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Rabies simulation in a non-endemic environment: development and application of a novel model

Salome Dürr[1], Michael P. Ward[2], [1]Veterinary Public Health Institute, Liebefeld, Switzerland; [2]The University of Sydney, Camden, Australia. Contact: salome.duerr@vetsuisse.unibe.ch

Purpose

Domestic dog rabies is an endemic disease in large parts of the world and also epidemic in previously free regions. For example, it continues to spread in eastern Indonesia and currently threatens adjacent rabies-free regions, including remote northern Australia. Disease spread models are useful tools to provide evidence on most effective disease control strategies and to inform policy decision. Existing rabies models typically focus on long-term control programs in endemic countries. However, for a region in which rabies is exotic, predictions of the effectiveness of different interventions following the initial detection of rabies are more relevant, and such models are lacking.

Methods

We here describe a stochastic, spatially explicit rabies simulation model, which was developed within a rabies free region. It is based on individual dogs in Indigenous communities in northern Australia, informed by dog census data and incorporates three types of rabies spread: within household, between households (based on a distance kernel fitted to field collected GPS data on the roaming behaviour of dogs) and between communities. Three types of control strategy are implemented in the model: a) dog vaccination (pre-emptive or reactive), b) culling (targeted or random) and c) movement ban between and within communities, with definable dog owner compliance.

Results

Outcomes suggest that vaccination with 70% coverage would significantly reduce the outbreak size while the other strategies only show a slightly positive effect when applied at high levels (50% culling and 80% ban compliance). Importantly in these Indigenous communities, culling of dogs is unlikely to be successful. Also, movement bans (which culturally would be difficult to implement) would have minor impact unless there was high compliance. The mean R0 was found to be 1.7 with epidemic peaks after 97 days post-incursion.

Conclusions/Relevance

This is, to the best of our knowledge, the first time a rabies model has been applied to compare control strategies for an epidemic situation with absence of rabies prior to the simulated incursion. It provides evidence on which to base preparedness plans and also to manage recent incursions.