Title: The impact of acute infection, testing, and post-diagnosis behavior change on HIV transmission among men who have sex with men (MSM) in Southern California

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1 Objectives

The specific aims of the current work are to integrate temporal infectiousness of HIV [1, 2, 3] with testing behavior of men who have sex with men (MSM) in Southern California and consequent post-diagnosis behavior change [4]. We use mathematical models to quantify the impact of these individual-level phenomena at the population level [5], taking the effect of potential confounding variables such as drug-use, testing behavior, and anti-retroviral treatment in to account. We will explicitly model the partnership structure in the population by accounting for mixing patterns (i.e. sexual mixing by race, age, HIV-status, sexual role and main and non-main partnerships) and the timing of these partnerships. The potential significance of this work is to help establish a threshold around the extent to which post-diagnosis behavior change can help reduce HIV incidence among MSM in Southern California.

2 Background

Men who have sex with men (MSM) form one of the highest risk groups for HIV in the United-States [5, 6, 7]. Sexual contact in MSM is estimated to account for 71.4% of the cumulative HIV cases in California males between 1983 and 2005, and a combination of sexual contact among MSM and injection drug use accounts for another 6.8% of the cumulative HIV cases in the same period [7].

A complex interplay of the behavioral mechanisms of MSM and the biology of HIV is

potentially fueling the epidemic among MSM. An HIV infected individual is most infectious during the first 6 to 12 weeks of infection [1, 2, 8, 9]. This period of "acute infection" is then followed by a long period of "chronic infection" and finally a rise in infectivity after the onset of AIDS and before death [9]. Often MSM are not aware of their diagnosis status during this stage because traditional antibody tests that are easily available can only detect HIV after the peak in viremia [10, 11]. Therefore, positive MSM may continue high-risk sexual activity through this stage of high infectiousness during the period of acute infection because they are not diagnosed in spite of testing if traditional anti-body tests are used. HIV RNA testing is needed to detect HIV during the acute phase of infection [10, 11]. However, HIV RNA tests are much more costly than the anti-body tests [12] and can be prohibitively expensive at the public health-level. The extent to which such RNA testing methods need to be instituted is not clear, and this modeling work might help estimate a "threshold" around which HIV RNA testing needs to be instituted in a population to detect HIV early enough to reduce incidence in Southern California MSM.

3 Data

We use data from the Southern California Acute Infection and Early Disease Research Program (AIEDRP) [4, 13]. This study collected baseline data from 225 HIV positive men in San-Diego and Los Angeles County between 2002 and 2006 and follow-up data collected every 3 months from the time of enrollment [4, 13]. Follow-up and baseline data are available for 193 men and 1011 partners (597 baseline and 414 follow-up). At baseline, respondents provided reports on behavior with their last three partners; follow-up data are limited to the last partner. In addition to sexual behavioral characteristics, respondents also reported their viral load at each visit, and their use of anti-retroviral treatment [13].

4 Methods

The nature of the project calls for explicit accounting of relational timing, formation and dissolution of partnerships, and the vital demographic process, and the vital demographic processes of birth, death and aging. For this purpose, we use the Exponential Random Graph Models (ERGM) which build on the concepts of social-network analysis. While social networks have a long history, the rich nature of detail and dependence structures in such models made implementation and estimation difficult. Tools to implement and estimate these models have only recently been developed, especially those that integrate vital demographic processes [14]. We build a fully dynamic model that allows for examination of the interaction of early detection of HIV and consequent behavior change on population-level incidence. We will use AIEDRP data to parametrize our models.

5 Significance

The significance of the proposed work lies in the integration of biological processes and behavioral mechanisms, with the partnership between the individuals as the primary unit of analysis. The class of models allows for the explicit representation of partnerships with a realistic mixing structure, and overlap in these partnerships over time which are an important factor in HIV transmission [15]. We develop a fully dynamic individual-based model that allows for quantification of population-level impacts from individual level behavior patterns. This model helps explicitly study how modification in behavior change can reduce the rate of HIV transmission among MSM, when confounders (such as meth-use) which play an important role in the HIV epidemiology of MSM are accounted for. Our results will help clarify the impact of different testing strategies in light of men's self-initiated post-diagnosis behavior change.

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