Published in final edited form as:
J Acquir Immune Defic Syndr. 2009 September 1; 52(1): 114–120. doi:10.1097/QAI.0b013e3181ab5e10.

Sexual Mixing Patterns and Heterosexual HIV transmission among African Americans in the Southeastern United States

Irene A Doherty, PhD[1], **Victor J Schoenbach, PhD**[2], and **Adaora A Adimora, MD MPH**[1,2]

[1]School of Medicine, University of North Carolina at Chapel Hill

[2]School of Public Health, University of North Carolina at Chapel Hill

Abstract

Objectives—Heterosexually transmitted HIV infection rates are disproportionately high among African Americans. HIV transmission is influenced by sexual network characteristics, including sexual partnership mixing patterns among sub-populations with different prevalences of infection.

Study Design—We conducted a cross-sectional analysis of previously collected data from a North Carolina population-based case-control study. Respondents were heterosexual black men and women who either: 1) had recently reported heterosexually transmitted HIV infection ("cases") or 2) were randomly selected from the general population ("controls").

Methods—Respondents reported their own and their three most recent sex partners' education and involvement in illicit drug use, concurrent sex partners, and incarceration. We examined sexual mixing patterns by comparing the characteristics and behaviors respondents reported for themselves with those they reported for their partners. We estimated Newman's assortativity coefficient (−1.0 to 1.0) as an aggregate, quantitative assessment of mixing patterns.

Results—Across the four strata (male and female cases, male and female controls), mixing was assortative (0.31–0.45) with respect to illicit drug use and minimally assortative with respect to having concurrent partners (0.14–0.22). Mixing patterns for incarceration were assortative for men (0.18 and 0.41) but not women (0.07 and 0.08). Mixing with respect to education was assortative primarily for male controls (0.33).

Conclusion—These sexual partnership patterns, driven in part by the social and economic context of life for African Americans, likely contribute to the heterosexually transmitted HIV epidemic.

Keywords

Heterosexual; HIV; assortative; mixing patterns; sexual network; African Americans

INTRODUCTION

Since the mid-1990s young African-American women in rural areas of the southeastern United States experienced the highest increase in HIV/AIDS incidence.[1–5] Although African Americans comprised only 12% of the US population in the 2000 US Census, during 2001–2005 they accounted for 51% of HIV/AIDS diagnoses, 44% among men, and 67% among

Corresponding author: Irene A Doherty, PhD, Research Assistant Professor, Division of Infectious Diseases, School of Medicine, University of North Carolina, Chapel Hill, 130 Mason Farm Rd Suite 2118 CB 7030, Chapel Hill, NC 27599-7030, doherty@med.unc.edu, phone: 1-919-843-3659, fax: 1-919-966-6794.

Meeting where preliminary results were presented:
International Society for STD Research, Amsterdam, The Netherlands, July 2005

women; 70% of African American women acquired the their infection through heterosexual contact.-acquired HIV infections.[1, 5, 6] Sexual networks and partnership patterns are critical determinants of these racial/ethnic disparities in HIV infection rates.[7–12]

Sexual mixing patterns are especially important in the transmission of HIV and other sexually transmitted infections (STIs). Assortative mixing refers to sexual partnerships among people with similar risk for STIs. Disassortative mixing occurs when partnerships form between higher and lower risk people.[12, 13] Partnerships between individuals who do not use illicit drugs and those who inject illicit drugs is an example of disassortative mixing associated with HIV infection.[14–17]

In this paper, we use a quantitative assessment of network mixing patterns to investigate the contribution of assortative and disassortative mixing to the marked disparities in heterosexual transmission of HIV infection among African Americans in the southeastern US.

METHODS

We conducted a cross-sectional descriptive analysis of mixing patterns among participants studied in the Rural Health Project, a case-control study that characterized heterosexually transmitted HIV infection among African Americans in North Carolina.[14, 18, 19] For brevity, we refer to the HIV-infected respondents as “cases” and uninfected respondents as “controls,” although the mixing analysis does not involve a case-control comparison.

Eligibility and ascertainment of cases and controls

North Carolina mandates name-based confidential reporting of all new diagnoses of HIV infection or AIDS to the North Carolina HIV/STD Prevention and Care Branch. Reported cases were eligible for the study if they were African American, aged 18–59, diagnosed within the previous six months, and denied past history of injection drug use and male homosexual activity. The catchment area for case ascertainment originally comprised 13 contiguous counties but subsequently expanded to include almost all of central and eastern North Carolina. When Disease Intervention Specialists (DIS) counseled eligible cases shortly after they received their HIV test results, the DIS discussed the study and obtained written permission from consenting cases to release their names to study staff for recruitment. Data collection took place between 1997 and early 2000.

The 1996 roster of drivers’ licenses and state identification cards of residents from the original 13 counties served as the sampling frame for controls.[20] African-American adults were randomly selected from these records within strata defined by the distribution of gender and 5-year age groups among cases and sent a letter inviting them to participate. Because injection drug users and men who had sex with other men were ineligible to be cases, we excluded controls from all analyses if they reported either of these behaviors. After data entry, all personal identifiers were removed from the blood specimens and questionnaire data, and controls’ blood specimens were tested for HIV infection. None of the controls were HIV-infected.

Female African-American nurse-interviewers visited participants at their homes to administer face-to-face questionnaires and to collect blood samples for syphilis serology. Participants received a $50 cash incentive. The institutional review board in the School of Medicine at the University of North Carolina at Chapel Hill approved all procedures.

Measures

The questionnaire assessed factors historically associated with HIV infection related to sexual behavior, illicit drug use, exchange of sex for money, incarceration history, and markers of

lower socioeconomic status. Respondents reported their own risk factors and those of their three most recent sex partners. We compared respondents' reports about themselves with those about their sex partners. Variables were chosen for analysis based on conceptual models and prior research; Table 1 outlines specific definitions of risk characteristics based on variables from the questionnaire.

Illicit drug use—Crack, cocaine, heroin, and injection drug use are traditional risk factors for HIV acquisition. Having sex partners who used crack or injection drugs was associated with HIV infection in our study and in another case-control study conducted in the rural southeastern US.[14, 15]

Concurrent sex partners—Sexual networks in which partnerships overlap in time permit more efficient transmission of STIs than do sexual networks characterized by sequential monogamy.[21] Among HIV-infected persons who denied high risk behaviors themselves, having non-monogamous sex partners was associated with HIV infection.[14]

Incarceration—Disproportionate incarceration rates among African-American men contribute to an imbalance in the ratio of black men to black women and thereby promote concurrent partnerships.[8, 22] Previous analyses revealed that incarceration history of sex partners is associated with concurrent partnerships.[18, 19]

Low education—Low education is a marker of poverty linked with poor health outcomes, including HIV infection and other STIs. [23]

As has been done elsewhere [24], we used the risk behaviors of *at least one* of the three partners as a marker of being in a high-risk sexual network. If the respondent reported, for example, that *at least one* partner had been incarcerated, we classified the respondent as mixing sexually with respect to incarceration. Respondents were classified as *not* mixing with respect to incarceration only if they reported that *all three partners* had never been incarcerated.

Data were missing for some of the partners' characteristics/risk attributes. For respondents who had missing data for one of their partners and reported that their *other partners did not have the characteristic*, we coded them as *not* mixing with respect to the attribute. As such, these respondents may have been misclassified, if in fact the partner with the missing data had the characteristic. Fifteen percent, 11%, 16% and 8% of respondents were missing data about one or two of their sex partners' education, illicit drug use, incarceration history, and concurrency, respectively.

Analysis

The extent that a population exhibits assortative, neutral, or disassortative sexual mixing patterns with respect to a given classification can be quantified.[25–28] We used Newman's *assortativity coefficient* to describe the mixing patterns in our sample.[27, 29] The assortativity coefficient is calculated from the mixing matrix – the proportional cross–tabulation of partnerships between people who do and do not have the risk attribute. The formula for the assortativity coefficient is:

$$r=(\mathrm{Tr}\,\mathbf{e}-\|\mathbf{e}^2\|)/(1-\|\mathbf{e}^2\|)$$

where r is the assortativity coefficient, $\mathbf{e}$ is the matrix whose elements are the cell values, e_{ij}, of the mixing matrix; Tr $\mathbf{e}$ is the trace of the matrix; and $\|*\mathbf{e}^2\|$ is the sum of the squared values of the elements in the matrix.

Coefficients above zero represent assortative mixing; the maximum value of 1.0 indicates that all partnerships are concordant for the characteristic. An assortativity coefficient of zero indicates the characteristic has no influence on partnering (random mixing). Disassortative mixing produces coefficients between −1.0 and 0; the value −1.0 indicates completely disassortative mixing where no one in the population is partnered with someone who shares the same characteristic. Coefficient values close to zero can be interpreted as disassortative mixing because random mixing will most often result in pairs that differ with respect to the characteristic.[27] Newman used racial/ethnic data from the AIDS Multi-Ethic Neighborhood study to illustrate this phenomenon.[27, 30]

We computed assortativity coefficients[27] for cross-classifications of presence or absence of risk characteristics for the respondent and *at least one* of the respondent's three most recent partners. Separate coefficients were calculated for male cases, female cases, male controls, and female controls.

Before Newman's coefficient was derived, studies assessed sexual mixing patterns with a less robust assessment, referred to as the Q-statistic.[26] The primary shortcoming of the Q-statistic is that the estimate can change considerably if the rows and columns of the mixing matrix are reversed.[27] In addition, the lower bound of the Q-statistic depends on the number of categories in the mixing matrix, rendering it difficult to compare mixing patterns across studies. For example in a 3-by-3 matrix, the lower bound is −0.5, whereas in a 9-by-9 matrix, the lower bound is −0.16 (e.g., [31]). In our data, Q-statistics for 2-by-2 matrices were roughly comparable to Newman's assortativity coefficients, thereby permitting approximate comparisons of our results to earlier studies.

A previous analysis of mixing with respect to number of sex partners for the general US population yielded a Q-statistic of approximately 0.35.[28] A study of couples attending an STD clinic in Seattle, Washington revealed highly assortative (Q=0.44) mixing by age, but less assortative mixing with respect to education (Q=0.23) and number of sex partners (Q=0.16).[13] On the basis of these studies, we have broadly categorized mixing coefficient values ≥ 0.35 as assortative, 0.26–0.34 as moderately assortative, 0.15–0.25 as minimally assortative, and <0.15 as discordant. (Mixing coefficients below 0 are exceptional in human social networks.[32])

RESULTS

DIS interviewed 482 apparently eligible African American HIV cases, 243 (50%) of whom released contact information to the study. Of these, 17 ultimately proved ineligible, 17 others were ineligible or unavailable and 3 subsequently declined participation. Distributions of age, gender, screening risk characteristics, and method of case detection were generally similar among consenting cases and those who did not participate. Consent rates were similar for women (49%) and men (44%) and declined slightly with age (53% for cases < 25 years, 47% for cases ≥ 40 years). Consenting cases were slightly more likely to report sex with an injection drug user (9% versus 4%). However, those who consented and those who refused were equally likely to report exchange of sex for drugs or money (18% vs 15%), or sex with a person with AIDS or HIV (33% vs 35%). History of sexual contact with a bisexual man was the same (4%) among women who participated and those who did not.

Women who participated were slightly more likely to have been diagnosed through prenatal screening (9%) than those who did not (6%), but consenting and non-consenting cases otherwise had similar modes of case detection including being named as contacts and tested by a public STD clinic or institutional screening.

A total of 1,063 potential controls were sampled from the driver's license file. Of these, 697 (67%) could not be located, largely because of outdated or incorrect addresses. An additional 22 potential controls were unavailable and 17 were ineligible. Of the 327 potential controls who were located and eligible, 226 (69%) were interviewed. All controls tested negative for HIV.

The sample comprised 156 men (78 cases, 78 controls) and 276 women (128 cases, 148 controls). Cases were more likely than controls to be poor. The annual household income was <$16,000 for 67% of cases and 30% of controls; 26% of cases and 14% of controls said that at some time in the previous 30 days they had been concerned about having enough food. Greater proportions of cases reported HIV risk behaviors than did controls such as exchanging sex (31% vs. 7%), crack cocaine use (31% vs. 5%), and binge alcohol consumption (26% vs. 12%).

Distribution of mixing characteristics

Assortativity coefficients were computed from the distributions of sexual partnerships with respect to the variables in Table 1. Correct interpretation of these coefficients requires knowing the underlying prevalence of each characteristic within each group (Table 2); the percents represent the distribution of respondents with the risk factor, cross-classified by whether or not at least one of the respondent's sex partners had the risk factor.

As expected, larger proportions of HIV-infected men and HIV-infected women reported risk factors historically associated with infection than did controls (Table 2).[14, 18, 19] The five-year prevalence of concurrent partnerships was high in all strata (31%–53%). The prevalence of past incarceration was also high; 64% of HIV-infected men, 26% of uninfected men, 25% of HIV-infected women, and 5% of uninfected women had been incarcerated for at least 24 hours. Moreover, 53% of uninfected women and 81% of HIV-infected women reported having had a sex partner who had been incarcerated.

Table 3 presents the distributions of risk characteristics among controls, stratified by their sex partners' risk characteristics. Comparable proportions of uninfected men and women did not use illicit drugs, but had at least one partner who smoked crack or injected drugs (11% men, 14% women, Fisher exact p-value=0.83). Among the 69% of female controls who did not have concurrent partnerships (Table 2), 56% had at least one partner they strongly believed was not monogamous; 35% of male controls who were not in concurrent partnerships had a non-monogamous partner (Table 3). Although only 5% of female controls had ever been incarcerated (Table 2), more than half (51%) had at least one partner who had been incarcerated. In contrast, only 5% of male controls, who had never been incarcerated themselves, had a partner who had previously been incarcerated. Almost all (87%) of both male and female controls completed high school (Table 2); among these respondents, 41% of women - compared to 20% of men - had a partner with less than a high school education.

Mixing assessments

Figure 1 displays point estimates of assortativity coefficients and 95% confidence intervals for each variable assessed, stratified by gender and HIV infection status.

Illicit drug use—Mixing was generally assortative with respect to illicit drug use (Figure 1a), with coefficients ranging from 0.31–0.45. Women controls (whose prevalence of illicit drug use was low) mixed slightly more discordantly than did cases.

Concurrent sex partners—Coefficients with respect to concurrency (Figure 1b) were minimally assortative across all strata (0.20 male cases, 0.14 female cases; 0.16 male controls,

0.22 female controls). Although these values appear comparable, the underlying partnership patterns differed across strata. For uninfected women, the coefficient primarily represents discordant partnerships for the 69% of women who did not have overlapping partnerships (Table 2): more than half (56%) had partners who were not monogamous (Table 3). Had the mixing pattern been assortative, the prevalence of having non-monogamous partners would have been lower than 56% for these uninfected, monogamous women.

Incarceration—The low coefficients for incarceration (Figure 1c) for both HIV-infected women (0.07) and uninfected women (0.08) indicate discordant mixing, a consequence of the much higher prevalence of incarceration among men than among women. The coefficient for uninfected men was significantly more assortative (0.41), perhaps because few women in the general population have been incarcerated.

Low Education—Eighty-seven percent of male and female controls completed high school. Male controls mixed assortatively with respect to education (0.33), but mixing among both female controls and female cases was minimally assortative (0.20 and 0.23, respectively). HIV-infected men had lower educational attainment (44% had less than high school education, Table 2) than uninfected men and women, but the mixing coefficient for HIV-infected men was nearly zero (0.07), indicating discordant mixing with high school graduates.

DISCUSSION

This study is one of the first published analyses of sexual mixing patterns among African Americans. We analyzed data from a study of heterosexual HIV transmission among HIV-infected and uninfected African Americans in the southeastern United States. We evaluated sexual mixing patterns by examining respondents' reports of their own behavior and the behavior of their three most recent sex partners with respect to illicit drug use, participation in concurrent partnerships, history of incarceration, and educational attainment. A quantitative measure assessed the extent of assortative sexual mixing patterns. Across all strata, mixing was assortative for illicit drug use and minimally assortative with respect to concurrency. Mixing patterns for incarceration and low education revealed significant gender differences for uninfected respondents; low risk uninfected males tended to have low risk partners, whereas many low risk uninfected females had higher risk partners. For example, among the uninfected respondents, only 20% of male versus 41% of female high school graduates had a recent partner who had not finished high school.

Our findings are consistent with the few published data concerning the extent of disassortative sexual mixing in non-clinic populations. Laumann and Youm's analysis of The National Health and Social Life Survey [33], a national probability sample of the general population, examined mixing by race/ethnicity and by sexual activity classes and revealed much more disassortative sexual mixing among African Americans than among whites.[12] Compared to whites, African Americans who reported only one sex partner in the past year (and were therefore at relatively low risk of STI) were five times as likely as whites to have a sex partner who had had at least four partners in that time frame (and were therefore at substantially higher risk of STI).

Although heterosexual partnerships tend to be assortative, the tendency toward assortative mixing can be impeded by imbalances in the availability of partners of the opposite sex. The sex ratio (the ratio of men to women) is notoriously low among African Americans because of increased male mortality due to disease and violence [34] and disproportionate incarceration of black men.[35, 36]

Consistent with national trends, the prevalence of incarceration history in this sample is high (26% in male controls, 5% in female controls) and is especially high among cases (64% in

males, 25% in females). Uninfected males mixed most assortatively with respect to incarceration history; female cases and controls mixed much more discordantly.

Concurrent sexual partnerships were relatively common among controls – and even more so among cases. People (particularly uninfected women) who remained monogamous often had partners who participated in concurrent partnerships. Given the association between concurrent partnerships and STIs, discordant mixing extends this risk to monogamous people as well.

Our mathematical microsimulation[37] explains how these partnership dynamics operate at the population-level: 1) Concurrent partnerships expedite dissemination of viral STIs by decreasing the time between sexual contacts between infected and susceptible people; and 2) discordant mixing facilitates transmission between subgroups with different risks or disease prevalence. Discordant mixing in combination with high concurrency levels work synergistically to spread disease faster throughout the entire population.

There are potential limitations of this study. Non-response among cases and controls could have resulted in selection bias. However, the distributions of gender, age, some important risk characteristics, and mode of case detection were similar among cases who consented to be in the study and those who did not. Similarly, the median income of controls was similar to that of blacks in eastern North Carolina, and prevalence of crack cocaine use among them (5%) was similar to the rate among blacks in the general US population (5.7%). We necessarily relied on participants' reports of their own and their partners' risk behaviors; partners were not interviewed directly, and respondents may have been unaware of partners' risk behaviors. The study was designed to identify people newly diagnosed with HIV as opposed to HIV-infected people who were diagnosed more than six months ago, a design feature which resulted in a relatively small sample size. The small sample size decreased the precision of the estimates of assortativity coefficients.

Our findings illuminate key sexual partnership patterns that contribute to the expanding epidemic of heterosexually-acquired HIV infection among African Americans and black women in particular. This analysis revealed sexual networks with relatively discordant sexual mixing, especially among the general population of black women who had otherwise low risk behavior. The low sex ratio of black men to black women likely contributes to these adverse mixing patterns. HIV prevention strategies in the US should extend beyond individual-level interventions to include policies concerning income support, education, and sentencing inequity and other criminal justice issues to foster long-term monogamous sexual relationships, which are the bulwark against transmission of HIV.

Acknowledgments

Funding sources:

The Rural Health Project was supported by National Institutes of Health (NIH) grant 1R01 AI 39176-01 and 1K02 AI01867-01 (to A.A.A.). Analysis and manuscript preparation was funded through NIH training grant 5 T32 AI007151-28 (to I.A.D.).

REFERENCES

1. CDC. Diagnoses of HIV/AIDS -- 32 States, 2000–2003. MMWR 2004;53(47):1106–1110. [PubMed: 15573027]
2. Fleming PL, Lansky A, Lee LM, Nakashima AK. The epidemiology of HIV/AIDS in women in the southern United States. Sex Transm Dis 2006 Jul;33(7 Suppl):S32–S38. [PubMed: 16794553]
3. Hader S, Smith D, Moore J, Holmberg S. HIV infection in women in the United States status at the millennium. Jama 2001;285(9):1186–1192. [PubMed: 11231749]

4. Peterman TA, Lindsey CA, Selik RM. This place is killing me: a comparison of counties where the incidence rates of AIDS increased the most and the least. J Infect Dis 2005 Feb 1;191:S123–S126. [PubMed: 15627222]
5. CDC. Update to Racial/Ethnic Disparities in Diagnoses of HIV/AIDS—33 States, 2001–2005. MMWR Recomm Rep 2007 Mar 9;56(09):189–193.
6. Census 2000 Summary File 3. US Census Bureau: 2000.
7. Adimora AA, Schoenbach VJ. Contextual factors and the black-white disparity in heterosexual HIV transmission. Epidemiology 2002 Nov;13(6):707–712. [PubMed: 12410013]
8. Adimora AA, Schoenbach VJ. Social context, sexual networks, and racial disparities in rates of sexually transmitted infections. J Infect Dis 2005 Feb 1;191:S115–S122. [PubMed: 15627221]
9. Aral SO. Sexual network patterns as determinants of STD rates: paradigm shift in the behavioral epidemiology of STDs made visible. Sex Transm Dis 1999 May;26(5):262–264. [PubMed: 10333278]
10. Aral SO. Understanding racial-ethnic and societal differentials in STI. Sex Transm Infect 2002 Feb; 78(1):2–4. [PubMed: 11872846]
11. Doherty IA, Padian NS, Marlow C, Aral SO. Determinants and consequences of sexual networks as they affect the spread of sexually transmitted infections. J Infect Dis 2005 Feb 1;191:S42–S54. [PubMed: 15627230]
12. Laumann EO, Youm Y. Racial/ethnic group differences in the prevalence of sexually transmitted diseases in the United States: a network explanation. Sex Transm Dis 1999;26(5):250–261. [PubMed: 10333277]
13. Aral SO, Hughes JP, Stoner B, et al. Sexual mixing patterns in the spread of gonococcal and chlamydial infections. Am J Public Health 1999 Jun;89(6):825–833. [PubMed: 10358670]
14. Adimora AA, Schoenbach VJ, Martinson FE, et al. Heterosexually transmitted HIV infection among African Americans in North Carolina. J Acquir Immune Defic Syndr 2006 Apr 15;41(5):616–623. [PubMed: 16652036]
15. Ellerbrock TV, Chamblee S, Bush TJ, et al. Human immunodeficiency virus infection in a rural community in the United States. Am J Epidemiol 2004 Sep 15;160(6):582–588. [PubMed: 15353419]
16. Kerr T, Stoltz JA, Strathdee S, et al. The impact of sex partners' HIV status on HIV seroconversion in a prospective cohort of injection drug users. J Acquir Immune Defic Syndr 2006 Jan 1;41(1):119–123. [PubMed: 16340484]
17. Panda S, Kumar MS, Lokabiraman S, et al. Risk factors for HIV infection in injection drug users and evidence for onward transmission of HIV to their sexual partners in Chennai, India. J Acquir Immune Defic Syndr 2005 May 1;39(1):9–15. [PubMed: 15851908]
18. Adimora AA, Schoenbach VJ, Martinson F, Donaldson KH, Stancil TR, Fullilove RE. Concurrent sexual partnerships among African Americans in the rural south. Ann Epidemiol 2004 Mar;14(3): 155–160. [PubMed: 15036217]
19. Adimora AA, Schoenbach VJ, Martinson FE, Donaldson KH, Stancil TR, Fullilove RE. Concurrent partnerships among rural African Americans with recently reported heterosexually transmitted HIV infection. J Acquir Immune Defic Syndr 2003 Dec 1;34(4):423–429. [PubMed: 14615661]
20. Adimora AA, Schoenbach VJ, Martinson FE, Stancil TR, Donaldson KH. Driver's license and voter registration lists as population-based sampling frames for rural African Americans. Ann Epidemiol 2001 Aug;11(6):385–388. [PubMed: 11454497]
21. Morris M, Kretzschmar M. Concurrent partnerships and the spread of HIV. AIDS 1997;11:641–648. [PubMed: 9108946]
22. Adimora A, Schoenbach V, Doherty I. Sexual network components, social context, and HIV among African Americans in the southern United States. Sex Transm Dis 2006;33(7):S39–S45. [PubMed: 16794554]
23. Poundstone KE, Strathdee SA, Celentano DD. The social epidemiology of human immunodeficiency virus/acquired immunodeficiency syndrome. Epidemiol Rev 2004;26:22–35. [PubMed: 15234945]
24. Kottiri BJ, Friedman SR, Neaigus A, Curtis R, DesJarlais DC. Risk Networks and Racial/Ethnic Differences in the Prevalence of HIV Infection Among Injection Drug Users. JAIDS 2002;30:95–104. [PubMed: 12048369]
25. Blower SM, McLean AR. Mixing ecology and epidemiology. Proc R Soc. Lond B 1991;245:187–192.

26. Gupta S, Anderson R, May R. Networks of sexual contacts: implications for the pattern of spread of HIV. AIDS 1989;3:807–817. [PubMed: 2517202]
27. Newman M. Mixing patterns in networks. Physical Review E 2003;67026126
28. Garnett GP, Hughes JP, Anderson RM, et al. Sexual mixing patterns of patients attending sexually transmitted diseases clinics. Sex Transm Dis 1996 May–Jun;23(3):248–257. [PubMed: 8724517]
29. Newman M. Assortative mixing in networks. Physical Review Letters 2002;89(20):208701. [PubMed: 12443515]
30. Peterson JL, Grinstead OA, Golden E, Catania JA, Kegeles S, Coates TJ. Correlates of HIV risk behaviors in black and white San Francisco heterosexuals: the population-based AIDS in multiethnic neighborhoods (AMEN) study. Ethn Dis. Fall 1992;2(4):361–370.
31. Haraldsdottir S, Gupta S, Anderson RM. Preliminary studies of sexual networks in a male homosexual community in Iceland. J Acquir Immune Defic Syndr 1992;5(4):374–381. [PubMed: 1548573]
32. Newman M. The structure and function of complex networks. SIAM Review 2003;45:167–256.
33. Laumann, EO.; Gagnon, JH.; Michael, RT.; Michaels, S. The social organization of sexuality: sexual practices in the United States. Chicago: University of Chicago Press; 1994.
34. Cherlin, A. Marriage, divorce, remarriage. Cambridge, MA: Harvard University Press; 1992.
35. Harrison, P.; Beck, A. Prison and jail inmates at midyear 2005. Vol. Vol. US Department of Justice; 2006 May. 2006
36. Pettit B, Western B. Mass imprisonment and the life course: Race and class inequality in US incarceration. Amer Sociological Rev 2004;69(2):151–169.
37. Doherty IA, Shiboski S, Ellen JM, Adimora AA, Padian NS. Sexual bridging socially and over time: a simulation model exploring the relative effects of mixing and concurrency on viral sexually transmitted infection transmission. Sex Transm Dis 2006 Jun;36(3):368–373. [PubMed: 16721330]

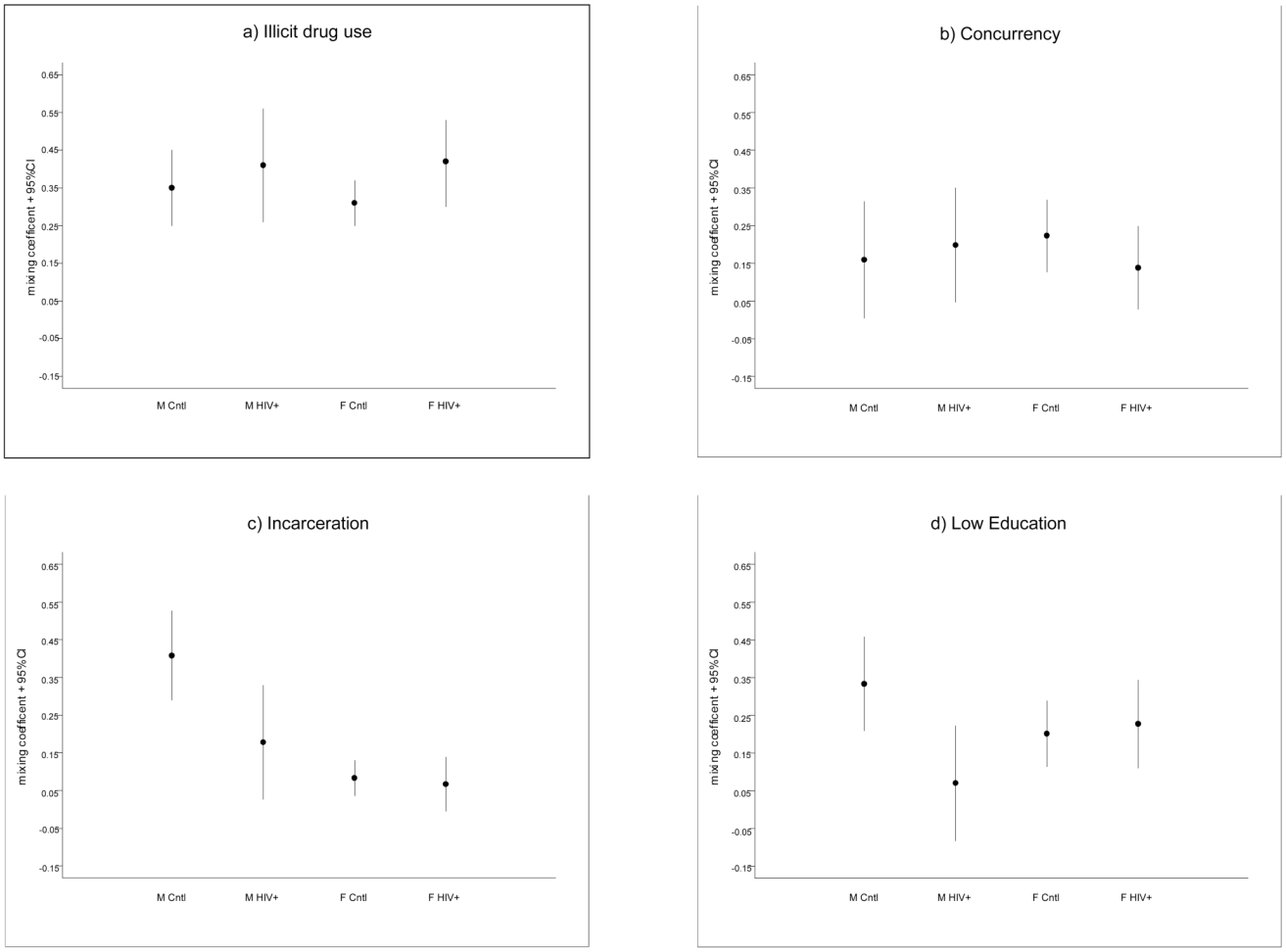

FIGURE 1.

Sexual mixing coefficients and 95 percent confidence intervals, North Carolina Rural Health Project, 1997–2000

M Cntl refers to male controls, M HIV+ refers to male cases, F Cntl refers to female controls, and F HIV+ refers to female cases.

TABLE 1

Definitions of variables assessed for sexual mixing patterns, Rural Health Project, North Carolina, 1997–2000

Variable assessed	Respondent characteristics	Sex partner characteristics* (reported by the respondent)
Illicit drug use	Respondent smoked crack or snorted cocaine or heroin	Respondent believed it was "very likely" that at least one partner had injected drugs or used crack
Concurrent partners in the past 5 years	Dates of first and last sex overlapped with at least 2 of the respondent's 3 most recent sex partners in the previous 5 years	Respondent reported that at least one partner "definitely" had sex with other people during the relationship with that partner
Incarceration	Respondent spent at least 24 hours in jail or prison	A partner spent at least 24 hours in jail or prison
Low education	less than a high school education	A partner had less than a high school education

* One or more of the three most recent partners.

TABLE 2

Distribution of risk characteristics among HIV + cases and controls and their three most recent sex partners, Rural Health Project, North Carolina 1997–2000

	Males				Females			
	HIV+ (n=78)		Controls (n=78)		HIV+ (n=128)		Controls (n=148)	
	Respondent	Partners	Respondent	Partners	Respondent	Partners	Respondent	Partners
Illicit drug use	38%	50%	9%	15%	30%	48%	5%	17%
Concurrent sex partners in past 5 years	63%	64%	53%	44%	58%	74%	31%	65%
Incarceration history	64%	49%	26%	14%	25%	81%	5%	53%
Less than a high school education	44%	58%	17%	27%	39%	57%	17%	47%

TABLE 3

Male and female *controls*' risk characteristics stratified by sex partners' risk characteristics, Rural Health Project, North Carolina 1997–2000

Males' sex partners		**Male Controls**			**Females' sex partners**		**Female Controls**		
Illicit drugs	No use		Drug use		**Illicit drugs**	No use		Drug use	
No use	63	89%	3	43%	No use	121	86%	2	25%
Drug use	8	11%	4	57%	Drug use	19	14%	6	75%
Concurrency	no overlap		overlap in 5 yr		**Concurrency**	no overlap		overlap in 5 yr	
monogamous w/respondent	24	65%	20	49%	monogamous w/respondent	45	44%	7	15%
concurrent	13	35%	21	51%	concurrent	57	56%	39	85%
Incarceration	Never		≥ once		**Incarceration**	Never		≥ once	
Never	55	95%	12	60%	Never	68	49%	0	0%
≥ once	3	5%	8	40%	≥ once	72	51%	7	100%
Education	≥high school		<high school		**Education**	≥high school		<high school	
≥high school	52	80%	5	38%	≥ high school	72	59%	6	24%
<high school	13	20%	8	62%	< high school	51	41%	19	76%