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Rabies Hotspot Detection Using Bipartite Network Modelling Approach

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ABSTRACT

Despite entering its fourth year, the rabies outbreak in the East Malaysian state of Sarawak has claimed another nine lives in 2020, culminating with a total of 31 laboratory-confirmed cases of human rabies as of 31st December 2020. One of the outbreak control challenges faced by the authorities within a previously rabies-free area, such as in the case of Sarawak, is the lack of information regarding possible starting sources, notably hotspot locations of the outbreak. Identification of potential high-risk areas for rabies infection is a *sine qua non* for effective disease interventions and control strategies. Motivated by this and in preparation for future similar incidents, this paper presented a preliminary study on rabies hotspot identification. The modelling approach adopted the bipartite network where the two disjoint sets of nodes are the Location node and Dog (Bite Cases) node. The formulation of the network followed closely the Bipartite Modeling Methodology Framework. Thorough model verification was done in an attempt to show that such problem domain can be modelled using the Bipartite Modeling approach.

Keywords: Bipartite Network Modeling Framework, BRC, Dog, Location, Rabies, Ranking

INTRODUCTION

An outbreak of rabies has killed 29 people to date and affected dozens of localities throughout the East Malaysian state of Sarawak. Various rabies control efforts have been carried out by the local government, which include canine rabies vaccination, human post-exposure prophylaxis and targeted removal of dogs through culling (Taib, Labadin, & Piau, 2019). Despite entering its fourth year, the disease has claimed another nine lives in 2020 alone and dog bite incidents remain relatively high (State Disaster Management Committee, 2020). As Sarawak was historically rabies-free, rabies surveillance and vaccination practice were not conducted prior to the initial outbreak in July 2017 (Navanithakumar *et al*., 2019). Hence, the government faced some difficulties to control the disease outbreak when it first started out which may be attributable to the lack of information regarding possible hotspots for rabies. Herein we focus on the identification of these possible starting sources or rather, hotspot locations of Sarawak rabies outbreak.

Over the past decades, mathematical modelling of dynamical systems has been a vital tool in analyzing the evolution of disease spread while also offering insights into the most efficient control strategies. According to Siettos and Russo (2013), current mathematical models of dynamical systems generally encompass four different approaches: (1) deterministic models, (2) stochastic models, (3) agent-based models and (4) network models. As such, previous rabies modelling studies mainly investigate the transmission dynamics of rabies using deterministic models (Asamoah, Oduro, Bonyah & Seidu, 2017; Huang, Ruan, Shu & Wu, 2019; Zhang, Jin, Sun, Sun & Ruan, 2012), stochastic models (Cao, Feng, Wen, Zu & Gao, 2020; Dürr & Ward, 2015; Hudson, Brookes, & Ward, 2017; Sparkes *et al.*, 2016), agent-based models (Brookes, Dürr, & Ward, 2019) and network models (Laager *et al*., 2018).