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Modeling the Role of Information and Limited Optimal Treatment on Disease Prevalence

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Abstract

Disease outbreaks induce behavioural changes in healthy individuals to avoid contracting infection. We first propose a compartmental model which accounts for the effect of individual's behavioural response due to information of the disease prevalence. It is assumed that the information is growing as a function of infective population density that saturates at higher density of infective population and depends on active educational and social programmes. Model analysis has been performed and the global stability of equilibrium points is established. Further, choosing the treatment (a pharmaceutical intervention) and the effect of information (a non-pharmaceutical intervention) as controls, an optimal control problem is formulated to minimize the cost and disease fatality. In the cost functional, the nonlinear effect of controls is accounted. Analytical characterisation of optimal control paths is done with the help of Pontryagin's Maximum Principle. Numerical findings suggest that if only control via information is used, it is effective and economical for early phase of disease spread whereas treatment works well for long term control except for initial phase. Furthermore, we observe that the effect of information induced behavioural response plays a crucial role in the absence of pharmaceutical control. Moreover, comprehensive use of both the control interventions is more effective than any single applied control policy and it reduces the number of infective individuals and minimizes the economic cost generated from disease burden and applied controls. Thus, the combined effect of both the control policies is found more economical during the entire epidemic period whereas the implementation of a single policy is not found economical viable.

Keywords: Lyapunov Function, Information, Behavioural Response, Limited Treatment, Optimal Control

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