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The Emerging HIV Epidemic on the Mexico-U.S. Border: An International Case Study Characterizing the Role of Epidemiology in Surveillance and Response

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PURPOSE: Human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome surveillance data are critical for monitoring epidemic trends, but they can mask dynamic subepidemics, especially in vulnerable populations that underuse HIV testing. In this case study, we describe community-based epidemiologic data among injection drug users (IDUs) and female sex workers (FSWs) in two northern Mexico-U.S. border states that identified an emerging HIV epidemic and generated a policy response.

METHODS: We draw from quantitative and qualitative cross-sectional and prospective epidemiologic studies and behavioral intervention studies among IDUs and FSWs in Tijuana, Baja California, and Ciudad Juarez, Chihuahua.

RESULTS: The recognition that the HIV epidemic on Mexico's northern border was already well established in subgroups in whom it had been presumed to be insignificant was met with calls for action and enhanced prevention efforts from researchers, nongovernmental organizations, and policy makers.

CONCLUSIONS: Successful policies and program outcomes included expansion of needle-exchange programs, a nationwide mobile HIV prevention program targeting marginalized populations, a successful funding bid from the Global Fund for HIV, TB, and Malaria to scale up targeted HIV-prevention programs, and the establishment of bi-national training programs on prevention of HIV and substance use. We discuss how epidemiologic data informed HIV prevention policies and suggest how other countries may learn from Mexico's experience.

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KEY WORDS: HIV, AIDS, Surveillance, Policy, Mexico, U.S. border, Epidemiology, Injection drug use, Sex work.

INTRODUCTION

Surveillance data play a critical role in the monitoring of epidemiologic trends and programmatic responses to infectious disease threats both nationally and globally. There is a long history in public health disease control and prevention in which epidemiologic and surveillance data have informed policy and interventions to reduce or alter risk even in the

absence of knowing the underlying mechanisms of disease transmission (1). In 1983, epidemiologic studies before the isolation of human immunodeficiency virus (HIV) had already identified many risk factors for which control measure policies were subsequently developed (1, 2). However, national and regional HIV/acquired immunodeficiency syndrome (AIDS) surveillance data can sometimes mask dynamic subepidemics that vary by country, region, sex, or HIV transmission group, especially when HIV incidence is increasing in vulnerable populations that underuse HIV testing and treatment services. In many countries, HIV/AIDS surveillance data are limited to programmatic data from clinics testing antenatal women, those being screened for sexually transmitted infections (STIs), or routine HIV testing among military personnel. The reliance on these types of sources, rather than HIV testing data drawn from community-based populations, can lead to erroneous conclusions about country-level HIV epidemic trends and the presumed impact of prevention interventions and policies (3).

Among the country-level HIV prevalence estimates across the Americas, Mexico's nationwide prevalence of

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Selected Abbreviations and Acronyms

AIDS = acquired immunodeficiency syndrome
FSW = female sex worker
HIV = human immunodeficiency virus
IDU = intravenous drug user
NEP = needle-exchange programs
NGO = nongovernmental organization
NIDA = National Institute on Drug Abuse
STI = sexually transmitted infections

0.3% is among the lowest. By 2007, there were an estimated 200,000 HIV-positive persons living in Mexico, and at the end of 2008, a total of 124,505 reported AIDS cases, among whom the vast majority were attributed to homosexual/bisexual activity. Since the first AIDS case was reported in Mexico in 1983 until 2007, the male/female AIDS case ratio decreased from 10:1 to 3:5 (4). Trends in the prevalence of HIV nationally by gender and risk group were similar to AIDS incidence data, but among Mexico's 32 states, Baja California—abutting the U.S. state of California—has consistently had the greatest cumulative incidence of AIDS cases, second only to Mexico's federal district, and the corresponding rate in the border state of Chihuahua has remained greater than the national average (5).

In 2002, del Rio and Sepulveda (6) reviewed and offered insights into Mexico's HIV epidemic and the national response; they concluded that Mexico had thus far averted a major HIV epidemic, in contrast to some of its neighbors (e.g., the United States and Honduras) (6). They pointed to Mexico's low national HIV prevalence, even among high-risk populations such as female sex workers (FSWs), among whom available HIV prevalence estimates were <1%. They contended that unlike in the United States, the HIV epidemic in Mexico had remained "nuclear," primarily affecting men who have sex with men in urban settings such as Mexico City, Guadalajara, Monterrey, and Tijuana (7). The proportion of AIDS cases attributed to the sharing of injection equipment among injection drug users (IDUs) in Mexico had consistently been <5% (6), which was attributed to the relatively few number of IDUs in most cities (6). The authors further posited that this relative containment of the HIV epidemic was a consequence of multiple prevention efforts enacted by governmental and nongovernmental organizations (NGOs). Since this review was published, epidemiologic data indicate that Mexico's HIV epidemic has evolved and that these assumptions require re-examination.

In this case study, we contrast Mexico's national and state-level HIV epidemic profile with data drawn from cross-sectional and prospective cohort studies conducted in two northern Mexican cities bordering the United States (Tijuana Baja California and Ciudad Juarez, Chihuahua). We then discuss how HIV/AIDS surveillance data initially

perpetuated spurious assumptions about the HIV epidemic profiles in these states and in Mexico overall, which hampered timely responses for targeting appropriate prevention and treatment. We show how epidemiologic data used in conjunction with qualitative data led to the recognition that the HIV epidemic in the Mexico–U.S. border region had already become well established in specific subgroups that had been presumed to be insignificant and isolated, many of whom were highly mobile.

These data played a significant role in stimulating calls for action from researchers, NGOs, and state policy makers. Several successful outcomes included formal endorsement and expansion of needle-exchange programs as a critical component to a combined HIV prevention response and the creation of a nationwide mobile HIV prevention program targeting marginalized populations. We discuss this experience in an international context and provide lessons learned to suggest ways in which other countries may benefit from how epidemiology played a key role in formulating policy for HIV prevention efforts. This case study also highlights the benefits of integrating research with training in a bi-national context, which is critical for capacity building and sustained policy responses in resource-limited settings.

CONTEXTUAL FACTORS: A CONCEPTUAL FRAMEWORK

As the HIV pandemic has unfolded, investigators, using epidemiologic and behavioral research, have identified the role that environments and social structures can play in the transmission process (8–10). Although behaviors of individuals are central to HIV transmission, the nonrandom nature of HIV transmission suggests that disease spread is influenced not only by virus–host interactions but by differences in cultural, political, economic, geographic, and social conditions (8–13).

The underlying framework that best characterizes our perspective on the intersection between epidemiologic data and HIV prevention responses in an international context is that of risk environments (10, 14, 15) and its corollary of risk clusters (16). Rhodes and colleagues (14, 17) describe the "HIV risk environment" as the space—whether social or physical—in which the interplay of factors exogenous to the individual increases their likelihood of engaging in risky behaviors that predispose to HIV infection or decreases their likelihood of accessing HIV prevention or treatment (15, 17). These exogenous factors can be categorized in terms of types (i.e., physical, social, economic, policy) that interact at the micro- and macro-levels of environmental influence. There are several important implications of this perspective.

First, this heuristic implies that HIV prevention is not merely a function of an individual's behavior but also a function of social, economic, and policy environments that act as risk regulators to present constraints and/or opportunities that shape individual behaviors (18). This approach therefore shifts the onus of responsibility for behavior change away from the individual and towards governments and policymakers, who should be tasked with creating and sustaining environmental conditions that promote safer behaviors (11, 17).

Second, the concept that HIV risk stems from a confluence of environmental factors operating at multiple spheres of influence requires that epidemiologists go beyond a narrow characterization of individual behaviors that confer protection or risk, to measure contextual circumstances that can help uncover the interactions, processes, and pathways that explain disease risk (11). Mixed methods approaches that integrate classical epidemiologic data collection with social science methodologies (e.g., ethnographic and qualitative data collection) are especially useful and can be incorporated into case-control studies, prospective cohorts, or randomized controlled trials (19).

Finally, the risk environment heuristic is consistent with the notion that HIV infections do not occur randomly within a population, and are prone to clustering (16). It is not just a matter of which environmental factors are

operating, but the fact that some subpopulations are more likely than others to experience a social structure in which risk factors intersect and cluster to potentiate HIV spread within a network (13). Farley's conceptual model of risk clustering suggests that it is not each risk factor itself that creates risk for HIV infection but rather the circumstances of how they cluster together to create an almost inescapable vulnerability (16). Below and in Figure 1, we describe factors at the physical, social, economic, and policy environment that appear to influence the HIV risk environment and risk clustering on the Mexico-U.S. border, based on the cumulative body of research.

Unique Features of the HIV Risk Environment in the Mexico-U.S. Border Region

The geographic and social landscape helps explain why the Mexico-U.S. border region is at heightened risk for infectious diseases such as HIV. Like many border regions, it is characterized by an economically disadvantaged population and exists as a nexus for drug use, prostitution, and mobility, as described in the sections to follow.

Place. The 2000-mile border between the United States and Mexico, which is the most extensive land frontier separating a developed and developing country, is a study in contrasts. The gap in median incomes between inhabitants of Mexico and the United States is the greatest between any

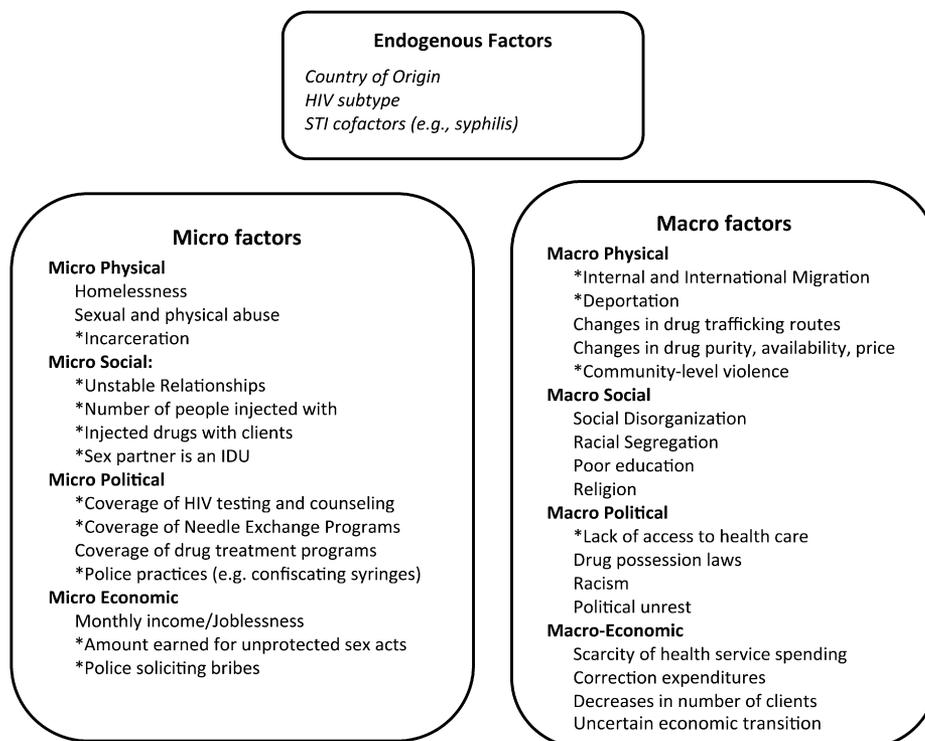


FIGURE 1. Conceptual framework depicting factors in the HIV risk environment operating in the Mexico-U.S. border region. *Factors supported by research in Mexico.

two contiguous countries (20). Of the 12.5 million people living in the Mexico–U.S. border region, 5.7 million live in Mexico, of whom, more than one-quarter live below the poverty index and only 41% of those ages 25 years and older have completed elementary school education (20). If this border region were to constitute the 51st U.S. state, it would rank last in health care access and per-capita income. It would also rank first in the number of school children living in poverty and without health care (21). Among the six Mexican–U.S. border states, Baja California has among the greatest number of physicians per capita (125 per 100,000) but the lowest number of hospitals/clinics (8.4 per 100,000) (20).

The inhabitants of the Mexico–U.S. border region tend to be young; 28.0% of Mexican border inhabitants are younger than 13 years of age (20). The large youth population in Mexico combined with their HIV-related vulnerabilities is one of the concerning factors that should drive prevention efforts. A significant percentage of Mexican youth (81%) start drinking by the age of 14 (22, 23) and come into contact with drugs or psychoactive substances between the ages of 12 and 29 years of age (22, 24).

Drug Trafficking and Drug Use. After Colombia, Mexico is the second most important source of heroin entering the United States (25); 90% of all methamphetamine entering the United States is produced in Mexico, and 70% of all cocaine entering the United States passes through Mexico (26) en route from South America. As a consequence, Tijuana and Cd. Juarez are situated on major drug-trafficking corridors (25). Illicit drug use—particularly injection drug use—has increased in Mexico during the past 10 years as local consumption markets emerged along these trafficking routes. In 1988, the first National Addictions Survey reported that 0.1% of the Mexican population used heroin, of whom 17,000 reported use in the previous year. By the time National Addictions Survey was conducted in 1993, 30,000 Mexicans reported heroin use in the previous year (27).

The greatest consumption of illegal drugs in Mexico is in Baja California. The proportion of the general population in Tijuana who are 12 to 65 years of age and who reported having ever used an illegal drug was 15%, which is almost three times the national average (28). In Mexico overall, men were 13 times more likely than women to have ever used an illicit drug, but in Tijuana the ratio was 6:1 (28). Tijuana has one of the fastest-growing IDU populations in Mexico. By 2002, heroin was the primary reason for seeking treatment for those attending drug treatment facilities in Tijuana (29); among those, nearly one-half reported that their onset of illicit drug use was between 10 and 14 years of age. Officials estimate there were ~6000 IDUs attending shooting galleries in Tijuana in 2003, but the total number of IDUs in the city is thought to be closer to 10,000 (30).

Among Mexican cities, Cd. Juarez is ranked second only to Tijuana in the number of illicit drug users, which is twice the national average. In 2001, it was estimated that there were ~6000 “heavy” heroin users in Cd. Juarez and as many as 186 *picaderos* (i.e., shooting galleries) (31) where IDUs rent and/or buy used needles. At least 200 *picaderos* were known to authorities in Tijuana in 2003 (30). Shooting galleries are uncommon in Western U.S. cities but are well known in the eastern U.S. and Puerto Rico, which experienced dramatic IDU-associated HIV epidemics linked to needle sharing in these establishments (32). However, addiction and infectious diseases are not the only health problem Mexico experiences related to drug use. Since 2007, more than 20,000 drug-related fatalities occurred nationwide in Mexico in association with warring drug-trafficking organizations. Ciudad Juarez and Tijuana have borne a disproportionate number of these deaths.

Legal and Social Context of Sex Work. Sex work is quasi-legal in Mexico. Sex with FSWs is encouraged as a display of virility and “machismo” at all socioeconomic levels (33). Many Mexican–U.S. border cities have thriving prostitution districts, or *zona rojas* (i.e., red light districts), frequented by thousands of U.S. and foreign tourists each year. Qualitative research suggests that most sex workers enter prostitution out of economic necessity, perhaps because of a failed relationship or poor working conditions in *maquiladoras* (i.e., manufacturing plants), and 95% have children (34). In some cities, such as Tijuana, a registration permit is required to practice sex work in the *zona roja*, but in practice, about one-half of the city’s estimated 9000 FSWs work without permits (35) and less than 5% of FSWs who inject drugs have permits. In other cities, such as Ciudad Juarez, the *zona rojas* exist less formally, and many sex workers have been recently displaced because of gentrification.

In Tijuana, FSWs who work in bars, motels, massage parlors, and street corners are typically highly concentrated within the *zona roja*, and the authors of a spatial epidemiology study indicated that relatively few sex work venues accounted for a large proportion of the STI burden (36). In addition, FSWs working at high-risk venues were more likely to speak English, to report drug use during sex, and were less likely to be registered with the health department. The *zona roja* in Tijuana also overlaps the *Zona Norte*, a border neighborhood known for its high density of IDUs, which leads to overlapping risks. In a recent study, nearly one-half of FSWs who injected drugs in Tijuana and Ciudad Juarez had initiated sex work before they were 18 years of age, and those that did so were more likely to report that their initiation into injection drug use had been through force (37). In our study of 400 male U.S. and Mexican men who had paid for sex with FSWs in Tijuana, one-half reported having unprotected sex with FSWs within the

last 4 months (38), which was associated with drug use during sex (39).

Migration, Cross-border Mobility, and Deportation.

Vast economic disparities between the United States and Mexico have fueled a major migration boom, drawing Mexican migrants to the United States and its border cities in search of employment. The number of manufacturing plants in the region exploded after North American Free Trade Agreement; by 2001, 2700 *maquiladoras* were operational predominantly from U.S. businesses. Between 1990 and 2000, the Mexico–U.S. border region experienced a 21% increase in population size (40), more than double the U.S. national average (40).

The Mexico–U.S. border region is also characterized by high levels of cross-border mobility. In 2008 alone, there were 44 million registered northbound crossings from Tijuana to San Diego County (41), making this the busiest land border crossing in the world. Mobile populations are often at greater risk of acquiring HIV because of changing social networks in the context of social isolation, loneliness, and the lure of anonymity (42). In our study of U.S. male clients of FSWs who had paid for sex in Tijuana in the last year, we found that they had crossed the border to pay for sex a mean number of 26 times (38). Tijuana and Ciudad Juarez are also primary corridors for migrants and truckers traveling from Central America and Southern Mexico en route to the United States. Similar dynamics of truck routes as major corridors for HIV/STI transmission have been seen in South Africa (43) and also in the United States, as the result of drug users from the Northeast traveling to the South via I-95 (44, 45).

U.S. immigration policies pose a considerable challenge to HIV prevention efforts in the United States and in Mexico. In the United States, undocumented persons are ineligible for health care and unable to access HIV testing and treatment. Between 1999 and 2007, the U.S. deported ~4.8 million migrants to Mexico; of these, ≥1.1 million migrants (~23%) were deported to Tijuana (46, 47). Many deportees stay in Tijuana to await U.S. re-entry; in 2010, more than one-half of those detained at the U.S.–Mexico border had been detained previously. Deportees are typically left at the border with no identification, few possessions, and no source of income. Many turn to drug dealing, substance use, or sex work out of desperation (48).

High levels of voluntary and involuntary mobility have influenced the sociodemographic profile of populations at high risk for HIV infection, along with their drug use and HIV risks. Among FSWs and IDUs in Tijuana and Ciudad Juarez, more than two-thirds are migrants, primarily from southern Mexican states and Central America (49, 50). Nearly one-half of migrants voluntarily returning to Mexico have ever used illicit drugs (51). Among male IDUs in Tijuana, those who had been deported from the United

States were more likely to have inject drugs daily but were less likely to receive medical care, to have ever been tested for HIV, or to have attempted drug treatment (50).

Cross-border HIV transmission is bi-directional. Across Mexico, 12.7% of Mexico's accumulated HIV cases reported through 2000 were migrants to the United States (52). However, the proportion of reported AIDS cases of Hispanic origin in San Diego County more than doubled from 19% during 1985–1989 to 44% during 2000–2004 (53). Without proper context, these statistics can spark a blame game, through which each country feels that its HIV cases are the fault of the other, which undermines efforts to improve HIV prevention and treatment on both sides of the border.

The Role of Religion. Almost 95% of Mexicans are Roman Catholics (22). The strong influence of the Catholic Church has thwarted attempts to make condoms widely accessible (54). In Mexico, some of those most vulnerable to the risk of HIV infection are those engaging in survival sex. Advocating for the use of a condom to prevent HIV transmission may seem reasonable, but this kind of leadership is largely lacking in Mexico. This opposition by the Church makes it difficult if not impossible in some areas to freely distribute condoms as a part of HIV prevention. For example, Church leaders in Tijuana have vehemently opposed harm-reduction measures (54). In both Tijuana and Ciudad Juarez, various religious groups frequently operate drug-treatment programs, some of which are not regulated by the state and have been accused of human rights violations (55).

Access to Sterile Syringes. The U.S. Congressional ban on federal support for needle-exchange programs (NEPs) and the U.S. lobby to prevent neighboring countries from supporting harm reduction contributed to Mexico's slow adoption of NEPs. Until the mid-2000s, the only active Mexican NEP was operated by an NGO in Ciudad Juarez, which began in the late 1980s and was unofficially sanctioned by Chihuahua's Secretary of Health. In 2004, Tijuana opened the second NEP in the country, operated by *Preven-casa A.C.* (56, 57) Meanwhile, CENSIDA and the National drug program (*Consejo Nacional contras las Adicciones; CONADIC*) published a position paper supporting harm reduction, including NEP, in 2003 (57), but its impact was limited until epidemiologic data spurred health officials to enact them more broadly (see timeline, Table 1).

EPIDEMIOLOGIC STUDIES OF HIV AND STIS AMONG IDUs AND FSWs IN TIJUANA AND CIUDAD JUAREZ

The first sign that drug use was more closely linked to HIV infection in the Mexico–U.S. border region than early surveillance data had suggested arose from a study of

TABLE 1. Timeline depicting HIV epidemiology surveillance and research in Mexico and the Response in the Mexico–U.S. border region

1983	First AIDS case reported in Mexico
1986	First heterosexual case of HIV among an IDU reported to the Mexican Federal health authorities
1988	Needle exchange began informally in Ciudad Juarez by an NGO (Programa Compañeros)
1990	Federal epidemiological HIV Surveillance in IDUs began in Baja California
2000	CONASIDA and the NGO Programa Compañeros published the first harm reduction manual
2003	The Mexican federal government published a position paper with the first open endorsement of the harm reduction programs
2004	The Mexican federal government develops workshops in Mexican border states for the implementation of harm reduction activities
2005	Baja California, Chihuahua, and Sonora formally begin needle-exchange programs
2006	Conasida began to distribute syringes to state-level AIDS programs
2007	Conasida commissioned a fleet of <i>condonetas</i> for all Mexican states, inspired by Tijuana's <i>Prevemovihl</i> and the NGO <i>Colectivo Sol's Condomovil</i> in Mexico City
2007	Needle-exchange programs now formally operating in seven Mexican states (Baja California, Chihuahua, Coahuila, Nuevo Leon, Oaxaca, Sonora, Zacatecas)
2007–2008	Mexican federal government establishes the first free-standing HIV/AIDS clinics in Tijuana and Ciudad Juarez (CAPACITS clinics)
2008	During the International AIDS Conference in Mexico City CONASIDA and Baja California authorities presented the first harm reduction video with BC minister of health promoting harm reduction
2009	Possession of small amounts of illicit drugs were decriminalized across Mexico Mexico was awarded \$76M in Global Fund resources in response to the HIV epidemiological data presented
2010	Mexican federal authorities signed the Vienna Declaration (www.viennadeclaration.com)
2010	Baja California Secretary of Health and federal Mexican health authorities publish <i>Lancet</i> commentary embracing harm reduction and decriminalization

AIDS = acquired immunodeficiency syndrome; HIV = human immunodeficiency virus; IDU = injection drug user; NGO = nongovernmental organization.

> 1000 pregnant women in Tijuana in 2003 (58). The prevalence of HIV was 1% overall and 6% among those who used drugs; all HIV cases were previously unidentified. Although Mexico reports low numbers of HIV-infected infants, Baja California and Chihuahua have had among the greatest rates of congenital syphilis in Mexico (59), which was an early warning that untreated syphilis could be serving as a cofactor of HIV transmission.

From 2004 to 2006, baseline results from a study of 924 FSWs in Tijuana and Cd. Juarez found that HIV prevalence was 8%; correlates of HIV infection included injection of cocaine and snorting/smoking methamphetamine (60). HIV prevalence was 12% among the subsample of FSWs who inject drugs in these cities, among whom nearly one-half had at least one active STI (61). HIV incidence among FSWs randomized to the control group of a subsequent behavioral intervention was 2 per 100 person-years (62).

In 2004, a qualitative study of IDUs in Tijuana and Ciudad Juarez was conducted through a partnership between UCSD researchers (authors S.A.S., T.L.P., and C.M.R.), Mexican NGOs (Programa Compañeros and ProComuSIDA), and Mexican health officials at the municipal, state, and federal levels. This study found that in both cities, needle sharing was normative and that problematic police practices such as confiscating syringes and arresting the IDUs on the basis of their disheveled appearance led IDUs to resort to injecting in shooting galleries (i.e., places in which IDUs inject drugs in groups with syringes that are rented or bought) (30, 63). Despite the fact that it was legal to purchase syringes at pharmacies without a prescription in

Mexico, in-depth interviews found that pharmacists often refused to sell syringes to IDUs, or charged them exorbitant prices, taking advantage of their desperate need to assuage their withdrawal symptoms (30, 64).

Drawing from these observations, the authors of a cross-sectional study subsequently recruited 207 IDUs in Tijuana and 197 in Ciudad Juarez through respondent-driven sampling. In Tijuana, recruitment of street-based IDUs was facilitated by the use of a modified recreational vehicle donated by the UCSD research team to one of the NGO partners. This *prevemovihl* (i.e., HIV prevention mobile) successfully accessed high-risk participants in the *callejones* (i.e., alleys), and in the rural *colonias* (i.e., neighborhoods). In both cities, HIV prevalence was low at 3% (65), but HCV prevalence was 95% (66). These data suggested that sharing of needles and other injection equipment in these cities could support an HIV epidemic because parenteral transmission of HCV and HIV is highly efficient. In particular, police confiscation of used and sterile syringes was associated with three-fold higher odds of receptive needle sharing in both cities (67).

A subsequent prospective study of 1056 Tijuana IDUs funded by the National Institute on Drug Abuse found that HIV prevalence among male IDUs remained low at 4% from 2006 to 2008 but had increased to 10% among female IDUs (68). Social and structural factors were more closely associated with HIV infection than individual-level behaviors. Specifically, among male IDUs, factors independently associated with HIV infection included injecting in groups, deportation from the United States, and being arrested for carrying used syringes, whereas among

female IDUs, HIV risk was independently associated with living in Tijuana for longer durations (68). A spatial analysis of HIV infections also found that these HIV infections were initially clustered in the *Zona Norte*, but incident HIV infections became dispersed after 2006, which coincided approximately with the escalation of violence and federal army presence that displaced many IDUs (69). A later study among FSWs who injected drugs in Tijuana and Cd. Juarez found that police confiscation of syringes and sharing needles with clients were both independently associated with HIV infection (70).

In addition to identifying environmental factors that exacerbated HIV risk behaviors, we found low coverage of HIV and STI testing and treatment programs, which appeared to be due in part to their centralized locations outside of the highest risk neighborhoods. In Tijuana and Ciudad Juarez, data from 2004 to 2006 suggested that only 49% of FSWs and 30% to 38% of IDUs had ever had an HIV test (71). Syphilis was consistently identified as being independently associated with HIV infection among IDUs, FSWs, and their clients (38, 60, 72). This was not surprising because approximately one-half of these syphilis infections had titers > 1:8, which is consistent with active infections that facilitate HIV transmission. Collectively, these studies suggest that factors operating at various levels in the HIV risk environment were central to shaping individual HIV risk behaviors in both cities.

Data accumulating from these epidemiologic studies were among the first estimates of HIV prevalence among FSWs and IDUs in the Mexico–U.S. border region and began to challenge assumptions that had been made about the context of the Mexican HIV epidemic. First, these data underscored the extent to which Mexico's HIV epidemic was not a single epidemic but had become regional subepidemics. Second, HIV prevalence among FSWs and female IDUs in Tijuana and Ciudad Juarez was much greater than expected, on the basis of HIV surveillance data. Third, it was now indisputable that there was considerable overlap between communities engaged in sex work and drug use. Finally, the importance of the HIV risk environment in shaping individual-level HIV risk behaviors could not be ignored, indicating that the responsibility for change should rest more on the shoulders of policy makers and program planners, rather than individuals themselves or the small under-resourced NGOs that served them.

LEVERAGING DATA TO INFLUENCING POLICY: THE ROLE OF EPIDEMIOLOGY

How could these epidemiologic data be leveraged to generate thoughtful policy changes without the United States or Mexico blaming each other for its HIV epidemic? Members of our binational team, which included federal and state

health officials, NGO leaders, and researchers, spent long hours contemplating this problem and embarked on a strategy to elicit a binational response. On the basis of available HIV prevalence and census data, we conducted a modeling exercise to estimate the number of HIV-infected persons in Tijuana by using a low-risk and a high-risk scenario. In the high-risk scenario, models were generated on the basis of the upper end of the 95% confidence intervals for each HIV prevalence estimate, which suggested that one in 125 persons aged 15 to 49 in Tijuana was infected with HIV in 2005 (73). These data indicated that the city's HIV epidemic had moved from low-level to concentrated, according to UNAIDS categorizations. Epidemiologic data were used to demonstrate the extent to which mobility was bi-directional among high-risk populations at the Mexico–U.S. border, which emphasized the potential for cross-border transmission of HIV and STIs from north to south or vice versa.

Coinciding with its publication in 2006, the findings from this paper were prepared in a press release in Spanish and English; shared with municipal, state, and federal health officials in Mexico before the press embargo was lifted; and released simultaneously to media in both countries. The findings received widespread coverage in both countries, and the research team was subsequently invited to present policy recommendations to the Governor of Baja California and the Mayor of San Diego in a joint meeting. Meanwhile, the Secretary of Health of Baja California, who had formerly served as the Health Commissioner in Tijuana, stated publicly that he endorsed NEPs as a critical component of a comprehensive strategy to prevent HIV infection. By 2008, dedicated HIV clinics (CAPACITS) were established in Tijuana and Ciudad Juarez. However, in Tijuana, local pressures from some religious and political figures forced the clinic to be located away from *colonias* where HIV was most concentrated, which remains a barrier to HIV care for vulnerable populations without means of transportation.

In 2007, following the example of using mobile vans for HIV prevention service delivery that had been employed both in Mexico City and by our NGO partner's *Prevemovihl* in Tijuana, federal and state health officials in Mexico commissioned a fleet of customized mobile vans that would later be delivered to every Mexican state. Equipped with a loudspeaker on the roof, a TV screen in the rear, adequate space for outreach workers to provide condoms and exchange syringes, and painted neon green with caricatures of dancing condoms, the *condoneta* was born. In conjunction, the national guidelines supporting harm reduction that had been published by CENSIDA without fanfare in 2005 now had ample epidemiologic data to justify the implementation of NEPs across Mexico. By 2007, there were small-scale NEPs supported by Mexico's federal government operating in seven states—Baja California, Chihuahua,

TABLE 2. Environmental HIV risk factors operating in the Mexico–U.S. border region: Implemented interventions and recommendations

HIV risk environment concept (8, 11)*	Environmental HIV risk factors identified	Recommended intervention	Interventions implemented
Physical			
Macro physical	Migration (68)	Dedicated services for migrants	–
Macro physical	Deportation (48, 50)	Change in immigration policies and practices	–
Macro physical	Sex trafficking (37)		–
Macro physical	Drug trafficking (25, 26)	Monitoring of trends in drug production, trafficking and use	Decriminalization of drug possession (75) NIDA-funded study to examine the intended and unintended consequences of drug policy reform on drug users' behaviors and HIV risks in Tijuana
Micro physical	Sex work venue (36, 84)	Venue-based interventions engaging bar owners, managers and <i>jaladores</i> (touts) (36)	
Social			
Micro social	Policing practices (63, 68, 70)	Educate police on harm reduction, HIV prevention and occupational risks of needle-stick injuries	HIV-prevention education curriculum development for police cadets
Macro social	Religion (54, 55, 85)	Education and outreach of clergy	–
Micro social	Risky client behavior (38, 39)	Develop interventions that reduce clients' HIV risk behaviors	NIDA-funded study to evaluate behavioral Intervention for clients of FSWs
Economic			
Macro economic	Limited HIV prevention resources (5)	Advocate for targeted funds for HIV prevention with local, state and federal policymakers in Mexico and the U.S.	- Global fund for HIV, TB, and Malaria awards Mexico \$76 million USD
Micro political	High cost of FSW registration (35)	Remove financial barriers to registration Evaluate policy of requiring FSWs to register to legally engage in sex work (86)	–
Micro economic	Pharmacies overcharging for syringes or refusing to sell to IDUs (30, 64)	Develop education and interventions for pharmacists	–
Policy			
Micro policy	Limited needle exchange (5, 54)		Federal and state endorsement and expand NEPs
Micro policy	Little condom access	Expand access to male and female condoms	Implementation of the <i>condoneta</i> , a mobile HIV-prevention unit, in all Mexican states
Macro policy	Low access to drug abuse treatment (55)	Provide free drug treatment on demand Expand availability of methadone and buprenorphine maintenance	Federal and state commitments in Mexico to expand drug abuse treatment
Macro policy	STI underdiagnosis (38, 60, 68, 70)	Integrate HIV, STI diagnosis and treatment services	–
Macro policy	Limited access to HIV testing/treatment (5, 58)		- Implementation of CAPISITS Clinics in Tijuana, Juarez and other Mexican cities

FSW = female sex worker; HIV = human immunodeficiency virus; IDU = injection drug user; NEP = needle-exchange program; NIDA = National Institute on Drug Abuse; STI = sexually transmitted infection.

*Also see Figure 1.

Coahuila, Nuevo Leon, Oaxaca, Sonora, and Zacatecas—and by 2010, nine Mexican states had NEPs.

The team also learned that the press could wield a double-edged sword. In 2008, a study of the male clients of FSWs in Tijuana showed that HIV prevalence was 5% and was equivalent among the clients who lived in the U.S. versus Mexico (38). More than two-thirds of FSWs in Tijuana and Ciudad Juarez reported being patronized by clients from the United States; these FSWs reported a greater tendency to inject drugs, have syphilis, and engage in unprotected sex for higher pay (74). However, the highly

politicized nature of these data proved difficult to manage; the headline from the *San Diego Tribune* read: “Sex with Americans Risky for Mexican Hookers.”

A more successful approach was met by working with U.S. health officials at the National Institute of Health to identify research questions that were of public health significance to both Mexico and the United States, which subsequently led to six successful peer-reviewed R01 grant applications with Mexican Co-PIs. In addition to funding received by the National Institute on Drug Abuse (NIDA) to study risk factors for HIV infection among IDUs at the individual,

social and environmental level, both NIDA and the National Institute of Mental Health funded behavioral intervention studies aimed at increasing condom use and reducing drug-related risk behaviors among FSWs and their clients. One such study demonstrated that a brief intervention incorporating motivational interviewing and role play surrounding condom use negotiation was associated with a 40% reduction in HIV/STI incidence among FSWs in Tijuana and Ciudad Juarez (62). A subsequent project was recently funded by NIMH with support from the Mexican federal government to study the organizational factors that promote or impede the scale-up of this intervention in 12 Mexican cities.

In 2010, NIDA funds were awarded to study the impact of drug policy reform on drug use behaviors in Tijuana, following Mexico's enactment of an unprecedented law that deregulates possession of small specified amounts of cocaine, heroin, methamphetamine, and marijuana for personal use (75). The law specifies that police who apprehend individuals who possess subthreshold amounts of these drugs will not pursue penal action until a third apprehension, when such individuals will be required to enter drug treatment or jail. This law is intended to redirect law enforcement to drug dealers and traffickers while embracing more of a harm-reduction approach with the scale-up of NEPs and methadone-maintenance treatment programs. Whether these reforms will have an impact on risk behaviors and HIV incidence is an open question, but in a high-profile *Lancet* commentary, national and state-level policy makers publicly pledged to ensure that their future health and drug policy decisions are evidence-based and grounded in a human rights approach (76).

Mexico's evolving HIV epidemic also garnered an international response. In 2009, Mexico was successful in its bid to secure funds from the Global Fund for HIV, TB and

Malaria for the first time. HIV prevalence and incidence data from the epidemiologic studies conducted on Mexico's northern border were instrumental in demonstrating that the prevalence of HIV had surpassed 5% in more than one risk group, which was a requirement for Global Fund eligibility. Accordingly, \$76M USD was awarded to scale-up HIV-prevention programs, which includes support for IDUs in Tijuana and Ciudad Juarez, as well as two cities where HIV prevalence among IDUs had recently begun to increase (i.e., Hermosillo and Guadalajara).

Central to the success of these studies is a commitment to recognizing bi-national partnerships. Study findings were published following guidelines for publication that were generated by the team that were included both U.S. and Mexican partners. NIDA, the Fogarty International Center, Hispanic Serving Health Professions Schools, and USAID also provided funding to support training programs to develop research skills and programmatic capacity-building for both U.S. and Mexican students and fellows. The majority of the team's publications to date have been led by students and fellows, many of whom are Mexican or Mexican-American.

LESSONS LEARNED

Box 1 (77–79) contrasts our experience in Mexico to an international case example that has been reported upon extensively in the HIV prevention literature: The 100% Condom Campaign in Bangkok, Thailand. In the Thai example, epidemiologic data were used to generate political will for a structural HIV prevention intervention enforcing brothels to comply to consistent condom use or suffer closure. This was shown to be a highly effective policy for controlling HIV transmission in brothel-based FSWs.

Box 1. Example of the Thai government's effective HIV prevention policies and strategies and their impact, 1991–1993.

Policy/strategy	Impact
Early recognition of HIV as a national health problem by both the Public Health Community and Government	Early coordinated collaboration and call to action by two influential public sector partners focusing on the urgency of the problem (77)
Careful analysis of the epidemiological data and trends, especially among subpopulations	Early identification of and focus on the more urgent impact and problem of HIV among sex workers and their clients (78)
Focus on HIV as a Public Health/Medical issue	Key partners were able to sidestep issues of morality and religion and focus on "high risk behaviors" instead of "high risk groups" to prevent HIV infections (77)
Deliberate and focused plan to recruit key community stakeholders, using evidence-based data and information on the current and future impact of HIV on the country	Development of the 100% Condom Use plan in brothels (77, 79) Early buy-in of the HIV-prevention plan and key interventions among sex workers and their clients by key public and private stake holders and partners (77, 79)
Ongoing epidemiological surveillance and evidence based risk reduction interventions among sex workers and their clients.	Initiated the 100% condom use program in brothels (77, 79) Increase in the use of condoms by sex workers from 14% in 1989 to 90% by 1992 (79) An estimated 200,000 new HIV infections averted between 1993 and 2000 (79)

HIV = human immunodeficiency virus.

Reliance on HIV/AIDS Surveillance Data Can Mask Emerging Regional Trends

Our case study illustrates how Mexico's early reliance on national and state-level HIV/AIDS surveillance data masked an emerging HIV subepidemic on the Mexico–U.S. border. HIV/AIDS surveillance data from India have also generated misleading results when inappropriately extrapolated to the regional level, which led the estimated number of HIV-infected persons in India to be revised significantly downward (80). In a review of the quality of HIV/AIDS surveillance data from 127 low- and middle-income countries (81), a fully functioning surveillance system was operating in only 40 countries. The authors recommended that countries with low-level and concentrated epidemics should focus on collecting serologic and behavioral data from all high risk populations, which would provide an early warning signal if HIV prevalence and incidence begins to escalate.

Simple Epidemiologic Data Can Generate Powerful Responses

Often, epidemiologic researchers rely on large-scale studies such as longitudinal cohort studies which require significant time and resource investments to determine solutions. As demonstrated in this case study, descriptive data, such as estimates of HIV prevalence, incidence, and associated risk behaviors can sometimes be sufficient for stimulating an effective policy response. By showing that HIV prevalence among some subpopulations in the Mexico–U.S. border region had surpassed the critical threshold of 5%, we demonstrated that the HIV epidemic in this region had shifted from “low level” to “concentrated,” making Mexico eligible to receive a large contract from the Global Fund. Coupled with qualitative data to provide context, simple epidemiologic data collected from multiple subgroups was also used to generate an epidemic profile that informed policy makers and program planners. This implies the need for community-based partnerships that facilitate the development of trust and sharing of information especially when working with marginalized populations that typically fall outside the health care system, and across borders.

The Importance of Risk Environment

Traditionally, epidemiologists are concerned with how individuals behave and focus interventions at the individual level. In this case study, environmental factors appeared to be the most important drivers of individual level risk behaviors (68, 70), which is consistent with the HIV risk environment heuristic (8, 11, 17) and incident HIV cases appeared to cluster (69), which supports Farley's conceptual framework (16). Moreover, systems and structural factors were

found to inhibit some subpopulations from accessing prevention programs. As shown in Table 2 (5, 8, 11, 25, 26, 30, 35–39, 48, 50, 54, 55, 58, 60, 63, 64, 68, 70, 75, 82–85) factors operating in the physical environment (voluntary and involuntary migration), social environment (police and pharmacists' practices that limited access to sterile syringes), economic environment (poverty, coupled with economic disparities between the United States and Mexico), and policy environment (low coverage of HIV and STI testing and treatment) were important underlying factors driving HIV transmission, consistent with Rhodes' heuristic of the HIV risk environment (14, 17). These findings exemplify how epidemiologic data were used to shift the responsibility for interventions towards governments and policy makers and away from individuals. The research studies presented in this case study were also informed by theory, which aided in their application to theory-based interventions. Embedding qualitative research in epidemiologic study designs was also shown to provide invaluable context and insights into potential mechanisms of risk and protection.

Mobilizing Key Stakeholders Is Critical for Generating Timely Policy Responses

This case study illustrates how involvement of policymakers and partners at all levels *from inception* is critical for developing trust, which in turn facilitates an appropriate and timely policy response. In this context, the team sought to include both Mexican and U.S. researchers and local NGOs. We engaged Mexican health officials at the municipal, state, and federal levels who not only were passive actors in terms of receiving information but at times played an active role in disseminating study results and interpreting it for the public. For example, Baja California's Secretary of Health presented results from our study at the International AIDS Conference in Mexico City in 2008 (86) and was lead author on a commentary in *Lancet* that outlined his strategy for preventing HIV and other drug-related harms (76), setting an example for other Mexican states. The case study also showed the benefits of a well-executed communication plan, by jointly issuing press releases in the US and Mexico in English and Spanish, to ensure that communities on both side of the border had equal access to study results which were used to justify the development of HIV prevention policies.

CONCLUSIONS

This case study illustrates how epidemiologic data were used to develop HIV-prevention policies directed at the Mexico–U.S. border region. The body of research presented identified several avenues for intervention that address structural

factors that potentiate HIV risks, some of which have been met with action, whereas others have yet to be addressed (Table 2). For example, police continue to confiscate syringes from drug injectors in both Tijuana and Ciudad Juarez, which undermines harm reduction initiatives such as NEPs. Although curricula have been developed to sensitize police to harm reduction, it has yet to be incorporated widely into police trainings across Mexico. Elsewhere in the United States and in South Asia, success has been met with police trainings that integrate HIV prevention with occupational safety (i.e., prevention of needle-stick injuries) to help align law enforcement with public health goals (87, 88).

Religious opposition to the promotion of condoms and sterile syringes in Mexico is another persistent barrier. In South Africa, advocating for the use of a condom not for contraceptive purposes, but to prevent the transmission of HIV has been endorsed by an Archbishop (89). In a 2010 interview (90), Pope Benedict openly stated that condom use for HIV prevention may be “justifiable in certain situations.” Although there has been much debate by religious leaders regarding what the Pope actually meant, this was the first time the qualified endorsement of condom use for HIV prevention has come directly from a Pope, marking an apparent, albeit subtle, policy shift in the Vatican’s thinking. This may prove useful for Catholic prelates and pastors in Mexico and other countries for supporting local efforts in the use of condoms to prevent HIV infections. Further development of HIV prevention policies in the Mexico–U.S. border region will therefore need to engage leaders outside the health sector.

Increased awareness of the value and benefits of considering an ecological approach to assessing “environments of risk” for HIV infection, not just individual behaviors, and the subsequent training of epidemiologists, public health scientists and other professional and lay workers on the ecological model and approach should lead to more efficient and targeted HIV prevention interventions throughout the world. Ongoing critical examination of effective and innovative evidence-based approaches to HIV prevention and the sharing of successful policies and strategies with those on the frontlines should be a high priority in the struggle against the HIV pandemic.

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