Social network investigation of a syphilis outbreak in Ottawa, Ontario

H D’Angelo-Scott PhD¹, J Cutler MHSc¹, D Friedman PhD², A Hendriks MPH², AM Jolly PhD³

BACKGROUND: The incidence of syphilis in Ottawa, Ontario, has risen substantially since 2000 to six cases per 100,000 in 2003, again to nine cases per 100,000 in 2007, and recently to 11 cases per 100,000 in 2010. The number of cases reported in the first quarter of 2010 was more than double that in the first quarter of 2009.

OBJECTIVE: In May 2010, the Ontario Ministry of Health and Long Term Care requested the assistance of the Field Epidemiology Program to describe the increase in infectious syphilis rates and to identify social network sources and prevention messages.

METHODS: Syphilis surveillance data were routinely collected from January 1, 2009 to July 15, 2010, and social networks were constructed from an enhanced social network questionnaire. Univariate comparisons between the enhanced surveillance group and the remaining cases from 2009 on non-normally distributed data were conducted using Kruskal-Wallis tests and χ² tests.

RESULTS: The outbreak cases were comprised of 89% men. Seventeen of the 19 most recent cases consented to answer the questionnaire, which revealed infrequent use of condoms, multiple sex partners and sex with a same-sex partner. Information regarding social venues where sex partners were met was plotted together with sexual partnerships, linking 18 cases and 40 contacts, representing 37% of the outbreak population and connecting many of the single individuals and dyads.

CONCLUSION: Uncovering the places sex partners met was an effective proxy measure of high-risk activities shared with infected individuals and demonstrates the potential for focusing on interventions at one named bar and one Internet site to reach a high proportion of the population at risk.

Key Words: Canada; Epidemiology; Public health; Sexually transmitted infections; Social network analysis; Syphilis

Since 1987, rates of infectious syphilis have been below 1.6 cases per 100,000 and elimination, defined as <0.5 cases per 100,000, appeared to be a realistic achievement in Canada (1,2). Cases of syphilis then rose from one case per 100,000 in 2000 to 8.85 per 100,000 in 2009 (3).

Ottawa, Ontario, with a population of 812,000 in 2006 (4), experienced a five-fold increase in syphilis since 2001, mostly in men who have sex with men, and a further increase in 2009 (Figure 1). In May 2010, Ottawa Public Health (OPH) requested the assistance of the Canadian Field Epidemiology Program of the Public Health Agency of Canada through the Ontario Ministry of Health and Long-Term Care. The objectives of the present investigation were to characterize the increase in reported infectious syphilis rates and to identify risk factors and social networks of cases indicative of transmission, which may then be used in interventions. In addition, we aimed to record patients’ views and reports regarding sexual-health messaging.

Figure 1: Reported infectious syphilis (primary, secondary and early latent cases only) rate per 100,000 population, Ottawa, Ontario, 2000 to 2009. Data source: Ontario Ministry of Health and Long-Term Care, integrated Public Health Information System, extracted December 23, 2014.
Social network analysis of a syphilis outbreak

TABLE 1
Characteristics of infectious syphilis cases, Ottawa, Ontario, January 2009 to June 2010*

| Risk exposures/settings | 2009–2010 cases† | Enhanced surveillance cases | Test statistic P |
|-------------------------|-------------------|----------------------------|------------------|
| Total                   | 72                | 17                         |                  |
| Sex, n (%)              |                   |                             |                  |
| Male                    | 68 (94.4)         | 17 (100)                   |                  |
| Female                  | 4 (5.6)           | 0 (0)                      | 0.73‡ 1.0        |
| Age, years, mean (%) reported | 38.8 (55)      | 44.0 (17)                   | 1.73§ 0.81       |
| Contacts, median         | 1 (1–1)           | 1(1–2)                      | 5.63§ 0.02       |
| (interquartile range)    |                   |                             |                  |
| Staging                 |                   |                             |                  |
| Primary                 | 28 (38.9)         | 2 (11.8)                    |                  |
| Secondary               | 32 (44.4)         | 11(64.7)                    |                  |
| Early latent            | 11 (15.3)         | 3 (17.6)                    |                  |
| Infectious neurosyphilis| 1 (1.4)           | 5 (9.5)                     | 5.46‡ 0.14       |
| HIV coinfection         | 19 (26.4)         | 1 (5.9)                     | 6.59‡ 0.01       |
| Risk exposures/settings |                   |                             |                  |
| No condom used           | 62 (86.1)         | 14 (82.4)                   |                  |
| Sex with opposite sex    | 55 (76.4)         | 13 (76.5)                   |                  |
| Partner is homosexual    | 52 (72.2)         | 13 (76.5)                   |                  |
| New partner in past two months | 29 (40.3)   | 10 (58.8)                   |                  |
| Multiple partners in past six months | 18 (25)   | 4 (23.5)                     |                  |
| Bathhouse                | 11 (15.3)         | 1 (5.9)                     |                  |
| Sex with opposite sex    | 10 (13.9)         | 3 (17.6%)                   |                  |
| Partner is HIV-positive  | 9 (12.5)          | 1 (5.9)                     |                  |
| Met partner through internet | 6 (8.3)    | 0 (0)                       |                  |
| Partner with multiple partners | 5 (6.9) | 1 (5.9)                      |                  |
| Travel outside province  | 3 (4.2)           | 0 (0)                       |                  |
| Judgement impaired by alcohol/drugs | 2 (2.8) | 0 (0)                       |                  |
| Sex for drugs            | 1 (1.4)           | 0 (0)                       |                  |
| Ethnic group             |                   |                             |                  |
| Caucasian                | N/A               | 14 (82.4)                   |                  |
| Aboriginal               | 1 (5.9)           |                             |                  |
| South Asian              | 1 (5.9)           |                             |                  |
| West Asian               | 1 (5.9)           |                             |                  |
| Named sex partners†‡**   |                   |                             |                  |
| 0                       | 11 (15.3)         | 2 (11.8)                    |                  |
| 1                       | 20 (27.8)         | 3 (17.6)                    |                  |
| 2–5                     | 29 (40.3)         | 6 (47.1)                    |                  |
| 6–10                    | 6 (8.3)           | 2 (11.8)                    |                  |
| 11–20                   | 2 (2.8)           | 1 (5.9)                     |                  |
| >20                     | 4 (5.6)           | 1 (5.9)                     | 5.63§ 0.02       |

Data presented as n (%) unless otherwise indicated. †Includes cases diagnosed up to June 15, 2010 only; §Kruskal-Wallis test; †t test; **Totals may differ due to different responses from the same individuals during routine and enhanced surveillance interviews.

Sexual networks can be constructed from routinely collected contact-tracing data for bacterial sexually transmitted infections (STIs), by connecting each case and contact point with lines, denoting sexual intercourse. The unusually thorough inquiries, which resulted in a network diagram of the first 44 individuals with HIV and their sex partners in 1984, was one of the first publications demonstrating the unique value of this network approach, clearly revealing the roles of different individuals in transmission (5). However, as was evident in that case, incomplete information regarding sexual contacts, who may be anonymous, often hampers contact tracing. Also evident from that investigation was the importance of self-reported links between men who attended social gatherings in whom AIDS was later diagnosed, and who may also have had sexual, as well as social, contact (5). Requesting information from cases regarding locations where sex partners or friends socialize makes use of ‘homophily’ in social networks, in which individuals with similar attributes, behaviours and interests cluster together in social groups (6). These social venues were key in defining the outbreak sources, whether as ‘pickup joints’ for sex partner recruitment or as shared air spaces for tuberculosis transmission (7,8). In a gonorrhea outbreak in northern Alberta, a social network analysis was used to investigate an increase in gonorrhoea infections in which cases initially appeared to be disconnected (9). Patronage to a specific bar was found to be the only risk marker in a case-control study. Because almost one-half of the outbreak population of cases and contacts may be accessed by visiting the bar, we decided to use the same approach for this outbreak of infectious syphilis in Ottawa.

METHODS

Residents of Ottawa diagnosed with infectious syphilis, defined according to national case definitions (10) from January 1, 2009 to June 15, 2010, were included in the investigation (n=72). Electronic records were retrieved from the Integrated Public Health Information System, they were then validated and supplementary information was added to each routine surveillance record. For example, contacts known only by an e-mail and sex-partner recruitment venues had not been added into the Integrated Public Health Information System but were added before the analysis, and greatly improved the social network links. An enhanced surveillance questionnaire was developed in consultation with the OPH investigative team and was pilot tested by a case manager. Out of concern for OPH’s relationship with the community of men having sex with men, community groups were consulted and approval was obtained from OPH’s Research Ethics Board. Twenty syphilis cases from January 2010 to June 2010, which represented 27.7% of all syphilis cases, were contacted up to three times using two different methods (telephone, letter, e-mail, home visits).

The questionnaire elicited types of sexual partners in the past 12 months including regular, casual and anonymous partners, sex trade clients and group-sex encounters. The questionnaire asked, “What types of partners have you had in the last 12 months before your diagnosis?” Then, there were check boxes for casual, regular and paying partners, without definitions, with a space for participants to indicate how many for each type. Respondents were prompted for visited venues including public venues (including bars), clubs, bath houses, spas, sex clubs, raves, circuit parties, cruising sites or pick-up joints, work, school, prisons, parks, family or friends’ homes, Internet sites, adult book and video stores, in Ottawa or in other cities, where they met their sex partners.

Clients were asked whether there had been sexual health messaging at their favorite social venues. Whether or not they had been added into the Integrated Public Health Information System but were added before the analysis, and greatly improved the social network links. An enhanced surveillance questionnaire was developed in consultation with the OPH investigative team and was pilot tested by a case manager. Out of concern for OPH’s relationship with the community of men having sex with men, community groups were consulted and approval was obtained from OPH’s Research Ethics Board. Twenty syphilis cases from January 2010 to June 2010, which represented 27.7% of all syphilis cases, were contacted up to three times using two different methods (telephone, letter, e-mail, home visits). These 20 cases were the most recent of all 72 cases and, therefore, were more likely to remember details than cases from 2009.

The questionnaire elicited types of sexual partners in the past 12 months including regular, casual and anonymous partners, sex trade clients and group-sex encounters. The questionnaire asked, “What types of partners have you had in the last 12 months before your diagnosis?” Then, there were check boxes for casual, regular and paying partners, without definitions, with a space for participants to indicate how many for each type. Respondents were prompted for visited venues including public venues (including bars), clubs, bath houses, spas, sex clubs, raves, circuit parties, cruising sites or pick-up joints, work, school, prisons, parks, family or friends’ homes, Internet sites, adult book and video stores, in Ottawa or in other cities, where they met their sex partners. Clients were asked whether there had been sexual health messaging at each social venue. Respondents were also asked their opinions regarding actions needed to address the increase in syphilis infections.

Data obtained using enhanced surveillance were combined with demographic data, syphilis staging, HIV coinfection, behavioural risk factors, the names of sexual contacts and incidental free-text fields regarding locations where partners were met were collected as part of a routine case follow-up. Some data regarding exposure and social venues were available through routine surveillance, although they were not consistently collected. It is important to note that the enhanced cases had two opportunities to provide data regarding their sex partners. All unique partners named at both interviews for the 2009 to 2010 period were incorporated into the network diagrams; however, only the data regarding numbers of partners from the first interview were used for statistical tests to avoid ascertainment bias. The incorporation of all routinely available data, together with enhanced data to show clustering around venues for sex partner recruitment, allowed for comparison with previous studies (8,9).
Data analysis
Descriptive and univariate analysis of the data ($\chi^2$, Student’s $t$ and Kruskal Wallis tests) were performed using Microsoft Office Excel version 7 (Microsoft Corporation, USA) and Epi Info 6.04 (Centres for Disease Control and Prevention, USA). Where numbers allowed, all cases were compared with the most recent cases for enhanced surveillance to demonstrate that the most recent sample represented the total population of syphilis cases in most respects. Pajek version 1.27 (Pajek, Slovenia) was used to construct and analyze the social networks, where lines represented sexual contact between individuals, who were represented by nodes. A network of all cases and named contacts available from routine data collection was constructed, as well as a network of all cases and contacts who frequented common venues. All of the networks were undirected because the direction of syphilis transmission was unknown. The numbers and sizes of components were counted in which were undirected because the direction of syphilis transmission was unknown. The number of links from one person to another immediately adjacent were also counted, which represented the total number of sex partners named by and who named an index case (degree).

RESULTS
Routinely collected case data from January 1, 2010 to June 15, 2010
Seventy-two individuals met the infectious syphilis case definition from January 1, 2009 to June 15, 2010 (Table 1). The epidemic curve of infectious syphilis cases during January 1, 2009 to June 15, 2010 was consistent with a propagated outbreak with person-to-person spread (Figure 2). The majority (94.4%) of reported cases were men, ranging from 19 to 63 years of age. Almost one-half of the cases presented with symptoms, testing and transmission of syphilis, as well as the importance of infectious syphilis in 2009 to 2010
during routine case follow-up, respondents reported various sex practices including infrequent condom use, use with a same-sex partner, a homosexual partner, a new partner in the past two months and multiple partners in the past six months (Table 1).

Enhanced surveillance data
Seventeen of 20 (89%) of the most recent cases chosen consented to be reinterviewed, two declined and one was not successfully contacted.

TABLE 2
Sexual health messaging at social venues reported by infectious syphilis cases through outbreak investigation, Ottawa, Ontario, January 2009 to June 2010 (n=17)

| Social venue          | Ottawa | Outside Ottawa |
|-----------------------|--------|----------------|
|                       | Yes    | No  | Do not know |
| Adult video/bookstore | 1 (33.3) | 1 (33.3) | 1 (33.3) |
| Bar/club              | 4 (33.3) | 1 (8.3)  | 2 (16.7) |
| Bath house/spas/sex club | 7 (50.0) | 0 (0)  | 2 (14.3) |
| Cruising sites        | 0 (0)  | 3 (100.0) | 0 (0)  |
| Family/friends        | 0 (0)  | 4 (100.0) | 0 (0)  |
| Internet              | 10 (58.8) | 7 (41.2) | 2 (11.8) |
| Private parties       | 1 (20.0) | 1 (8.3)  | 0 (0)  |
| Other                 | 0 (0)  | 4 (57.1)  | 0 (0)  |

Data presented as n (%) unless otherwise indicated
Social network analysis of a syphilis outbreak

general public using television, radio and magazines were also suggested to ensure all populations are aware of the messaging. Raising awareness and education of family and emergency room physicians about syphilis was also identified.

Social network data analysis
Including the social venue information collected through routine surveillance, only 155 cases and contacts were linked by sexual intercourse in 55 components consisting of 18 single cases; (11.6% of all cases and contacts) (Figure 3); 23 dyads (only two individuals linked; 29.7%), six triads (11.6%); three tetrads (7.7%) and components of six, eight, 12 and 16 each, with the largest being 19 individuals (12%) (Figure 3). Of the 19 infectious syphilis cases coinfected with HIV, 63% were in small components of one or two cases and/or contacts. However, the potential for HIV transmission is illustrated in components eight and 14 (marked by arrows) in which cases who had been diagnosed with HIV were linked to HIV-negative individuals with syphilis or untested contacts.

The 17 enhanced surveillance respondents reported 42 social venues, which included those already noted in the routine surveillance reports; 16 social venues outside of Ottawa and six Internet sites. The most frequently reported social venue was a specific bathhouse in Ottawa, named by six (35%) of the respondents and followed by a popular gay Internet site (29%). Three different bathhouses in Montreal (Quebec) were identified as places to meet partners (24%). In addition, 16 venues in locations >200 km away, such as Florida and Georgia (USA) and Alberta were also named, comprising 38% of all venues.

The above venue data were combined with the networks of 72 routine and enhanced surveillance cases and their 83 named contacts (Figure 4). The network consisted of 45 components ranging in size from one to 95 nodes including 42 social venues. Furthermore, the largest component, previously composed of only 19 nodes (12%), expanded three-fold to contain 18 cases and 40 contacts, representing 37% of the outbreak population (Figure 5). Importantly, a second case with HIV and a female contact who were previously in separate components were now included.

DISCUSSION
Contact tracing of sex partners for individuals with infectious syphilis is universally recommended for the education and treatment of contacts; however, this intervention is limited to known individuals in a sexual relationship. The risk for acquiring an STI is associated with the individual’s entire sexual network and not solely with the number of immediate and known sexual partners (9,11,12). In this investigation, the construction of venue-based networks identified previously unknown links between a greater number of infectious syphilis cases and their sex partners, and increased connectivity among cases and contacts. This emphasized the concept of HIV and syphilis transmission through an entire sexual network of individuals, rather than as isolated cases for whom the source is unidentified.

We found that more than one-third (37.4%) of the 17 cases within the past six months who answered the enhanced surveillance questions patronized a specific bathhouse in Ottawa and a website. This is a similar proportion to the findings of two previous social network analyses (8,9) in which 49% and 42% of cases and contacts were linked to one local venue. Social network methods are valuable in STI investigation because they include the social context in which sexual intercourse occurs and serve as a proxy measure of homophily, where patronage of
places and websites indicates shared, high-risk behaviours. In practice, focusing interventions on a few commonly patronized sites for sexual-health messaging and testing may have the advantage of both precision and efficiency. Conversely, we noted that the men who reported recruiting sex partners >200 km away were significantly more likely to report higher numbers of partners than those who named venues closer to Ottawa (Kruskal-Wallis, P<0.001). This agrees with previous findings that individuals with sex partners recruited from long distances engage in higher risk behaviours than those with local sex partners (13,14). The combination of sex partners locally and far away is ideal in the ability to 'catch' rarer pathogens, such as HIV and syphilis, in a wide net and then transmit them locally (14,15). HIV transmission is two to five times more likely in couples in which one has concomitant syphilis (16). Concomitant HIV infection in individuals with syphilis has been reported in several recent outbreaks in Canada (17-21); however, the position in sexual networks of most of the HIV positive men was peripheral, limiting the spread of HIV (22). Furthermore, there were the two HIV-positive men in the large component of the social network from whom HIV may easily spread to the rest.

The present investigation generated several new directions for the public health unit. First, the recording of information regarding venues where cases meet partners was valuable and should continue prospectively so to better serve prevention. Second, thematic analysis of suggestions for interventions identified the need for more sexual-health messaging both at specific, named gay and nongay venues. Finally, an increased need for education of physicians of both gay and heterosexual populations about syphilis symptoms, testing, transmission and the need to use condoms during oral and anal sex, was cited. OPH re-established public health visits to the bathhouses to provide safe-sex practice information and referrals for syphilis testing. OPH also expanded syphilis awareness campaigns, in particular the "Syphilis is Back" campaign, at the 2010 PRIDE events, and educated front line health care providers by hosting a continuing medical education event covering syphilis basics, attended by 200 primary care providers.

There were several limitations associated with the present investigation. First, only 30% of the cases during the time period of interest were followed-up for enhanced surveillance. The cases who completed the enhanced syphilis surveillance questionnaire did not represent the 72 infectious syphilis cases during the investigation period in that they had higher numbers of partners reported, higher numbers of named contacts and lower proportions of coinfection with HIV. An additional limitation was missing sexual partner data, possibly due to poor recall, anonymous partners or unwillingness to identify the partner. However, sex partners who were forgotten have been shown to be similar to those remembered with regard to the proportions subsequently testing positive (23). Finally, verification of the accuracy of the responses regarding the presence of sexual messaging was not possible.

The present investigation demonstrated that inclusion of social venues in network construction increases the connectivity between cases when compared with networks based solely on cases and sexual partners to include previously unknown links. Finally, we found that social network analysis provided a greater understanding of syphilis transmission in the context of the national and international sexual connections, and an opportunity to focus prevention interventions at key locations.

DISCLOSURES: The authors have no financial disclosures or conflicts of interest to declare.