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Stochastic model-based predictions on post-exposure prophylaxis strategies for prevention of HIV infection

Antiretroviral treatment (ART) leads to a much lower viral load in HIV patients and thus improves quality and length of life. When used as a post-exposure prophylaxis (PEP) shortly after exposure to HIV, ARTs are also known to reduce the risk of infection. However, many aspects of the very early stages of HIV infection remain poorly understood because the associated low viral loads are difficult to measure clinically. We present a continuous-time branching process model of early HIV infection in order to capture dynamics of the small number of virus particles. Using the related Chapman-Kolmogorov differential equation and the associated probability generating function we derive an expression for the virus extinction probability which we solve numerically. This allows us to predict the efficacy of different PEP strategies, considering initiation time, duration, and multi-drug regimens. We also evaluate the risk of emergent drug resistance in the event of PEP failure and then discuss how our results can be used to guide public health decisions on optimal PEP strategies.