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Conference

2022


May 18th, 11:00 AM - 11:30 AM

Staged HIV Transmission and Treatment in a Dynamic Model with Long-term Partnerships

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The transmission dynamics of HIV are closely tied to the duration and overlap of sexual partnerships. A serodiscordant long-term partnership presents repeated exposures to the infected partner. If concurrency exists, an increase in partnership duration can increase infection rates. However, non-infected monogamous pairs are protected. We develop an autonomous population model that can account for the possibilities of an infection from either a casual sexual partner or a long-term partner who was either infected at the start of the partnership or was newly infected since the onset of the partnership. The impact of the long-term partnerships on the rate of infection is captured by calculating the expected values of the rate of infection from these extended contacts. The model includes three stages of infectiousness: acute, chronic, and virally suppressed, to study the effect of different intervention strategies. We calculate HIV incidence and the fraction of new infections attributed to casual contacts and long-term partnerships allowing for variability in the condom usage, the effect of achieving and maintaining viral suppression, and early intervention by beginning HAART during the acute phase of infection. We present our results using data on MSM HIV transmission from the CDC in the U.S. from 2005- 2019. While the acute stage is the most infectious, most of the new infections will be transmitted by long-term partners in the chronic stage when condom use is infrequent as is common in long-term relationships. Time series analysis of the solution, as well as parameter sensitivity analysis, are used to determine which strategy has the largest impact.