Contact patterns of inpatients in a regional healthcare system

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http://www.csc.kth.se/~pholme/

Epidemiology 101

- R_0—the expectation value of number of others an infectious individual will infect in a susceptible population.
- The crudest approximation: There can be an epidemic in a population if $R_0 > 1$.

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R_0 of Smallpox

Outbreak	R_0
Boston, USA (1721)	4.3
Burford, UK (1758)	3.4
Paris, France (1766)	4–5
Warrington, UK (1773)	4.0–5.3
Chester, UK (1774)	5.8
London, UK (1836–1870)	~ 5
Europe (1958–1973)	10–12
Kosovo (1972)	10.8

Stay out of hospitals!

- Infectious diseases are a big threat to public health.
- Hospitals have a key-role in spreading of many kinds of disease.
- In epidemics of smallpox, TB, Ebola and SARS hospitals have played a crucial role.
- Other pathogens like MRSA, norovirus or *Mycoplasma pneumoniae* can be endemic within a health care system.

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network epidemiology

- Hospitals change the contact patterns / network structure.
- Network epidemiology: How does network structure affect the spread of disease.
- This work: How does the relevant network look like for nosocomial infections.
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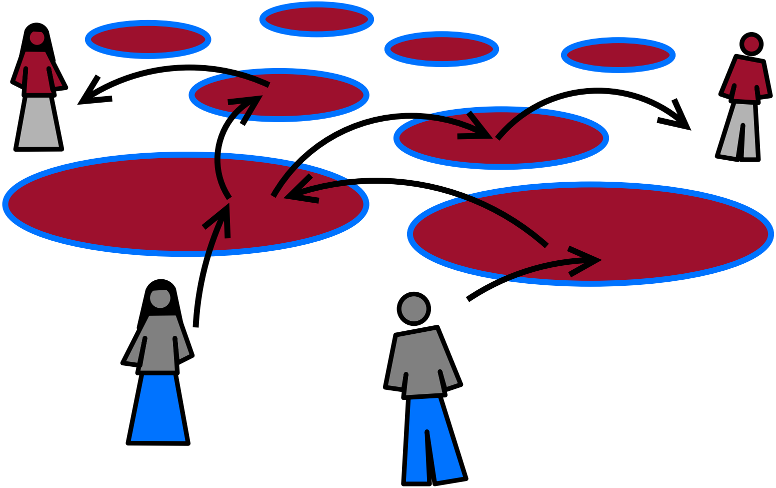
A health care system



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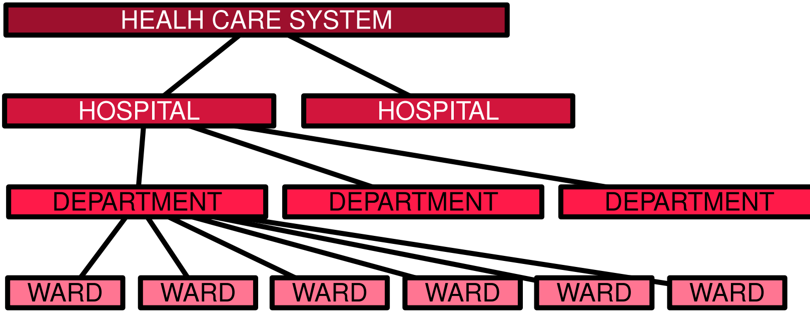

Our data

- All hospitalizations of people in the Stockholm region of Sweden the years 2001 and 2002.
- 1.7 million inhabitants.
- 570,382 hospitalizations.
- 295,108 patients.
- 702 wards.

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Constructing the networks

- What we want: Construct simple graphs where edges represent “high enough” probability of disease transmission.
- Measure network structure → use theoretical results to say something about how contact patterns affect disease spread. “high enough” probability of disease transmission.
- Could be improved to valued graphs.

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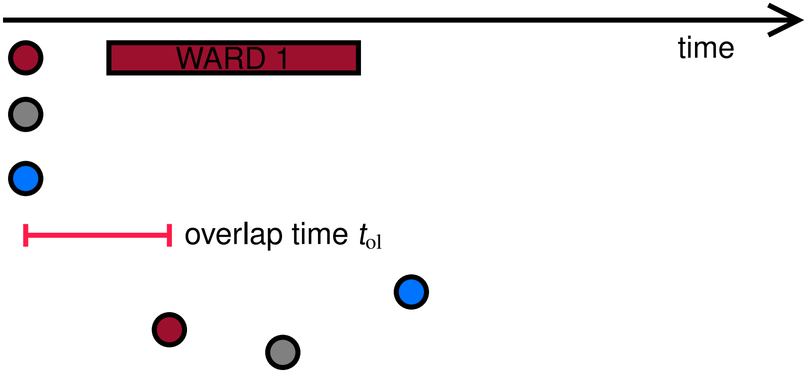

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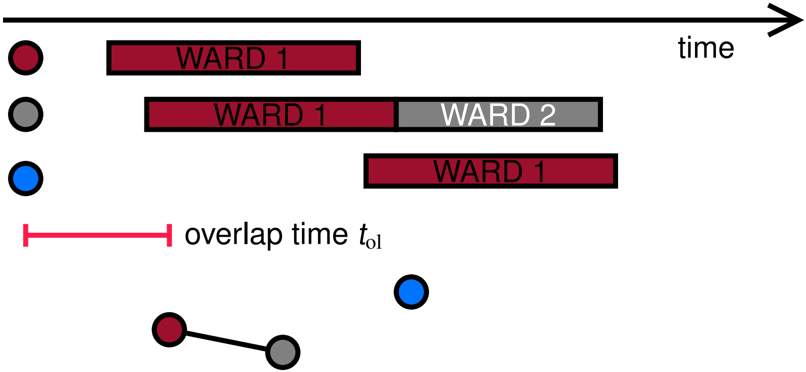

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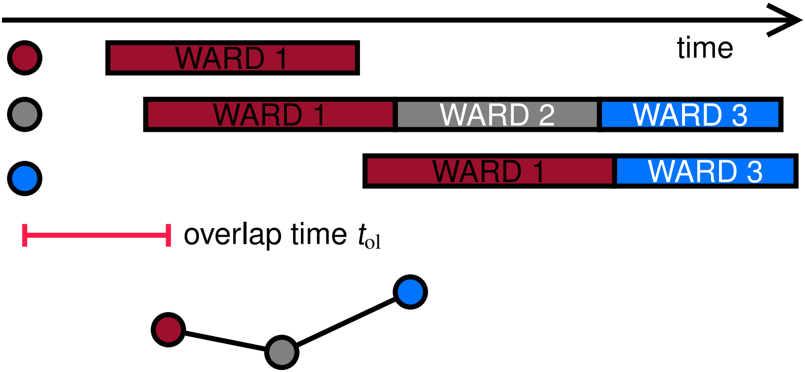
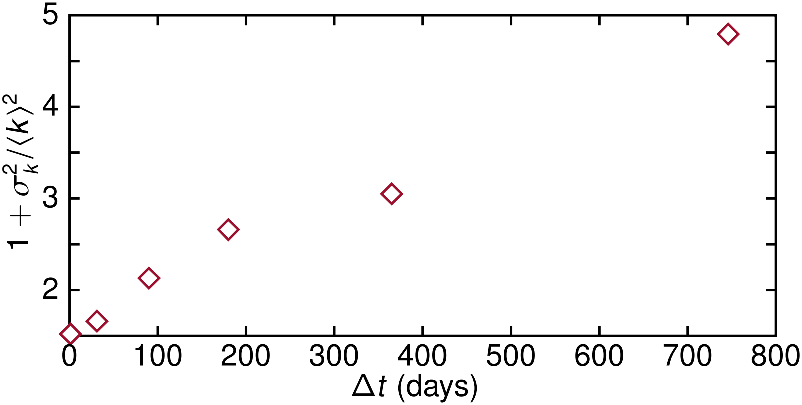


Corrected reproduction number

Fluctuations in number of contacts $\Rightarrow$ R_0 needs to be corrected by a factor $\boxed{1 + \sigma_k^2/\langle k \rangle^2}$



Clustering coefficient

- Measuring the density of triangles.
- High clustering coefficient — slow growth.

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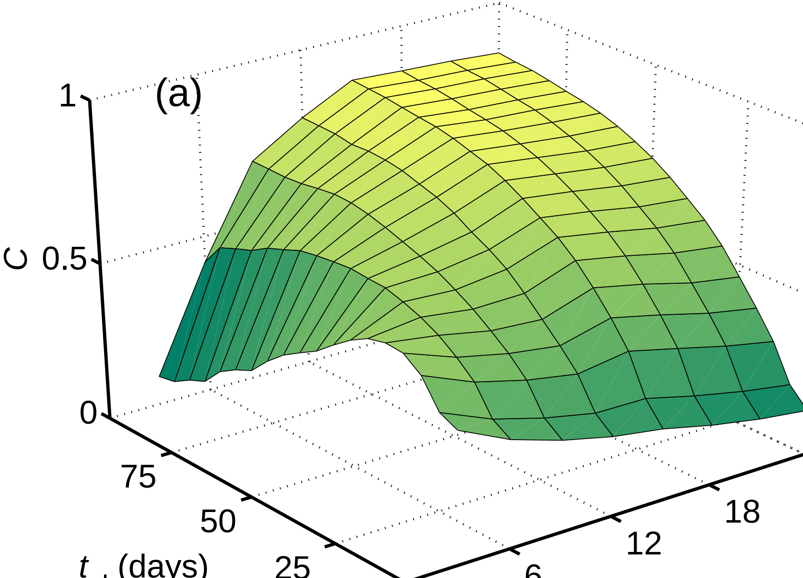

Assortativity

- Measuring the correlations of degree at either side of an edge.
- Large assortativity — high probability of epidemic outbreaks, low outbreak sizes (if an outbreak occurs).
- Large disassortativity — low probability of epidemic outbreaks, large outbreak sizes.

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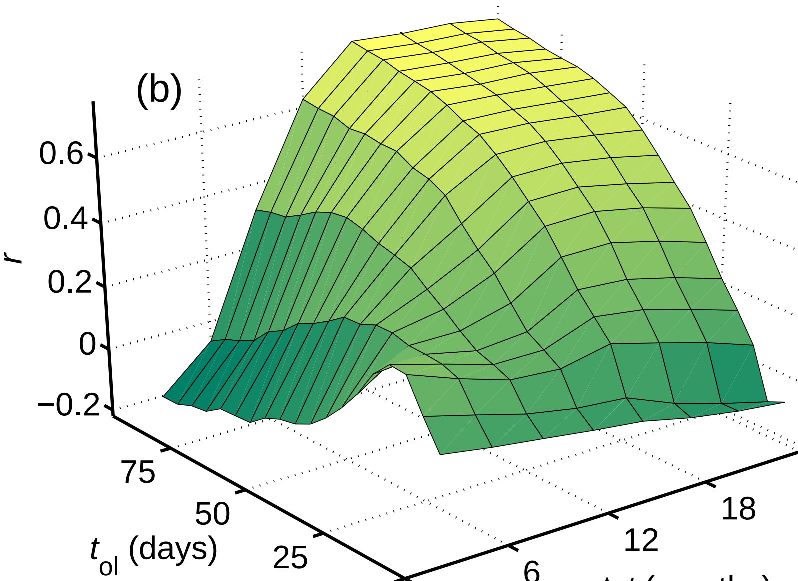
Degree-degree correlations



An agent-based model

- A population of N individuals.
- A health care system with N_w wards of equal capacity.
- Each healthy (non-hospitalized) agent is, with probability p_1, hospitalized at a random ward.
- A hospitalized patient is assigned a duration $t \in P_t$ of the hospital stay.
- After a t days the patient is, with probability $p_2 > p_1$, rehospitalized at a random ward.

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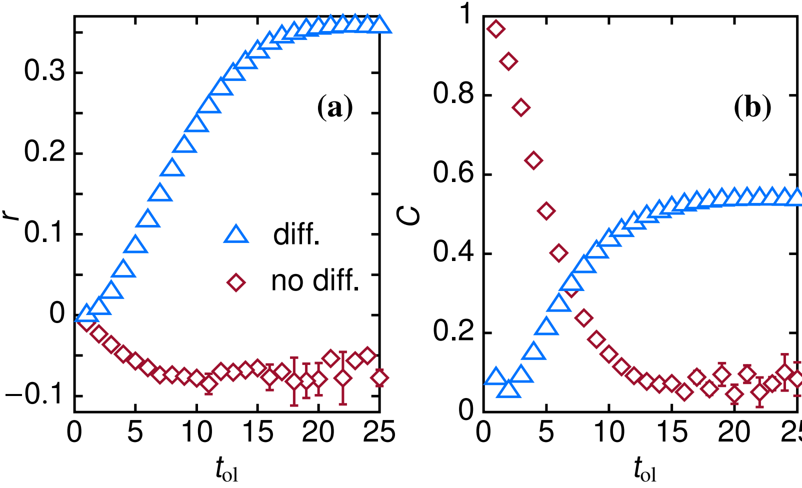
Results for the model



Summary & conclusions

- Disease spreading within a health care system is important.
- A health care system for a population of 1.7 million → proximity networks of patients.
- Power-law distribution of hospitalization times & a skewed degree distribution.
- Both clustering and assortative mixing coefficients increase with both sampling and overlap times.
- The differentiation of hospitalization times per ward is necessary to explain this
- Future work include e.g. dynamic modeling of disease spreading.

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