Social Network Effects on the Transmission of Sexually Transmitted Diseases

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Background: **Only a limited number of studies have examined the effects of social networks on sexually transmitted diseases (STDs), although the findings of such studies would be helpful in designing more effective prevention strategies.**

Goal: **This study attempts (1) to determine whether there are any social network effects on STD transmission after controlling for other risk factors and (2) to explore the possible mechanisms by which social networks exert their effects.**

Study Design: **Logistic regressions examine the effects of friendship networks on STD transmission using data drawn from the Chicago Health and Social Life Survey (CHSLS). Additional logistic regressions probe the possible mechanisms (social control versus information and dyadic versus third party) that account for how the observed effects of networks might arise.**

Results and Conclusion: **Among people who had fewer than 13 lifetime sex partners, those with no social friends were only 0.4 times as likely to be infected as those with one or more social friends. Among people who had 13 or more lifetime partners, those with many friends (5 or 6) but weak ties to them (talking less than once a day with them) were only 0.2 times as likely to be infected as those with either fewer friends or stronger ties to their friends. Additional regressions suggest that network effects resting on dyadic control prevail among those with fewer than 13 lifetime sex partners. In contrast, network effects resting on information exchange among third parties prevail among those with 13 or more lifetime partners.**

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SEXUALLY TRANSMITTED DISEASES (STDs) are a serious social problem in the United States. Rates of curable STDs are the highest in the industrialized world and are even higher than those in some developing regions.[1] Half of the most commonly reported infections in the United States are STDs,[2] and STDs accounted for 87% of the reported cases of the 10 leading notifiable diseases in 1995.[3] The Centers for Disease Control and Prevention estimated 15.3 million new cases in 1996,[4] and the annual costs of selected major STDs, excluding HIV infections, are estimated to be $10 billion.[5] In addition, various STDs may lead to cancer, infertility, ectopic pregnancy, spontaneous abortion, stillbirth, and low birth weight for infants and increased risk for acquiring HIV.[6]

Historically, the main focus of STD epidemiology has been on the attributes and behaviors of individuals, this being consistent with the dominant perspectives in clinical medicine, chronic disease epidemiology, and psychology.[1] Since the late 1980s, however, many researchers have recognized the important role of sexual networks in sustaining the extraordinarily high infection rates in the United States. Unlike chronic diseases, the odds of being infected (and also infecting others) are determined by factors above the level of the individual: they depend not only on the individual person's risk factors but also on that person's sex partners' risk factors. Thus, sexual network effects on the dynamics of STDs have steadily gained research attention.[7–16] In sharp contrast to the increasing attention devoted to *sexual* networks, research on *social* network effects on STD transmission has rarely been emphasized, and empirical research is limited due to the lack of pertinent data in the United States, with a few notable exceptions.[17–19] In Europe, although some research, based on the pooling of 16 population surveys across 11 countries undertaken by the European Concerted Action on Sexual Behavior and Risks of HIV Infection program,[20,21] has succeeded in revealing that social factors (or social relationships) are critical to the spread of HIV, most research has focused on social relationship in general instead of probing the specific features of social networks that mediate these effects.

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Without paying close attention to social factors (or social networks in particular), research on the spread of STDs is necessarily incomplete because risk factors are socially constructed, as confirmed in many European research studies.[22–24] Although sex has a biologic underpinning, sexual behavior is one of the most socially diverse human activities. As a direct result of this fact, risk factors regarding sexual behaviors are rooted in and consistently affected by social environments around them. For example, the same person bears quite different levels of risks or different odds of changing sexual behavior, depending on whether the sexual relationship is defined in his or her social milieu as short-term and casual or regular and ongoing, voluntary or forced, or supported or unsupported by the couple's social peers.

Research on the effects of social networks is vital for establishing effective primary prevention—intervention that prevents infection from occurring in the first place. Improved diagnostic tests for STDs have recently revealed that asymptomatic infections are much more prevalent than symptomatic diseases[25] and that most STDs do not result from contact with clinically apparent diseases but rather with unnoticed and frequently subclinical infections.[26] Given this situation, primary prevention is crucial for curbing STDs.[5] However, reaching a targeted population for primary prevention (persons who are at risk but not yet infected) with the necessary information about avoiding STDs is not straightforward because most people do not get their information about STDs from the media. Instead, people primarily obtain and transmit information about STDs through their informal social networks, especially their friends. Analysis of the National Health and Social Life Survey, based on a nationally representative sample, found that about 40% of the adult population primarily relied on close, informal, non-kin networks (friends or sex partners) for learning about sexual matters when they were growing up, while only 8% primarily relied on school instruction (and only 1% on TV or medical clinics).[27]

Using data from the Chicago Health and Social Life Survey (CHSLS), including information about both sexual partnerships and social relationships, this study attempted (1) to determine whether there are any social network effects on STD transmission after controlling for other risk factors and (2) to explore the possible mechanisms by which social networks exert their effects.

Methods

Data

The CHSLS provides a rare opportunity to explore these issues. While the CHSLS is a large project that includes multiple surveys of a cross-section of Cook County residents, residents of four selected neighborhoods in the city, and an extensive ethnographic component, we used in this analysis data from only a representative sample of 890 Cook County residents, collected in 1995 in face-to-face interviews averaging 90 minutes in duration. We asked respondents to enumerate up to six of their friends, including up to three free-time partners (adults with whom the respondent spent time for his/her enjoyment after work or school or on the weekend) and up to three discussion partners (adults with whom the respondent most often discussed important matters). Respondents were asked to exclude their sex partners when they enumerated friends. There were also questions about the respondents' sex partners as well as various sexual behaviors, including number of sex partners and history of STDs.

Measures

Control versus information. Social networks can change STD transmission dynamics through their effects on (1) the social control exercised by social network members over the focal individual's choice of sex partner(s) and behavior and (2) the flow of pertinent information about the risks posed by particular sex partners, behaviors, and meeting places such as local bars. Both control and information can work thorough either dyadic ties or third parties. Let us elaborate on these alternative pathways of social influence.[28] First, people's sexual behaviors are shaped and controlled by various stakeholders in the sexual relationship.[27] Social control or influence over one another's behavior can be exerted directly by the two immediate stakeholders themselves, i.e., the sex partners in the dyadic relationship itself, or via third parties, such as parents or friends, who constitute the individual's informal social network. The stronger the control exerted through either the dyadic relationship itself or third parties (such as parents) with stakes in the maintenance of that particular relationship, the less likely the partnership will involve risky behavior (especially a high turnover of partners).

Strong social control from social peers such as friends or neighbors, however, can have the opposite effect. If a young man is tightly embedded in a circle of young men who regard having large numbers of sex partners as normal and even desirable for enhancing one's social standing (i.e., reputation) in the group, he is likely to have a higher turnover of partners than he would have otherwise. On the one hand, being strongly tied to parents or to the dyadic relationship with one's current sex partner (i.e., being strongly embedded in these relationships) decreases risky behavior in general. On the other hand, being strongly embedded in a peer group can have either positive or negative effects on risky behavior, depending on the characteristics of the peer group.

Turning to a consideration of the second mechanism, we observe that people typically obtain and transmit pertinent

sexual information through their social networks.[29] From general knowledge about safe sex or techniques to avoid STDs to specific information about locales that are likely to have safe casual sex partners, people heavily rely on their informal social networks because such information is more likely to be available, credible, trustworthy, timely, and specific in such networks. For example, in Bangladesh, a social network approach that utilized local influential persons was five times more efficient in transmitting modern contraceptive practices than a traditional approach that sent field workers on home visits.[30] The media are poor sources for such information because they are overly generalized (or lacking in specificity), lagging in timeliness, trustworthiness, and reliability in their availability—in short, they lack credibility and immediacy of access to locally relevant information. People with timely, accurate information are less likely to acquire STDs. Although sexual information, in principle, can flow through either third parties or the dyadic relationship itself, we believe that most (especially information regarding potential new sex partners) flows mainly through third-party connections and not through the dyadic sexual tie itself. Needless to say, third-party mechanisms and dyadic mechanisms are interacting in many ways. For example, strong support from the third party can increase self-esteem or bargaining power in dyadic control. We do not attempt to analyze this interaction effect separately because of the small number of cases available.

Friendship networks. We differentiate social friendship networks on the two dimensions of range and cohesion in order to distinguish the network mechanisms of information and control. We treated "five or six friends" as a large friendship circle (and "fewer than five" as small), and we assumed that if people talk to their friends every day on average, they have a strong friendship network (while a weak network involves friends with whom the respondent talks less frequently than once a day). Note that "strong friendship" means intense dyadic ties between ego and friends, not necessarily strong or tight embeddedness of a relationship through a third party as discussed above. Somebody can have a strong friendship while his or her sexual relationship is weakly embedded within each partner's kin networks. Four types of friendship circle are distinguished: no friends, strong and small friendship circles, weak and large circles, and a combination of strong and large circles and weak and small circles (the final categorization was made after evaluating various cut-off points such as "three or more friends" for large friendship or "several calls a week" for strong friendship).

In general, strong and intensive ties are believed to produce greater mutual commitment and social control, while weak ties provide more information than control.[31,32] Also, many social ties will lead to the provision of more information than fewer ties. Few and strong ties are more likely to produce social control and influence, while weak and many ties are more likely to be sources of nonredundant and thus useful information from the multiplicity of ties. Thus, in friendship networks as well, we can assume this general property of social networks. The category of "no friend" will manifest strong dyadic control (only the sex partner is present to exercise control) without third-party integration (no extrarelational ties exist). A "strong and small friendship circle" implies strong control through third parties (friends) in a small clique who can communicate with one another about the matters at hand, and a "large and weak friendship circle" is likely to produce large information flows among the participants (friends) who do not belong to the same small clique and thus have access to different sources of information. Other intermediate types, such as the "strong and large circle" or the "weak and small circle," are not easy to interpret because we cannot specify a priori whether the control or information effect is dominant without more detailed information about the social networks around the respondent.

Dyadic control/information. As discussed above, social networks exert social control or influence and disseminate information in two ways: through the sexual dyad itself and through third parties. Dyadic control will be measured by four variables: (1) the amount of free time spent with the most recent partner, (2) conflict with the most recent partner arising from sexual jealousy, (3) ever having forced sex (forced or being forced), and (4) easiness of discussing sexual topics with the most recent partner. We assumed that spending free time with one's sex partner provides more opportunities to exert influence over one another as well as to index tighter control over one another. We use the incidence of jealous conflict to index the failure of strong dyadic control. Also, if sex was forced, it is apparent that there is a considerable disparity in power between the partners. Unlike the other forms of dyadic control, this expression of strong control over a victimized partner, we believe, will have a positive effect on the probability of having been infected because of the intrinsic nature of forced sex. Effective negotiations on safe sexual activities during intercourse (for example, condom use) might simply be impossible under these circumstances. We also assume that the uneasiness of talking about sexual topics with the partner can be a proxy measure for the power relationship between the partners[33]: a very unequal relationship does not allow sexual topics to be discussed. Although we do not anticipate that information exchange about STD risk factors is especially likely to occur within the dyad itself, "shared free time" and "easy talk about sexual topics" can be related with diffusion of information within the partnership. The easier it is to talk about sexual topics and the more people share their free time, the greater the information flow is likely to be.

Third-party control/information. Limitations in the availability of pertinent data in the survey make it much more difficult to distinguish between control and information effects due to third-party embeddedness. In our previous example regarding the young men tightly embedded in a social circle of very sexually active men, it is highly probable that his peers exert a powerful social influence over him and, at the same time, that they provide him with useful information about the potential risks of his sexual activities. When sex partners who have many mutual acquaintances begin their sexual relationship, it is likely that the mutual acquaintances, as stakeholders, will work both as information providers about the partners' respective strengths and weaknesses and as an influence in persuading them that they are a good (or bad) match, thus affecting the duration of the relationship.[34–36] As an indicator of third-party influence (without being able to distinguish between the effects of control and information), we used "number of mutual acquaintances when the respondent met his/her most recent partner" and "acquaintance with more than half of the current neighbors who live in the same building or on the same street." One kind of third-party control, however, is explicitly measured, namely, the most recent partner's acquaintance with the respondent's parents. If the partner knows both parents of the respondent, we assume that the couple is strongly integrated in an overlapping kinship network and thus risky behavior is decreased through the mechanism of social control (rather than information exchange).

Analyses

Logistic regressions. Below we present two sets of regressions in order to answer two questions: (1) can we observe effects of friendship networks on the likelihood of having ever been infected with an STD, even after controlling for other risk factors? and (2) can we demonstrate that social network effects operate through two distinct mechanisms, either dyadic control/information or third-party control/information? Preliminary log-linear results suggested that we should divide the sample into two subgroups because there is strong evidence that social networks work on the likelihood of ever having been infected with STDs in opposed directions, depending on whether a respondent has had many lifetime sex partners (13 or more) or relatively few. (Cut-off points other than "13 or more" were tested by log-linear analysis to determine which one best captured the nonlinear effect.) Thus, all the logistic regressions are examined separately for these two subgroups.

Dependent variable. The dependent variable, "ever infected with any STDs during lifetime," is measured on the basis of the following survey passage: "There are several diseases or infections that can be transmitted during sex. These are sometimes called venereal diseases, or VD. We will be using the term *sexually transmitted diseases*, or *STDs*, to refer to them." After giving the respondent a card listing each STD (sometimes including their vernacular terms, for example, "clap" or "drip" for gonorrhea), the interviewer asked: "As I read each STD, tell me whether you have *ever* been told by a doctor that you had it." A distinction was drawn only between ever infected and never infected: we did not distinguish people who were infected only once from people who were infected several times.

Control variables. Demographic attributes, including age, gender, marital status, racial/ethnic groups, and educational level, are included in the logistic regressions as control variables. Other control variables measuring the respondent's other risk factors for STDs include ever experiencing same-gender sex, ever having injected nonprescribed drugs, number of lifetime sex partners, and having a concurrent partnership during the most recent sexual partnership.

Please note that although the partner-related network variables all refer to the most recent sex partners and both the neighborhood-related and friend-related variables are also current (they refer to current neighbors or current friends), the dependent variable refers to lifetime experiences with STDs. This undesirable reversal in the time order of the dependent and independent variables was necessitated because the current (or last year's) STD prevalence is too low (only 1.9%) to sustain statistical analysis. (In contrast, the lifetime prevalence is 19%, providing a much more substantial case base to sustain analysis.) This important limitation will be examined in detail in the discussion section later. All the variables in the logistic regression are summarized in Table 1.

Results

Existence of Friendship Network Effect

Table 2 reveals not only that friendship networks do have effects on the transmission of STDs, even after controlling for other risk factors, but also that friendship networks have different effects, depending on the number of sex partners the respondent has.

The first logistic regression was for people with few lifetime sex partners (1 to 12 partners) and the second logistic regression was for those with many lifetime sex partners (more than 12). Among the people with few lifetime partners, those with no close social friends were only 0.4 times as likely to be infected as people with one or more social friends. Among people who had many lifetime sex partners, those with many friends but weak ties to them were only 0.2 times as likely to be infected as those with either fewer friends or stronger ties to their friends.

TABLE 1. Summary Description of the Independent and Dependent Variables

Variable	Summary	n
Categorical		
STDs ever*	Ever (19%), never (81%)	887
Number of sex partners over lifetime	1 to 2 (52%), 3 to 12 (32%), 13 or more (16%)	827
Gender	Male (42%), female (58%)	890
Ever married	Never (37%), ever (63%)	890
Racial/ethnic group	Whites (55%), blacks (28%), others (18%)	890
Education	Less than HS (15%), HS (35%), more than HS (50%)	890
Same-gender sex	Never (94%), ever (6%)	880
Drug injection	Never (97%), ever (3%)	880
Having concurrent partners†	No (80%), yes (20%)	886
Trade sex for drug	Never (94%), ever (6%)	846
Talk about sexual topics†	Very easy (61%), not very easy (39%)	846
Jealous conflict†	Never (74%), ever (26%)	844
Spend free time together†	All free time (15%), not all free time (85%)	848
Forced/was forced to have sex	Never (84%), ever (16%)	880
Partner knows both respondent's parents†	Both parents (57%), not both (43%)	835
Mutual acquaintances at the beginning†‡	Less than 5 (63%), 5 or more (37%)	843
Acquaintance with the current neighbors	More than half (74%), less than half (26%)	888
Nature of friendship circle§	None (12%), strong/small (23%), weak/large (10%), others (55%)	890
Continuous		
Age	36.8 (mean), 10.8 (standard deviation)	890

*The list includes gonorrhea, syphilis, herpes, chlamydia, genital warts, hepatitis B, nongonococcal urethritis (male only), vaginitis (not yeast infection; female only), and pelvic inflammatory disease (female only).
†Items refer to the most recent sex partners.
‡Number of mutual acquaintances at the beginning of the most recent sexual relationship.
§Items refer to the current friends (up to six).
HS = high school.

Consistent with previous research, both regressions show that women in general and black men and women in particular are much more likely to have had an STD sometime during their lifetime. Concurrent partnership during the most recent partners has opposite effects, depending on the number of lifetime sex partners the respondent has had. Concurrency increases the odds of having been infected for those with few lifetime partners but decreases the odds for those with many lifetime partners. This is an unexpected finding and will be discussed in the discussion section below.

Social Network Effects

In order to probe mechanisms producing the effects of social networks on the differential likelihood of having had STDs, we ran an additional logistic regression for each of the two subgroups defined on the number of lifetime sex partners. Table 3 summarizes these two logistic regressions.

People with few lifetime partners. Four variables pertaining to dyadic control/information were added to examine its effect. Two seem to be very effective: when persons report jealous conflict in their relationship, which, we assume, implies a failure of strong dyadic control, they are almost twice as likely to be infected. Having forced sex (the respondent either forced or was forced) increases the odds of being infected about three times. A serious power discrepancy between partners, and thus serious difficulty in negotiating for safe sex practices, increases the odds of being infected. Spending more free time with the partner and easy discussion of sexual topics, however, do not seem to be effective in avoiding STDs.

The effects of third-party control/information exchange were examined by three variables. Only integration with the parents is significant: persons whose most recent partner knows both their parents are only 0.6 as likely to be infected. This is regarded as third-party control rather than third-party information because parents rarely give sexual information to their adult children. "Having many mutual acquaintances" or "acquaintance with more than half of neighbors," however, does not exert significant effects.

People with many sex partners. Neither of the dyadic mechanisms (control and information exchange) is operative among people with many lifetime sex partners. Among the third-party control/information mechanisms, "acquaintance with more than half of the neighbors" is very effective in avoiding STDs. People who knew more than half of their neighbors who live in the same building or on the same street are only 0.2 as likely to be infected.

Discussion

Although the CHSLS is rare in having a representative data set that contains such a comprehensive inventory of

TABLE 2. Existence of Friendship Network Effects (Odds Ratios and 95% CIs for Ever Any STDs in Lifetime)

	Regression Among People With	
Variable	Moderate Number of Partners	Many Partners
Demographic variable		
Age	1.00 (0.98–1.03)	1.04 (0.98–1.10)
Women	[b]1.81 (1.11–2.95)	[b]2.83 (1.06–7.56)
Ever married	0.95 (0.57–1.59)	1.40 (0.47–4.16)
Black*	[a]3.17 (1.95–5.15)	[c]2.55 (0.95–6.82)
Other racial groups*	0.97 (0.47–1.99)	1.80 (0.40–8.18)
High school education†	0.73 (0.38–1.43)	3.57 (0.48–26.54)
More than high school education†	0.99 (0.53–1.86)	3.03 (0.43–21.62)
Risk behavior		
Ever same-gender sex	1.06 (0.37–2.99)	1.80 (0.60–5.40)
Ever injected drugs	1.12 (0.33–3.76)	1.05 (0.13–8.15)
Ever traded sex for drugs	1.25 (0.53–3.00)	[c]5.03 (0.95–26.58)
Having concurrent partners	[b]1.85 (1.08–3.17)	[b]0.38 (0.15–0.95)
3 to 5 lifetime sex partners‡	0.97 (0.55–1.73)	
6 to 12 sex partners‡	[a]2.61 (1.49–4.57)	
20 to 40 sex partners§		0.71 (0.23–2.19)
41 or more sex partners§		1.71 (0.50–5.84)
Friendship network		
None‖	[b]0.37 (0.14–0.98)	
Weak, large friendship circle¶		[b]0.18 (0.04–0.88)
Number of cases	683	129
Pseudo R square	0.11	0.18

Moderate number = 1 to 12 sex partners for lifetime; many = 13 or more lifetime sex partners.
[a]Significant at 1% alpha level.
[b]Significant at 5% alpha level.
[c]Significant at 10% alpha level.
*Compared with whites.
†Compared with less than high school.
‡Compared with 1 to 2 lifetime partners.
§Compared with 13 to 19 partners.
‖Compared with the rest of the people who have one or more friends.
¶Compared with the rest of the people who have no friends at all or only a small number of friends (fewer than 5) or who have a large but strong (talking everyday, on average) friendship circle.

both a person's sex life and social network information, our models all suffer from a fundamental inconsistency in the time order between the dependent variable (which refers to the acquisition of STDs over the adult lifetime) and some of the independent variables that refer only to a narrowly defined, recent period. It is thus even possible that in our regressions, part of the causation may occur in the opposite direction: experience of STD infection caused subsequent change in the informal social networks. This can be possible especially if the infection was very serious, such as HIV/AIDS that has extremely low prevalence.

However, we contend that this reversal of the time order is not fatal to our purposes because individuals' patterns of organizing their informal social ties tend to be relatively stable over the life course,[37–40] especially once demographic characteristics such as gender, age, education, and especially marital status are controlled.[41–44] In short, the measure of the respondent's current social network can be regarded as a proxy measure of the adult respondent's lifetime structure of informal social ties. In a study of the friendship ties of 1013 white men living in Detroit, for example, Laumann[37] found that the men characterized themselves as either "having just one or two *really close* friends" or "having a large number of people they felt really close and friendly with" and that whether they had few or many friends was associated with a basic personality need for affiliation as well as the actual number of friends they presently had. There is also an extensive literature in social psychology that links various measures of extraversion and sociability with actual patterns of socializing with others that strongly imply stability in the structuring of a person's social network about size and density over his/her adult life course, especially in the research on attachment styles.[45–51]

Even though we firmly believe that an individual's informal social network pattern tends to be stable over time, reflecting his or her level of social competence, social position, and capacity to sustain ties with others, and thus that the current network may be treated as a proxy for the past, only future data that provide longitudinal network information as well as time-ordered information about sexual activities can provide a definitive test of our hypotheses. Fully acknowledging this limitation in our data, we believe

TABLE 3. Different Social Network Effects (Odds Ratios and 95% CIs for Ever any STDs in Lifetime)

Variable	People With Moderate Number of Partners (1 to 12 Since Age 18 y)	People With Many Partners (13 or More Since Age 18 y)
Demographic variable		
Age	1.00 (0.98–1.03)	[b]1.07 (1.00–1.15)
Women	1.26 (0.75–2.15)	[c]3.28 (0.99–10.91)
Ever married	1.15 (0.66–2.01)	1.34 (0.41–4.44)
Black*	[a]3.23 (1.93–5.41)	[b]4.05 (1.17–14.02)
Other racial groups*	0.91 (0.43–1.95)	2.76 (0.50–15.06)
High school education†	0.66 (0.33–1.34)	2.79 (0.32–24.14)
More than high school education†	1.03 (0.53–1.02)	1.92 (0.24–15.38)
Risk behavior		
Ever same-gender sex	0.78 (0.26–2.35)	2.55 (0.68–9.63)
Ever injected drugs	0.93 (0.28–3.14)	1.51 (0.13–17.50)
Ever traded sex for drugs	1.08 (0.42–2.78)	[b]11.86 (1.36–103.30)
Having concurrent partners	1.61 (0.91–2.85)	[c]0.35 (0.12–1.02)
3 to 5 lifetime sex partners‡	0.87 (0.47–2.61)	
More than 5 sex partners‡	[a]2.26 (1.26–4.07)	
20 to 40 sex partners§		0.79 (0.22–2.88)
41 or more sex partners§		1.62 (0.37–6.99)
Friendship network		
None‖	0.41 (0.14–1.19)	2.70 (0.32–22.85)
Weak, large friendship circle‖	0.55 (0.20–1.50)	[c]0.15 (0.02–1.09)
Other forms of friendship circle‖	0.96 (0.55–1.68)	0.59 (0.20–1.74)
Dyadic information control		
Very easy discussion of sex topics¶	1.05 (0.65–1.69)	1.15 (0.37–3.53)
Jealous conflict	[b]1.76 (1.06–2.92)	1.58 (0.49–5.12)
Spend all free time together	1.36 (0.68–2.73)	4.46 (0.69–29.04)
Ever having forced sex	[a]3.02 (1.76–5.19)	0.86 (0.23–3.18)
Third-party information/control		
Partner knows both of respondent's parents	[b]0.59 (0.37–0.96)	0.79 (0.29–2.12)
5 or more mutual acquaintances#	0.75 (0.47–0.21)	0.36 (0.11–1.24)
Knows more than half neighbors**	0.97 (0.58–1.63)	[b]0.19 (0.05–0.77)
Number of cases	664	126
Pseudo R square	0.16	0.28

[a]Significant at 1% alpha level.
[b]Significant at 5% alpha level.
[c]Significant at 10% alpha level.
*Compared with whites.
†Compared with less than high school.
‡Compared with 1 to 2 lifetime partners.
§Compared with 13 to 19 partners.
‖Compared with strong, small friendship circle (having fewer than 5 friends and talk everyday, on average).
¶Compared with people for whom it is not very easy (somewhat easy, somewhat difficult, or difficult) to discuss sexual topics with partner.
#Compared with less than 5 mutual acquaintances when the respondent met the most recent partner.
**Compared with "knows half or less of the current neighbors" who live in the same building or on the same street.

that the CHSLS provides highly suggestive evidence of the strong and consistent effects of informal social networks on STD transmission dynamics.

In Table 2, "concurrent partnership" decreases the odds of being infected among people with many sex partners, which is counterintuitive and requires discussion (even though it loses most of its statistical significance once we control for other network-related variables in Table 3). Instead of making a specific argument here, we would like to suggest a hypothesis for future research because this is an unexpected and potentially important finding that requires testing with regression models and data more appropriately designed for the purpose. Let's assume there is a person who had *many* sex partners in a given period (for example, 5 partners last year). With high partner turnover in a given period, overlap between partners is more likely to happen than when a person has only a few partners in the same period. Thus, if someone has many sex partners but with no overlap, each partnership is likely to be short and thus casual, approximating one-night stands between strangers with all the risk that entails. In this sense, concurrency may imply longer and thus less risky relationships for people with many sex partners. This reasoning cannot apply to people with few sex partners because they are likely to have

long, stable partnerships even without overlap, approximating serial monogamy.

We have found that there is indeed an important effect of friendship networks on the likelihood of having had STDs, even after controlling for other risk factors. Furthermore, depending on the number of lifetime sex partners, different friendship patterns exert different effects. Among the people with few lifetime sex partners (up to 12 partners), having no friend is effective in avoiding STDs, while having many friends with weak ties is helpful among the people with many lifetime sex partners. We speculate that people who are socially isolated (lacking any current friends) are likely to focus their energy and social resources on their sex partners, and thus when they secure them, it results in strong mutual control and influence over one another. This reduces the risk factors to the sex partners and results in lowering the odds of being infected over the lifetime. Also the fact that only a "weakly tied, large friendship network" confers a preventive advantage among the people who have many lifetime sex partners hints that information (rather than control) is the critical factor; thus, third-party information is especially essential for avoiding STDs for people with high partner turnover.

Persons with many sex partners find it difficult, even should they want to, to exert strong dyadic control over each of their numerous partners because of two considerations. First, they simply do not have sufficient time, resources, and energy to exercise strong control over each partner. Second, they suffer a loss of legitimacy in making claims for sexual exclusivity when they themselves do not provide it to any of their partners. Instead, they must rely on third-party embeddedness to mitigate risks. This finding leads us to conclude that the people in real danger are those who not only have many sex partners but also have only a small number of friends with whom they have strong ties (in short, they constitute one small clique).

These accounts gain further support in the results obtained in the logistic regressions reported in Table 3. Among the people with few lifetime sex partners, dyadic control is especially effective: control or power within dyadic relationship is very effective (measured by "jealous conflict" or "forced sex"). Parental control (measured by both parents knowing the most recent partner) is also helpful in avoiding STDs. In sharp contrast to the prevalence of dyadic control among the people with few lifetime partners, no dyadic control or dyadic information exchange is effective among the people with many lifetime sex partners. Only acquaintance with the current neighbors is important. Knowing many neighbors may provide critical information about potential partners or a good place to meet safe partners. Also neighbors may work as stakeholders in encouraging stable and norm-complying relationships, even though we believe this is not as important as information exchange for the people who have many sex partners.

References

1. Aral SO. Sexual network patterns as determinants of STD rates: paradigm shift in the behavioral epidemiology of STDs made visible. Sex Transm Dis 1999; 26:262–264.
2. Division of STD Prevention. Sexually Transmitted Disease Surveillance, 1996. Atlanta: Centers for Disease Control and Prevention, 1997.
3. Centers for Disease Control and Prevention. Ten leading national notifiable infectious diseases, United States 1995. MMWR Morb Mortal Wkly Rep 1996; 45:883–884.
4. Alexander LL, Cates JR, Herndon N, Ratcliffe JF, eds. Sexually Transmitted Diseases in America: How Many Cases and at What Cost? Research Triangle Park, North Carolina: American Social Health Association, 1998.
5. Eng TR, Butler WT, eds. The Hidden Epidemic. Washington, DC: National Academy Press, 1997.
6. Van Devanter N. Prevention of sexually transmitted diseases: the need for social and behavioral science expertise in public health departments. Am J Public Health 1999; 89:815–818.
7. Aral SO. The social context of syphilis persistence in the southeastern United States. Sex Transm Dis 1996; 23:9–15.
8. Aral SO, Hughes J, Stoner B, et al. Sexual mixing patterns in the spread of gonococcal and chlamydial infections. Am J Public Health, 1999; 89:825–833.
9. Garnett GP, Anderson RM. Contact tracing and the estimation of sexual mixing patters: the epidemiology of gonococcal infections. Sex Transm Dis 1993; 20:181–191.
10. Garnett GP, Anderson RM. Sexually transmitted diseases and sexual behavior: insights from mathematical models. J Infect Dis 1996; 174(suppl 2):S150–161.
11. Laumann EO, Youm Y. Race/ethnic group differences in the prevalence of sexually transmitted diseases in the United States: a network explanation. Sex Transm Dis 1999; 26:250–261.
12. Potterat J, Rothenberg RB, Woodhouse DE, et al. Gonorrhea as a social disease. Sex Transm Dis 1985; 12:25–32.
13. Potterat JJ, Rothenberg RB, Muth SQ. Network structural dynamics and infectious disease propagation. Int J STD AIDS 1999; 10:182–185.
14. Rothenberg RB, Potterat JJ. Temporal and social aspects of gonorrhea transmission: the force of infectivity. Sex Transm Dis 1988; 15:88–92.
15. Rothenberg RB, Potterat JJ, Woodhouse DE. Personal risk taking and the spread of disease: beyond core groups. J Infect Dis 1996; 174(suppl):144–149.
16. Rothenberg RB, Sterk C, Toomey KE, et al. Using social network and ethnographic tools to evaluate syphilis transmission. Sex Transm Dis 1998; 25:154–160.
17. Wasserheit J, Aral SO. The dynamic topology of sexually transmitted disease epidemics: implications for prevention strategies. J Infect Dis 1996; 174(suppl 2):S201–S213.
18. Martina M, Zavisca J, Dean L. Social and sexual networks: their role in the spread of HIV/AIDS among young gay men. AIDS Educ Prev 1995; 7(suppl):24–35.
19. Rosenberg D, Moseley K, Kahn R, et. al. Networks of persons with syphilis and at risk for syphilis in Louisiana: evidence of core transmitters. Sex Transm Dis 1999; 26:108–114.
20. Van Campenhoudt L, Cohen M, Guizzardi G, Hausser D, eds. Sexual Interactions and HIV Risk: New Conceptual Perspectives in European Research. London: Taylor and Francis, 1997.
21. Hubert M, Bajos N, Sandfort T, eds. Sexual Behaviour and HIV/AIDS in Europe: Comparisons of National Surveys. London: UCL Press, 1998.
22. Aggleton P, O'Reilly K, Slutkin G, Davies P. Risking everything? Risk behavior, behavior change, and AIDS. Science 1994; 265:341–345.
23. Bajos N. Social factors and the process of risk construction in HIV sexual transmission. AIDS Care 1997; 9:227–237.
24. Delor F, Hubert M. Revisiting the concept of 'vulnerability.' Soc Sci Med 2000; 50:1557–1570.
25. Sparling PF, Aral SO. The importance of an interdisciplinary approach to prevention of sexually transmitted diseases. In: Wasserheit JN, Aral SO, Holmes KK, Hitchcock PJ, eds. Research Issues in Human Behavior and Sexually Transmitted Diseases in

the AIDS Era. Washington, DC: American Society for Microbiology, 1991:10–11.
26. Judson FN, Paalman M. Behavioral interventions in developed countries. In: Wasserheit JN, Aral SO, Holmes KK, Hitchcock PJ, eds. Research Issues in Human Behavior and Sex Transmitted Diseases in the AIDS Era. Washington, DC: American Society for Microbiology, 1991:296–304.
27. Laumann EO, Gagnon JH, Michael RT, Michaels S. The Social Organization of Sexuality: Sexual Practices in the United States. Chicago: The University of Chicago Press, 1994.
28. Friedkin NE. A Structural Theory of Social Influence. New York: Cambridge University Press, 1998.
29. Sprecher S, McKinney K. Sexualities. Newbury Park, CA: Sage Publications, 1993.
30. Kinkaid DL. Social networks, ideation, and contraceptive behavior in Bangladesh: a longitudinal analysis. Soc Sci Med 2000; 50:215–231.
31. Burt R. Structural Holes: The Social Structure of Competition. Cambridge, Massachusetts: Harvard University Press, 1992.
32. Sandefur R, Laumann E. A paradigm for social capital. Rationality Soc 1998; 10:481–502.
33. Ferrand A, Marquet J, Van Campenhoudt L. Social networks and normative context. In: Hubert M, Bajos N, Sandfort T, eds. Sexual Behaviour and HIV/AIDS in Europe: Comparisons of National Surveys. London: UCL Press, 1998:303–327.
34. Krane M. A definition of dyadic boundaries and an empirical study of boundary establishment in courtship. Int J Sociol Fam 1977; 7:107–123.
35. Lewis R. Social reaction and the formation of dyads: an interactionist approach to mate selection. Sociometry 1973; 36:409–418.
36. Parks MR, Stan CM, Eggert LL. Romantic involvement and social network involvement. Soc Psychol Q 1983; 46:116–131.
37. Laumann EO. Bonds of pluralism: the form and substance of urban social networks. New York: Wiley Interscience, 1973.
38. Blieszner R, Adams RG. Adult Friendship. Newbury Park, CA: Sage Publications, 1992.
39. McCall GJ, McCall MM, Denzin NK, Suttles GD, Kurth SD. Social Relationships. Chicago: Aldine Publishing Company, 1970.
40. McCall GJ, Simmons JL. Identities and Interactions: An Examination of Human Associations in Everyday Life. New York: Free Press, 1978.
41. Huang G, Tausig M. Network range in personal networks. Soc Networks 1990; 12:261–8.
42. Kurth SB. Friendship and friendly relations. In: McCall GJ, eds. Social Relationships. Chicago: Aldine Publishing Company, 1970:136–170.
43. Moore G. Structural determinants of men's and women's personal networks. Am Sociol Rev 1990; 55:726–735.
44. Wellman B, Wong RY, Tindall D, Nazer N. A decade of network change: turnover, persistence and stability in personal communities. Soc Networks 1996; 19:27–50.
45. Baldwin MW, Fehr B. On the instability of attachment style ratings. Pers Relation 1995; 2:247–261.
46. Collins NL, Read SJ. Adult attachment, working models, and relationship quality in dating couples. J Pers Soc Psychol 1990; 58:644–663.
47. Feeney JA, Noller P, Hanrahan M. Attachment style and romantic love: relationship dissolution. J Soc Pers Relation 1994; 8:187–215.
48. Keelan JP, Dion KL, Dion KK. Attachment style and heterosexual relationships among young adults: a short-term panel study. J Soc Pers Relation 1994; 11:201–214.
49. Scharfe E, Bartholomew K. Reliability and stability of adult attachment patterns. Pers Relation 1994; 1:23–43.
50. Senchak M, Leonard KE. Attachment styles and marital adjustments among newlywed couples. J Soc Pers Relation 1992;9:51–64.
51. Shaver PR, Brennan KA. Attachment styles and the big five personality traits: their connections with each other and with romantic relationship outcomes. Pers Soc Psychol Bull 1992;18:536–545.