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On the spread of epidemics in a closed heterogeneous population: Stochastic aspects

In [1,2] we presented an attempt to formulate a general deterministic theory of the spread of an infectious disease in a closed heterogeneous population. Specifically, we looked into heterogeneity in disease parameters (such as susceptibility to a disease); disease parameters were considered as an inherent and invariant property of individuals, whereas the parameter values could vary between individuals. The two major findings for a heterogeneous SIR model were: 1) we derived the equation for the final size of an epidemic for an arbitrary initial distribution of susceptibility, which shows that the initial susceptibility distribution is crucial in determining the part of the population that escapes infection; 2) the widely used power transmission function was deduced from the model with distributed susceptibility and infectivity with the initial gamma-distribution of the disease parameters, therefore, a mechanistic derivation of the phenomenological model, which is believed to mimic reality with high accuracy, was provided.

Here we additionally discuss stochastic aspects of the model, which are impossible to study within the framework of deterministic models, namely:

- In which way the parametric heterogeneity changes the probability of a major outbreak;
- What are the consequences of the parametric heterogeneity on the mean duration of an epidemic;
- What are the mean and variance of the distribution of the final epidemic size for different initial susceptibility distributions.

References

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[2] A. S. Novozhilov. *Heterogeneous susceptibles–infectives model: Mechanistic derivation of the power law transmission function.* Dynamics of Continuous, Discrete and Impulsive Systems (Series A, Mathematical Analysis), **16**(S1):136–140, 2009.