The Pandemic Response: Food Distribution Planning for Pandemic Flu

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**PROJECT SUMMARY**

**Pandemic Flu**
- A pandemic flu will hit the world in the near future (Bird flu-H5N1)
- $71.3-165.5$ billion economic impact on US (CDC)
- $2.7-4.4$ million people might die (WHO)
- U.S. Department of Health & Human Services and U.S. Department of Commerce estimates
  - $20\%$ of working adults will become ill
  - $40\%$ workforce loss during peak

**Problem Description**
- Interruption in services due to infection
- Infected individuals may not be able to obtain food
- How to deliver food to ill people?

**Objective**
- Model the spread of pandemic flu geographically and over time
- Evaluate the effectiveness of intervention strategies
- Develop a facility location and resource allocation model for food distribution

**DISEASE SPREAD MODEL**
- An individual-based stochastic disease spread model
  - Age specific disease parameters
  - 5 age groups (0-5, 6-11, 12-18, 19-64, 65+)
- Infection types:
  - Households
  - Peer groups
  - Community (other daily interactions)
  - Import (people coming out of network)
- Night-day differentiation
- Disease progress
  - Within an individual (Wu et al. 2006) (based on age)

**RESULTS: GEORGIA CASE**
- Each census tract corresponds to a community
  - 1,615 census tracts
  - Total population is 9,071,756

**Data**
- Household statistics for each census tract
- Tract-to-tract worker flow data
- Classroom sizes
- Population age statistics

**Simulation Results**
- Percentage of symptomatic or hospitalized individuals for different $R_0$ values:

![Graph showing percentage of symptomatic or hospitalized individuals for different R0 values.]

- Summary of results

<table>
<thead>
<tr>
<th>$R_0$ Value</th>
<th>Peak Infectivity</th>
<th>Peak Day</th>
<th>CAR</th>
<th>IAR</th>
<th>Death Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>3.5%</td>
<td>70</td>
<td>92.3%</td>
<td>64.8%</td>
<td>0.27%</td>
</tr>
<tr>
<td>1.9</td>
<td>4.5%</td>
<td>50</td>
<td>64.8%</td>
<td>67.1%</td>
<td>0.09%</td>
</tr>
<tr>
<td>2.1</td>
<td>5.0%</td>
<td>40</td>
<td>52.2%</td>
<td>75.2%</td>
<td>0.09%</td>
</tr>
</tbody>
</table>

CAR: Clinical attack rate
IAR: Infection attack rate

**INTERVENTION POLICY: VOLUNTARY QUARANTINE**
- Individuals comply with the quarantine voluntarily with some compliance rate
  - Compliance rate: 50%
- The effect of timing and length of quarantine on
  - Peak infectivity (for $R_0 = 1.8$)

![Graph showing the effect of timing and length of quarantine on peak infectivity.]

- Infection attack rate (for $R_0 = 1.8$)

![Graph showing the infection attack rate for different quarantine lengths.]

**Conclusion**
- Both the timing and the length of the quarantine is important
- There is a diminishing rate of return as the length of the quarantine increases

**ESTIMATING THE FOOD NEED**
- Serve the households
  - with an infected (symptomatic or hospitalized) individual
  - with an infected individual that are below poverty level
  - with all adults infected
  - with all adults infected that are below poverty level
  - that are quarantined in case of a quarantine

**Food need for Metropolitan Atlanta Area for $R_0 = 1.8$ assuming an individual needs 3 meals a day**
- Households with an infected individual are served

**RESULTS: GEORGIA CASE**
- The optimal timing of an 8-week quarantine
  - Start of week 4 is best for reducing peak infectivity
  - Start of week 6 is best for reducing infection attack rate

**Summary of Results for an 8-week Quarantine**

<table>
<thead>
<tr>
<th>$R_0$ Value</th>
<th>Quarantine Start</th>
<th>Peak Infectivity</th>
<th>Peak Day</th>
<th>CAR</th>
<th>IAR</th>
<th>Death Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>7</td>
<td>8.0%</td>
<td>50</td>
<td>92.3%</td>
<td>64.8%</td>
<td>0.27%</td>
</tr>
<tr>
<td>1.9</td>
<td>4</td>
<td>1.8%</td>
<td>63</td>
<td>90.2%</td>
<td>64.8%</td>
<td>0.27%</td>
</tr>
<tr>
<td>2.1</td>
<td>3</td>
<td>3.8%</td>
<td>40</td>
<td>61.9%</td>
<td>62.9%</td>
<td>0.33%</td>
</tr>
</tbody>
</table>

**CONCLUSIONS AND CONTRIBUTIONS**
- The diminishing rate of return as the length of the quarantine increases:
  - An 8-week quarantine is almost equivalent to a 12-week quarantine in terms of reducing the peak infectivity
  - An integrated disease spread and food distribution model