
Research article

Dynamic study of the pathogen-immune system interaction with natural delaying effects and protein therapy

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Abstract: This study aims to propose and analyze a mathematical model of the competitive interaction of the pathogen-immune system. Some effects of the existence of natural delays and the addition of therapeutic proteins are considered in the model. A delay arises from the indirect response of the host body when a pathogen invades. The other comes from the maturation of immune cells to produce immune memory cells since the immune system and antigenic substances responsible for provoking the production of immune memory cells. Analytical investigations suggest several sufficient conditions for the existence of a positive steady-state solution. There is a critical pair of delays at which oscillatory behavior appears around the positive steady-state solution. Numerical simulations were carried out to describe the results of the analysis and show that the proposed model can describe the speed of pathogen eradication due to the addition of therapeutic proteins as antigenic substances.

Keywords: pathogen-immune system interaction; therapeutic protein; delay differential equations; Hopf bifurcation

Mathematics Subject Classification: 92F05, 34K20, 34K18

1. Introduction

The immune system is a complex system consisting of many interrelated processes that form a