

Social network investigation of a syphilis outbreak in Ottawa, Ontario

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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 rose 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 χ^2 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 2012 (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.

Une enquête sur les réseaux sociaux d'une écloison de syphilis à Ottawa, en Ontario

HISTORIQUE : L'incidence de syphilis à Ottawa, en Ontario, a beaucoup augmenté depuis 2000, passant de six cas sur 100 000 habitants en 2003 à neuf cas sur 100 000 habitants en 2007, puis à 11 cas sur 100 000 habitants en 2010. Le nombre de cas signalés pendant le premier trimestre de 2010 a plus que doublé par rapport à celui du premier trimestre de 2009.

OBJECTIF : En mai 2010, le ministère de la Santé et des Soins de longue durée de l'Ontario a demandé l'aide du Programme canadien d'épidémiologie de terrain pour décrire l'augmentation du taux de syphilis infectieuses, en déterminer l'origine dans les réseaux sociaux et établir les messages de prévention.

MÉTHODOLOGIE : Les chercheurs ont colligé systématiquement les données de surveillance sur la syphilis entre le 1^{er} janvier 2009 et le 15 juillet 2010 et en ont établi les réseaux sociaux à partir d'un questionnaire amélioré sur les réseaux sociaux. Au moyen du test de Kruskal-Wallis et des tests du chi carré, ils ont effectué des comparaisons univariées des données non distribuées normalement entre le groupe de surveillance améliorée et les autres cas de 2009.

RÉSULTATS : Les cas d'écloison se composaient de 89 % d'hommes. Dix-sept des 19 cas les plus récents ont consenti à répondre au questionnaire, qui a révélé un usage peu fréquent du condom, de multiples partenaires sexuels et des relations sexuelles avec des partenaires de même sexe. Les chercheurs ont transcrit sur un graphique l'information relative aux lieux où les partenaires sexuels se sont rencontrés, ce qui a permis de relier 18 cas et 40 contacts, soit 37 % de la population de l'écloison, et d'associer de nombreux individus uniques et de dyades.

CONCLUSION : La découverte des lieux où les partenaires sexuels se sont rencontrés s'est révélée une mesure indirecte efficace des activités à haut risque partagées avec des personnes infectées et a démontré le potentiel d'intervenir seulement dans un bar précis et un site Internet donné pour joindre une forte proportion de la population à risque.

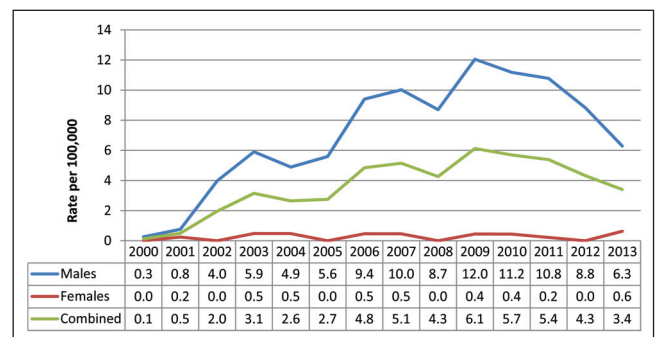


Figure 1 Reported infectious syphilis (primary, secondary and early latent cases only) rate per 100,000 population, males and females, Ottawa, Ontario, 2000 to 2009. Data source: Ontario Ministry of Health and Long-Term Care, integrated Public Health Information System, extracted December 23, 2014.

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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 gonorrhoea 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). 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 sexual 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

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

	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 (interquartile range)	1 (1–1)	1 (1–2)	5.63 [¶]	0.02
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)	1 (5.9)	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 same 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)	8 (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; [†]Includes only the earliest episode for 4 cases involving 2 episodes each of infectious syphilis in 2009 to 2010; [‡] χ^2 test; [§]t test; [¶]Kruskal-Wallis test; ^{**}Totals may differ due to different responses from the same individuals during routine and enhanced surveillance interviews

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 (χ^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 each person was connected to at least one other place or person. 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 secondary syphilis (44.4%) and 19 (26.4%) were HIV positive. Five of 19 individuals were diagnosed with HIV within one year of their syphilis diagnosis, while 14 cases were diagnosed with HIV more than one year before their diagnosis of syphilis.

Sixty-one (84.7%) cases reported a total of 321 sexual partners ranging from one to 50 partners for each case, of whom only 69 (21.5%) were named. The distribution of the number of named partners (degree) used in the network analysis revealed a highly skewed distribution, known as a 'small world network', in which 90% of respondents who named contacts had one to three partners in the past 12 months, while the remainder had four to 16 named partners. Cases who did not report contact information were similar to those who did, in sex and age (mean of 46.2 and 39.6 years of age, respectively; $P=0.14$ [Student's *t* test]).

During routine case follow-up, respondents reported various sex practices including infrequent condom use, sex 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	Sexual health messaging at venue						Total, n
	Ottawa			Outside Ottawa			
	Yes	No	Do not know	Yes	No	Do not know	
Adult video/bookstore	1 (33.3)	1 (33.3)	1 (33.3)				3
Bar/club	4 (33.3)	1 (8.3)	2 (16.7)	2 (16.7)	1 (8.3)	2 (16.7)	12
Bath house/spas/sex club	7 (50.0)	0 (0)	2 (14.3)	5 (14.3)	1 (7.1)	1 (7.1)	16
Cruising sites	0 (0)	3 (100.0)	0 (0)				3
Family/friends	0 (0)	4 (100.0)	0 (0)				4
Internet	10 (58.8)	7 (41.2)	2 (11.8)				19
Private parties	1 (20.0)	1 (8.3)	0 (0)		1 (20.0)	0	3
Other	0 (0)	4 (57.1)	0 (0)	1 (14.3)	2 (28.6)	0	7

Data presented as n (%) unless otherwise indicated

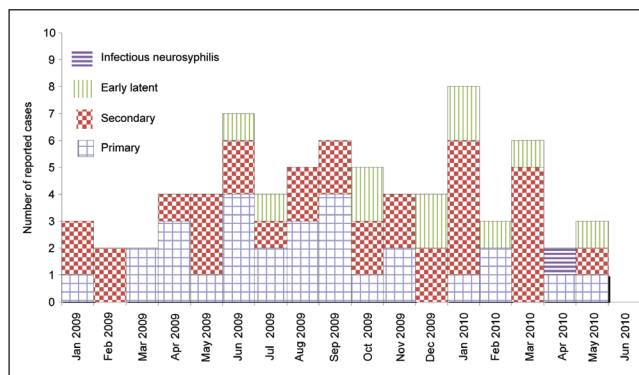


Figure 2) Reported infectious syphilis cases (primary, secondary and early latent cases only) by month and year of episode, Ottawa, Ontario, January 2009 to June 2010 (includes cases diagnosed up to June 15, 2010 (n=72) [includes only the earliest episode for four cases involving two episodes each of infectious syphilis in 2009 to 2010])

All respondents were men, resembling the majority (94.4%) of routinely reported cases and were of similar ages and syphilis stages compared with the routinely notified group (Table 1). One of the enhanced surveillance respondents (5.9%) was coinfecting with HIV, compared with coinfection in 19 (26.4%) of the routine cases ($\chi^2=6.59$; $P=0.01$). Ethnic background for the 72 reported cases was not collected; however, the majority of the cases who responded to the enhanced surveillance questionnaire were Caucasian (82.4%). The 17 cases contacted for enhanced surveillance reported a total of 81 sexual partners, although only 17 (21.0%) according to name, similar to the routinely reported cases. However, they reported higher numbers of total partners than reported according to routinely notified cases ($P=0.02$ [Kruskal-Wallis]) (Table 2). Eleven of 17 (64.7%) cases reported having regular sexual partners, 12 (70.6%) reported having casual partners, 11 (64.7%) reported having anonymous partners and four (23.5%) reported having group-sex encounters. There were no cases reporting exchanging sex for money in the past 12 months.

There was no sexual-health messaging reported at informal venues (Table 2). However, there was an awareness of sexual-health messaging in bars and clubs (four of seven responses) and in bathhouses, spas and sex clubs (seven of nine responses) in Ottawa and outside of Ottawa (five of seven responses). The proportion of respondents aware and unaware of sexual-health messaging on Internet sites was evenly split.

Respondents suggested that OPH increase education regarding symptoms, testing and transmission of syphilis, as well as the importance of condom use for oral and anal sex. They suggested targeting specific social venues frequented by the gay population such as bars, Internet sites and bathhouses. The respondents also stressed the need for messaging in other venues, such as public washrooms, to include men who have sex with both women and men. Advertisements directed at the

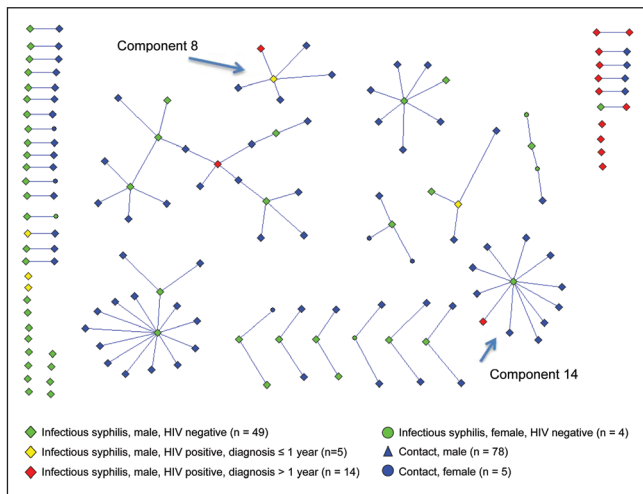


Figure 3) Sexual network of infectious syphilis cases generated using routinely collected cases and contact data only in a syphilis outbreak, Ottawa, Ontario, January 2009 to June 2010 (n=155). Lines represent sexual contact between individuals

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 coinfecting 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

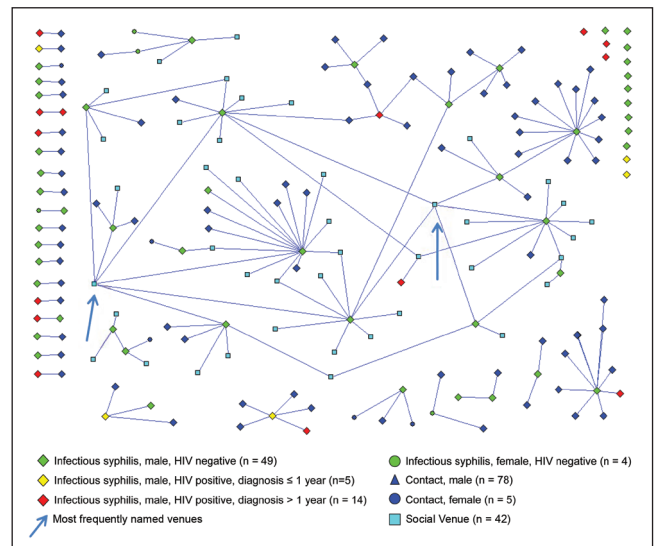


Figure 4) Social network of infectious syphilis cases, contacts and all venues using data collected from routine and enhanced surveillance cases, according to sex and HIV status, Ottawa, Ontario, January 1, 2009 to June 15, 2010 (n = 197). Squares represent a venue, lines between individuals represent sexual contact while those between individuals and venues represent patronage to that venue

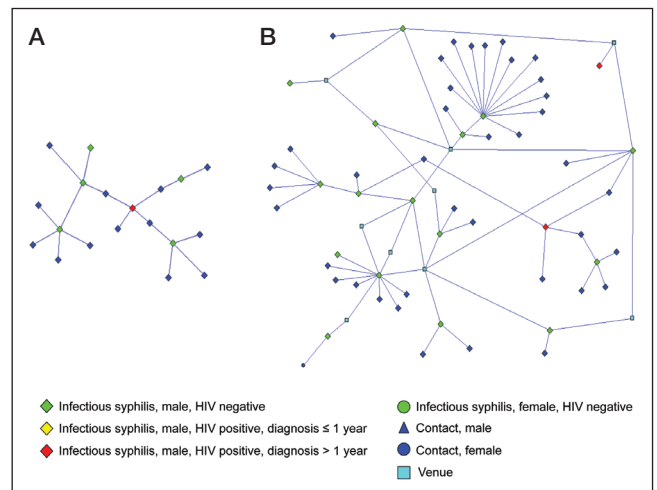


Figure 5) Largest component of infectious syphilis cases contacts using routinely collected data only (A) and largest component generated from routinely collected data and adding only those venues named by two or more individuals, according to sex and HIV status (B), Ottawa, Ontario, January 1, 2009 to June 15, 2010. Lines between individuals represent sexual contact while those between individuals and venues represent patronage to that venue

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 whom 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.

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