Transition dynamics of HIV disease in a cohort of African prostitutes: a Markov model approach

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Abstract:

The progression of HIV-related disease from infection to death is represented as a staged Markov model. Transitions between stages are considered reversible. The model is fitted to data from a cohort of African prostitutes by means of maximum likelihood. It appears that the progression to symptomatic disease (Centers for Disease Control stage IV) in this population is considerably more rapid than that reported from studies in Western countries. PIP: Identifying the incubation period of HIV infection is important for individual prognoses, for developing and testing intervention strategies, for determining the reproductive rate of the disease, and for prevalence of the disease. Mathematical modeling of HIV infection in Africa is necessitated because the disease is more widespread and the immune system is constantly active due to the exposure to diseases such as malaria and tuberculosis. The Markov model for this analysis was selected because parametric estimation is not based on the time a stage is entered, but on the duration between observations and the stages at the time of observation. The HIV infected female prostitutes in the Pumwani area of Nairobi, Kenya (a population primarily of Tanzanian origin) have been identified as a study population since 1985, and seen every 6 months in clinic, or as needed. Data are constricted by the movement out of the area in the end stage of disease, which is only partially solved by tracking with community health workers. The stages identified in incubation estimation are stage 1: seropositive but symptom free (CDC stage II); stage 2: generalized lymphadenopathy (CDC stage III); stage 3: symptomatic disease (CDC stage IV); and stage 4: death. Data reflect the movement back and forth between stage 1 and 2, between 2 and 3, so the model is not a pure Longini model but rather a timed homogeneous staged model with reversible stages called transition parameters computed in a numerical differentiation. The Fortran computer program for the analyses is available from the authors. The results suggest a quick transition between seroconversion and lymphadenopathy (2.4 months) and unlikely reversal, with the mean waiting time until passage to stage 3 is approximately 2.6 years and conversions are common. Since opportunistic infections are treatable, this makes sense. Assuming a correct model, the estimation of the transition time of 20 months of h34 value of .01 and .05, the mean passage time from stage 1, 2, 3 to 4 (death) is 9.1, 8.9, and 6.2 years 12.9, 12.7, and 10.1 years respectively. The implications are that 1) when infectiousness is hypothesized to be not uniform, peak infectivity occurs earlier in Africa than in the West at least among prostitutes, or 2) if infectivity is constant throughout the incubation period, then HIV transmission must be higher in Africa to explain the high rate of infection