The dynamics of the HIV infection: a time-delay differential equation approach

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In this work we introduce a differential equation model with time-delay that describes the three-stage dynamics and the two time scales observed in HIV infection. Assuming that the virus has high mutation and rapid reproduction rates that stress the immune system throughout the successive activation of new responses to new undetectable strains, the delay term describes the time interval necessary to mount new specific immune responses. This single term increases the number of possible solutions and changes the phase space dynamics if compared to the model without time delay. We observe very slow transits near the unstable fixed point, corresponding to a healthy state, and long time decay to the stable fixed point that corresponds to the infected state. In contrast to the results obtained for models using regular ODE, which only allow for partial descriptions of the course of the infection, our model describes the entire course of infection observed in infected patients: the primary infection, the latency period and the onset of acquired immunodeficiency syndrome (AIDS). The model also describes other scenarios, such as the very fast progression to the disease and the less common outcome in which, although the patient is exposed to HIV, he/she does not develop the disease.

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