

論文の内容の要旨

論文題目 Forecasting HIV in Japan

(日本における HIV の予想に関する研究)

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Background: Although HIV prevalence in Japan is low, new HIV notifications are increasing rapidly amongst men who have sex with men (MSM). Recent trends show a linear increase in new cases, suggesting a potentially quadratic or faster increase in prevalence. Testing behavior appears to be low in Japanese MSM compared to their counterparts, and little is known about the size of the MSM population in Japan or about their sexual risk behavior. Given these gaps in knowledge, little is known about the dynamics of the HIV epidemic, or about the best methods for preventing the spread of the disease. Prevention efforts to date have focused on behavioral change, promoted through activities in MSM community organizations. The continuing increase in new cases suggests that current efforts are not sufficient to contain the epidemic, and little is known about which interventions are most effective in preventing transmission of HIV in such a population. Understanding how the disease is spreading, and future trends in prevalence is essential to planning interventions and setting priorities for the health system.

Objectives: This study used a deterministic compartmental mathematical model of HIV to understand the dynamics of the HIV epidemic in Japan, to project trends 30 years into the future, and to identify interventions that may be effective in controlling the epidemic.

Methods: I developed a deterministic compartmental model of HIV/AIDS that divides the population into ten compartments based on HIV serostatus, CD4 count, knowledge

of HIV serostatus and treatment activity. This model was applied to three risk groups: MSM, low-risk women and low-risk men. Identification of serostatus was assumed to lead to reductions in risk behavior, and entry into treatment was assumed to reduce infectiousness. I used the next generation method to analyze the equilibrium properties of the system of ordinary differential equations describing the mathematical model, and derived an analytical expression for the basic reproduction number of this model in a simplified MSM-only population. I used this equation to analyze the effect on the basic reproduction number of key parameters related to behavioral and biomedical interventions.

I used data on numbers of MSM, HIV/AIDS cases, and disease transmission parameters to develop forecasts of HIV prevalence in the three risk groups over the next 30 years. I developed these projections for two different scenarios describing possible behavioral and treatment-seeking contexts in Japan:

1. *A high HIV risk scenario* that models what is currently known about Japanese risk and treatment-seeking behavior, and assume that this behavior does not change over the course of the study
2. *A lower HIV risk scenario* that models reasonable and achievable improvements in sexual risk and treatment-seeking behavior, reflecting effective interventions initiated immediately and sustained across the 30 years of the study

Sensitivity analysis was conducted to simulate the progress of the epidemic under different starting parameters, which were assumed to lie on a distribution of values around the most likely value for each parameter. The best 200 model runs were retained for forecasting and statistical analysis. Results from the model runs were analyzed statistically to identify determinants of epidemic spread.

Results: Figure 1 shows projected HIV prevalence under the base case high HIV risk scenario, with a histogram of prevalence amongst MSM at 30 years. In this scenario, HIV prevalence amongst MSM increased over 30 years from a baseline value of 2.1% to 10.4% (sensitivity range: 7.4—18.7%).

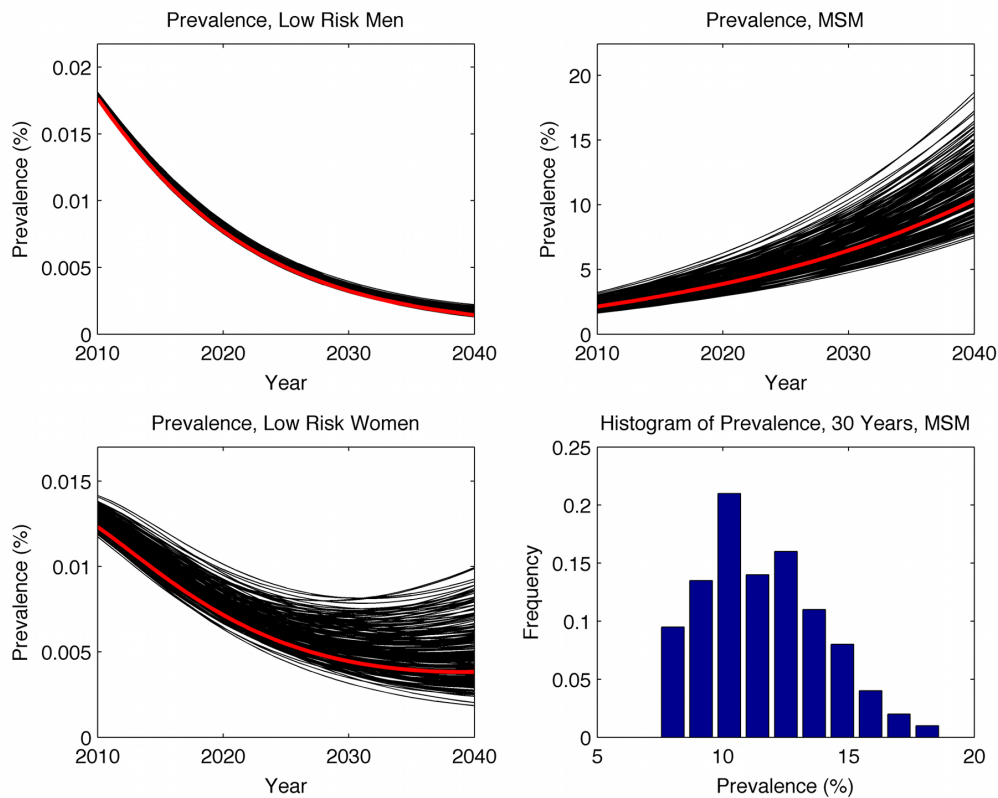


Figure 1: HIV Prevalence in three risk groups over 30 years, high HIV risk scenario

In the high HIV risk scenario, prevalence decreased amongst low-risk men women, but in a minority of models prevalence amongst low risk women began to increase again after 20 years, probably because of limited sexual contact with MSM. With moderate changes to sexual risk and treatment-seeking behavior proposed in the lower HIV risk scenario, prevalence at 30 years amongst MSM was 1.1%, with a sensitivity range between 0.2% and 4.1%. In the higher HIV awareness scenario there was no risk of epidemic growth amongst low-risk men and women in any model run.

Mathematical analysis of the basic reproduction number showed that the progress of the epidemic is highly dependent on testing rates, partner numbers and condom use rates. Small increases in testing rates can have a large effect on epidemic size in communities with low testing rates, but in communities with very large numbers of partners or very low rates of condom use, even large increases in testing rates will be insufficient to contain the epidemic. Based on the best available research within Japan on sexual

behavior among MSM, current Japanese sexual and treatment-seeking behaviors are on the edge of the parameter space required to contain the epidemic, and even small changes in one or more of these parameters may, if sustained, be sufficient to prevent future growth in the prevalence of HIV.

Conclusion: Both projections and mathematical analysis suggested that small changes in sexual risk and treatment-seeking behavior would be sufficient to contain the epidemic in Japanese MSM. However, if these changes do not occur, the projections in this study show that the HIV epidemic amongst MSM will grow rapidly in scale over the next 30 years. There is also a small risk that the epidemic will spread to low-risk women, depending on rates of heterosexual partnership amongst sexually active MSM. The mathematical analysis suggests that sexual and treatment-seeking behavior amongst MSM is near the edge of the parameter space required to contain the HIV epidemic, and thus only small and achievable changes in a range of behaviors are needed to bring the epidemic under control. In order to achieve this, urgent improvements in testing rates, changes to treatment guidelines to encourage early entry into treatment, and scaling up of current interventions to a more coherent and intensive, community-wide program are essential. Furthermore, little is known about sexual behavior in Japan, and especially amongst Japanese MSM, and interventions in MSM communities should be accompanied by more intensive efforts to understand the sexual, treatment-seeking and cultural context in which HIV risk behavior occurs. With these changes, it will be possible to prevent further spread of this disease in a marginalized and vulnerable population.

Keywords: HIV/AIDS, Japan, mathematical model, epidemiology, HAART, sexual behavior