Global dynamics for spatial epidemic models with infection during transportation

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abstract:

Many infectious diseases are transmitted during long distance transportation. We consider a class of spatial epidemic models that includes this phenomenon, thus having a dynamics not only at geographic locations, but also during travel. The system is naturally age structured, where age refers to the time elapsed since start of travel, and equivalent to a time delay system.

When the disease dynamics is SIS type, we arrive to an explicit system of delay differential equations. Then, after a dimension reduction using the theory of asymptotically autonomous semiflows, and applying the theory of cooperative sublinear dynamical systems, we give a complete characterization of the global dynamics by means of various reproduction numbers. When the transportation network is strongly connected, there is a single threshold parameter, that determines whether the disease will be eradicated on each patch, or we have convergence to an endemic equilibrium on each patch. However, when the network is not strongly connected, numerous interesting patterns can emerge: the disease may die out in some patches, while it may remain endemic in other patches. We show that there is always a globally asymptotically stable equilibrium, and we provide a method which can precisely determine the endemic pattern belonging to this equilibrium, depending on the local reproduction numbers and the network topology. Then we examine the effect of travel restrictions on the global dynamics.

In more realistic situations the underlying disease dynamics is more complicated, and the delayed feedback is only implicitly given in the obtained system, causing further difficulties in the analysis. As an application, we adapt and parametrize our model to influenza and use Canadian air traffic data for simulations, to assess the impact of travel related infections on the spread of a global pandemic.

If time allows, we mention a stochastic model for travellers visiting a tournament in an endemic region. The model is applicable for example to the previous Euro 2012 football championship. The following strange act will also be discussed: the result of a football game can cause measles epidemics in various European countries.