VACCINATION CLINIC LOCATION OPTIMIZATION

RTI-DUKE DATA+ PRACTICUM

PROBLEM STATEMENT
What are the best locations for immunization and vaccination clinics in Durham County if there is a Zika virus outbreak?

ZIKA VIRUS BACKGROUND
- Zika Virus Genus: Flavivirus
- Transmission Routes: Vector-borne (Aedes aegypti mosquito), Vertical, and Sexual
- Symptoms: Rash, joint pain, conjunctivitis, and fever
- Problem: If a pregnant woman is infected, can cause microcephaly and other birth defects in the child

SYNTHETIC POPULATION DATA
- Synthetic Population: Computer-generated projections of distribution of households based on household income, number of occupants in household, and race and age of head of household
- Data prepared from 2010 US Decennial Census by RTI International

METHODS
- Populate Simulated Virus
- Monte Carlo Simulation
- Placement Algorithms
- Cluster Centers Proximity
- Cover Tree
- Recursive Population Removal
- Impact Modeling for Optimization
- Data Visualization
ANALYSIS & RESULTS

PLACEMENT ALGORITHMS
Clinics must only be placed in schools that Durham County Residents attend.

Cluster Centers Proximity: Find schools within 1 mile sq. radius of natural cluster centers (k-means) that serve most people within a 3.5 mile sq. radius.

Cover Tree: Use basic cover tree data structure concepts to place clinics for maximum coverage of population.

Recursive Population Removal: Find school that serves the most people within a 3.5 mile sq. radius, remove those people from the population, recurse.

IMPACT MODEL OPTIMIZATION
Used 4 clinic sites for initial model because 4 natural population clusters.

Ross-McDonald Model used for disease spread analysis with simultaneous vaccination spread.

Cover Tree clinic set determined as most efficient in vaccinating and limiting disease within the population.

CLINIC SITES
Mangum Elementary School
Hillandale Elementary School
Rogers-Herr Middle School
Lowes Grove Middle School

IMPACT MODELING RESULTS

<table>
<thead>
<tr>
<th></th>
<th>Cluster Center Proximity</th>
<th>Cover Tree</th>
<th>Recursive Population Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to Herd Immunity</td>
<td>50 Days</td>
<td>29 Days</td>
<td>41 Days</td>
</tr>
<tr>
<td>Total Vaccinated</td>
<td>202,085 (76.1%)</td>
<td>205,394 (77.3%)</td>
<td>204,687 (77.0%)</td>
</tr>
<tr>
<td>Total Infected</td>
<td>5,830 (2.2%)</td>
<td>3,445 (1.3%)</td>
<td>4,240 (1.6%)</td>
</tr>
</tbody>
</table>

COVER TREE CLINIC PLACEMENT RESULTS

Durham County Population Density, Schools and Selected Clinic Sites

Durham County Population Segmented by Closest Chosen Clinic
FINAL PRODUCT & CONCLUSIONS

R/SHINY IMPACT MODEL VISUALIZATION APPLICATION
Interactive application to explore impact model and demographic break downs

PLACEMENT ALGORITHM CHOICE
- Cover Tree provides the best model in selecting schools that will reach the most people in Durham County in the shortest amount of time, limiting the number of people infected
- Does not distribute population evenly among clinics, but instead provides closer access to entire population
- Can select different model for more even distributions if the desired clinic specifications change

IMPACT MODELING ADAPTATION
- Adaptable model can easily select any number of schools in Durham County to use as vaccination clinic sites
- Model can also be adapted for other diseases by replacing Ross-McDonald Model for appropriate disease spread model and disease-specific parameters

OPPORTUNITIES FOR FURTHER RESEARCH
- Expand placement algorithms to include more advanced spatial scanning statistics
- Inclusion of traffic patterns
- Analysis of clinic capacities and vaccination scheduling
- Account for budget constraints