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Modelling of spatial infection spread through heterogeneous population: from lattice to PDE models

We present a simple model for the spread of an infection that incorporates spatial variability in population density. Starting from first principle considerations, we explore how a novel PDE with state-dependent diffusion can be obtained. This model exhibits higher infection rates in the areas of higher population density, a feature that we argue to be consistent with epidemiological observations. The model also exhibits an infection wave whose speed varies with population density. In addition, we demonstrate the possibility that an infection can "jump" (i.e., tunnel) across areas of low population density towards the areas of high population density. We briefly touch upon the data reported for coronavirus spread in the Canadian province of Nova Scotia as a case example with a number of qualitatively similar features as our model. Lastly, we propose a number of generalizations of the model towards future studies.