Research Project

Multiscale dynamics of dog rabies elimination

Third-party funded project

Project title Multiscale dynamics of dog rabies elimination
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Multiscale dynamics of dog rabies elimination The aim of this project is to elucidate the contributions of population vaccination coverage and the vaccine immunity of individual dogs on the interruption of dog rabies transmission; determine the role of population density of dogs in the transmission of rabies; and identify the optimal frequency and coverage of vaccination campaigns. The proposed project will help define the most cost-effective dog mass vaccination strategies for rabies elimination in Africa and Asia. Rabies is a zoonotic disease that is responsible for substantial human mortality in Asia and Africa, but recent studies have suggested that elimination is possible. We hypothesize that the population level aspects of vaccination coverage contribute more to the dynamics of dog rabies elimination than the kinetics of protective antibodies within individual dogs; and that the transmission of dog rabies is density dependent below a threshold of 100 dogs per km2. Approach: In 2012 and 2013 we vaccinated 18,200 and 20,000 dogs in N'Djaména, Chad, reaching a population coverage of more than 70%. Dog rabies incidence dropped from one rabid dog per week prior to the mass vaccination to less than one rabid dog in eight months afterwards. The last rabid dog was recorded in January 2014. Because of the multiple scales (between dogs and within dogs) in rabies transmission and immune dynamics, this unique data set will be used for comparative mathematical modeling approaches with individual based (contact networks and machine learning) and population-based models. First, we use dog to dog and dog to human contact network data, collected by observational studies, to extrapolate individual dog contact networks to a citywide contact network as a basis for rabies transmission models. Next we will develop metapopulation models that extend an existing compartmental model into 4 or 5 interconnected sub-models, based on the spatial heterogeneity of dog populations in N'Djaména, with assumptions of both frequency-dependent and density-dependent contact rates. Finally we will develop an individual dog based machine learning model and simulate the kinetics of protective antibodies in new populations. The three sets of models will be calibrated to existing data from the previous vaccination campaigns and compared by goodness of fit measures that evaluate parsimony and determine best fitting models (and model assumptions). The models will be used to predict the effectiveness of vaccination campaigns at various frequencies and coverage levels in preventing rabies epidemics due to imported cases. These predictions can then be validated against numbers of any new dog and human rabies cases through the project duration. Expected results and societal impact: This project will generate new knowledge on dog rabies transmission dynamics and potential for elimination; provide advice on optimal vaccination strategies; and identify the most realistic and parsimonious models for the follow-up of forthcoming dog mass vaccination campaigns in Africa and Asia in the framework of the Global Alliance for Rabies Control (GARC).

Keywords Transmission dynamics, Metapopulation model, Rabies elimination, Mass vaccination, Machine learning, Contact network model
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