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Regular biennial cycles in epidemics caused by parametric resonance

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Abstract

The interaction between nonlinearity and seasonal forcing in childhood infectious diseases often leads to multiyear cycles with large amplitude. Regular biennial cycles in particular, were observed in measles reports throughout the world. The objective of this paper is to understand the mechanism of such biennial cycles, especially the conditions under which the large amplitude biennial oscillation might appear. It is proposed that such biennial cycles is caused by parametric resonance, which might occur when varying the parameter at a frequency close to twice the natural frequency of the system. The analysis is carried out by solving an SIR model semi-analytically using method of multiple scales (MMS). This analysis shows how parametric resonance occurs due to the interaction between nonlinearity and periodic forcing. Using the MMS solution, the boundary between the resonance region and non-resonance region in the parameter space is obtained. The effects of different parameters on the triggering of parametric resonance are studied, such as transmission rate, recovery rate, birth rate and amplitude of seasonality. The effects of stochasticity on the onset of parametric resonance are studied also.

Keywords: Childhood Infectious Diseases, SIR Model, Method of Multiple Scales

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