Motivation

- Epidemics spread over a person-person contact network.
- Forecasting disease outbreak and finding effective intervention strategies is a difficult task.
- It is hard to obtain social contact networks using survey based methods.
- At NDSSL, we synthesize detailed social contact networks by combining data from multiple sources.
- Then conduct simulations of disease outbreaks over these networks using EpiSimdemics, a high performance computing software developed at NDSSL.
- In big cities, tourists play an important role in transmitting diseases as they often visit high traffic areas in the city and come in contact with each other and residents.
- In the present work, we extend the synthetic population for the Washington DC Metro Area to include a transient population consisting of leisure and business travelers.

The Synthetic Population

- Social contact network is constructed using people-location graph.
- If two persons are at the same location, at the same time, then there is an edge among them.
- Tourist locations serve as home locations for transients.
- A party is assumed to stay at one hotel.
- Hotel locations are identified from Dun and Bradstreet data.
- Preference is given to hotels in downtown.
- Probability of a hotel being chosen for a party is given by

\[ P(i | \text{num}_{\text{employees}}(i))^3 * \text{distance}_\text{from_white_house} \]

Demographics

- Individuals
- Household structure
- Statistically identical to US Census
- Assigned home and activity location

Activities and Location

- Demographically assign activity schedule at household level.
- Assign appropriate locations by activity type, distance from home and work locations.

Social Contact Network

People Vertex:
- Age
- Gender
- Household size
- Income

Edge Labels:
- Activity type: work, school, shop
- (start time, end time)

Data Sources

- United States Census
- National Household and Travel Survey
- National Center for Educational Statistics
- Dun and Bradstreet
- Navteq Street data

The Transient Population

- Hotel locations serve as home locations for transients.
- A party is assumed to stay at one hotel.
- Hotel locations are identified from Dun and Bradstreet data.
- Preference is given to hotels in downtown.
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Locating Tourists

- Red dots show tourist hotel locations.
- For four major tourist destinations (NASM, NMNH, NMAH, and the National Art Gallery), we do detailed sub-location modeling where people keep moving to different sub-locations (rooms) after a few minutes.

Assigning and Locating Activities

- Create activity template.
- All people in a party go to the same places. However, within a location (i.e. museum), they can move around by themselves.

Experiment Setup

- Simulate a flu-like disease for Washington DC metro area.
- Initial infections are same for all the cases.
- We run 50 simulations.
- Simulate disease for 120 days.
- Every day 20% of the transients leave DC and new transients with exact same demographics replace them.

Experiments and Conclusion

Interventions:
- Location specific (NASM, NMNH, NMAH, and the National Art Gallery).
- Closing museums
- For 5 days when current number of (resident + transient) infections are more than 50000.
- For 14 days when current number of (resident) infections are more than 50000.
- Hand Sanitizers
- 50% compliance.
- With various efficacy (i.e. 60% efficacy reduces the infectivity and the susceptibility to 60% of the original value).

Results and Conclusion

- Evaluate epidemics in terms of the number of residents infected at peak, cumulative infections, and the day of the peak.
- Transient population makes a significant difference in epidemic spread.
- Closing museums does not show statistically significant effect at reducing outbreak.
- Hand sanitizers are very effective based on the efficacy:
  - Efficacy of 60% is as effective as eliminating the effect of transients and delaying outbreak.
  - Efficacy of 40% and 20% reduces the number of infections and delays peak significantly.
- We speculate that transients have an effect on the epidemic because they are a source of susceptible people that is constantly replenished. We would like to examine this analytically using differential equation based model.
- Promoting sanitary behavior such as the use of hand sanitizers helps reducing disease spread.
- We would also like to evaluate intervention strategies more systematically to determine optimal strategies.

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