Epidemiology of the spread of antimicrobial resistance within healthcare networks

Hajo Grundmann, University Medical Centre Freiburg, Germany
No COI to declare
Overview

- Transmission
- Network properties
- Phylogeography of MRSA
Transmission

Not only a property of the causative agent but also a property of the host.
National patient referral networks
National patient referral networks
National patient referral networks
The English health care network

51.1 million inhabitants in England in 2007
From the NHS Hospital Episode Statistics (HES)
  • Financial Year 2007
146 acute care hospital trusts
  • 25 University hospitals
  • 42 Large acute care
  • 50 Medium acute care
  • 29 Small acute care
7.4 million patients
12.9 million admissions
Network properties
The English Hospital Patient Referral Network

[1] London (S & W)
[2] London (N)
[6] Bristol
[7] Leeds
[8] Newcastle
[9] Cambridge
[10] Southampton
[11] Liverpool
[12] Sheffield
Properties of Health care Networks

• Regionality
• Centrality
MRSA rates correlate with patient movements
Properties of Health care Networks

- Regionality
- Centrality
- Scale-freeness
Introduction of Health Care-associated Pathogens

- Patients do not move randomly
- Health care utilisation creates structured networks
  - **Centrality**
    - High indegree
    - Strong connectedness
  - **Health care collectives**
    - Geographical cooperativeness
Properties of Health care Networks

- Regionality
- Centrality
- Scale-freeness
- Small World
- Tipping point dynamics
The fate of national epidemics

**Diagram A**
- Hospitals infected over time (Weeks)
- Y-axis: Hospitals infected
- X-axis: Time (Weeks)

**Diagram B**
- Mean prevalence (%) over time (Weeks)
- Y-axis: Mean prevalence (%)
- X-axis: Time (Weeks)

**Diagram C**
- Fraction of simulations over time to 50 hospitals infected (Weeks)
- Y-axis: Fraction of simulations
- X-axis: Time to 50 hospitals infected (Weeks)

**Diagram D**
- Fraction of simulations ended in disease-free population
- Y-axis: Fraction of simulations ended in disease-free population
- X-axis: Country (England, Netherlands)
Health care collectives are non-hermetic
Health care collectives vs. Strategic Health Authorities
Hospital choices

A

B

Mean per km
Cumulative mean
Baseline

% Admissions outside collective

Distance (km)

Mean per km
Cumulative mean
Baseline

% Readmissions outside collective

Distance (km)
From watersheds to germsheds
Phylogeography of MRSA in England
Opportunistic sample

- Retrospective convenience sample
- British Society for Antimicrobial Chemotherapy (BSAC)
  - Bacteraemia surveillance
  - First 7 MRSA Bac. Isolates Selected:
    - Clonal Complex 22
    - 1058 samples
    - Hospital >25 samples
Regional population structure
Genetic Homogeneity between Hospital Populations
Single events
Conclusions

- Transmission of health care-associated MDROs is characterized by highly non-normal dynamics, whereby few cause many and many cause few.

- Infection control measures should regard regional health care networks and not only individual hospitals as the target for interventions.

- Real-time patient tracking combined with rapid genomic analysis is essential for the early management of emergence and introduction of High Risk Clones in hospitals.
Thanks

University Medical Center Groningen
Tjibbe Donker
Alex Friedrich

Addenbrooke’s Hospital Cambridge
Sharon Peacock
Sandra Reuter

Sanger Centre
Matt Holden
Stephen Bentley
Julian Parkhill

University of Bath
Ed Feil
Santiago Castillo-Ramirez

Imperial College London
David Aanesen
Brian Spratt

Central Bureau voor Statistic,
The Hague, NL

Hospital Episode Statistics, NHS,
Hemel-Hempstead, UK