# Herd immunity in a network

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# Introduction

Herd immunity

Disease types

Networks

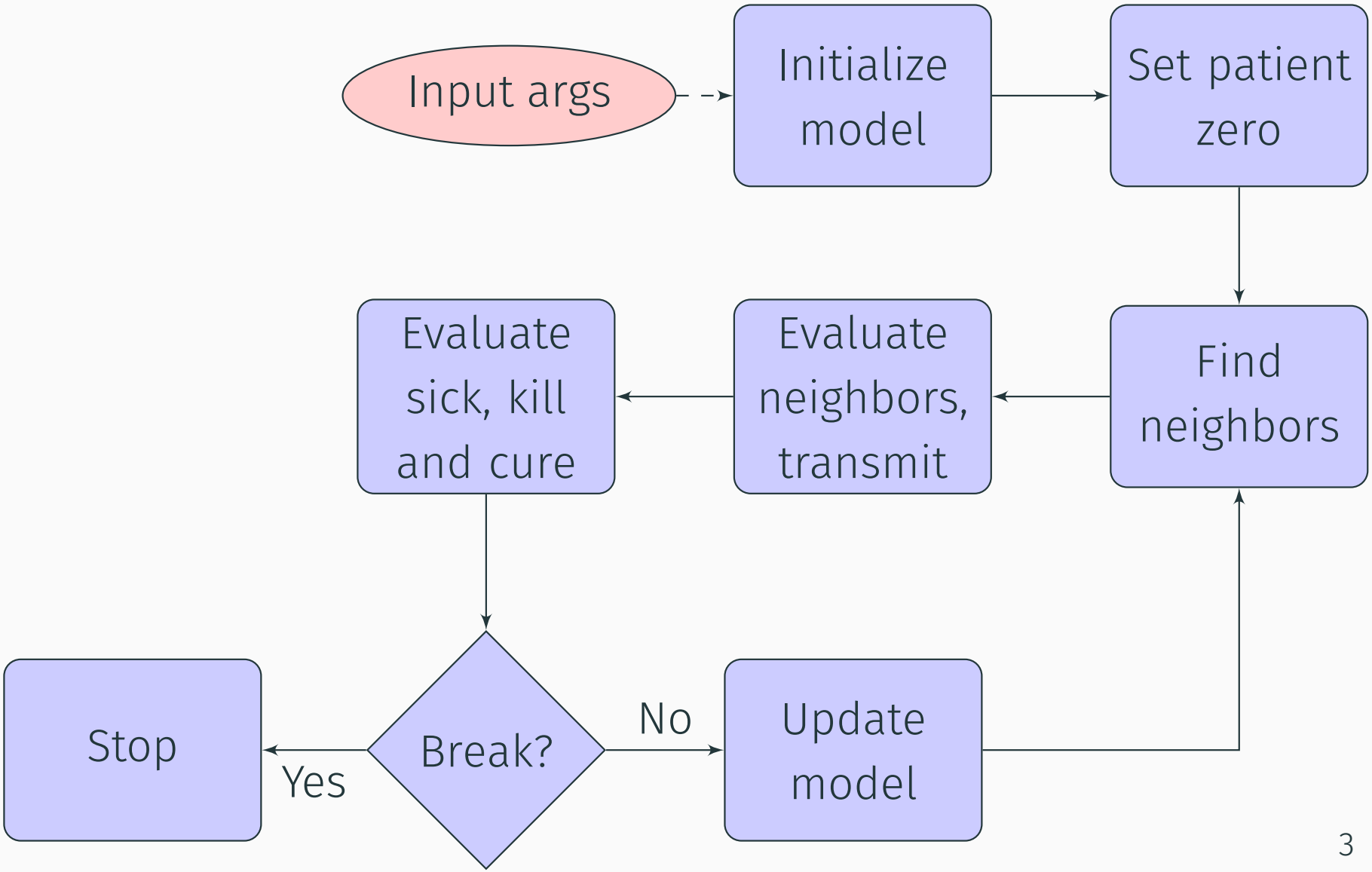
# Herd immunity

Protect the flock by immunizing

Disease types

Networks

# Code


Input args
Initialize model
Set patient zero
Find neighbors
Evaluate neighbors, transmit
Evaluate sick, kill and cure
Break?
No
Yes
Update model
Stop

# Herd immunity

- $R_0$: 'basic reproduction number'

  Avg. no. of people infected pr. person

- $p_c$: herd immunity threshold

  $p_c = 1 - 1/R_0$

- Herd immunity passively protects whole population

# Diseases

| | $R_0$ | Mortality rate | HIT |
|---|---|---|---|
| Ebola | 1.5-2.5 | 0.25-0.90 | 0.33-0.60 |
| Bubonic plague | 3 | 0.6 | 0.67 |
| Pneumonic plague | 2 | 0.90-0.95 | 0.50 |
| Measles | 12-18 | 0.15 | 0.92-0.94 |
| Flu | 1.5-1.8 | 0.001 | 0.33-0.44 |
| SARS | 2-5 | 0.096 | 0.50-0.80 |
| Polio | 5-7 | 0.15-0.30 | 0.80-0.86 |

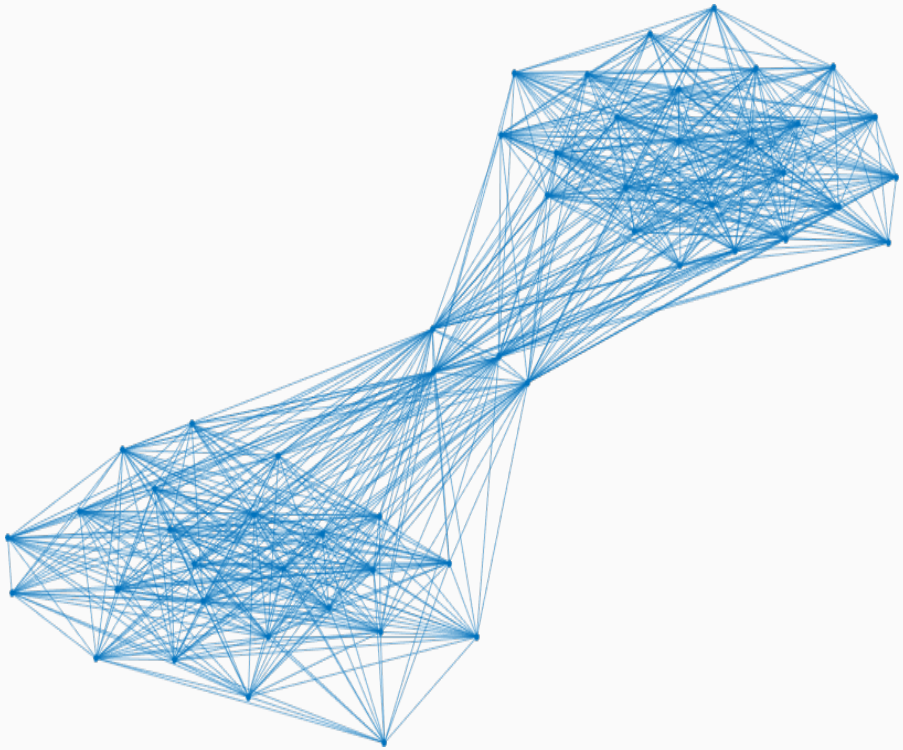
**Table 1:** Data from `https://en.wikipedia.org/wiki/Herd_immunity` & `https://www.duo.uio.no/bitstream/handle/10852/45490/KDPlagueThesis.pdf?sequence=9`

# Networks

- Small world
- Scale free
- Random
- Custom network (two cities with commuters)

# Custom network

Custom network, simulating two towns with commuters



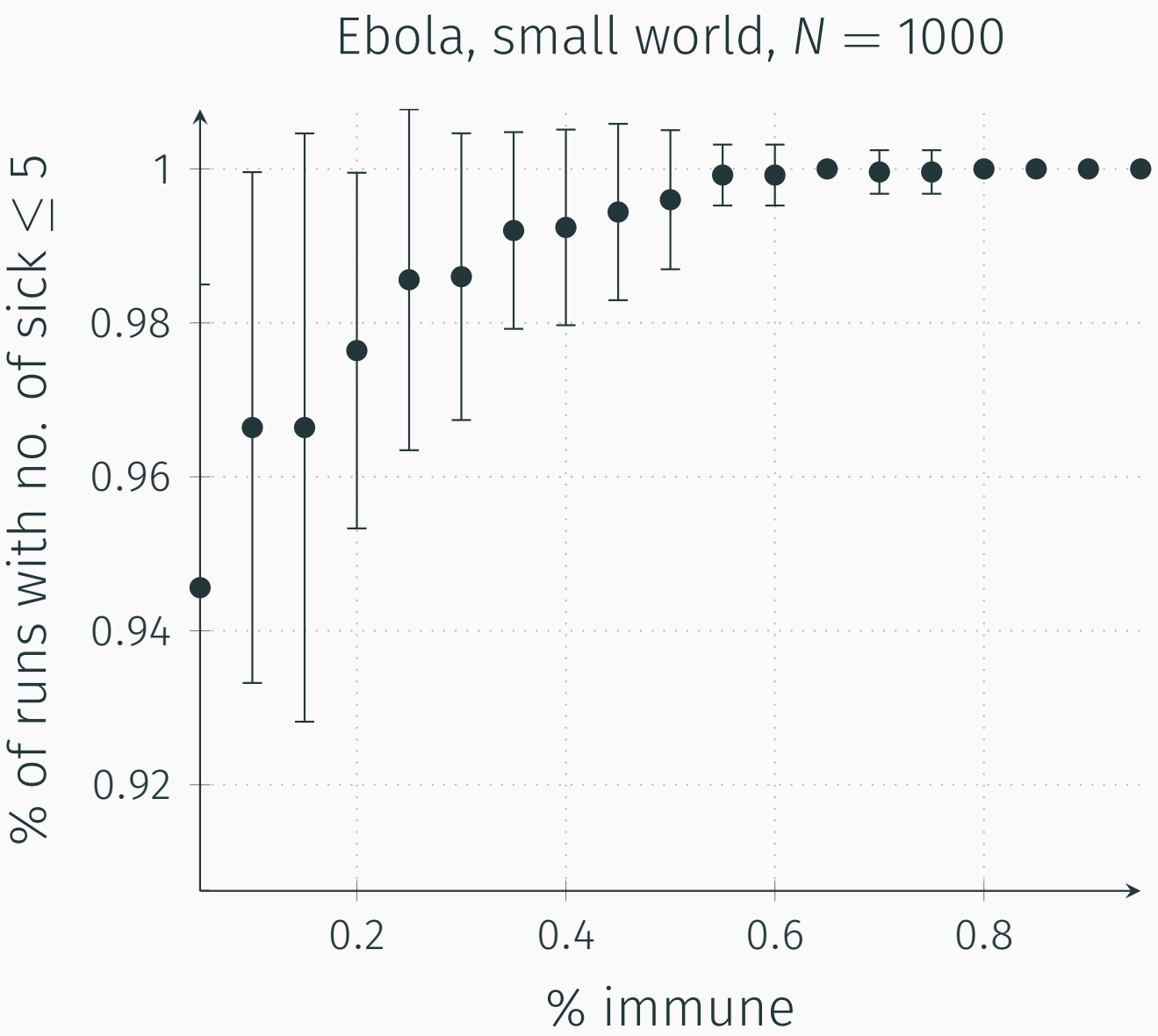
# Success criteria

- Real world
  - No percolation
  - Disease no longer endemic
- Our model
  - Unable to define percolation
  - Discussion of alternate criteria
    - Total sick $<$ arbitrary threshold
    - Effective reproductive number $\leq 1$
    - $n_{\text{sick}} = 0$ and $n_{\text{healthy}} \neq 0$

# The simulations

- Run each disease 50 times on each network
- With 20 $p_I$ values
- Save all output

# Results


Ebola, small world, $N = 1000$
% of runs with no. of sick $\leq 5$
1
0.98
0.96
0.94
0.92
0.2
0.4
0.6
0.8
% immune