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The Impact of City Mobility on Propagation of Infectious Diseases: Mathematical Modelling Approach

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Abstract : Infectious diseases are among the most prominent threats to human beings. They cause morbidity and mortality to an individual and collapse the social, economic, and political systems of the whole world collectively. Mathematical models are fundamental tools and provide a comprehensive understanding of how infectious diseases spread and designing the control strategy to mitigate infectious diseases from the host population. Modeling the spread of infectious diseases using a compartmental model of inhomogeneous populations is good in terms of complexity. However, in the real world, there is a situation that accounts for heterogeneity, such as ages, locations, and contact patterns of the population which are ignored in a homogeneous setting. In this work, we study how classical an SEIR infectious disease spreading of the compartmental model can be extended by incorporating the mobility of population between heterogeneous cities during an outbreak of infectious disease. We have formulated an SEIR multi-cities epidemic spreading model using a system of 4k ordinary differential equations to describe the disease transmission dynamics in k-cities during the day and night. We have shownthat the model is epidemiologically (i.e., variables have biological interpretation) and mathematically (i.e., a unique bounded solution exists all the time) well-posed. We constructed the next-generation matrix (NGM) for the model and calculated the basic reproduction number R0for SEIR-epidemic spreading model with cities mobility. R0of the disease depends on the spectral radius mobility operator, and it is a threshold between asymptotic stability of the disease-free equilibrium and disease persistence. Using the eigenvalue perturbation theorem, we showed that sending a fraction of the population between cities decreases the reproduction number of diseases in interconnected cities. As a result, disease transmissiondecreases in the population.

Keywords : SEIR-model, mathematical model, city mobility, epidemic spreading
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