Individual, Social, and Environmental Influences Associated With HIV Infection Among Injection Drug Users in Tijuana, Mexico

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Objective: We examined correlates of HIV infection among injection drug users (IDUs) in Tijuana, Mexico, a city bordering the United States, which is situated on major migration and drug trafficking routes.

Methods: IDUs aged ≥18 years were recruited using respondent-driven sampling. Participants underwent antibody testing for HIV and syphilis and structured interviews. Weighted logistic regression identified correlates of HIV infection.

Results: Of 1056 IDUs, the median age was 37 years, 86% were male, and 76% were migrants. HIV prevalence was higher in female participants than in male participants (8% vs. 3%; $P = 0.01$). Most IDUs testing HIV-positive were previously unaware of their serostatus (93%). IDUs reported injecting with a median of 2 people in the prior 6 months and had been arrested for having injection stigmata (ie, "track-marks") a median of 3 times. Factors independently associated with HIV infection were being female, syphilis titers consistent with active infection, larger numbers of recent injection partners, living in Tijuana for a shorter duration, and being arrested for having track-marks.

Conclusions: Individual, social, and environmental factors were independently associated with HIV infection among IDUs in Tijuana. These findings suggest the need to intervene not solely on individual risk behaviors but on social processes that drive these behaviors, including problematic policing practices.

Key Words: HIV, injection drug use, Mexico, mobility, policing, sexually transmitted infections

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There is growing recognition of social and structural processes that shape individual risks and heighten vulnerability to HIV infection.[1–7] The risk environment has been defined as the social or physical space in which factors exogenous to the individual interact to increase vulnerability to HIV infection.[2,5] Examples include social networks; injection locations; population mobility; cross-border trade and transport; policies, laws, and policing; inequities in relation to ethnicity, gender, and sexuality; and social stigma and discrimination. Such factors interplay across macro- and micro-levels of environment, having direct and indirect effects on HIV risks. Structural interventions are those that intervene in these social processes, policies, or environments.

Several characteristics of the social networks of injection drug users (IDUs) heighten their vulnerability to HIV infection. Having an IDU sex partner[8,9] or larger numbers of IDU peers has been associated with higher levels of needle sharing,[10] overdose,[11] and lower drug use cessation.[12] A small dense network may be protective if no network members are infected;[13] however, network turnover as a result of migration, incarceration, or drug market transition could lead to rapid HIV transmission within the same network. Network-based behavioral interventions can successfully reduce HIV risk behaviors among IDUs.[6,14] Yet, microsocial networks are themselves situated within broader environmental contexts that may limit the impact of network, individual, and other behavioral interventions. For example, interventions aiming to change social norms about needle sharing may not be uniformly successful in settings in which purchase or possession of syringes is illegal[15] or where aggressive policing leads IDUs to inject in shooting galleries.[16] Such factors as poverty, violence, and fear of withdrawal symptoms or police may reduce the salience of risk reduction norms among IDUs.[17]

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Specific physical settings, such as shooting galleries, other injecting environments,[4,14,15,18–21] and prisons,[22] have been associated with elevated levels of needle sharing and HIV infection. In such environments, HIV risk behaviors are shaped by the interplay of structural constraints placed on the availability of HIV prevention materials or the capacity of IDUs to enact risk reduction and what can be termed *spatial practices* arising from placed-based behavioral routines, norms, and risk perceptions.[23] Homelessness and unstable housing have been associated with a greater risk of HIV infection,[24–27] perhaps because homeless IDUs have closer engagement with street-based cultures of drug use and transactional sex and are more likely to experience situational disruptions in protective behaviors.[28] In contrast, stable living arrangements have been associated with higher rates of entry into drug abuse treatment.[29]

Policing practices may have a significant impact on IDUs' ability to adhere to safe injection practices, thereby influencing their risk of acquiring HIV. Qualitative evidence shows that local policing practices influence how, where, and under what circumstances IDUs obtain and use injection equipment.[28,30–34] Disruptions to IDUs' risk reduction practices and engagement in HIV risk behavior have been linked to high-visibility policing and fear of arrest or detainment,[30] which exacerbates withdrawal symptoms. Quantitative studies report that aggressive policing practices are associated with higher levels of needle sharing[35–38] and lower utilization of syringe exchange programs (SEPs).[39,40] In an ecologic study of the macrolegal environment in 89 metropolitan areas in the United States, Friedman and colleagues[41] showed that higher levels of legal repressiveness were positively associated with HIV prevalence among IDUs. Studies are lacking to determine how such effects interplay alongside individual and social network factors.

Mobility is emerging as an important risk factor in the transmission dynamics of communicable diseases, including HIV.[42–45] Migration and mobility are associated with family separation, disintegration of social networks, sudden changes in the cultural environment, homelessness, poverty, social isolation, and a greater sense of anonymity, which may enable riskier behaviors.[46–50] In one study, social pressures, including legal problems, entering drug treatment, and the desire to conduct illegal activities, were primary reasons for travel.[51] Mobile IDUs may lack established social networks for obtaining drugs, leading them to inject in unsafe settings.[26] In Alaska, transnational migrant IDUs were up to 6 times more likely to share injection equipment compared with the local homeless drug-using population.[52] IDUs with newcomer status consistently report riskier injection practices, including sharing injecting equipment and injecting in public places and shooting galleries.[46,52,53] Mobility may also increase the probability that IDUs encounter HIV-positive persons and decrease the utilization of health services, including substance abuse treatment.[54]

Border regions may heighten HIV susceptibility through social disruption and the intermingling of vulnerable populations, including IDUs, migrants, and other mobile IDUs.[5,48] We studied correlates of HIV infection in Tijuana, Mexico, a city bordering the United States, which is situated on major migration and drug trafficking routes. Because prior qualitative studies documented barriers to the purchase of sterile syringes without a prescription,[33] aggressive policing practices,[34,38] and a high degree of mobility among IDUs in Tijuana,[55] we hypothesized that these exogenous factors would be independently associated with HIV infection after accounting for individual- and network-level risk factors.

METHODS

Setting

Tijuana is the largest city on the Mexican-US border in the state of Baja California, with an estimated population of 1,410,700 persons.[56] Approximately half of Baja California's population lives in Tijuana, although more than half of its inhabitants were born outside the state.[56] The border crossing between Tijuana and San Diego is the busiest land crossing in the world, with >53 million northbound crossings between Tijuana and San Diego County in 2006.[57] In 2003, approximately 6000 IDUs attended shooting galleries in Tijuana,[20] although the total IDU population is likely closer to 10,000.[33]

It is legal to purchase or carry syringes without a prescription in Mexico.[33] A small SEP began operating in Tijuana in 2003. During the study period, there were 5 methadone maintenance programs in the city, all privately operated.

Recruitment

Between April 2006 and April 2007, IDUs were recruited in Tijuana into a prospective study of behavioral and contextual factors associated with HIV, syphilis, and tuberculosis (TB) infections. Eligibility criteria included being ≥18 years of age; having injected illicit drugs within the past month, as confirmed by inspection of injection stigmata ("track-marks"); ability to speak Spanish or English; being able to provide informed consent; and having no plans to permanently move out of the city in the next 18 months. Methods were approved by the Institutional Review Board of the University of California, San Diego and the Ethics Board of the Tijuana General Hospital.

Respondent-driven sampling (RDS) was used to recruit participants.[58] Briefly, a diverse group of "seeds" (heterogeneous by age, gender, and neighborhood) was selected and given uniquely coded coupons to refer their peers to the study. Waves of recruitment continued as subjects returning with coupons were given coupons to recruit members of their social networks. Recruitment and interviews were conducted by indigenous outreach workers through the use of a modified recreational vehicle and a storefront office.

Study Instrument

IDUs completed an interviewer-administered survey eliciting information on sociodemographic, behavioral, and contextual characteristics. Sociodemographic questions included place of birth, migration history, income, and living arrangements. Participants were asked about their lifetime and current (past 6 months) sexual behaviors and drug use. Participants were also asked whether they had ever been

arrested; those answering affirmatively were asked whether they had ever been arrested for possessing used or unused/sterile syringes or for having track-marks, because these reasons were commonly reported in a prior qualitative study.[34] Finally, subjects were asked to indicate whether they had ever been in a jail, prison, or drug abuse treatment program and, if so, for what duration and whether they had ever been diagnosed with HIV, TB, or specific sexually transmitted infections (STIs).

Laboratory Testing

The Determine rapid HIV antibody test (Abbott Pharmaceuticals, Boston, MA) was administered to determine the presence of HIV antibodies. All reactive samples were tested using an HIV-1 enzyme immunoassay and immunofluorescence assay. Syphilis serology used the rapid plasma reagin (RPR) test (Macro-Vue; Becton Dickinson, Cockeysville, MD). RPR-positive samples were subjected to confirmatory testing using the *Treponema pallidum* particle agglutination assay (TPPA; Fujirebio, Wilmington, DE). Specimen testing was conducted at the San Diego County Health Department. Those testing positive were referred to the Tijuana municipal health clinic for free care.

Statistical Analysis

Statistical analyses compared HIV-positive and HIV-negative IDUs. Continuous outcomes were examined using *t* tests and the Wilcoxon rank sum test for differences in group distributions for normally and nonnormally distributed variables, respectively. Binary outcomes were examined using the Pearson χ^2 or Fisher exact test.

Univariate and multivariate logistic regressions were performed to identify factors associated with HIV-positive serostatus. A manual procedure was used, whereby all the variables that had attained a significance level $<10\%$ in univariate models were considered for inclusion in multivariate models. Although not significant in univariate analyses, we also considered receptive syringe sharing in multivariate models because it is a known HIV risk factor. The likelihood ratio test was used to compare nested models, using a significance level of 5%. All 2-way interactions were explored.

We also explored potential effects of RDS on our estimates. To assess if bias introduced by the nonrandom selection of seeds was eliminated, we conducted compositions convergence analyses using the RDS Analysis Tool (version 5.6.0; Cornell University, New York, NY, October 2006). Trait groups selected for these analyses were HIV serostatus, active syphilis status (syphilis titer $\geq$1:8 or syphilis titer $<$1:8), gender, age group, migration status, and homelessness. Convergence analyses compared the actual final sample compositions with the RDS estimated sample equilibrium compositions by means of tolerance, a measure developed by Heckathorn[58] to indicate how well the sample compositions approximate the theoretic equilibrium compositions. Tolerance is defined as the absolute mean difference between the actual sample compositions and the equilibrium sample compositions, and a tolerance of 2% or smaller indicates that the actual sample compositions have converged to reach equilibrium. Tolerance values for our primary trait groups were lower than the 2% cutoff, indicating that the bias introduced by the nonrandom selection was gradually eliminated, and the final RDS sample compositions converged to equilibrium. Next, we calculated estimates for the population compositions. To account for discrepancies between these estimates and the corresponding sample compositions, we generated overall sampling weights based on recruitment and degree weights[58] and applied these to the logistic regression model.

Finally, to identify effects that might arise from correlation between recruiters and recruitees, we developed a random effects logistic regression model in which covariates of interest were used as fixed effects and the design matrix of random effects indicated who was recruited by whom using WinBUGS (version 1.4.1; Imperial College and Medical Research Council, United Kingdom, 2004). Results were obtained using 2 Markov chains. In one chain, initial parameter estimates were taken from the ordinary logistic regression models; in the other chain, initial values were set to 0. Odds ratios (ORs) and 95% confidence intervals (CIs) produced by the RDS analyses were compared with our multiple logistic regression model. No significant differences between the adjusted and unadjusted models were identified; therefore unadjusted values are presented as recommended.

RESULTS

A total of 1052 IDUs were enrolled, of whom 86% were male. Overall, the crude (unweighted) HIV prevalence was 4.0%, but it was higher in female participants than in male participants (8.3% vs. 3.3%; $P = 0.01$). The RDS-adjusted HIV prevalence was lower at 2.3% but remained higher in female participants relative to male participants (3.1% vs. 2.1%; $P = 0.003$). Among 42 IDUs diagnosed as HIV-positive, most (93%) were previously unaware of their HIV serostatus.

Compared with HIV-negative IDUs, HIV-positive IDUs were significantly younger (median: 34 vs. 37 years; $P = 0.04$) and were more likely to be female (29% vs. 13%; $P = 0.01$) (Table 1). The groups did not differ in their educational attainment, income, or marital status.

We next examined group differences in terms of social influences. HIV-positive IDUs spent significantly more time on the street (median = 12 vs. 10 hours per day; $P = 0.001$), injected with more people in the prior 6 months (median: 3 vs. 2 persons; $P = 0.002$), and perceived their risk of HIV infection as high more often (68% vs. 44%; $P = 0.002$) compared with HIV-negative individuals. HIV-positive individuals were only marginally more likely to report HIV-positive persons in their social network (median: 0.5 vs. 0 persons; $P = 0.1$). Groups did not differ in terms of the proportion with an IDU sex partner or the number of IDUs in their social networks.

A range of individual-level behaviors and associated characteristics were next examined. HIV-positive IDUs reported that they had been injecting drugs for shorter durations than their HIV-negative counterparts (median: 10 vs. 15 years; $P = 0.04$). HIV-positive IDUs were significantly more likely than their HIV-negative counterparts to report

TABLE 1. Characteristics of IDUs With and Without HIV Infection in Tijuana, Mexico: 2006 to 2007

Baseline Characteristics	HIV-Positive (n = 42)	HIV-Negative (n = 1010)	Total (n = 1052)	*P*
Sociodemographics				
Median (IQR) and mean (SD) age, y	34 (28 to 41) 34.5 (8.4)	37 (31 to 42) 37.2 (8.3)	37 (31 to 42) 37.1 (8.3)	0.04
Female	12 (29%)	133 (13%)	145 (14%)	0.01
Median (IQR) and mean (SD) education completed, y	6 (6 to 9) 6.9 (3.2)	8 (6 to 9) 7.4 (3.4)	7 (6 to 9) 7.4 (3.4)	0.38
Speaks some English	21 (50%)	486 (48%)	507 (48%)	0.88
Average monthly income ≥3000 pesos	30 (77%)	676 (69%)	706 (69%)	0.38
Married/common-law	15 (36%)	314 (31%)	329 (31%)	0.61
Social influence				
Sex partner is an IDU*	1 (3%)	24 (3%)	25 (3%)	1.00
Median (IQR) and mean (SD) no. IDUs in social network	70 (50 to 200) 140.4 (167.8)	70 (40 to 138) 136.4 (358.1)	70 (40 to 140) 136.5 (352.4)	0.19
Median (IQR) and mean (SD) time spent daily on the street, h*	12 (10 to 15) 13.2 (4.8)	10 (6 to 12) 10.6 (5.6)	10 (7 to 12) 10.7 (5.6)	0.001
Median (IQR) and mean (SD) no. people usually injected with*	3 (2 to 5) 4.6 (8.4)	2 (1 to 3) 2.5 (4.6)	2 (1 to 3) 2.6 (4.9)	0.002
Ever been forced to have sex	4 (10%)	48 (5%)	52 (5%)	0.14
High perceived risk of HIV infection compared with others	28 (68%)	432 (44%)	460 (45%)	0.002
Median (IQR) and mean (SD) no. HIV-positive people known personally	0.5 (0 to 3) 2.6 (4.8)	0 (0 to 2) 1.8 (5.2)	0 (0 to 2) 1.8 (5.2)	0.10
Individual behaviors/risks				
Median (IQR) and mean (SD) duration of injection, y	10 (6 to 19) 13.2 (9.8)	15 (9 to 22) 15.7 (9.1)	15 (9 to 22) 15.6 (9.1)	0.04
Any receptive needle sharing*	22 (52%)	595 (59%)	617 (59%)	0.42
Shared injection paraphernalia half the time or more often*	1 (2%)	88 (9%)	89 (9%)	0.25
Used new/sterile needle half the time or more often*	20 (48%)	447 (44%)	467 (45%)	0.75
Obtained syringes from needle exchange program*	1 (2%)	36 (4%)	37 (4%)	0.99
Ever had unprotected sex with HIV-infected person	6 (15%)	18 (2%)	24 (2%)	<0.0001
Syphilis titer ≥1:8	9 (22%)	69 (7%)	78 (7%)	0.002
Positive for syphilis antibodies	16 (38%)	145 (14%)	161 (15%)	<0.0001
Ever traded sex in exchange for money, drugs, goods, or shelter	10 (24%)	231 (23%)	241 (23%)	0.85
Ever had sex with a male partner (men only)	6 (20%)	246 (28%)	252 (28%)	0.41
Ever tested for HIV	12 (29%)	417 (41%)	429 (41%)	0.11
Structural/environmental factors				
Born outside Baja, California	35 (83%)	665 (66%)	700 (67%)	0.02
Median (IQR) and mean (SD) time lived in Tijuana (IQR), y	10 (5 to 17) 13.3 (11.8)	15 (5 to 30) 18.2 (14.9)	15 (5 to 30) 17.9 (14.8)	0.12
Homeless*	8 (19%)	133 (13%)	141 (13%)	0.25
Normally injected drugs outside*	11 (26%)	236 (23%)	247 (24%)	0.71
Normally injected drugs at shooting gallery*	13 (31%)	387 (39%)	400 (38%)	0.42
Ever traveled to United States	30 (71%)	785 (78%)	815 (78%)	0.34
Ever been arrested	36 (86%)	871 (87%)	907 (87%)	0.82
Ever arrested for carrying used needle/syringe†	17 (49%)	381 (44%)	398 (44%)	0.61
Ever arrested for carrying unused needle/syringe†	16 (46%)	341 (39%)	357 (39%)	0.48
Median (IQR) and mean (SD) no. times arrested for carrying unused needle/syringe†	0 (0 to 4) 3.5 (8.7)	0 (0 to 3) 2.5 (6.1)	0 (0 to 3) 2.6 (6.3)	0.37
Ever arrested for having track-marks†	26 (74%)	558 (64%)	584 (64%)	0.28
Median (IQR) and mean (SD) no. times arrested for having track-marks†	3 (0 to 15) 12.5 (22.3)	3 (0 to 10) 7.5 (11.8)	3 (0 to 10) 7.7 (12.4)	0.35
Ever arrested for carrying drugs†	15 (43%)	333 (39%)	348 (39%)	0.72
Median (IQR) and mean (SD) no. times arrested for carrying drugs†	0 (0 to 5) 2.6 (4.5)	0 (0 to 3) 2.8 (6.9)	0 (0 to 3) 2.8 (6.8)	0.56
Median (IQR) and mean (SD) no. times in jail/prison	1 (1 to 3) 1.9 (1.9)	2 (0 to 3) 3.0 (6.2)	2 (0 to 3) 2.9 (6.1)	0.66
Ever injected in jail‡	19 (58%)	433 (60%)	452 (60%)	0.86

*Past 6 months.
†Among those ever arrested (n = 907).
‡Among those ever incarcerated (n = 750).

having had unprotected sex with an HIV-infected partner (15% vs. 2%; $P < 0.0001$), to test positive for syphilis antibody (38% vs. 14%; $P < .0001$), and to present with syphilis antibody titers ≥1:8 (22% vs. 7%; $P = 0.002$). Groups did not differ in their reported receptive needle sharing; frequency of sharing injection paraphernalia; use of new/sterile needles; obtaining syringes from the SEP; ever trading sex; or, among male participants, ever having sex with a male partner.

Finally, we examined group differences for a variety of structural influences. HIV-positive IDUs were significantly more likely to have been born outside Baja, California (83% vs. 66%; $P = 0.02$) compared with HIV-negative individuals. Groups did not differ significantly in the probability of being homeless, injecting locations, having traveled to the United States, having ever been arrested, having been arrested for carrying new or used syringes, having been arrested for carrying drugs, or the number of times they had been in jail or prison. Although not significant by Wilcoxon rank sum tests, number of years lived in Tijuana (OR = 0.78 per year, 95% CI: 0.61 to 0.99; $P = 0.04$) and ever having been arrested for having track-marks (OR = 1.10, 95% CI: 1.00 to 1.20; $P = 0.04$) were associated with HIV infection in univariate logistic regression models (Table 2). HIV-positive and HIV-negative IDUs reported being arrested more frequently for carrying used or unused needles/syringes than for carrying drugs.

Fifteen variables attaining P values ≤0.10 in univariate regressions were considered in multivariate models. Five factors remained independently associated with testing HIV-positive, which included variables at the level of the individual, social network, and environment (Table 3). At the individual level, HIV-positive IDUs were nearly 4 times more likely to have syphilis antibody titers ≥1:8 (OR = 3.6) and were nearly 3 times more likely to be female (OR = 2.84). At the network level, odds of HIV positivity increased 24% for every 5 additional injection partners in the prior 6 months. At the environmental/structural level, IDUs who had lived in Tijuana for shorter durations were more likely to test HIV-positive; for every 10 years lived in Tijuana, odds of HIV positivity decreased by 11%. IDUs who reported having been arrested for having track-marks were more likely to test HIV-positive; the odds of testing HIV-positive increased by 12% for every 5 arrests attributed to this cause.

TABLE 2. Factors Associated With HIV Infection Among IDUs in Tijuana, Mexico

Baseline Characteristics	Univariate OR	95% CI
Sociodemographics		
Age (per y)*	0.96	0.92 to 1.00
Female*	2.64	1.32 to 5.28
Education completed (y)	0.95	0.87 to 1.04
Speaks English	1.07	0.58 to 1.98
Average monthly income ≥3000 pesos	1.52	0.71 to 3.24
Married/common-law	1.22	0.64 to 2.33
Social influence		
Sex partner is an IDU	0.90	0.12 to 6.87
No. IDUs in social network (per 5 people)	1.00	0.996 to 1.004
No. hours spent daily on the street*†	1.08	1.03 to 1.13
No. people usually injected with (per 5 people)*†	1.20	1.03 to 1.40
Ever been forced to have sex*	2.15	0.74 to 6.29
High perceived risk of HIV infection compared with others*	2.79	1.43 to 5.44
No. HIV-positive people known personally	1.02	0.98 to 1.06
Individual behaviors		
Duration of injection (y)*	0.97	0.93 to 1.00
Any receptive needle sharing†	0.76	0.41 to 1.41
Shared injection paraphernalia half the time or more often†	0.25	0.03 to 1.87
Used new/sterile needle half the time or more often†	1.13	0.61 to 2.11
Obtained syringes from needle exchange program†	0.66	0.09 to 4.91
Ever had unprotected sex with HIV-infected person*	9.37	3.50 to 25.1
Syphilis titer ≥1:8*	3.82	1.75 to 8.32
Positive for syphilis antibodies*	3.67	1.92 to 7.01
Ever traded sex for money, drugs, goods, or shelter	1.08	0.52 to 2.23
Ever had sex with a male partner (men only)	0.64	0.26 to 1.58
Ever had an HIV test*	0.56	0.29 to 1.11
Structural/environmental factors		
Born outside Baja, California*	2.55	1.12 to 5.80
Length of time lived in Tijuana (per 10 y)*	0.78	0.61 to 0.99
Homeless†	1.54	0.70 to 3.40
Normally injected drugs outside†	1.16	0.57 to 2.34
Normally injected drugs at shooting gallery†	0.72	0.37 to 1.39
Ever traveled to United States	0.70	0.35 to 1.39
Ever arrested	0.92	0.38 to 2.22
No. arrests for having track-marks (per 5 arrests)*	1.10	1.01 to 1.21
No. arrests for carrying used needle/syringe (per 5 arrests)	1.10	0.95 to 1.28
No. arrests for carrying unused needle/syringe (per 5 arrests)	1.09	0.89 to 1.32
No. arrests for carrying drugs (per 5 arrests)	0.98	0.75 to 1.27
No. times in jail/prison (per 5 times)	0.68	0.37 to 1.24
Ever injected in jail	0.89	0.44 to 1.80

*$P \leq 0.10$.
†Refers to past 6 months.

DISCUSSION

The unique contribution of this study is the finding that environmental influences such as migration and policing practices were independently associated with HIV infection among IDUs in Tijuana, after accounting for risks at the individual and network levels. These findings suggest that interventions aimed at the structural level could reduce the risk of acquiring HIV infection, which has important policy implications in this resource-limited setting.

IDUs living in Tijuana for shorter durations were more likely to be HIV-infected. Number of years lived in Tijuana was highly correlated with having been born outside Baja, California, which was reported by two thirds of our study

TABLE 3. Factors Independently Associated With HIV Infection Among IDUs in Tijuana, Mexico

Variable	Adjusted OR	95% CI
Female	2.84	1.31 to 6.17
Syphilis antibody titer ≥1:8	3.60	1.55 to 8.35
No. different people usually injects with* (per 5 people)	1.24	1.07 to 1.43
Length of time lived in Tijuana (per 10-y increase)	0.78	0.61 to 1.01
No. arrests for track-marks (per 5 arrests)	1.12	1.01 to 1.25

*Past 6 months.

sample. Although approximately half of Tijuana's residents were born outside Baja, California,[56] the percentage of migrants among our IDU sample seems disproportionately higher.

Our finding that migrant IDUs had a higher risk of HIV infection is consistent with literature reporting that IDUs who are newcomers or highly mobile are more likely to report higher risk injection behaviors.[46,52,53] Our study extends these findings by documenting an association with migration and HIV infection among an IDU population in a low-prevalence setting. An earlier study by our group found that IDUs who were more recent migrants to Tijuana were more likely to report receptive needle sharing.[20] In a study of 600 male Mexican migrant workers in California, 1% tested newly HIV-positive.[59] Because mobile populations may play a critical role in "seeding" a nascent HIV epidemic, prevention efforts should occur on both sides of the US-Mexico border (eg, migrant camps, immigration and deportation centers).

IDUs who reported frequent arrest for track-marks were more likely to be HIV-infected. Although syringes may be legally purchased or carried without a prescription in Mexico, IDUs in Tijuana and Ciudad Juarez, another Mexican city bordering the United States, often report being arrested for carrying syringes or even having track-marks that label them as a drug injector.[33,34] In both cities, being arrested for carrying used or unused syringes was independently associated with receptive needle sharing[38] and shooting gallery attendance.[60] Policing practices may have an indirect effect on HIV acquisition by pressuring IDUs to inject hurriedly or in shooting galleries, where they are at greater risk of sharing needles. Policing has been associated with such high-risk injection behaviors in other settings;[35–37] however, to our knowledge, this is the first study to show policing practices to be independently associated with HIV infection at the individual rather than the aggregate level.

Another possible interpretation is that being arrested for track-marks is a marker for social stigma that could influence susceptibility to HIV and other infections through a different pathway. IDUs are stigmatized by most societies, but those who are street-based or otherwise socially marginalized as a result of disheveled appearance or scarring from injection stigmata or tattoos or who are more visible because of newcomer status may be more vulnerable to social forces of discrimination. Anecdotal reports from a recent focus group of IDUs in Tijuana support these assertions. A US study found that IDUs who perceived themselves to be discriminated against were more likely to have poor mental and physical health.[61] Bourgois et al[7] suggest that historically rooted and institutionally enforced power relations contribute toward differential patterns of drug consumption, social and institutional relations, and health among African-American versus white IDUs in San Francisco. Similar inferences have been drawn among other populations in which the impact of social discrimination and structural violence results in reduced community capacity for HIV risk avoidance.[62,63] Recent qualitative research in the United Kingdom shows how particular injecting environments can act as contextual amplifiers of stigma and shame, thus feeding risk rather than its avoidance.[23]

Relations between stigma and HIV risks may be circular, with greater levels of stigma driving higher risk behaviors and/or lower access to prevention and treatment services among IDU subgroups, contributing to their further marginalization and vulnerability to other exogenous influences (eg, homelessness, arrest, incarceration). This "vicious circle" has been documented among IDUs of Dai ethnicity in China, a highly stigmatized subgroup that is overrepresented among HIV cases.[64] Although social stigma and/or discrimination may be risk factors for HIV infection, these relations have been understudied among IDUs and warrant further investigation.[23,61,65]

We also identified risk factors for HIV infection that have been previously reported in other settings. The odds of HIV infection were nearly 3-fold higher among female IDUs, although they represented only 13% of the cohort. Although 1 study has documented higher HIV incidence among female IDUs,[66] studies conducted in settings with established HIV epidemics have not.[67,68] Because studies in our setting and elsewhere have shown significant gender differences in HIV risks,[67–69] there is a need to examine contextual factors that influence how sexual and injecting risks overlap among female injectors.

Antibody titers consistent with infectious syphilis were independently associated with nearly a 4-fold higher risk of HIV infection in our study. Although not surprising, because syphilis is a known cofactor of HIV transmission,[70] the relatively high prevalence of IDUs with titers ≥1:8 underscores the need to integrate HIV and STI prevention and treatment. Although HIV prevalence among IDUs was low, most HIV-positive IDUs were unknowingly infected, indicating a need to expand voluntary HIV counseling and testing. Mobile programs that provide on-site HIV/STI screening and treatment may be especially useful for targeting migrant, female, and other hidden IDUs who are beyond the reach of conventional programs.

At the network level, IDUs who injected with larger numbers of people were more likely to be HIV-infected. This association may be explained by a high degree of mixing between permeable social networks, which increases the probability of sharing needles with an HIV-infected person.[13] Studies have consistently shown an important role of peers on HIV risk perception,[14,71] needle-sharing norms and behaviors,[10] and entry into drug abuse treatment.[29,72] Network-based

interventions may promote successful behavioral outcomes among injectors, assuming that structural barriers can be overcome.

Our study was limited by the fact that it was cross-sectional, and we could not determine whether factors independently associated with HIV infection were influential before versus after HIV was acquired. Although our sample included a low proportion of female participants, IDUs were recruited through RDS and tests of its assumptions showed results to be robust. We are therefore confident that the associations we observed reflect the experience of the target population.

Despite the need to confirm these associations and explore potential mechanisms with prospective studies, these findings suggest that individual, social, and environmental factors were independently associated with HIV infection among IDUs in Tijuana. There is therefore a need to intervene not solely on individual risk behaviors but on the social processes that drive these behaviors, such as policing practices and mobility. Wegbreit et al[73] suggested that interventions should be matched to the stage of an HIV epidemic (ie, low-level, concentrated, generalized). Our findings suggest that this approach may require further refinements, for example, if certain subgroups (eg, migrants) experience greater vulnerability to HIV infection in earlier versus later stages of an HIV epidemic.

Based on our findings, examples of structural interventions that should be considered in Tijuana include harm reduction education for law enforcement officials at the municipal, state, and federal levels; prevention programs for mobile populations; expansion and integration of HIV/STI testing and drug abuse treatment programs; and safer injection facilities.

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