Zoonotic MERS-CoV transmission: modeling, backward bifurcation and optimal control analysis

Indrajit Ghosh[1], Sk Nadim[1], and Joydev Chattopadhyay[1]

[1]Indian Statistical Institute

May 15, 2020

Abstract

Middle East Respiratory Syndrome Coronavirus (MERS-CoV) can cause mild to severe acute respiratory illness with a high mortality rate. As of January 2020, more than 2,500 cases of MERS-CoV resulting in around 860 deaths were reported globally. In the absence of neither effective treatment nor a ready-to-use vaccine, control measures can be derived from mathematical models of disease epidemiology. In this manuscript, we propose and analyze a compartmental model of zoonotic MERS-CoV transmission with two co-circulating strains. The human population is considered with eight compartments while the zoonotic camel population consist of two compartments. The expression of basic reproduction numbers are obtained for both single strain and two strain version of the proposed model. We show that the disease-free equilibrium of the system with single stain is globally asymptotically stable under some parametric conditions. We also demonstrate that both models undergo backward bifurcation phenomenon, which in turn indicates that only keeping R_0 below unity may not ensure eradication. To the best of the authors knowledge, backward bifurcation was not shown in a MERS-CoV transmission model previously. Further, we perform normalized sensitivity analysis of important model parameters with respect to basic reproduction number of the proposed model. Furthermore, we perform optimal control analysis on different combination interventions with four components namely preventive measures such as use of masks, isolation of strain-1 infected people, strain-2 infected people and infected camels. Optimal control analysis suggests that combination of preventive measures and isolation of infected camels will eventually eradicate the disease from the community.

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