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Network-Centric Interventions to Contain the Syphilis Epidemic in San Francisco

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The number of reported early syphilis cases in San Francisco has increased steadily since 2005. It is not yet clear what factors are responsible for such an increase. A recent analysis of the sexual contact network of men who have sex with men with syphilis in San Francisco has discovered a large connected component, members of which have a significantly higher chance of syphilis and HIV compared to non-member individuals. This study investigates whether it is possible to exploit the existence of the largest connected component to design new notification strategies that can potentially contribute to reducing the number of cases. We develop a model capable of incorporating multiple types of notification strategies and compare the corresponding incidence of syphilis. Through extensive simulations, we show that notifying the community of the infection state of few central nodes appears to be the most effective approach, balancing the cost of notification and the reduction of syphilis incidence. Additionally, among the different measures of centrality, the eigenvector centrality reveals to be the best to reduce the incidence in the long term as long as the number of missing links (non-disclosed contacts) is not very large.

Since 2001, San Francisco has experienced a sustained syphilis epidemic that has been nearly exclusively limited to men who have sex with men (MSM)[1]. The epidemic, which was declining a few years ago, is now experiencing a new resurgence, not only in San Francisco but also across the USA and Europe[2]. Innovative prevention measures are needed to reduce syphilis morbidity among MSM, and thus avoid spreading to a larger population. Previous work on sexually transmitted diseases has shown that sexual contact networks can be very useful to tailor mitigation strategies[3].

The San Francisco Department of Public Health (SFDPH) maintains legally mandated case-based surveillance for syphilis which includes collected sociodemographic, treatment, and contact tracing information on reported and investigated syphilis cases. This surveillance system allows for the description of sexual networks among reported cases that are investigated. Each pair of individuals who have had a sexual encounter at least once in a time span are connected to each other with a link. The number of early syphilis cases in San Francisco has increased steadily from 26.6/100,000 cases in 2007 to 157.1/100,000 cases in 2015. Network theory indicates the importance of core individuals in sustaining sexually transmitted infections (STI) epidemics. An algorithm was developed in ref. 4 to identify the sexual contact network in the MSM community of San Francisco from case data routinely collected by the SFDPH to better understand the epidemiology of recent syphilis cases and explore possible new approaches for disease control. A sexual contact network with 2,428 nodes and 2,046 links was created. Within this network, a total of 457 disconnected components were identified. Of these, 78% consisted of only 2 or 3 individuals. Eleven components of 10 or more clients were identified, including a large connected component of 953 individuals. Clients in this largest component were more likely to be HIV-positive ($P < 0.001$ from Chi-square) and to have had more cases of syphilis in the past ($P < 0.0001$ from ANOVA) than clients belonging to smaller connected components[4].

A partner notification (PN) system is a process in which an infected individual (called an index case) notifies (directly or indirectly) his partners (neighbors in the sexual network) of his infectious state[5]. It is hoped that partners of the index case will then seek evaluation and possible treatment (alert state). Partner notification is considered the cornerstone of sexually transmitted disease control, aiming at controlling transmission by (1) treating exposed partners, (2) preventing reinfection of the index cases, and (3) preventing infection of healthy partners.

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