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A qualitative analysis of dog-mediated human rabies dynamics in Malawi: the role of multiple interventions in disease control

Elias Mwakilama[1,2], Milliward Maliyoni[1]

[1]School of Natural & Applied Sciences,
Dept. of Mathematical Sciences, University of Malawi, Zomba, Malawi
mwakilamae@gmail.com

[2]Dept. of Pure & Applied Mathematics,
Jomo Kenyatta University of Agriculture & Technology, Nairobi, Kenya
mwakilama.elias@students.jkuat.ac.ke

Improved rabies surveillance or diagnostic systems can help curb rabies globally. In spite of studies suggesting that secondary interventions such as homeopathic or pre-or post-exposure prophylaxis (PEP) remedies can help reduce chances of infection after exposure; their unavailability, shortage in supply, and high cost of access mean that mass dog vaccination remains a key intervention for sub-Saharan Africa (SSA). However, characterizing the efficacy of mass dog vaccination, together with secondary interventions, may provide relevant information for understanding the disease dynamics and the development of policy measures in SSA. Premised on the notion that reliance on mass dog vaccination alone is insufficient to curb or control the spread of rabies, the current study proposes and presents a double compartmental model for evaluating the efficacy of multiple interventions in controlling the spread of rabies in Malawi. Qualitatively, the formulated model is analysed to assess the existence, positivity, and boundedness of the model solutions. To obtain the disease reproduction number(s), R_0, both at disease-free equilibrium (extinct) and endemic equilibrium (persistent) states for assessing the existence or persistence of dog-mediated human rabies in Malawi, we use the method of Next-Generation matrix. Using the model fitted data parameters, the half-normalization technique is employed to isolate key influential parameters for assessing rabies disease persistence or extinction. Since the proposed model provides room for investigating roles of other rarely modelled interventions such control of dog birth rate and use of PEP, the current study unravels key parameters influencing the dynamics of rabies disease in Malawi, thereby providing indicator measures for optimal control of the disease to the policyholders.

Keywords: rabies; qualitative analysis; multiple interventions; double compartmental SEIR model; Malawi

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