Original Contribution

Incidence and Predictors of HIV and Sexually Transmitted Infections Among Female Sex Workers and Their Intimate Male Partners in Northern Mexico: A Longitudinal, Multilevel Study

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Preventing human immunodeficiency virus (HIV) infection and other sexually transmitted infections (STIs) requires an understanding of sexual relationship factors beyond the individual level. We estimated HIV/STI incidence and identified time-varying predictors of STI acquisition in a prospective cohort study of female sex workers and their intimate (noncommercial) male partners in northern Mexico. From 2010 to 2013, couples underwent behavioral and biological assessments biannually for 24 months. Among 413 initially HIV-uninfected participants, 8 seroconverted during follow-up. Incidence of HIV (1.12 cases/100 person-years (PY)), chlamydia (9.47 cases/100 PY), active syphilis (4.01 cases/100 PY), and gonorrhea (1.78 cases/100 PY) was higher among women than among men (HIV: \( P = 0.069 \); all STIs combined: \( P < 0.001 \)). In multivariable conditional logistic regression with individual fixed effects and correlated error terms within couples, risk of STI acquisition was significantly higher among women who had recently used cocaine, crack, or methamphetamine (adjusted odds ratio (OR) = 2.13, 95% confidence interval (CI): 1.07, 4.28). STI risk was lower among women who reported physically assaulting their male partners (adjusted OR = 0.44, 95% CI: 0.22, 0.86) and among men whose female partners had regular sex-work clients (adjusted OR = 0.38, 95% CI: 0.14, 1.03). Improving vulnerable couples' sexual health will require addressing the contexts in which drug use, interpersonal conflict, and economic vulnerability converge.

drug use; female sex workers; heterosexual couples; HIV; incidence; Mexico; prospective studies; sexually transmitted infections

Abbreviations: CI, confidence interval; FSW, female sex worker; HIV, human immunodeficiency virus; OR, odds ratio; PY, person-years; STI, sexually transmitted infection.

Epidemiologic research on infectious disease transmission is increasingly recognizing the importance of factors beyond the individual level of analysis (1, 2). In particular, the spread of human immunodeficiency virus (HIV) and other sexually transmitted infections (STIs) involves interactions that occur within relationship contexts (3). Analyses focused on individual-based exposures and outcomes may fail to adequately identify interpersonal drivers of HIV/STI transmission (4). As a result, prevention scientists have called for novel approaches to understanding and addressing interpersonal factors that exacerbate heterosexual HIV epidemics (5, 6). Despite the prevalence of unprotected sex and the gendered power imbalances that shape HIV/STI risk within couples (7), prospective assessments of HIV/STI acquisition within couples in many lower- and middle-income countries remain scarce.

Globally, female sex workers (FSWs) comprise one of the most vulnerable populations for HIV/STI acquisition, experiencing 13 times’ higher odds of HIV infection than other women of reproductive age (8). Abundant literature describes HIV/STI transmission between FSWs and their commercial male partners (clients); however, many FSWs worldwide (25%–95%) have steady, noncommercial (intimate) male partners.
partners (9–11). Emerging research has investigated HIV/STI risk within these couples, finding that unprotected sex is 2–5 times more likely than it is within FSWs’ sexual encounters with clients (9–14). While behavioral interventions have increased condom use among FSWs and their clients (15), improving condom negotiation and use within FSWs’ intimate relationships has proven difficult (16). As in other intimate relationship contexts, unprotected sex within these partnerships is common and may reflect demonstrations of trust, power, and other relationship dynamics (13).

To understand how relationship characteristics influence HIV/STI acquisition within FSWs’ intimate partnerships, we prospectively studied FSWs and their intimate (noncommercial) male partners. We focused on 2 urban centers along Mexico’s northern border with the United States, where sex work is socially and legally tolerated (17) and illicit drug use is increasingly common due to “spillover” from trafficking routes that supply US markets (18, 19). Extensive surveillance and social epidemiologic research in this region has shed light on the ways in which widespread sex work, drug use, economic inequality, and population mobility shape localized HIV/STI epidemics (20). Among street-based FSWs in Tijuana and Ciudad Juárez (adjacent to San Diego, California, and El Paso, Texas, respectively), HIV prevalence has been documented at 6% (20) and the prevalence of active syphilis infection has been estimated at 14% (21).

In addition to research characterizing the prevalence of HIV/STIs and related risk behaviors among individual FSWs in this resource-poor setting (22), a small but growing body of cross-sectional and qualitative research has described HIV/STI risk behaviors and prevalence within FSWs’ intimate partnerships. These studies have shown that the majority of couples engage in unprotected sex despite the presence of concurrent sexual partnerships, illicit drug and injection drug use, and prevalent STIs (23–27). To our knowledge, no studies have prospectively assessed HIV/STI incidence among these couples; thus, we sought to identify novel time-varying risk factors for STI acquisition within FSWs’ intimate partnerships. Based on existing research findings, we hypothesized that time-varying individual- and relationship-level factors, including relationship instability (e.g., interpersonal conflict) (26, 28), drug use (24, 26, 27), and unprotected sex with clients and with other outside, concurrent sexual partners (25), would increase participants’ risk of acquiring new infections.

METHODS

Study population

From 2010 to 2013, we conducted Proyecto Parejas (Project Couples), a prospective cohort study of the social epidemiology of HIV/STIs among high-risk heterosexual couples in Tijuana and Ciudad Juárez, Mexico. Using targeted and snowball sampling methods, we recruited women in areas where sex work was known to occur (29). Eligible women were aged ≥18 years; had exchanged sex for money, drugs, or other goods in the past month; had ever used heroin, cocaine, crack, or methamphetamine; had had a noncommercial (intimate) male partner for ≥6 months; had had sex with that intimate partner in the past month; and did not anticipate experiencing severe intimate-partner violence as a result of participating in the study, as assessed using direct questions detailed in our relationship safety protocol (29). We invited eligible women to bring their primary male partners to study offices for eligibility screening, which required being aged ≥18 years and involved in a verified relationship with an eligible FSW (29). We used both active and passive follow-up methods based on our binational team’s extensive experience in retaining vulnerable populations in research studies (30). Participants were compensated US$20 for undergoing interviewer-administered questionnaires and biological assessments biannually for 24 months. Institutional review boards at the University of California, San Diego (San Diego, California), Hospital General de Tijuana (Tijuana, Mexico), El Colegio de la Frontera Norte (Tijuana, Mexico), and the Universidad Autónoma de Ciudad Juárez (Ciudad Juárez, Mexico) approved all study protocols, and participants provided written informed consent.

Exposure and outcome assessment

Individual-level factors measured at baseline included self-reported sociodemographic characteristics (e.g., age, educational attainment, average monthly income). Relationship-level measures that theoretically should not vary within dyads (e.g., relationship duration in years) were constructed by averaging data from both partners’ individual responses within dyads (31). Time-varying exposures of interest included incidents of physical assault and sexual coercion (perpetration or victimization) within intimate relationships during the past 6 months (from the 4-item assault and sexual coercion subscales of the revised Conflict Tactics Scale—Short Form (32), trust of intimate partners (a single item ranked from 1 to 10) (33), condom use with intimate partners in the past month (percentage of vaginal sex acts protected), number of steady concurrent partners in the past 6 months (from the dates of first and most recent sex with up to 5 other steady partners) (34), frequency of condom use with clients in the past month (dichotomized as often/always vs. rarely/never), current harmful alcohol drinking (from the 10-item Alcohol Use Disorders Identification Test, dichotomized as score ≥8 points vs. <8 points) (35), and use or injection of any illicit drugs in the past 6 months (heroin, cocaine, crack, or methamphetamine).

Outcome assessment involved obtaining blood and urine samples biannually for 24 months to test for HIV, Treponema pallidum, Neisseria gonorrhoeae, and Chlamydia trachomatis. We used the advanced Quality Rapid Anti-HIV (1&2) Test (InTec Products, Inc., Xiamen, China) to detect HIV antibodies. We conducted confirmatory HIV testing of reactive samples using an HIV-1 enzyme immunoassay and an immunofluorescence assay. We screened for active syphilis using rapid plasma reagin qualitative tests. We used the SERODIA TP-PA T. pallidum particle agglutination test to confirm reactive samples (Fujirebio Diagnostics, Inc. Malvern, Pennsylvania). Self-collected urine samples were tested for N. gonorrhoeae and C. trachomatis using transcription-mediated amplification tests (Gen-Probe, San Diego, California) conducted at the San Diego County Health Department laboratory. Participants received pre- and posttest risk counseling and HIV and active syphilis rapid test results immediately.

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All other results were delivered to participants within 30 days. Participants with confirmed HIV infection were referred to public clinics for free medical care and treatment. Free STI treatment was provided on the basis of US and Mexican guidelines.

Statistical analysis

Data were structured as individuals nested within couples, requiring a multilevel approach (31). We calculated descriptive statistics (frequencies, medians, ranges) for baseline variables, which were compared between women and men using logistic regression with clustered standard errors within couples. This longitudinal dyadic approach to inference allows for unrestricted correlations between the error terms across FSWs and their male partners over the entire sample period. We calculated the incidence density of HIV and each STI, overall and separately for women and men, by dividing the number of new infections by the total number of person-years at risk (calculated by summing the amounts of time at risk for each participant). Participants who tested HIV-positive at baseline \( (n = 11) \) were excluded from HIV incidence calculations. All participants contributed time at risk for each STI incidence calculation. Infection dates were estimated as the midpoint between the last known negative and first known positive test dates. In all analyses, we estimated 95% confidence intervals by clustering standard errors within couples, allowing unobservable determinants of infection that are correlated within intimate relationships to affect inference (36). Confidence intervals were computed using a block bootstrap procedure with 500 iterations in which couples were resampled with replacement.

We used conditional logistic regression with individual fixed effects to identify time-varying predictors of incident STIs, defined as a binary dependent variable excluding HIV in order to retain participants with prevalent HIV infection (who would still be at risk for STIs) in our analyses. Individual fixed effects account for all time-invariant omitted variables that predict STI incidence, allowing interpretations of time-varying effects as deviations from individuals’ average attributes and behaviors throughout the study period. The small number of HIV seroconversions in our sample precluded separate regression analyses to identify predictors of new HIV infection. Analyses were restricted to couples in which both partners completed surveys and biological assessments at \( \geq 2 \) visits \( (n = 370) \). We first examined unadjusted associations between hypothesized time-varying exposures of interest (e.g., recent relationship conflict, sex-work practices, substance use) and incident STIs. Next, within single regression models preserving the couple as a unit of analysis, we examined whether these associations varied by sex through the inclusion of interaction terms. Significant variables and interaction terms were retained in our final multivariable model, providing different estimates for women and men. All hypothesis tests were 2-sided. Analyses were conducted using Stata SE, version 13 (StataCorp LP, College Station, Texas).

Sensitivity analyses

Sensitivity analyses assessed the potential influence of loss to follow-up on incidence calculations and longitudinal regression estimates. We examined attrition patterns and relationships between baseline characteristics and attrition to identify differences between participants retained and those lost to follow-up. Key results were qualitatively unchanged when we restricted the data to couples observed at all 5 visits (i.e., complete cases). However, complete-case analysis methods (i.e., restricting the analysis to persons who participated at every visit) are subject to biases that can be mitigated through the use of inverse probability weighting (37, 38). We used inverse probability weighting retaining couple-level clustered standard errors and weights based on initial period covariates and STI incidence in our main regression (39–41), which did not yield statistically significant departures from the presented parameter estimates. In additional sensitivity checks, we assessed the role of calendar time and different dependent variables (e.g., any STI, including HIV), but this did not yield qualitatively different results.

RESULTS

Study population

For the 424 individuals (212 couples) who met inclusion criteria and enrolled in Proyecto Parejas, detailed baseline characteristics are provided in Table 1. At baseline, women were actively involved in sex work, with 56% reporting that they used condoms often/always with clients and 88% reporting that they had had regular (repeat) clients in the past month. Following baseline, 185, 161, 147, and 142 (complete) couples completed surveys and biological assessments at follow-up visits 2, 3, 4, and 5, respectively, contributing a total of 742 person-years of follow-up. Including baseline, the median number of visits was 3 among both women (interquartile range, 2–4) and men (interquartile range, 1–4). The median duration of time between visits was 184 days (interquartile range, 172–202).

HIV and STI incidence

At baseline, 11 individual participants (2.6%), including 1 seroconcordant-positive couple \( (n = 2 \) individuals \), tested HIV-positive and were excluded from HIV incidence analyses. Among the 413 HIV-uninfected participants, 8 seroconverted during follow-up, resulting in 2 seroconcordant-positive couples \( (n = 4 \) HIV-infected individuals \) and 4 serodiscordant couples \( (n = 4 \) HIV-infected individuals \). As shown in Table 2, HIV incidence was 1.12 cases/100 person-years (PY) overall (95% confidence interval (CI): 0.34, 1.89) and was higher among women than among their male partners \( (1.58 \text{ per 100 PY vs. } 0.60 \text{ per 100 PY}; P = 0.069) \). Over the course of the study, we detected a total of 145 new STI infections (chlamydia: 91; active syphilis: 36; gonorrhea: 18). The highest STI incidence was identified for chlamydia \( (9.47 \text{ cases/100 PY}) \), followed by active syphilis \( (4.01 \text{ cases/100 PY}) \) and gonorrhea \( (1.78 \text{ cases/100 PY}) \). Incidence of all STIs combined (excluding HIV) was 15.20 per 100 PY and was significantly higher in women than in men \( (P < 0.001; \text{Figure 1}) \).

Factors associated with incident STIs among couples

For 185 couples in which both partners completed surveys and biological assessments at \( \geq 2 \) visits \( (n = 370) \), Table 3
Table 1. Baseline Characteristics of a Cohort of Female Sex Workers and Their Intimate Male Partners, Northern Mexico, 2010–2013a

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Women (n = 212)</th>
<th>Men (n = 212)</th>
<th>Overall (n = 424)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median (IQR) No. %</td>
<td>Median (IQR) No. %</td>
<td>Median (IQR) No. %</td>
</tr>
<tr>
<td>Age, years</td>
<td>33 (26–39) 81 38</td>
<td>37 (31–43) 103 49</td>
<td>34 (29–41) 184 43</td>
</tr>
<tr>
<td>Educational attainment, years</td>
<td>6 (6–9) 7 (6–9)</td>
<td>7 (6–9) 7 (6–9)</td>
<td>7 (6–9) 7 (6–9)</td>
</tr>
<tr>
<td>Income &lt;US$200 per month</td>
<td>81 38</td>
<td>103 49</td>
<td>184 43</td>
</tr>
<tr>
<td>Duration of relationship, years (dyad average)</td>
<td>3.0 (1.6–5.4)</td>
<td>206 49</td>
<td>202 48</td>
</tr>
<tr>
<td>Physically assaulted intimate partner in the past year</td>
<td>98 46</td>
<td>108 51</td>
<td>206 49</td>
</tr>
<tr>
<td>Physically assaulted by intimate partner in the past year</td>
<td>87 41</td>
<td>115 54</td>
<td>202 48</td>
</tr>
<tr>
<td>Perpetrated sexual coercion within relationship in the past year</td>
<td>19 9</td>
<td>22 10</td>
<td>41 10</td>
</tr>
<tr>
<td>Victim of sexual coercion within relationship in the past year</td>
<td>20 9</td>
<td>16 8</td>
<td>36 8</td>
</tr>
<tr>
<td>Trust of partner (out of 10 possible points)</td>
<td>9 (7–10) 9 (8–10)</td>
<td>9 (7–10) 9 (8–10)</td>
<td>9 (7–10) 9 (8–10)</td>
</tr>
<tr>
<td>Percentage of vaginal sex acts with intimate partner that were unprotected in the past month (dyad average)</td>
<td>54 25</td>
<td>13 6</td>
<td>67 16</td>
</tr>
<tr>
<td>Any steady concurrent sex partners in the past year</td>
<td>42 20</td>
<td>55 26</td>
<td>97 23</td>
</tr>
<tr>
<td>Hazardous/harmful alcohol drinking in the past 6 months</td>
<td>136 64</td>
<td>130 61</td>
<td>266 63</td>
</tr>
<tr>
<td>Use of heroin in the past 6 months</td>
<td>126 59</td>
<td>103 49</td>
<td>229 54</td>
</tr>
<tr>
<td>Use of stimulant drugs (cocaine, crack, or methamphetamine) in the past 6 months</td>
<td>132 62</td>
<td>123 58</td>
<td>255 60</td>
</tr>
<tr>
<td>Injection of any drugs in the past 6 months</td>
<td>100 82–100</td>
<td>100 82–100</td>
<td>100 82–100</td>
</tr>
<tr>
<td>Positive STI test result</td>
<td>11 2.6</td>
<td>25 5.9</td>
<td>32 8</td>
</tr>
<tr>
<td>HIV</td>
<td>8 3.8</td>
<td>3 1.4</td>
<td>11 2.6</td>
</tr>
<tr>
<td>Chlamydia</td>
<td>16 7.5</td>
<td>9 4.3</td>
<td>25 5.9</td>
</tr>
<tr>
<td>Gonorrhea</td>
<td>2 0.9</td>
<td>3 1.4</td>
<td>5 1.2</td>
</tr>
<tr>
<td>Active syphilis</td>
<td>3 1.4</td>
<td>3 1.4</td>
<td>6 1.4</td>
</tr>
<tr>
<td>Any STI (excluding HIV)</td>
<td>19 9</td>
<td>13 6</td>
<td>32 8</td>
</tr>
</tbody>
</table>

Abbreviations: HIV, human immunodeficiency virus; IQR, interquartile range; STI, sexually transmitted infection.

a P values represent P for the difference between women and men (logistic regression with standard errors clustered within couples).

b P < 0.01.

c P < 0.05.

d P < 0.10.

Table 2. Incidence of Human Immunodeficiency Virus Infection and Sexually Transmitted Infections in a Cohort of Female Sex Workers and Their Intimate Male Partners (n = 424),a Northern Mexico, 2010–2013b

<table>
<thead>
<tr>
<th>STI</th>
<th>Women (n = 212)</th>
<th>Men (n = 212)</th>
<th>Overall (n = 424)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cases/100 PY 95% CI</td>
<td>Cases/100 PY 95% CI</td>
<td>Cases/100 PY 95% CI</td>
</tr>
<tr>
<td>HIV</td>
<td>1.58 0.32, 2.84</td>
<td>0.60 −0.23, 1.43</td>
<td>1.12 0.34, 1.89</td>
</tr>
<tr>
<td>Chlamydia</td>
<td>13.79 10.01, 17.58</td>
<td>4.59 2.27, 6.91</td>
<td>9.47 7.19, 11.76</td>
</tr>
<tr>
<td>Gonorrhea</td>
<td>2.53 0.96, 4.09</td>
<td>0.89 −0.12, 1.91</td>
<td>1.78 0.81, 2.74</td>
</tr>
<tr>
<td>Active syphilis</td>
<td>4.31 2.26, 6.37</td>
<td>3.64 1.58, 5.70</td>
<td>4.01 2.55, 5.47</td>
</tr>
<tr>
<td>Any STI (except HIV)</td>
<td>20.81 16.07, 25.55</td>
<td>8.88 5.59, 12.17</td>
<td>15.20 12.25, 18.15</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; HIV, human immunodeficiency virus; PY, person-years; STI, sexually transmitted infection.

a The STI analyses included 212 women and 212 men; 11 participants tested HIV-positive at baseline and were excluded from the HIV analysis (n = 413).

b P values represent P for the difference between women and men, based on confidence intervals computed using a block bootstrap procedure with 500 iterations in which couples were resampled with replacement.

c P < 0.01.

d P < 0.10.
shows unadjusted associations between time-varying behavioral and relationship factors and incident STIs. Among women, unadjusted analyses revealed that using stimulant drugs (cocaine, crack, or methamphetamine), perpetrating physical assault within the relationship, being a victim of assault within the relationship, or having concurrent sexual partners during the last follow-up period increased the risk of STI acquisition, but the latter 2 findings were only marginally statistically significant ($P = 0.061$ and $P = 0.060$, respectively). Among men, a greater percentage of protected sex acts within the relationship and having a female partner who had recently had regular sex-work clients decreased STI risk, but the latter variable was only marginally statistically significant ($P = 0.092$).

Multivariable analyses accounting for correlation within couples identified 3 time-varying factors (representing deviations from individuals’ averages during the study) that were significantly and independently associated with incident STIs (Table 4). First, the risk of STI acquisition was higher among women who had recently used stimulant drugs (cocaine, crack, or methamphetamine; adjusted odds ratio (OR) = 2.13, 95% CI: 1.07, 4.28; $P = 0.033$). Second, STI risk was reduced among women who reported physically assaulting their male partners during the last follow-up period (adjusted OR = 0.44, 95% CI: 0.22, 0.86; $P = 0.016$). Third, among men, having a female partner who had recently had regular sex-work clients was independently associated with lower STI risk (adjusted OR = 0.38, 95% CI: 0.14, 1.03), but this result was only marginally statistically significant ($P = 0.057$).

### DISCUSSION

We conducted a longitudinal study (the first, to our knowledge) to assess HIV and STI incidence among high-risk

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Women ($n = 185$)</th>
<th>Men ($n = 185$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income &lt;2,500 pesos (&lt;US$200) in the past month</td>
<td>1.18, 0.67, 2.08</td>
<td>1.49, 0.56, 3.92</td>
</tr>
<tr>
<td>Perpetrated physical assault of intimate partner during the last follow-up period</td>
<td>0.45&lt;sup&gt;d&lt;/sup&gt;, 0.23, 0.89</td>
<td>2.02, 0.70, 5.79</td>
</tr>
<tr>
<td>Victim of physical assault by intimate partner during the last follow-up period</td>
<td>0.48&lt;sup&gt;e&lt;/sup&gt;, 0.22, 1.04</td>
<td>1.86, 0.63, 5.52</td>
</tr>
<tr>
<td>Perpetrated sexual coercion within relationship during the last follow-up period</td>
<td>0.82, 0.20, 3.27</td>
<td>2.41, 0.70, 8.64</td>
</tr>
<tr>
<td>Victim of sexual coercion within relationship during the last follow-up period</td>
<td>0.84, 0.23, 3.06</td>
<td>0.31, 0.05, 2.00</td>
</tr>
<tr>
<td>Trust of partner (out of 10 possible points)&lt;sup&gt;f&lt;/sup&gt;</td>
<td>0.96, 0.81, 1.15</td>
<td>1.11, 0.77, 1.60</td>
</tr>
<tr>
<td>Percentage of vaginal sex acts with partner that were protected in the past month&lt;sup&gt;g&lt;/sup&gt;</td>
<td>0.50, 0.14, 1.74</td>
<td>0.06&lt;sup&gt;d&lt;/sup&gt;, 0.01, 0.48</td>
</tr>
<tr>
<td>Any reported steady concurrent sex partners during the last follow-up period</td>
<td>0.38&lt;sup&gt;e&lt;/sup&gt;, 0.14, 1.04</td>
<td>1.36, 0.12, 15.5</td>
</tr>
<tr>
<td>Female partner reported any regular clients in the past month</td>
<td>0.74, 0.38, 1.44</td>
<td>0.44&lt;sup&gt;e&lt;/sup&gt;, 0.15, 1.25</td>
</tr>
<tr>
<td>Female partner often/always used condoms with clients (vs. rarely/never) in the past month&lt;sup&gt;h&lt;/sup&gt;</td>
<td>1.06, 0.55, 2.04</td>
<td>1.03, 0.44, 2.41</td>
</tr>
<tr>
<td>Hazardous/harmful alcohol drinking (AUDIT score $\geq 8$ points)&lt;sup&gt;i&lt;/sup&gt;</td>
<td>2.35, 0.75, 7.36</td>
<td>2.31, 0.50, 10.7</td>
</tr>
<tr>
<td>Use of heroin during the last follow-up period</td>
<td>1.13, 0.54, 2.39</td>
<td>2.29, 0.45, 11.7</td>
</tr>
<tr>
<td>Use of stimulant drugs (cocaine, crack, or methamphetamine) during the last follow-up period</td>
<td>2.05&lt;sup&gt;d&lt;/sup&gt;, 1.05, 4.01</td>
<td>2.46, 0.73, 8.24</td>
</tr>
<tr>
<td>Injection of any drugs during the last follow-up period</td>
<td>1.36, 0.63, 2.95</td>
<td>2.57, 0.51, 12.8</td>
</tr>
</tbody>
</table>

Abbreviations: AUDIT, Alcohol Use Disorders Identification Test; CI, confidence interval; OR, odds ratio.

<sup>a</sup> 185 couples in which both partners completed surveys and biological assessments at $\geq 2$ visits.

<sup>b</sup> $P$ values were calculated in single regression models with standard errors clustered within couples.

<sup>c</sup> Unadjusted association between each time-varying risk factor and the acquisition of any sexually transmitted infection (chlamydia, gonorrhea, or active syphilis) during observation.

<sup>d</sup> $P < 0.05$.

<sup>e</sup> $P < 0.10$.

<sup>f</sup> ORs represent a 1-point increase in the variable.
couples comprising FSWs and their intimate, noncommercial male partners in northern Mexico. Despite the high prevalence of risk behaviors and unprotected sex within these couples, we observed a low overall incidence of HIV and specific STIs over a 4-year period, with all incidence rates being higher among women than among men. At 1.58 cases/100 PY, HIV incidence among these partnered FSWs was slightly lower than the incidence identified in a control group of FSWs who completed a 2008 sexual risk reduction intervention trial (2.01 cases/100 PY) in the same cities (42), possibly reflecting the improved health and behavioral profiles of persons involved in steady, intimate relationships (43). Our sample also excluded FSWs who were concerned about severe intimate partner violence (29). Such women are probably at elevated risk of HIV/STI infection (28); thus, our findings may have underestimated incidence among FSWs in this region. Nevertheless, our findings of low HIV/STI incidence among partnered FSWs—and even lower incidence among their intimate male partners—underscores previous calls for continued prevention efforts directed toward the large binational population of male sex clients in this region (26), among whom incidence has not been established. The need for continued surveillance and prevention efforts among FSWs’ male clients and other high-risk populations in border cities may become even more pressing following the end of major international donor support for HIV surveillance and prevention in Mexico (e.g., the Global Fund to Fight AIDS, Tuberculosis and Malaria).

We also identified specific time-varying risk factors for STI acquisition (i.e., changes in behaviors leading to changes in incident infections). First, we found that recent use of stimulant drugs increased women’s STI risk during follow-up, extending cross-sectional findings that methamphetamine and cocaine use are associated with high-risk sexual behaviors and prevalent HIV/STIs among FSWs in these cities and globally (21, 26, 44, 45). However, our study additionally highlights how initiating or re-initiating stimulant use (i.e., transitioning from not using stimulants to using stimulants between study visits) promotes STI acquisition among women. This suggests that HIV/STI prevention initiatives in the US-Mexico border region should consider how changes in individual drug cessation and relapse and international drug production and trafficking (e.g., cocaine and methamphetamine being transported through Tijuana and Ciudad Juárez, respectively) may influence changes in individuals’ drug consumption in local settings (18, 19). Although it is not possible from our data to determine why this finding applies to women and not their male partners, previous research in this setting has suggested that stimulant drugs may be particularly detrimental for STI acquisition among economically vulnerable women by increasing their involvement in sex work, increasing their numbers of clients, or compromising their ability to negotiate condom use with commercial partners (21, 46–48). While viable treatment options for stimulant use are still being developed and evaluated, our findings underscore the urgent need for increased access to comprehensive drug treatment services in this region (49), including programs that are sensitive to the unique needs of couples and families (50).

We also found that women who reported physically assaulting their male partners during the previous follow-up period experienced lower STI risk. Although we did not find evidence that women who perpetrated assault were acting in retaliation for conflict perpetrated by their male partners (data not shown), women in this sample who reported greater sexual decision-making power within their intimate relationships had a lower baseline prevalence of HIV/STIs (26). This association could reflect higher levels of empowerment, self-esteem, and self-efficacy with respect to condom use that could translate into reduced risk of STI acquisition over time. However, it is important to note that our sample excluded couples in which women reported fearing severe, life-threatening intimate-partner violence, which could have attenuated the association we observed and prevents us from generalizing our findings to all FSWs involved in steady partnerships. Nonetheless, with baseline levels of conflict approaching 50% in this sample (26) and without significant differences between men and women in terms of conflict

### Table 4. Independent (Adjusted) Associations of Time-Varying Factors With Incident Sexually Transmitted Infections in a Cohort of Female Sex Workers and Their Intimate Male Partners (n = 370),a Northern Mexico, 2010–2013b

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Women (n = 185)</th>
<th>Men (n = 185)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>aORc 95% CI</td>
<td>aORc 95% CI</td>
</tr>
<tr>
<td>Use of stimulant drugs (cocaine, crack, or methamphetamine) during the last follow-up period</td>
<td>2.13d 1.07, 4.27</td>
<td>2.12d 0.67, 6.72</td>
</tr>
<tr>
<td>Physically assaulted intimate partner during the last follow-up period</td>
<td>0.44d 0.22, 0.86</td>
<td>1.90 0.78, 4.66</td>
</tr>
<tr>
<td>Female partner reported any regular sex-work clients in the past month</td>
<td>0.79 0.39, 1.57</td>
<td>0.38e 0.14, 1.03</td>
</tr>
</tbody>
</table>

*Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; HIV, human immunodeficiency virus; STI, sexually transmitted infection.*

* 185 couples in which both partners completed surveys and biological assessments at ≥2 visits.
* P values were calculated in single regression models with standard errors clustered within couples.
* Association between each time-varying risk factor and the acquisition of any STI (chlamydia, gonorrhea, or active syphilis) during observation. aORs were adjusted for all other covariates in the multivariable model.
* P < 0.05.
* P < 0.10.
perpetration or victimization, it appears that relationship conflict is widespread and may be exacerbated by the material and physical insecurity that characterizes couples’ lives in the US-Mexico border region (51). Interpersonal violence is often embedded within broader contexts of structural violence, as research on drug trafficking–related violence in Ciudad Juárez has suggested (52). Clearly, additional research is needed to more precisely understand the specific pathways through which relationship conflict influences STI transmission in this setting (53).

Finally, we found that men whose female partners had recently had regular sex-work clients experienced lower STI risk over the course of follow-up (although this finding was only marginally statistically significant). In qualitative research, FSWs in this region have described higher levels of trust for regular clients, who they perceived to be less risky (23). FSWs also described deriving more dependable financial support from regular clients, allowing them to avoid exposure to multiple, higher-risk clients (23). We cannot determine why our present analysis did not reveal a protective influence of regular clients on women’s own STI risk; additional longitudinal research among FSWs and different types of clients is needed. Nevertheless, our finding regarding reduced STI risk among FSWs’ intimate male partners confirms the importance of investigating transmission dynamics within interpersonal relationships and broader social contexts (6). Analysis of traditional, individual-based exposure and outcome data could fail to identify this important association (4). This finding also suggests that interventions designed to increase FSWs’ empowerment (e.g., the ability to select higher-paying, lower-risk, and less violent clients), which have been shown to reduce FSWs’ own HIV/STI risk (54–56), may also reduce their intimate male partners’ HIV/STI risk over relatively short periods of time. Taken together with our other findings, we argue that effective couple-based intervention approaches must actively involve male partners (57–59) in supporting their female partners’ empowerment. Couple-based interventions to reduce conflict and promote communication about external risks (e.g., sex and drug use outside of steady partnerships) are also needed (7).

Our study had limitations. First, prospective studies in general and studies of socially marginalized populations in particular often suffer from attrition. However, with over 90% of FSWs and their intimate male partners returning for their first follow-up visits, attrition in our study was comparable to that in other cohort studies of socially marginalized FSWs in this setting, demonstrating the utility of intensive retention efforts (e.g., street-based tracking by outreach workers) (30, 42, 60). Our use of inverse probability weighting to restore representation of participants lost to follow-up did not yield substantially different estimates, suggesting that attrition was unlikely to have substantively biased our findings in any particular direction (39–41). Nevertheless, attrition was present, possibly reflecting high levels of community violence and policing practices (30). Future community-based research is needed to understand how to further improve retention. Second, we relied on recall and self-reporting of stigmatized behaviors. However, self-reported risk behaviors among drug users have been found to be reliable (61), and our binational team has developed numerous strategies to guard against underreporting, including cultivating participant trust and providing numerous assurances of confidentiality (30). Third, low HIV/STI incidence precluded a thorough examination of the independent predictors of HIV as compared with other STIs; future analyses with larger samples are needed. Finally, we could not discern the direction of transmission among couples in which both partners received concordant STI diagnoses at the same visit; genotypic analyses are needed to better understand these transmission dynamics.

Despite these limitations, a key strength of our study was the application of longitudinal and multilevel methods to a novel cohort of FSWs and their intimate male partners, which allowed us to identify important differences in biological outcomes (incident HIV/STIs) between women and men in heterosexual relationships. We also identified time-varying predictors of incident STIs, which underscores the ways in which fluctuations in behaviors and relationship contexts influence HIV/STI transmission dynamics. We believe that our findings carry important implications for research and prevention efforts. In particular, dyadic, qualitative, and mixed-methods studies are needed to explore how changing patterns and contexts surrounding drug use and relationship conflict (including violence perpetration, victimization, and mutuality) influence HIV/STI risk. Interventions are also needed to promote FSWs’ empowerment, including their ability to select and retain regular clients over time and reduce or abstain from stimulant drug use. Ultimately, couples-based approaches that engage male partners and work to improve risk communication need to be developed and evaluated for improved STI prevention among FSWs and their partners in this and other resource-poor settings.

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