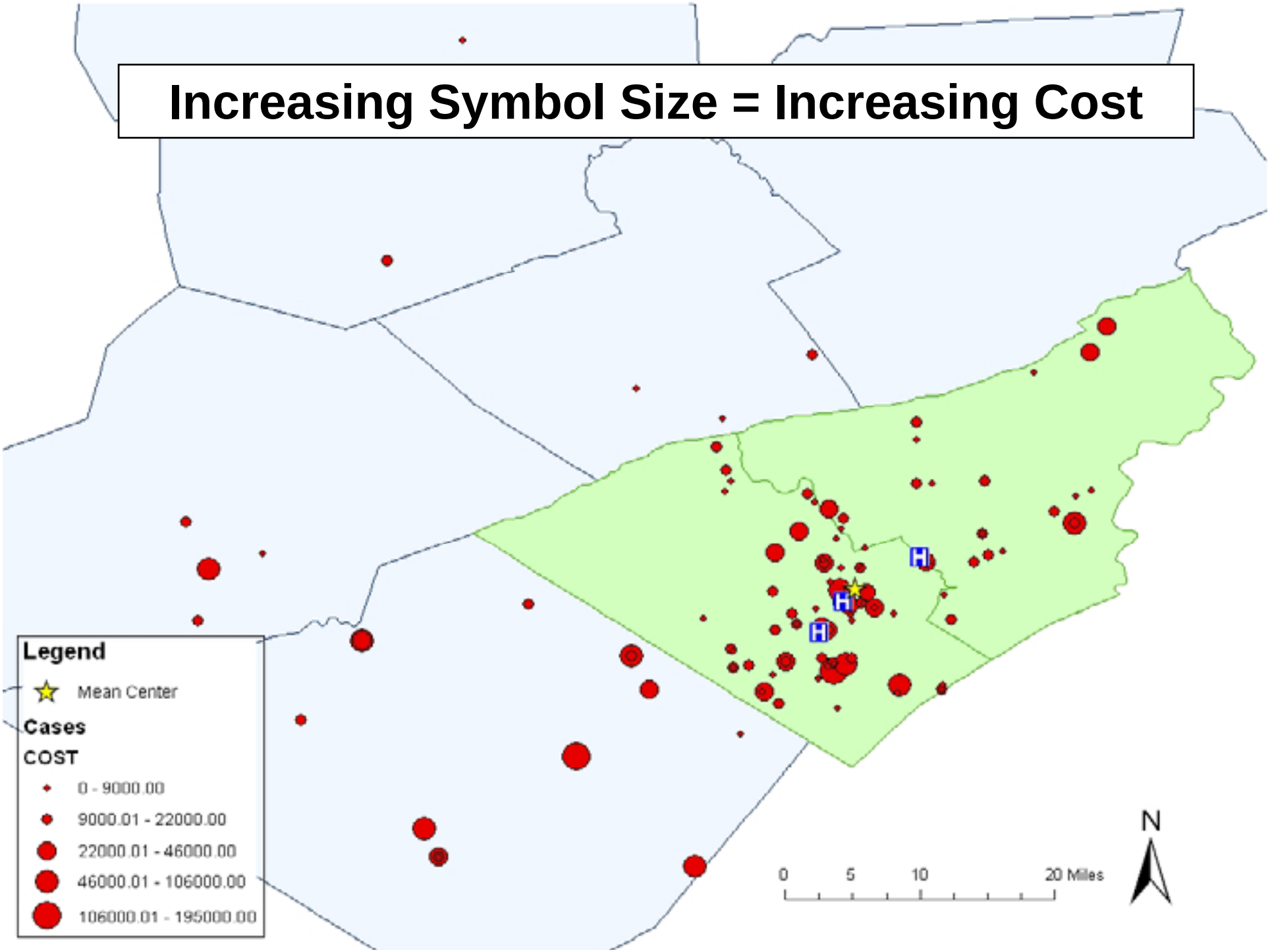

Study Area
H
H
H
0
5
10
20 Miles
N


Mean Center for All Points, Across Counties
H
H
H
N
0
5
10
20 Miles

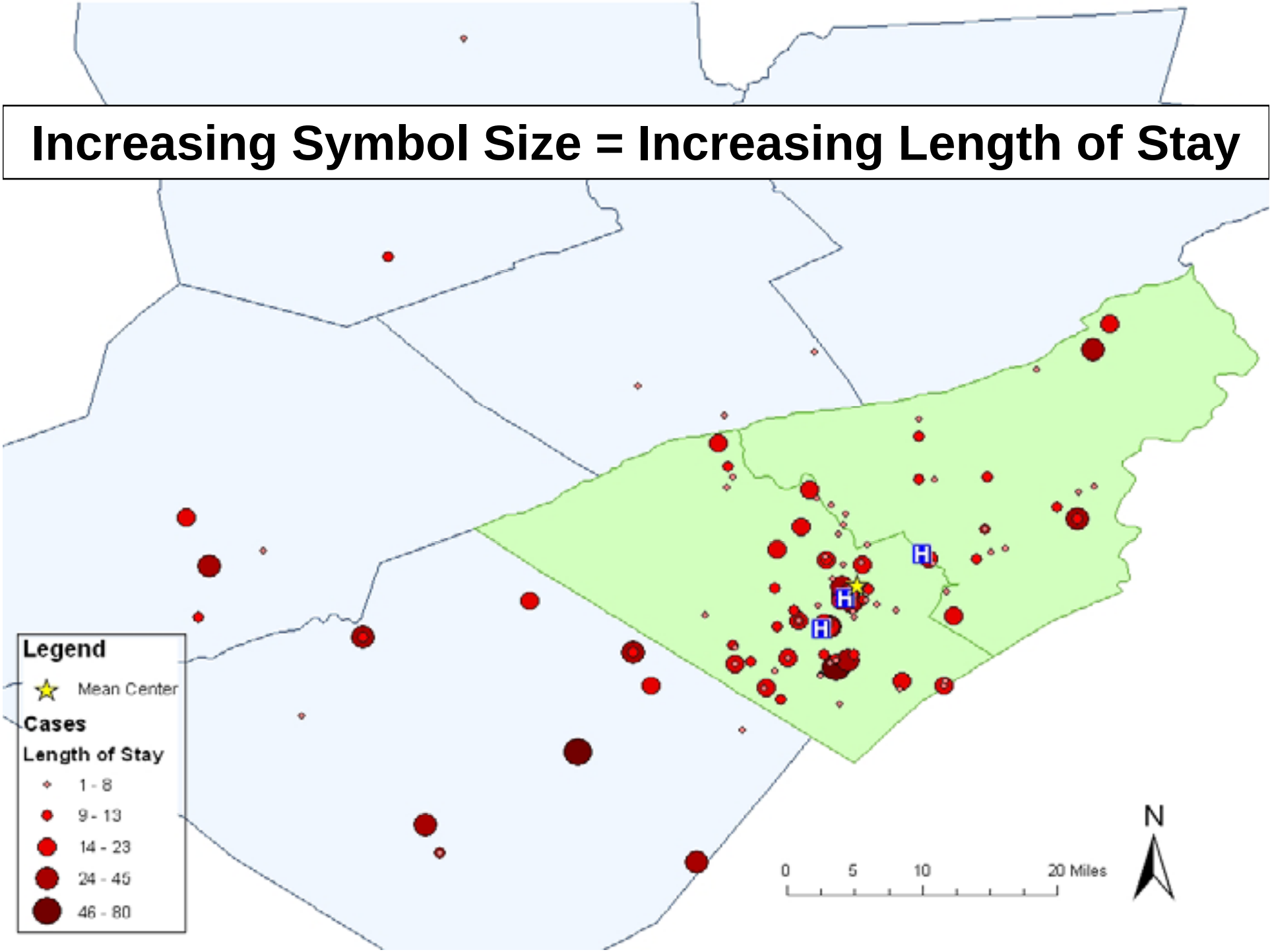

Offset of Mean Center by Changing Aerial Unit of Analysis
N
0
1.5
3
6 Miles
Mean Center, All points, all counties
Mean Center, Lehigh & Northampton

Mean Center for Points Within Lehigh & Northampton Counties




Increasing Symbol Size = Increasing Cost
Legend
Mean Center
Cases
COST
0 - 9000.00
9000.01 - 22000.00
22000.01 - 46000.00
46000.01 - 106000.00
106000.01 - 195000.00
0
5
10
20 Miles
N

Increasing Symbol Size = Increasing Length of Stay



Geostatistical Patterns

- Cases were significantly clustered:
  - *Over all counties* ($z = -13.74$, $p<0.001$)
  - Within primary counties ($z= -9.00$, $p<0.001$)
- Deaths significantly dispersed ($z=2.22$, $p<0.05$)
- No correlation between distance and cost ($z = -0.10$) or length of stay ($z = -0.40$)

Conclusions

- These analyses provide a baseline snapshot for our surveillance purposes
- Brings to light a spatial concentration of points in an area that we know to be socioeconomically disadvantaged
- Illuminates outliers in Berks County, which need to be examined more closely

Limitations

- Data were not collected specifically for GIS
- Billing addresses (not confirmed residence)
- Several major outliers that influenced the analysis
- Data do not include patients who sought treatment from a non-hospital facility
- Data may include some recurrent cases of CDAD.
- Populations served by the different hospital facilities differ markedly in demographic characteristics
- Geostatistical analyses were based on large areas
- Use of TIGER files rather than ESRI's StreetMap may have influenced the geographic validity of the data.

Future Directions

- Examine SES and demographic data
- Overlay with population density
- Examine by smaller area of analysis
- Obtain isolates from infected patients
- Examine time as a variable
- Collaborate with other local hospitals to assess the true burden of disease in the Lehigh Valley

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