UNIVERSITY OF CALIFORNIA, SAN DIEGO

SAN DIEGO STATE UNIVERSITY

Poverty and Place: Structural Determinants of Infectious Disease Risk in Mexico and Central America

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in

Public Health (Global Health)

by

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2016

The Dissertation of Erin Elizabeth Conners is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

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Chair

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Dedication

This dissertation is dedicated to my parents, Kitty and Dave Conners, for instilling in me the importance of common sense, consideration, and a love of learning.

Thank you for reading to me when I was little.

Epigraph

"Social injustice is killing people on a grand scale."

-*Commission on Social Determinants of Health*

"…the idea that some lives matter less is the root of all that's wrong with the world."

-*Tracy Kidder, Mountains Beyond Mountains*

"In biology, nothing is clear, everything is too complicated, everything is a mess, and just when you think you understand something, you peel off a layer and find deeper complications beneath. Nature is anything but simple."

-*Richard Preston, The Hot Zone*

"You don't know what you don't know."

-*Dr. Kaiping Peng*

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Acknowledgements

Thank you to my closest friends for being a constant source of support, laughter, and adventures. I would especially like to thank Kelly Collins, Anindita Dasgupta, and Richard Armenta for their comradery throughout the PhD journey.

To my Grandpa for always reading my publications, even if it was just as an excuse to nap. Also, thank you to my fav San Diego family for keeping me well fed and providing weekend escapes.

I am grateful for my amazing primary mentor, Dr. Kimberly Brouwer, who was a continual source of guidance and a motivator through times of doubt. I could not have asked for a better advisor. I would also like to thank Dr. Thomas Novotny who tirelessly supported me in all my academic and career endeavors. I would like to thank Krissy Meckel-Parker and Valerie Mercer for their work on the *Mapa de Salud* and *Cruzando Fronteras* studies. Not only were they instrumental to helping me get these data, but I appreciate all the extra time they took to answer my questions (in both English and Spanish).

This dissertation research was supported by a UC MEXUS Dissertation Grant and NIDA T32 Training Grant (T32DA023356, PI Strathdee). I would also like to acknowledge the other financial support that I received during my time in the Joint Doctoral Program, notably the UC San Diego Friendship Scholarship, San Diego State Sharp HealthCare Health & Human Services Scholarship, and the Inamori Fellowship.

Finally I would like to thank all of my dissertation committee members, Drs. Kate Swanson, John Weeks, Mark Reed, and David FitzGerald, for their support, feedback, and unique perspectives along the way.

Chapter 2, in part, is currently being prepared for submission for publication of the material. Conners, EE, Gaines, TL, & Brouwer, KC. Structural Factors Associated with Methamphetamine Smoking Among Female Sex Workers in Mexico.

Chapter 3, in part, is currently being prepared for submission for publication of the material. Conners, EE, Mercer VJ, Fernández-Casanueva, C, & Brouwer, KC. HIV Risk Behaviors and Correlates of Inconsistent Condom Use Among Substance Using Central American Migrants.

Chapter 4, in part, is currently being prepared for submission for publication of the material. Conners, EE, Lopez-Ordonez, T, Fernández-Casanueva, C, & Brouwer, KC. Chagas Disease Among Migrants at the Mexico/Guatemala Border.

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ABSTRACT OF THE DISSERTATION

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by

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Doctor of Philosophy in Public Health (Global Health)

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Background: Structural determinants of health are gaining recognition as being a prominent force in influencing risk of infectious diseases. Both HIV and Chagas disease are strongly influenced by structural inequities and represent significant burdens of communicable disease in terms of disability-adjusted life years in Latin America. **Objective**: Using the risk environment framework as a guide, the primary objective of this dissertation is to explore physical, social, and individual factors associated with increased risk for two diseases of interest: HIV and Chagas disease. Specific aims of each manuscript chapter are: To test structural factors associated with smoking methamphetamine among a cohort of female sex workers (FSWs) in Tijuana, Baja California, Mexico (Chapter 2); To determine the

prevalence of sexual risk behaviors, HIV, and syphilis and to analyze variables associated with inconsistent condom use among casual partners among a sample of substance using migrants residing at the Mexico/Guatemala border (Chapter 3); To determine the seroprevalence of Chagas disease in regional and international migrant populations at the Mexico/Guatemala border and assess correlates of infection including migration path, sociodemographic, and socioeconomic variables (Chapter 4). **Methods**: Chapter 2 uses data from a longitudinal cohort study of FSWs in Tijuana (*Mapa de Salud*). Chapters 3 and 4 use data from a cross-sectional study among international and regional migrants at the Mexico/Guatemala border (*Cruzando Fronteras*). Chapter 4 also uses data from a UC MEXUS dissertation grant on Chagas disease. **Results**: We found that FSWs and migrants who used substances were at heightened risk for HIV via their substance use and sexual risk behaviors. The key social and physical structural factors associated with those risk behaviors were neighborhood, housing, and access to condoms. For Chagas disease, key physical structural factors were impoverished housing and being born in a rural area. **Conclusions**: The risk environment framework was a useful way to conceptualize the hypothesized relationships between structural factors and individual risk behaviors. This dissertation highlights multiple areas of structural vulnerability in order to suggest potential intervention points and shed greater light on the spaces in which our participants live.

Chapter 1. Introduction

OVERVIEW

Public health is often focused on understanding individual behaviors and biology in order to control disease risk. However, "place" can be both the context in which health occurs and a direct influencer of health. This dissertation goes upstream to examine the physical and social structural determinants of health. Structural determinants refer to the context external to an individual in which health is produced. Structural determinants of health are gaining recognition as being a prominent force in influencing risk of infectious diseases.[1-3] Therefore, the primary objective of this dissertation is to explore physical, social, and individual factors associated with increased risk for two diseases of interest: HIV and Chagas disease. Both HIV and Chagas disease are strongly influenced by structural inequities and represent significant burdens of communicable disease in terms of disability-adjusted life years (DALYs) in Latin America.[4,5] Specific aims of each manuscript chapter are:

1. To determine the prevalence and correlates of smoking methamphetamine (a risk factor for HIV) among a cohort of female sex workers (FSWs) in Tijuana, Baja California, Mexico. Structural factors include residential transience, homelessness, deportation history, arrest, and migration history.

2. To determine the prevalence of sexual risk behaviors, HIV and syphilis; and to analyze variables associated with inconsistent condom use among casual partners by gender among a sample of substance using migrants residing at the Mexico/Guatemala border. Specifically, we tested individual substance use and sexual behaviors, migration history, and social and physical structural determinants (e.g., access to condoms, separation from spouse, deportation).

3. To determine the seroprevalence of Chagas disease in regional and international migrant populations at the Mexico/Guatemala border and assess correlates of infection, including migration path, sociodemographic, and socioeconomic variables.

CONCEPTUAL FRAMEWORK

The overall conceptual framework for this dissertation research is an adaptation of Rhodes' risk environment framework.[3] The risk environment framework provides a heuristic for organizing how the space external to an individual may influence their health risks. The purpose of using such a framework is to encourage thoughts about the context where health risks are produced and "to tackle vulnerability as a means of promoting public health".[3] By identifying higher level environmental influences, one can also attempt to affect sustainable change at a population level.

The original risk environment framework, developed for reduction of drug-related harms, emphasizes physical, social, economic, and policy levels of influence at the micro (e.g., individual) and macro (e.g., national) level. This dissertation focuses on the physical and social environments at the micro and macro levels.

We chose this conceptual model because our infectious diseases of interest are strongly influenced by space. While on the surface Chagas disease and HIV appear completely distinct, both diseases disproportionately affect marginalized populations and are diseases of poverty.[4] Both HIV and Chagas are chronic, often silent, conditions where people are both largely unaware of their status and face significant barriers to accessing care.

This dissertation studies disease risk within vulnerable population groups: migrants, persons who use illicit substances, and sex workers. Additionally, all of these groups were sampled from areas of Central America and Mexico that are characterized by high levels of poverty and risk. The risk environment framework asserts that individual behaviors cannot be extricated from the surrounding context.

The risk environment framework provides a unifying focus across infectious diseases and populations. Using this conceptual framework as a guide, each manuscript chapter focuses on the social and physical risk environments and their associations with health behaviors and disease outcomes. By exploring structural associations with the outcomes (smoking methamphetamine, Chagas disease, and

inconsistent condom use) in specific populations, we aimed to identify potential future targets for intervention.

BACKGROUND

US/Mexico border context

Substance use

The Mexican city of Tijuana, Baja California is situated along the US-Mexico border and is the site of the world's busiest land border crossing.[6] In addition to the frequent movement of people, there is also the trafficking of illicit drugs, especially methamphetamine and heroin, destined for the United States.[7] In 2014, US-Mexico border methamphetamine confiscations were highest at the Southwestern border near Tijuana.[8] These major drug trafficking routes have resulted in the spread of drugs within the local Tijuana economy, resulting in higher levels of substance abuse compared to other parts of Mexico.[9,10]

Sex work

Tijuana has a well-established sex trade industry, with an estimated 9,000 women practicing sex work.[11] Sex work is concentrated in the *Zona Roja* (red light district) near the border with the US, and is legal for women who obtain a work permit from the Municipal Health Department. The permit requires monthly registration fees and regular testing for HIV and STIs at centralized facilities. The cost of the permit, along with structural barriers to testing (e.g., facility hours, unwelcome conditions) are barriers to many women working legally. Despite the

purported permissive environment, many female sex workers (FSWs) face police harassment, social stigmatization, and violence.[12-14] FSWs who use drugs are particularly targeted by police.[12,15] While sex work is concentrated in the Zona Roja, throughout the city FSWs work in a wide variety of venues including bars, hotels, on the street, private homes, and massage parlors. Chapter 1 utilizes data from a cohort of FSWs in Tijuana.

Migration

A study of FSWs in Tijuana and Ciudad Juarez (another US/Mexico border city), found that 61% of the women were migrants.[16] Another study of FSW who inject drugs found that 27% had ever migrated to the US and nearly half had been deported at least once.[17] While many FSWs in Tijuana are migrants, research is mixed as to whether migration leads to changes in health outcomes.[18-20]

In studies of men who inject drugs, deportation to the US/Mexico border has been linked to poorer living conditions, increased frequency of substance use, and greater HIV risk.[20,21] Because of the lower numbers of women deported, the potential effects of deportation on substance use or HIV risk are currently unknown.[21]

HIV

In Tijuana, the substance use and sex work economies have converged to contribute to a rise in HIV prevalence among high-risk groups. FSWs in Mexico have

an HIV prevalence as high as 6% [22], 30 times that of the national prevalence.[23,24] The prevalence is doubled again to 12% among FSWs who also inject drugs.[25]

Smoking methamphetamine

A previous study of FSWs in Mexico found women who smoked or snorted methamphetamine had 3 times higher odds of HIV infection, independent of their injection drug use.[16] In women generally, use of methamphetamine has been associated with riskier sexual behavior including sex trade, increased number of sexual partners, anal intercourse, and unprotected intercourse, as well as directly with HIV/STIs.[16,26-30]

In the Mexico/US border region, it has been hypothesized that Mexican border communities may be more vulnerable to methamphetamine epidemics via social and physical factors including migration, dislocation due to deportation, poverty, and geographic proximity to drug use environments.[31] Despite the known risks of methamphetamine, there have been no prior studies of factors associated with its use among FSW in this context. Chapter 2 examines the relationship between smoking methamphetamine and physical and social factors including homelessness, residential transience, family structure, deportation, migration, arrest, work venue type, and neighborhood.

Mexico/Guatemala border context

Migration

In contrast to the US/Mexico border, the southern Mexico border region is much more porous, and large numbers of migrants pass through the border region

between Mexico and Guatemala each day.[32] Migrants in the region are largely from Central America and are either in transit to the United States or traveling for seasonal work in one of the many fincas (plantations) in the southeastern Soconusco agricultural region of Mexico.[32]

Due to heightened violence and persistent inequality in Central America, increasing numbers of migrants are also fleeing north to the United States.[33] Among Central Americans deported from the US, close to half intend to return to the US within 12 months.[34] At the same time, enhanced immigration enforcement in Mexico is leading to rising numbers of Central American deportations.[35] Despite the heterogeneity of migration experiences in this region, the majority of research on migrant health is among Mexican migrants to and from the United States. Chapters 2 and 3 use data from a sample of Central American and Mexican regional and international migrants at the Mexico/Guatemala border.

Substance use

In addition to the movement of people, the Mexico/Guatemala border is a major transit corridor for illicit drugs destined for the United States. As much as 90% of the South American cocaine destined for the US passes through Guatemala and Mexico. Similar to the drug crisis at the northern border, in the past decade, local drug use along the Guatemala-Mexico border region has soared.[36,37] In the early 2000's, cocaine and crack use sharply increased on both sides of the Mexico/Guatemala border, a trend thought to be initiated by both US deportees and drug trafficking trends.[38-41] Recent trends in increasing amounts of seizures of

poppy crops and methamphetamine portend a similar increase of heroin and methamphetamine use in the area.[42-44]

Migration has been shown to be a social and structural driver of substance use vulnerability and HIV.[10,21,45,46] The majority of substance use literature in the Mexico/Central America region is among migrants traveling to and from the United States. Mexican migrants to the United States have been shown to have higher rates of illicit drug use, alcohol consumption, and substance abuse than their non-migrating peers.[47-49] National statistics in Mexico have found that migrants to the US have both greater lifetime use and more drug dependence than non-migrants in Mexico.[48,50] However, less is known about substance use among circular or internal migrants within Central America and Mexico. Epidemiologic data on substance use among Central American migrants and other migration pathways are lacking, but sorely needed in light of the heightened substance use risk and changing migration patterns at the Mexico/Guatemala border. Chapter 3 reports on the prevalence of specific drug use and risk behaviors among migrants with active drug use or problem drinking.

HIV

While the overall adult HIV prevalence in Guatemala (0.7%)[51] and Mexico (0.2%)[52] is low, there is a concentrated epidemic among MSM (12-18% in Guatemala, 12-22% in Mexico) and commercial sex workers (4-15% in Guatemala, 6-24% in Mexico), particularly in border regions.[51,52] Research has found overlap in migrating populations and high risk behaviors (e.g., sex work).[49,53]

Social isolation, socio-economic impacts of displacement, gender inequalities, and stigma have been identified as the key structural factors of HIV risk among migrants in Latin America.[46] A UNAIDS report on Central America suggests that the combination of unequal socioeconomic development and a highly mobile population may contribute to the spread of HIV/AIDS in the region.[54] Circular migration between the US and rural Mexican communities has been implicated in the spread of HIV in Mexico, with an estimated 25-39% of HIV infections in rural Mexico found to be in men with a travel history in the US.[55-57] In 2002 Martinez-Donate et al found no HIV in a study of 1,400 US-bound or returning migrants at the Mexico/US border, while a study 5 years later found >1% HIV prevalence in deportees, suggesting a need to understand which mobile populations are at greatest risk in order to counter the spread of disease.[56,58] Of concern, both studies found that unprotected sex with multiple partners was common, thus paving the road for rapid transmission of HIV and STIs, if exposed to risky networks.[58,59] Chapter 3 reports on the prevalence of HIV and sexual and drug risk behaviors, by gender among the migrant cohort.

Inconsistent condom use

When used correctly, condoms are highly effective at preventing the spread of sexually transmitting infections (STIs), including HIV.[60] However in order to be effective, condoms must be used at every risky sexual encounter. “Inconsistent condom use” is the term used to describe less than perfect condom use. Assessing

inconsistent condom use is one way to capture an individual or group's risk of acquiring an STI/HIV.

In Chapter 3, we present correlates of inconsistent condom use by gender. Social factors included access to healthcare services, interpersonal relationships (e.g., using drugs with a partner), and social support (i.e., migrating with friends or family). Physical determinants included migration history (e.g., previously lived in US), availability of healthcare services (e.g., free condoms) and housing status. Individual correlates studied included sexual and drug risk behaviors and sociodemographic characteristics.

Chagas disease

Chagas is a neglected tropical disease of Latin America caused by the protozoan parasite *Trypanosoma cruzi*. Chagas disease is primarily a vector-borne illness spread via the feces of infected blood feeding triatomine bugs through the bite wound.[61] Vector-borne transmission occurs only in the Americas, but successful vector control campaigns in Latin America have decreased the size of endemic areas. Without treatment, Chagas disease is a lifelong chronic infection and may be transmitted from mother to child, through blood donation, and less commonly, through tissue donation.[61-63] Human migration has changed the epidemiology of the disease, bringing infected individuals into non-endemic regions throughout Latin America and the world.[64]

Chagas disease disproportionally affects people living in poverty and is largely driven by structural inequalities.[65] The physical environment plays a key role in the transmission of Chagas disease in endemic areas. Poor housing conditions in endemic regions provide a place where the vector can live and potentially infect its occupants.[66-69]

The social environment of Chagas disease is one largely of neglect. Because it affects poor, marginalized populations knowledge of the disease and access to diagnostics and treatment are often limited.[70-73] It is hypothesized that migrants may be particularly vulnerable to contacting Chagas disease both as a function of their poverty pre-migration and living and working conditions during and post-migration.[74,75]

A recent report by the World Health Organization found Mexico had the second highest number of new Chagas disease cases due to vector transmission.[76] Prevalence estimates range from about 1% countrywide to as high as 13% in parts of the Mexican state of Chiapas at the Mexico-Guatemala border.[77,78] To the south of Mexico, Guatemala, El Salvador and Honduras account for 85% of new Chagas disease cases in Central America.[76]

The epidemiology of Chagas disease is rapidly changing because of human migration, thus Chapter 4 utilized a sample of migrants at the Mexico/Guatemala border in order to study the prevalence and correlates of Chagas disease. Chapter 4 tests whether the physical housing conditions as a child and/or recent housing

conditions are associated with Chagas disease. To examine social vulnerabilities of migrants, we also assessed migration history, Chagas disease knowledge, and medical history.

OVERVIEW OF RESEARCH STUDIES

Mapa de Salud (R01DA028692) was a longitudinal cohort study of the HIV risk environments of 301 FSWs in Tijuana. Chapter 2 uses *Mapa de Salud* baseline, 6 and 12 month data. *Cruzando Fronteras* (R01DA029899) was a cross-sectional study of substance use and HIV risk among international and regional migrants at the Mexico/Guatemala border. Chapters 3 and 4 utilize data from the *Cruzando Fronteras* study. Chapter 4 also uses data from a UC MEXUS dissertation grant (*Potential Role of Migration in Chagas Disease Expansion*) that was awarded to Erin Conners to study the prevalence and correlates of Chagas disease at the Mexico/Guatemala border. The study was nested within the *Cruzando Fronteras* migrant cohort. The grant allowed for the addition of Chagas disease testing as well as survey questions on potential correlates of Chagas disease.

REFERENCES

1. CSDH. *Closing the Gap in a Generation: Health Equity through Action on the Social Determinants of Health. Final Report of the Commission on Social Determinants of Health.* Geneva. World Health Organization 2008.

2. Marmot M. Social Determinants of Health Inequalities. *Lancet.* Mar 19-25 2005;365(9464):1099-1104.

3. Rhodes T. The 'Risk Environment': A Framework for Understanding and Reducing Drug-Related Harm. *International journal of drug policy.* 2002;13(2):85-94.

4. Hotez PJ, Dumonteil E, Woc-Colburn L, et al. Chagas Disease: "The New Hiv/Aids of the Americas". *PLoS Negl Trop Dis.* 2012;6(5):e1498.

5. World Health Organization. Daly Estimates, Who Regions, 2000-2012. 2012; http://www.who.int/healthinfo/global_burden_disease/estimates/en/index2.html. Accessed July 7, 2014.

6. Becker A, Armendariz A. California Border Crossing: San Ysidro Port of Entry Is the Busiest Land Border in the World *Huffington Post* 2012. http://www.huffingtonpost.com/2012/06/22/california-border-crossing_n_1619067.html. Accessed January 25, 2016.

7. Brouwer KC, Case P, Ramos R, et al. Trends in Production, Trafficking, and Consumption of Methamphetamine and Cocaine in Mexico. *Subst Use Misuse.* 2006;41(5):707-727.

8. US Department of Justice Drug Enforcement Agency. *2015 National Drug Threat Assessment Summary* 2015.

9. Bucardo J, Brouwer KC, Magis-Rodriguez C, et al. Historical Trends in the Production and Consumption of Illicit Drugs in Mexico: Implications for the Prevention of Blood Borne Infections. *Drug Alcohol Depend.* Sep 1 2005;79(3):281-293.

10. Rachlis B, Brouwer KC, Mills EJ, Hayes M, Kerr T, Hogg RS. Migration and Transmission of Blood-Borne Infections among Injection Drug Users: Understanding the Epidemiologic Bridge. *Drug Alcohol Depend.* Oct 8 2007;90(2-3):107-119.

11. Patterson TL, Mausbach B, Lozada R, et al. Efficacy of a Brief Behavioral Intervention to Promote Condom Use among Female Sex Workers in Tijuana and Ciudad Juarez, Mexico. *Am J Public Health.* Nov 2008;98(11):2051-2057.

12. Beletsky L, Martinez G, Gaines T, et al. Mexico's Northern Border Conflict: Collateral Damage to Health and Human Rights of Vulnerable Groups. *Rev Panam Salud Publica.* May 2012;31(5):403-410.

13. Conners EE, Silverman JG, Ulibarri M, et al. Structural Determinants of Client Perpetrated Violence among Female Sex Workers in Two Mexico-U.S. Border Cities. *AIDS Behav.* Jun 26 2015.

14. Ulibarri MDS, S.A.; Lozada, R.; Magis-Rodriguez, C.; Amaro, H.; O'Campo, P.; Patterson, T.L. Prevalence and Correlates of Client-Perpetrated Abuse among Female Sex Workers in Two Mexico-U.S. Border Citeis. *Violence Against Women.* 2014;20(4):427-445.

15. Strathdee SA, Lozada R, Martinez G, et al. Social and Structural Factors Associated with Hiv Infection among Female Sex Workers Who Inject Drugs in the Mexico-Us Border Region. *PLoS One.* 2011;6(4):e19048.

16. Patterson TL, Semple SJ, Staines H, et al. Prevalence and Correlates of Hiv Infection among Female Sex Workers in 2 Mexico-Us Border Cities. *J Infect Dis.* Mar 1 2008;197(5):728-732.

17. Ojeda VD, Burgos JL, Rangel AG, Lozada R, Vera A. U.S. Drug Use and Migration Experiences of Mexican Female Sex Workers Who Are Injection Drug Users. *J Health Care Poor Underserved.* Nov 2012;23(4):1733-1749.

18. Platt L, Grenfell P, Fletcher A, et al. Systematic Review Examining Differences in Hiv, Sexually Transmitted Infections and Health-Related Harms between Migrant and Non-Migrant Female Sex Workers. *Sexually Transmitted Infections.* 2013;89(4):311-319.

19. Ojeda VD, Strathdee SA, Lozada R, et al. Associations between Migrant Status and Sexually Transmitted Infections among Female Sex Workers in Tijuana, Mexico. *Sex Transm Infect.* Oct 2009;85(6):420-426.

20. Strathdee SA, Lozada R, Ojeda VD, et al. Differential Effects of Migration and Deportation on Hiv Infection among Male and Female Injection Drug Users in Tijuana, Mexico. *PLoS One.* 2008;3(7):e2690.

21. Pinedo M, Burgos JL, Ojeda VD. A Critical Review of Social and Structural Conditions That Influence Hiv Risk among Mexican Deportees. *Microbes Infect.* May 2014;16(5):379-390.

22. Strathdee SA, Lozada R, Semple SJ, et al. Characteristics of Female Sex Workers with Us Clients in Two Mexico-Us Border Cities. *Sex Transm Dis.* Mar 2008;35(3):263-268.

23. UNAIDS. Unaids. 2012. Human Development Report. 2012; http://www.unaids.org/en/regionscountries/countries/mexico/ Accessed February 28, 2014.

24. CENSIDA. *La Epidemia Del Vih Y El Sida En Mexico.* 2013.

25. Strathdee SA, Philbin MM, Semple SJ, et al. Correlates of Injection Drug Use among Female Sex Workers in Two Mexico-U.S. Border Cities. *Drug Alcohol Depend.* Jan 1 2008;92(1-3):132-140.

26. Zule WA, Costenbader EC, Meyer WJ, Jr., Wechsberg WM. Methamphetamine Use and Risky Sexual Behaviors During Heterosexual Encounters. *Sex Transm Dis.* Sep 2007;34(9):689-694.

27. Weiser SD, Dilworth SE, Neilands TB, Cohen J, Bangsberg DR, Riley ED. Gender-Specific Correlates of Sex Trade among Homeless and Marginally Housed Individuals in San Francisco. *J Urban Health.* Jul 2006;83(4):736-740.

28. Urada LA, Strathdee SA, Morisky DE, et al. Sex Work and Its Associations with Alcohol and Methamphetamine Use among Female Bar and Spa Workers in the Philippines. *Asia Pac J Public Health.* Mar 2014;26(2):138-146.

29. Lorvick J, Martinez A, Gee L, Kral AH. Sexual and Injection Risk among Women Who Inject Methamphetamine in San Francisco. *J Urban Health.* May 2006;83(3):497-505.

30. Kang D, Liao M, Jiang Z, et al. Commercial Sex Venues, Syphilis and Methamphetamine Use among Female Sex Workers. *AIDS Care.* Jun 2011;23 Suppl 1:26-36.

31. Case P, Ramos R, Brouwer KC, et al. At the Borders, on the Edge: Use of Injected Methamphetamine in Tijuana and Ciudad Juarez, Mexico. *J Immigr Minor Health.* Feb 2008;10(1):23-33.

32. Isacson A, Meyer M, Morales G. Mexico's Other Border: Security, Migration, and the Humanitarian Crisis at the Line with Central America. 2014; http://www.wola.org/files/mxgt/report/. Accessed September 9 2014.

33. US Department of Homeland Security. *Cbp Border Security Report.* 2014.

34. Woodhouse M. Reluctant Migration: The Vicious Cycle of Debt, Deportation and Flawed Policy That Drives Central Americans over the Border Again and Again. 2013; http://truth-out.org/news/item/13596-reluctant-migration-the-vicious-cycle-of-debt-deportation-and-flawed-policy-that-drives-central-americans-over-the-border-again-and-again. Accessed January 31, 2016.

35. Secretaría de Gobernación Mexico. *Boletín Mensual De Estadísticas Migratorias [Monthly Bulletin of Immigration Statistics].* Mexico, D.F. 2014.

36. Maertens F, Philip de Andrés A. David against Goliath: Can Mexico, Central America and the Caribbean Effectively Fight Drug Trafficking,Organised Crime and Terrorism? *FRIDE.* Feb 2009(Comment):1-10.

37. National Drug Intelligence Center - U.S. Department of Justice. National Drug Threat Assessment 2009. Document Id: 2008-Q0317-005. 2008.

38. Moser CON, McIlwaine C. *Violence in a Post-Conflict Context: Urban Poor Perceptions from Guatemala.* Washington, D.C.: The World Bank; 2000.

39. Schwartz J. Two Decades after Ravaging U.S., Crack Cocaine Sweeps Mexico. *The Oxford Press/Cox News Service.* May 20, 2005.

40. Secretaría de Salubridad y Asistencia (SSA). Sistema De Vigilancia Epidemiológica De Las Adicciones (Sisvea). Informes 2008. 2008; http://www.dgepi.salud.gob.mx/sis/descrip.htm. Accessed November 5, 2009.

41. Organization of American States - Comisión Interamericana para el Control del Abuso de Drogas (CICAD). Perfiles De Las Estadisticas Sobre Drogas Por Pais [Drug Statistics Profiles by Country]. 2006; http://www.cicad.oas.org/apps/oidstat.aspx?lang=ESP&Country=G. Accessed Nov 7, 2009.

42. Bargent J. Guatemala Poppy Eradication Campaign Takes on Rising Cultivation. *In SightCrime* 2014; http://www.insightcrime.org/news-briefs/guatemala-poppy-eradication-campaign-takes-on-rising-cultivation, October 4, 2014.

43. Prensa Libre. [Seizures of Precursors up 22%, Says Government]. 2012; http://www.prensalibre.com/noticias/justicia/Ministro-Gobernacion-Detencion-precursores-incrementa_0_756524591.html. Accessed October 4, 2014.

44. McCleskey C. Will Meth Overtake Cocaine on the Southwest Border? *In SightCrime* 2013; http://www.insightcrime.org/news-analysis/meth-cocaine-trafficking-mexico-us-southwest-border. Accessed October 4, 2014.

45. Weine SM, Kashuba AB. Labor Migration and Hiv Risk: A Systematic Review of the Literature. *AIDS Behav.* Aug 2012;16(6):1605-1621.

46. Goldenberg S, Strathdee S, Perez-Rosales M, Sued O. Mobility and Hiv in Central America and Mexico: A Critical Review. *Journal of Immigrant and Minority Health.* 2012;14(1):48-64.

47. Guerrero EG, Villatoro JA, Kong Y, Gamino MB, Vega WA, Mora ME. Mexicans' Use of Illicit Drugs in an Era of Drug Reform: National Comparative Analysis by Migrant Status. *Int J Drug Policy.* May 2014;25(3):451-457.

48. Avila HM. Migration: Health Challenges in Mexico. Paper presented at: 96th Meeting of the IOM Council2008.

49. Magis-Rodriguez C, Lemp G, Hernandez MT, Sanchez MA, Estrada F, Bravo-Garcia E. Going North: Mexican Migrants and Their Vulnerability to Hiv. *J Acquir Immune Defic Syndr.* May 1 2009;51 Suppl 1:S21-25.

50. Guerrero EG, Villatoro JA, Kong Y, et al. Barriers to Accessing Substance Abuse Treatment in Mexico: National Comparative Analysis by Migration Status. *Subst Abuse Treat Prev Policy.* 2014;9:30.

51. USAID. *Hiv/Aids Health Profile Guatemala.* 2010.

52. CENSIDA. *National Progress Report on the Response to Hiv and Aids: Mexico 2014 [Informe Nacional De Avances En La Repuesta Al Vih Y El Sida: México 2014].* 2014.

53. Sanchez MA, Hernandez MT, Hanson JE, et al. The Effect of Migration on Hiv High-Risk Behaviors among Mexican Migrants. *J Acquir Immune Defic Syndr.* Dec 15 2012;61(5):610-617.

54. USAID. *Hiv/Aids Health Profile Central America.* 2011.

55. Magis-Rodriguez C, Del Río-Zolezzi A, Valdespino-Gómez J, García-García M. Casos De Sida En El Área Rural En México. *Salud Publica Mex.* 1995;37:615-623.

56. Rangel MG, Martinez-Donate AP, Hovell MF, et al. A Two-Way Road: Rates of Hiv Infection and Behavioral Risk Factors among Deported Mexican Labor Migrants. *AIDS Behav.* Aug 2012;16(6):1630-1640.

57. Bronfman M, Sejenovich G, Uribe P. *Migración Y Sida En México Y América Central: Una Revisión De La Literatura.* Consejo Nacional para la Prevencion y Control del SIDA; 1998.

58. Martinez-Donate AP, Rangel MG, Hovell MF, Santibanez J, Sipan CL, Izazola JA. Hiv Infection in Mobile Populations: The Case of Mexican Migrants to the United States. *Rev Panam Salud Publica.* Jan 2005;17(1):26-29.

59. Rangel MG, Martinez-Donate AP, Hovell MF, Santibanez J, Sipan CL, Izazola-Licea JA. Prevalence of Risk Factors for Hiv Infection among Mexican Migrants and Immigrants: Probability Survey in the North Border of Mexico. *Salud Publica De Mexico.* Jan-Feb 2006;48(1):3-12.

60. UNAIDS. Unfpa, Who, and Unaids: Position Statement on Condoms and the Prevention of Hiv, Other Sexually Transmitted Infections and Unintended Pregnancy. 2015.

http://www.unaids.org/en/resources/presscentre/featurestories/2015/july/20150702_condoms_prevention.

61. Rassi A, Jr., Rassi A, Marin-Neto JA. Chagas Disease. *Lancet.* Apr 17 2010;375(9723):1388-1402.

62. Coura JR. The Main Sceneries of Chagas Disease Transmission. The Vectors, Blood and Oral Transmissions--a Comprehensive Review. *Mem Inst Oswaldo Cruz.* May 2015;110(3):277-282.

63. Carlier Y, Sosa-Estani S, Luquetti AO, Buekens P. Congenital Chagas Disease: An Update. *Mem Inst Oswaldo Cruz.* May 2015;110(3):363-368.

64. Pinto Dias JC. Human Chagas Disease and Migration in the Context of Globalization: Some Particular Aspects. *J Trop Med.* 2013;2013:789758.

65. Hotez PJ, Bottazzi ME, Franco-Paredes C, Ault SK, Periago MR. The Neglected Tropical Diseases of Latin America and the Caribbean: A Review of Disease Burden and Distribution and a Roadmap for Control and Elimination. *PLoS Negl Trop Dis.* 2008;2(9):e300.

66. Bustamante DM, De Urioste-Stone SM, Juarez JG, Pennington PM. Ecological, Social and Biological Risk Factors for Continued Trypanosoma Cruzi Transmission by Triatoma Dimidiata in Guatemala. *PLoS One.* 2014;9(8):e104599.

67. King RJ, Cordon-Rosales C, Cox J, Davies CR, Kitron UD. Triatoma Dimidiata Infestation in Chagas Disease Endemic Regions of Guatemala: Comparison of Random and Targeted Cross-Sectional Surveys. *PLoS Negl Trop Dis.* 2011;5(4):e1035.

68. Enger KS, Ordoñez R, Wilson ML, Ramsey JM. Evaluation of Risk Factors for Rural Infestation Bytriatoma Pallidipennis(Hemiptera: Triatominae), a Mexican Vector of Chagas Disease. *Journal of Medical Entomology.* 2004;41(4):760-767.

69. Weeks EN, Cordon-Rosales C, Davies C, Gezan S, Yeo M, Cameron MM. Risk Factors for Domestic Infestation by the Chagas Disease Vector, Triatoma Dimidiata in Chiquimula, Guatemala. *Bull Entomol Res.* 2013;103(6):634-643.

70. Minneman RM, Hennink MM, Nicholls A, et al. Barriers to Testing and Treatment for Chagas Disease among Latino Immigrants in Georgia. *J Parasitol Res.* 2012;2012.

71. Sanchez DR, Traina MI, Hernandez S, Smer AM, Khamag H, Meymandi SK. Chagas Disease Awareness among Latin American Immigrants Living in Los Angeles, California. *Am J Trop Med Hyg.* Nov 2014;91(5):915-919.

72. Pérez de Ayala Balzola A, Pérez-Molina J, Navarro Beltrá M, López-Vélez R. *Enfermedad De Chagas En Personas Procedentes De Latinoamérica Residentes En España [Chagas Disease in Persons Coming from Latin America Living in Spain].* Madrid. Ministerio de Sanidad y Politicaca Social; 2009.

73. Bonney KM. Chagas Disease in the 21st Century: A Public Health Success or an Emerging Threat? *Parasite.* 2014;21:11.

74. Bern C, Montgomery SP. An Estimate of the Burden of Chagas Disease in the United States. *Clin Infect Dis.* Sep 1 2009;49(5):e52-54.

75. Bayer AM, Hunter GC, Gilman RH, et al. Chagas Disease, Migration and Community Settlement Patterns in Arequipa, Peru. *PLoS Neglected Tropical Diseases.* 2009;3(12).

76. World Health Organization. *Chagas Disease in Latin America: An Epidemiological Update Based on 2010 Estimates.* Geneva 2015.

77. Cruz-Reyes A, Pickering-López JM. Chagas Disease in Mexico: An Analysis of Geographical Distribution During the Past 76 Years - a Review. *Memorias do Instituto Oswaldo Cruz.* 2006;101(4):345-354.

78. Pan American Health Organization. *Quantitative Estimation of Chagas Disease in the Americas.* Montevideo, Uruguay 2006.

Chapter 2. Structural Factors Associated with Methamphetamine Smoking Among Female Sex Workers in Mexico

ABSTRACT

Background: Methamphetamine use is rising in the southwestern US/Mexico border region. Methamphetamine use has been shown to be common among women and is related to a greater risk for HIV. Female sex workers (FSWs) may be at particular risk of negative health consequences of using methamphetamine, however structural determinants of methamphetamine in this setting are unknown. Objectives: To test for social and physical structural factors associated with smoking methamphetamine among a prospective cohort of FSWs in the Mexico/US border city of Tijuana, Mexico. Methods: We enrolled 301 FSWs from sex work venues throughout Tijuana. At three visits, participants underwent questionnaires on behaviors and mapping of home and work neighborhoods. We ran bivariate and multivariable multinomial logistic regression using generalized estimating equations (GEE) to identify individual, structural and neighborhood variables associated with smoking methamphetamine. Results: Methamphetamine use, particularly smoking, was highly prevalent in our sample of FSWs. More than half (61%) of the women had ever used methamphetamine in their lifetime and 38% currently smoked methamphetamine at baseline. In the final multivariate GEE model, smoking methamphetamine daily was associated with living in the red light district (OR=2.72, 95% CI=1.23-6.02) and with homelessness, but only among women with a good financial situation (OR=4.08, 95% CI=1.58-10.50). Smoking

methamphetamine less than daily was associated with older age (OR=1.06, 95% CI=1.02-1.10). Conclusions: Our findings point to the important dynamic between the home environment and more severe methamphetamine use. Given the high prevalence of smoking methamphetamine among FSWs in Tijuana, more informed drug treatment options are needed.

INTRODUCTION

Crystal methamphetamine abuse in the Americas is growing.[1] This epidemic is especially pronounced at the southwestern border of the United States and Mexico, which lies along major methamphetamine and heroin drug trafficking routes.[2] Methamphetamine seizures from the US/Mexico border have been increasing since 2008.[3,4] One of the hardest hit areas is at the California (US)/Baja California (Mexico) border between the cities of San Diego in the United States and Tijuana in Mexico.[5,6] In Baja California, methamphetamine is the most commonly cited main drug of abuse (34%) among those admitted to drug treatment centers.[7] While current figures for Tijuana are lacking, in San Diego, deaths related to methamphetamine use have increased by more than 70 percent between 2008 and 2012.[5] Methamphetamine use has numerous serious health consequences including cognitive decline, damage to the heart (cardiotoxicity), stroke, and increased risk of communicable diseases, including HIV.[8,9]

Compared to other illicit drugs that are disproportionately used by men, rates of methamphetamine use are comparable among men and women.[10,11] In the

context of Tijuana, a study of persons who inject drugs found that methamphetamine use was more prevalent among women than men (80% versus 68%) and that women were less likely to seek drug treatment.[12] A review of gender differences in methamphetamine use found that compared to men, women may initiate use earlier, be more likely to use methamphetamine exclusively, and become more dependent.[13] Motivations for using methamphetamine also differ by gender, as women are more likely than men to report using methamphetamine for weight loss, to boost energy, or to self-medicate for depression.[13,14]

The route of using methamphetamine use also often differs by gender, with women more likely to smoke methamphetamine than inject it.[12,14,15] Routes of administration affect both the duration and intensity of the high, as well as the potential for abuse and disease transmission.[9,16] The pharmacokinetics of smoking methamphetamine are most similar to injecting and both routes result in a more immediate and intense high compared to swallowing or snorting.[9] While smoking methamphetamine eliminates needle sharing as a potential pathway for the spread of blood-borne diseases, the other health harms associated with smoking methamphetamine are typically as severe as injecting.[16] Over the past decade, smoking methamphetamine has increased in Mexican border cities, mirroring the rising epidemic in the United States.[17]

Methamphetamine use has strongly been linked to riskier sexual behaviors.[18-24] While this link was first described among men who have sex with

men, a growing body of evidence shows an association between methamphetamine use and HIV/STI risk among women. Among women, use of methamphetamine is associated with the sex trade, having more sexual partners, anal intercourse, and HIV/STIs.[20-22,25,26] In a survey of pregnant women in Tijuana, methamphetamine use was the single strongest predictor of HIV infection.[27] Among women who inject drugs, use of methamphetamine has been significantly associated with both riskier sexual (e.g., more partners) and drug behaviors (e.g., syringe-sharing).[21]

Given that women are more likely to report methamphetamine use, and that methamphetamine use is associated with riskier sexual behaviors, the study of methamphetamine use among female sex workers (FSWs) is urgently needed. However, there is a dearth of information on the correlates of methamphetamine use among FSWs. In other contexts, FSWs who used methamphetamine were more likely to have unprotected sex, syphilis infection, experience homelessness, and inject heroin.[28,29] A study in Mexico found FSWs who smoked or snorted methamphetamine had 3 times higher odds of HIV infection independent of injection drug use.[22]

There is currently no standard treatment to curb methamphetamine use and treatments that are available are limited to psychosocial interventions, which may not be designed specifically for methamphetamine addiction.[9] Evidence-based treatment options are especially lacking for women who abuse substances in resource-constrained countries.[1] With individual-level interventions still nascent,

understanding the social and structural context of methamphetamine use in FSWs is urgently needed.

Rhodes' proposed Risk Environment Framework outlines how structural factors external to an individual may shape substance use risk.[30] Results from a study of FSWs in Canada pointed to the importance of physical and social environments in shaping methamphetamine use.[28] In the Mexico/US border region, it has been hypothesized that Mexican border communities may be more vulnerable to methamphetamine epidemics via social factors including migration, dislocation due to deportation, poverty, and geographic proximity to drug use environments.[31] However structural determinants of smoking methamphetamine in this setting have not been studied.

Therefore, we examined the prevalence and correlates of smoking methamphetamine among a cohort of FSWs in Tijuana, Baja California, Mexico. Using the risk environment framework to guide our analysis, we examined key physical and social vulnerabilities including venue environment, residential transience, homelessness, neighborhood, and deportation, arrest, and migration histories on the effect of methamphetamine smoking.

METHODS

Study population and recruitment

From March 2013-March 2014, 301 FSWs from Tijuana, Baja California, Mexico were enrolled into a longitudinal study examining social, spatial and

physical factors affecting HIV/STI transmission, drug use, and access to healthcare (Mapa de Salud study, NIH R01DA028692).

Participants were selected through modified time-location sampling within both indoor and street venues. Women were recruited from the Zona Roja, a concentrated red light district near the border, and from sex work venues dispersed throughout the city. No more than 15 women were recruited from any particular work venue. Recruiters were trained local Mexican field staff with previous experience working with FSWs and other vulnerable groups.

Eligibility criteria included: 1) being 18 years or older; 2) biologically female; 3) reporting having exchanged sex for money or goods in the past month; 4) willing to undergo treatment for any STIs detected; and 5) residing in Tijuana with no plans to move out of the city in the next 18 months. All participants provided written informed consent and were reimbursed $20 USD at baseline, with an additional $5 added to this amount for each follow-up visit.

Data collection

Quantitative survey

At baseline and follow-up visits every six-months, participants came into the study office for laboratory testing for HIV/STIs and a quantitative interview. Trained interviewers administered interviews in English or Spanish using computer assisted personal interview (CAPI) technology on a laptop in a private room.

The quantitative survey elicited information on sociodemographics, community and personal violence experiences, current and former substance use, sexual behaviors and experiences, sex work history, HIV knowledge, incarceration history and other interactions with police. For the present study, we used data from the baseline, 6, and 12 month follow-up visits.

Geospatial data

At each study visit participants were asked to provide the spatial location where they live, work, and use drugs (if applicable). Using Google Maps (including street view) as a visual, interviewers worked alongside participants to identify each location. All coordinates were captured in Google Maps, recorded in an Excel spreadsheet, and imported into ArcMap 10.2.2 (ESRI, Redlands, CA).

All study activities were approved by the Institutional Review Boards of the University of California, San Diego, San Diego State University, and El Colegio de la Frontera Norte in Tijuana.

Measures

Outcome variable. The outcome of interest was frequency of smoking methamphetamine coded into a three-category variable of behavior over the past 6-month period: never used, used less than daily (i.e., "occasional use"), and used once daily or more.

Substance use. Participants were asked about the frequency (lifetime or past 6 months) of use of a variety of illicit drugs by different routes of administration. We

selected the most prevalent types and routes of substance use as covariates. Any injection drug use was a dichotomous variable of "ever" use versus no use in the past 6 months and included any injection of tranquilizers, amphetamine, cocaine, methamphetamine, heroin, or combinations of heroin and cocaine (i.e., speedball), methamphetamine and cocaine, or methamphetamine and heroin. Non-injection cocaine use was a dichotomous variable of ever snorting or smoking cocaine versus no use in the past 6 months. We also asked women to select all types of places they used drugs in the past 6 months: at your home; at someone else's home; shooting gallery; other indoor site (e.g., bar, hangout); outdoor public location (e.g., alley); other.

Individual variables included age reported at baseline, years of education reported at baseline (continuous variable dichotomized to 9 years or less versus more than 9 years, which is the cutoff of compulsory education in Mexico), and has children living at home (yes versus no). Financial situation was coded from a 5 point scale into (very good/good/neutral versus bad/extremely bad). Self-report of financial situation was considered a more accurate measure than income, because it takes into account a wider range of financial hardship (e.g., debt, household expenses). Depression was calculated using the Center for Epidemiologic Studies Depression Scale (CES-D) which has a suggested cutoff score of >10 as indicating depression.[32] Years of smoking methamphetamine was calculated by subtracting age at first use from age at baseline.

Structural variables at baseline included migrant status, indicated by whether or not the participant was born in the state of Baja California (where Tijuana is located) and whether they had moved to the city because of deportation.

Sex work venue environment was captured by classifying women's primary venue as a bar/club/dance hall versus other venues or as working outdoors/on the street versus other venues. Participants were also asked if they live and work in the same place.

At baseline, arrest history was assessed by asking participants if they had ever been arrested for anything, and if so, categorical responses for how recent (within the past 30 days; 1 month or more ago, but less than 6 months; 6 months or more ago, but less than 1 year; a year or more ago). This was coded into arrest 6 months ago or more versus never/less than 6 months ago. At subsequent visits, arrest was assessed by asking if participants had been arrested in the past 6 months.

Homelessness was defined as self-reported homelessness in the past 6 months (yes versus no). Transience was coded from a continuous report of number of places lived in the past 6 months and dichotomized into: lived two or more places versus did not move.

Neighborhood variables included whether or not the woman resided in the red light district (Zona Roja) or worked in the Zona Roja. The Zona Roja was defined as encompassing the Zona Norte and Zona Centro neighborhoods. Primary work and housing locations came from the geospatial data.

Statistical analysis

Preliminary analyses included chi-square tests to compare factors across visits. Sensitivity analyses were conducted to assess if participants lost to follow-up after baseline were significantly different than participants with at least one follow-up visit. Baseline descriptive statistics and Chi-square tests were run to compare differences in variables by the outcome.

We ran bivariate and multivariable multinomial logistic regression to identify individual, structural and neighborhood variables associated with smoking methamphetamine using generalized estimating equations (GEE). GEE is used for repeated measures and accounts for correlated data within participants using a variance-covariance matrix. The multinomial outcome required the use of an independent variance-covariance matrix. An independent working correlation structure is also recommended for models with time-dependent covariates.[33,34] We assessed the matrix by comparing the robust and model-based variance-covariance matrices and determined the independent structure was acceptable. Time was by visit and classified as 0, 6, or 12 months. Both bivariate and multivariable models controlled for time. Multivariable models were a priori controlled for years of smoking methamphetamine.

Prior to model building, we ran Pearson Correlation Coefficients to assess potential collinearity. Manual forward stepwise model building proceeded using a hierarchical block method in order to see the impact of the three levels of risk (individual, structural, neighborhood). Individual-level variables significant at p=0.1

in the bivariate were first added together. Variables greater than p=0.1 in both comparisons (daily use versus none and some use versus none) were removed. Variables at p <0.1 or statistical confounders were retained and "locked" into the model. The same procedure was followed for the substance use, structural and neighborhood blocks. Any non-significant associations in the final model are the result of "locking" them in previous hierarchical blocks. Finally, we tested the following hypothesized interactions: homelessness and residential neighborhood; homelessness and financial situation; transience and residential neighborhood. All analyses were conducted using SAS software version 9.4 (SAS, Cary, NC).

RESULTS

Data from this analysis come from the baseline, 6 and 12 month visits. A total of 301 women were enrolled at baseline. Between baseline and the 6 month visit, 1 woman withdrew and 3 women died, leaving 297 able to return for follow-up. Subsequent follow-up rates were 77% (n=228) at month 6 and 79% (n=234) at month 12.

Using Chi-square goodness of fit tests, we found significant differences in transience (p<0.01), homelessness (p=0.05), working in a bar (p<0.01), and non-injection cocaine use (p<0.01) by time, with the prevalence of all four factors decreasing over the course of the study. Response rates for the outcome variable were very complete, with only one missing observation. Women who reported their primary venue was the street were more likely to return for follow-up visits.

However, there were no other statistically significant differences in baseline characteristics of women who did and did not return for at least one follow-up visit.

Baseline characteristics

Women enrolled had a median age of 32, and a majority lived at home with their children (57%) and had a spouse or steady partner (56%). Three quarters of participants had more than secundaria education (equivalent to middle school in the US) and 62% reported their financial situation as neutral to very good.

At baseline, methamphetamine was the most commonly used illicit drug (besides marijuana), with 182 (61%) of FSW reporting they had ever used it, followed in frequency by cocaine (49%) and heroin (28%). Among the 134 women who used methamphetamine in the past 6 months, smoking was the most common route of use (n=115, 86%), followed by snorting (n=49, 37%), and injecting (n=28, 21%). Women who used methamphetamine reported having done so for a median of 10 years (IQR: 6-16). At baseline 21% of women smoked methamphetamine daily, 17% smoked less than daily, and 62% never smoked methamphetamine in the past 6 months.

When asked about all the locations where they used (any) drugs, 57% of FSWs reported using drugs at home, 34% used at another public indoor location (e.g., bar, work), 27% used at someone else's home, and 11% used outside. Baseline characteristics of the women are in Table 2.1, which also shows that there were

significant differences in variables between women who did and did not smoke methamphetamine.

Longitudinal bivariate associations with methamphetamine smoking

Table 2.2 provides results from the bivariate longitudinal analysis (controlling only for time) using GEE to determine associations with smoking methamphetamine daily (versus never) and smoking less than daily (versus never).

Compared to non-methamphetamine smokers, FSWs who smoked methamphetamine daily or less than daily were more likely to: be older, have a bad financial situation, depressed, and inject drugs. Daily or occasional smokers were less likely to have their children living at home with them. Compared to non-users, daily smokers had higher odds of using non-injection cocaine and smoking methamphetamine for more years.

Structural variables positively associated with occasional or daily smoking were: primarily working on the street, living and working in the same place, being arrested in the past 6 months, having a history of deportation, living or working in the red light district,. Working in a bar was negatively associated with daily or occasional methamphetamine smoking. Transience was only associated with daily smoking of methamphetamine.

We found no relationship between non-smokers and daily or occasionally smoking methamphetamine and education level, having a spouse or steady partner, and migration history.

Longitudinal multivariable associations with methamphetamine smoking

Results of the multivariable multinomial GEE model are shown in Table 2.3. The final model controls for time, years of smoking methamphetamine, other variables significant at $p<0.1$, and variables included as a result of locking them in previous blocks.

Smoking methamphetamine less than daily was associated with older age (adjusted odds ratio [aOR]=1.06, 95% CI=1.02-1.10). Smoking methamphetamine daily was associated with living in the red light district (aOR=2.72, 95% CI=1.23-6.02). An interaction between homelessness and financial situation regressed on methamphetamine smoking was also significant (Table 2.4). Among women who had a good financial situation, those who were homeless were 4 times more likely to smoke methamphetamine daily than those who were never homeless (aOR=4.08, 95% CI=1.58-10.50). There was not a statistically significant relationship between homelessness and smoking methamphetamine daily among those with a poor financial situation (aOR=0.89, 95% CI=0.35-2.25). A sub-analysis found that homelessness was positively associated with living in the Zona Roja (OR=1.38, 95% CI:1.03-1.84, p=0.03). Figure 2.1 shows the distribution of methamphetamine smoking and homelessness in the study region.

DISCUSSION

Methamphetamine use, particularly smoking, was highly prevalent in our sample of FSWs. More than half (61%) of the women had ever used methamphetamine in their lifetime and 38% currently smoked methamphetamine

at baseline. This behavior appeared to be entrenched in the cohort, as the median length of time smoking methamphetamine was 10 years.

We found an almost 3-fold increase in the odds of smoking methamphetamine daily among women who live in the Zona Roja, independent of other individual and structural factors. Compared to non-users, smoking methamphetamine daily was also associated with homelessness, but only among women who also reported having a good financial situation. Compared to non-users, less than daily methamphetamine use was associated with older age.

The Zona Roja neighborhood is an area with a high density of sex work venues and an open and largely tolerated sex work economy. Considered a destination for sex tourism, drug and alcohol use is also common. The Zona Roja is adjacent to "The Canal", an area where injection drug use and homelessness was rampant at the time of this study. This risky sex and drug activity is thought to pervade both public spaces and the private home environment in this area.[35] Neighborhood environments have previously been shown to be independently associated with increased or riskier substance use.[36-38] While this is the first study to specifically look at the Zona Roja in terms of methamphetamine use, other studies have found associations between the area and heighted risk for HIV and STIs.[39,40] It is believed that macro-level inequalities in neighborhoods (e.g., income, segregation, deprivation) can lead to varying levels of access to harmful and helpful physical and social resources.[37]

While we found a strong relationship between smoking methamphetamine daily and the Zona Roja, we were unable to establish whether this level of use occurred prior to or after moving to the neighborhood. Prior in-depth interviews with women in sex work found both voluntary movement into the Zona Roja in order to fund substance use and initiation of substance use after arrival.[41,42] Research in other contexts has also been mixed as to whether substance use or poor housing is the "causal" factor.[36,43] While knowing which came first can have implications for prioritizing interventions (e.g., providing housing versus providing substance use treatment), it's important to recognize that the relationship is likely a dynamic one.[43] Future work should explore the specific pathways in which the Zona Roja and methamphetamine use interact (e.g., through social networks or lack of supportive resources), as these pathways may indicate targets for intervention.

We found that FSWs who experienced a period of homelessness, but still maintained a good financial situation, were more likely to smoke methamphetamine daily. A sub-analysis also found that homelessness was higher in the Zona Roja than in other areas of Tijuana. Substance use may increase as a way to cope with the stressors of being homeless, however whether women can actually access the drug is limited by economics.[44,45] This economic finding echoes another study conducted among women who inject drugs in Tijuana, which found that higher income was associated with smoking methamphetamine.[12]

Only older age was associated with less than daily smoking of methamphetamine, compared to non-smokers. Daily use was not associated with older age, which could reflect that more entrenched and extreme cases of substance abuse may have been less likely to participate in our study. There may also be a smaller cohort of older, daily users given that negative health effects of methamphetamine may lead to greater mortality.[9]

We did not find any structural factors associated with less than daily smoking methamphetamine. It could be that this group reflects a more mixed group of women - those who are occasional users as well as more frequent users who have cycled off daily use because of economics or availability. Thus finding structural factors associated with the continuum of methamphetamine use would likely warrant a larger sample of women who use methamphetamine.

The majority of women reported that they used drugs within their home. This is similar to qualitative and spatial research among women who use drugs in Tijuana, which found women prefer to buy and use drugs within their homes or in the neighborhood close by.[39,46,47] The risk environment of FSWs is often framed in terms of the workplace environment rather than the home, because of the emphasis on understanding HIV risk.[48,49] While we found residential neighborhood to be associated with daily methamphetamine use, we did not find an association between venue type or venue neighborhood and smoking methamphetamine. This differs from a study of street-based FSWs in Canada, which found methamphetamine use

was associated with working in industrial areas.[28] While venues remain an important intervention point for FSWs, especially in terms of HIV risk, we believe that more work is needed to understand how the home environments of FSWs influence their substance use.

Current rehabilitation centers in Tijuana predominantly serve men and suffer from unstandardized treatment, overcrowding, and poor conditions.[7,50] Without a supportive rehabilitation environment that is tailored to women with methamphetamine addiction, treatment is likely to fail. In light of our findings about the important relationship between the home environment and methamphetamine use, we suggest two strategies that warrant consideration for intervention. The first strategy is to work within the Zona Roja neighborhood to support women living there who want to reduce their methamphetamine use. The second is the development of safe and affordable supportive housing located outside of the Zona Roja as a potential rehabilitation option for FSWs who want to reduce their methamphetamine use. "Housing first" strategies prioritize getting people into stable housing first, followed by provision of any necessary services (e.g., mental health, drug treatment). While this approach has been successful in retaining persons who use substances in stable housing, whether it leads to a reduction in substance use is unclear.[51-54] However, the potential public health benefits resulting from safe and supportive housing for FSWs extend beyond methamphetamine addiction.[55-57]

The results of this analysis should be considered in light of certain limitations. First, we were not able to determine causality between the covariates and smoking methamphetamine. Secondly, data were self-reported and therefore may have underestimated undesirable behaviors, biasing results towards the null. Finally, because women whose primary venue was the street were more likely to have returned for a follow-up visit, our findings may not be representative of all groups of FSWs working in Tijuana.

Conclusions

Given the high prevalence of smoking methamphetamine among FSWs in Tijuana, more informed drug treatment options are needed. Our findings point to the important dynamic between the home environment and more severe methamphetamine use. Future work in the region should explore particular mechanisms that link the residential neighborhood to individual substance use behaviors.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the women who participated in this study. Funding for this study was provided by the National Institute on Drug Abuse (NIDA) R01DA028692. Erin Conners was supported by a NIDA T32 training grant (T32DA023356).

Chapter 2, in part, is currently being prepared for submission for publication of the material. Conners, EE, Gaines, TL, & Brouwer, KC. Structural factors associated with methamphetamine smoking among female sex workers in Mexico.

Table 2.1 Characteristics of female sex workers by reported frequency of smoking methamphetamine in the past 6 months, baseline visit, Tijuana (N=301)

		Smoked methamphetamine, past 6 months			
	Total N=301	**Never n=186**	**Occasionally n=52**	**Daily n=63**	**Chi-2**
	N(%)	**n (%)**	**n (%)**	**n (%)**	**(p-value) †**
Socio-demographic factors					
Median age, years (IQR)	32 (25-40)	30 (23-37)	35 (27-45)	33 (29-42)	12.10 (<0.01)
≤9 years of education (ref: >9years) (n=292)	74 (25)	44 (24)	15 (31)	15 (24)	0.86 (0.65)
Current financial situation bad or extremely bad (ref: very good to neutral)	113 (38)	61 (33)	23 (44)	29 (46)	4.72 (0.09)
Currently lives with children at home	172 (57)	125 (68)	25 (48)	22 (35)	22.68 (<0.01)
Has spouse or steady partner	169 (56)	100 (54)	27 (52)	42 (67)	3.64 (0.16)
Current depression (CES-D ≥10)	190 (64)	106 (57)	37 (73)	47 (76)	9.26 (0.01)
Substance use					
Injection drug use (any drug)[a]	71 (24)	18 (10)	19 (37)	34 (54)	57.07 (<0.01)
Non-injection cocaine use[a]	52 (17)	23 (12)	11 (21)	18 (29)	9.31 (<0.01)
Median years smoking methamphetamine (IQR)	10 (6-16)	8 (5-13)	8 (3-15)	13 (8-18)	15.84 (<0.01)
Structural					
Primary work venue a bar/club, past 30 days	98 (33)	75 (40)	14 (27)	9 (14)	15.44 (<0.01)
Primary work venue the street, past 30 days	90 (30)	36 (19)	17 (33)	37 (59)	35.04 (<0.01)
Currently live and work in same place	22 (7)	4 (2)	6 (12)	12 (19)	21.49 (<0.01)
Self-reported homelessness[a] (ref: stably housed)	69 (23)	26 (14)	10 (19)	33 (52)	39.76 (<0.01)
Transience[a] (ref: lived 1 place)	102 (34)	51 (27)	19 (37)	32 (51)	11.67 (<0.01)
Arrested[a]	70 (23)	21 (11)	18 (35)	31 (49)	42.12 (<0.01)
Born outside Baja California ("migrant")	193 (64)	125 (67)	31 (60)	37 (59)	2.02 (0.36)
Moved to city because deported from US	18 (6)	4 (2)	5 (10)	9 (14)	13.80 (<0.01)
Neighborhood					
Primary residence in the red light district	81 (28)	31 (18)	16 (33)	34 (54)	30.71 (<0.01)
Primary work venue in the red light district	172 (59)	93 (51)	31 (61)	48 (79)	14.14 (<0.01)

† P-values are based on chi-square tests, non-parametric Kruskal-Wallis Test or Fisher's Exact test

[a] Within the past 6 months

Table 2.2 Bivariate GEE logistic regression analysis of factors associated with methamphetamine smoking frequency in the past 6 months among female sex workers in Tijuana, Mexico

	Smoke methamphetamine less than daily [b]			Smoke methamphetamine daily [b]		
	uOR†	**(95% C.I.)**	**p-value**	**uOR†**	**(95%C.I.)**	**p-value**
Socio-demographic factors						
Age	1.04	(1.01-1.07)	**<0.01**	1.03	(1.01-1.06)	**0.02**
≤9 years of education (ref: >9years) (n=292)	1.18	(0.64-2.19)	0.60	0.92	(0.48-1.76)	0.80
Current financial situation bad or extremely bad (ref: very good to neutral)	2.11	(1.22-3.35)	**<0.01**	2.70	(1.73-4.22)	**<0.01**
Currently lives with children at home	0.40	(0.23-0.70)	**<0.01**	0.35	(0.20-0.62)	**<0.01**
Current spouse or steady partner	1.03	(0.64-1.65)	0.90	1.33	(0.84-2.13)	0.23
Current depression (CES-D ≥10)	1.74	(1.09-2.78)	**0.02**	2.25	(1.41-3.59)	**<0.01**
Substance use						
Injection drug use (any drug)[a]	3.95	(2.19-7.11)	**<0.01**	7.62	(4.23-13.74)	**<0.01**
Non-injection cocaine use [a]	1.27	(0.65-2.48)	0.49	2.02	(1.14-3.58)	**0.02**
Years of smoking methamphetamine	1.01	(0.96-1.06)	0.67	1.09	(1.04-1.14)	**<0.01**
Structural						
Primary work venue a bar/club, past 30 days	0.40	(0.22-0.73)	**<0.01**	0.23	(0.11-0.46)	**<0.01**
Primary work venue the street, past 30 days	1.88	(1.14-3.12)	**0.01**	4.98	(3.09-8.02)	**<0.01**
Live and work in same place	3.99	(1.80-8.81)	**<0.01**	7.00	(3.02-16.24)	**<0.01**
Self-reported homelessness [a] (ref: stably housed)	1.73	(1.02-2.91)	**0.04**	4.38	(2.64-7.26)	**<0.01**
Transience [a] (ref: lived 1 place)	1.51	(0.91-2.51)	0.11	2.39	(1.55-3.70)	**<0.01**
Arrested [a]	2.89	(1.70-4.93)	**<0.01**	5.67	(3.48-9.25)	**<0.01**
Born outside Baja California ("migrant")	0.82	(0.48-1.41)	0.47	0.73	(0.41-1.30)	0.28
Moved to city because deported from US	4.69	(1.67-13.20)	**<0.01**	4.85	(1.63-14.45)	**<0.01**
Neighborhood						
Primary residence in the red light district	2.06	(1.17-3.62)	**<0.01**	4.59	(2.64-7.97)	**<0.01**
Primary work venue in the red light district	2.17	(1.23-3.85)	**<0.01**	3.59	(1.97-6.52)	**<0.01**

† All models were adjusted for months since baseline visit

[a] Within the past 6 months

[b] Reference group: Never smoked methamphetamine

Table 2.3 Multivariable GEE logistic regression analysis of factors associated with methamphetamine smoking frequency in the past 6 months among female sex workers in Tijuana, Mexico

	Smoke methamphetamine, less than daily [b]			Smoke methamphetamine, daily [b]		
	OR†	**95% CI**	**p-value**	**OR†**	**95% CI**	**p-value**
Socio-demographic						
Age	**1.06**	**(1.02-1.10)**	**0.01**	0.99	(0.94-1.03)	0.61
Current depression (CES-D ≥10)	1.35	(0.71-2.58)	0.36	1.68	(0.89-3.20)	0.11
Substance use						
Injection drug use (any drug)[a]	1.20	(0.55-2.59)	0.65	1.67	(0.79-3.52)	0.18
Non-injection cocaine use[a]	1.34	(0.58-3.80)	0.49	1.72	(0.78-3.75)	0.18
Structural						
Primary work venue the street, past 30 days	0.91	(0.43-1.92)	0.81	1.62	(0.81-3.23)	0.17
Currently live and work in same place	2.38	(0.88-6.43)	0.09	2.72	(0.85-8.70)	0.09
Neighborhood						
Primary residence in the red light district	1.08	(0.49-2.38)	0.84	**2.72**	**(1.23-6.02)**	**0.01**

† All models were adjusted for all other variables listed, years of meth use, time (in months) of study visit, and an interaction term between homelessness and financial situation (see table 2.4)
‡ Model also adjusted for interaction term between financial situation and homelessness
[a] Within the past 6 months
[b] Reference group: Never smoked methamphetamine

Table 2.4 Interaction between financial situation and homelessness among daily methamphetamine smokers (reference: non-users)

Good financial situation		Poor financial situation	
	OR (95% CI)		**OR (95% CI)**
Not homeless	1.00	Not homeless	1.00
Homeless	**4.08 (1.58-10.50)**	Homeless	0.89 (0.35-2.25)

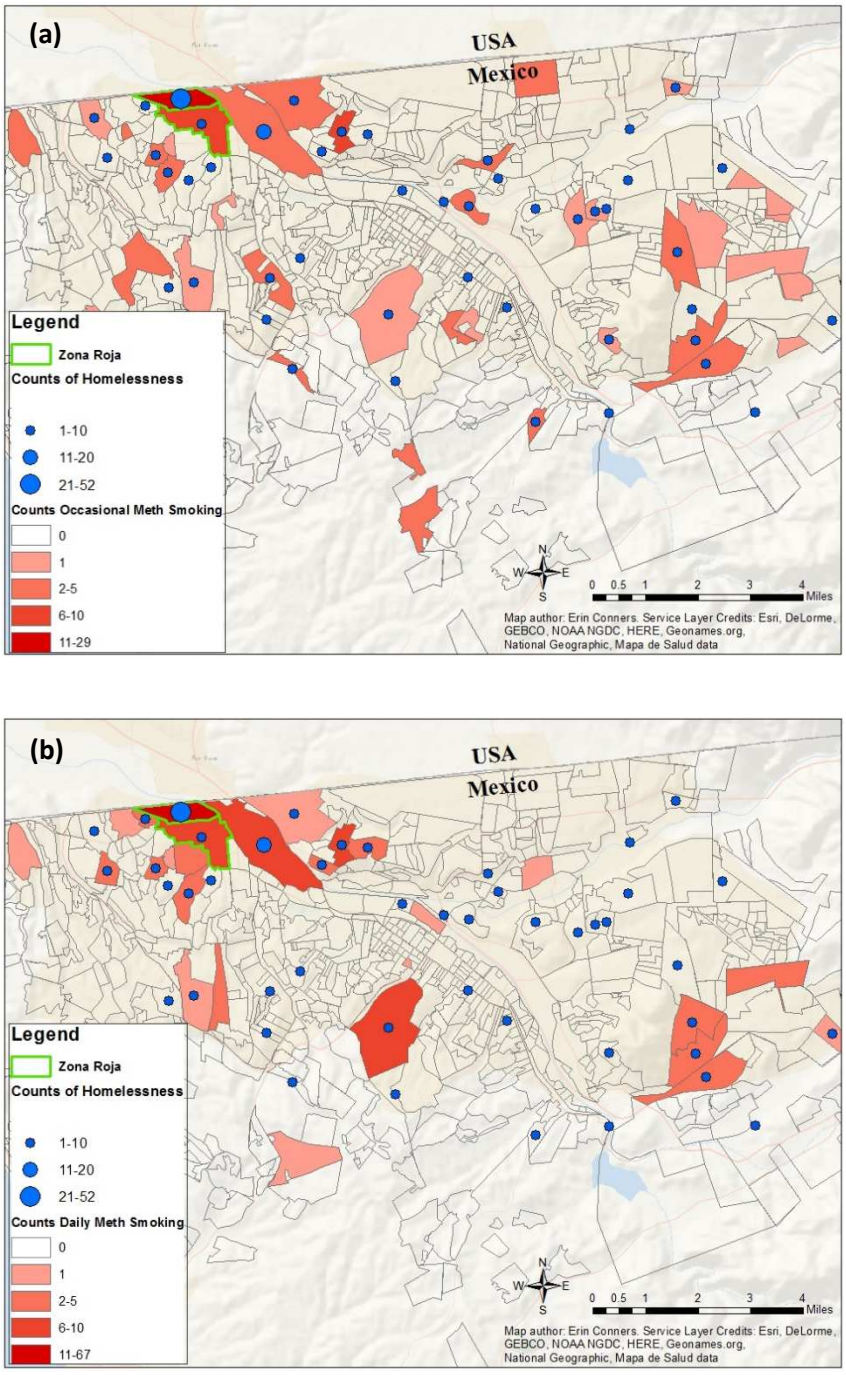

Figure 2.1 Counts of (a) occasional and (b) daily methamphetamine smoking and homelessness by neighborhood of residence, all study visits

REFERENCES

1. United Nations Office on Drugs and Crime. *World Drug Report.* 2015.

2. Brouwer KC, Case P, Ramos R, et al. Trends in Production, Trafficking, and Consumption of Methamphetamine and Cocaine in Mexico. *Subst Use Misuse.* 2006;41(5):707-727.

3. Stevens E. Us Meth Production Falls as Mexican Imports Increase. *InSight Crime.* 2015. http://www.insightcrime.org/news-briefs/us-meth-production-falls-as-mexican-imports-increase.

4. US Department of Justice Drug Enforcement Agency. *2015 National Drug Threat Assessment Summary* 2015.

5. US Department of Justice Drug Enforcement Agency. *2014 National Drug Threat Assessment Summary* 2014.

6. Lopez-Zetina J, Sanchez-Huesca R, Rios-Ellis B, Friis R, Torres-Vigil I, Rogala B. Initiation to Methamphetamine Use in a Binational Sample of Women at the Us-Mexico Border. *J Ethn Subst Abuse.* 2010;9(1):28-39.

7. Secretaría de Prevención y Promoción de La Salud. *Sistema De Vigilancia Epidemiológica Para Las Adicciones (Sisvea) Informe 2014.* 2014.

8. Darke S, Kaye S, McKetin R, Duflou J. Major Physical and Psychological Harms of Methamphetamine Use. *Drug Alcohol Rev.* May 2008;27(3):253-262.

9. Courtney KE, Ray LA. Methamphetamine: An Update on Epidemiology, Pharmacology, Clinical Phenomenology, and Treatment Literature. *Drug Alcohol Depend.* Oct 1 2014;143:11-21.

10. Substance Abuse and Mental Health Services Administration. *The Teds Report: Gender Differences in Primary Substance of Abuse across Age Groups.* Rockville, MD. 2014.

11. Cohen JB, Greenberg R, Uri J, Halpin M, Zweben JE. Women with Methamphetamine Dependence: Research on Etiology and Treatment. *J Psychoactive Drugs.* Nov 2007;Suppl 4:347-351.

12. Rusch ML, Lozada R, Pollini RA, et al. Polydrug Use among Idus in Tijuana, Mexico: Correlates of Methamphetamine Use and Route of Administration by Gender. *J Urban Health.* Sep 2009;86(5):760-775.

13. Dluzen DE, Liu B. Gender Differences in Methamphetamine Use and Responses: A Review. *Gend Med.* Mar 2008;5(1):24-35.

14. Brecht ML, O'Brien A, von Mayrhauser C, Anglin MD. Methamphetamine Use Behaviors and Gender Differences. *Addict Behav.* Jan 2004;29(1):89-106.

15. Semple SJ, Grant I, Patterson TL. Female Methamphetamine Users: Social Characteristics and Sexual Risk Behavior. *Women & Health.* 2005;40(3):35-50.

16. McKetin R, Ross J, Kelly E, et al. Characteristics and Harms Associated with Injecting Versus Smoking Methamphetamine among Methamphetamine Treatment Entrants. *Drug Alcohol Rev.* May 2008;27(3):277-285.

17. Maxwell JC, Cravioto P, Galvan F, Ramirez MC, Wallisch LS, Spence RT. Drug Use and Risk of Hiv/Aids on the Mexico-USA Border: A Comparison of Treatment Admissions in Both Countries. *Drug Alcohol Depend.* May 2006;82:S85-S93.

18. Schwarcz S, Scheer S, McFarland W, et al. Prevalence of Hiv Infection and Predictors of High-Transmission Sexual Risk Behaviors among Men Who Have Sex with Men. *Am J Public Health.* Jun 2007;97(6):1067-1075.

19. Carey JW, Mejia R, Bingham T, et al. Drug Use, High-Risk Sex Behaviors, and Increased Risk for Recent Hiv Infection among Men Who Have Sex with Men in Chicago and Los Angeles. *AIDS Behav.* Dec 2009;13(6):1084-1096.

20. Zule WA, Costenbader EC, Meyer WJ, Jr., Wechsberg WM. Methamphetamine Use and Risky Sexual Behaviors During Heterosexual Encounters. *Sex Transm Dis.* Sep 2007;34(9):689-694.

21. Lorvick J, Martinez A, Gee L, Kral AH. Sexual and Injection Risk among Women Who Inject Methamphetamine in San Francisco. *J Urban Health.* May 2006;83(3):497-505.

22. Patterson TL, Semple SJ, Staines H, et al. Prevalence and Correlates of Hiv Infection among Female Sex Workers in 2 Mexico-Us Border Cities. *J Infect Dis.* Mar 1 2008;197(5):728-732.

23. Forrest DW, Metsch LR, LaLota M, Cardenas G, Beck DW, Jeanty Y. Crystal Methamphetamine Use and Sexual Risk Behaviors among Hiv-Positive and Hiv-Negative Men Who Have Sex with Men in South Florida. *J Urban Health.* May 2010;87(3):480-485.

24. Hoenigl M, Chaillon A, Moore DJ, Morris SR, Smith DM, Little SJ. Clear Links between Starting Methamphetamine and Increasing Sexual Risk Behavior: A Cohort Study among Men Who Have Sex with Men. *J Acquir Immune Defic Syndr.* Nov 2 2015.

25. Weiser SD, Dilworth SE, Neilands TB, Cohen J, Bangsberg DR, Riley ED. Gender-Specific Correlates of Sex Trade among Homeless and Marginally Housed Individuals in San Francisco. *J Urban Health.* Jul 2006;83(4):736-740.

26. Urada LA, Strathdee SA, Morisky DE, et al. Sex Work and Its Associations with Alcohol and Methamphetamine Use among Female Bar and Spa Workers in the Philippines. *Asia Pac J Public Health.* Mar 2014;26(2):138-146.

27. Viani RM, Araneta MR, Ruiz-Calderon J, et al. Perinatal Hiv Counseling and Rapid Testing in Tijuana, Baja California, Mexico: Seroprevalence and Correlates of Hiv Infection. *J Acquir Immune Defic Syndr.* Jan 1 2006;41(1):87-92.

28. Shannon K, Strathdee S, Shoveller J, Zhang R, Montaner J, Tyndall M. Crystal Methamphetamine Use among Female Street-Based Sex Workers: Moving Beyond Individual-Focused Interventions. *Drug Alcohol Depend.* Jan 1 2011;113(1):76-81.

29. Kang D, Liao M, Jiang Z, et al. Commercial Sex Venues, Syphilis and Methamphetamine Use among Female Sex Workers. *AIDS Care.* Jun 2011;23 Suppl 1:26-36.

30. Rhodes T. The 'Risk Environment': A Framework for Understanding and Reducing Drug-Related Harm. *International journal of drug policy.* 2002;13(2):85-94.

31. Case P, Ramos R, Brouwer KC, et al. At the Borders, on the Edge: Use of Injected Methamphetamine in Tijuana and Ciudad Juarez, Mexico. *J Immigr Minor Health.* Feb 2008;10(1):23-33.

32. Andresen EM, Malmgren JA, Carter WB, Patrick DL. Screening for Depression in Well Older Adults: Evaluation of a Short Form of the Ces-D (Center for Epidemiologic Studies Depression Scale). *Am J Prev Med.* Mar-Apr 1994;10(2):77-84.

33. Pepe MS, Anderson GL. A Cautionary Note on Inference for Marginal Regression-Models with Longitudinal Data and General Correlated Response Data. *Communications in Statistics-Simulation and Computation.* 1994;23(4):939-951.

34. Lalonde TL, Nguyen AQ, Yin J, Irimata K, Wilson JR. Modeling Correlated Binary Outcomes with Time-Dependent Covariates. *J Data Sci.* 2013;11:715-738.

35. Goldenberg SM, Strathdee SA, Gallardo M, Rhodes T, Wagner KD, Patterson TL. "Over Here, It's Just Drugs, Women and All the Madness": The Hiv Risk Environment of Clients of Female Sex Workers in Tijuana, Mexico. *Soc Sci Med.* Apr 2011;72(7):1185-1192.

36. Chami G, Werb D, Feng C, DeBeck K, Kerr T, Wood E. Neighborhood of Residence and Risk of Initiation into Injection Drug Use among Street-Involved Youth in a Canadian Setting. *Drug Alcohol Depend.* Oct 1 2013;132(3):486-490.

37. Galea S, Rudenstine S, Vlahov D. Drug Use, Misuse, and the Urban Environment. *Drug Alcohol Rev.* Mar 2005;24(2):127-136.

38. Hembree C, Galea S, Ahern J, et al. The Urban Built Environment and Overdose Mortality in New York City Neighborhoods. *Health Place.* Jun 2005;11(2):147-156.

39. Brouwer KC, Rusch ML, Weeks JR, et al. Spatial Epidemiology of Hiv among Injection Drug Users in Tijuana, Mexico. *Ann Assoc Am Geogr.* 2012;102(5):1190-1199.

40. Rusch ML, Brouwer KC, Lozada R, Strathdee SA, Magis-Rodriguez C, Patterson TL. Distribution of Sexually Transmitted Diseases and Risk Factors by Work Locations among Female Sex Workers in Tijuana, Mexico. *Sex Transm Dis.* Oct 2010;37(10):608-614.

41. Goldenberg S, Silverman J, Engstrom D, Bojorquez-Chapela I, Strathdee S. “Right Here Is the Gateway”: Mobility, Sex Work Entry and Hiv Risk Along the Mexico-U.S. Border. *International Migration.* Epub June 14 2013.

42. Goldenberg SM, Silverman JG, Engstrom D, et al. Exploring the Context of Trafficking and Adolescent Sex Industry Involvement in Tijuana, Mexico: Consequences for Hiv Risk and Prevention. *Violence Against Women.* Apr 2015;21(4):478-499.

43. Roy E, Robert M, Vaillancourt E, Boivin JF, Vandermeerschen J, Martin I. Residential Trajectory and Hiv High-Risk Behaviors among Montreal Street Youth--a Reciprocal Relationship. *J Urban Health.* Aug 2011;88(4):767-778.

44. Dickson-Gomez J, Hilario H, Convey M, Corbett AM, Weeks M, Martinez M. The Relationship between Housing Status and Hiv Risk among Active Drug Users: A Qualitative Analysis. *Subst Use Misuse.* 2009;44(2):139-162.

45. Latkin CA, Williams CT, Wang J, Curry AD. Neighborhood Social Disorder as a Determinant of Drug Injection Behaviors: A Structural Equation Modeling Approach. *Health Psychol.* Jan 2005;24(1):96-100.

46. Loza O, Ramos R, Ferreira-Pinto J, Hernandez MT, Villalobos SA. A Qualitative Exploration of Perceived Gender Differences in Methamphetamine Use among Women Who Use Methamphetamine on the Mexico–U.S. Border. *J Ethn Subst Abuse.* 2015:1-20.

47. Cruz MF, Mantsios A, Ramos R, et al. A Qualitative Exploration of Gender in the Context of Injection Drug Use in Two Us-Mexico Border Cities. *AIDS Behav.* Mar 2007;11(2):253-262.

48. Shannon K, Strathdee SA, Goldenberg SM, et al. Global Epidemiology of Hiv among Female Sex Workers: Influence of Structural Determinants. *Lancet.* Jan 3 2015;385(9962):55-71.

49. Pitpitan EV, Kalichman SC, Eaton LA, Strathdee SA, Patterson TL. Hiv/Sti Risk among Venue-Based Female Sex Workers across the Globe: A Look Back and the Way Forward. *Curr HIV/AIDS Rep.* Mar 2013;10(1):65-78.

50. Guerrero J. Tijuana Mandates Drug Treatment for Hundreds of Homeless. *KPBS.* 2015. http://www.kpbs.org/news/2015/apr/13/tijuana-homeless-get-compulsory-treatment/.

51. Palepu A, Patterson ML, Moniruzzaman A, Frankish CJ, Somers J. Housing First Improves Residential Stability in Homeless Adults with Concurrent Substance Dependence and Mental Disorders. *Am J Public Health.* Dec 2013;103 Suppl 2:e30-36.

52. Edens EL, Tsai J, Rosenheck RA. Does Stimulant Use Impair Housing Outcomes in Low-Demand Supportive Housing for Chronically Homeless Adults? *Am J Addict.* May-Jun 2014;23(3):243-248.

53. Kertesz SG, Crouch K, Milby JB, Cusimano RE, Schumacher JE. Housing First for Homeless Persons with Active Addiction: Are We Overreaching? *Milbank Q.* Jun 2009;87(2):495-534.

54. Kirst M, Zerger S, Misir V, Hwang S, Stergiopoulos V. The Impact of a Housing First Randomized Controlled Trial on Substance Use Problems among

Homeless Individuals with Mental Illness. *Drug Alcohol Depend.* Jan 1 2015;146:24-29.

55. Reed E, Gupta J, Biradavolu M, Devireddy V, Blankenship KM. The Role of Housing in Determining Hiv Risk among Female Sex Workers in Andhra Pradesh, India: Considering Women's Life Contexts. *Soc Sci Med.* Mar 2011;72(5):710-716.

56. Duff P, Deering K, Gibson K, Tyndall M, Shannon K. Homelessness among a Cohort of Women in Street-Based Sex Work: The Need for Safer Environment Interventions. *BMC Public Health.* 2011;11:643.

57. Lazarus L, Chettiar J, Deering K, Nabess R, Shannon K. Risky Health Environments: Women Sex Workers' Struggles to Find Safe, Secure and Non-Exploitative Housing in Canada's Poorest Postal Code. *Soc Sci Med.* Dec 2011;73(11):1600-1607.

Chapter 3. HIV Risk Behaviors and Correlates of Inconsistent Condom Use Among Substance Using Central American Migrants

ABSTRACT

Background: The prevalence of sexual and drug risk behaviors among migrants within Central America and Mexico is largely unknown. Among Latino migrants, casual partner relationships have been associated with greater risk behaviors than either commercial sex partners or spouses. Methods: This study assessed the prevalence of sexual risk behaviors and STIs and correlates of inconsistent condom use with casual partners, among a sample of 392 migrants at the Mexico/Guatemala border who were current substance users or problem drinkers. Correlates examined included individual substance use and sexual behaviors, as well as migration history, and social and physical structural determinants (e.g., access to condoms, separation from spouse, deportation). Separate bivariate logistic regression models were run for men and women; multivariate logistic regression models were run for men, but small sample size precluded running them for women. Results: The syphilis prevalence was 1.2% among women and 2.3% among men. The HIV prevalence was 2.4% among women and 1.3% among men. Women who exchanged sex for money or goods were less likely to inconsistently use condoms with casual partners. Women with greater education were more likely to inconsistently use condoms. In an adjusted logistic regression among men, results reveal that less access to free condoms, using drugs with sexual partners, and using drugs before sex were significantly associated with

inconsistent condom use with casual partners. Conclusion: Prevalence of sexual and substance use risk behaviors were high. We suggest that public health interventions aimed at increasing condom use among persons with casual partners should focus on both genders and expand their scope beyond most-at risk populations.

INTRODUCTION

Migration has been shown to be a social and structural driver of both HIV and substance use vulnerability.[1-4] While the act of migration, either internationally or intra-regionally, is not inherently risky, factors before, during and after the journey may influence risk behaviors.[5,6] Within Latin America, disruption of social networks, exposure to more liberal social norms, poverty, gender inequalities, and stigma and discrimination have all been implicated as underlying mechanisms associating HIV/STI risk with mobility.[3,7-11]

Due to heightened violence and persistent inequality in Central America, increasing numbers of migrants are fleeing north to the United States.[12] At the same time, enhanced immigration enforcement in Mexico is leading to rising numbers of Central American deportations.[13] This shift is making migration "less like a compass pointing north and more like a hub with many spokes".[14]

Despite this shifting landscape, to date, most of the research on HIV risk factors among Latino migrants has been among Mexican migrants with a past or current history of living in the United States. For example, a study of male Mexican migrants found that after moving to the US, there were significant increases in rates

of sex: with sex workers; while drunk or high; sold; and with male partners.[15] Within Mexican states research found that individuals who had previously lived in the US had more sexual partners than non-migrants.[16] Conversely, migration to the US may also have a protective effect, as seen by higher rates of condom use or history of HIV testing among Mexicans with a history of US migration.[15-17] It is believed that differing social norms and practices in the US, coupled with structural vulnerabilities of migration, drive these changes in sexual risk behaviors.

Although the HIV literature predominantly focuses on international migration between Mexico and the US, there are a few studies which suggest migration within Mexico and Central America may influence HIV risk behaviors as well. Studies in Guatemala found increases in STI symptoms and HIV seroprevalance among women who reported a sexual partner who was a migrant worker.[18,19] Qualitative interviews with internal migrant female factory workers found that unprotected sex was common and misconceptions about HIV transmission were high.[20] Finally, at the US/Mexico border, Mexican male migrants still in transit within Mexico had the highest rates of HIV compared to those in the pre-departure, interception or return phases.[21]

In addition to sexual risk behaviors, substance use type and frequency may also be affected by migration. Mexican migrants to the United States have been shown to have higher rates of illicit drug use, alcohol consumption, and substance abuse than their non-migrating peers.[16,22-24] For example, national Mexican statistics

found that 21.5% of migrants versus 7.2% of non-migrants had ever used an illicit drug.[23] Less is known about substance use among circular or internal migrants within Central America and Mexico. While injection drug use is not currently considered a major factor driving HIV in Mexico and Central America, substance use may indirectly drive HIV infections through increases in sexual risk behaviors.[25] Therefore understanding the intersection of sexual risk, substance use, and migration is critical to monitoring HIV in Mexico and Central America.

In Central America and Mexico, HIV is primarily transmitted sexually and the epidemic is concentrated among most-at risk populations (MARPs) - commercial sex workers and men who have sex with men. The HIV prevalence among MARPs is as high as 4 to 13%, compared to the regional rates among adults of 0.2 to 1.5%.[26,27]

While commercial sex workers are at heightened risk of HIV and STIs, some studies have found that migrants use condoms with sex workers fairly consistently.[28-30] The high condom use with sex workers may in part be a reflection of public health messaging, but also attributable to Latin American social norms surrounding condom use. While commercial sex workers are viewed as "dirty" or "loose" women that necessitate the use of condoms, condom use with one's steady partner or spouse is viewed negatively because it challenges the sense of trust and intimacy.[31] Not surprisingly, studies in Mexico consistently find low condom use with main partners.[31,32]

Casual partners seem to lie within a gray area, as familiarity often reduces the perceived need for condoms. Among current and former Latino migrants to the US, consistent condom use was highest among commercial partners, followed by casual partners, then main partners.[28,29] A study of HIV risk behaviors among male agricultural migrants in Mexico found a significantly higher sexual risk behavior score with casual partners than with main partners.[33] This suggests that casual partner relationships may be associated with greater risk behaviors than either commercial partners or spouses. Considering that the number of casual partners may be elevated with Latino migrants, understanding factors related to helping or hindering condom use is important.[16,34]

The Mexico/Guatemala border region is at a nexus of poverty, rising availability of drugs, and increasing migration. This area bisects major Central American migration pathways and is home to circular seasonal agricultural migrants, as well as many deported migrants. A UNAIDS report on Central America cites that the combination of unequal socioeconomic development and a highly mobile population may contribute to the spread of HIV/AIDS in the region.[26] Given the relative lack of information on HIV risk factors among migrants in this region, our study enrolled recent migrants on both sides of the Mexico/Guatemala border who had active substance use or problem drinking.

The first aim of this study was to report the prevalence of sexual risk behaviors, HIV and syphilis. The second aim was to analyze variables associated

with inconsistent condom use among casual partners by gender. Specifically, we explored individual substance use and sexual behaviors, as well as migration history, and social and physical structural determinants (e.g., access to condoms, separation from spouse, deportation). We focused our attention on casual partner relationships, which may be higher risk than steady partners and more culturally open to interventions designed to increase condom usage.

METHODS

Study population and recruitment

Participants were recruited as part of a mixed methods, cross-sectional study (*Cruzando Fronteras,* NIDA R01DA029899) of substance use and HIV risk. Recruitment sites were focused in and around the cities of Ciudad Hidalgo and Tapachula in Mexico and Quetzaltenango and Tecún Umán in Guatemala (Figure 3.1). Cities were selected for their location along major migration routes at the Mexico/Guatemala border.

Participants were recruited using a combination of modified time-location sampling of migrant "venues" (e.g., migrant shelters, at border crossings) and peer referrals. To be included, participants had to: i) be at least 18 years of age; ii) Spanish speaking; iii) be willing and able to provide informed consent; iv) willing to undergo testing for HIV, HCV, and syphilis; v) have used an illicit substance or have problem drinking in the past 2 months; and vi) meet the definition of a recent

regional, international, or seasonal migrant (see paragraph below). Problem drinking was assessed by an Audit-C score of at least 4 for men or 3 for women.[35]

Recent migrants included individuals with at least one of the following characteristics: i) Moved states or countries (to live) within the past 5 years; ii) Traveled to another country or state for work for at least 3 months of the year, or had a trip that lasted at least 1 month at a time; iii) were deported (from any country) within the past 5 years. All study activities were approved by The Human Research Protections Program of the University of California San Diego; San Diego State University Institutional Review Board; the Comisión de Bioética del Estado de Chiapas, Mexico; and the Comité de Ética of the Universidad del Valle in Guatemala.

Quantitative survey

After giving written informed consent, participants underwent a quantitative survey administered by trained local outreach workers. Interviews were conducted in Spanish and administered using computer-assisted personal interviewing technology. The survey included questions about: sociodemographics; substance use; sexual behaviors and experiences; medical history; access to care; incarceration history; history of community and personal violence; and mental health. The survey took approximately 90 minutes to complete.

Study measures

Outcome: *Inconsistent condom use* with a casual partner. Casual partners were defined as partners with whom participants had sex without any commitment

(i.e., once or occasionally met up with to have sex without an emotional attachment and without the exchange of money). Condom use was measured by asking, how often they used a condom during vaginal or anal sex (never, sometimes, about half of the time, often, always) in the past 6 months. We defined inconsistent condom use as not "always" using a condom during these casual encounters.

We examined associations between inconsistent condom use with casual partners in the past 6 months and: sociodemographic factors, individual substance use and sexual risk behaviors, migration history, and social and physical structural determinants (access to care, arrest, homelessness, deportation).

Education level was categorized into less than secondary school versus higher than secondary school. Primary occupation was assessed by a multiple-choice categorical variable with an optional fill-in response. The most common sources of income were classified into the following categories: salaried; informal work; agricultural work; sex work; or assistance from family or government. Length of stay in interview city was dichotomized into less than 5 years versus 5 or more years and excluded mobile individuals who said "I'm not staying here/I'm just passing through".

Hard drug use in the past 6 months was coded as any heroin, crack, cocaine, methamphetamine or injection drug use. Years using drugs was calculated by subtracting the age the participant started using drugs from their current age. Specific drug use was captured by a question of if they had "ever" used followed by a

question on frequency of use (never, once per month or less, 2 to 3 days per month, one time per week, 2 to 3 days per week, 4 to 6 days per week, once a day, more than once a day).

HIV knowledge was assessed using a modified HIV Knowledge Questionnaire (HIV-KQ-18). All items on the original scale were asked except "A natural skin condom works better against HIV than does a latex condom". That question was excluded during pilot testing because it was not considered locally relevant. The HIV knowledge score was out of 17, with 1 point given for correct answers and no points given for incorrect or "don't know" responses.

Initiation of sex work or drug use was assessed in relation to migration as either being: before I moved/migrated; during the journey; while at the destination of my travels; or after returning to my home state/country. Those who initiated during the journey or after returning to their home state/country were not reported.

HIV seropositivity was detected by two positive HIV rapid tests: Determine HIV 1/2 (Alere) and SureCheck HIV ½ (Chembio). Syphilis was determined by a positive rapid test (SD Bioline Syphilis 3.0, Standard Diagnostics), confirmed by a positive FTA-Abs result. Active syphilis was classified as any positive result with a VDRL titer $\geq$1:8. Participants received pre- and post-test counseling and any individuals testing positive were referred to local health services.

Statistical analysis

We ran descriptive statistics on the total sample and by gender. There were no individual items that had greater than 5% missing data; cases with missing data were deleted listwise. Frequencies were calculated for dichotomous variables. All continuous variables had non-normal distributions and therefore we calculated medians and interquartile ranges (IQR). Pearson's chi-square tests and Wilcoxon Rank Sum test were run to compare variables with the outcome.

Univariate logistic regressions were performed to identify factors associated with inconsistent condom use with casual partners. Among women, we did not run multivariate models due to the small sample size. For men, variables significant at a $p<0.1$ cutoff were considered for inclusion in a final multivariable logistic regression model.[36] Correlated variables ($r>0.4$) were not included in the same model. Using a manual backwards procedure for model building, variables were removed from the model individually and confounding was considered for any changes greater than 20% in the odds ratio of remaining variables. Only variables considered to be confounders or that were significant at $p<0.05$ were retained in the final model. Multicollinearity of the final model was assessed using a tolerance test using a minimum cutoff of 0.1. All analyses were run using SPSS software (SPSS Inc., Chicago, Illinois).

RESULTS

Sample characteristics and risk behaviors

From April to August 2015, 392 individuals met the inclusion criteria of recent migration history and current substance use and were enrolled from sites along the Mexico/Guatemala border (175 in Mexico and 217 in Guatemala). Of these, 85 (22%) were women, 303 (77%) were men, and 4 (1%) were transgendered women. Transgendered women were excluded from subsequent analyses because of the small sample and likely different correlates of condom use. Sociodemiographic characteristics are summarized in Table 3.1. Migrants were predominantly born in Guatemala (49%), with 45% from other Central American countries (Honduras, El Salvador, Nicaragua, and Panama). Women were more likely than men to rely on family or government assistance (12% vs. 4%, $p<0.01$) or sex work (30% vs. 3%, $p<0.01$) as their main source of income. Men were more likely to work in agriculture (11% vs. 4%, $p=0.04$) or have informal jobs (32% vs. 20%, $p=0.03$). Men were much more likely than women to have ever been to the United States (36% vs. 6%, $p<0.01$). Men and women did not significantly differ on other demographic variables or type of migration.

Substance use prevalence

The most commonly used drugs in the past 6 months were marijuana (47%), non-injection cocaine or crack (33%), and inhalants (6%). Among the sample, 34% had used "hard" drugs (heroin, crack, cocaine, methamphetamine) or had injected drugs in the past 6 months and 11% had ever injected drugs. Men were more likely than women to report current hard drug use (34% vs. 18%, $p<0.01$).

Sexual partners

Having a casual partner in the past 6 months was common (57%) and did not significantly differ by gender (Table 3.1). Most participants were married or had a steady partner (71%), but only 52% had a sexual relationship with that spouse/partner in the past 6 months. Concurrency (overlapping in time) of steady and casual sexual partners was 26% among women and 29% among men.

Close to half (41%) of women and 19% of men had sold sex in the past 6 months. Thirty-seven percent of men had paid for sex in the past 6 months. Among men, 13% reported having had sex with a man in the past 6 months.

Condom use with steady partners was extremely low, with only 8% of partnered participants reporting always or often using a condom. Individuals with casual partners inconsistently used condoms 69% of the time. Men who had sold sex were much more likely than female sex workers to inconsistently use condoms with clients in the past 6 months (74% vs. 29%, $p<0.01$).

HIV and syphilis prevalence

The prevalence of current or past syphilis infection was 1.2% among women and 2.3% among men. Of those testing positive for syphilis, only one case was an active infection. The HIV prevalence was 2.4% among women and 1.3% among men. Of the 6 individuals who tested HIV positive, three had previously been tested: two reported their previous HIV test was negative and one knew their status. An

additional participant was positive on his first HIV rapid test, but refused the second test and was therefore unconfirmed. He reported knowing his HIV positive status and that he was currently in care, but not taking anti-retrovirals.

Condom behaviors

When asked where they usually obtained condoms, women reported buying them from pharmacies/stores (34%), getting them from municipal clinics (28%) or from NGOs (15%). Men predominantly purchased condoms from a pharmacy/store (65%) and to a lesser extent, from free municipal clinics (21%).

For both men and women, the top reason they did not use a condom with casual partners was that they "did not want to", or that they "did not like using them" (52% of women, 49% of men). For women, the second most cited reason (32%) was that their partner didn't want to; whereas for men, it was because condoms are uncomfortable/ "it's not the same" (30%). Also, for 18% of men and 28% of women "[partner] seemed healthy" was a common reason for deciding not to use a condom.

In regards to who usually decides to use a condom, 69% of women said that they decide and 17% said they decide in collaboration with their partners. Men said that 61% of the time they decide and 25% of the time they decide with their partner.

Variables associated with inconsistent condom use: women

In the sample 63% of women with causal partners inconsistently used condoms in the past 6 months. The specific breakdown of condom use was: 22%

never, 33% sometimes, 5% about half the time, 3% often, and 37% always. Characteristics of women with casual partners are described in Table 3.2. Inconsistent condom use with casual partners was associated with reduced odds of having exchanged sex for money or goods (unadjusted odds ratio (uOR): 0.24, 95% confidence interval (CI): 0.06-0.98). Women with greater education were more likely to inconsistently use condoms (uOR: 11.6, 95% CI: 2.11-63.13). We did not find any association between inconsistent condom use and migration history.

In a sub analysis exploring these differences, we found a statistically significant association between involvement in sex work within the past 6 months and both always having access to free condoms (uOR: 11.30, 95% CI:2.91-43.87) and lower education (uOR: 2.89, 95% CI: 1.12-7.45).

Variables associated with inconsistent condom use: men

Characteristics of men with casual partners are described in Table 3.3. In the sample 70% of men with causal partners inconsistently used condoms in the past 6 months. The specific breakdown of condom use with casual partners was: 30% never, 26% sometimes 7% about half the time, 7% often, and 30% always. In the bivariate analyses inconsistent condom use was associated with: lower education (uOR: 2.21, 95% CI: 1.14-4.26), problem drinking (uOR: 6.44, 95% CI: 1.21-34.33), ever injecting drugs (uOR: 4.70, 95% CI: 1.05-21.12), using drugs with a sexual partner (uOR: 3.63, 95% CI: 1.18-11.15), and homelessness (uOR: 2.23, 95% CI: 1.13-4.40). Inconsistent condom use with casual partners was less likely among men

who had previously been tested for HIV (uOR: 0.49, 95% CI: 0.25-0.94) or who were able to always get condoms for free (uOR: 0.30, 95% CI: 0.12-0.72).

In the multivariate model adjusting for other significant variables, inconsistent condom use was independently associated with using drugs with sexual partners (adjusted odds ratio (aOR): 3.38, 95% CI 1.04-10.96) and using drugs before sex (aOR: 2.59, 95% CI: 1.14-5.91) (Table 3.4). Inconsistent condom use with casual partners was less likely among men who always had access to free condoms (aOR: 0.26, 95% CI 0.08-0.72).

DISCUSSION

In a study of migrants who use illicit substances or have problem drinking, there was a high prevalence of concurrent risk factors for HIV, including inconsistent condom use with casual partners, commercial sex work, and male sex with men. The overall HIV prevalence was 1.5%.

We found that more educated women were less likely to use condoms on a consistent basis with their casual partners, which is opposite of what we would have predicted given past literature.[37-39] However, we also found that women who had worked as sex workers in the past 6 months were less educated and more likely to use condoms on a regular basis. While the small sample size precluded us from testing multivariate models, it is plausible that sex work explains the inverse relationship between condom use and education. Past studies among Latinos have found higher rates of condom usage among sex workers or as reported by clients of

sex workers.[28-30,40] This result is also in line with qualitative work among Mexican female migrants, which found that the use of condoms was often stigmatized because condoms were perceived as being used by "unclean" women.[20] These findings highlight the need for programs to increase the acceptability and use of condoms among women not engaged in sex work. The engagement of women is especially critical in this population considering that we found that 69% of women with casual partners said that they made decisions about when a condom would be used.

Men who reported that they use drugs with sexual partners or that they had been high in the two hours prior to sex with a causal partner were significantly more likely to inconsistently use condoms. Having sex with casual partners, coupled with alcohol and drug use, has also been documented with indigenous migrant workers in Mexico.[33] While the focus of many HIV prevention activities may be with persons who inject drugs, our finding lends further support to the importance of non-injection drug use and HIV/STI risk.[25,41]

In this alcohol and drug using population, 11% of men had ever injected an illicit drug, but recent injection drug use was low. In the bivariate analyses for men, a past history of injection was associated with inconsistent condom use with casual partners. While not an independent predictor of inconsistent condom use in the final model, nevertheless injection drug use poses a greater risk for the introduction of blood-borne diseases into the population. Also of concern is the potential for

overlap in the sexual networks between injection and non-injection persons who use drugs.[25]

Among men, inconsistent condom use with casual partners was negatively associated with access to free condoms—in other words, those who reported always having access to free condoms had a four-fold increase of *consistently* using condoms. We found that the majority of men bought their condoms from a pharmacy or store, rather than getting them from a free source. While cost was not directly cited as a major barrier to condom use, freely and easily accessible condoms for men may be a starting point for intervention.

Although it was not the main outcome of interest, the high rates of inconsistent condom use with clients (74%) among men who reported sex work was concerning. This was contrary to our hypothesis that condom use would be higher during transactional sex than with casual partners. Also, while only 5% of men reported identifying as gay or bisexual, 13% reported having sex with a man in the past 6 months. This gap highlights the need to provide HIV prevention messaging to men more broadly, rather than just targeting men who identify as MSM. Also, given the stigmatization of homosexuality in Central America and Mexico, it is likely these behaviors are underreported.

This study had four main limitations: cross-sectional study design, lack of a comparison group, use of self-reported risk behaviors, and non-probabilistic sampling. First, while the cross-sectional study design allowed us to interview

migrants without the challenges of maintaining a highly mobile population in follow-up, it did not allow for any prediction of inconsistent condom use. Secondly, without a comparison group of either sending communities or the general population in the Mexico/Guatemala border region, we were unable to determine whether the prevalence of HIV and risk factors differ in non-migrants. Thirdly, behaviors may have been underreported due to social desirability bias. To minimize socially desirable responses, interviews were conducted in private settings with trained interviewers. Finally, these data were not a representative sample of all Central American migrants because we recruited individuals who were active problem drinkers or illicit drug users. The non-probabilistic sampling strategy was employed in order to gain greater access into this hard-to-reach and vulnerable population. It is expected that HIV and risk behaviors in this sample are likely elevated from that of the general migrant population. Therefore, our conclusions are limited to recommendations among substance using migrants in this border region.

Conclusions

Among alcohol and substance using male and female recent migrants, we found high rates of inconsistent condom use with casual partners and very little condom use with spouses. Among male migrants, we found the potential for substance use to both indirectly (i.e., riskier sex) and directly (i.e., injection) affect transmission of HIV. While associations with inconsistent condom use with casual partners differed by gender, both men and women reported having decision making

power in using condoms. For both genders, we recommend broader public health messaging on condom use that goes beyond targeting MARPs.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the participants, community collaborators, and study staff in both Guatemala and Mexico. Funding for this study was provided by the National Institutes of Drug Abuse (NIDA) R01DA029899 and Ms. Conners was supported by a NIDA training grant (T32DA023356).

Chapter 3, in part is currently being prepared for submission for publication of the material. Conners, EE; Mercer VJ; Fernández-Casanueva, C; Brouwer KB. HIV Risk Behaviors and Correlates of Inconsistent Condom Use Among Substance Using Central American Migrants. The dissertation author was the primary author of this material.

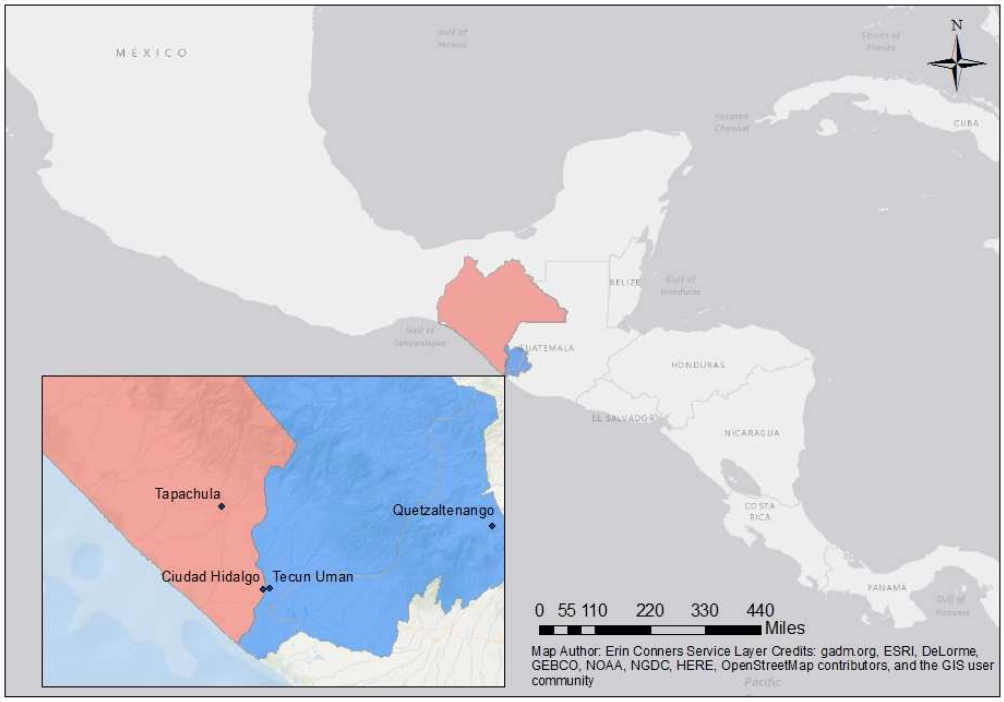

Figure 3.1 Map of main recruitment locations in Mexico and Guatemala

Table 3.1 Sociodemographic, migration history and selected risk behaviors of recent substance using recent migrants, by gender (N=388).

	All (N=388)	Female* (n=85) n, %	Male (n=303) n, %	
	N (%)	N (%)	N (%)	Test statistic (p-value)†
Country of interview				
Mexico	171 (44)	50 (59)	121 (40)	
Guatemala	217 (56)	35 (41)	182 (60)	**9.6 (<0.01)**
Sociodemographics				
Age [median, IQR]	31 [24-37]	32 [25-40]	31 [24-37]	-1.88 (0.06)
Current financial situation bad to extremely bad (ref: extremely good to neutral)	203 (52)	45 (53)	158 (52)	0.02 (0.90)
Sexual orientation				
Heterosexual/Straight	366 (95)	80 (95)	286 (95)	
Homosexual/Gay/Lesbian	2 (1)	0 (0)	2 (1)	
Bisexual	17 (4)	4 (5)	13 (4)	--
Less than secondary education (ref: secondary or above)	227 (59)	51 (60)	176 (58)	0.10 (0.75)
Married/common law (ref: Single, divorced, separated, widow)	274 (71)	63 (74)	211 (70)	0.58 (0.45)
Top sources of income				
Salaried	133 (35)	28 (33)	105 (36)	0.13 (0.72)
Informal work	113 (30)	17 (20)	96 (32)	**4.66 (0.03)**
Agricultural work	36 (10)	3 (4)	33 (11)	**4.38 (0.04)**
Sex work	33 (9)	25 (30)	8 (3)	**60.41 (<0.01)**
Assistance (family/government)	22 (6)	10 (12)	12 (4)	**7.39 (<0.01)**
Country of birth				
Mexico	23 (6)	7 (8)	16 (5)	1.04 (0.31)
Guatemala	191 (49)	36 (42)	155 (51)	2.06 (0.15)
Honduras	92 (24)	21 (25)	71 (23)	0.06 (0.81)
El Salvador	70 (18)	19 (22)	51 (17)	1.37 (0.24)
Nicaragua	11 (3)	2 (2)	9 (3)	0.09 (0.76)
Panama	1(<1)	0 (0)	1(1)	--
Member of indigenous group	38 (10)	4 (5)	34 (12)	3.10 (0.08)
Migration history				
Recent international migrant (w/n 5 years)	260 (68)	51 (61)	209 (69)	1.79 (0.18)
Recent regional migrant (w/n 5 years)	213 (55)	45 (54)	168 (56)	0.05 (0.82)
Seasonal migrant country or state (w/n 1 year)	233 (62)	47 (58)	186 (63)	0.68 (0.41)
Current undocumented migrant	197 (51)	39 (46)	158 (52)	1.04 (0.31)
Ever been to the United States	115 (30)	5 (6)	110 (36)	**29.62 (<0.01)**
Sexual partners				
Had spouse or steady partner, past 6 months	195 (52)	46 (57)	149 (51)	1.00 (0.32)
Inconsistent condom use spouse/stable partner, past 6 months (ref: always/often use condom)	174 (92)	41 (91)	133 (92)	0.07 (0.79)
Had a casual partner, past 6 months	216 (57)	41 (50)	175 (59)	2.09 (0.15)
Median number [IQR], causal	3 [1-5]	3 [1-5]	3 [1-5]	0.00 (1.00)

Table 3.1 continued:

Inconsistent condom use casual partner, past 6 months (ref: always/often use condom)	148 (69)	25 (63)	123 (70)	0.92 (0.34)
Ever bought sex, past 6 months	111 (29)	1 (1)	110 (37)	**39.6 (<0.01)**
Median number [IQR], sex work partners	-	-	2.5 [2-4]	-
Ever sold sex, past 6 months	92 (24)	34 (41)	58 (19)	**17.1 (<0.01)**
Median number [IQR], clients	6 [2-24]	22.5 [7-58]	3 [1-7]	**-5.31 (<0.01)**
Inconsistent condom use client, past 6 months (ref: always/often use condom)	52 (57)	10 (29)	42 (74)	**17.04 (<0.01)**
MSM, past 6 months	-	-	40 (13)	-
Ever tested for HIV	200 (52)	53 (62)	147 (49)	**5.09 (0.02)**
Substance use				
Hard drug use, past 6 months	131 (34)	15 (18)	116 (38)	**12.64 (<0.01)**
Ever injection drug use	32 (11)	3 (7)	29 (11)	0.60 (0.44)
STI testing results				
HIV	6 (2)	2 (2)	4 (1)	0.47 (0.49)
Syphilis (1 active)	8 (2)	1 (1)	7 (2)	0.43 (0.51)

*Only included biological females, not transgender women

† Test statistics and p-values are based on chi-square tests, non-parametric Wilcoxon rank sum tests or Fisher's Exact test

Table 3.2 Variables associated with recent female migrants inconsistent consistent condom use with casual partners in the past 6 months (n=40).

	Consistent condom use N=15	**Inconsistent condom use N=25**		
	N (%)	**N (%)**	**Test statistic (p-value) †**	**uOR [95% CI]**
Sociodemographics				
Age	29 [22-31]	3 [24-37]	-1.43 (0.16)	1.08 [0.98-1.19]
Youths (<25 years)	5 (33)	8 (32)	0.01 (0.93)	0.94 [0.24-3.68]
Sexual orientation Heterosexual/Straight Bisexual	 15 (100) 0 (0)	 24 (96) 1 (4)	0.61 (0.43)	N/A
Less than secondary education (ref: secondary or above)	13 (87)	9 (36)	9.72 (<0.01)	**0.09 [0.02-0.47]****
Married/common law (ref: Single, divorced, separated, widow)	12 (80)	20 (80)	0.00 (1.00)	1.00 [0.20-4.96]
Current financial situation bad to extremely bad (ref: extremely good to neutral)	5 (33)	15 (60)	2.67 (0.10)	3.00 [0.79-11.45]
Member of indigenous group	0 (0)	1 (4)	(1.00) [a]	N/A
Ever homeless, past 6 months	4 (27)	6 (24)	0.04 (0.85)	0.87 [0.20-3.77]
Ever arrested, less 6 months ago	2 (13)	2 (8)	(0.62) [a]	0.57 [0.07-4.50]
Migration history				
Migrated to current city alone	3 (20)	10 (42)	1.95 (0.16)	2.86 [0.64-12.84]
Currently lives in different country than civil partner	3 (30)	3 (25)	(1.00) [a]	0.78 [0.12-5.10]
Living in interview city less than 6 months (ref: more than 6 months)	9 (64)	13 (54)	0.37 (0.54)	0.66 [0.17-2.55]
International migrant, past 5 years	11 (73)	17 (71)	0.03 (0.87)	0.88 [0.21-3.74]
Regional migrant, past 5 years	10 (67)	11 (46)	1.61 (0.20)	0.42 [0.11-1.62]
Seasonal migrant, past year	11 (79)	12 (52)	2.58 (0.11)	0.30 [0.07-1.35]
Current undocumented migrant	7 (47)	9 (36)	0.44 (0.51)	0.64 [0.18-2.36]
Ever been to the United States	2 (13)	0 (0)	(0.13)*	N/A
Deported from non-US country, past 5 years	2 (13)	7 (28)	1.16 (0.28)	2.53 [0.45-14.20]
Substance use [b]				
Audit C score ≥3	15 (100)	24 (100)	--	N/A
Ever used illegal drugs (n=22)	11 (73)	11 (44)	3.26 (0.07)	**0.29 [0.07-1.15]***
Start of drug use at the destination of travels (ref: started before first migration)	6 (55)	3 (30)	(0.39)[a]	0.36 [0.06-2.16]
Years used drugs	9 [2-12]	10 [4-17]	-1.16 (0.27)	1.07 [0.95-1.20]
Used any illegal drug, past 6 months	7 (47)	9 (36)	0.44 (0.51)	0.64 [0.17-2.36]
Crack or cocaine (no inj) past 6mo	3 (20)	6 (24)	0.09 (0.77)	1.26 [0.27-6.03]
Marijuana, past 6 months	6 (40)	7 (28)	0.62 (0.43)	0.58 [0.15-2.26]

Table 3.2 continued:

Hard drugs (heroin, crack, cocaine, amphetamine, methamphetamine) past 6mo	3 (20)	6 (24)	0.09 (0.77)	1.26 [0.27-6.03]
Ever injected drugs	1 (9)	1 (9)	(1.00)[a]	1.00 [0.05-18.30]
Use drugs with sexual partner	3 (38)	2 (22)	(0.62)[a]	0.48 [0.06-3.99]
Drunk 2 hours prior to sex with casual partner, past 6 months	9 (60)	19 (76)	1.14 (0.29)	2.11 [0.53-8.41]
High 2 hours prior to sex with casual partner, past 6 months	3 (20)	6 (25)	0.13 (0.72)	1.33 [0.28-6.39]
Access to care				
Ever previously been tested for HIV	10 (67)	14 (56)	0.44 (0.51)	0.64 [0.17-2.41]
Needed to see a doctor but did not go, past year	6 (40)	4 (16)	2.88 (0.09)	**0.29 [0.07-1.26]***
Always can get condoms for free (ref: never-often)	5 (33)	2 (8)	(0.08)[a]	**0.17 [0.03-1.05]***
Median HIV knowledge (out of 17)	10 [9-12]	11 [9-13]	-0.37 (0.72)	1.05 [0.78-1.42]
Participant was carrying a condom	4 (27)	3 (12)	(0.39)[a]	0.38 [0.07-1.98]
Sexual partners and behaviors				
Median number of male partners, past 6 months [IQR]	7 [2-25]	3 [2-8]	-0.85 (0.41)	1.00 [0.99-1.01]
Spouse or stable partner, past 6 months	10 (67)	12 (48)	1.32 (0.25)	0.46 [0.12-1.75]
Inconsistent condom use spouse/stable partner, past 6 months (ref: always/often use condom)	8 (89)	12 (100)	(0.43)	N/A
Median number of casual sex partners, past 6 months [IQR]	5 [1-10]	2 [1-4]	-1.48 (0.16)	0.93 [0.84-1.02]
Exchanged sex, past 6 months	11 (73)	10 (40)	4.18 (0.04)	**0.24 [0.06-0.98]****
Inconsistent condom use client, past 6 months (ref: always/often use condom) (n=21)	1 (9)	4 (40)	(0.15)[a]	6.67 [0.60-74.51]
Start of sex work at the destination of travels (n=20) (ref: started before first migration)	6 (60)	4 (40)	0.80 (0.37)	0.44 [0.07-2.66]
Ever forced to have sex, past year	3 (21)	2 (8)	(0.33)[a]	0.32 [0.05-2.19]

IQR=interquartile range
N/A=statistic not available due to insufficient sample size
[a] Fischer's exact
[b] No women reported injecting drugs, smoking or snorting methamphetamines, using hallucinogens, or using inhalants in the past 6 months
† P-values are based on chi-square tests, non-parametric Wilcoxon rank sum tests or Fisher's Exact test
* $p<0.1$
** $p<0.05$

Table 3.3 Variables associated with recent male migrants inconsistent consistent condom use with casual partners in the past 6 months (n=175).

	Consistent condom use N=52	**Inconsistent condom use N=123**		
Sociodemographics	**N (%)**	**N (%)**	**Test statistic (p-value) †**	**uOR [95% CI]**
Age [IQR]	27 [21-32]	29 [23-37]	-1.60 (0.11)	1.02 [0.99-1.06]
Youths (<25 years)	20 (39)	39 (32)	0.75 (0.39)	0.74 [0.38-1.46]
Sexual orientation				
Heterosexual/Straight	3 (6)	6 (5)	0.54 (0.46)	
Homosexual/Gay/Lesbian	1 (2)	0 (0)	(0.30)[a]	
Bisexual	48 (92)	117 (95)	0.06 (0.81)	--
Less than secondary education (ref: secondary or above)	22 (42)	76 (62)	5.63 (0.02)	**2.21 [1.14-4.26]****
Married/common law (ref: Single, divorced, separated, widow)	37 (71)	93 (76)	0.38 (0.54)	1.26 [0.61-2.60]
Current financial situation bad to extremely bad (ref: extremely good to neutral)	21 (40)	65 (53)	2.27 (0.13)	1.65 [0.86-3.19]
Member of indigenous group	4 (8)	15 (12)	0.69 (0.41)	1.63 [0.51-5.17]
Ever homeless, past 6 months	17 (33)	64 (52)	5.50 (0.02)	**2.23 [1.13-4.40]****
Ever arrested, less 6 months ago	9 (17)	20 (16)	0.03 (0.87)	0.93 [0.39-2.20]
Migration History				
Migrated to current city alone	33 (65)	75 (62)	0.16 (0.69)	0.87 [0.44-1.72]
Currently lives in different country than civil partner	15 (56)	27 (44)	0.96 (0.33)	0.64 [0.25-1.58]
Living in interview city less than 6 months (ref: more than 6 months)	25 (57)	77 (67)	1.42 (0.23)	1.54 [0.76-3.14]
International migrant, past 5 years	43 (83)	87 (71)	2.73 (0.10)	**0.51 [0.22-1.15]***
Regional migrant, past 5 years	27 (52)	73 (59)	0.82 (0.36)	1.35 [0.70-2.60]
Seasonal migrant, past year	29 (59)	81 (67)	0.92 (0.34)	1.40 [0.71-2.77]
Current undocumented migrant	30 (58)	68 (55)	0.09 (0.77)	0.91 [0.47-1.75]
Ever been to the United States	16 (31)	39 (32)	0.02 (0.90)	1.05 [0.52-2.11]
Deported from US, past 5 years	9 (18)	26 (21)	0.27 (0.60)	1.25 [0.54-2.90]
Deported from non-US country, past 5 years	21 (41)	47 (38)	0.13 (0.71)	0.88 [0.45-1.72]
Substance use (ever or past 6m)				
Audit C score ≥4	47 (90)	121 (98)	(0.03)[a]	6.44 [1.21-34.33]*
Ever used illegal drugs (n=157)	49 (94)	108 (88)	1.64 (0.20)	0.44 [0.12-1.59]
Start of drug use at the destination of travels (ref: started before first migration)	18 (40)	27 (30)	1.45 (0.23)	0.63 [0.30-1.34]
Years used drugs	9 [6-17]	11 [7-19]	-1.06 (0.29)	1.01 [0.97-1.05]
Used any illegal drug, past 6 months	35 (67)	90 (73)	0.62 (0.43)	1.33 [0.66-2.68]
Crack or cocaine (no inj), past 6 months	20 (39)	63 (51)	2.39 (0.12)	1.68 [0.87-3.25]
Smoked or snort meth, past 6 months	2 (4)	8 (7)	0.48 (0.49)	1.74 [0.36-8.48]
Hallucinogens, past 6 months	3 (6)	6 (5)	0.06 (0.81)	0.84 [0.20-3.48]
Inhalants, past 6 months	2 (4)	12 (10)	1.73 (0.19)	2.70 [0.58-12.53]
Marijuana, past 6 months	31 (60)	75 (61)	0.03 (0.87)	1.06 [0.55-2.05]

Table 3.3 continued.

Hard drugs (heroin, crack, cocaine, methamphetamine, injection), past 6 months	20 (39)	62 (50)	2.09 (0.15)	1.63 [0.84-3.15]
Ever injected drugs	2 (4)	18 (17)	4.8 (0.03)	**4.70 [1.05-21.12]****
Injected drugs, past 6 months (n=20)	0 (0)	2 (11)	(1.00)[a]	N/A
Use drugs with sexual partner	4 (11)	29 (30)	5.55 (0.02)	**3.63 [1.18-11.15]****
Drunk 2 hours prior to sex with casual partner, past 6 months	30 (58)	87 (71)	2.80 (0.09)	**1.77 [0.90-3.48]***
High 2 hours prior to sex with casual partner, past 6 months	19 (37)	65 (53)	3.89 (0.05)	**1.95 [1.00-3.79]***
Access to care				
Ever previously been tested for HIV	30 (58)	49 (40)	4.71 (0.03)	**0.49 [0.25-0.94]****
Needed to see a doctor but did not go, past year	10 (19)	29 (24)	0.40 (0.53)	1.30 [0.58-2.90]
Always can get condoms for free (ref: never-often)	13 (26)	11 (9)	7.77 (<0.01)	**0.30 [0.12-0.72]*****
Median HIV knowledge (out of 17)	11 [9-13]	10 [8-13]	-0.87 (0.38)	0.95 [0.87-1.04]
Participant was carrying a condom	7 (14)	12 (10)	0.52 (0.47)	0.70 [0.26-1.88]
Sexual Partners				
Median number of partners, past 6 months [IQR]				
Women	3 [1-6]	3.5 [2-6]	-1.23 (0.22)	1.00 [0.98-1.03]
Men	0 [0-1]	1 [0-3]	-1.56 (0.12)	0.99 [0.95-1.03]
Trans	0 [0-2]	1 [0-2]	-0.84 (0.40)	1.3 [0.75-2.22]
Had sex with a man, past 6 months	6 (12)	25 (20)	1.94 (0.16)	1.96 [0.75-5.10]
Spouse or stable partner, past 6 months	27 (52)	61 (50)	0.03 (0.85)	0.94 [0.49-1.80]
Inconsistent condom use spouse/stable partner, past 6 months (ref: always/often use condom)	24 (89)	57 (98)	(0.09)[a]	**7.13 [0.71-71.99]***
Median number of casual sex partners, past 6 months [IQR]	2 [1-3]	3 [1-6]	-1.69 (0.09)	**1.11 [1.0-1.23]***
Bought sex within past 6 months	21 (40)	59 (48)	0.85 (0.36)	1.36 [0.71-2.63]
Had sex with a male sex worker, 6mo	1 (2)	1 (1)	(0.51)[a]	0.42 [0.03-6.81]
Had sex with a female sex worker, 6mo	20 (39)	59 (48)	1.33 (0.25)	1.48 [0.76-2.86]
Exchanged sex, past 6 months	11 (21)	33 (27)	0.63 (0.43)	1.37 [0.63-2.97]
Inconsistent condom use client, past 6 months (ref: always/often use condom)	3 (30)	28 (85)	11.48 (<0.01)	**13.07 [2.50-68.29]*****
Start of sex work at the destination of travels (ref: started before first migration)	7 (58)	23 (55)	0.05 (0.83)	0.87 [0.24-3.17]
Ever forced to have sex, past year	2 (4)	2 (2)	(0.58)[a]	0.41 [0.06-3.02]

IQR=interquartile range
[a] Fischer's exact
† P-values are based on chi-square tests, non-parametric Wilcoxon rank sum tests or Fisher's Exact test
* p<0.1
**p<0.05

***p<0.01

Table 3.4 Multivariate logistic regression of variables associated with male migrant's inconsistent condom use with casual partners in the past 6 months.

	aOR* [95% CI], p-value
Always have access to free condoms	0.26 [0.08-0.72], 0.01
Use drugs with sexual partners	3.38 [1.04-10.96], 0.04
Use drugs before sex	2.59 [1.14-5.91], 0.02

*Variables are adjusted for the others in the model

REFERENCES

1. Weine SM, Kashuba AB. Labor Migration and Hiv Risk: A Systematic Review of the Literature. *AIDS Behav.* Aug 2012;16(6):1605-1621.

2. Pinedo M, Burgos JL, Ojeda VD. A Critical Review of Social and Structural Conditions That Influence Hiv Risk among Mexican Deportees. *Microbes Infect.* May 2014;16(5):379-390.

3. Goldenberg S, Strathdee S, Perez-Rosales M, Sued O. Mobility and Hiv in Central America and Mexico: A Critical Review. *Journal of Immigrant and Minority Health.* 2012;14(1):48-64.

4. Rachlis B, Brouwer KC, Mills EJ, Hayes M, Kerr T, Hogg RS. Migration and Transmission of Blood-Borne Infections among Injection Drug Users: Understanding the Epidemiologic Bridge. *Drug Alcohol Depend.* Oct 8 2007;90(2-3):107-119.

5. Zimmerman C, Kiss L, Hossain M. Migration and Health: A Framework for 21st Century Policy-Making. *PLoS Med.* 2011;8(5):e1001034.

6. Gushulak BD, MacPherson DW. The Basic Principles of Migration Health: Population Mobility and Gaps in Disease Prevalence. *Emerg Themes Epidemiol.* 2006;3:3.

7. Brockerhoff M, Biddlecom AE. Migration, Sexual Behavior and the Risk of Hiv in Kenya. *International Migration Review.* 1999;33:836-856.

8. Massey DS, Arango J, Hugo G, Kouaouci A, Pellegrino A. An Evaluation of International Migration Theory: The North American Case. *Population and Development Review.* 1994;20(4):699-751.

9. Peterson W. A General Typology of Migration. *American Sociological Review.* 1958;23:256-265.

10. Brindis C, Wolfe, A.L., McCarter, V., Ball, S., Starbuck-Morales, S. The Associations between Immigrant Status and Risk-Behavior Patterns in Latino Adolescents. *J. Adolesc. Health.* 1995;17:99-105.

11. Cooper SP, Weller, N.F., Fox, E.E., Cooper, S.R. Comparative Description of Migrant Farmworkers Versus Other Students Attending Rural South Texas Schools: Substance Use, Work and Injuries. *J. Rural Health.* 2005;21:361-366.

12. US Department of Homeland Security. *Cbp Border Security Report.* 2014.

13. Secretaría de Gobernación Mexico. *Boletín Mensual De Estadísticas Migratorias [Monthly Bulletin of Immigration Statistics].* Mexico, D.F. 2014.

14. Cave D. Migrants' New Paths Reshaping Latin America. *New York Times*2012.

15. Sanchez MA, Hernandez MT, Hanson JE, et al. The Effect of Migration on Hiv High-Risk Behaviors among Mexican Migrants. *J Acquir Immune Defic Syndr.* Dec 15 2012;61(5):610-617.

16. Magis-Rodriguez C, Lemp G, Hernandez MT, Sanchez MA, Estrada F, Bravo-Garcia E. Going North: Mexican Migrants and Their Vulnerability to Hiv. *J Acquir Immune Defic Syndr.* May 1 2009;51 Suppl 1:S21-25.

17. Fosados R, Caballero-Hoyos R, Torres-López T, Valente TW. Condom Use and Migration in a Sample of Mexican Migrants: Potential for Hiv/Sti Transmission. *Salud Publica De Mexico.* 2006;48(1):57-61.

18. Ikeda JM, Schaffer JR, Sac Ixcot ML, Page K, Hearst N. Risk of Sexually Transmitted Infections among Mayan Women in Rural Guatemala Whose Partners Are Migrant Workers. *AIDS Behav.* Jan 2014;18 Suppl 1:S32-36.

19. Johri M, Morales RE, Hoch JS, et al. A Cross-Sectional Study of Risk Factors for Hiv among Pregnant Women in Guatemala City, Guatemala: Lessons for Prevention. *Int J STD AIDS.* Dec 2010;21(12):789-796.

20. Kendall T, Pelcastre BE. Hiv Vulnerability and Condom Use among Migrant Women Factory Workers in Puebla, Mexico. *Health Care Women Int.* Jun 2010;31(6):515-532.

21. Martinez-Donate AP, Hovell MF, Rangel MG, et al. Migrants in Transit: The Importance of Monitoring Hiv Risk among Migrant Flows at the Mexico-Us Border. *Am J Public Health.* Mar 2015;105(3):497-509.

22. Guerrero EG, Villatoro JA, Kong Y, Gamino MB, Vega WA, Mora ME. Mexicans' Use of Illicit Drugs in an Era of Drug Reform: National Comparative Analysis by Migrant Status. *Int J Drug Policy.* May 2014;25(3):451-457.

23. Avila HM. Migration: Health Challenges in Mexico. Paper presented at: 96th Meeting of the IOM Council2008.

24. Borges G, Breslau J, Orozco R, et al. A Cross-National Study on Mexico-Us Migration, Substance Use and Substance Use Disorders. *Drug Alcohol Depend.* Aug 1 2011;117(1):16-23.

25. Strathdee SA, Stockman JK. Epidemiology of Hiv among Injecting and Non-Injecting Drug Users: Current Trends and Implications for Interventions. *Curr HIV/AIDS Rep.* May 2010;7(2):99-106.

26. USAID. *Hiv/Aids Health Profile Central America.* 2011.

27. UNAIDS. *Epidemiological Fact Sheet on Hiv and Aids: Belize.* 2013.

28. Kissinger P, Kovacs S, Anderson-Smits C, et al. Patterns and Predictors of Hiv/Sti Risk among Latino Migrant Men in a New Receiving Community. *AIDS Behav.* Jan 2012;16(1):199-213.

29. Magis-Rodriguez C, Gayet C, Negroni M, et al. Migration and Aids in Mexico - an Overview Based on Recent Evidence. *Jaids-Journal of Acquired Immune Deficiency Syndromes.* Nov 1 2004;37:S215-S226.

30. Parrado E, Flippen, CA, McQuiston, C. Use of Commercial Sex Wokers among Hispanic Migrants in North Carolina: Implications for the Spread of Hiv. *Persp Sex Reprod Health.* 2004;36:150-156.

31. Hirsch JS, Higgins J, Bentley ME, Nathanson CA. The Social Constructions of Sexuality: Marital Infidelity and Sexually Transmitted Disease-Hiv Risk in a Mexican Migrant Community. *American Journal of Public Health.* 2002;92(8):1227-1237.

32. Caballero-Hoyos R, Torres-Lopez T, Pineda-Lucatero A, Navarro-Nunez C, Fosados R, Valente TW. Between Tradition and Change: Condom Use with Primary Sexual Partners among Mexican Migrants. *AIDS Behav.* Jul 2008;12(4):561-569.

33. Caballero-Hoyos R, Villasenor-Sierra A, Millan-Guerrero R, Trujillo-Hernandez B, Monarrez-Espino J. Sexual Risk Behavior and Type of Sexual Partners in Transnational Indigenous Migrant Workers. *AIDS Behav.* Jun 2013;17(5):1895-1905.

34. Montealegre JR, Risser JM, Selwyn BJ, McCurdy SA, Sabin K. Prevalence of Hiv Risk Behaviors among Undocumented Central American Immigrant Women in Houston, Texas. *AIDS Behav.* Aug 2012;16(6):1641-1648.

35. Bradley KA, DeBenedetti AF, Volk RJ, Williams EC, Frank D, Kivlahan DR. Audit-C as a Brief Screen for Alcohol Misuse in Primary Care. *Alcohol Clin Exp Res.* Jul 2007;31(7):1208-1217.

36. Hosmer Jr DW, Lemeshow S, Sturdivant RX. *Applied Logistic Regression.* Vol 398: John Wiley & Sons; 2013.

37. Fernandez-Esquer ME, Atkinson J, Diamond P, Useche B, Mendiola R. Condom Use Self-Efficacy among U.S. And Foreign-Born Latinos in Texas. *J Sex Res.* Nov 2004;41(4):390-399.

38. Lagarde E, Carael M, Glynn JR, et al. Educational Level Is Associated with Condom Use within Non-Spousal Partnerships in Four Cities of Sub-Saharan Africa. *AIDS.* Jul 27 2001;15(11):1399-1408.

39. Uribe-Salas F, Del Rio-Chiriboga C, Conde-Glez CJ, et al. Prevalence, Incidence, and Determinants of Syphilis in Female Commercial Sex Workers in Mexico City. *Sex Transm Dis.* Mar-Apr 1996;23(2):120-126.

40. Morales-Miranda S, Jacobson JO, Loya-Montiel I, et al. Scale-up, Retention and Hiv/Sti Prevalence Trends among Female Sex Workers Attending Vicits Clinics in Guatemala. *PLoS One.* 2014;9(8):e103455.

41. Deiss RG, Lozada RM, Burgos JL, et al. Hiv Prevalence and Sexual Risk Behaviour among Non-Injection Drug Users in Tijuana, Mexico. *Glob Public Health.* 2012;7(2):175-183.

Chapter 4. Chagas Disease Among Migrants at the Mexico/Guatemala Border

ABSTRACT

Background: Caused by the protozoan parasite *Trypanosoma cruzi* (*T. cruzi*), Chagas disease results in the largest burden in terms of disability-adjusted-life-years of any parasitic disease in the Americas. Monitoring Chagas disease among migrants is critical to controlling its spread and to serving the needs of the migrant community. Objectives: To determine the prevalence and correlates of Chagas disease in regional and international migrant populations at the Mexico/Guatemala border. Methods: Data were collected as part of a larger study of HIV and migration. Participants were a convenience sample of recent regional and international migrants who used an illicit substance or had recent problem drinking. *T. cruzi* infection was classified as testing positive on two different ELISAs. Interviewer administered surveys captured sociodemographics, migration history, Chagas disease knowledge, and access to care. Results: We enrolled 390 participants and the prevalence of Chagas disease was 2.6%. Only 19% of participants reported having ever heard of the disease and less than 1% had been previously tested. *T. cruzi* positive participants were more likely to have been born in a rural area or town than a city (90% vs. 59%, $p=0.05$) and have lived in a house with a makeshift roof (40% vs. 8%, $p<0.01$), walls (50% vs. 12%, $p<0.01$), or floor (60% vs. 21%, $p<0.01$). Conclusions: This is the first study to look at the prevalence of Chagas disease among migrants in Central America and Mexico. We found both current

poverty and past history of living in a rural area to be associated with increased prevalence of disease. Knowledge of the disease was low among all migrants.

BACKGROUND

Caused by the protozoan parasite *Trypanosoma cruzi* (*T. cruzi*), Chagas disease results in the largest burden in terms of disability-adjusted-life-years of any parasitic disease in the Americas.[1,2] An estimated 6 to 7 million people are currently infected with *T. cruzi* and 13% of the population of Latin America is at risk for vector-borne transmission.[3] Chagas disease is classified as a re-emerging infection because human migration has led to the recent urbanization and globalization of the disease.[4-7]

Chagas disease is primarily a vector-borne illness spread via the feces of infected blood-feeding triatomine bugs, usually through the bite wound. Vector species are found throughout Latin America and in some parts of the southern United States. Despite the considerable control of the vector through spraying campaigns, such as the Central American Chagas Disease Vector Control Initiative, the disease is still endemic in many parts of Latin America. While the vector can be controlled through spraying in domestic settings, the disease and the vector persist in animals, making it near impossible to eradicate. The disease can also be transmitted person-to-person: from mother to child, through blood donation, and less commonly, through tissue donation.[8-10]

Chagas disease has two main stages: an acute phase that lasts 6-8 weeks and a lifelong chronic phase. Among chronically infected individuals, 20-30% will go on to develop cardiac, gastrointestinal, or both cardiac and gastrointestinal damage (known as the determinate form of disease).[10-12] While current treatments are efficacious during the acute phase, challenges with drug side effects, and economic and logistical impediments to obtaining the drugs mean most people with the disease remain untreated.[10,13,14] An estimated 10,000 people die from Chagas each year and the morbidity and mortality associated with Chagas disease results in a US$7.2 billion annual global economic burden.[2,12]

It is unknown whether migrants in Latin America are at heightened risk of Chagas disease. Traditionally, Chagas is considered a disease of rural poverty and low socioeconomic status - situations that are often the underlying push factors for migration.[15] In these rural areas, substandard housing conditions promote contact with vectors and are often used as a marker for determining risk. While regional variations exist, mud floors, tile roof and adobe walls are all associated with increased risk of either presence of the vector or infection.[16-19]

Additionally, groups such as seasonal migrant farmworkers may have higher contact with vectors through their occupation.[20] For example, a 2009 qualitative study by Bayer et al. in Peru suggested that the act of agricultural migrants circulating between temporary shelters in endemic regions and peri-urban communities puts them at risk for infection.[20] They also suggested that the

introduction of the rural practices of domestic animal husbandry into peri-urban areas with poor housing conditions may have facilitated the spread of the vector.[20] Because Chagas disease is also transmitted in animals, having animals or livestock in or near the home is associated with increased risk of disease.[18,21,22] However the hypothesis that migrants are at greater risk of disease has not been quantitatively tested.

Finally, because of stigma or discrimination against migrants, diminished access to health services may preclude diagnosis and treatment of Chagas disease.[20] In particular, undocumented migrants may be unwilling or unable to access health services. We recently conducted a systematic review that found current disease estimates among migrants to be poor, in part because of an overall lack of screening.[23]

A large number of migrants pass through the border region between Mexico and Guatemala each day. Migrants in the region are from Central America and are either in transit to the United States or traveling for seasonal work in the southeastern Soconusco agricultural region of Mexico.[24] Recent years have seen increases in both migrants from Central America headed to the United States and migrants deported out of the US and Mexico back to Central America.[25-27]

Chagas disease is endemic in Mexico, however current prevalence estimates are considered imprecise because official case reporting is not required.[28] A recent report by the World Health Organization found Mexico had the second highest

number of new cases due to vector transmission.[3] Prevalence estimates range from about 1% countrywide to as high as 13% in parts of the Mexican state of Chiapas at the Mexico-Guatemala border.[29,30] Guatemala, El Salvador and Honduras account for 85% of new Central American cases of Chagas disease.[3] In addition to higher disease burden, Guatemala, El Salvador and Honduras also have the greatest out-migration in Central America.[31] Given the confluence of increasing migration and the potential for a higher burden of disease among migrants, monitoring Chagas disease in this region is critical to controlling its spread and to serving the needs of the migrant community.

Human migration represents both a risk for the re-emergence of new Chagas disease infections and for the expansion of the geographical distribution of chronic Chagas cases. Therefore, the aims of this project were to: 1) determine the seroprevalence of Chagas disease in regional and international migrant populations at the Mexico/Guatemala border; 2) assess correlates of infection including migration history, sociodemographic, and socioeconomic variables.

METHODS

Study population and recruitment

Participants were recruited as part of an NIH-funded cross-sectional study (*Cruzando Fronteras*) exploring substance use and HIV risk in migrants. From April to August 2015, 392 migrants were enrolled from sites along the Mexico/Guatemala border (175 in Mexico and 217 in Guatemala). Recruitment sites were along major

migration routes in and near the cities of Ciudad Hidalgo and Tapachula in Mexico and Quetzaltenango and Tecún Umán in Guatemala.

Participants were recruited using a combination of modified time-location sampling of migrant "venues" (e.g., migrant shelters) and peer referrals. To be included in this study, participants must have been: i) at least 18 years of age; ii) able to speak Spanish; iii) willing and able to provide informed consent; iv) be willing to undergo testing for Chagas disease; v) have used an illicit substance or have problem drinking in the past 2 months (criteria for the parent study, *Cruzando Fronteras*); and vi) meet the definition of a recent regional, international, or seasonal migrant.

Recent migrants included individuals with at least one of the following characteristics: i) Moved states or countries within the past 5 years; ii) Traveled to another country or state for work for at least 3 months of the year or had a trip that lasted at least 1 month at a time ; iii) Been deported within the past 5 years. All study activities were approved by The Human Research Protections Program of the University of California San Diego, San Diego State University, the Comisión de Bioética del Estado de Chiapas, Mexico and the Comité de Ética of the Universidad del Valle in Guatemala.

Data collection and laboratory methods

Chagas disease testing

In Guatemala, serum samples were tested at a laboratory in Quetzaltenango using a commercially available ELISA (CHAGAS Rec, InVitro). In Mexico, serum samples were tested using a locally developed ELISA at the Centro Regional de Investigación en Salud Pública (CRISP). All positive samples from Guatemala were given a second ELISA at CRISP. All positive samples from Mexico were sent to the National Autonomous University of Mexico for their second ELISA test.

Per WHO guidelines for epidemiologic studies, *T. cruzi* infection may be considered for any sample that tests positive on two different ELISAs.[11] Therefore we defined "positive" results as two positive ELISA results and "indeterminate" results for those who tested positive on only one ELISA.

Screener

In addition to inclusion criteria questions, recruiters asked individuals willing to be screened for the study the following questions about Chagas disease: if they had ever heard of the disease, if they had ever been tested, or if they ever had Chagas disease. Interviewers also asked individuals the type of place they lived in most as a child (ranch, village, town or city).

Quantitative survey

As part of *Cruzando Fronteras* project, eligible participants underwent a quantitative survey administered by local outreach workers trained in interviewing. Interviews were conducted in Spanish and administered using computer-assisted

personal interviewing (CAPI) technology. Sociodemographic measures from the survey included in this analysis were age, gender, education level, civil status, rating of current financial situation, and indigenous ethnicity. We also specifically looked at whether the participant's main source of income came from agricultural work in the last year, as this occupation was hypothesized to be associated with increased Chagas disease risk.

Migration variables examined included country and department of birth, migration type (international, regional, seasonal), whether or not they had migration documents, and whether they had ever been forced to move because of violence.

Participants were asked questions about the house they lived the longest in as a child and their most common housing situation in the past 6 months. Measures on housing included whether there were animals in or near the house; and if they saw triatomines in the house. Interviewers showed a photograph of the triatomines and provided multiple local slang terms for the insect (e.g., *chinche*). Participants were also asked to report all construction materials that applied for the roof, walls, and floor of their childhood home and current living situation. Types of materials were grouped based on prior research and hypotheses about materials that may facilitate or hinder vector infestation.[16-19] Individuals were also asked if they were ever homeless in the past 6 months.

Chagas disease-specific questions included: lifetime history of diagnosis or treatment of Chagas disease; history of blood transfusion; and whether they had a family member diagnosed with Chagas disease. Knowledge was assessed by asking if they had ever heard of the disease and if it was possible to have Chagas disease and not know it.

We created a measure of Chagas disease transmission knowledge based on the following question: please tell me all the ways one can be infected with Chagas disease. Correct answer choices included: triatomine, blood transfusion, mother to child, and organ transplant. Incorrect answer choices included: mosquito, skin contact, and sexual contact. Correctly identified choices received a score of 1 and incorrect or "don't know" responses received a 0, for a total possible score of 7.

Statistical analysis

Descriptive statistics on demographics, migration history, childhood and recent housing characteristics, Chagas disease knowledge, and medical history were run for the total sample and by those who did and did not test positive for Chagas disease. Frequencies were calculated for dichotomous variables; age was non-normal and continuous and therefore median and interquartile range (IQR) was calculated. Pearson's chi-square tests and Wilcoxon Rank Sum test were run to compare variables with the outcome (Chagas disease). Using screener data, we also tested for differences between migrants and non-migrants and between substance

using migrants and non-substance using migrants. All analyses were run using SPSS software (SPSS Inc., Chicago, Illinois).

RESULTS

We tested 390 recent migrants for Chagas disease. Of these participants, 10 (2.6%) were positive for *T. cruzi* and 23 (5.9%) were indeterminate. The majority of migrants were born in Guatemala (49%), followed by Honduras (24%), El Salvador (18%), Mexico (6%), Nicaragua (3%), and Panama (<1%) (Table 4.1). The median age of the sample was 31 and the majority were men (77%). Knowledge of Chagas disease was low, with only 19% of participants reporting having ever heard of it. Among those that had heard of Chagas disease, most (82%) knew it could be asymptomatic. The median score on the transmission knowledge questions was 5 (out of 7); 56% correctly identified triatomines as spreading the disease but only 12% knew about mother to child transmission. Only 2 (<1%) persons had been previously tested for Chagas disease. There were no significant differences (alpha=0.05) in demographic characteristics, migration history, Chagas disease knowledge, or medical history between those testing positive for *T. cruzi* and those testing negative (Table 4.1).

T. cruzi positive participants were more likely to have been born in a ranch, farm, village, or town than in a city (90% vs. 59%, p=0.05). There were no statistically significant differences in housing characteristics at place of birth between the groups. In the past 6 months, *T. cruzi* positive participants were more

likely to have lived in a house with a makeshift roof (40% vs. 8%, p<0.01), walls (50% vs. 12%, p<0.01), or floor (60% vs. 21%, p<0.01). "Makeshift" materials included sleeping outdoors, or with nylon, plastic or cardboard materials.

The age, department and country of origin, and the number of years lived in place of birth for all participants positive for *T. cruzi* are in Table 4.3. We also created a map highlighting the departments of birth and the proportion of the population living in poverty in El Salvador, Honduras, and Guatemala (Figure 4.1).

A total of 668 individuals were screened for potential participation in the study. Of these, 413 (75%) used drugs or were problem drinkers, and 554 (83%) had ever migrated internationally or regionally. Migrants who used substances did not significantly differ from non-users in terms of age (p=0.50), Chagas disease knowledge (p=0.67), prior Chagas disease testing (p=1.00), diagnosis of Chagas disease (p=1.00), or growing up in a rural area (p=0.09).

Migrants (either international or regional) who were screened were more likely than non-migrants to be from a city (42% vs. 19%, p<0.01) and to have heard of Chagas disease (23% vs. 13%, p=0.03).

DISCUSSION

The prevalence of Chagas disease among a sample of migrants at the Mexico/Guatemala border was 2.6%. Of concern, almost no (<1%) participants reported having ever been tested for Chagas disease previously and knowledge of the disease was low. Early detection of Chagas disease is critical for both the patient

and the larger community. Treatment for Chagas disease is considered more efficacious when administered earlier in the disease progression.[10] Further, asymptomatic infection remains a threat to public health because of the potential for mother to child and blood transmission.

We found differences in current housing materials between those with and without *T. cruzi* infection. Notably, those with *T. cruzi* infection lived in homes with extremely poor construction materials in the past 6 months (living outdoors or in tents) in a greater proportion than those without infection. We originally sought to assess housing materials because past studies have shown associations between certain materials and greater triatomine infestation.[16-19] While we found that recently living in housing with makeshift materials was associated with Chagas disease, this may be a proxy for disadvantaged socioeconomic status rather than an indicator of recent infection. However, because we are unable to determine when or how a person became infected with Chagas disease, we cannot formally test that hypothesis. Either outcome points to the fact that Chagas is a disease of poverty, and that poverty may persist even after moving out of rural areas. Thus any screening campaigns in rural and urban areas should target persons living in substandard housing for testing.

While current housing materials differed between those with and without *T. cruzi* infection, we did not find a similar relationship with the construction materials of their childhood home. Past studies have found mixed associations of particular

housing materials based on both the region and the species of the vector.[16-19] Because our sample of migrants came from multiple countries and regions, it may have masked any ability to detect significant effects. Additionally, the longer period of recall for participants may have resulted in inaccurate reporting of housing materials during childhood. However, any recall bias would likely be equal among those with and without Chagas disease, as no participants knew of their disease status at the time of the interview.

Similar to other studies, we found more *T. cruzi* positive individuals were born in rural areas than in cities compared to participants negative for *T. cruzi*.[32-34] While there is growing evidence that domiciliated vectors have spread to urban and peri-urban areas, the majority of current infections still arise from infection in rural regions.[35-37] Our map of the departments (states/provinces) participants were born in shows a wide diversity of geographical locations and levels of poverty. This points to the utility of screening programs that cast a wider net in addition to targeting of highly endemic areas. Recent economic evaluations of the cost of Chagas disease have found that not screening for chronic cases is the most costly to healthcare systems.[38,39] However, the benefits of screening are diminished if improvements in diagnostic testing and availability of efficacious treatment are not made in tandem.

Knowledge of Chagas disease in our sample was low, with only 19% of participants reporting having ever heard of the disease. Among those who had heard of the disease, 44% did not recognize triatomines as transmitting the disease.

However, counter to our hypothesis that migrants may be less likely to receive public health messages, based on screener data we found that migrants were more likely to have heard about Chagas disease than non-migrants. This could be because of more extensive educational campaigns in rural areas of Central America. Nevertheless, the relatively low levels of knowledge point to an increased need for educational campaigns among all individuals staying in this border region.

The median age of individuals testing positive for *T. cruzi* was 30 (IQR: 23-38). The potential progression from asymptomatic (indeterminate) to the symptomatic determinate form usually occurs 10-30 years after the initial infection. Given that the spraying campaigns for Chagas disease were in the 1990's, it is expected the cohort of individuals infected prior to the campaigns are still coming into the age of reactivation.[10] However this study did not assess symptoms of participants and, thus, we are unable to classify participants as having indeterminate or determinate infection.

Limitations

The data presented here are from a non-random sample of substance using migrants, and therefore may not be generalizable to all migrants in the region. However, using data from screening visits, we found no difference between substance users and non-substance users in terms of Chagas disease knowledge, prior Chagas disease testing, or living in a rural area. Also, as most people become

infected with *T. cruzi* as a child, we would not expect different prevalence estimates of disease between the two groups.[12]

No screening gold standard test exists for Chagas disease, however we believe the use of two different ELISAs strengthens our findings. Data were cross sectional and we could not determine when a particular individual was infected with Chagas disease. However, we believe the findings still provide a useful snapshot of prevalence in this southern Mexico/Guatemala border region.

Conclusions

With migration rapidly changing the distribution of Chagas disease, more work needs to be done to identify those who are chronically infected. Spain, the United States, and other non-endemic countries are increasingly recognizing the importance of screening for Chagas disease within migrant communities.[40-42] Determining the most at-risk individuals and creating targeted screening and surveillance programs are necessary for: getting patients indicated for treatment into care, tracking the geographical spread of disease, and preventing non-vector disease transmission mechanisms.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the participants, community collaborators, and study staff in both Guatemala and Mexico. Funding for this study was provided by the National Institute on Drug Abuse (NIDA) R01DA029899 and a UC MEXUS Dissertation grant.

Chapter 4, in part is currently being prepared for submission for publication of the material. Conners, EE; López-Ordóñez T, Fernández-Casanueva C & Brouwer KB. Chagas Disease Among Migrants at the Mexico/Guatemala Border.

Table 4.1 Characteristics of migrants with and without Chagas disease (N=390)

Variable	Total (n=390) N(%)†	*T. cruzi* Negative (n=357) N(%)	*T. cruzi* Positive (n=10) N(%)	P-value§
Country of interview				
Guatemala	215 (55)	185 (52)	8 (80)	0.08
Mexico	175 (45)	172 (48)	2 (20)	
Demographics and behaviors				
Median age (IQR)	31 (24-37)	31 (24-38)	30 (23-38)	0.84
Biological sex				0.87
Female	89 (23)	79 (22)	2 (20)	
Male	301 (77)	278 (78)	8 (80)	
Less than secondary education (ref: secondary or above)	228 (59)	201 (56)	8 (80)	0.14
Married/common law (ref: Single, divorced, separated, widow)	277 (71)	255 (72)	7 (70)	0.91
Current financial situation bad to extremely bad (ref: extremely good to neutral)	204 (52)	187 (52)	7 (70)	0.27
Member of indigenous group	38 (10)	34 (10)	1 (10)	0.98
Agricultural worker, past year	36 (9)	29 (8)	2 (20)	0.19
Since birth, rural area for more than 6mo?	235 (60)	210 (59)	7 (70)	0.48
Ever used illicit drugs (besides marijuana)	298 (76)	272 (76)	10 (100)	0.08
Ever injected illicit drugs	32 (8)	30 (11)	1 (10)	0.92
Migration				
Country of Birth				
Mexico	23 (6)	23 (6)	0 (0)	0.41
Guatemala	192 (49)	172 (48)	4 (4)	0.61
Honduras	92 (24)	85 (24)	7 (30)	0.65
El Salvador	71 (18)	65 (18)	3 (30)	0.34
Nicaragua	11 (3)	11 (3)	0 (0)	0.57
Panama	1 (<1)	1 (<1)	0 (0)	-
International migrant, past 5 years	262 (67)	238 (67)	8 (80)	0.40
Regional migrant, past 5 years	214 (55)	193 (55)	7 (70)	0.33
Seasonal migrant, past year	235 (60)	208 (60)	8 (80)	0.21
Current undocumented migrant	199 (51)	186 (52)	5 (50)	0.90
Forced to move because of violence	166 (43)	151 (42)	6 (60)	0.26
Knowledge				
Have you ever heard of CD?	75 (19)	68 (19)	4 (40)	0.10
Transmission knowledge score (out of 7) (IQR) (n=75)	3 (2-4)	3 (2-4)	3 (0.5-5)	0.98
Is it possible to have CD and not know it? (n=75)	53 (82)	49 (82)	2 (67)	0.52
Medical				
Have you ever been tested for CD?	2 (0.5)	1 (0.3)	0(0)	0.87
Have you ever been told by a provider you have CD?	0 (0)	0 (0)	0 (0)	-
Has anyone in your family been told by a provider they have CD?	3 (1)	3 (1)	0 (0)	0.80
Have you ever received a blood transfusion?	54 (14)	53 (15)	0 (0)	0.19

†23 had indeterminate results

§ P-values are based on chi-square tests, non-parametric Wilcoxon rank sum tests or Fisher's Exact test

Table 4.2 Characteristics of housing and housing materials of recent migrants by Chagas disease status

	Total (n=390) N(%)†	*T. cruzi* Negative (n=357) N(%)	*T. cruzi* Positive (n=10) N(%)	P-value§
Childhood home				
Type of place of birth (ranch/farm/village/town vs. city)	233 (60)	**209 (59)**	**9 (90)**	**0.05**
Seen triatomine in house?	191 (49)	174 (49)	4 (40)	0.56
Animals in/near home?	331 (85)	302 (85)	8 (80)	0.69
Roof (select all)				
Thatched (straw, palm)	32 (8)	30 (8)	0 (0)	0.34
Wood	7 (2)	7 (2)	0 (0)	0.66
Cement	40 (10)	38 (11)	0 (0)	0.28
Metal (tin, iron, steel)	238 (61)	218 (61)	7 (70)	0.57
Tile (clay, shingles)	80 (21)	70 (20)	3 (30)	0.42
Makeshift (none, nylon, plastic, cardboard)	1 (<1)	1 (<1)	0 (0)	0.87
Walls				
Natural (bamboo, adobe, dirt, palm)	128 (33)	117 (33)	3 (30)	0.85
Wood	70 (18)	60 (17)	4 (40)	0.06
Makeshift (none, nylon, plastic)	8 (2)	8 (2)	0 (0)	0.63
Cinderblock	144 (37)	132 (37)	3 (30)	0.65
Metal (aluminum)	8 (2)	7 (20)	0 (0)	0.66
Durable (cement, brick, drywall, rock)	72 (19)	70 (20)	1 (10)	0.45
Floor				
Wood	5 (1)	5 (1)	0 (0)	0.71
Durable (cement, brick, granite, rock)	171 (44)	158 (44)	3 (30)	0.37
Metal (iron)	0 (0)	0 (0)	0 (0)	-
Tile	68 (17)	63 (18)	1 (10)	0.53
Makeshift (dirt, outdoors, cardboard)	161 (41)	143 (40)	7 (70)	0.06
Recent housing, past 6 months				
Seen triatomine in places slept/stayed?	82 (21)	75 (21)	3 (30)	0.50
Animals in/near places slept/stayed?	237 (61)	211 (59)	8 (80)	0.18
Ever homeless, past 6 months	150 (39)	135 (38)	4 (40)	0.89
Roof				
Thatched (straw, palm)	29 (7)	23 (7)	2 (20)	0.10
Wood	30 (8)	27 (8)	1 (10)	0.78
Cement	142 (36)	136 (38)	3 (30)	0.59
Metal (tin, iron, steel)	257 (66)	230 (65)	9 (90)	0.10
Tile (clay, shingles)	34 (9)	29 (8)	1 (10)	0.84
Makeshift (none, nylon, plastic, cardboard)	35 (9)	**29 (8)**	**4 (40)**	**<0.01**
Walls		52 (15)	1 (10)	0.68
Natural (bamboo, adobe, dirt, palm)	59 (15)			
Wood	41 (11)	35 (10)	2 (20)	0.30
Makeshift (none, nylon, plastic)	53 (14)	**41 (12)**	**5 (50)**	**<0.01**
Cinderblock	249 (64)	222 (63)	9 (90)	0.08
Metal (aluminum)	4 (1)	4 (1)	0 (0)	0.74
Durable (cement, brick, drywall, rock)	136 (35)	127 (36)	2 (20)	0.30
Floor				
Wood	12 (3)	9 (3)	0 (0)	0.61
Durable (cement, brick, granite, rock)	277 (71)	251 (71)	8 (80)	0.52
Metal (iron)	2 (<1)	2 (1)	0 (0)	0.81
Tile	120 (31)	111 (31)	2 (20)	0.45
Makeshift (dirt, outdoors, cardboard)	86 (22)	**73 (21)**	**6 (60)**	**<0.01**

†23 had indeterminate results

§ P-values are based on chi-square tests, non-parametric Wilcoxon rank sum tests or Fisher's Exact test

Table 4.3 Details of participants with positive serology for *T. cruzi*

Participant	Age	Country of birth	Department of birth	Years lived place of birth	Type
1	25	Guatemala	Santa Rosa	8	Town
2	35	Guatemala	Huehuetenango	2	Ranch/farm
3	46	Guatemala	Retalhuleu	30	Town
4	52	Guatemala	San Marcos	19	Town
5	21	Honduras	El Paraíso	8	Ranch/farm
6	31	Honduras	Santa Bárbara	29	Town
7	34	Honduras	Olancho	16	Town
8	19	El Salvador	La Libertad	14	City
9	24	El Salvador	Morazán	11	Village
10	29	El Salvador	Santa Ana	14	Village

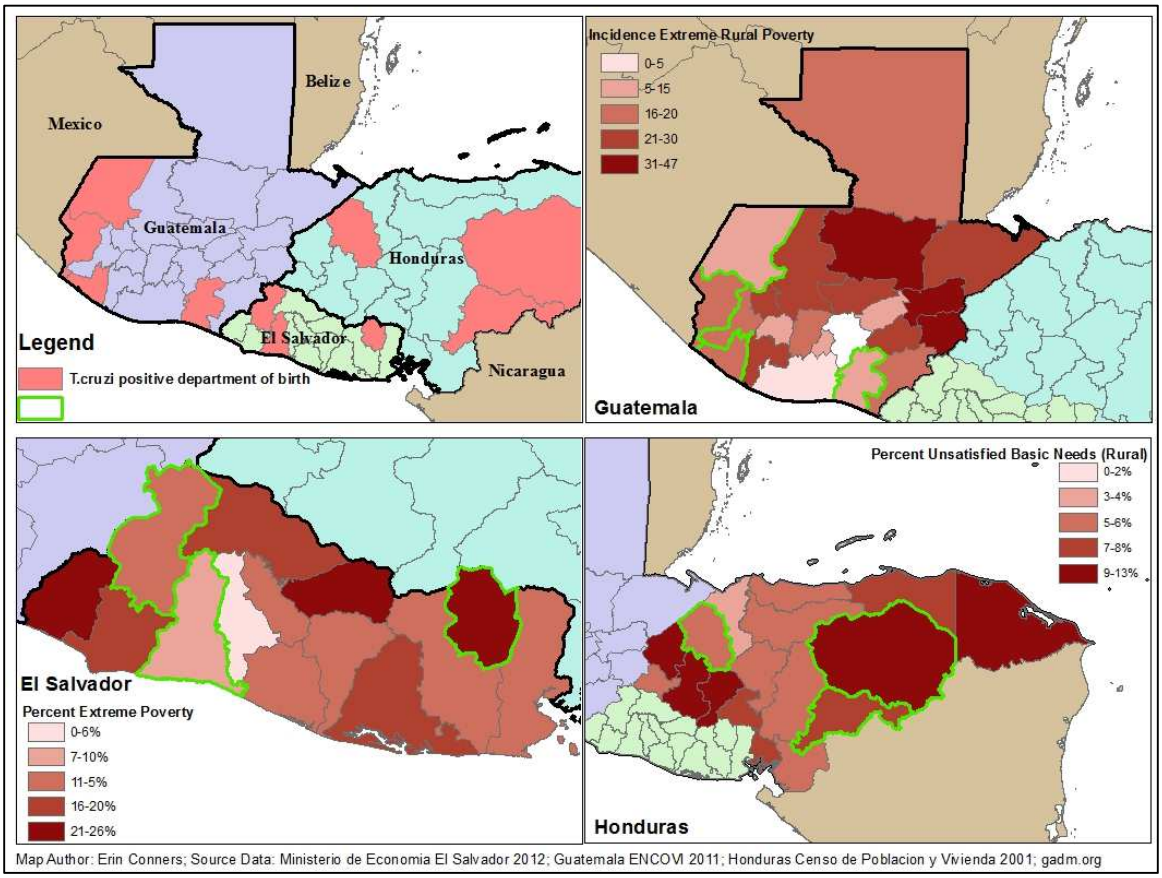

Figure 4.1 Maps of poverty levels and departments of origin for T. cruzi positive participants

REFERENCES

1. World Health Organization. Daly Estimates, Who Regions, 2000-2012. 2012; http://www.who.int/healthinfo/global_burden_disease/estimates/en/index2.html. Accessed July 7, 2014.

2. Lee BY, Bacon KM, Bottazzi ME, Hotez PJ. Global Economic Burden of Chagas Disease: A Computational Simulation Model. *Lancet Infect Dis.* Apr 2013;13(4):342-348.

3. World Health Organization. *Chagas Disease in Latin America: An Epidemiological Update Based on 2010 Estimates.* Geneva 2015.

4. Mackey TK, Liang BA, Cuomo R, Hafen R, Brouwer KC, Lee DE. Emerging and Reemerging Neglected Tropical Diseases: A Review of Key Characteristics, Risk Factors, and the Policy and Innovation Environment. *Clin Microbiol Rev.* 2014;27(4):949-979.

5. Hotez PJ. Ntds V.2.0: "Blue Marble Health"-Neglected Tropical Disease Control and Elimination in a Shifting Health Policy Landscape. *Plos Neglected Tropical Diseases.* Nov 2013;7(11).

6. World Health Organization. Sustaining the Drive to Overcome the Global Impact of Neglected Tropical Diseases: Second Who Report on Neglected Tropical Diseases. *Sustaining the Drive to Overcome the Global Impact of Neglected Tropical Diseases: Second Who Report on Neglected Tropical Diseases.* 2013:1-138.

7. Nunes MCP, Dones W, Morillo CA, Encina JJ, Ribeiro AL, Soc CCDI. Chagas Disease an Overview of Clinical and Epidemiological Aspects. *Journal of the American College of Cardiology.* Aug 27 2013;62(9):767-776.

8. Coura JR. The Main Sceneries of Chagas Disease Transmission. The Vectors, Blood and Oral Transmissions--a Comprehensive Review. *Mem Inst Oswaldo Cruz.* May 2015;110(3):277-282.

9. Carlier Y, Sosa-Estani S, Luquetti AO, Buekens P. Congenital Chagas Disease: An Update. *Mem Inst Oswaldo Cruz.* May 2015;110(3):363-368.

10. Rassi A, Jr., Rassi A, Marin-Neto JA. Chagas Disease. *Lancet.* Apr 17 2010;375(9723):1388-1402.

11. World Health Organization. *Control of Chagas Disease: Second Report of the Who Expert Committee* Geneva 2002.

12. World Health Organization. *Working to Overcome the Global Impact of Neglected Tropical Diseases: First Who Report on Neglected Tropical Diseases.* Geneva 2010.

13. Bonney KM. Chagas Disease in the 21st Century: A Public Health Success or an Emerging Threat? *Parasite.* 2014;21:11.

14. Ribeiro I, Sevcsik AM, Alves F, et al. New, Improved Treatments for Chagas Disease: From the R&D Pipeline to the Patients. *PLoS Negl Trop Dis.* 2009;3(7):e484.

15. Hotez PJ, Bottazzi ME, Franco-Paredes C, Ault SK, Periago MR. The Neglected Tropical Diseases of Latin America and the Caribbean: A Review of Disease Burden and Distribution and a Roadmap for Control and Elimination. *PLoS Negl Trop Dis.* 2008;2(9):e300.

16. Bustamante DM, De Urioste-Stone SM, Juarez JG, Pennington PM. Ecological, Social and Biological Risk Factors for Continued Trypanosoma Cruzi Transmission by Triatoma Dimidiata in Guatemala. *PLoS One.* 2014;9(8):e104599.

17. King RJ, Cordon-Rosales C, Cox J, Davies CR, Kitron UD. Triatoma Dimidiata Infestation in Chagas Disease Endemic Regions of Guatemala: Comparison of Random and Targeted Cross-Sectional Surveys. *PLoS Negl Trop Dis.* 2011;5(4):e1035.

18. Enger KS, Ordoñez R, Wilson ML, Ramsey JM. Evaluation of Risk Factors for Rural Infestation Bytriatoma Pallidipennis(Hemiptera: Triatominae), a Mexican Vector of Chagas Disease. *Journal of Medical Entomology.* 2004;41(4):760-767.

19. Weeks EN, Cordon-Rosales C, Davies C, Gezan S, Yeo M, Cameron MM. Risk Factors for Domestic Infestation by the Chagas Disease Vector, Triatoma Dimidiata in Chiquimula, Guatemala. *Bull Entomol Res.* 2013;103(6):634-643.

20. Bayer AM, Hunter GC, Gilman RH, et al. Chagas Disease, Migration and Community Settlement Patterns in Arequipa, Peru. *PLoS Neglected Tropical Diseases.* 2009;3(12).

21. Ramsey JM, Alvear AL, Ordoñez R, et al. Risk Factors Associated with House Infestation by the Chagas Disease Vector Triatoma Pallidipennis in Cuernavaca Metropolitan Area, Mexico. *Medical and Veterinary Entomology.* 2005;19(2):219-228.

22. Molina-Garza ZJ, Rosales-Encina JL, Mercado-Hernandez R, Molina-Garza DP, Gomez-Flores R, Galaviz-Silva L. Association of Trypanosoma Cruzi Infection with Risk Factors and Electrocardiographic Abnormalities in Northeast Mexico. *BMC Infect Dis.* 2014;14:117.

23. Conners EEV, J.M.; Weeks, J.R.; Brouwer, K.C. . A Global Systematic Review of Chagas Disease Prevalence among Migrants. *Acta Trop.* 2016;In Press.

24. Isacson A, Meyer M, Morales G. Mexico's Other Border: Security, Migration, and the Humanitarian Crisis at the Line with Central America. 2014; http://www.wola.org/files/mxgt/report/. Accessed September 9 2014.

25. Secretaría de Gobernación Mexico. *Boletín Mensual De Estadísticas Migratorias [Monthly Bulletin of Immigration Statistics].* Mexico, D.F. 2014.

26. US Department of Homeland Security. *Cbp Border Security Report.* 2014.

27. Villegas RD, Rietig V. *Migrants Deported from the United States and Mexico to the Northern Triangle: A Statistical and Socioeconomic Profile.* Washington, DC Migration Policy Institute 2015.

28. Carabarin-Lima A, González-Vázquez MC, Rodríguez-Morales O, et al. Chagas Disease (American Trypanosomiasis) in Mexico: An Update. *Acta Tropica.* 2013;127(2):126-135.

29. Cruz-Reyes A, Pickering-López JM. Chagas Disease in Mexico: An Analysis of Geographical Distribution During the Past 76 Years - a Review. *Memorias do Instituto Oswaldo Cruz.* 2006;101(4):345-354.

30. Pan American Health Organization. *Quantitative Estimation of Chagas Disease in the Americas.* Montevideo, Uruguay 2006.

31. United Nations Department of Economic and Social Affairs. International Migrant Stock by Origin and Destination 2015.

32. Roca C, Pinazo MJ, Lopez-Chejade P, et al. Chagas Disease among the Latin American Adult Population Attending in a Primary Care Center in Barcelona, Spain. *PLoS Negl Trop Dis.* 2011;5(4):e1135.

33. Custer B, Agapova M, Bruhn R, et al. Epidemiologic and Laboratory Findings from 3 Years of Testing United States Blood Donors for Trypanosoma Cruzi. *Transfusion.* Sep 2012;52(9):1901-1911.

34. Muñoz J, Coll O, Juncosa T, et al. Prevalence and Vertical Transmission of Trypanosoma Cruzi Infection among Pregnant Latin American Women

Attending 2 Maternity Clinics in Barcelona, Spain. *Clinical Infectious Diseases.* 2009;48(12):1736-1740.

35. Gürtler RE. Sustainability of Vector Control Strategies in the Gran Chaco Region: Current Challenges and Possible Approaches. *Memorias do Instituto Oswaldo Cruz.* 2009;104(SUPPL. 1):52-59.

36. Levy MZ, Bowman NM, Kawai V, et al. Periurban Trypanosoma Cruzi-Infected Triatoma Infestans, Arequipa, Peru. *Emerging Infectious Diseases.* 2006;12(9):1345-1352.

37. Medrano-Mercado N, Ugarte-Fernandez R, Butrón V, et al. Urban Transmission of Chagas Disease in Cochabamba, Bolivia. *Memorias do Instituto Oswaldo Cruz.* 2008;103(5):423-430.

38. Ramsey JM, Elizondo-Cano M, Sanchez-Gonzalez G, Pena-Nieves A, Figueroa-Lara A. Opportunity Cost for Early Treatment of Chagas Disease in Mexico. *PLoS Negl Trop Dis.* Apr 2014;8(4):e2776.

39. Imaz-Iglesia I, Garcia-San Miguel L, Ayala-Morillas LE, et al. Economic Evaluation of Chagas Disease Screening in Spain. *Acta Tropica.* Aug 2015;148:77-88.

40. Bern C, Montgomery SP. An Estimate of the Burden of Chagas Disease in the United States. *Clin Infect Dis.* Sep 1 2009;49(5):e52-54.

41. Arena R, Mathews CE, Kim AY, Lenz TE, Southern PM. Prevalence of Antibody to Trypanosoma Cruzi in Hispanic-Surnamed Patients Seen at Parkland Health & Hospital System, Dallas, Texas. *BMC Research Notes.* 2011;4.

42. Gascon J, Bern C, Pinazo MJ. Chagas Disease in Spain, the United States and Other Non-Endemic Countries. *Acta Trop.* Jul-Aug 2010;115(1-2):22-27.

Chapter 5. Discussion

SUMMARY OF RESULTS

Using the risk environment framework, we identified individual and social, and physical structural factors associated with HIV risk and Chagas disease.

HIV and substance use risk

We found that FSWs and migrants who used substances were at heightened risk for HIV via their substance use and sexual risk behaviors. The key social and physical structural factors associated with those behaviors were neighborhood, housing, and access to condoms.

In Chapter 2, we determined that over a third of our sample of FSWs living in Tijuana smoked methamphetamine. This finding is concerning given the body of literature linking smoking methamphetamine to sexual risk behaviors generally, and to HIV specifically. We found that the residential neighborhood environment was the strongest predictor of smoking methamphetamine daily. Women who live in the Zona Roja (red light district) may be exposed to greater social disorder, availability of substance use, and violence, which may in turn influence substance use. Homelessness was also related to smoking methamphetamine, but only among women who also had the financial means to purchase the drug.

In Chapter 3 we found the prevalence of HIV in a sample of substance using recent migrants at the Mexico/Guatemala border was 2.4% among women and 1.3% among men. In this cohort, we found the most frequently used drugs were

marijuana, non-injection cocaine or crack, and inhalants. While 11% reported ever injecting a drug, few people were active users.

Over half of the migrants had casual partners with whom condoms were inconsistently used. Among men with casual partners, substance use during the sexual encounter and having partners that also use drugs were both strongly associated with inconsistently using condoms. However, access to free condoms increased men's odds of using condoms with partners. Our findings highlight that while HIV prevalence was not as high as in samples of most at risk populations (MARPs), the potential for disease transmission through sexual risk was great.

Chagas disease

The key structural factors associated with Chagas disease were impoverished housing and being born in a rural area. In Chapter 4, we determined the prevalence of Chagas disease was 2.6%. We found that currently living in a poor physical housing environment was more often found with individuals positive for *T. cruzi*. Knowledge of Chagas disease among migrants was low, but may have been higher than that of non-migrating populations in non-endemic areas. Individuals living in rural areas and migrants living in poverty in urban areas may be populations with the greatest need for testing and treatment.

Migration

With this dissertation we were able to describe Chagas disease and HIV disease risks among migrant populations. However, we had also conceptualized that

the migration process itself is a type of distal structural factor that asserts its influence on behavior via more proximal determinants (e.g., access to care, stigma). While we had hypothesized that migration would have an effect on structural factors and individual behaviors, we did not clearly see that borne out in the studies.

In Chapter 2, we did not find an association between migration or deportation and smoking methamphetamine. It should be noted that similar to other studies, deportation was low among our sample and we may have been underpowered to see effects. We suggest that a purposeful sample of deported women would be necessary in order to truly understand the relationship between deportation and substance use risk. It may be that we did not see any effect because we could not classify women as having migrated voluntarily or not. Past studies have suggested that women who migrated to Tijuana voluntarily may be protected from sexual and substance use risk, at least for a period of time.[1]

In Chapter 3, we did not find associations between migration history and negative health outcomes. This could be that regardless of the type of migration (e.g., international, regional), all migrants are at a similar level of risk. In fact, we did see that within the migrant population, there was a high prevalence of risk behaviors, including both men and women selling sex in the past six months and men using drugs prior to sex. However, without a comparison group of non-migrants, we were unable to draw any conclusions regarding whether these behaviors were increased due to migration.

Finally, in Chapter 4 we had hypothesized that there may be a relationship between seasonal agricultural work or more vulnerable migrants (e.g., undocumented, forced migration) and Chagas disease. The small sample of agricultural workers may have precluded us from seeing any effects. Also given the high levels of poverty in this Central America and Mexico region, migration may not exert a detectable change in proximal disease outcomes.

STRENGTHS & LIMITATIONS

Generalizability

All three Chapters used data from studies that used time location sampling to capture high-risk individuals. Time-location sampling is considered a valid method of recruiting hard to reach and marginalized populations in research.[2,3] The *Mapa de Salud* project (Chapter 2) had recruitment caps on the number of women recruited from each sex work venue and had target recruitment goals for different areas of the city (i.e, inside versus outside the red light district). These efforts resulted in one of the most diverse samples of FSWs in Tijuana to date. The *Cruzando Fronteras* study (Chapters 2 and 3) used similar time-location sampling methods, plus peer referrals. Because of the use of non-random recruitment, we caution the generalizability of our results to other populations.

Self-report

Behaviors and demographics were collected through self-reported measures. Because of concerns with low computer literacy levels among the populations, the surveys were administered by an interviewer. All interviewers were trained in the

ethical conduct of research and most had prior experience working with marginalized populations (e.g., persons living with HIV). Prior to and during the studies, local staff were very engaged with the communities, building rapport and trust, thus increasing the likelihood of obtaining honest accounts of behaviors. Despite these precautions, there is always the potential for social desirability bias, which would decrease the reporting of sensitive behaviors.

Additionally, participants were asked to recall past behaviors and experiences, which may have led to inaccurate responses. While there is the potential for recall bias, studies of substance users have suggested that the ability to recall sexual and drug use behaviors over 6 months is good.[4,5]

A strength was that the studies directly tested for diseases (HIV, syphilis, Chagas disease) rather than relying on self-reported measures. Because these infections can be asymptomatic and because screening is low, the use of self-reported symptoms would have likely resulted in a large underestimation of the burden of disease.

Measurement

When possible, we used standardized measures for the quantitative survey (e.g., AUDIT-C, CES-D). Other measures were drawn from past studies of HIV and substance use in Mexico. Spanish translations of all measures were done by native speakers. Prior to recruitment, surveys were reviewed by Mexican and Guatemalan

field teams. Informal pilot testing of measures with FSWs or migrants were conducted by local staff and poor measures were revised.

RECOMMENDATIONS

FSW

We recommend further examination of the specific pathways linking the residential neighborhood and homelessness to frequent methamphetamine use. The home environment is a key intermediary space that links broader processes (e.g., poverty) to the immediate physical and social environment of individuals.[6] Multi-level models of specific neighborhood characteristics would be one way to look at the relative effects of neighborhood (e.g., social disorder) versus individual behaviors. Qualitative interviews may be warranted to study the context of how women are interacting with place and to better understand factors influencing substance use among FSWs.

Our findings pointed to the important dynamic between the home environment and more severe methamphetamine use. While venues remain an important intervention point for FSWs, especially in terms of HIV risk, we believe that more work is needed to understand how the home environments of FSWs influence their substance use. In light of our findings, we suggest that the development of safe and affordable supportive housing located outside of the Zona Roja as a potential rehabilitation option for FSWs who want to reduce their methamphetamine use. The potential public health benefits resulting from safe and supportive housing for FSWs extend beyond methamphetamine addiction.[7-9]

Migrants

At the Mexico/Guatemala border, we suggest public health programs need to engage migrant women and find ways to increase acceptability of condoms outside of sex worker populations. Rather than creating targeted messaging to any particular migrant subgroups (e.g., international migrants), we found that any migrants who use substances would benefit from increased access and acceptability of condom use with casual partners. We suggest that studies of MARPs (FSWs, MSM, IDUs) in the region capture migration history as part of their study in order to better track diseases and behaviors among mobile populations.

Greater outreach to men who engage in sex work is critical, considering that we found very low use of condoms in this population. Messaging on condom use may be more acceptable if marketed broadly rather than to just to MSM. That recommendation is in light of both the low social acceptability of homosexuality in Mexico and Central America and our finding that men who identified as heterosexual were also having sex with men.

Our analysis into inconsistent condom use among women was limited because of the small sample. Future work should enroll a sample of migrant women in order to better understand their risk and behaviors.

At the Mexico/Guatemala border, we also found an increased need for Chagas disease awareness and education campaigns among individuals living in the region. Organizations looking to screen for individuals at heightened risk for Chagas

disease should consider both rural and urban areas with high poverty, as well as testing migrants generally. We believe a larger community sample of migrants in the region is needed in order to more accurately characterize the burden of disease.

CONCLUSIONS

The risk environment framework was a useful way to generate hypothesized relationships between structural factors and individual risk behaviors. We identified housing, poverty, and access to care as some of the key factors influencing infectious disease risk. Overall, this dissertation highlights multiple areas of structural vulnerability in order to suggest potential intervention points and shed greater light on the spaces in which our participants live.

REFERENCES

1. Strathdee SA, Lozada R, Ojeda VD, et al. Differential Effects of Migration and Deportation on Hiv Infection among Male and Female Injection Drug Users in Tijuana, Mexico. *PLoS One.* 2008;3(7):e2690.

2. Garfein RS, Rondinelli A, Barnes RF, et al. Hcv Infection Prevalence Lower Than Expected among 18-40-Year-Old Injection Drug Users in San Diego, Ca. *J Urban Health.* Jun 2013;90(3):516-528.

3. Heckathorn DD. Respondent-Driven Sampling: A New Approach to the Study of Hidden Populations. *Social Problems.* May 1997;44(2):174-199.

4. Darke S, Hall W, Heather N, Ward J, Wodak A. The Reliability and Validity of a Scale to Measure Hiv Risk-Taking Behaviour among Intravenous Drug Users. *AIDS.* Feb 1991;5(2):181-185.

5. De Irala J, Bigelow C, McCusker J, Hindin R, Zheng L. Reliability of Self-Reported Human Immunodeficiency Virus Risk Behaviors in a Residential Drug Treatment Population. *Am J Epidemiol.* Apr 1 1996;143(7):725-732.

6. Aidala AA, Sumartojo E. Why Housing? *AIDS Behav.* Nov 2007;11(6 Suppl):1-6.

7. Reed E, Gupta J, Biradavolu M, Devireddy V, Blankenship KM. The Role of Housing in Determining Hiv Risk among Female Sex Workers in Andhra Pradesh, India: Considering Women's Life Contexts. *Soc Sci Med.* Mar 2011;72(5):710-716.

8. Duff P, Deering K, Gibson K, Tyndall M, Shannon K. Homelessness among a Cohort of Women in Street-Based Sex Work: The Need for Safer Environment Interventions. *BMC Public Health.* 2011;11:643.

9. Lazarus L, Chettiar J, Deering K, Nabess R, Shannon K. Risky Health Environments: Women Sex Workers' Struggles to Find Safe, Secure and Non-Exploitative Housing in Canada's Poorest Postal Code. *Soc Sci Med.* Dec 2011;73(11):1600-1607.