Modelling the transmission dynamics of nosocomial pathogens with data of a recent VRE-outbreak at a University Hospital

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Background
Nosocomial infections due to multi-resistent pathogens like vancomycin-resistent enterococci (VRE) or methicillin-resistant staphylococcus aureus (MRSA) are a major infection control problem, especially in intensive-care and haematology units. Beside increasing costs, they play an important role in prolonging the length of stay in hospitals. Several outbreaks of VRE have occurred in hospitals in the United States and in Europe, especially in older patients and patients with a compromised immune system. Intervention strategies are essential to control the outbreak and reduce transmisson of multi-resistent pathogens. Mathematical modelling can help to understand the transmission dynamics and the pattern of spread, especially when exploring the impact of interventions.

Methods
Austin et al. [1,2] applied the deterministic Ross-Macdonald model [3] which originally models vector-borne malaria transmission. This model will be used for the VRE transmission via hands of health-care workers. Differential equations describe the temporal transmission dynamics of an VRE-outbreak on a unit or a department under specific conditions. We collected data from an outbreak of VRE between June 2004 and August 2005 at the University Hospital of Freiburg, where more than 100 patients were colonised or infected with VRE [4]. Several important parameters like the basis reproduction number, admission colonisation prevalence, length of stay etc. could be identified. These were included in the model; Gaussian noise was superimposed to get information about precision. Additional to the deterministic models, stochastic simulations via counting processes were performed.

Results
Descriptive results of the outbreak at Freiburg University Hospital will be presented. With these models, we are able to determine the final size of this outbreak and predict the effect of intervention strategies like hand hygiene, cohorting infected patients and reduction of antibiotics usage in order to get an infection-free steady state. Graphical results show which combinations of these strategies are appropriate for varying values and different scenarios. Thus, these results can be applied to other settings and will therefore help to understand and control epidemic spread of nosocomial pathogens.

Discussion
In the deterministic Ross-Macdonald model only the indirect transmission via hands of health-care workers is modelled, but there might be additional ways for the pathogen to infect humans. A VRE-transmission might also be possible if patients share the same washrooms or toilets. An extension of the Ross-Macdonald model, where this kind of transmission will be taken into account, will be discussed.

Reference:

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