

Class 8: Spread of disease in networks

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Sociology 204: Social Networks, Spring 2021
Princeton University

1/3: Spread of disease



- ▶ directed search and broadcast search

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Today: broadcast search because that's what diseases use

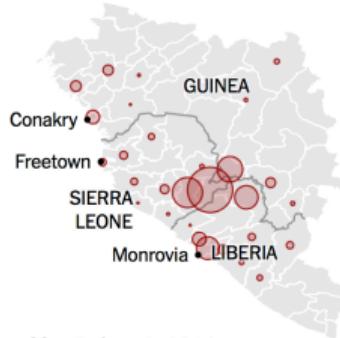
Average new cases each week

5 20 50



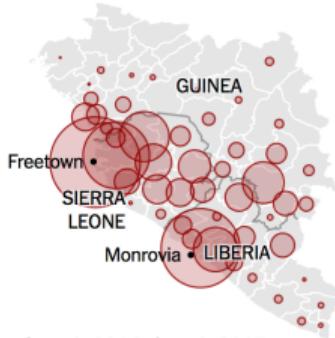
Dec. 30, 2013-May 4, 2014

The Outbreak Begins



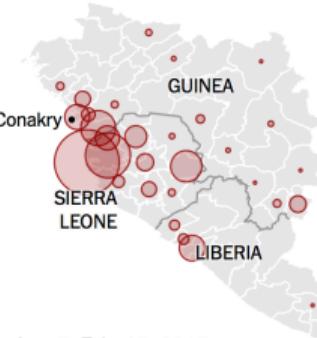
May 5-Aug. 3, 2014

New Cases Rise Rapidly



Aug. 4, 2014-Jan. 4, 2015

W.H.O. Sounds the Alarm



Jan. 5-Feb. 15, 2015

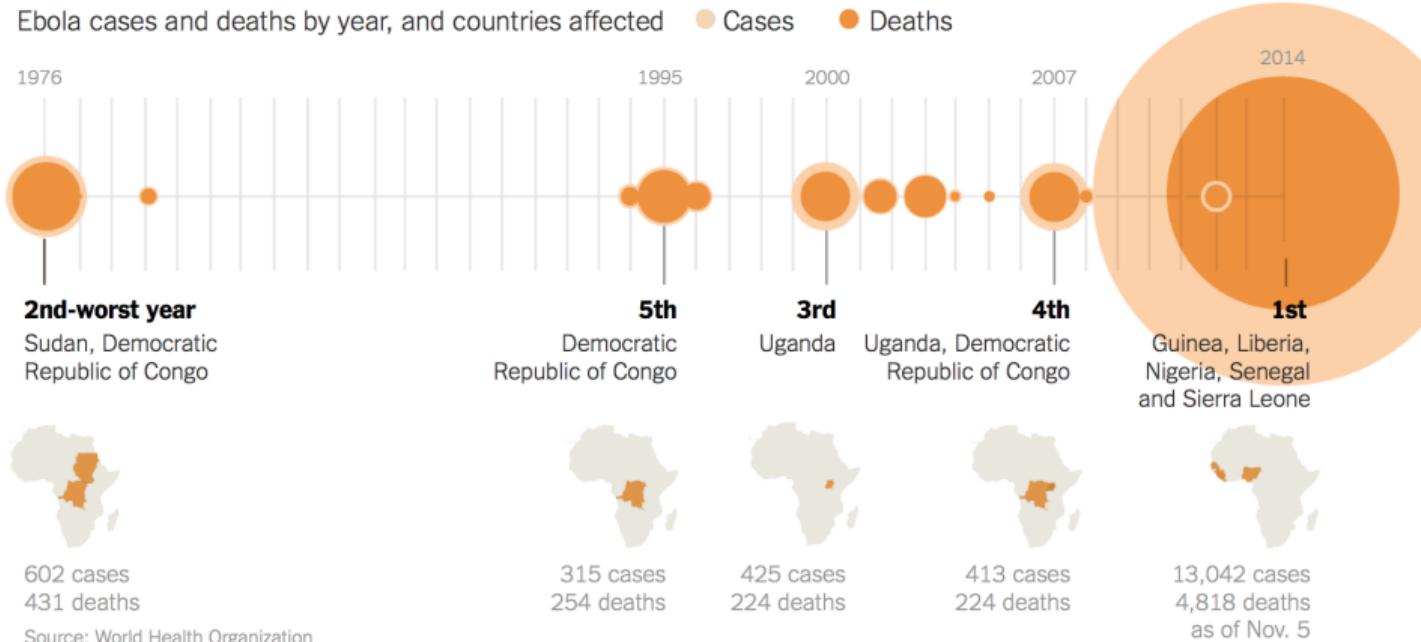
Trying to Get to Zero

<http://www.nytimes.com/interactive/2015/02/24/world/africa/2015-02-24-ebola-outbreak.html>

How Does This Compare to Past Outbreaks?

UPDATED NOV. 5

It is the deadliest, eclipsing an outbreak in 1976, the year the virus was discovered.

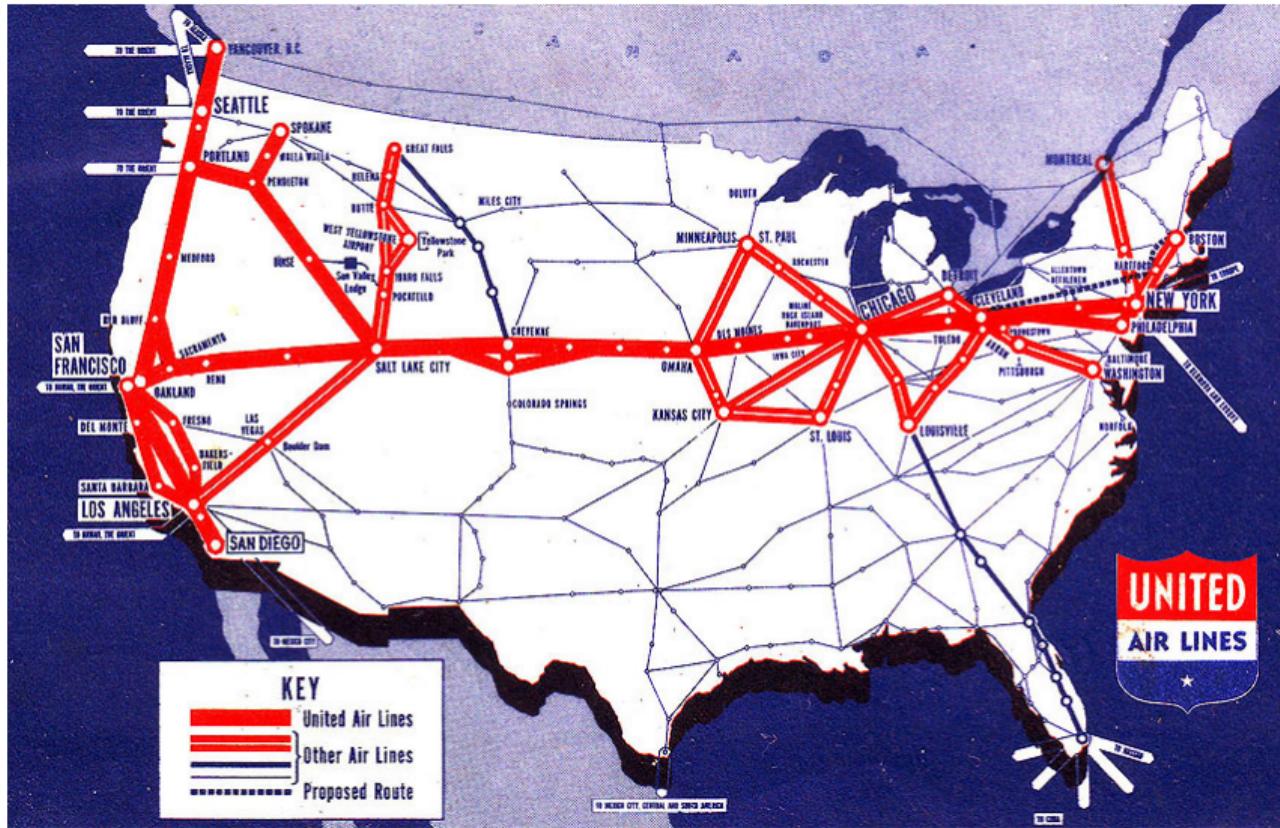


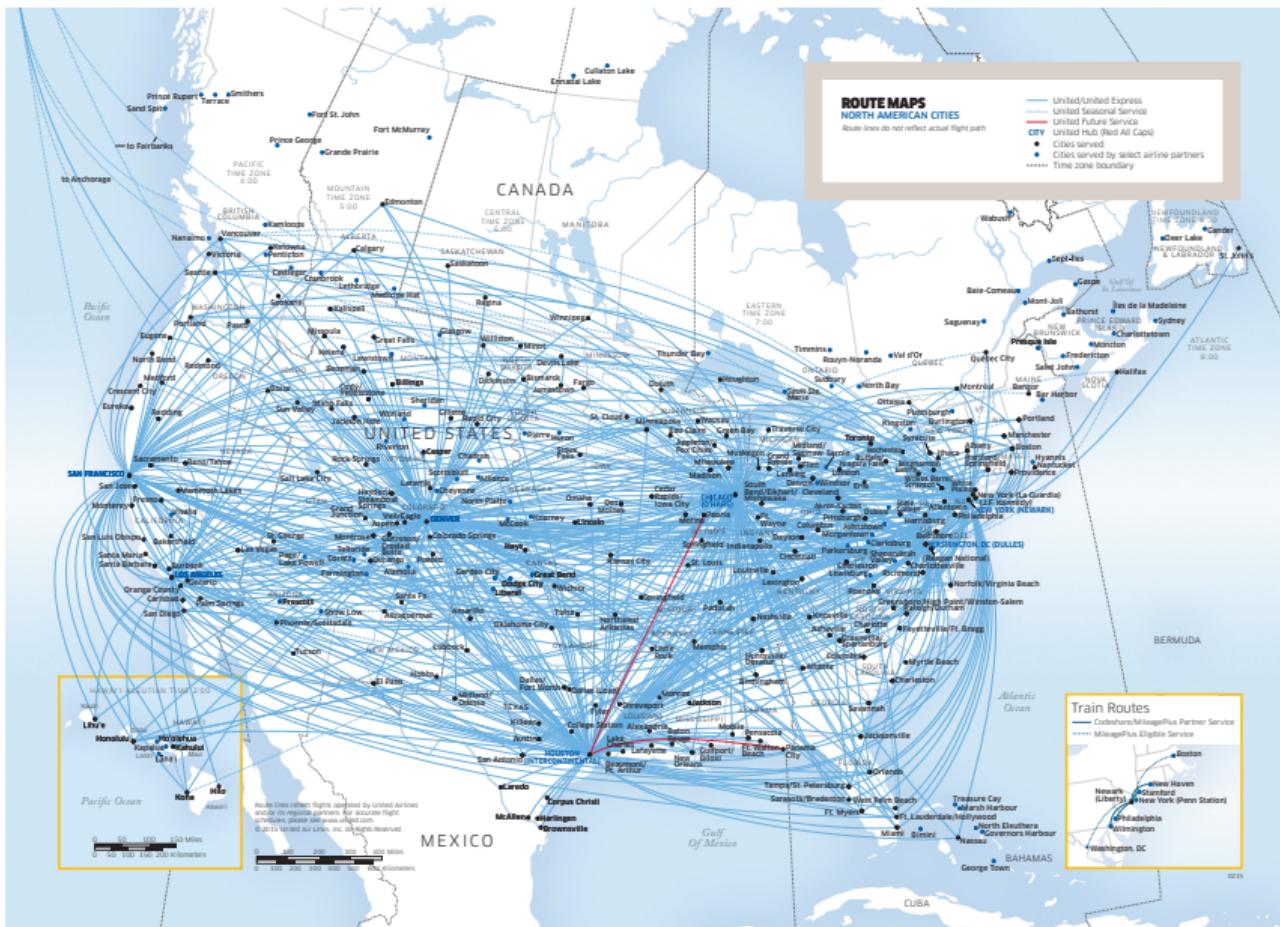
Reduced vaccination and the risk of measles and other childhood infections post-Ebola

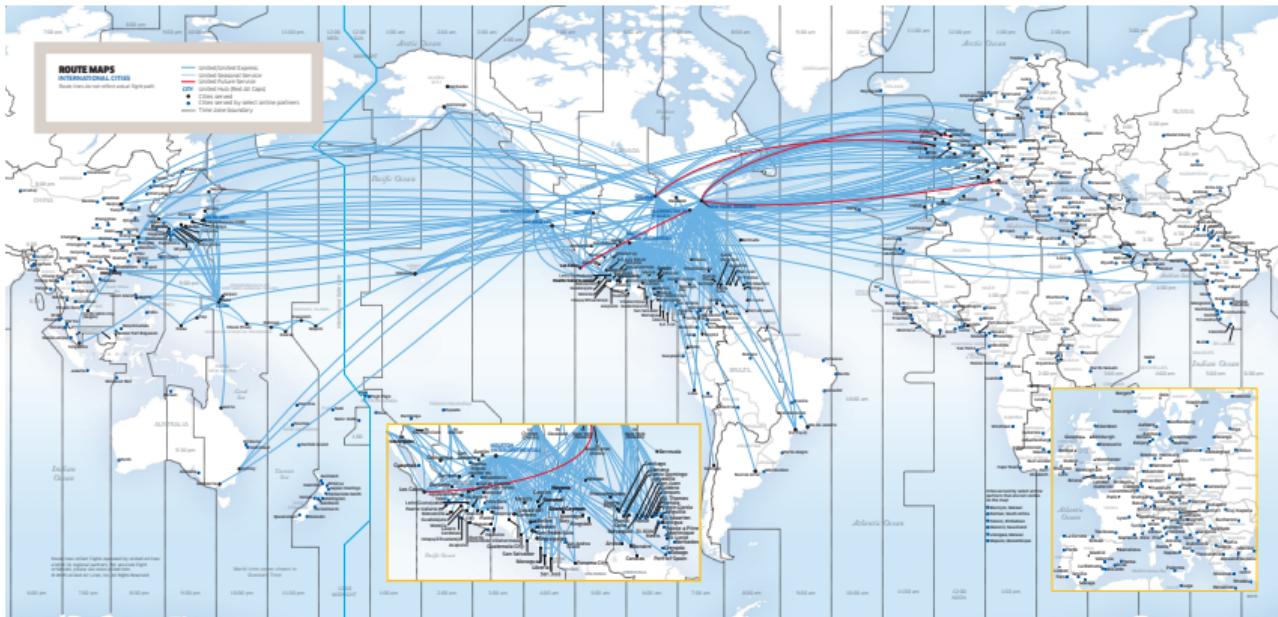
Saki Takahashi,¹ C. Jessica E. Metcalf,^{1,2} Matthew J. Ferrari,³ William J. Moss,⁴
Shaun A. Truelove,⁴ Andrew J. Tatem,^{5,6,7} Bryan T. Grenfell,^{1,6} Justin Lessler^{4*}

<http://dx.doi.org/10.1126/science.aaa3438>

What does the future of global pandemics look like? Is technology going to help us or hurt us?







http://www.united.com/CMS/Documents/pdfs/route-maps/UAL_WORLD_Map_2015_02_01.pdf

Is technology going to help or hurt with the next global pandemic?

1. help
2. hurt

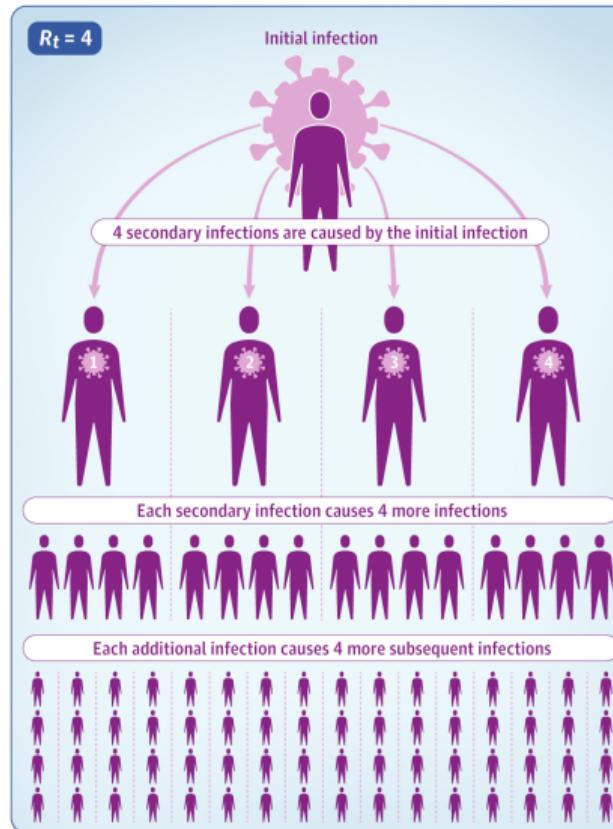
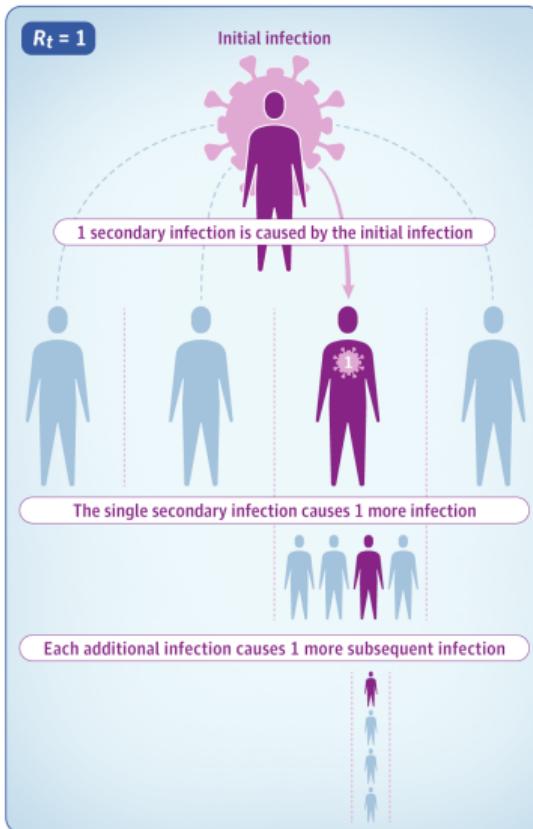
Main tools for thinking about epidemics:

- ▶ R_0
- ▶ SIR model

- ▶ R_0 : Number of new cases when a disease is introduced into a fully susceptible population

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- ▶ R : Reproduction rate: the average number of new infections generated by each currently infected individual

The effective reproduction number (R_t) of a viral infection is the mean number of additional infections caused by an initial infection in a population at a specific time.



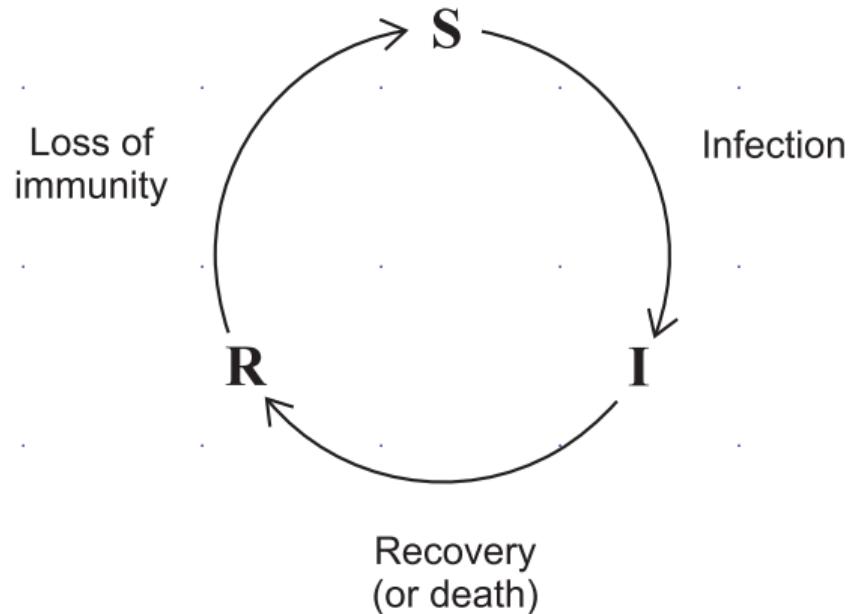
R can vary of space and time

<http://metrics.covid19-analysis.org/>

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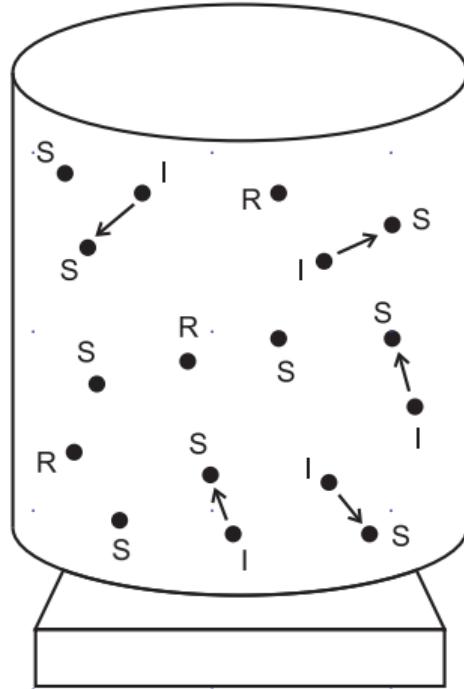
- ▶ R_0
- ▶ SIR model

6.1

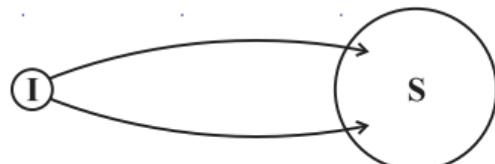


R in SIR model $\neq R_0 \neq R$

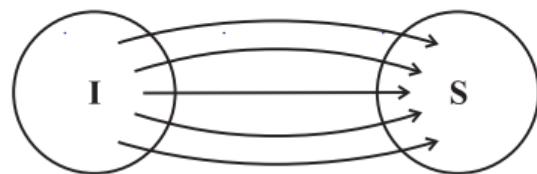
6.2



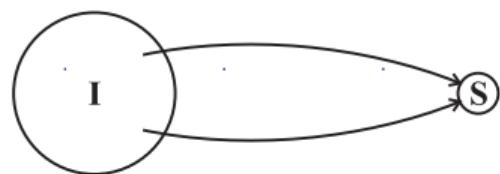
6.3



Slow Growth Phase

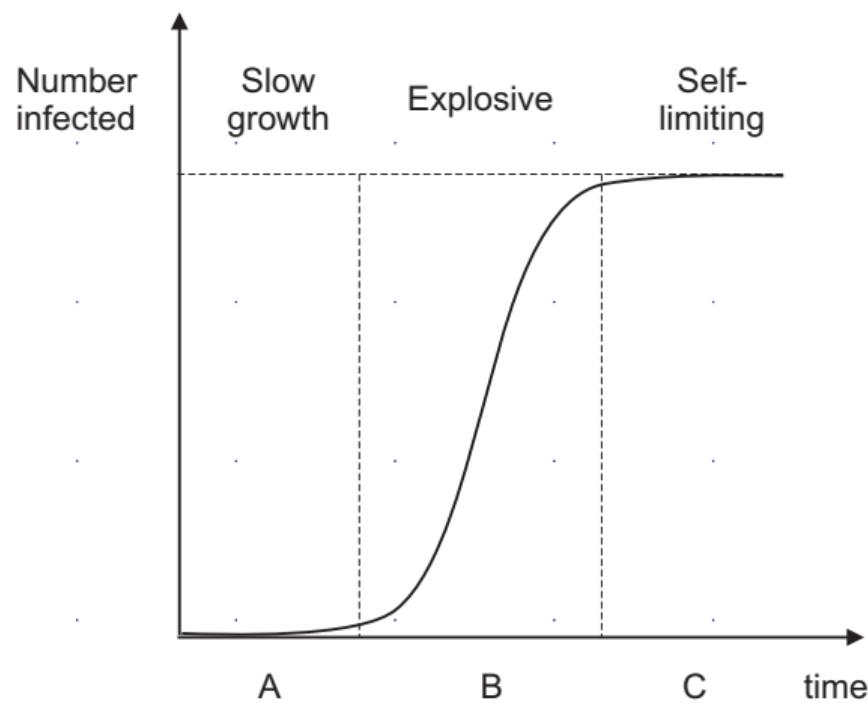


Explosive Phase

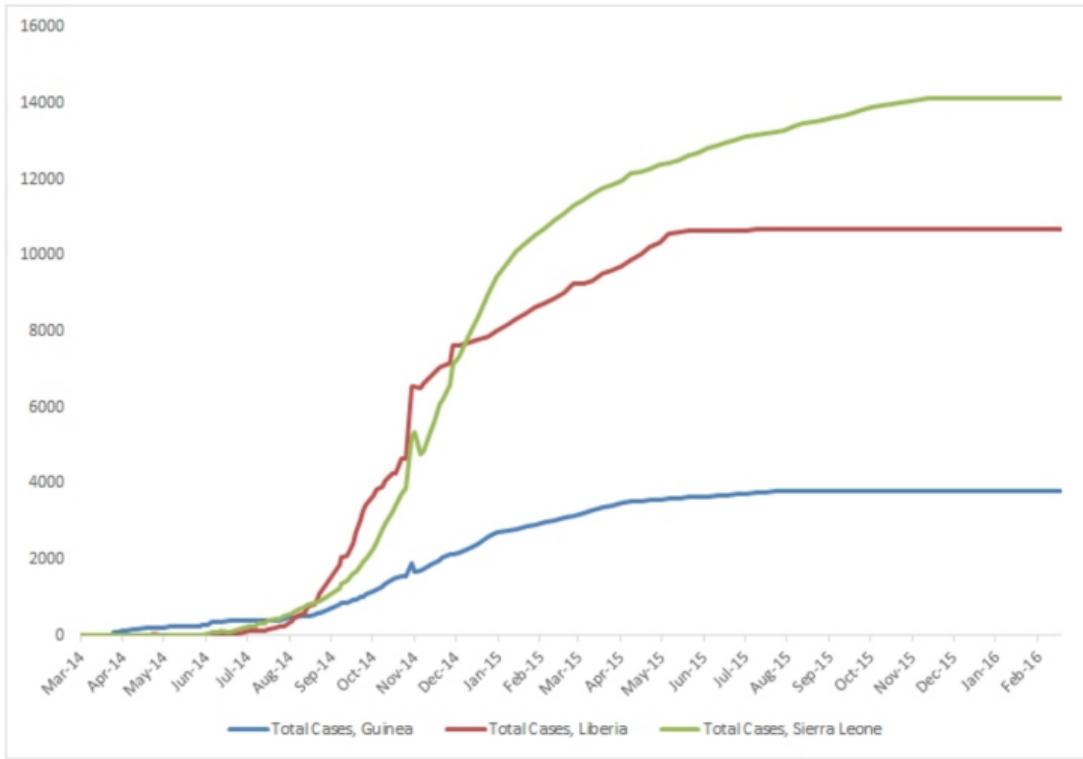


Burn Out

6.4



What shape will the Ebola time series have?

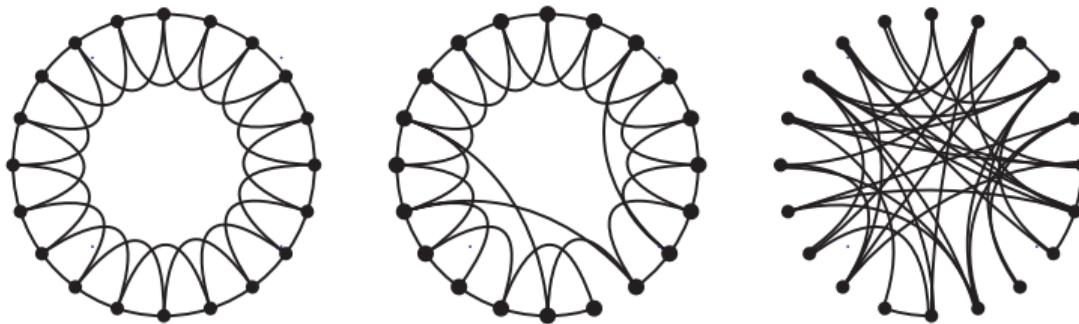


Graph 1 shows the total reported suspected, probable, and confirmed cases in Guinea, Liberia, and Sierra Leone provided in [WHO situation reports](#) beginning on March 25, 2014 through the most recent situation report on February 17, 2016.

<https://www.cdc.gov/vhf/ebola/outbreaks/2014-west-africa/>

Relationship between networks and disease

3.6

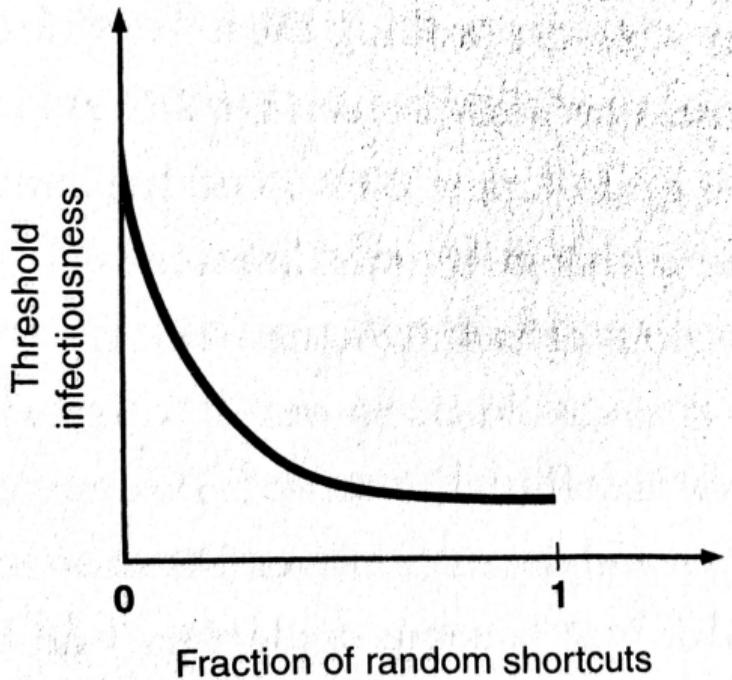


$\beta = 0$



$\beta = 1$

Increasing randomness



The small-world effect is a modern phenomenon

Seth A. Marvel,¹ Travis Martin,² Charles R. Doering,^{1,3} David Lusseau,⁴ and M. E. J. Newman³

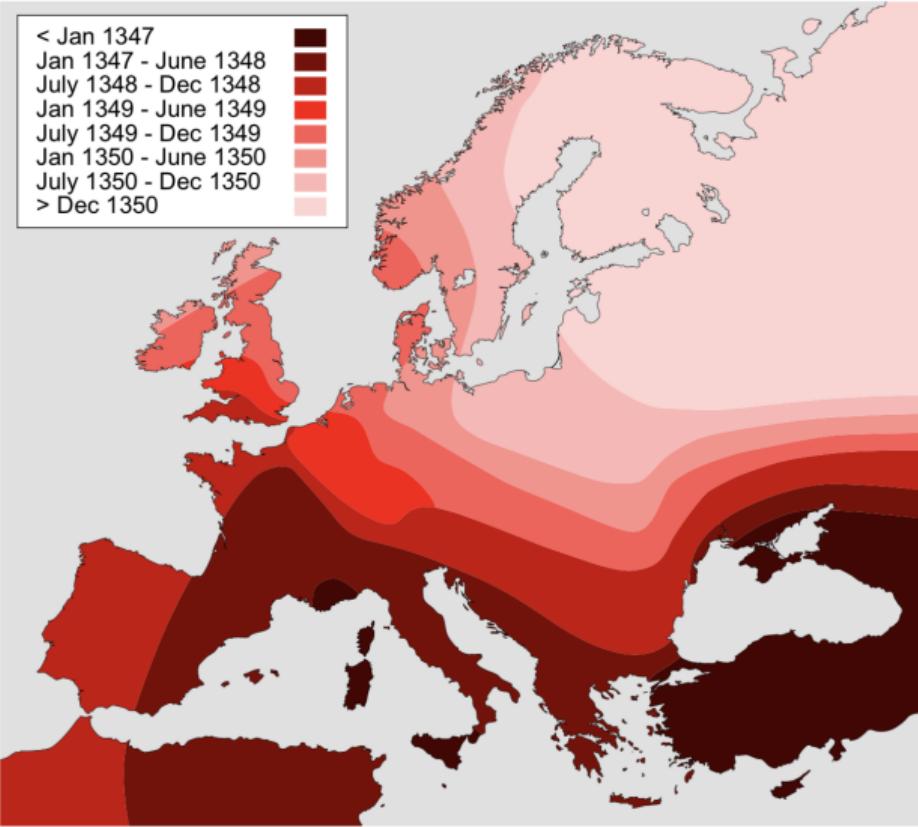
¹*Department of Mathematics, University of Michigan, Ann Arbor, MI 48109, U.S.A.*

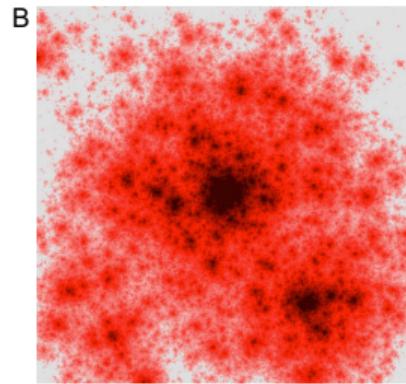
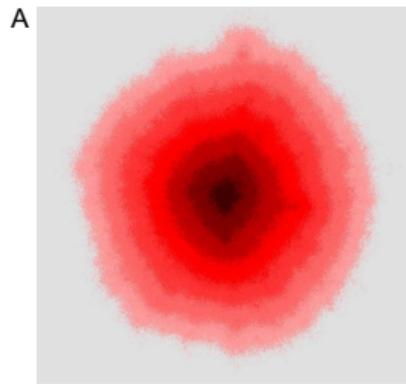
²*Department of Electrical Engineering and Computer Science,
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³*Department of Physics and Center for the Study of Complex Systems,
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⁴*Institute of Biological and Environmental Sciences, University of Aberdeen, Aberdeen, U.K.*

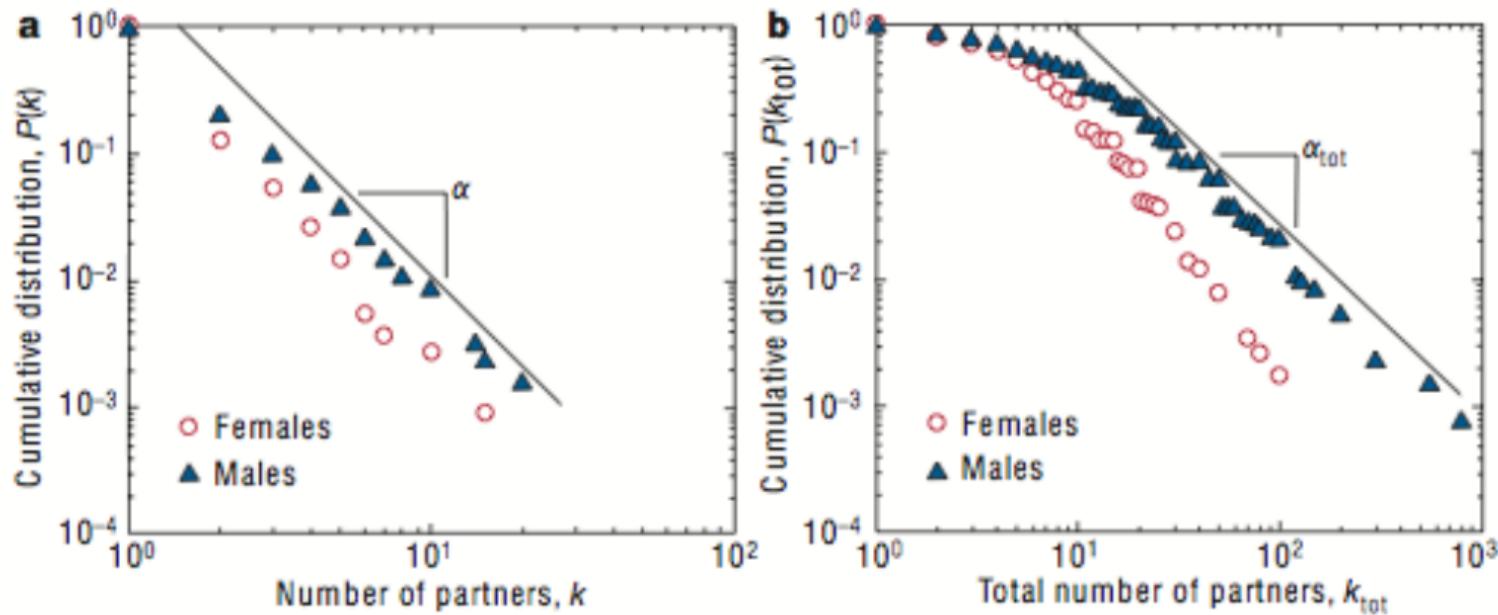
<http://arxiv.org/pdf/1310.2636v1.pdf>





- ▶ Top: Disease spread with no shortcuts
- ▶ Bottom: Disease spread with long distance connections

Important to match the disease you are studying to the appropriate contact network.
For STDs, this is the sexual network.
Recall, this image of the sexual networks in Sweden.



But what is the structure of sexual networks?