Nonlinear Dynamics and Systems Theory, 25 (2) (2025) 187-205



## Analysis of an HIV-1 Infection Model with Delay Including Quiescent Cells and Cell-to-Cell Transmission

Meriem Lamraoui<sup>1\*</sup>, Bilal Boulfoul<sup>2</sup> and Mahiéddine Kouche<sup>3</sup>

 <sup>1</sup> Laboratory of Numerical Analysis, Optimization and Statistics (LANOS), Badji Mokhtar - Annaba University, 12, P.O.Box, 23000, Annaba, Algeria.
<sup>2</sup> Faculty of Technology, University of 20 August 1955, 26, P.O.Box, 21000, Road El Hadaiek-Skikda, Skikda, Algeria.
<sup>3</sup> Laboratory of Applied Mathematics (LMA), Badji Mokhtar - Annaba University, 12, P.O.Box, 23000, Annaba, Algeria.

Received: September 27, 2024; Revised: April 1, 2025

Abstract: In this paper, we propose a model describing the transmission of HIV-1 infection by cell-free virus and cell-to-cell transfer mode under antiretroviral therapy. The model that we propose is derived from that proposed by Kouche et al. [1]. First, we consider the case without delay and we prove that the basic reproduction number of the model is the sum of the basic reproduction number of cell-free infection and that of cell-to-cell infection. We prove that when the basic reproduction number is less than one, the infection is cleared, and when it is greater than one, the endemic steady state is globally asymptotically stable. In the second part of the paper, we introduce an intracellular delay to take into account the incubation period of the infection. We give a complete stability analysis for both free and endemic steady states. Finally, we illustrate our study by some numerical simulations to evaluate the effects of time delay on the virus dynamics. Our analytical and computational results show that the intracellular delay has no effect on the quiescent cells but reduces the viral load.

**Keywords:** *HIV-1* infection; cell-to-cell transmission; delay; stability analysis; antiretroviral therapy.

Mathematics Subject Classification (2020): 92B05, 92B99, 34C23, 93D30, 34D23.

<sup>\*</sup> Corresponding author: mailto:meriem.lamraoui@univ-annaba.dz

<sup>© 2025</sup> InforMath Publishing Group/1562-8353 (print)/1813-7385 (online)/http://e-ndst.kiev.ua187