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A simple mathematical model for the annual variation of epidemic outbreak with prevention level affected by incidence size in the last season

Annual or seasonal fluctuation of the incidence size has been observed for a variety of infectious diseases, for example, influenza, measles, rubella, mumps, chickenpox etc. Here the *incidence size in the epidemic season* means the *final size* of epidemic at the season, which gives the fraction or the size of infected population in the epidemic season. Such fluctuations have been attracting many researchers in mathematical biology, and giving discussions about its driving factors. It would be taken natural that one of the important factors is seasonally varying environment, caused by the temporal variation of contact rate, infection rate, or recruitment rate, for example due to social aggregation of hosts or seasonally restricted breeding season.

In our work, in contrast to these factors of population dynamics, we consider the effect of a change of social behavior which determines the prevention level for the considered infectious disease. In case when the incidence size in the last epidemic season is large, the people in the community would tend to increase the prevention level against the infectious disease, for instance, with promoting washing hands, gargling, wearing a mask, and available vaccination. Such increase of the prevention level is reflected to the reduction of infection rate or recovery rate according to the disease. Differently from those factors potentially causing the annual or seasonal fluctuation of the incidence size, this social factor is what is affected by the incidence size in the last season or the past seasons.

To consider the essential effect of such social factor on the potentiality of incidence size fluctuation, we construct and analyze a simple mathematical model of discrete dynamical system, which is derived from the final-size equation of Kermack–McKendrick SIR model. We demonstrate that such social factor could potentially or partially contribute to the driving force causing the annual or seasonal fluctuation of the incidence size for some infectious diseases.