The Impact of Media on the Control of Infectious Diseases

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We develop a three dimensional compartmental model to investigate the impact of media coverage to the spread and control of infectious diseases (such as SARS) in a given region/area. Stability analysis of the model shows that the disease-free equilibrium is globally-asymptotically stable if a certain threshold quantity, the basic reproduction number ($R_0$), is less than unity. On the other hand, if $R_0 > 1$, it is shown that a unique endemic equilibrium appears and a Hopf bifurcation can occur which causes oscillatory phenomena. The model may have up to three positive equilibria. Numerical simulations suggest that when $R_0 > 1$ and the media impact is stronger enough, the model exhibits multiple positive equilibria which poses challenge to the prediction and control of the outbreaks of infectious diseases.

KEY WORDS: Infectious disease; SEI model; media impact; Hopf bifurcation; multiple outbreaks.

1. INTRODUCTION

In recent years, attempts have been made to develop realistic mathematical models for the transmission dynamics of infectious diseases. In modelling of communicable diseases, the incidence function has been considered to play a key role in ensuring that the models indeed give
reasonable qualitative description of the transmission dynamics of the diseases [3,9]. Some factors, such as media coverage, density of population and life style, may affect the incidence rate directly or indirectly.

In the classical endemic models, the incidence rate is assumed to be mass action incidence with bilinear interactions given by $\beta SI$, where $\beta$ is the probability of transmission per contact (a positive constant), and $S$ and $I$ represent the susceptible and infected populations, respectively. However, there are several reasons for using non-linear incidence rates such as saturating and nearly bilinear. For instance, Yorke and London [20] showed that the incidence rate $\beta(1-cI)IS$ with positive $C$ and time dependent $\beta$ is consistent with the results of the simulations for measles outbreaks. In order to avoid the unboundedness of the contact rate, Capasso and Serio [4] used a saturated incidence function of the form $\frac{\beta SI}{1+\beta I}$, $\delta > 0$. To incorporate the effect of the behavioral changes of the susceptible individuals, Liu and coworkers [10,11] used a non-linear incidence rate given by $\frac{kI}{1+\alpha I}S$ with $k, l, \alpha, h > 0$. Ruan and Wang, [14] showed that endemic models with such non-linear incidence rates exhibit various bifurcations include Hopf, homoclinic, and even Bogdanov-Takens bifurcations. There have been many models using variety of different non-linear incidence functions to study the disease transmission, we refer the reader to Levin et al. [9] for a more detailed summarization.

The aim of this paper is to investigate the impact of media coverage to the spread and control of infectious diseases in a given region. In [12], the authors consider a model with the compartments of exposed (E), infectious (I) and hospitalized (H) individuals to explore the possible mechanism for multiple outbreaks of emerging infectious diseases due to the psychological impact of the reported numbers of infectious and hospitalized individuals. The model was simplified by assuming that the total population size remain a constant. In this paper, we extend the classical SEI model and the ideas in [12] to consider a new incidence functional which reflects the impact of the media coverage to the spreading and control of the disease.

This study was also originated from the observation of the spread of SARS coronavirus in Asia and some other regions of the world. SARS [7,15,19] as a new emerging infection disease, it was first appeared in Guangdong province, China in November, 2002. Then in the following year the SARS coronavirus spread rapidly throughout Asia and certain other part of the world [16,18]. For SARS in the cities of Beijing, Hongkong and Toronto, the spreading and outbreaks all experienced a typical process for people to see how the media coverage and the public alerting plays a role in the whole course of the spreading. For the case