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Discord, Discordance, and Concurrency: Comparing Individual and Partnership-Level Analyses of New Partnerships of Young Adults at Risk of Sexually Transmitted Infections

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Background and Objectives: **Partnerships that are discordant by demographic and behavioral characteristics or are concurrent may facilitate transmission of sexually transmitted infections (STIs) by bridging sexual networks.**

Goal: **The goal of this study was to examine if STI risk within partnerships is associated with discordance and concurrency using the partnership as the unit of analysis.**

Study: **One hundred ninety-two individuals, in 96 new partnerships, recruited from sexually transmitted disease and family planning clinics, underwent a computer-assisted interview; were tested for chlamydia, gonorrhea, and trichomonas; and their medical records were reviewed. Partnership variables for discordance by ethnicity, education level, number of lifetime partners, and relationship commitment, as well as concurrency and consistent condom use were tested for associations with partnership STI by chi-squared analysis and logistic regression. Associations between individual level STI, individual characteristics, relationship commitment, and concurrency were tested in bivariate and multivariate models.**

Results: **STI was detected in 22% of partnerships; discordance for demographics or relationship commitment was reported in 40% to 50%; and partner concurrency in 26%. Few partnerships (18%) reported consistent condom use in the prior month. In multivariate analyses, partnership-level STI was associated with discordance by ethnicity (odds ratio [OR], 3.4; $P = 0.04$), commitment (OR, 4.2; $P = 0.02$), number of lifetime partners (OR, 4.9; $P = 0.01$), and concurrency (OR, 3.8; $P = 0.03$). Individual-level STI was associated with the individual's concurrency and Hispanic ethnicity.**

Conclusions: **Discordance and concurrency are associated with STI at the partnership level and may reflect bridging between high- and low-risk STI networks. Partnership factors allowed additional assessment of STI risk over individual factors, suggesting that data on partnerships may identify individuals linked to risky networks.**

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THE IMPORTANCE OF THE SEXUAL mixing patterns within populations in maintaining and spreading sexually transmitted infections (STIs) has been highlighted through modeling of transmission dynamics of STIs.[1] Assortative mixing (like with like) was theoretically shown in population models to promote the maintenance of STIs in a "core group" without facilitating spread to other groups.[2] Assortative sexual mixing implies concordance or similarity between sex partners by factors such as age, residence location, ethnicity, socioeconomic status, or the rate of sex partner acquisition (sexual activity level). In comparison, disassortative mixing (also referred to as "nonself-selecting") implies discordance or dissimilarity and has been shown empirically to allow spread of STIs from a "core group" to others within the population.[3,4]

Discordance between sexual partners (disassortative mixing) may represent a proxy measure of bridging between 2 sexual networks because sexual networks are largely composed of individuals concordant for geographic residence, age, ethnicity, and sexual activity level.[3,5] Such bridging may enhance the movement of STIs between sexual networks by exposing an individual from a low-risk network to a person more likely to have an STI because they are from a network composed of individuals with higher numbers of sexual partners. Discordant pairing of 2 people in a sexual partnership by ethnicity, age, and education was found in a Seattle sexually transmitted disease (STD) clinic to be associated with increased risk for chlamydial infection and gonorrhea,[6] and discordance for number of lifetime partners was found to be associated with reported STI history.[7] Adolescents in partnerships discordant for ethnicity, age, and school of attendance were more likely to report a history of STI[8] than those not in discordant partnerships. Additionally, among female but not male adolescents, a history of any STI was associated with partnership discordance by age and ethnicity.[9] Finally, discordance by age has been associated with HIV transmission among men who have sex with men (MSM) in San Francisco[10] and in some sub-Saharan African countries where young women often have older male partners.[11]

Concurrent partnerships, defined as sexual partnerships in which one or both of the members have other sexual partners while continuing sexual activity with the original partner,[12] may involve either assortative or disassortative mixing. When a person has concurrent partnerships with individuals from different sexual

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networks, that person becomes a particularly efficient bridge, potentially carrying STIs between groups. There are few data on the proportion of concurrent partnerships that involve bridging of networks or on the proportions of potential bridgers who have concurrent partnerships (as opposed to serial partnerships) with members of different sexual networks.[13]

Partnerships that involve discordance, as well as concurrent partners, have the potential to rapidly accelerate the spread of STIs/HIV in a population. Previous studies showing associations between discordance and STI were based on partner data from index reports, used self-reported STI history, or used historical data. To consider whether discordance and concurrency within partnerships represent risks for having STI, we collected behavioral and biologic data from both members of new partnerships to examine associations with STI. We considered discordance by ethnicity, number of lifetime partners, education level, and contemplation of partnership termination. Concurrency at the start of the partnership was also examined.

Methods

Between August 2000 and September 2001, 96 young heterosexual adults (aged 18–25 years) seeking care at STD and family planning (FP) clinics in San Diego County and their new sexual partners (aged 18–30 years) were recruited to participate in a 12-month longitudinal study of sexual partnerships. A new sexual partner was defined as someone with whom the index partner had had vaginal intercourse for the first time within the previous 3 months. For 43 partnerships, the index partner was male and for 53, the index partner was female; 51 partnerships were recruited from FP clinics and 45 from STD clinics. Participation rates of those who met eligibility criteria (new sexual partnership, aged 18–25 and heterosexual) were 80% to 90%; all of those who declined participation reported that their partner was not willing to participate with them.

Eligible participants attended their initial visit together as a couple and were interviewed using a 240-item audio-computer-assisted self-interview (ACASI) of 60 minutes' duration simultaneously in separate, private locations. Urine specimens collected from all participants at the initial visit were tested for *Chlamydia trachomatis* and *Neisseria gonorrhoeae* by ligase chain reaction (LCR; Abbott Diagnostics, Abbott Park, IL). Current *Trichomonas vaginalis* infection was determined using culture (InPouch; Biomed Diagnostics, San Jose, CA) of urine specimens from men and self-collected vaginal swabs from women. For 90 patients (including 45 participants recruited from the STD clinic, 11 of their partners, and 34 recruited from FP clinics who visited the STD clinic), medical records were reviewed for previous 3-month history of gonorrhea, chlamydial infection, trichomoniasis, nongonococcal urethritis (NGU), mucopurulent, cervicitis and pelvic inflammatory disease. Of those participants with STI-positive reports in their medical records, most (89%; n = 25) had been diagnosed within 1 week before or after the baseline interview. Of the 3 remaining STI-positive individuals, all were diagnosed 15 to 70 days before the baseline interview and after initiation of the partnership with the interview partner.

All participants were deemed mentally fit at the time of enrollment, received a study code to protect confidentiality, and received financial compensation for participation. The Institutional Review Boards of the University of California, Los Angeles, and San Diego State University reviewed and approved the protocol. All participants gave informed consent.

These analyses use data from the initial baseline visit. All partnership characteristic analyses (ie, discordance) were based on partnership level variables. Discordance variables were created by comparing partners' responses to the following: lifetime number of partners (grouped by 9 or fewer lifetime partners vs. 10 or greater, as previously examined by Laumann and Youm[5]), contemplation of partnership termination (ever vs. never contemplated termination of partnership), education level (less than high school, completed high school, or more than high school), and ethnicity (self-report of any of 7 different ethnic groups). Partnerships in which responses to these questions were the same were considered concordant; partnerships in which partners reported different responses to the same question were considered discordant. Additionally, partnerships were classified as 1) concurrent if 1 or both partners reported additional partners at the start of their partnership; 2) using condoms consistently if both partners reported consistent condom use within the past month; and 3) having an STI within the partnership if 1 or both members had an STI at baseline or within the prior 3 months.

In analyses examining STI risk in the 192 individuals by individual characteristics, chi-squared analysis, *t* tests, and logistic regression were used to determine the associations between STI within the past 3 months and age, education, ethnicity, consideration of partnership termination, number of lifetime partners, condom use, and concurrency. For all individual-level analyses, survey estimation techniques in STATA 7.0 SE, which were designed to correct for nonindependence of clusters in the regression model,[14] were used to control for the presence of both members of the partnership. At the partnership level, using the 96 partnerships as the unit of analysis, chi-squared analysis and multivariate logistic regression were used to determine associations between partnership STI and partnership discordance by ethnicity, educational level, number of lifetime partners, or consideration of partnership termination; partnership concurrency; and consistent condom use. Data were entered by participant response into Ci3 (Sawtooth Technologies, Northbrook, IL) and analyzed using STATA version 7.0 SE (STATA Corp., College Station, TX).

Results

Of the 192 participants, the mean age was 21.8 years (Table 1). The majority (60.9%) reported education beyond high school. Participants represented a wide range of ethnic groups, with less than half identifying themselves as white; and 75% reported at least part-time employment. Fifty-three percent of participants reported having 10 or more lifetime sexual partners and 62% reported ever contemplating partnership termination with their enrollment partner. Only 26% of participants reported consistent condom use in the past month with their enrollment partner; 14% reported having a concurrent partner at the start of this partnership.

STIs (chlamydial infection, gonorrhea, or trichomoniasis) were detected in 11.5% of individuals at baseline, and another 3.1% had a recent history of STIs (identified by review of the past 3 months of their medical records in the STD clinic), producing a total 14.6% of individuals with recent or current STI. Mean age of sexual debut, and mean number of sexual partners during the past month and past 12 months did not differ significantly for individuals with and without STI. Compared with those without an STI, significantly more participants with STIs reported concurrency at first sexual contact with their enrollment partner ($P = 0.02$) and reported Hispanic ethnicity ($P = 0.03$; Table 1). By logistic regression (data not shown in the table), the odds of having a current or recent STI was 3.1 for those who reported a concurrent partner at the start of their partnership as compared with those who did not ($P = 0.02$) and was 3.2 for those who reported Hispanic ethnicity compared with all others ($P = 0.04$). Age, education,

TABLE 1. Individual Background Characteristics by Current or Recent* Sexually Transmitted Infections (n = 192)

	STI-Positive (n = 28) No. (%)	No STI (n = 164) No. (%)	Total (n = 192) No. (%)
Age, mean (median)	20.8 (20.5)	21.5 (22.0)	21.4 (22.0)
Education, mean years (median)	12.1 (12.5)	13.2 (13.0)	13.1 (13.0)
Education (categorical)			
Less than high school	6 (21.4)	27 (16.5)	33 (17.2)
Completed high school	8 (28.6)	34 (20.7)	42 (21.9)
More than high school	14 (50.0)	103 (62.8)	117 (60.9)
Ethnicity			
African American/Black	2 (7.1)	14 (8.5)	25 (13.0)
Asian/ Pacific Islander	6 (21.4)	19 (11.6)	16 (8.3)
Caucasian/white-non-Hispanic	9 (32.1)	25 (15.2)	89 (46.4)
Hispanic/Latino	8 (28.6)	81 (49.4)	34 (17.7)
Other ethnicity	1 (3.6)	8 (4.9)	9 (4.7)
Mixed ethnicity	2 (7.1)	17 (10.4)	19 (9.9)
Hispanic Ethnicity vs. all others†	9 (32.1)	25 (15.2)	34 (17.7)
Current employment			
Full	14 (50.0)	66 (40.2)	80 (41.7)
Part	6 (21.4)	60 (36.6)	66 (34.4)
None	8 (28.6)	38 (23.2)	46 (23.9)
Contemplating partnership termination	19 (67.9)	100 (61.0)	119 (62.0)
Mean age sexual debut (median)	15.8 (16)	15.9 (16)	16 (15.9)
Mean no. of partners past month (median)	1.3 (1.0)	1.5 (1.0)	1.4 (1.0)
Mean no. of partners past year (median)	3.7 (3.0)	4.5 (3.0)	4.3 (3.0)
Mean no. of lifetime sex partners (median)	14.8 (9.5)	17.5 (10.0)	17.1 (10.0)
Reports 10 or more lifetime partners	14 (50.0)	87 (53.1)	101 (52.6)
Always condom use past month–new partner	8 (28.6)	40 (24.4)	48 (25.5)
Never condom use past month–new partner	8 (28.6)	48 (29.3)	56 (29.8)
Report concurrent partner at start of partnership†	8 (28.6)	19 (11.6)	27 (14.1)
Female	12 (42.6)	84 (51.2)	96 (50.0)

*Recent STI obtained from 3-mo review of STD clinic medical charts.
†*P* value <0.05.
STI = sexually transmitted infection.

number of lifetime partners, contemplation of partnership termination, and condom use were not associated with STIs at the individual level by logistic regression.

Of the 96 partnerships, 22% had a least 1 member who had had a current or recent STI (Fig. 1); in one third of those partnerships, *both* members had a current or recent STI. In 82% of partnerships, at least 1 member reported inconsistent condom use in the past month. In 26% of partnerships, 1 or both partners reported having concurrent sex partners at the start of the partnership with the enrollment partner; both partners reported having a concurrent partner in 13% of partnerships. There were high levels of discordance within partnerships: 43% were discordant by number of lifetime partners, 41% by contemplation of partnership termination, 50% by educational level, and 49% by ethnicity (Fig. 1).

By chi-squared analysis (Table 2), current or recent STI in the partnership was significantly associated with discordance by contemplation of partnership termination (33% vs. 14% concordant, $P = 0.02$) and lifetime number of partners (35% vs. 13% of concordant partnerships, $P = 0.01$). When discordance by lifetime number of partners was broken down into 1) discordant, 2) concordant for 9 or fewer partners, and 3) concordant by 10 or greater partners, those most likely to have an STI either individually or within their partnership were in discordant partnerships (8% of partnerships concordant for 9 or fewer partners, 9% concordant for 10 or greater partners, and 22% of those discordant had STI; $P = 0.03$). Additionally, a greater percentage of partnerships that were discordant by ethnicity had an STI than those that were concordant (30% vs. 14%), which was nearly statistically significant ($P =$

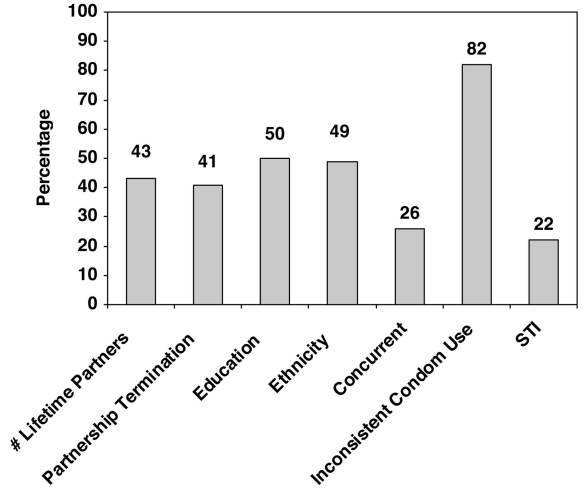

Fig. 1. Percentage of partnerships discordant, concurrent at the start of the partnership, using condoms consistently, and with sexually transmitted infection in the partnerships (n = 96). (**A**) Discordant by number of lifetime partners = 9 or fewer partners versus 10 or greater. (**B**) Discordant by partnership termination = ever versus never considered separation or termination of partnership. (**C**) Discordant by education = less than high school versus high school versus more than high school. (**D**) Discordant by ethnicity = self-report of any of the 7 different ethnic groups.

TABLE 2. Univariate Analysis: Associations Between Partnership Current or Recent STI and Discordance, Concurrency, and Condom Use (n = 96)

No (% STI-Positive)	Concordant (% STI-Positive)	Discordant (% STI-Positive)	*P* Value	Odds Ratio (95% CI)
Ethnicity	14.3	30.0	0.066	2.55 (0.9–7.0)
Education	20.8	22.9	0.805	1.13 (0.4–2.0)
Contemplating partnership termination	14.0	33.3	0.022*	3.06 (1.1–8.3)
No. of lifetime partners	13.2	35.0	0.013*	3.17 (1.2–8.8)
	No (% STI-Positive)	Yes (% STI-Positive)		
Concurrency	16.9	36.0	0.047*	2.8 (1.0–7.7)
Condom use				
100% time past month	20.0	26.9	0.466	1.64 (0.5–5.3)

*$P < 0.05$.
STI = sexually transmitted infection; CI = confidence interval.

0.07). Significantly more partnerships with concurrency at the start of their partnership had a recent or current STI (36% with concurrency vs. 17% without concurrency, $P = 0.05$). Discordance by education level and reported condom use within the partnership were not associated with current STI (Table 2).

Multivariate logistic regression models gave results similar to the univariate analyses (Table 3). Current or recent STI within the partnership was significantly associated with ethnic discordance (odds ratio [OR], 3.4; $P = 0.04$), discordance by contemplation of partnership termination (OR, 4.2; $P = 0.02$), discordance by lifetime number of partners (OR, 4.9; $P = 0.01$), and partnership concurrency (1 or both members with concurrent partners at start of the partnership; OR, 3.8; $P = 0.03$). Educational discordance and partnership condom use were not significantly associated with an STI in the partnership at either the univariate or multivariate levels. It is important to note, however, that when each of the identified partnership risk factors was stratified by condom use, the size of the effect of the risk was greater among partnerships with inconsistent condom use.

Discussion

For young heterosexuals with new sexual partners, characteristics of their partnerships may provide representations of STI risk beyond individual characteristics by identifying whether their partners inhabit different sexual networks. Analyses of individual STI by individual characteristics in this study only revealed that reporting a concurrent partner at the start of the partnership or Hispanic ethnicity were associated with STI. However, when the partnership served as the unit of analysis, those more likely to have a recent or current STI were discordant by ethnicity, number of lifetime partners, and contemplation of partnership termination. Moreover, if one or both members of the partnership reported a concurrent partner at the time of first sexual contact with their enrollment partner, the partnership was 3.8 times more likely to have a recent or current STI. These findings suggest that young adults with bridging behaviors, whether temporal (ie, concurrency) or social (by discordance), are more likely to acquire and transmit STIs. Therefore, there is a potential to enhance the STI risk assessments conducted in STD and FP clinics by capturing the risk embedded in patients' partnerships.

Our results are consistent with previous studies of partnership discordance and STI that suggest that discordance may be associated with STI acquisition because it is a marker for bridging between high and low STI prevalence groups.[3–7,15] Discordance by number of lifetime partners represents a connection between high and low STI prevalence populations. Partnerships discordant by number of lifetime partners were more likely to have an STI than partnerships that were concordant, regardless of sexual activity class (8% had STIs among those concordant for fewer than 10 lifetime partners, 9% had STIs among those concordant for 10 or more partners vs. 22% with STIs among those discordant by lifetime partners). For these young adults, being with a partner from a network with a different level of partner change represents a greater risk for STIs than having a partner from a network with the same level of partner change as oneself, reiterating that a patient's STI risk may not only be a result of their behavior, but their partner's behavior as well.[16,17]

Discordance by ethnic group is another proxy for bridging between higher and lower STI prevalence populations and was associated with current STI in this study and others.[3,4,7,15] Our data on ethnic discordance may also support the concept of STI persistence within groups in which most partners are ethnically concordant[3,7] and may demonstrate the importance of STI bridging between groups discordant by ethnicity in spreading infection across a population. We found that partnerships that were discordant by ethnicity and had a recent or current STI were most often composed of white and black or white and Hispanic individuals, whereas those which were concordant by ethnicity and had an STI were most often Hispanic. In Colorado Springs, discordant partnerships between white and black individuals was a marker of bridging from the core group to geographically adjacent and peripheral populations.[3,4] In our data, we could be observing a similar trend in which our Hispanic participants were a subset for a high STI prevalence group and the white and black participants with discordant partners were the bridgers. For these young adults in San Diego, it appears that assortative mixing by Hispanic participants was a risk for STI, whereas disassortative mixing increased

TABLE 3. Logistic Regression Analysis: Associations Between Partnerships With STI and Partnership Discordance, Concurrency, and Condom Use (n = 96)

	Odds Ratio	95% CI	*P* Value
Discordant by ethnicity	3.42	1.1–11.2	0.043*
Discordant by education	0.85	0.3–2.7	0.776
Discordant by partnership termination	4.23	1.3–13.6	0.015*
Discordant by lifetime partners	4.89	1.5–16.5	0.010*
Concurrency in partnership	3.77	1.2–12.2	0.026*
Condom use 100% time past month	2.47	0.6–9.7	0.185

*$P < 0.05$.
STI = sexually transmitted infection; CI = confidence interval.

the risk of STI for white and black participants. Additionally, ethnic discordance has previously been shown to be associated with decreased condom use among adolescent partnerships,[15] which may contribute to increased risk of STI. Although condom use was not associated with STI or ethnic discordance in our study, when stratified by condom use, the association between STI and ethnic discordance was significant only among those partnerships with inconsistent condom use (29.4% had STIs that were discordant by ethnicity compared with 11.1% who were concordant; $P = 0.05$).

Discordance by contemplation of partnership termination may have more to do with partnership dynamics or partnership "discord" than bridging between high and low STI prevalence populations. Partnerships concordant by a commitment to remain together or in which both are contemplating separation are 2 different types of partnerships, the first representing committed partnerships and the second more casual partnerships. Partnerships discordant on contemplating relationship termination are those in which each partner sees the partnership differently, one regarding it as casual or ending while the other believes it is committed. Condom use was not significantly associated with STI or with discordance by partnership termination, and it was not lower among partners concordant by commitment; however, very few partnerships reported consistent condom use so there may have been too little power to detect an effect. Additionally, concurrency was not associated with discordance by contemplating partnership termination; however, concurrency may not necessarily reflect a lack of relationship commitment. Our previous work has shown that individuals may practice concurrency to meet needs 1 partner may not be able to fulfill, although they remain committed to and involved sexually with this partner.[18] Therefore, the association between partnership termination, or discord in these partnerships and STI risk may be the result of risk factors that lie beneath this discord, which may not have been directly measured in the study.

Partnership-level concurrency, as well as individual-level concurrency, was independently associated with STI in this study. This is consistent with previous studies of concurrency and STI.[12,19–21] Moreover, within our sample, concurrency and discordance coexisted and were not mutually exclusive. This combination of concurrency and bridging may enhance the spread of STI at the network level. Bridging alone can bring STI from higher STI prevalence populations to lower STI prevalence populations; and concurrency alone links individuals into clusters of sexual connections at one point in time,[22] increasing the probability of STI spread to many members of the network within a short period of time. Both scenarios increase the spread of STI in different ways. Thus, if 2 populations (or networks) were bridged by individuals who have concurrent partners, the increase in STI would be at least additive, if not multiplicative, in nature. However, STI transmission will only be observed if concurrency or bridging occurs within or across networks in which STI already exists. Regardless, measuring concurrency among both members of a partnership may allow for a more complete understanding of the interaction between concurrency and bridging, as well as an individual's risk as a result of their partner's behavior.[17]

This study is limited in its ability to fully explore associations between STI and age or educational discordance as a result of the study design. First, those in the most age-discordant partnerships (with more than 10 years apart) were excluded. Second, the ability to examine educational differences was limited because many of our participants in their late teens and early 20s may not yet have completed their educational careers, again limiting the ability to fully examine the effect of this type of discordance. There may also be limitations in detecting small, significant differences as a result of sample size. For example, condom use was not associated directly with STI; however, it was a powerful stratifying variable that enhanced associations between STI and discordance.

These findings, as well as data from other studies examining both members of sexual partnerships, may provide valuable insight for mathematical models that examine the role of sexual mixing patterns and concurrency in the invasion, persistence, and elimination of STIs. Although models that have examined either bridging[3,4,6,7,9,10,23,24] or concurrency[13,25–30] have greatly advanced the understanding of STI transmission, the information they provide may not be complete. This study indicates that concurrency (temporal mixing) and bridging (social mixing) are not independent of one another. However, concurrency and discordance by number of lifetime partners, ethnicity, and consideration of partnership termination were each independently associated with an increased risk of STI in our sample. Therefore, models that can account for the overlap in temporal (concurrency) and social (bridging) mixing patterns are likely to provide a more realistic impression of transmission dynamics. More data on how individuals choose partners and decide on concurrent partners may be needed before models can be constructed that better account for the coexistence of discordance and concurrency. Individuals with discordant and concurrent partners (bridges) represent extremely efficient routes for STI/HIV epidemics to spread across a population by carrying disease across distinct sexual networks; therefore, it is important that clinicians and counselors in STD and FP clinics are able to incorporate partnership level assessments to help identify them and focus special attention on future prevention of STIs on these individuals.

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