

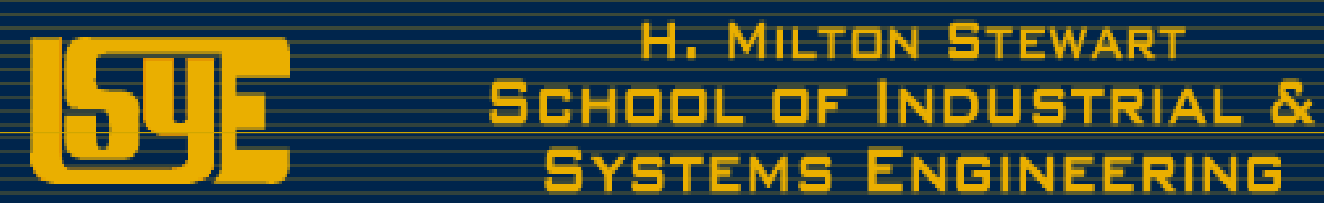
# The Pandemic Response: Food Distribution Planning for Pandemic Flu

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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 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

### Objective

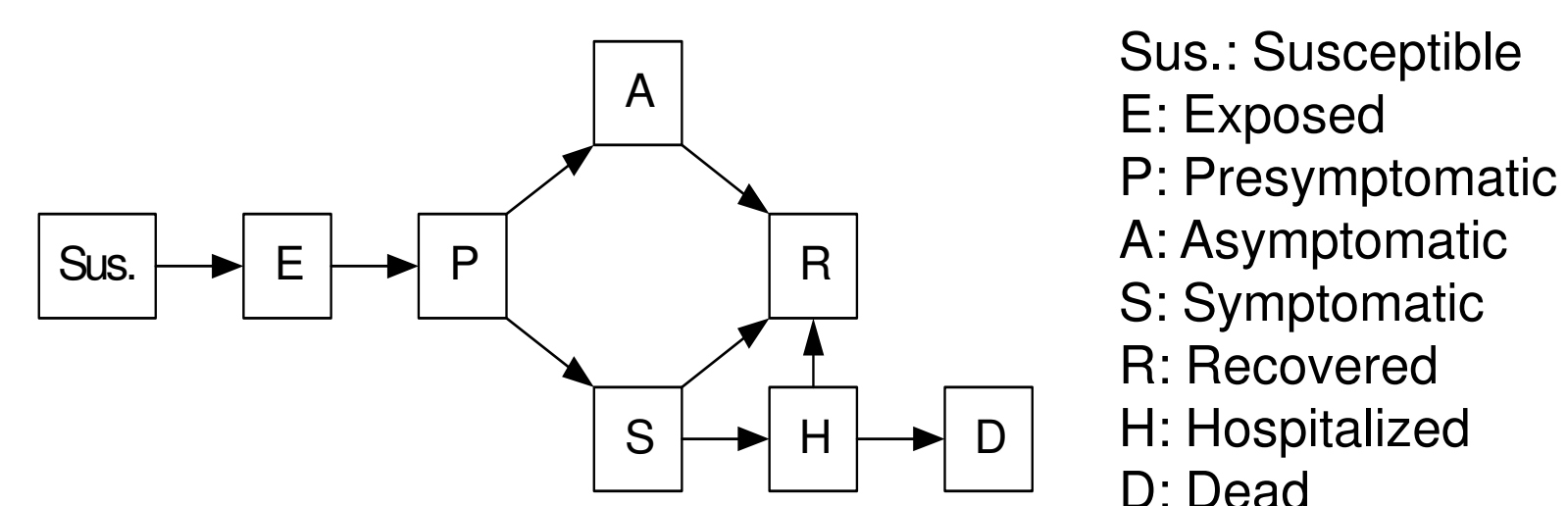
- Model the spread of pandemic flu geographically and over time
- Evaluate the effectiveness of intervention strategies
- Develop a facility location and resource allocation model for food distribution

## DISEASE SPREAD MODEL

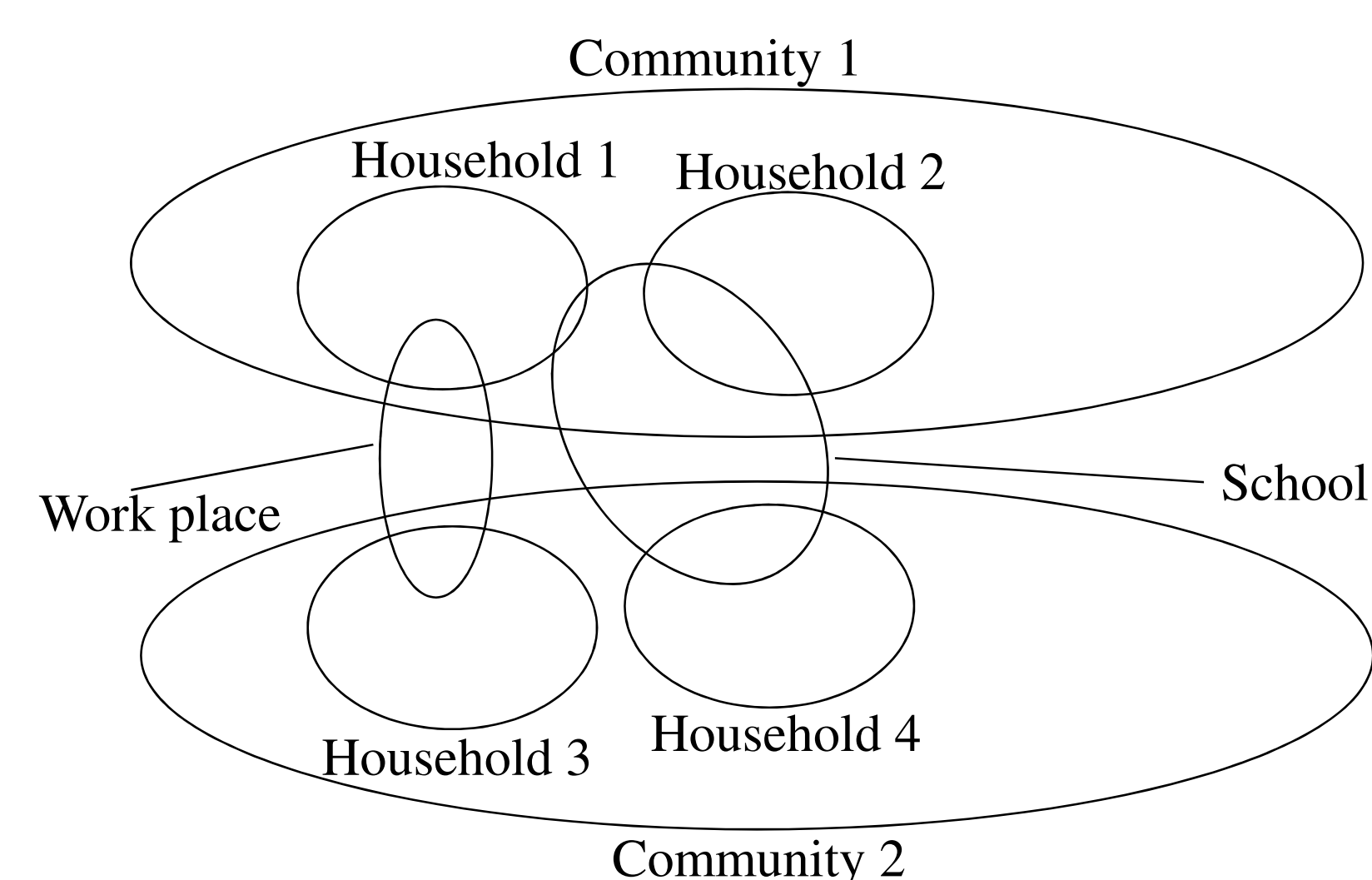
- An individual-based stochastic disease spread model

### Model Assumptions

- 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)



- Within the population



## RESULTS: GEORGIA CASE

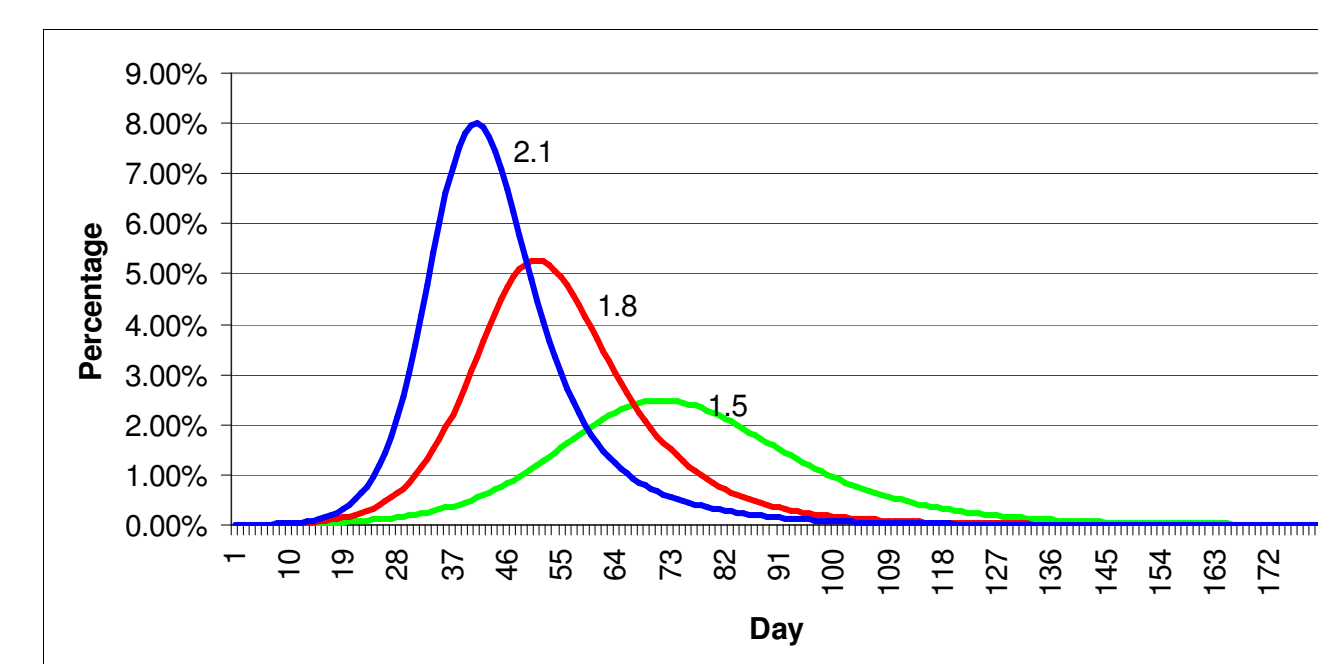
- Each census tract corresponds to a community
  - 1615 census tracts
  - Total population is 9,071,756

### 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:



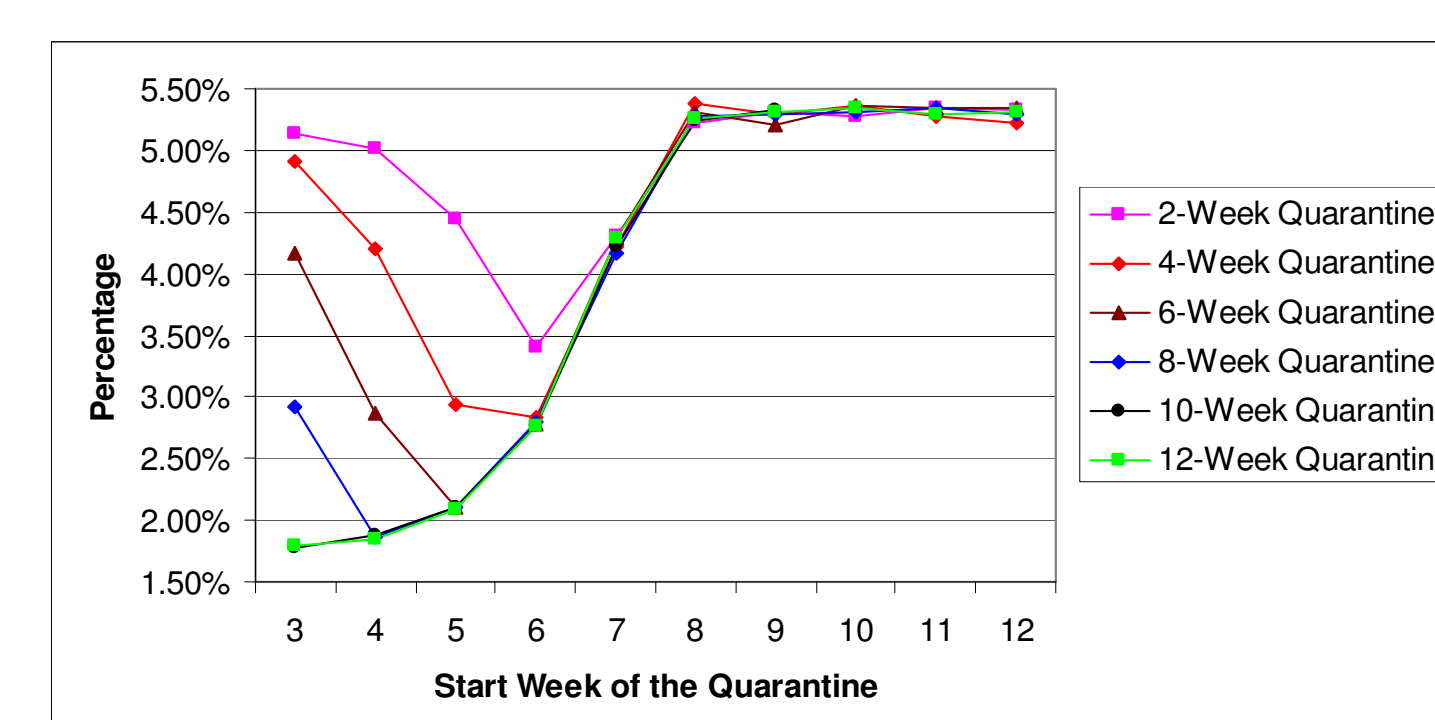
### Summary of results

$R_0$ Value	Peak Infectivity	Peak Day	CAR	IAR	Death Ratio
1.5	2.48%	70	32.50%	49.65%	0.57%
1.8	5.27%	50	44.20%	67.49%	0.80%
2.1	8.01%	40	51.27%	78.27%	0.93%

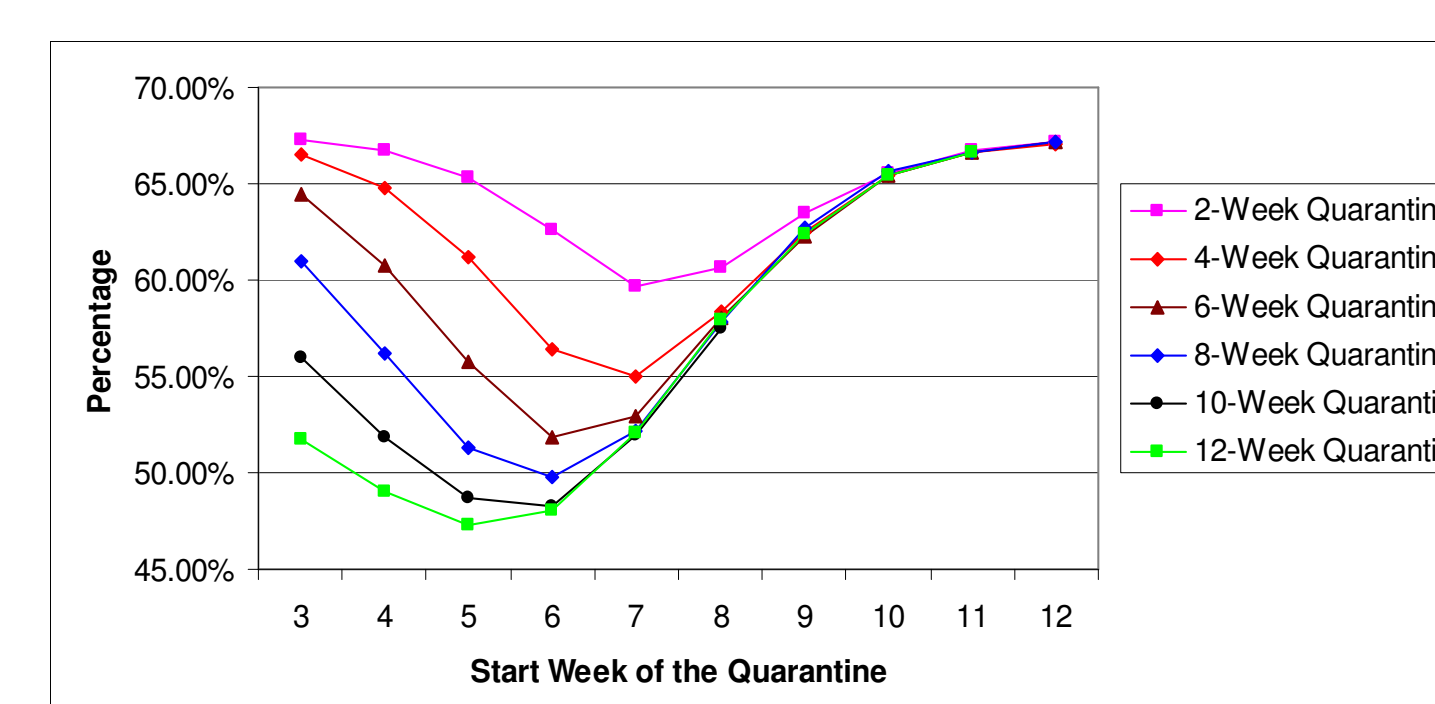
CAR: Clinical attack rate  
IAR: Infection attack rate

## 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  $R_0 = 1.8$ )



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



### 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

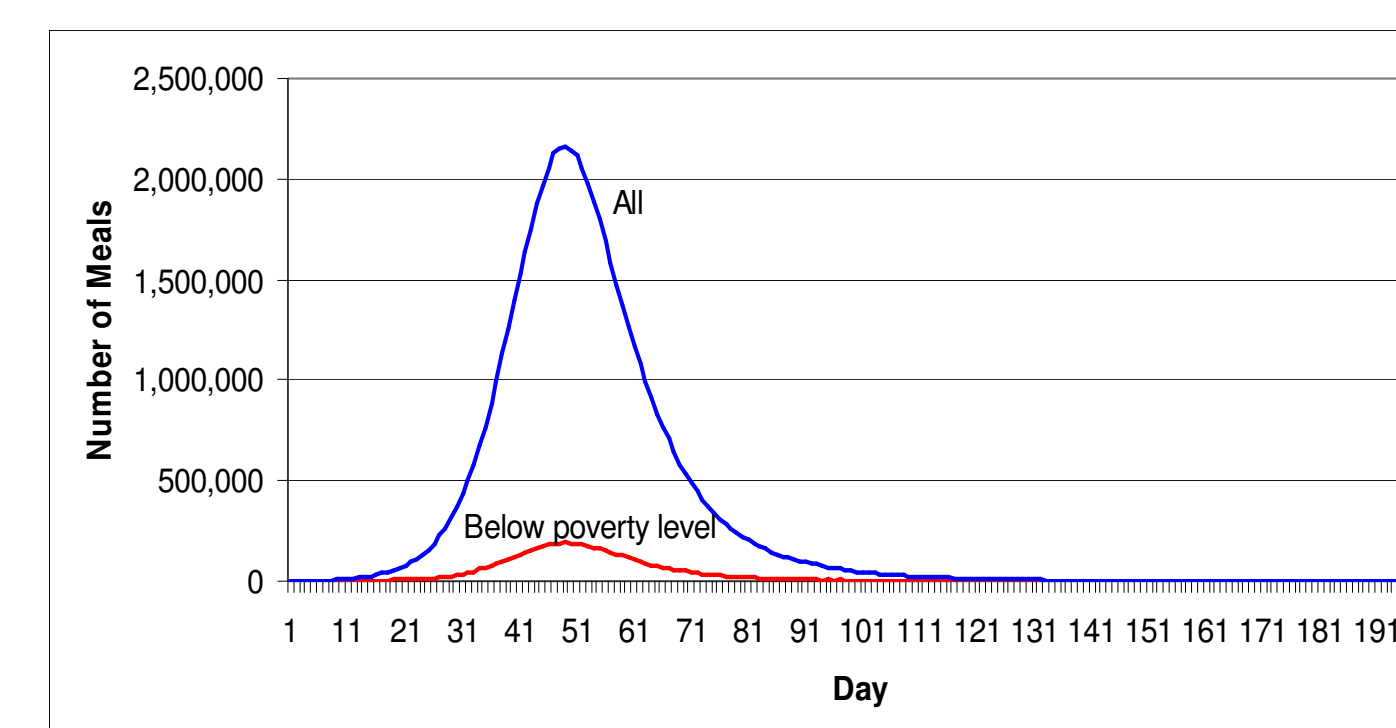
- The optimal timing of an 8-week quarantine
  - Start of week 4 is best for reducing peak infectivity
  - Start of week 6 is best for reducing infection attack rate

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

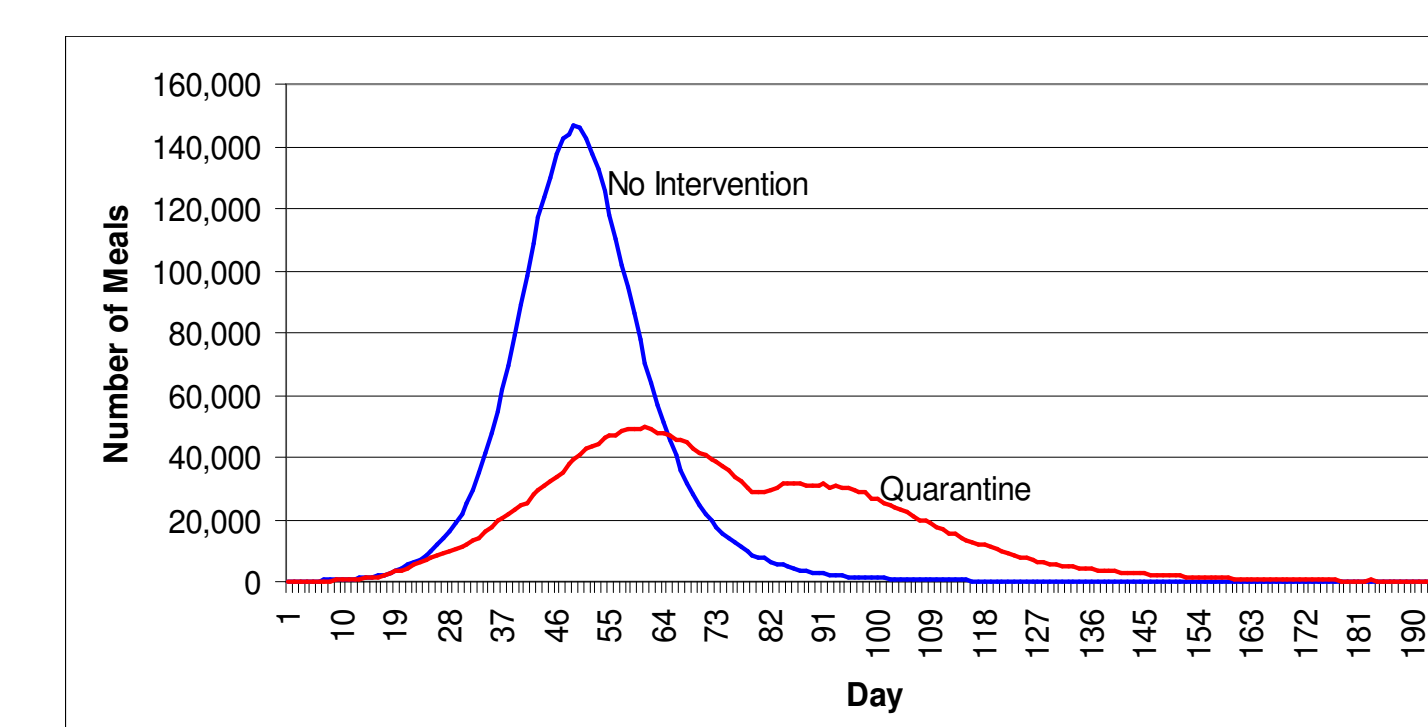
$R_0$ Value	Quarantine Start	Peak Infectivity	Peak Day	CAR	IAR	Death Ratio
1.5	7	0.80%	52	26.52%	40.46%	0.47%
1.8	4	1.86%	63	36.82%	56.14%	0.66%
2.1	3	3.97%	49	41.26%	62.87%	0.75%

## 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

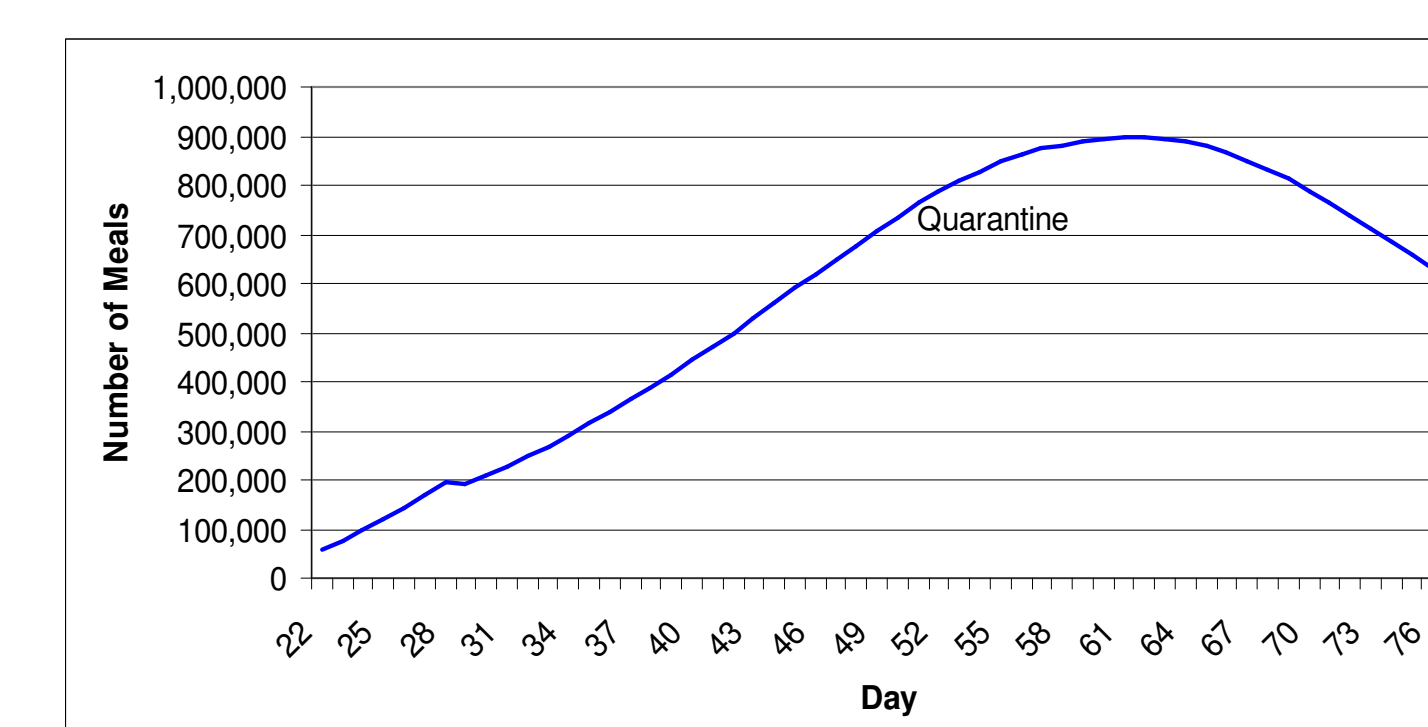


- Households with all adults infected are served
  - No intervention
  - 8-week quarantine



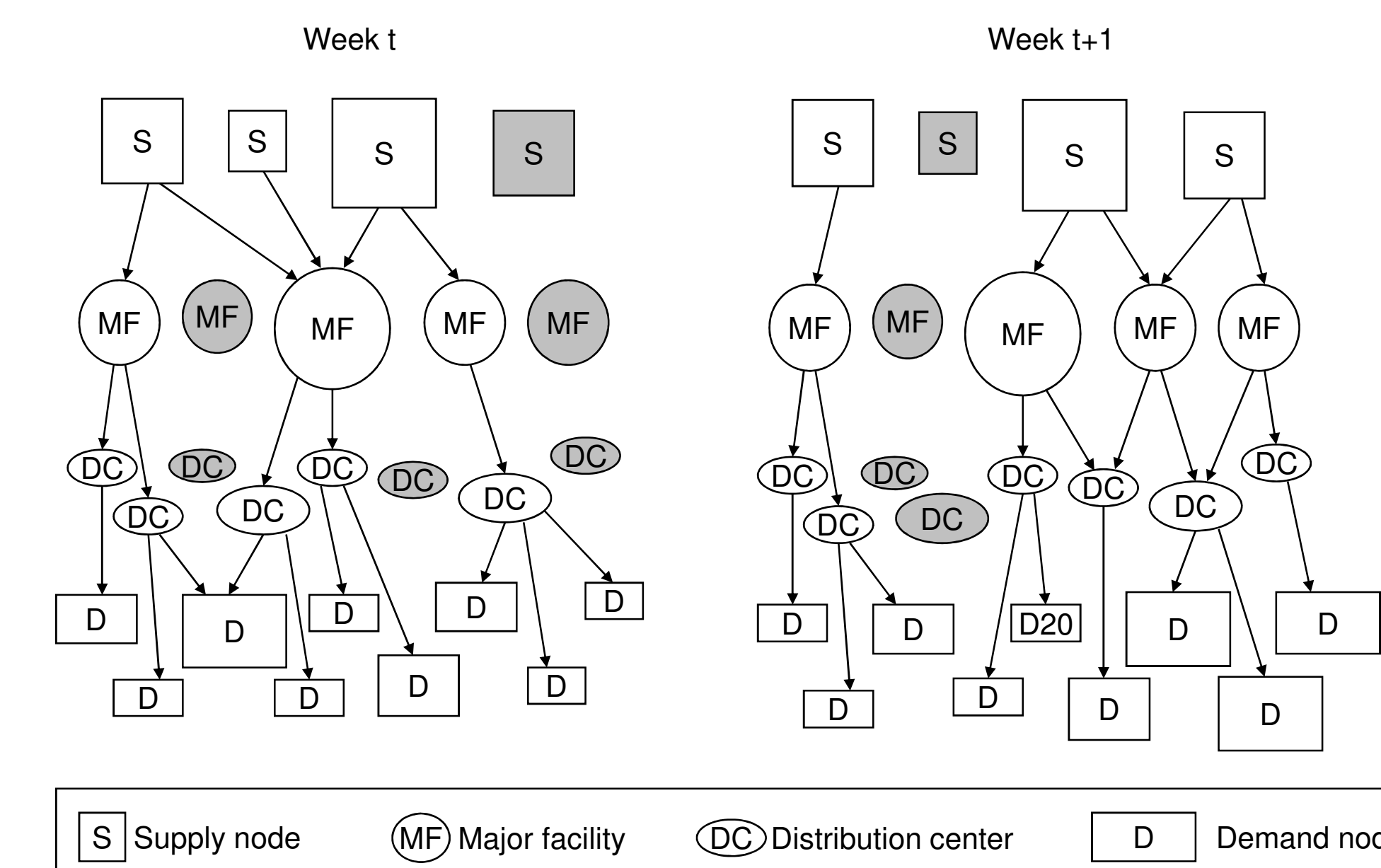
- Two peaks occur in quarantine case
  - The release of quarantine increases the number of interactions in the community and, thus, the number of infections

- Quarantined households are served under 8-week quarantine



## FACILITY LOCATION MODEL AND SOLUTION APPROACHES

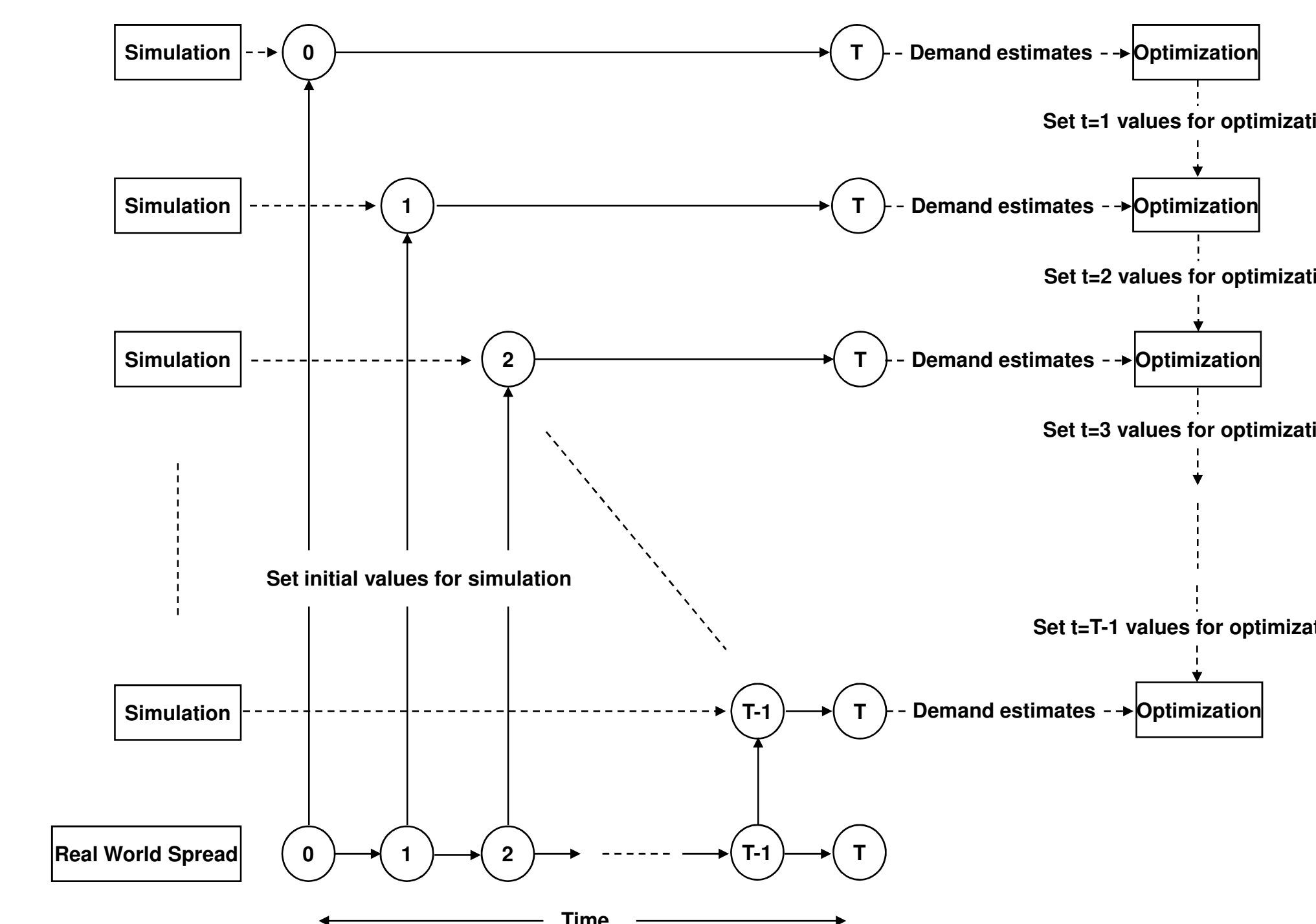
### Food Distribution Network



- Objective: minimize total cost subject to all demand is satisfied
  - Each census tract is considered as a separate demand node

### Application Strategy

- Deterministic approach
  - Simulate at the very beginning
  - Solve the optimization model using the estimated demand
- Dynamic update approach
  - Simulate at discrete time intervals to update the estimates based on the real progress
  - Resolve the optimization model after each update



- Comparison base: Optimal solution for the real world spread (Perfect Solution)

### Results

- Dynamic update; in 3.76% less total cost than deterministic approach
- Optimality gap of the dynamic update is 6.94%

## CONCLUSIONS, 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