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The effects of housing stability and the residential environment on HIV risk factors and tuberculosis

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy

in

Public Health (Global Health)

by

Ryan Paul Lindsay

Committee in charge:

University of California, San Diego

Professor Melanie Rusch, Chair
Professor Steffanie Strathdee
Professor Monica Ulibarri

San Diego State University

Professor Scott Roesch
Professor Suzanne Lindsay

2012

The Dissertation of Ryan Paul Lindsay is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

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Chair

University of California, San Diego

San Diego State University

2012

DEDICATION

To Kristen, whose belief in me was both unflinching and essential to this project. To Margaret, Jane and Jack for joining the adventure and demanding hugs before heading out the door. To Mom and Dad, Bryan and Linda, for having high expectations of us, then helping us meet them.

EPIGRAPH

“Medicine is a social science, and politics is
nothing more than medicine on a grand scale.”
-Rudolf Virchow

“When I give food to the poor, they call me a saint.
When I ask why the poor have no food, they call me a communist.”
-Dom Hélder Câmara

TABLE OF CONTENTS

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Chapter 2, in part, is in preparation for submission to a journal with the citation: Lindsay, Ryan P; Rangel, Gudelia; Martinez, Gustavo; Vera, Alicia; Lindsay, Suzanne P; Strathdee, Steffanie A; Rusch, Melanie L. Determining housing instability in a longitudinal study of female sex workers that inject drugs along the northern Mexico border.

Chapter 3, in part, is currently being prepared for submission to a journal with the citation: Lindsay, Ryan P; Roesch, Scott; Rangel, Gudelia;

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Chapter 4 is being prepared for publication with the citation: Lindsay, Ryan P, Shin, Sanghyuk S; Garfein, Richard; Rusch, Melanie L; Novotny, Thomas E. The association between lifetime, active and passive smoking and latent tuberculosis infection in adults and children in the United State: results from NHANES.

VITA

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ABSTRACT OF THE DISSERTATION

The effects of housing stability and the residential environment on HIV risk factors and tuberculosis

by

Ryan Paul Lindsay

Doctor of Philosophy in Public Health (Global Health)

University of California, San Diego, 2012
San Diego State University, 2012

Professor Melanie Rusch, Chair

Background: Structural and environmental factors are that influence risk behaviors for HIV and tuberculosis (TB) outcomes are increasingly relevant in determining risk. The impact of the residential environment, including the social and physical living space, may be particularly influential in HIV or TB risk.

Aims: Our main objectives in this study were to (1) describe and characterize housing types and changes in housing over time among female sex workers that inject drugs (FSW-IDU) living along the Northern Mexico border to define an appropriate housing stability measure (2) determine the

association of the housing environment (i.e. housing stability) with HIV/STI sexual risk behaviors (i.e. unprotected sex by partner type) among FSW-IDU (3) determine the impact of drug use in the social living environment (passive smoking) on latent TB infection (LTBI) in the US civilian non-institutionalized population.

Methods: Chapters 2 and 3 used quantitative housing data from the longitudinal *Mujer Mas Segura* dataset of FSW-IDU in Ciudad Juarez and Tijuana. Chapter 2 uses data on housing types and longitudinal trends in housing to consider what characterizes housing stability among FSW-IDU. Chapter 3 describes the association between housing stability measures and unprotected sex by client type among FSW-IDU. Chapter 4 used available data from the US National Health and Nutrition Examination (NHANES) survey to describe the association between passive smoking and LTBI.

Results: Chapter 2 found that FSW-IDU frequently moved; only 11.5% were in the same housing type across all visits (18 months). Less than a quarter of FSW-IDU lived in stable housing and receptive needle sharing and unprotected sex where higher among those with greater housing instability. Chapter 3 found that improving housing categories was associated with less unprotected sex in bivariate associations, but was not significantly associated after adjustment with individual and social level covariates. Chapter 4 found a marginally significant association between passive smoking and LTBI in the

general adult population after adjustment for confounders. Among the foreign-born in the US, passive smoking was significantly associated with LTBI.

Conclusion: Both the residential environment and individual risk factors are important when determining risk of HIV and TB.

CHAPTER 1

Introduction

Structural and environmental factors that influence risk behaviors and biological health outcomes are increasingly relevant in understanding complex layers of influence on the disease transmission of HIV and tuberculosis (TB). The impact of the residential environment, including the social and physical living space where people spend most of their time, may be particularly influential in HIV and TB risk. The objectives of this dissertation are:

1. To describe and characterize housing types and changes in housing over time among female sex workers that inject drugs (FSW-IDU) living along the Northern Mexico border to define an appropriate housing stability measure (Chapter 2);
2. To determine the association of the housing environment (i.e. housing stability) with HIV/STI sexual risk behaviors (i.e. unprotected sex by partner type) among FSW-IDU, controlling for known social living environment and individual-level correlates (Chapter 3);
3. To determine the impact of drug use in the social living environment (passive smoking) on latent TB infection (LTBI) in the US civilian non-institutionalized population (Chapter 4).

Background and significance

HIV and tuberculosis

HIV and tuberculosis (TB), both communicable diseases but transmitted in different ways, share common structural and social risk factors for transmission including poverty[1-4] and housing instability[5-10]. Substance use is also a common risk factor that may influence transmission of HIV or TB, though it is dependent on the drug and route of administration[11-14]. Both diseases are major causes of morbidity and mortality worldwide[15], and as comorbidities, are particularly harmful[16].

The shift in health promotion from mainly individual-level intervention efforts to a broader consideration of the conditions that effect health at the social and environmental levels was formalized in the Ottawa Charter of the World Health Organization in 1986[17]. Since then, focus on structural or social determinants of health has become increasingly relevant in improving health. Given the amount of time typically spent at home, as well as the relationships and behaviors encountered within the home, a person's residential environment likely affects transmission of various diseases including HIV and TB.

Residential environment

In HIV research, the environment has been broadly defined as "the space—whether social or physical—in which a variety of factors exogenous to

the individual interact to increase the chances of HIV transmission"[18]. The same definition of environment could be applied to TB transmission.

A residence is a person's home, or the place where a person primarily lives and sleeps. Therefore the residential environment is the primary living space—whether social or physical—in which a variety of factors exogenous to the individual interact to increase the chances of HIV/TB transmission. Among the variety of structural and social-level influences on HIV and TB transmission, this dissertation focuses specifically on the residential environment.

Theoretical framework

Holistic theoretical frameworks that portray the shift from individual to structural levels have conceptualized layers of risk for disease transmission. An early model that applied to more than disease transmission, the socio-ecological model, posited that biological disease outcomes were influenced by individual, interpersonal, community, and macro-level influences on health[19]. Sweat and Denison applied similar levels of causation (individual, environmental, structural, superstructural) to HIV incidence[20]. Rhodes' risk environment further stipulated that policy, economic, social and physical risk environments interact and operate at both micro and macro levels of influence on HIV transmission[18,21].

Rhodes' distinction of physical and social risk environments is particularly applicable to the residential environment. Homelessness is an

example of a micro-physical risk environment while substance use at home is an example of micro-social risk environment. Our framework adapts Sweat and Denison's model of levels of causation for HIV and Rhodes' heuristic of micro-social and micro-physical aspects of the environment as a framework for understanding the risks of the residential environment on HIV and TB transmission. While developed for HIV, we apply these frameworks to transmission of both HIV (Figure 1.1) and TB (Figure 1.2) as a result of influences from the residential environment. The residential environment distinguishes between housing conditions and social living conditions (see Figure 1.1). The micro-physical residential environment includes the type and consistency of housing (i.e. housing stability, housing type, and whether one lives at the place of employment), to be explored in chapter 2 and 3. The social living environment focuses on the relationships and behaviors found within the residential environment (i.e. presence of steady partner/spouse/dependents at home, substance use behaviors in home) and disease transmission, which is investigated in chapters 3 and 4.

The micro-physical residential environment and HIV

The micro-physical residential environment may refer to both the type and consistency of shelter (i.e. housing stability, housing type, living where you work) but may also include physical characteristics of the home (i.e. lack of security, or insufficient space to store condoms). Homelessness and unstable housing (usually defined as having basic amenities but little control

over the local environment, for example temporary housing, incarceration, living with family, friends or strangers[9]) have been associated with increased HIV/STI risk behaviors, and HIV/STI transmission in diverse settings[8-10,22].

The micro-social residential environment and HIV

The micro-social residential environment considers co-habitants and behaviors that occur within the home (i.e. living with partners, dependents, family members, using substances or injecting drugs at home).

The micro-physical residential environment and TB

Physical characteristics of a residence such as poor ventilation and poor exposure to sunlight are examples of the micro-physical residential environment that may affect household transmission. There were no indicators of windows, household light or ventilation in NHANES; therefore, the micro-physical residential environment and TB was not explored in chapter 4.

The micro-social residential environment and TB

Social influences in the home that effect TB transmission are, living with someone with TB, overcrowding, and substance use (e.g., passive smoking) within the home.

Structural and social influences on FSW/IDU

The structural and social context in which HIV/STI transmission occurs is a growing point of focus in HIV research among female sex workers (FSW) and injection drug users (IDU)[23]. Understanding the risk environment for women who trade sex and inject drugs (FSW-IDU) is of particular importance

as these women have an elevated risk for HIV through both injection and sexual transmission routes. Structural, social and individual risk factors are shown to influence HIV risk among FSW and FSW-IDU[20,21,24]. However, a recent analysis from the Mujer Mas Segura (MMS) study of FSW-IDU (the same dataset used in this analysis) indicated that correlates of HIV infection for FSW-IDUs were primarily structural and environmental factors, and to a lesser extent individual behaviors. The authors concluded "researchers should consider different levels and types of the HIV risk environment that shape risk behaviors"[25].

Housing instability and FSW

FSW consistently rate housing as a top priority to be addressed in order to live healthier lives, particularly among street-based FSW [26,27]. Preliminary studies on Mexico's northern border report that FSW have poor housing conditions with frequent changes in place of residence[28-30]. One study of FSW in Tijuana (TJ) and Ciudad Juarez (CJ) found that FSW-IDU were less likely to live in their own home and were more likely to live in rented rooms compared to FSW that do not inject[30]. Recent gentrification of areas in CJ, including areas where FSW live and work, has also occurred since 2008[31], though its effect on housing stability among FSW is still unknown. These early studies show that in Mexico, FSW and FSW-IDU experience housing instability; FSW-IDU may experience even greater housing instability than other FSW.

Measuring housing instability

Housing stability measures in the context of HIV/STI research have been defined differently in many studies but are usually based on a single dichotomous variable (homeless versus housed, unstable versus stable housing). These definitions of housing stability warrant further consideration, which Weir et al. cover in their review of housing measures in HIV research[9]. Homelessness typically refers to "sleeping or living on the streets, in a car, in a homeless shelter, in an abandoned building, or other places not intended for sleeping"[9]. Unstable housing refers to "living in transitional housing, a drug treatment facility, jail or prison, or living with family, friends, or strangers"[9]. Stable housing generally means residing in one's own house or apartment[9]. However, there is wide variation in the use of this terminology, for example, homelessness may or may not be included in definitions of unstable housing. The notion of owning a house or being the primary person on the lease of an apartment are linked to the broader idea of having control over the space in which you live. For example, control over the housing environment is important in the context of keeping condoms or safe-injection equipment in the home[18]. Control over the housing environment varies widely across cultures, where social norms and at times legislation may preclude women from home ownership[32].

Housing stability measured over time

Though single-variable housing measures may be able to distinguish between homeless, unstably housed and/or stably housed individuals, Weir et al. suggest the use of longitudinal data and multiple questions on housing be used to build a better quality construct of housing stability[9]. Longitudinal studies provide an opportunity to capture not only housing types, but housing consistency determined by the frequency of changes in housing, and improving or worsening housing conditions (here defined as housing movement) over time. Furthermore, housing stability determined solely by categories of housing type in cross-sectional studies may be inaccurate, especially among subpopulations that frequently change place of residence or move between housing categories.

Assessing housing over time has yielded important information unavailable in cross-sectional assessments. Frequent changes in housing "may reflect an accumulation of stressful events, disruption of social networks, and reduced connection to a larger community."[9] Longitudinal studies have shown that brief periods of consistent housing, even for a period as short as one month in unstable housing, has been associated with a decrease in multiple HIV risk behaviors among street youth in Montreal, including sex work and drugs use[33]. Another longitudinal study showed that a change from stable to unstable housing led to more involvement in sex work among HIV positive individuals in the US[10]. Measuring the number of housing changes, evictions,

improvement or worsening of housing, periods of homelessness or stability, and perceived homelessness all provide additional context. Therefore, suggestions that housing measurements account for multiple measures of housing, including stability over time, carry particular weight in the context of FSW and IDU[9].

Longitudinal studies also allow researchers to know the temporality of events, which is important given a reciprocal relationship of causation between housing and HIV/STI risk outcomes[9,33-35]. In theory, FSW-IDU in Mexico may encounter difficulties in acquiring housing as a result of their substance use or stigma from being a sex worker while evictions from stable housing may also be a result of substance use, involvement in sex work or economic instability[9,35].

Cultural context of housing

Categorizing housing stability may be complicated by differences in the way people live in different cultural settings, and different ideas of inadequate or unstable housing across geographic boundaries or amongst subpopulations. The majority of studies on housing and HIV have taken place in developed countries, where housing constructs may or may not translate contextually to Mexico or other lower or middle income countries. For example, young adults co-residing with parents may be traditionally categorized as having “unstable” housing in the U.S. and Canada since ownership and control over living space belongs to a parent. However, this

may not be as accurate among Latinos where a higher proportion of family members co-reside. Latinos in the U.S. were twice as likely to co-reside compared with whites and Mexican young adults report higher prevalence and increasing incidence of intergenerational co-residence compared with other developing nations [36], [37]. Therefore, housing categories should be culturally adjusted to local customs and realities.

Mechanisms through which housing affects HIV/STI risk behaviors

Currently, the mechanisms by which housing instability affects HIV/STI risk behaviors among FSW are not fully understood. Unstable housing was associated with increased HIV risk among FSW in India after controlling for individual-level risk factors suggesting that the mechanisms by which unstable housing increases HIV/STI risk are in part explained by structural- social factors[38]. Since housing is a complex structural and social construct, it is likely that multiple mechanisms for increasing HIV/STI risk behaviors co-occur with unstable housing. Potential mechanisms are briefly described below and are categorized in terms of economic, environment, social and psychosocial mechanisms.

Economic mechanism

Homelessness and unstable housing are a marker for poverty, and women that are economically dependent on other people, usually men, are less able to negotiate condom use, and more likely to accept offers of more money for sex without a condom, thus increasing HIV/STI risk[39-43]. In India,

FSW reporting a higher number of evictions were more likely to accept more money for unprotected sex than FSW with fewer evictions[38]. However, poor housing conditions may have an effect on HIV behaviors after controlling for income.

Environmental mechanism

Some studies suggest that unstable housing is associated with increased HIV risk due to the risk behaviors that occur as a direct result of the unstable housing environment. More harmful injection drug use behaviors including syringe sharing, or inability to adequately discard or clean injection equipment may be a result of unstable housing[10,22]. Homelessness or unstable housing may affect whether condoms can be stored, the characteristics of clients with whom sex is traded, and where clients are solicited and serviced. These could all effect a woman's ability to negotiate condom use. For example, studies in the US found that homeless FSW were more likely to encounter clients that refused to use condoms than non-homeless FSW[44,45]. Other studies have found that FSW servicing clients in public spaces are more likely to be homeless[46] and to have experienced coercive unprotected sex by clients[47]. These studies point to the vulnerability that homeless or unstably housed FSW may experience as a direct result of their environment that creates barriers to their ability to decrease HIV/STI risk behaviors.

Social mechanism

Social network characteristics are intrinsically linked with housing status; greater social support predicts housing stability[48,49]. At the same time, social network characteristics influence HIV/STI risk behavior[50-53] and have also been shown to influence both positive and negative changes in housing. For example, having a steady partner was associated with moving to improved housing; yet having a sex partner who used drugs predicted a decreased odds of improved housing[50,54].

Psychosocial mechanism

Housing stability and psychosocial health have a reciprocal relationship of causation where unstable housing has predicted poor mental health outcomes and vice versa[55,56]. Increased injection drug use may be a coping mechanism for despair experienced as a result of having few housing options[44]. Reciprocally, prior physical or sexual abuse resulting in depressive symptoms among FSW in Mexico may lead to illicit drug use[57,58] which in turn could complicate the ability to acquire stable housing.

Structural and social influences on TB

Mortality from tuberculosis in developed nations drastically declined over the previous century. Most of this drop occurred prior to chemotherapy and was due in large part to improvements in infrastructure and socioeconomic status in nutrition, sanitation and hygiene, segregation of infected patients (sanatoriums), and housing including less crowding within

homes[59,60]. The link between socioeconomic status and poverty to TB have caused some to label TB as "the quintessential public health disease" [61] or "a social disease with a medical aspect"[62].

The appearance of HIV, economic instability, continued immigration from high TB incidence countries, and drug-resistant forms of TB due to a lack of treatment adherence and development of new drugs have kept TB as a persistent public health problem in the US and other developed countries. However, another risk factor, cigarette smoke exposure, has received increasing attention for its effects on TB.

Smoking and TB

Smoking has been associated with a two-fold increase in odds of infection, activation of latent TB, progression of active TB, and mortality among active TB cases[14,63-65]. While active smoking has been associated with increased risk of latent TB infection (LTBI)[66-69], fewer studies have investigated the association between passive smoking (environmental or secondhand smoke exposure) and TB infection in adults[70-74] or children[75-80], which may contribute to the household spread of TB. Neither the association of active nor passive smoking with LTBI has been investigated on a nationwide, representative sample in the US.

Measuring passive smoking

Where smoking and TB relationships have been explored, researchers have relied almost completely on self-reported smoking status which can be

subject to recall or social desirability biases. Cotinine, a metabolite of nicotine, is considered the gold-standard for assessing nicotine exposure and reduces biases through self-report[81]. While self-reported current smoking status is 80-90% concordant with cotinine levels in nationwide studies in the US[82], there has been less agreement among adolescents where smoking may be more sporadic and where embarrassment or fear may lead to under-reporting of current or passive smoking[83].

Assessing dose-response relationships between smoking and TB among self-reported current smokers can be complicated by recall bias in the amount of cigarettes smoked or additional passive smoke exposure unaccounted for. Among those exposed to passive smoke, assessing a dose-response through self-reported passive smoking exposure is even more challenging. Self-reported passive smokers tend to underestimate the amount of smoke exposure indicated by serum cotinine[84].

Two studies have used cotinine levels to assess the relationship between smoking and TB. The first used urine cotinine to confirm passive smoking status of adolescent pulmonary TB contacts in Spain and found that contacts of TB patients that became infected with TB had higher average cotinine levels than contacts who did not become TB infected[85]. The second study, conducted in South Africa, found no association between cotinine-determined current smoking status and LTBI or active TB infection among

adults[86]. Given the discrepancy in the relationship in studies assessing cotinine-confirmed smoking status and TB, more research is warranted.

Specific Aims

The overall goal of this dissertation is to determine how the physical and social residential environment, may impact risk behavior and disease outcomes. The first two aims focus on the impact of the residential environment on sexual risk behavior (i.e. condom use, receptive needle sharing) among FSW-IDUs along the northern border of Mexico. The third aim focuses on the association between an aspect of the social residential environment, passive smoking, on LTBI. This goal is parsed into three specific aims and two hypotheses. These are:

1. To describe the housing environment and characterize housing types and changes in housing over time to define an appropriate housing stability measure among FSW-IDU living along the Northern Mexico border.
2. To determine the association of the housing environment (i.e. housing stability) with HIV/STI sexual risk behaviors (i.e. condom use by partner type) among FSW-IDU, controlling for known social living environment and individual-level correlates.

   H2.1 Living in stable housing will be positively associated with more frequent condom use with clients and spouse/sexual partners compared to those in less stable housing.

3. To determine the impact of drug use in the social living environment (passive smoking) on latent TB infection (LTBI) in the US civilian non-institutionalized population.

   H3.1 Passive smoking will be positively associated with LTBI

Dissertation Outline

This dissertation is organized into 5 chapters comprised of an introduction to residential environment as it relates to HIV and TB risk (chapter 1), and then three distinct manuscripts (Chapter 2-4), followed by a discussion of findings from all three manuscripts (chapter 5). The first manuscript (chapter 2), entitled "Determining housing instability in a longitudinal study of female sex workers that inject drugs along the northern Mexico border", describes and compares different measures of housing stability among FSW-IDU living along Mexico's northern border. The second manuscript (chapter 3), "Exploring the association between housing instability and unprotected sex by client type among female sex workers who inject drugs along the Northern Mexico border", builds upon the first manuscript by assessing associations of measures of housing stability with unprotected sex. The third manuscript (chapter 4), "The association between lifetime, active and passive smoking and latent tuberculosis infection in adults and children in the United State: results from NHANES" details the impact of passive smoking on LTBI in a nationally representative sample of the US population. The final chapter

discusses findings and themes throughout the manuscripts, as well as implications and future research directions.

Overview of Research Methods

Data for this dissertation come from two datasets: The first, Mujer Mas Segura (MMS), or Safer Women, was an intervention study of FSW-IDU from Tijuana and Ciudad Juarez conducted between 2008-2010 that was designed to promote condom use and safer injection behavior. MMS measured housing and social residential environment variables, as well as individual drug use history and HIV/STI risk behavior questions. As a longitudinal study, these items were asked at baseline and over 3 quarterly visits occurring over 18 months. The second dataset is the cross-sectional US National Health and Nutrition Examination Survey (NHANES), a nationally representative survey of the civilian non-institutionalized population that measures multiple indicators of health through an extensive survey of demographic and behavior-related items as well as a physical examination that includes laboratory testing. The latest available NHANES dataset that measured TB infection was the 1999-2000 cycle. The NHANES survey oversamples among minority and elderly populations.

Chapter 2: Determining housing instability in a longitudinal study of female sex workers that inject drugs along the northern Mexico border

The relationship between housing instability and HIV/STI risk behaviors is complex and culturally nuanced. Few studies describe housing instability

and its effect on HIV/STI risk behaviors among FSW in resource-poor nations. Chapter 2 explores definitions of housing stability among FSW-IDU in Tijuana and Ciudad Juarez.

Data collection

Mujer Mas Segura is a NIH-funded behavioral intervention study seeking to reduce the use of shared injection equipment and increase condom use among a cohort of FSW-IDU in Northern Mexico[31,87]. There were 620 FSW-IDU enrolled from two sites, with equal numbers in CJ and TJ, between October 2008 and July 2010. Outreach workers recruited participants from street and sex work venues (bars/hotels). To be eligible for the study, enrollees had to report having unprotected vaginal or anal sex with a male client, injecting drugs and sharing syringes or injection paraphernalia within the previous month. Also, enrollees had to speak Spanish or English, provide informed consent, agree to free STI treatment and have no plans to move to another city in the following 18 months. Interviewer-administered surveys and HIV/STI testing occurred at baseline and over 3 quarterly follow-up visits.

Data analysis

In order to determine a culturally accurate categorization of housing stability among FSW-IDU living along the Northern Mexico border, we categorized housing types traditionally according to previous literature from the US and Canada. We then created two adaptations of traditional housing categories to explore possible cultural differences. Using Chi-square tests,

these three different categorization schemes were compared in terms of sociodemographics, housing consistency and movement between housing categories, and HIV risk behaviors at baseline to characterize housing stability among FSW-IDU in Mexico.

Chapter 3: Exploring the association between housing instability and unprotected sex by client type among female sex workers who inject drugs along the Northern Mexico border

As a continuation of chapter 2, chapter 3 explores the association between housing stability measures, social residential environment measures and unprotected sex among FSW-IDU in Tijuana and Ciudad Juarez after accounting for individual factors.

Data collection

Chapter 3 used the Mujer Mas Segura dataset described in the Chapter 2 overview of research methods.

Data analysis

Bivariate and multivariate linear regression was used to describe associations between housing stability measures, social residential environment variables and individual-level covariates and unprotected vaginal sex acts. Models were stratified by client type and study site. Adjustment using generalized estimating equations (GEE) accounted for the clustering of subjects with repeated measures in longitudinal data. Intervention group, days since baseline, and the number of vaginal sex acts for each respective client

type were included in every model to account for intervention effects and volume of sex acts. A hierarchical "block" analysis was used to analyze the three different levels of risk (individual, social residential environment, housing measures)[88].

Chapter 4: The association between lifetime, active and passive smoking and latent tuberculosis infection in adults and children in the United States: results from NHANES

While some studies have reported a positive association between passive smoking and TB disease, most have assessed this relationship using self-reported smoke exposure which can be difficult to estimate. Furthermore, few studies on the relationship between active and passive smoking and TB have been conducted among a national sample. In this manuscript, the association between smoking status (active and passive) confirmed with serum cotinine measurement and LTBI among a nationally representative sample in the United States is described.

Data collection

The National Health and Nutrition Examination Survey (NHANES) is administered in 2 year cycles through the CDC National Center for Health Statistics (NCHS) and comprises a nationally representative sample of the US civilian (non-institutionalized) population (≥ 1 year of age) with oversampling of persons aged ≥60 years, and minority racial/ethnic groups. The 1999-2000 NHANES survey administered home interviews and subsequent physical

examinations during which biomarkers including serum cotinine were collected (for ages ≥3 years) and Tuberculin Skin Tests (TST) were placed. Respondents must return to have TST tests read 48-72 hours after placement. The unweighted sample size of adults for the home interview was 4880 (response rate = 76.2%) and for the examination was 4444 (response rate = 69.4%). For children 1-19, 4612 were interviewed (response rate 88.0%) and 4388 examined (response rate 83.8%). Among adults and children, 97% of those that had a physical examination returned to have their TST test read[89]. Though serum cotinine is gathered each year as part of the examination, the 1999-2000 survey is the latest available NHANES dataset that includes measurement of TB infection.

Data analysis

The outcome variable was LTBI status as determined by TST. Active, passive or non-smoking status was determined by responses to interview questions and serum cotinine levels. Chi-square and t-tests were used to calculate differences between smoking measures and LTBI status. Nationwide prevalence estimates of LTBI among those with personal or household smoking behaviors were calculated using weighted proportions for survey data. Associations between smoking measures and LTBI were explored using weighted bivariate and multivariate logistic regression (α=.05). Weighted analyses were used to account for oversampling of the elderly and other

race/ethnicity groups. Adults ≥20 years of age and children ≥3-20 were analyzed separately.

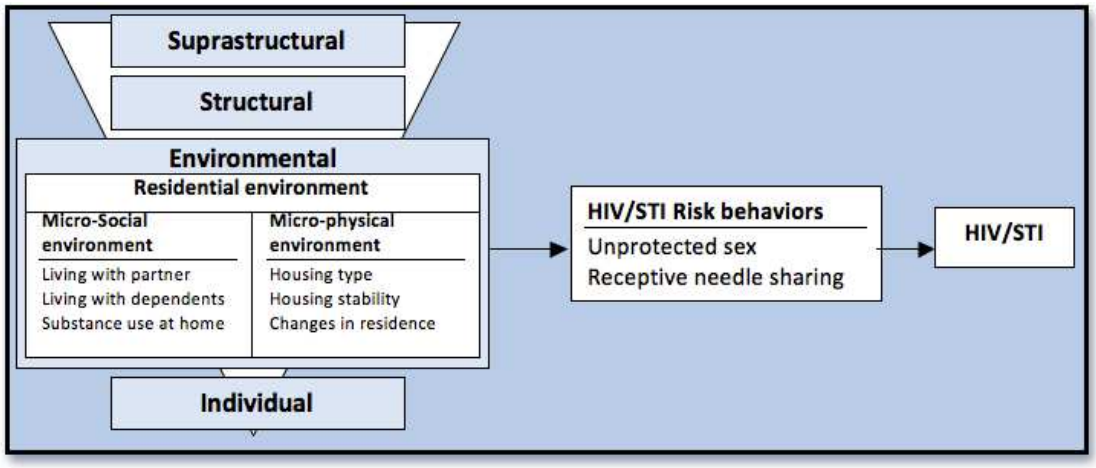

Figure 1.1: Framework of the impact of the residential environment on HIV/STI risk behaviors and outcomes

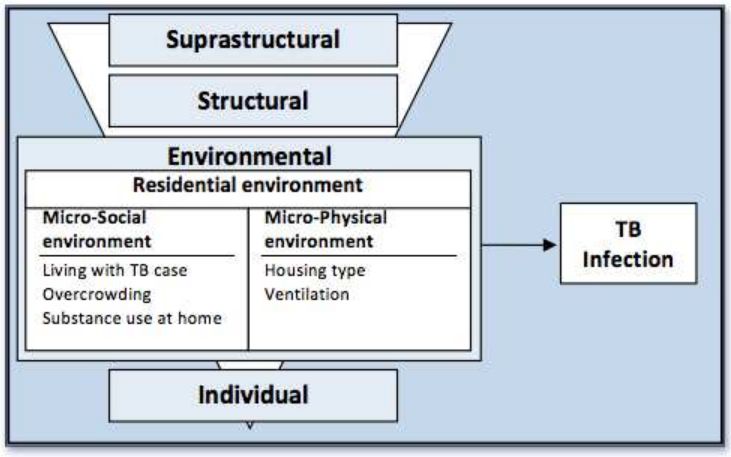

Figure 1.2: Framework of the impact of the residential environment on TB infection

References

1. Schoeman JH, Westaway MS, Neethling A. The relationship between socioeconomic factors and pulmonary tuberculosis. International journal of epidemiology 1991;20(2):435-40.

2. Harling G, Ehrlich R, Myer L. The social epidemiology of tuberculosis in South Africa: a multilevel analysis. Social science & medicine 2008;66(2):492-505.

3. Krueger LE, Wood RW, Diehr PH, Maxwell CL. Poverty and HIV seropositivity: the poor are more likely to be infected. AIDS 1990;4(8):811-4.

4. Simon PA, Hu DJ, Diaz T, Kerndt PR. Income and AIDS rates in Los Angeles County. AIDS 1995;9(3):281-4.

5. Haddad MB, Wilson TW, Ijaz K, Marks SM, Moore M. Tuberculosis and homelessness in the United States, 1994-2003. JAMA : the journal of the American Medical Association 2005;293(22):2762-6.

6. Nava-Aguilera E, Andersson N, Harris E, Mitchell S, Hamel C, Shea B, et al. Risk factors associated with recent transmission of tuberculosis: systematic review and meta-analysis. The international journal of tuberculosis and lung disease : the official journal of the International Union against Tuberculosis and Lung Disease 2009;13(1):17-26.

7. Barnes PF, el-Hajj H, Preston-Martin S, Cave MD, Jones BE, Otaya M, et al. Transmission of tuberculosis among the urban homeless. JAMA : the journal of the American Medical Association 1996;275(4):305-7.

8. Marshall BD, Kerr T, Shoveller JA, Patterson TL, Buxton JA, Wood E. Homelessness and unstable housing associated with an increased risk of HIV and STI transmission among street-involved youth. Health & place 2009;15(3):753-60.

9. Weir BW, Bard RS, O'Brien K, Casciato CJ, Stark MJ. Uncovering patterns of HIV risk through multiple housing measures. AIDS and behavior 2007;11(6 Suppl):31-44.

10. Aidala A, Cross JE, Stall R, Harre D, Sumartojo E. Housing status and HIV risk behaviors: implications for prevention and policy. AIDS and behavior 2005;9(3):251-65.

11. Lonnroth K, Williams BG, Stadlin S, Jaramillo E, Dye C. Alcohol use as a risk factor for tuberculosis - a systematic review. BMC public health 2008;8:289.

12. Mathers BM, Degenhardt L, Phillips B, Wiessing L, Hickman M, Strathdee SA, et al. Global epidemiology of injecting drug use and HIV among people who inject drugs: a systematic review. Lancet 2008;372(9651):1733-45.

13. Shuper PA, Neuman M, Kanteres F, Baliunas D, Joharchi N, Rehm J. Causal considerations on alcohol and HIV/AIDS--a systematic review. Alcohol and alcoholism 2010;45(2):159-66.

14. Bates MN, Khalakdina A, Pai M, Chang L, Lessa F, Smith KR. Risk of tuberculosis from exposure to tobacco smoke: a systematic review and meta-analysis. Archives of internal medicine 2007;167(4):335-42.

15. World Health Organization. Global Burden of Disease: 2004 Update. In. Geneva: WHO; 2008.

16. Narain JP, Raviglione MC, Kochi A. HIV-associated tuberculosis in developing countries: epidemiology and strategies for prevention. Tubercle and lung disease : the official journal of the International Union against Tuberculosis and Lung Disease 1992;73(6):311-21.

17. Ottawa charter for health promotion. Canadian journal of public health. Revue canadienne de sante publique 1986;77(6):425-30.

18. Rhodes T, Singer M, Bourgois P, Friedman SR, Strathdee SA. The social structural production of HIV risk among injecting drug users. Social science & medicine 2005;61(5):1026-44.

19. Bronfenbrenner U. Ecological Systems Theory: Jessica Kingsley Publishers; 1992.

20. Sweat MD, Denison JA. Reducing HIV incidence in developing countries with structural and environmental interventions. AIDS 1995;9 Suppl A:S251-7.

21. Rhodes T, Stimson GV, Crofts N, Ball A, Dehne K, Khodakevich L. Drug injecting, rapid HIV spread, and the 'risk environment': implications for assessment and response. AIDS 1999;13 Suppl A:S259-69.

22. Corneil TA, Kuyper LM, Shoveller J, Hogg RS, Li K, Spittal PM, et al. Unstable housing, associated risk behaviour, and increased risk for HIV infection among injection drug users. Health & place 2006;12(1):79-85.

23. Friedman SR, Kippax SC, Phaswana-Mafuya N, Rossi D, Newman CE. Emerging future issues in HIV/AIDS social research. AIDS 2006;20(7):959-65.

24. Munoz FA, Pollini RA, Zuniga ML, Strathdee SA, Lozada R, Martinez GA, et al. Condom access: Associations with consistent condom use among female sex workers in two northern border cities of Mexico. AIDS education and prevention : official publication of the International Society for AIDS Education 2010;22(5):455-65.

25. Strathdee SA, Lozada R, Martinez G, Vera A, Rusch M, Nguyen L, 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.

26. Yahne CE, Miller WR, Irvin-Vitela L, Tonigan JS. Magdalena Pilot Project: motivational outreach to substance abusing women street sex workers. Journal of substance abuse treatment 2002;23(1):49-53.

27. Kurtz SP, Surratt HL, Kiley MC, Inciardi JA. Barriers to health and social services for street-based sex workers. Journal of health care for the poor and underserved 2005;16(2):345-61.

28. Katsulis Y, Durfee A. Prevalence and correlates of sexual risk among male and female sex workers in Tijuana, Mexico. Global public health 2012;7(4):367-83.

29. Lindsay RR, G; Martinez, G; Vera, A; Lindsay, SP ; Strathdee, SA; Rusch, ML. Determining housing instability in a longitudinal study of female sex workers that inject drugs along the northern Mexico border. TBD In production.

30. Strathdee SA, Philbin MM, Semple SJ, Pu M, Orozovich P, Martinez G, et al. Correlates of injection drug use among female sex workers in two Mexico-U.S. border cities. Drug and alcohol dependence 2008;92(1-3):132-40.

31. Vera A, Abramovitz D, Lozada R, Martinez G, Rangel MG, Staines H, et al. Mujer Mas Segura (Safer Women): A combination prevention intervention to reduce sexual and injection risks among female sex workers who inject drugs. BMC public health 2012;12(1):653.

32. Deere C. The Gender Asset Gap: Land in Latin America. World Development 2003;31(6):925-947.

33. 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. Journal of urban health : bulletin of the New York Academy of Medicine 2011;88(4):767-78.

34. Aidala AA, Lee G, Garbers S, Chiasson MA. Sexual behaviors and sexual risk in a prospective cohort of HIV-positive men and women in New York City, 1994-2002: implications for prevention. AIDS education and prevention : official publication of the International Society for AIDS Education 2006;18(1):12-32.

35. Elifson KW, Sterk CE, Theall KP. Safe living: the impact of unstable housing conditions on HIV risk reduction among female drug users. AIDS and behavior 2007;11(6 Suppl):45-55.

36. Ruggles S, Heggeness M. Intergenerational Coresidence in Developing Countries. Population and development review 2008;34(2):253-281.

37. Sarkisian N, Gerena M, Gerstel N. Extended Family Ties Among Mexicans, Puerto Ricans, and Whites: Superintegration or Disintegration? Family Relations 2006;55:331-344.

38. 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. Social science & medicine 2011;72(5):710-6.

39. Strathdee SA, Lozada R, Semple SJ, Orozovich P, Pu M, Staines-Orozco H, et al. Characteristics of female sex workers with US clients in two Mexico-US border cities. Sexually transmitted diseases 2008;35(3):263-8.

40. de la Torre A, Havenner A, Adams K, Ng J. Premium sex: Factors influencing the negotiated price of unprotected sex by female sex workers in Mexico. Journal of Applied Economics 2010;13(1):67-90.

41. Worth D. Sexual decision-making and AIDS: why condom promotion among vulnerable women is likely to fail. Studies in family planning 1989;20(6 Pt 1):297-307.

42. Amaro H. Love, sex, and power. Considering women's realities in HIV prevention. The American psychologist 1995;50(6):437-47.

43. Krishnan S, Dunbar MS, Minnis AM, Medlin CA, Gerdts CE, Padian NS. Poverty, gender inequities, and women's risk of human immunodeficiency virus/AIDS. Annals of the New York Academy of Sciences 2008;1136:101-10.

44. El-Bassel N, Witte SS, Wada T, Gilbert L, Wallace J. Correlates of partner violence among female street-based sex workers: substance abuse, history of childhood abuse, and HIV risks. AIDS patient care and STDs 2001;15(1):41-51.

45. Surratt HL, Inciardi JA. HIV risk, seropositivity and predictors of infection among homeless and non-homeless women sex workers in Miami, Florida, USA. AIDS care 2004;16(5):594-604.

46. 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.

47. Shannon K, Strathdee SA, Shoveller J, Rusch M, Kerr T, Tyndall MW. Structural and environmental barriers to condom use negotiation with clients among female sex workers: implications for HIV-prevention strategies and policy. American journal of public health 2009;99(4):659-65.

48. Calsyn RJ, Winter JP. Social support, psychiatric symptoms, and housing: A causal analysis. Journal of Community Psychology 2002;30(3):247-259.

49. Mizuno Y, Purcell DW, Zhang J, Knowlton AR, De Varona M, Arnsten JH, et al. Predictors of current housing status among HIV-seropositive injection drug users (IDUs): results from a 1-year study. AIDS and behavior 2009;13(1):165-72.

50. Davey-Rothwell MA, Latimore A, Hulbert A, Latkin CA. Sexual networks and housing stability. Journal of urban health : bulletin of the New York Academy of Medicine 2011;88(4):759-66.

51. Latkin CA, Knowlton AR, Hoover D, Mandell W. Drug network characteristics as a predictor of cessation of drug use among adult injection drug users: a prospective study. The American journal of drug and alcohol abuse 1999;25(3):463-73.

52. Latkin CA, Kuramoto SJ, Davey-Rothwell MA, Tobin KE. Social norms, social networks, and HIV risk behavior among injection drug users. AIDS and behavior 2010;14(5):1159-68.

53. Latkin CA, Knowlton AR. Micro-social structural approaches to HIV prevention: a social ecological perspective. AIDS care 2005;17 Suppl 1:S102-13.

54. Palepu A, Marshall BD, Lai C, Wood E, Kerr T. Addiction treatment and stable housing among a cohort of injection drug users. PloS one 2010;5(7):e11697.

55. Evans GW, Wells NM, Chan HY, Saltzman H. Housing quality and mental health. Journal of consulting and clinical psychology 2000;68(3):526-30.

56. Suglia SF, Duarte CS, Sandel MT. Housing Quality, Housing Instability, and Maternal Mental Health. Journal of urban health : bulletin of the New York Academy of Medicine 2011.

57. Ulibarri MD, Semple SJ, Rao S, Strathdee SA, Fraga-Vallejo MA, Bucardo J, et al. History of abuse and psychological distress symptoms among female sex workers in two Mexico-U.S. border cities. Violence and victims 2009;24(3):399-413.

58. Alegria M, Vera M, Freeman DH, Jr., Robles R, Santos MC, Rivera CL. HIV infection, risk behaviors, and depressive symptoms among Puerto Rican sex workers. American journal of public health 1994;84(12):2000-2.

59. Newsholme A. An Inquiry into the Principal Causes of the Reduction in the Death-rate from Phthisis during the last Forty Years, with Special Reference to the Segregation of Phthisical Patients in General Institutions. The Journal of hygiene 1906;6(3):304-84.

60. Lienhardt C. From exposure to disease: the role of environmental factors in susceptibility to and development of tuberculosis. Epidemiologic reviews 2001;23(2):288-301.

61. Long R. Tuberculosis control in Alberta. A federal, provincial and regional public health partnership. Canadian journal of public health. Revue canadienne de sante publique 2002;93(4):264-6.

62. Grzybowski S, Allen EA. Tuberculosis: 2. History of the disease in Canada. CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne 1999;160(7):1025-8.

63. Lin HH, Ezzati M, Murray M. Tobacco smoke, indoor air pollution and tuberculosis: a systematic review and meta-analysis. PLoS Med 2007;4(1):e20.

64. Slama K, Chiang CY, Enarson DA, Hassmiller K, Fanning A, Gupta P, et al. Tobacco and tuberculosis: a qualitative systematic review and meta-analysis. Int J Tuberc Lung Dis 2007;11(10):1049-61.

65. Bates MN, Khalakdina A, Pai M, Chang L, Lessa F, Smith KR. Risk of tuberculosis from exposure to tobacco smoke: a systematic review and meta-analysis. Arch Intern Med 2007;167(4):335-42.

66. Anderson RH, Sy FS, Thompson S, Addy C. Cigarette smoking and tuberculin skin test conversion among incarcerated adults. American journal of preventive medicine 1997;13(3):175-81.

67. Plant AJ, Watkins RE, Gushulak B, O'Rourke T, Jones W, Streeton J, et al. Predictors of tuberculin reactivity among prospective Vietnamese migrants: the effect of smoking. Epidemiology and infection 2002;128(1):37-45.

68. Solsona J, Cayla JA, Nadal J, Bedia M, Mata C, Brau J, et al. Screening for tuberculosis upon admission to shelters and free-meal services. European journal of epidemiology 2001;17(2):123-8.

69. den Boon S, van Lill SW, Borgdorff MW, Verver S, Bateman ED, Lombard CJ, et al. Association between smoking and tuberculosis infection: a population survey in a high tuberculosis incidence area. Thorax 2005;60(7):555-7.

70. Alcaide J, Altet MN, Plans P, Parron I, Folguera L, Salto E, et al. Cigarette smoking as a risk factor for tuberculosis in young adults: a case-control study. Tuber Lung Dis 1996;77(2):112-6.

71. Ariyothai N, Podhipak A, Akarasewi P, Tornee S, Smithtikarn S, Thongprathum P. Cigarette smoking and its relation to pulmonary tuberculosis in adults. The Southeast Asian journal of tropical medicine and public health 2004;35(1):219-27.

72. Dong B, Ge N, Zhou Y. [Smoking and alcohol consumption as risk factors of pulmonary tuberculosis in Chengdu: a matched case-control study]. Hua Xi Yi Ke Da Xue Xue Bao 2001;32(1):104-6.

73. Leung CC, Lam TH, Ho KS, Yew WW, Tam CM, Chan WM, et al. Passive smoking and tuberculosis. Arch Intern Med 2010;170(3):287-92.

74. Tekkel M, Rahu M, Loit HM, Baburin A. Risk factors for pulmonary tuberculosis in Estonia. The international journal of tuberculosis and lung disease : the official journal of the International Union against Tuberculosis and Lung Disease 2002;6(10):887-94.

75. Altet MN, Alcaide J, Plans P, Taberner JL, Salto E, Folguera LI, et al. Passive smoking and risk of pulmonary tuberculosis in children immediately following infection. A case-control study. Tuber Lung Dis 1996;77(6):537-44.

76. den Boon S, Verver S, Marais BJ, Enarson DA, Lombard CJ, Bateman ED, et al. Association between passive smoking and infection with Mycobacterium tuberculosis in children. Pediatrics 2007;119(4):734-9.

77. du Preez K, Mandalakas AM, Kirchner HL, Grewal HM, Schaaf HS, van Wyk SS, et al. Environmental tobacco smoke exposure increases Mycobacterium tuberculosis infection risk in children. The international journal of tuberculosis and lung disease : the official journal of the International Union against Tuberculosis and Lung Disease 2011;15(11):1490-6, i.

78. Kuemmerer JM, Comstock GW. Sociologic concomitants of tuberculin sensitivity. The American review of respiratory disease 1967;96(5):885-92.

79. Singh M, Mynak ML, Kumar L, Mathew JL, Jindal SK. Prevalence and risk factors for transmission of infection among children in household contact with adults having pulmonary tuberculosis. Archives of disease in childhood 2005;90(6):624-8.

80. Tipayamongkholgul M, Podhipak A, Chearskul S, Sunakorn P. Factors associated with the development of tuberculosis in BCG immunized children. The Southeast Asian journal of tropical medicine and public health 2005;36(1):145-50.

81. Cummings SR, Richard RJ. Optimum cutoff points for biochemical validation of smoking status. American journal of public health 1988;78(5):574-5.

82. Caraballo RS, Giovino GA, Pechacek TF, Mowery PD. Factors associated with discrepancies between self-reports on cigarette smoking and measured serum cotinine levels among persons aged 17 years or older: Third National Health and Nutrition Examination Survey, 1988-1994. American journal of epidemiology 2001;153(8):807-14.

83. Caraballo RS, Giovino GA, Pechacek TF. Self-reported cigarette smoking vs. serum cotinine among U.S. adolescents. Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco 2004;6(1):19-25.

84. Max W, Sung HY, Shi Y. Who is exposed to secondhand smoke? Self-reported and serum cotinine measured exposure in the U.S., 1999-2006. International journal of environmental research and public health 2009;6(5):1633-48.

85. Altet MN, Alcaide J, Plans P, Taberner JL, Salto E, Folguera LI, et al. Passive smoking and risk of pulmonary tuberculosis in children immediately following infection. A case-control study. Tubercle and lung disease : the official journal of the International Union against Tuberculosis and Lung Disease 1996;77(6):537-44.

86. Brunet L, Pai M, Davids V, Ling D, Paradis G, Lenders L, et al. High prevalence of smoking among patients with suspected tuberculosis in South Africa. The European respiratory journal : official journal of the European Society for Clinical Respiratory Physiology 2011;38(1):139-46.

87. Morris MD, Case P, Robertson AM, Lozada R, Vera A, Clapp JD, et al. Prevalence and correlates of 'agua celeste' use among female sex workers who inject drugs in Ciudad Juarez, Mexico. Drug and alcohol dependence 2011.

88. Victora CG, Huttly SR, Fuchs SC, Olinto MT. The role of conceptual frameworks in epidemiological analysis: a hierarchical approach. International journal of epidemiology 1997;26(1):224-7.

89. Bennett DE, Courval JM, Onorato I, Agerton T, Gibson JD, Lambert L, et al. Prevalence of tuberculosis infection in the United States population: the national health and nutrition examination survey, 1999-2000. Am J Respir Crit Care Med 2008;177(3):348-55.

CHAPTER 2: Determining housing instability in a longitudinal study of female sex workers that inject drugs along the northern Mexico border

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Abstract

The relationship between housing instability and HIV/STI risk behaviors is complex and culturally nuanced. Housing data from a longitudinal study of 633 female sex workers that inject drugs (FSW-IDU) in Tijuana and Ciudad Juarez, Mexico were collected over 4 visits in 2008-2010. Constructs of unstable housing and the effect on HIV/STI risk behaviors were examined by traditional and culturally-adapted categorizations of housing types. Longitudinal consistency in housing categories was determined. Using a traditional categorization of housing, 23.54%, 68.40%, and 8.06% of FSW-IDU lived in stable, unstable and inadequate housing, respectively. Rented rooms represented the most consistent form of housing. Housing type was

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differentially associated with vulnerability to HIV/STI risk behaviors; those living in rented rooms were less likely to report receptive needle sharing, but reported less condom use relative to those in inadequate housing. Cultural context is important when considering measures of housing stability in new subpopulations or geographical areas.

Introduction

The environment in which HIV/STI transmission occurs is a growing point of focus in HIV research among female sex workers (FSW) and injection drug users (IDU)[1]. The risk environment, broadly defined as "the space—whether social or physical—in which a variety of factors exogenous to the individual interact to increase the chances of HIV transmission" provides a framework for understanding how structural, social and individual factors have influenced risk among FSW and FSW who also inject drugs (FSW-IDU) [2-5].

Understanding the risk environment for FSW-IDU is of particular importance as these women have an elevated risk for HIV through both injection and sexual contact transmission routes[6]. Mexico is experiencing a concentrated HIV epidemic among high risk groups, with increasing HIV prevalence among FSW in some Mexico-US border cities [7]. Two Mexico-US border cities, Tijuana and Ciudad Juarez, sit on major drug trafficking routes and have thriving commercial sex industries (n=6,000 FSWs and n=4,000 FSWs respectively)[8]. In a study among FSWs in these cities approximately 14% in Ciudad Juarez and 22% in Tijuana also reported injection drug use[9].

Compared with FSW that do not inject, FSW-IDU exhibit more frequent risk behaviors associated with HIV and other STIs [10-12] and were reported to have double the HIV prevalence (12% vs. 6%) in one intervention study in Tijuana and Ciudad Juarez[12].

Housing instability has been described among FSW along the Northern border of Mexico previously in cross-sectional analyses. Approximately 31% of FSW in Tijuana reported changing place of residence three or more times in the past 6 months and 21% reported not having a safe place to live in the past 3 years[13]. FSW-IDU were less likely to live in their own home than FSW that did not inject (9.6% vs. 25.0%; p= <0.01)[9]. Both of these studies were conducted prior to 2006 and gentrification of the Zona Roja (red light district) in Ciudad Juarez and increased drug-related violence in both cities may have contributed to housing instability. Therefore, a current and longitudinal assessment of housing instability among FSW-IDU in Northern Mexico is needed.

Recent analysis on correlates of HIV infection for FSW-IDU in Ciudad Juarez and Tijuana found that primarily structural and environmental factors, and to a lesser extent individual behaviors were influential in shaping HIV risk[14]. Housing represents an important structural component and basic human need that significantly affects daily life. Furthermore, FSW consistently rate housing as a top priority to be addressed in order to live healthier lives, particularly among street-based FSW [15,16]. Many components of the risk

environment of FSW and IDU can be altered by unstable or inadequate housing including ability to store risk reduction equipment (condoms, clean needles), negotiate risk reducing behaviors, vulnerability to violence and economic exploitation[5,17].

Homelessness and unstable housing have been associated with higher levels of sexual and drug-related HIV/STI risk behaviors [18,19] as well as HIV/STI transmission [20,21]. Involvement in sex work has been associated with homelessness and unstable housing among drug users[19,20,22-24], FSWs[25] and people living with HIV/AIDS[18,26]. Also, unprotected sex has been associated with homeless or unstable housing[22,26-28] Homeless FSW in Miami were more likely to encounter clients that refused to use condoms than housed FSW[27]. Also, injection drug use [26,29] receptive needle sharing [20] and recurrent injection drug use after cessation [29] have all been associated with homelessness and unstable housing.

Homelessness or inadequate housing is typically characterized as sleeping in a place not intended for sleeping (i.e. streets, vehicle, abandoned building, etc.). Unstable housing is usually defined as having basic amenities but little control over the local environment (i.e. temporary housing such as shelters, doubling up or living with family, friends or strangers). Stable housing usually implies having more control over one's local environment (own house, apartment)[19]). Weir et al. emphasize that measures of housing ideally come

from more than one indicator of stability and should include both the type and consistency of shelter[19].

Categorizing housing stability may be complicated by differences in the way people live in different cultural settings, and different ideas of inadequate or unstable housing across geographic boundaries or amongst subpopulations. The majority of studies on housing and HIV have taken place in developed countries, where housing constructs may or may not translate contextually to Mexico or other lower or middle income countries. For example, young adults co-residing with parents may be traditionally categorized as having "unstable" housing in the U.S. and Canada since ownership and control over living space belongs to a parent. However, this may not be as accurate among Latinos where a higher proportion of family members co-reside. Latinos in the U.S. were twice as likely to co-reside compared with whites and Mexican young adults report higher prevalence and increasing incidence of intergenerational co-residence compared with other developing nations [30], [31]. Therefore, housing categories should be culturally adjusted to local customs and realities.

To address the gap in research examining housing stability and HIV risk among populations outside of the US, our objectives are to 1) describe and categorize housing types among FSW-IDU living along the Northern Mexico border, including an examination of housing consistency (i.e. number of changes in housing types, consistent vs. inconsistent housing) and movement

between housing stability categories over time and 2) assess the association of housing stability with HIV/STI risk behaviors, comparing a standard category used in the HIV literature to categories adapted for FSW-IDU in Mexico. We expect to find cultural nuances unique to this population that require special considerations when determining housing stability.

Methods

Study design

Mujer Más Segura ('Safer Women') is a behavioral intervention study seeking to reduce the use of shared injection equipment and increase condom use among FSW-IDU in Northern Mexico[14,32]. FSW-IDU were enrolled from two sites, with equal number of participants from Ciudad Juarez and Tijuana, between October 2008 and July 2010. Outreach workers recruited participants from street and sex work venues (bars, hotels). To be eligible for the study, enrollees had to report each of the following behaviors in the previous month: 1) having unprotected vaginal or anal sex with a male client, 2) injecting illicit drugs and 3) sharing syringes or other injection equipment. Also, enrollees had to speak Spanish or English, provide informed consent, agree to free STI treatment if clinically indicated and have no plans to move to another city in the following 12 months. Interviewer-administered surveys and HIV/STI testing occurred at baseline and three quarterly follow-up visits over one year. The institutional review boards at the University of California, San Diego, Tijuana General Hospital and Universidad Autonoma de Ciudad Juarez approved the

study. More detailed account of methods for this study has been published previously [14].

Housing measurements

As part of the interviewer-administered surveys, participants were asked to recall "In the last month, what kind of place did you live or sleep in most of the time?" The recall period was adjusted to the last 4 months at each follow-up visit. Only one response option was permitted among 13 possible response options. "Other" responses were open-ended and responses included various forms of inadequate housing types and incarceration.

Housing categorization and analysis

Responses to the question on housing type were used to categorize housing stability according to a traditional 3-category measure of stability (inadequate/homeless, unstable, stable). We then re-categorized the traditional housing category groupings to include living with parents or a spouse/sexual partner in the "stable" category in adaptation #1. This was done in order to test if living with extended family members could be considered stable housing. Also, given the large proportion of FSW-IDU living in rented rooms (hotel or boarding rooms), we created adaptation #2 which treated this as its own housing category along with stable, unstable and inadequate/homeless categories. These three different categorization schemes were then compared in terms of housing consistency and movement between categories, sociodemographics and HIV risk behaviors at baseline.

Descriptive analysis of consistency among housing types and movement between housing categories was conducted on those with follow-up housing data. Consistency (the number of housing types and changes in housing type) was calculated among those with complete longitudinal housing data (Baseline and 3 follow-up visits; n=470). The mean number of housing types lived in during the study (range 1-4) and changes from one housing type to another (range 0-3) was calculated. For example, a respondent that lived in her own house, then her parent's house, then her own house, and then in an apartment would have three housing types throughout the study and the maximum of three housing changes during the study (i.e. at each follow-up visit reported living in a different housing type than at the previous visit).

Movement between housing categories at follow-up visits was calculated for each categorization scheme and described as having improved, remained unchanged or worsened. There were 613 respondents with at least one follow-up visit, 15 of which only had follow-up visits in supportive housing (drug treatment, hospital) or incarceration and were thus excluded from the analysis of movement between housing categories. Overall movement across the entire follow-up period was described by examining patterns of movement across housing categories at all follow-up visits. This was done by classifying women as 1) only improved (at least one improvement and no worsening), unchanged (no changes), varied (instances of both improvement and worsening), and only worsened (at least one worsening and no improvement).

The traditional housing categorization was compared to the culturally-adapted categorizations to assess differences in the association of housing with sociodemographics, including age, income, interview location, family dynamics (children <18 years at home, have spouse/steady partner), and sex work characteristics (duration, client load, client types, working and living in the same location). Two HIV risk outcomes, any condom use with male clients in the previous month (Y/N) and having injected in the previous month with a needle or syringe that was known or suspected to have been previously used ("always"/"often" vs "about half of the time"/ "sometimes"/ "never") were used to compare risk behavior according to standard and culturally-adapted housing categorizations. Chi-square tests were used to evaluate differences between housing categories in each categorization scheme in terms of sociodemographic, family dynamic, sex work and HIV risk behavior characteristics. Where a potential trend was observed, the Mantel-Haenszel test for trend was used to determine statistical significance.

Results

At baseline, FSW-IDU (n=633) were evenly split (by design) between living in Tijuana (49.6%) and Ciudad Juarez (50.4%). The majority (84.5%) were 25 years of age or older with less than half (47.9%) earning more than 3500 pesos per month. Many respondents reported having a spouse/steady partner (39.5%), and children under the age of 18 living at home (38.2%). Regarding sex work characteristics, nearly half (54.0%) had regularly traded

sex for a period of 10 years or more. Approximately half reported having more than 25 clients per month with the majority servicing both regular and non-regular client types (81.4%). Living and working in the same location was common among 22.8% of FSW-IDU.

Housing type at baseline

FSW-IDU reported living primarily in the following housing types at baseline (in order of descending frequency; see Figure 2.1): rented rooms/hotel/boarding houses (40.8%), relative's house/friend's house/borrowed room (12.8%), own house (12.3%), apartment (11.2%), parent's house (9.3%), streets/vehicle/abandoned building/shooting gallery/canal/transit station/park/alley (8.1%), spouse's house (2.5%), sexual partners house (1.9%), workplace (1.0%).

Housing type over time

As seen in Figure 2.1, the proportion of respondents living in rented rooms, with relatives, parents or friends, and in inadequate housing all decreased throughout the study while those incarcerated or living primarily in drug treatment center/shelter/hospital increased from 0.0% at baseline to 4.5% and 10.0%, respectively, at visit 4.

Housing categorization

The three housing categorization schemes, traditional, adaptation #1, and adaptation #2 are presented in Table 2.1. When categorizing housing

types traditionally, there were 23.5% in stable, 68.4% in unstable, and 8.1% in inadequate housing at baseline.

These categorization schemes were compared with longitudinal measures of consistency and movement between categories (Table 2.2). We considered the inadequate/ homeless housing category well-defined and did not adjust housing types into other categories in the adapted versions.

The definition between unstable and stable housing was more nuanced. Consistency did not change in the stable category after adding those living in parent's or spouse/sexual partner's houses to the stable category in adaptations #1 and #2; the mean number of housing changes moved from 1.99 to 2.08, and the number of housing types moved from 2.68 to 2.77 (p-values >0.05). However, this unexpectedly increased housing consistency in the unstable category from a mean of 1.83 housing changes to 1.73, fewer changes on average than those in stable or inadequate housing at baseline. A large proportion of our sample resided in unstable housing (rented rooms, hotels, boarding rooms and the workplace). To further highlight differences in HIV risk behaviors among this common but less understood housing option, we kept those in rented rooms as its own category ("less stable") in adaptation #2. Counterintuitively to traditional categorization schemes, those living in rented rooms represented the most consistent form of housing with the lowest mean number of changes in housing type (1.56; SE=.08) compared to any other housing category.

Of the 613 FSW-IDU recruited into the study with at least one follow-up visit, 470 (76.7%) had complete housing data across all 4 visits. Those without complete housing data were less likely to have a spouse/steady partner (p=.025), but otherwise were not significantly different in terms of sociodemographics or HIV risk behavior compared to those with complete housing data.

The results of the two measures of housing consistency are discussed below and shown in table 2.2. Overall, there were on average 2.56 (SE=.04, Range 1-4) housing types reported among FSW-IDU. Approximately 11.5% of FSW-IDU reported living in the same housing type across all visits compared to 13.6% that lived in 4 different housing types during the study (a new housing type at each visit). FSW-IDU changed their housing type on average 1.89 times during the study (SE=.05, Range 0-3). More specifically, 31.7% changed their primary housing type between every follow-up visit and 37.2% changed housing between 2 of their 3 follow-up visits.

Movement between housing categories throughout the study was classified as “improved”, “unchanged”, “worsened” or “varied” (instances of both improving and worsening during the study). This was done for all three categorization schemes and is presented in table 2.2, though the results presented in the following text reference movement data from adaptation #2. Between the four study visits there are three opportunities to assess movement between categories, or 1,839 events of potential movement

between housing categories among the 613 with at least one follow-up visit. If a participant was missing housing data in visits 2 or 3 then the subsequent visit was used to calculate movement (supportive housing and incarceration were treated as missing). Using adaptation #2, of 1,660 total movement events, 47.9% did not change, 20.9% worsened, and 23.2% improved their housing category (8.0% moved into supportive housing or were incarcerated). In other words, at any given follow-up visit, less than half (47.9%) of FSW-IDU in this study were in the same housing category as their previous visit.

When considering the overall pattern of all movement events for each respondent from baseline, 19.1% only improved housing categories across visits (had upward trajectories), 18.4% only worsened (had downward trajectories), 34.3% varied between housing categories (had instances of both worsening and improving between housing categories during the study) and 28.4% remained in the same housing category throughout the study. Of those remaining in the same housing category, nearly all were in the stable (41.2%) or less stable (50.0%) categories with only 4.1% and 4.7% perpetually in inadequate or unstable housing through the study, respectively. Those categorized into the less stable category at baseline had a higher percentage remaining in the same category throughout the study than those in the stable category (34.4% vs. 30.8%).

Approximately 18.5% FSW-IDU had lived in inadequate housing at some point during the study, of those 73.5% were in Tijuana. More than half

(51.7%) lived in stable housing (using the narrowest traditional housing categorization) at some point during the study, of those 68.2% were in Ciudad Juarez.

Sex worker characteristics across housing categories

Those in inadequate housing were mainly from Tijuana (82.4%) and had lower incomes than those in more stable housing. There was no significant difference in age across housing categories (tables 2.3 and 2.4). In terms of family dynamics, those in stable housing were more likely to have children <18 living with them (50.5%) compared to those in less stable, unstable or inadequate housing (p-value=<0.001). Those living in unstable housing in adaptation #2 (living in a relative or friend's house) were less likely to have a spouse or steady partner compared with those in other housing categories (p-value=0.054).

The proportion of FSW-IDU servicing more than 25 clients per month increased in a dose-response manner from inadequate to stable housing categories across all categorization schemes (p-value=<0.001). Those in less stable housing were more likely to report living and working in the same location compared to those in stable and unstable categories (36.4% vs. 7.2% and 12.2% respectively). Among those living in less stable housing at baseline, a higher proportion in Ciudad Juarez reported living and working in the same place than in Tijuana (61.5% vs. 39.5%; <0.001). Duration of sex work differed significantly when housing was categorized traditionally, with

those in unstable housing working fewer years on average compared to those in stable or inadequate housing. However, this lost significance in the adapted versions. Otherwise, sex workers serviced similar proportions of non-regular and regular clients across housing categories.

HIV/STI Risk Behaviors

Overall, any condom use with male clients in the previous month was reported by 64.7% of the FSW-IDU. More than half (53.6%) reported “often” or “always” using previously used needles or syringes to inject in the previous month. Using housing adaptation #2, FSW-IDU in stable housing reported using condoms with male clients in the previous month more than those in the less stable, unstable and inadequate housing categories (80.7% versus 56.9%, 52.9% and 64.3%, respectively; p-value <.0001).

Those reporting “often/always” injecting with used needles increased across stable (45.1%), less stable (56.8%), unstable (59.8%), and inadequate (66.7%) housing categories indicating a dose-response pattern of increasing risk of HIV transmission with increasing instability of housing among FSW-IDU (χ^2 test for trend p=<0.001). This was true regardless of housing categorization scheme.

Discussion

Our study showed that FSW-IDU along the Northern Mexico border report many different housing types and changes in housing throughout a short period of time. Furthermore there was much movement between housing

stability categories, regardless of categorization scheme. When considering longitudinal housing consistency and movement as well as HIV risk behaviors, living in a parent's or spouse/sexual partner's house accurately reflects traditionally stable housing (support for adaptation #1) living in rented rooms denote a unique housing group at high sexual risk for HIV comparable to those in inadequate housing. Unexpectedly, living in rented rooms represented the most consistent form of housing for FSW-IDU along the Northern Mexico border.

Aside from important differences in housing consistency, our adapted categorizations revealed that adding those living with parents or a spouse/sexual partner to the stable category didn't significantly alter the demographic, sex work, or HIV/STI risk profile of those living in their own house/apartment. Given that these forms of housing were also comparable in consistency, in the context of FSW-IDU in Mexico, living with parent's and with a spouse/sexual partner appears to represent stable housing.

Categorizing FSW-IDU living in rented rooms (hotel, boarding room) into their own "less stable" category allowed us to compare this common yet unique form of housing to other categories. Those living in rented rooms were more likely to have a spouse/steady partner and live and work in the same location than those in unstable housing. FSW-IDU living in rented rooms were dissimilar to those in stable housing; they had lower income, were less likely to have children at home, and more likely to live in Tijuana and live and work in

the same location compared to FSW-IDU in stable housing. Thus, even though the “less stable” category represented the most consistent housing type, those in the “less stable” category had more similar demographic, sex work, and HIV/STI risk profiles to those in unstable housing than those in stable housing.

Rented rooms

Our descriptive findings showed between one-third and one-half of the FSW-IDU in our sample was living in less stable housing (rented rooms, hotel or rooming house) throughout the study. Those in rented rooms at baseline had less movement into other housing categories compared to those in other housing categories. Housing in single-room occupancy housing has been independently associated with HIV infection and illicit drug use in Vancouver where occupants reported moving a median number of 5 times in the past year [33]. While we are unable to determine the total number of moves over a specific-time period, in terms of consistency, renting rooms in the context of FSW-IDU in Mexico may represent a relatively consistent housing option compared to other housing categories. However, sexual risk was increased among FSW in this housing type.

With nearly a quarter of our sample reporting living and working in the same location (primarily those in the rented rooms, including hotels and boarding rooms, and inadequate housing) our rates were nearly three times that of a previous survey of FSW in Tijuana and Ciudad Juarez that found that

8.8% of FSW-IDU live and work in the same location [9]. In the same study, living and working in the same location was an independent protective factor associated with recent injection drug use. Living at the place of work has also been associated with a decreased risk of STI among FSW in Tijuana, however significant differences in HIV/STI incidence by venue exist[34]. Living and working in the same location may alter the structural (i.e. venue policies, body guards) and social (i.e. peer support) risk environment, allowing FSW to have more control over her residential environment, an important aspect of housing [19,35]. This was suggested by research among FSW living in supportive housing that also functioned as unsanctioned indoor sex work environment in Vancouver[36]. However, a distinction should be made between those that live and work in rented rooms versus those in inadequate housing. Those in rented rooms may have more control regarding whether or not to service clients in their living space while those in inadequate housing may be forced to service clients in public spaces which carries increased risk for FSW[37]. Given the evidence that living and working in the same location may affect HIV/STI risk, more research is needed to further describe whether rented rooms are attached to work venues, if and how rent contracts are negotiated, whether clients are serviced within the living space of rented rooms, and how these living arrangements may impact HIV/STI risk in Mexico.

Housing consistency and movement

That nearly a third of FSW-IDU changed housing types between every follow-up visit is concerning considering that residential transience (characterized by frequent moving) has been independently associated with increased drug use and sharing needles [38,39]. Roy et al. found that when street youth were consistently housed anywhere but on the street for a period of one month, they were less likely to be involved with commercial sex, injection drug use and other HIV risk behaviors[40]. Therefore, increasing consistency in housing, even for brief periods, may result in decreases in risk behaviors.

Measuring movement between housing categories instead of housing types allowed broader patterns of change to be analyzed and added context to consistency measures. In our study much of the observed movement in housing among FSW-IDU was between categories and not within. More than two-thirds of our sample changed housing categories during the study and approximately a third had instances of both improved and worsened housing during the study. Such movement between stability categories has been shown to affect HIV risk elsewhere. Even brief periods of moving from more stable housing to homelessness have been associated with increased drug and sexual HIV risk behaviors among FSW in Miami[27]. Improvement in housing among HIV positive people in the U.S. has reduced drug use, needle sharing and unprotected sex, while worsened housing increased involvement in commercial sex [18]. Spouses or sexual partners may play an important role

in improving and worsening housing conditions; drug users receiving money from a partner has been associated with improvement from homeless to housed conditions while having a partner that uses drugs has been associated with worsening housing conditions[41].

Also, given such volatility between categories among our sample, the validity of a cross-sectional analysis using housing categories as an independent predictor variable is diminished. This underscores previous calls for housing stability measures that incorporate housing type or category alongside longitudinal data, especially among subpopulations where housing is inconsistent.

While changing housing types may represent negative (i.e. evictions) or positive change (i.e. to escape abuse or in an attempt to avoid risk behaviors), frequent changes in housing can disrupt social networks, and limit access to resources [38]. Similarly, consistent housing could be indicative of either housing stability or a controlled/coerced housing arrangement. More research is needed to determine both the experiences and motivations for moving or staying in certain housing arrangements.

Limitations

Our study has important limitations that impact our results and could be improved upon by future researchers. We relied on one self-reported housing question that captured the primary place of residence over the previous 4 months to categorize housing stability and calculate consistency and

movement. Furthermore, follow-up visits in the same housing type do not necessarily denote living in the exact locale as the previous visit, which we were unable to decipher. Therefore we likely underestimated the mean number of changes in housing in our consistency measure, particularly among the most common housing types such as rented rooms – nevertheless, there was a high degree of movement, even with this conservative measure. Asking specifically about the number of moves since the last visit, and reasons for moving (including reasons for not moving) would have been informative in understanding housing consistency. Our constructs of living in less stable housing and living and working in the same location were broad and further research is needed to determine the process (how often and with whom) through which contracts for rented rooms are negotiated, and compare differences among those who work and live in the same location with those who do not.

Future research including regression models comparing consistency and movement to HIV/STI risk behaviors adjusting for other individual and social aspects of the risk environment would be informative. Exploring consistency of housing, reasons for moving and the experience of living in rented rooms through qualitative studies are needed among FSW-IDU along the northern border of Mexico.

Conclusion

Housing stability among FSW-IDU along the northern border in Mexico is best described as a complex and dynamic process rather than a static state. Cultural context is important when considering housing stability categories. When considering longitudinal housing consistency and movement as well as HIV risk behaviors we conclude that living in a parent's or spouse/sexual partner's house accurately reflects traditionally stable housing (support for adaptation #1), while living in rented rooms denote a unique housing group at high sexual risk for HIV comparable to those in inadequate housing. Regardless, the inconsistency in housing and high proportion of FSW-IDU moving into more unstable housing over time highlights the importance of promoting programs that ensure housing stability among groups at high risk for HIV. Cultural context is important when considering housing stability categories; living in a parent's or spouse/sexual partner's house could be considered stable housing among FSW-IDU in Tijuana and Mexico. Regardless of housing stability category, housing for these women is characterized by residential transience between diverse housing types and across housing categories, with many experiencing unstable and/or inadequate housing. The type of housing that FSW-IDU reside in alters the HIV risk environment that impacts HIV/STI risk behaviors differently. Longitudinal housing data can show consistency between housing types and inter-category movement that provides further understanding of housing stability.

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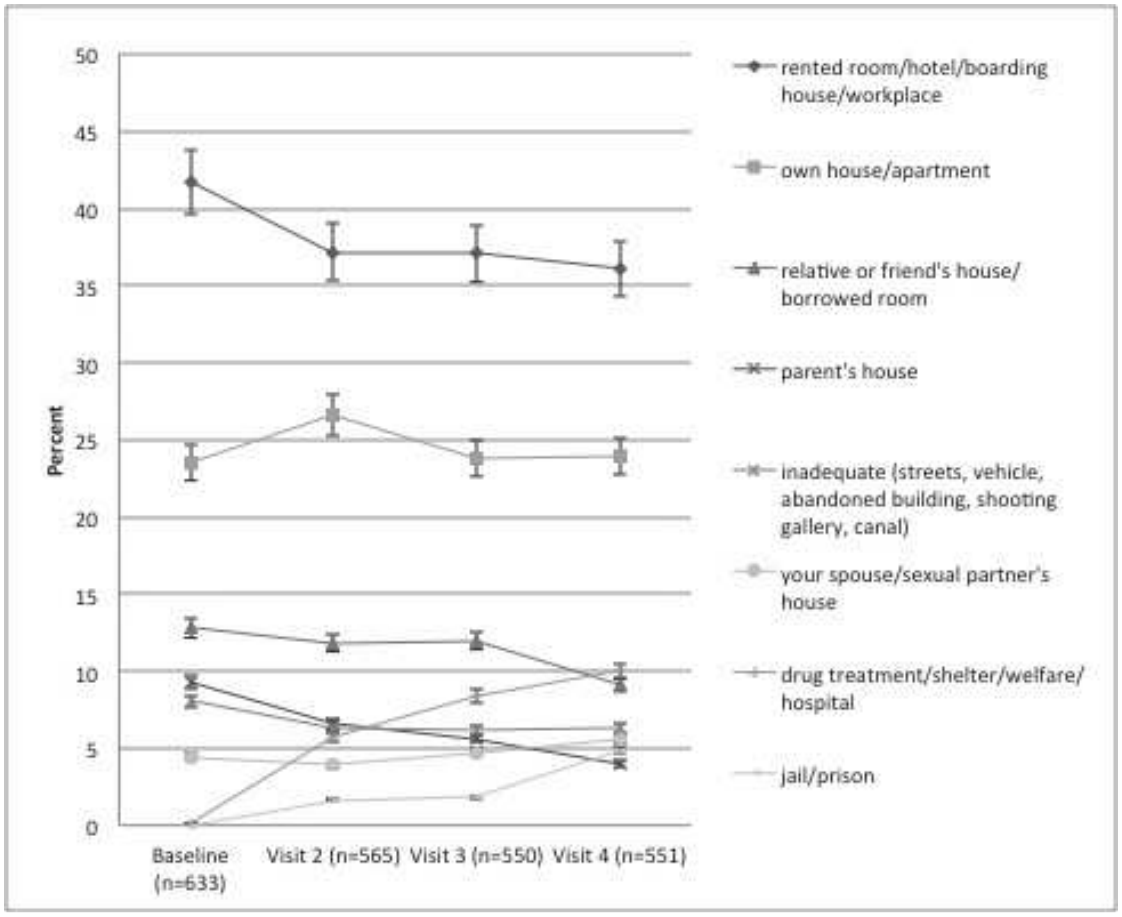

Figure 2.1: Primary type of housing reported by FSW-IDU at baseline and each follow-up visit

Table 2.1 Traditional and adapted categorizations of housing types among FSW-IDU and longitudinal measures of housing stability

Housing Category	Housing types
Overall	
Traditional	
Stable (n=145)	Own house, apartment
Unstable (n=407)	Parent, spouse, sexual partner, relative, or friend's house; rented room (hotel, boarding room)/workplace
Inadequate/ Homeless (n=46)	Streets, vehicle, abandoned building, canal (Tijuana), shooting gallery
Adaptation #1 (3 category)	
Stable (n=227)	Own house; apartment; parent's house; spouse or sexual partner's house
Unstable (n=325)	Relative or friend's house; rented room (hotel or rooming house)/workplace
Inadequate/ Homeless (n=46)	Streets, vehicle, abandoned building, canal (Tijuana), shooting gallery
Adaptation #2 (4 category)	
Stable (n=227)	Own house; apartment; parent's house; spouse or sexual partner's house
Less stable (n=247)	Rented room (hotel or rooming house)/workplace
Unstable (n=78)	Relative or friend's house
Inadequate/ Homeless (n=46)	Streets, vehicle, abandoned building, canal (Tijuana), shooting gallery

Table 2.2 Traditional and adapted categorizations and longitudinal measures of housing stability

	Consistency^		Movement between categories*			
Housing Category	**Mean # of changes in housing type[a] (SE)**	**Mean # of housing types (SE)[b]**	**Only improved N (row %)**	**Unchanged N (row %)**	**Varied N (row %)**	**Only Worsened N (row %)**
Overall	1.89 (.05)	2.56 (.04)				
Traditional						
Stable (n=145)	1.99 (.08)	2.68 (.07)	-	25 (17.24)	47 (32.41)	73 (50.34)
Unstable (n=407)	1.83 (.06)	2.48 (.05)	80 (19.66)	204 (50.12)	103 (25.31)	20 (4.91)
Inadequate/Homeless (n=46)	2.14 (.15)	2.86 (.14)	24 (52.17)	8 (17.39)	14 (30.43)	-
Total			104 (17.39)	237 (39.63)	164 (27.42)	93 (15.55)
Adaptation #1 (3 category)						
Stable (n=227)	2.08 (.06)	2.77 (.06)	-	70 (30.84)	62 (27.31)	95 (41.85)
Unstable (n=325)	1.73 (.07)	2.37 (.06)	80 (24.62)	144 (44.31)	88 (27.08)	13 (4.00)
Inadequate/Homeless (n=46)	2.14 (.15)	2.86 (.14)	21 (45.65)	8 (17.39)	17 (36.96)	-
Total			101 (16.89)	222 (37.12)	167 (27.93)	108 (18.06)
Adaptation #2 (4 category)						
Stable (n=227)	2.08 (.06)	2.77 (.06)	-	70 (30.84)	74 (32.60)	83 (36.56)
Less stable (n=247)	1.56 (.08)	2.21 (.06)	56 (22.67)	85 (34.41)	83 (33.60)	23 (9.31)
Unstable (n=78)	2.27 (.11)	2.86 (.10)	37 (47.44)	6 (7.69)	31 (39.74)	4 (5.13)
Inadequate/Homeless (n=46)	2.14 (.15)	2.86 (.14)	21 (45.65)	8 (17.39)	17 (36.96)	-
Total			114 (19.06)	169 (28.26)	205 (34.28)	110 (18.39)

^ n=470 (calculated among those with complete housing data at baseline and 3 follow-up visits)
[a] Range = 0-3
[b] Range = 1-4
* n=598 (calculated relative to baseline housing category among those with at least one follow-up visit aside from supportive housing; supportive housing treated as missing)
Only improved = improved housing categories and had no worsening movement events during study
Only worsened = worsened housing categories and had no improving movement events during study
Varied = had both improving and worsening movement events during study

Table 2.3: FSW-IDU characteristics according to housing categories (traditional and adaptation #1) (N=633)

	Traditional categorization				Adaptation #1 (3 category)			
	Stable N=149 n(%)	Unstable N=433 n(%)	Inadeq-uate N=51 n(%)	p-value	Stable N= 236 n(%)	Unstable N= 346 n(%)	Inadeq-uate N=51 n(%)	p-value
Demographics								
Income				0.001				<0.001
> 3500 pesos	91 (61.07)	192 (44.34)	20 (39.22)		140 (59.32)	143 (41.33)	20 (39.22)	
Age				0.243				0.313
≥25	131 (87.92)	364 (84.06)	40 (78.43)		197 (83.47)	298 (86.13)	40 (78.43)	
Interview Location				<0.001				<0.001
Tijuana	47 (31.54)	225 (51.96)	42 (82.35)		77 (32.63)	195 (56.36)	42 (82.35)	
Ciudad Juarez	102 (68.46)	208 (48.04)	9 (17.65)		159 (67.37)	151 (43.64)	9 (17.65)	
Family dynamics								
Children <18 yrs. at home				0.001				<0.001
Yes	71 (51.82)	137 (34.51)	14 (29.79)		109 (50.46)	99 (31.13)	14 (29.79)	
Have spouse/ steady partner				0.870				0.551
Yes	61 (40.94)	168 (38.8)	21 (41.18)		99 (41.95)	130 (37.57)	21 (41.18)	
Sex work								
Duration as sex worker				0.035				0.519
>10 years (median)	92 (61.74)	218 (50.46)	31 (60.78)		129 (54.66)	181 (52.46)	31 (60.78)	
Client load				0.001				0.001
>25 clients per month (median)	93 (62.42)	236 (54.5)	16 (31.37)		141 (59.75)	188 (54.34)	16 (31.37)	
Type of clients serviced				0.128				0.052
Only non-regular clients	16 (10.88)	37 (8.56)	9 (17.65)		26 (11.11)	27 (7.83)	9 (17.65)	
Only regular clients	16 (10.88)	33 (7.64)	6 (11.76)		25 (10.68)	24 (6.96)	6 (11.76)	
Both client types	115 (78.23)	362 (83.8)	36 (70.59)		183 (78.21)	294 (85.22)	36 (70.59)	
Live and work in the same location				<0.001				<0.001
Yes	7 (4.7)	116 (26.79)	21 (41.18)		17 (7.2)	106 (30.64)	21 (41.18)	
HIV/STI risk behaviors								
Used condoms previous month				<0.001				<0.001
Yes	121 (81.76)	261 (60.28)	27 (52.94)		185 (78.72)	197 (56.94)	27 (52.94)	
Used previously used needles/syringes				<0.001				.002
Often/always	54 (36.49)	251 (57.97)	34 (66.67)		106 (45.11)	199 (57.51)	34 (66.67)	

Table 2.4: FSW-IDU characteristics according to housing categories (Adaptation #2) (N=633)

	Adaptation #2 (4 category)				
	Stable N=236 n(%)	Less Stable N=264 n(%)	Unstable N=82 n(%)	Inadeq-uate N=51 n(%)	p-value
Demographics					
Income					<0.001
> 3500 pesos	140 (59.32)	109 (41.29)	34 (41.46)	20 (39.22)	
Age					0.389
≥25	197 (83.47)	225 (85.23)	73 (89.02)	40 (78.43)	
Interview Location					<0.001
Tijuana	77 (32.63)	155 (58.71)	40 (48.78)	42 (82.35)	
Ciudad Juarez	159 (67.37)	109 (41.29)	42 (51.22)	9 (17.65)	
Family dynamics					
Children <18 yrs. at home					<0.001
Yes	109 (50.46)	73 (29.92)	26 (35.14)	14 (29.79)	
Have spouse/ steady partner					0.054
Yes	99 (41.95)	109 (41.29)	21 (25.61)	21 (41.18)	
Sex work					
Duration as sex worker					0.711
>10 years (median)	129 (54.66)	137 (52.09)	44 (53.66)	31 (60.78)	
Client load					0.003
>25 clients per month (median)	141 (59.75)	146 (55.3)	42 (51.22)	16 (31.37)	
Type of clients serviced					0.150
Only non-regular clients	26 (11.11)	21 (7.98)	6 (7.32)	9 (17.65)	
Only regular clients	25 (10.68)	18 (6.84)	6 (7.32)	6 (11.76)	
Both client types	183 (78.21)	224 (85.17)	70 (85.37)	36 (70.59)	
Live and work in the same location					<0.001
Yes	17 (7.2)	96 (36.36)	10 (12.2)	21 (41.18)	
HIV/STI risk behaviors					
Used condoms previous month					<0.001
Yes	185 (78.72)	147 (55.68)	50 (60.98)	27 (52.94)	
Used previously used needles/syringes					.005
Often/always	106 (45.11)	150 (56.82)	49 (59.76)	34 (66.67)	

References

1. Friedman SR, Kippax SC, Phaswana-Mafuya N, Rossi D, Newman CE. Emerging future issues in HIV/AIDS social research. AIDS 2006;20(7):959-65.

2. Sweat MD, Denison JA. Reducing HIV incidence in developing countries with structural and environmental interventions. AIDS 1995;9 Suppl A:S251-7.

3. Rhodes T, Stimson GV, Crofts N, Ball A, Dehne K, Khodakevich L. Drug injecting, rapid HIV spread, and the 'risk environment': implications for assessment and response. AIDS 1999;13 Suppl A:S259-69.

4. Mehta SR, Delport W, Brouwer KC, Espitia S, Patterson T, Pond SK, et al. The relatedness of HIV epidemics in the United States-Mexico border region. AIDS research and human retroviruses 2010;26(12):1273-7.

5. Rhodes T, Singer M, Bourgois P, Friedman SR, Strathdee SA. The social structural production of HIV risk among injecting drug users. Social science & medicine 2005;61(5):1026-44.

6. Iniguez-Stevens E, Brouwer KC, Hogg RS, Patterson TL, Lozada R, Magis-Rodriguez C, et al. [Estimating the 2006 prevalence of HIV by gender and risk groups in Tijuana, Mexico]. Gaceta medica de Mexico 2009;145(3):189-95.

7. UNAIDS. Global report: UNAIDS report on the global AIDS epidemic 2010.; 2010.

8. Patterson TL, Mausbach B, Lozada R, Staines-Orozco H, Semple SJ, Fraga-Vallejo M, et al. Efficacy of a brief behavioral intervention to promote condom use among female sex workers in Tijuana and Ciudad Juarez, Mexico. American journal of public health 2008;98(11):2051-7.

9. Strathdee SA, Philbin MM, Semple SJ, Pu M, Orozovich P, Martinez G, et al. Correlates of injection drug use among female sex workers in two Mexico-U.S. border cities. Drug and alcohol dependence 2008;92(1-3):132-40.

10. El-Bassel N, Terlikbaeva A, Pinkham S. HIV and women who use drugs: double neglect, double risk. Lancet 2010;376(9738):312-4.

11. Ulibarri MD, Strathdee SA, Patterson TL. Sexual and drug use behaviors associated with HIV and other sexually transmitted infections among female sex workers in the Mexico-US border region. Current opinion in psychiatry 2010;23(3):215-20.

12. Patterson TL, Semple SJ, Staines H, Lozada R, Orozovich P, Bucardo J, et al. Prevalence and correlates of HIV infection among female sex workers in 2 Mexico-US border cities. The Journal of infectious diseases 2008;197(5):728-32.

13. Katsulis Y, Durfee A. Prevalence and correlates of sexual risk among male and female sex workers in Tijuana, Mexico. Global public health 2012;7(4):367-83.

14. 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. Social science & medicine 2011;72(7):1185-92.

15. Yahne CE, Miller WR, Irvin-Vitela L, Tonigan JS. Magdalena Pilot Project: motivational outreach to substance abusing women street sex workers. Journal of substance abuse treatment 2002;23(1):49-53.

16. Kurtz SP, Surratt HL, Kiley MC, Inciardi JA. Barriers to health and social services for street-based sex workers. Journal of health care for the poor and underserved 2005;16(2):345-61.

17. 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. Social science & medicine 2011.

18. Aidala A, Cross JE, Stall R, Harre D, Sumartojo E. Housing status and HIV risk behaviors: implications for prevention and policy. AIDS and behavior 2005;9(3):251-65.

19. Weir BW, Bard RS, O'Brien K, Casciato CJ, Stark MJ. Uncovering patterns of HIV risk through multiple housing measures. AIDS and behavior 2007;11(6 Suppl):31-44.

20. Corneil TA, Kuyper LM, Shoveller J, Hogg RS, Li K, Spittal PM, et al. Unstable housing, associated risk behaviour, and increased risk for HIV infection among injection drug users. Health & place 2006;12(1):79-85.

21. Marshall BD, Kerr T, Shoveller JA, Patterson TL, Buxton JA, Wood E. Homelessness and unstable housing associated with an increased risk of HIV and STI transmission among street-involved youth. Health & place 2009;15(3):753-60.

22. Elifson KW, Sterk CE, Theall KP. Safe living: the impact of unstable housing conditions on HIV risk reduction among female drug users. AIDS and behavior 2007;11(6 Suppl):45-55.

23. Andia JF, Deren S, Kang SY, Robles RR, Colon HM, Oliver-Velez D, et al. Residential status and HIV risk behaviors among Puerto Rican drug injectors in New York and Puerto Rico. The American journal of drug and alcohol abuse 2001;27(4):719-35.

24. Coady MH, Latka MH, Thiede H, Golub ET, Ouellet L, Hudson SM, et al. Housing status and associated differences in HIV risk behaviors among young injection drug users (IDUs). AIDS and behavior 2007;11(6):854-63.

25. Miller CL, Fielden SJ, Tyndall MW, Zhang R, Gibson K, Shannon K. Individual and structural vulnerability among female youth who exchange sex for survival. The Journal of adolescent health : official publication of the Society for Adolescent Medicine 2011;49(1):36-41.

26. Kidder DP, Wolitski RJ, Pals SL, Campsmith ML. Housing status and HIV risk behaviors among homeless and housed persons with HIV. Journal of acquired immune deficiency syndromes 2008;49(4):451-5.

27. Surratt HL, Inciardi JA. HIV risk, seropositivity and predictors of infection among homeless and non-homeless women sex workers in Miami, Florida, USA. AIDS care 2004;16(5):594-604.

28. Aidala AA, Lee G, Garbers S, Chiasson MA. Sexual behaviors and sexual risk in a prospective cohort of HIV-positive men and women in New York City, 1994-2002: implications for prevention. AIDS education and prevention : official publication of the International Society for AIDS Education 2006;18(1):12-32.

29. Shah NG, Galai N, Celentano DD, Vlahov D, Strathdee SA. Longitudinal predictors of injection cessation and subsequent relapse among a cohort of injection drug users in Baltimore, MD, 1988-2000. Drug and alcohol dependence 2006;83(2):147-56.

30. Ruggles S, Heggeness M. Intergenerational Coresidence in Developing Countries. Population and development review 2008;34(2):253-281.

31. Sarkisian N, Gerena M, Gerstel N. Extended Family Ties Among Mexicans, Puerto Ricans, and Whites: Superintegration or Disintegration? Family Relations 2006;55:331-344.

32. Vera A, Abramovitz D, Lozada R, Martinez G, Rangel MG, Staines H, et al. Mujer Mas Segura (Safer Women): A combination prevention intervention to reduce sexual and injection risks among female sex workers who inject drugs. BMC public health 2012;12(1):653.

33. Shannon K, Ishida T, Lai C, Tyndall MW. The impact of unregulated single room occupancy hotels on the health status of illicit drug users in Vancouver. International Journal of Drug Policy 2006;17(2):107-114.

34. 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. Sexually transmitted diseases 2010;37(10):608-14.

35. Riley ED, Gandhi M, Hare C, Cohen J, Hwang S. Poverty, unstable housing, and HIV infection among women living in the United States. Current HIV/AIDS reports 2007;4(4):181-6.

36. Krusi A, Chettiar J, Ridgway A, Abbott J, Strathdee SA, Shannon K. Negotiating Safety and Sexual Risk Reduction With Clients in Unsanctioned Safer Indoor Sex Work Environments: A Qualitative Study. American journal of public health 2012;102(6):1154-1159.

37. Shannon K, Strathdee SA, Shoveller J, Rusch M, Kerr T, Tyndall MW. Structural and environmental barriers to condom use negotiation with clients among female sex workers: implications for HIV-prevention strategies and policy. American journal of public health 2009;99(4):659-65.

38. German D, Davey MA, Latkin CA. Residential transience and HIV risk behaviors among injection drug users. AIDS and behavior 2007;11(6 Suppl):21-30.

39. Rosenthal D, Rotheram-Borus MJ, Batterham P, Mallett S, Rice E, Milburn NG. Housing stability over two years and HIV risk among newly homeless youth. AIDS and behavior 2007;11(6):831-41.

40. 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. Journal of urban health : bulletin of the New York Academy of Medicine 2011;88(4):767-78.

41. Davey-Rothwell MA, Latimore A, Hulbert A, Latkin CA. Sexual networks and housing stability. Journal of urban health : bulletin of the New York Academy of Medicine 2011;88(4):759-66.

CHAPTER 3: Exploring the association between housing instability and unprotected sex by client type among female sex workers who inject drugs along the Northern Mexico border

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Abstract

There is mixed evidence between the effect of housing instability on condom use among FSW. Further, patterns of condom use vary between client type and between cities. Longitudinal housing data and the number of unprotected sex acts from 618 female sex workers that inject drugs (FSW-IDU) in Tijuana (TJ) and Ciudad Juarez (CJ), Mexico were collected over 4 visits in 2008-2010. The associations between current housing, as well as longitudinal housing movement (improved, same, worsened), and number of unprotected sex acts were explored using linear regression with generalized estimating equations. Compared to those who did not change housing categories between visits, having improved housing was associated with 5.55, 2.21 and 5.25 fewer unprotected vaginal sex acts on average among non-regular clients in CJ (p-value=0.04), and regular clients in CJ (p-value=0.05) and TJ (p-value=0.03), respectively. Compared with those in stable housing, living in unstable housing was associated with more unprotected vaginal sex among regular and non-regular clients in TJ. After controlling for individual and

social living environment covariates, neither current housing or housing movement was consistently associated with condom use among FSW. More research is needed in the pathways through which housing instability affects condom use among FSW-IDU.

Introduction

Unprotected sex, multiple sexual partners, sex work, and injection drug use have long been established as major individual-level risk factors for both HIV and sexually transmitted infections (STIs)[1]. Although major drivers of infection, recent research has begun to focus on social determinants of HIV infection. A framework for understanding multiple levels of HIV risk influencing individual-level behaviors, known as the risk environment, describes physical, social, economic and policy environments that affect individual HIV risk behaviors at differing degrees of proximity from the micro to macro level[2].

The residential living environment – the place where someone lives or spends most of their time - is an important aspect of the HIV risk environment that has both micro physical (i.e. characteristics of the physical residential structure to provide shelter, privacy, security) and micro social components (i.e. characteristics of social living within a residence such as drug use, and living with children or a partner). Both physical and social aspects of the residential living environment are likely to affect HIV behaviors. Housing stability measurements in many HIV studies have typically either used only one measure of housing that distinguishes between the housed and the

homeless, or a measure which further distinguishes between those who own their own or rent their own home/apartment (stable) from those who rent rooms, or stay with family or friends (unstable)[3]. Ideally, multiple housing measures, including longitudinal changes in housing over time, should be used to provide a better understanding of housing stability[3].

Previous studies have found associations between unstable housing and homelessness and HIV risk factors including unprotected sex, sex work and injection drug use[3-7]. Fewer studies have assessed the association of unstable housing and unprotected sex among female sex workers (FSW)[7], in particular housing stability among FSW in resource poor nations[8].

Mexico is experiencing an HIV epidemic concentrated among certain risk groups[9]. FSW and injecting drug users (IDU) are both key populations at heightened risk for HIV/STI. HIV prevalence is increasing among FSW in the cities of Tijuana (TJ) and Ciudad Juarez (CJ) where commercial sex industries provide services to clients from both the US and Mexico[9,10]. Commercial sex work operates at quasi-legal status in Mexico and in TJ there is a designated tolerance zone [9,10]. There are approximately 6,000 FSWs in TJ and 4,000 FSWs in CJ. FSWs in these cities face multiple HIV risk factors including high rates of unprotected sex with clients[10-12] and elevated prevalence of injection drug use (20%)[13]. Female sex workers that inject drugs (FSW-IDU) have the dual risk of HIV infection from unprotected sex and sharing of injection drug paraphernalia. A recent study in TJ and CJ showed that HIV prevalence is

twice as high among FSW-IDU (12%) compared to FSW (6%)[14]. These studies also demonstrated that, compared with FSW that do not inject, FSW-IDU exhibit more frequent risk behaviors associated with HIV[14-16] including using drugs before sex and higher rates of unprotected sex with clients[13].

Preliminary studies on Mexico's northern border report that FSW have poor housing conditions with frequent changes in place of residence[13,17,18]. Recent gentrification of areas in CJ, including areas where FSW live and work, has also occurred since 2008[19], though its effect on housing stability among FSW is still unknown. One study of FSWs in TJ and CJ found that FSW-IDU were less likely to live in their own home and more likely to live in rented rooms compared to FSW that do not inject[13]. Over 18 months, FSW-IDU had a low level of housing consistency with only 11.5% who lived in the same housing type (i.e. own house, apartment, rented room) across all 3 quarterly follow-up visits[18]. Nearly a third (31.7%) of FSW-IDU, changed their housing type at every follow-up visit[18]. HIV risk behaviors such as no condom use in the previous month and receptive needle sharing among FSW-IDU were higher among those in unstable and homeless categories compared to those in stable housing[18]. These studies show that in Mexico, FSW-IDU experience more housing instability and higher HIV risk compared to FSW.

In terms of HIV risk, FSW-IDU may benefit more than FSW from structural-level interventions since individual risk reduction interventions have had less effect among FSW-IDU than FSW[16]. Structural interventions,

including improving housing conditions, have the promise of reducing multiple individual risk factors simultaneously[20,21]. Prior to intervening in the residential environment, a better understanding of the residential living environment could lead to improvements in future interventions among FSW and FSW-IDU. For example, an individual-level intervention study in the US was less effective among those with unstable housing; FSW that used drugs and were unstably housed did not improve condom use with casual clients to the same degree as those in stable housing[5]. In order to develop structural-level interventions that affect FSW-IDU, an understanding of mechanisms through which housing effects HIV risk behaviors is necessary.

Currently, the mechanisms by which housing instability affects condom use among FSW are not fully understood. Social support and mental health have been shown to influence both housing stability and HIV outcomes[22-25]. Homelessness and unstable housing are a marker for poverty, and women that are economically dependent are less able to negotiate condom use, and more likely to accept offers of more money for sex without a condom, thus increasing HIV/STI risk[26-30]. However, poor housing conditions may have an effect on HIV behaviors after controlling for income. Homelessness or unstable housing may affect whether condoms can be stored, the characteristics of clients with whom sex is traded, and where clients are solicited and serviced. These could all effect women's ability to negotiate condom use. For example, studies in the US found that homeless FSW were more likely to encounter

clients that refused to use condoms than non-homeless FSW[7,31]. In India, FSW reporting a higher number of evictions were more likely to accept more money for unprotected sex than FSW with fewer evictions[8]. Other studies have found that FSW servicing clients in public spaces are more likely to be homeless[32] and to have experienced coercive unprotected sex by clients[33]. Condom use by FSW has been shown to vary by client type and be affected by housing stability in other populations[5,34,35]. These studies point to the vulnerability that homeless or unstably housed FSW may experience that creates barriers to their ability to access condoms and negotiate condom use with certain client types.

Our objective was to assess the association between multiple measures of housing stability (housing categories, housing movement) and unprotected vaginal sex by client type among FSW-IDU in TJ and CJ. We examined two main hypotheses on the association between FSW-IDU and housing measures: 1) living in unstable/inadequate housing or homeless status will be independently associated with more unprotected sex acts across client types compared to those living in stable housing; 2) improving housing categories between 4-month follow-up visits will correspond with less unprotected sex acts compared with those who remain in the same housing category, while movement into unstable or homeless categories will be associated with an increase in unprotected sex acts.

Methods

Study sample and parent study

Mujer Mas Segura (safer women) is a NIH-funded behavioral intervention study seeking to reduce the use of shared injection equipment and increase condom use among a cohort of FSW-IDU in Northern Mexico[12,19]. There were 620 FSW-IDU enrolled from two sites, with equal numbers in CJ and TJ, between October 2008 and July 2010. Outreach workers recruited participants from street and sex work venues (bars/hotels). To be eligible for the study, enrollees had to report having unprotected vaginal or anal sex with a male client, injecting drugs and sharing syringes or injection paraphernalia within the previous month. Also, enrollees had to speak Spanish or English, provide informed consent, agree to free STI treatment and have no plans to move to another city in the following 18 months. We further excluded 2 participants without baseline data and another 19 subjects were excluded because they did not have any follow-up housing data leaving 599 for longitudinal analysis.

Interviewer-administered surveys and HIV/STI testing occurred at baseline and over 3 quarterly follow-up visits. The institutional review boards at the University of California, San Diego, Tijuana General Hospital and Universidad Autonoma de Ciudad Juarez approved the study protocol.

The intervention had a 2x2 factorial design where participants were randomized into one of four groups; Group A: didactic safer sex and didactic injection risk education; Group B: interactive injection risk intervention and

didactic safer sex education; Group C: interactive safer sex intervention and didactic injection risk education; Group D: Both interactive injection risk and safer sex interventions. Advice regarding the importance of condom use, how to properly use a condom, and condom use negotiation was given to all participants. The manner in which information was given accounted for the difference in the didactic vs interactive intervention. Detailed information on the intervention and sampling methods are found elsewhere[19].

Measures

Respondents were asked to report the total number of vaginal sex acts and the number of times a condom was used for vaginal sex with each partner type (non-regular and regular clients, spouse/steady partners). Non-regular clients were defined as men who do not come back for regular visits or men that were only serviced once or twice whereas regular clients were defined as men who have returned for multiple visits over time. A spouse or steady partner was defined as someone who did not pay for sex with whom FSW were married or had a relationship with over time. The outcome variable, the number of unprotected vaginal sex acts in the previous month, was calculated by subtracting the number of protected sex acts from the total number of sex acts for each partner type. Unprotected vaginal sex acts were only calculated if the respondent reported at least one vaginal sex act in the follow-up period.

In order to determine housing type, at baseline and each follow-up visit participants were asked “In the last month, what kind of place did you live or

sleep in most of the time?" (recall period "previous month" at baseline, "last 4 months" at follow-up visits). One response option was permitted among 13 possible response options. "Other" responses were open-ended and responses included various forms of inadequate/homeless housing types and incarceration. Housing types were categorized into three housing categories: 1) stable housing consisted of those living in their own house/apartment, parent's house, or spouse/steady partner's house 2) unstable housing were those living in a rented room (hotel or rooming house), at their workplace, or at a relative or friend's house 3) Inadequate/homeless were those living primarily on the streets, in a vehicle, abandoned building, canal (TJ), or shooting gallery, or other place not intended for sleep. Movement between housing categories (housing movement) was calculated by assessing changes between the 3 housing categories between follow-up visits for each respondent (improved, worsening, no change).

Other covariates included variables known to effect condom use (access to free condoms, affordability of condoms, and hormonal contraceptive use). Also a condom use self-efficacy scale, developed by Jamner and colleagues[36], is a 5-item measure of the ability to properly use a condom (4-point scale 1 = Strongly Disagree to 4 = Strongly Agree). The outcome expectancies scale is a 6-item measure of expectations from condom use which was developed for use with FSW in Mexico[10] and uses the same 4-point scale mentioned above. Sample items include ""I believe that using

condoms will protect me from getting HIV" Demographics (income, age), sex worker characteristics (type of sex worker, duration, client load) and recent drug use behavior (injection frequency, methamphetamine use, alcohol or drug use prior to sex with clients)[10,11] were also measured.

Statistical analysis

Bivariate and multivariate associations between covariates and unprotected vaginal sex acts, stratified by client type, were performed using linear regression adjusted using generalized estimating equations (GEE) to account for the clustering of subjects with repeated measures in longitudinal data. Significant bivariate associations were included in a manual forward stepwise selection of covariates (entry and exit alpha=0.1) during model building for those with non-regular and regular clients. For spouse/steady partners, there were few significant bivariate associations between covariates and unprotected sex among partners; a backwards stepwise variable selection procedure was used with all covariates (entry and exit also alpha=0.1). Intervention group, days since baseline, and the number of vaginal sex acts for each respective client type were included in every model to account for intervention effects and volume of sex acts. A hierarchical "block" analysis was used to analyze the three different levels of risk (individual, social living environment, housing measures)[37]. Significant correlates at the individual-level were "locked" into the model, and the next block (social living environment) was assessed. Finally, we ran separate models, one with each housing

measure with individual and social-level levels already locked. Associations greater than p=0.1 in the final model are the result of locking previous hierarchical levels. This method allows researchers to see the impact of each theorized hierarchical level. Models of unprotected sex were stratified by client type. Also, potential interactions with individual, social and structural variables by study site necessitated further stratification by study site. Collinearity between covariates was evaluated using tolerance values less than 0.1. Software programs XTGEE and QIC were used to conduct regression analyses and assess correlation structure within STATA version 12. An exchangeable correlation structure was the best fit for all models.

Results

Of 618 FSW-IDU at baseline, 557 (90.1%) reported having non-regular clients and 550 (89.0%) reported having regular clients. Of 599 FSW-IDU with longitudinal data, FSW-IDU reported a median of 20 non-regular clients and 5 regular clients per month. More than a third (39.2%) reported having a spouse or steady partner (see table 3.1). At baseline, the median number of vaginal sex acts in the previous month with non-regular clients, regular clients and spouse/steady partners was 25, 20, and 10 with a median of 12, 10.5, and 10 unprotected vaginal sex acts, respectively.

In terms of housing categories, 37.6% FSW-IDU lived in stable housing, 54.3% in unstable housing, and 8.1% were homeless or lived in inadequate housing at baseline. At visits 2, 3 and 4, 64.9%, 64.1% and 64.2% listed a

change in housing type compared to their previous visit. Much of this change in housing type was across housing categories. At each follow-up visit between 18.6% and 22.2% of FSW-IDU moved into unstable or homeless/inadequate housing categories and a similar proportion (19.0% - 20.9%) improved housing categories (i.e. moved from inadequate to unstable or stable, or from unstable to stable).

FSW-IDU in TJ had fewer non-regular clients compared to FSW-IDU in CJ (one-way anova: p-value=<0.001 and 0.081 respectively; see table 3.1). The opposite was true regarding the number of regular clients, which were higher in TJ (median 6 vs. 4: p-value=0.007). There were no differences in the proportions of FSW-IDU in TJ and CJ that reported having a spouse or steady partner or unprotected vaginal sex with steady partners between cities. TJ had a higher proportion of FSW-IDU living in homeless or inadequate living conditions (13.6% vs. 2.8%; p-value=<0.001) and proportionately half as many FSW-IDU in stable housing compare to CJ (24.9% vs. 49.7%; p-value= <0.001). The proportions who reported worsening or improving housing categories at subsequent visits did not differ by site (data not shown). FSW-IDU in TJ had significantly lower income, and were more likely to be street-based compared to their counterparts in CJ. In terms of drug use, FSW-IDU in TJ were less likely to report alcohol use prior to sex with clients, more likely to use methamphetamines, and injected drugs more frequently than in CJ. In terms of contraceptives, FSW-IDU in TJ reported more access to free

condoms, less ability to buy condoms, and less hormonal contraceptive use than in CJ.

Bivariate associations between social and structural level variable and unprotected sex

The results of the bivariate associations between the social and structural living environment by site are found in tables 3.2 and 3.3. Compared to those who did not change housing categories between visits, having improved housing was associated with 5.55, 2.21 and 5.25 fewer unprotected vaginal sex acts on average among non-regular clients in CJ (p-value=0.04), and regular clients in CJ(p-value=0.05) and TJ (p-value=0.03), respectively. Compared with those in stable housing, living in unstable housing was associated with more unprotected vaginal sex among regular and non-regular clients in TJ.

In the social living environment, having a spouse/steady partner, and injecting drugs at home were associated with less unprotected vaginal sex with non-regular and regular clients in TJ. Having children < 18 years at home was associated with more unprotected vaginal sex acts on average among non-regular and regular clients compared with those without kids at home in CJ but not TJ.

Factors independently associated with unprotected sex among non-regular clients

Tijuana (TJ) and Ciudad Juarez (CJ)

In both TJ and CJ, none of the housing variables of interest were significantly associated with the number of unprotected vaginal sex acts with non-regular clients after controlling for intervention group, calendar time since baseline, the number of vaginal sex acts with non-regular clients, and other individual and social-level covariates (see tables 3.4-3.6). Individual–level covariates were independently associated with unprotected vaginal sex among non-regular clients. FSW-IDU who always reported using hormonal contraceptives in the past 6 months had, on average, 2.09 and 3.02 more unprotected vaginal sex acts with non-regular clients, in TJ and CJ respectively, compared to those who used hormonal contraceptives less than always (p-value=0.038; 0.020;). Also, for every point scored on the standardized condom use positive expectancy scale, there was a decrease of 2.59 and 1.76 unprotected vaginal sex acts with non-regular clients (p-values=<0.001; 0.023) in TJ an CJ, respectively.

Tijuana (TJ)

In TJ only, those with income < 3500 pesos per month had on average 3.71 more unprotected vaginal sex acts in the previous month compared to those earning 3500 pesos per month or more (p-value=<0.001). Also in TJ, having access to free condoms was independently associated with having on

average 3.80 less unprotected vaginal sex acts with non-regular clients compared to those with less access to free condoms (p-value=0.004).

Ciudad Juarez (CJ)

In CJ, FSW-IDU who had regularly worked in sex work for less than 10 years had on average 2.41 less unprotected vaginal sex acts (p-value=<0.001). An increase of one point on the standardized condom use self-efficacy scale was independently associated with a decrease in 3.47 unprotected vaginal sex acts with non-regular clients in the past month in CJ.

Factors independently associated with unprotected vaginal sex among regular clients

Tijuana (TJ) and Ciudad Juarez (CJ)

Similar to results for non-regular partners housing movement was not significantly associated with unprotected vaginal sex after adjustment in TJ or CJ.

Tijuana (TJ)

In TJ, unstable housing was marginally associated with less unprotected vaginal sex acts with regular clients compared to those in stable housing (p=0.09). As with non-regular clients in TJ, lower income was associated with an increase in unprotected vaginal sex acts with regular clients, whereas higher scores on the condom use positive outcome expectancy scale were associated with a decrease in unprotected vaginal sex with regular clients in TJ. Any alcohol use prior to having sex with clients was

associated with an increase in unprotected sex with regular clients by 2.90 on average in TJ.

Ciudad Juarez (CJ)

In CJ, younger age and condom use self-efficacy was associated with less unprotected sex while always using hormonal contraceptives was associated with a significant increase in unprotected sex with regular clients.

Factors independently associated with unprotected vaginal sex among spouse/steady partner

Tijuana (TJ)

In TJ, injecting drugs at home and having access to free condoms were associated with a decrease in unprotected sex acts, while any use of methamphetamines was associated with an increase in unprotected sex acts in TJ.

Ciudad Juarez (CJ)

In CJ, improving housing categories was marginally associated with 1.11 less unprotected vaginal sex acts with a spouse/steady partner ($p=0.052$). Younger age was associated with a decrease of 1.46 in the number of unprotected sex acts with a spouse/steady partner in CJ.

Discussion

Contrary to our hypotheses, we did not find an association of social living or housing measures with unprotected sex acts among FSW after controlling for individual level variables. There was no pattern of any form of

housing measurement consistently affecting unprotected sex across site, or client type. This was unexpected given the consistency of the direction and magnitude of association of many of the bivariate associations between housing measures (specifically improving housing) and unprotected sex.

Other studies have failed to find an association between housing and unprotected sex in the presence of individual-level factors[5,32,38]. However, none of these studies used a hierarchical regression design, which arguably decreased the probability of housing measurements to be significant in a regression model when entered into the model last. Our theoretical framework warranted a hierarchical approach to see if structural factors like housing are important after controlling for social and individual level factors.

Another explanation for a lack of an association between housing measurements and unprotected sex may be that our measures of housing were not specific enough to measure true differences in housing instability among FSW-IDU who regularly changed housing types across housing stability categories. When considering housing stability in terms of housing consistency, those reporting stable housing had similar rates of being inconsistently housed over time compared to those in unstable and homeless/inadequate housing categories. This indicates that most of our sample could be considered inconsistently housed, and therefore unstably housed. More detailed housing measures including a detailed history of all of the types of housing, the number of moves over the past month, and the

reasons for moving, would be helpful in determining meaningful differences in housing stability among residentially transient groups such as FSW-IDU.

In terms of individual risk factors, positive outcome expectancy showed a consistent association with decreased unprotected sex acts. Condom use self-efficacy was also associated with less unprotected vaginal sex with non-regular clients in both cities and among regular clients in CJ. Interventions that improve self-efficacy and positive outcome expectancy scores would likely impact unprotected sex across all client types.

Always using hormonal contraceptives was associated with an increase in unprotected vaginal sex among non-regular clients in both cities and among regular clients in CJ. Since less than half of FSW-IDU reported consistent use of hormonal contraceptives over the previous 6 months, we speculate that some FSW-IDU may be less concerned about pregnancy while some using hormonal contraceptives may be less concerned about STIs. That hormonal contraceptive use may reduce condom use has been reported elsewhere[39,40], and highlights the need for promoting dual protection among FSW. Integration of family planning/reproductive health and STI prevention efforts for FSW is needed.

Earning less than 3500 pesos per month had the largest impact on increasing unprotected sex among non-regular and regular clients in TJ. Similarly, inability to afford condoms was marginally significant in increasing unprotected sex with non-regular clients in CJ. Since the effect of housing

categories on unprotected sex could be moderated by income, we paid particular attention to how income modified the effect between unprotected sex and housing measures. However, the number of vaginal sex acts per partner type, more than income, removed the bivariate association between improved housing and unprotected sex.

Models of correlates of unprotected sex in TJ were unique compared to those in CJ in terms of access to free condoms and drug use. Always having access to free condoms in TJ was independently associated with a decrease in unprotected sex among both non-regular clients and steady partners in our study. Access to free condoms was also positively associated with condom use in an earlier study among FSW in TJ and CJ conducted in 2004-2005[11]. Since that time, our study indicates that access to free condoms has increased in both cities, but continues to be significantly higher in TJ compared to CJ. Still, few FSW-IDU have consistent access to free condoms.

Younger age or shorter duration in sex work was associated with a decrease in unprotected sex, but only in CJ. This was an unexpected finding, as others have reported older FSW to have a higher likelihood of negotiating condom use[41]. More research is needed regarding potential age disparities in condom use among FSW.

Limitations

Our study has important limitations that could impact our findings. Given that having recent unprotected sex and injection drug use were part of

the inclusion criteria, the ability to generalize to broader groups of FSW is reduced. However, with high rates of unprotected sex still common among FSW in Mexico there is likely overlap between risk factors for FSW and FSW-IDU. Self-reported sexual behavior may have resulted in recall bias; participants were asked to recall any behaviors, including the number of vaginal sex acts by client type and the number of vaginal sex acts that were protected. As with all longitudinal studies, loss to follow-up could have been a source of bias affecting our outcomes. However our retention rates were very high (85.9%) considering a hard-to-reach and often transient population. Those who were lost to follow-up were not significantly different in their housing measurements or rates of unprotected sex compared to those who remained in the study.

Conclusion

Our findings indicate that housing measurements and social level risk factors were not consistently associated with unprotected sex across partner types or study site. In order to assess housing instability among highly unstable populations such as FSW-IDU, further research and development of housing measurements are needed. Individual-level factors such as attitudes, drug use, and hormonal contraceptive use, continue to play an important role in influencing unprotected sex. Positive attitudes and self-efficacy for condom use were associated with less unprotected sex across all partner types in both TJ and CJ.

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Table 3.1: Individual, social and structural level characteristics of FSW-IDU at baseline by location

	Tijuana (n=302)	Ciudad Juarez (n=316)	p-value
Variable	% (95% CI)	% (95% CI)	
Individual-level			
Demographics			
Income (< 3500 pesos/mo.)	64.6 (59.2-70.0)	39.6 (34.1-45.0)	**<0.001**
Age (<25)	12.3 (8.5-16.0)	18.4 (14.1-22.6)	**0.036**
Sex worker characteristics			
Type of sex worker (street)	74.8 (69.8-79.7)	60.6 (55.2-66.0)	**<0.001**
Live & work in same location	21.9 (17.2-26.5)	23.7 (19.0-28.4)	0.578
Duration in sex work (<10 years)	45.2 (39.5-50.8)	46.2 (40.7-51.7)	**0.003**
Median # of vaginal sex acts (IQR)			
Non-regular clients	10 (5-20)	60 (25-98)	**<0.001**
Regular clients	20 (5-40)	16 (8-32)	0.806
Spouse/ steady partner	8 (3-30)	10 (4-30)	0.958
Median # of clients (IQR)			
Non-regular clients	8 (3-15)	51 (20-96)	**<0.001**
Regular clients	6 (3-15)	4 (2-6)	**0.007**
Condom use characteristics			
Median # of unprotected sex acts			
Non-regular clients	9 (2-15)	20 (7-50)	**<0.001**
Regular clients	18 (3-37)	8 (3-18)	0.081
Spouse/ steady partner	10 (4-30)	12 (4-30)	0.754
Condom use self-efficacy (mean, CI, range=1-4)	2.82 (2.76-2.87)	2.88 (2.81-2.94)	0.173
Positive outcome expectancy for condom use (mean, CI, range=1-4)	2.61 (2.56-2.66)	2.74 (2.67-2.80)	**0.003**
Always use hormonal contraceptives^	23.8 (19.0-28.7)	34.6 (29.3-39.9)	**0.003**
Always have access to free condoms	9.3 (6.0-12.6)	1.6 (0.2-3.0)	**<0.001**
Can afford to buy own condoms	47.2 (41.5-52.8)	64.6 (59.3-70.0)	**<0.001**
Drug use characteristics			
Inject drugs more than once a day*	94.4 (91.8-97.0)	85.8 (81.9-89.6)	**<0.001**
Any methamphetamine use*	77.2 (72.4-81.9)	1.6 (0.2-3.0)	**<0.001**
Any alcohol use before sex w/ client*	35.2 (29.8-40.6)	63.9 (58.6-69.2)	**<0.001**
Any drug use before sex w/ client*	89.0 (85.5-92.6)	92.4 (89.5-95.3)	0.149

*past month; ^past 6 months

Table 3.1 Continued: Individual, social and structural level characteristics of FSW-IDU at baseline by location

	Tijuana (n=302)	Ciudad Juarez (n=316)	p-value
Variable	% (95% CI)	% (95% CI)	
Social living environment variables			
Have spouse/steady partner	38.7 (33.2-44.3)	39.6 (34.1-45.0)	0.836
Have children <18 at home	31.6 (26.1-37.2)	44.1 (38.4-49.8)	**0.002**
Inject drugs at home*	44.0 (38.4-49.7)	36.4 (31.1-41.7)	**0.053**
Structural living environment			
Current housing category			**<0.001**
Stable	24.9 (20.0-29.8)	49.7 (44.2-55.2)	
Unstable	61.5 (55.9-67.0)	47.5 (41.9-53.0)	
Inadequate/homeless	13.6 (9.7-17.5)	2.8 (1.0-4.7)	

*past month; ^past 6 months

Table 3.2: Results of bivariate linear regression using GEE of unprotected vaginal sex acts by partner type among FSW-IDU in Ciudad Juarez

	# of unprotected sex acts with non-regular clients (n=305)		# of unprotected sex acts with regular clients (n=301)		# of unprotected sex acts with Spouse/steady partner (n=192)	
Variable	Coeff. (95% CI)	P-value	Coeff. (95% CI)	P-value	Coeff. (95% CI)	P-value
Individual-level						
Demographics						
Income (< 3500 pesos/mo.)	**-15.35 (-19.25--11.44)**	**<0.001**	**-4.27 (-8.43--0.12)**	**0.044**	**-3.69 (-7.74-0.36)**	**0.074**
Age (<25)	4.00 (-2.07-10.07)	0.197	**7.28 (0.80-13.76)**	**0.028**	-2.16 (-8.39-4.06)	0.496
Sex worker characteristics						
Type of sex worker (street)	0.01 (-4.66-4.68)	0.997	**-6.05 (-10.77--1.32)**	**0.012**	0.37 (-4.87-5.61)	0.889
Live & work in same location	2.65 (-2.38-7.68)	0.303	7.34 (2.24-12.45)	0.005	-0.02 (-6.41-6.38)	0.996
Duration (<10 years)	**5.17 (0.38-9.97)**	**0.034**	**4.70 (0.29-9.12)**	**0.037**	3.27 (-1.01-7.54)	0.134
# of vaginal sex acts (by client type)						
Non regular	**0.49 (0.46-0.51)**	**<0.001**	-	-	-	-
Regular	-	-	**0.81 (0.78-0.83)**	**<0.001**	-	-
Spouse/ steady partner	-	-	-	-	**0.99 (0.98-1.01)**	**<0.001**
# of clients (by client type)						
Non regular	**0.42 (0.23-0.60)**	**<0.001**	**1.20 (1.07-1.33)**	**<0.001**	-0.03 (-0.17-0.11)	0.677
Regular	**0.50 (0.47-0.52)**	**<0.001**	**0.19 (0.15-0.23)**	**<0.001**	0.00 (-0.04-0.04)	0.893
Condom use covariates						
Condom use self-efficacy (mean, CI, range=1-4)	**-5.51 (-7.19--3.83)**	**<0.001**	**-1.63 (-2.59--0.68)**	**0.001**	-0.47 (-2.14-1.20)	0.581
Positive outcome expectancy for condom use (mean, CI, range=1-4)	**-5.37 (-7.19--3.56)**	**<0.001**	**-3.22 (-5.16--1.28)**	**0.001**	**-1.59 (-3.43-0.26)**	**0.092**

Table 3.2 Continued: Results of bivariate linear regression using GEE of unprotected vaginal sex acts by partner type among FSW-IDU in Ciudad Juarez

	# of unprotected sex acts with non-regular clients (n=305)		# of unprotected sex acts with regular clients (n=301)		# of unprotected sex acts with Spouse/steady partner (n=192)	
Variable	Coeff. (95% CI)	P-value	Coeff. (95% CI)	P-value	Coeff. (95% CI)	P-value
Condom use covariates (cont'd)						
Hormonal contraceptive use (always vs. less than always)^	**7.13 (2.82-11.44)**	**0.001**	0.97 (-3.43-5.38)	0.665	-0.12 (-4.29-4.04)	0.953
Free access to condoms (always vs less than always)	-10.31 (-26.10-5.49)	0.201	-0.82 (-15.95-14.31)	0.915	-2.10 (-16.39-12.19)	0.773
Afford to buy your own condoms (Y vs. N)	**-3.94 (-8.10-0.22)**	**0.063**	**-3.83 (-8.18-0.51)**	**0.084**	-1.95 (-6.29-2.39)	0.379
Drug use covariates						
Injection frequency (more than 1 time daily vs. once daily or less) *	**12.30 (7.22-17.38)**	**<0.001**	**5.43 (0.23-10.63)**	**0.041**	2.63 (-2.26-7.53)	0.292
Methamphetamine use (Y vs. N) *	**-14.05 (-28.57-0.47)**	**0.058**	-2.85 (-15.85-10.15)	0.667	-4.90 (-18.30-8.50)	0.474
Alcohol use before sex w/ client (any vs. never) *	**5.09 (0.84-9.34)**	**0.019**	2.59 (-1.82-7.00)	0.249	-	-
Drug use before sex w/ client * (any vs. never)	**12.28 (6.59-17.97)**	**<0.001**	2.43 (-3.32-8.17)	0.408	-	-

Table 3.2 Continued: Results of bivariate linear regression using GEE of unprotected vaginal sex acts by partner type among FSW-IDU in Ciudad Juarez

	# of unprotected sex acts with non-regular clients (n=305)		# of unprotected sex acts with regular clients (n=301)		# of unprotected sex acts with Spouse/steady partner (n=192)	
Variable	Coeff. (95% CI)	P-value	Coeff. (95% CI)	P-value	Coeff. (95% CI)	P-value
Social living environment variables						
Have spouse/steady partner	1.75 (-2.58-6.07)	0.428	2.51 (-1.79-6.80)	0.253	-	-
Have children <18 at home	**4.96 (0.30-9.63)**	**0.037**	**4.21 (-0.50-8.92)**	**0.079**	0.28 (-4.15-4.71)	0.902
Inject drugs at home*	-1.34 (-6.09-3.41)	0.580	-2.10 (-6.92-2.71)	0.392	-1.12 (-5.60-3.36)	0.623
Structural living environment						
Housing movement (worsened vs. no change)	-0.98 (-5.98-4.01)	0.699	1.12 (-0.90-3.15)	0.277	-2.68 (-9.74-4.37)	0.456
(improved vs. no change)	**-5.55 (-10.77--0.33)**	**0.037**	**-2.21 (-4.37--0.05)**	**0.045**	-4.34 (-10.57-1.89)	0.172
Housing categories (ref=stable)						
Current housing (unstable vs stable)	0.51 (-3.69-4.71)	0.812	3.41 (-0.84-7.66)	0.116	0.03 (-4.23-4.29)	0.988
(inadequate/homeless vs. stable)	1.22 (-10.11-12.55)	0.833	-0.13 (-13.30-13.04)	0.984	-1.58 (-12.96-9.80)	0.786

Table 3.3 Results of bivariate linear regression using GEE of unprotected vaginal sex acts by partner type among FSW-IDU in Tijuana

	Non-regular clients (n=265)		Regular clients (n=270)		Partners (n=196)	
	Coeff. (95% CI)	P-value	Coeff. (95% CI)	P-value	Coeff. (95% CI)	P-value
Individual-level						
Demographics						
Income (< 3500 pesos/mo.)	**4.95 (1.77-8.14)**	**0.002**	**8.85 (5.16-12.53)**	**<0.001**	**3.51 (-0.59-7.60)**	**0.093**
Age (≥25 (median))	3.71 (-1.71-9.13)	0.180	-3.06 (-8.89-2.77)	0.304	-1.31 (-7.92-5.30)	0.697
Sex worker characteristics						
Type of sex worker (street vs other)	**3.62 (-0.51-7.74)**	**0.086**	1.78 (-2.74-6.31)	0.439	-1.89 (-7.82-4.05)	0.533
Live & work in same location	2.15 (-1.73-6.03)	0.278	**7.57 (2.93-12.22)**	**0.001**	3.65 (-2.54-9.83)	0.248
Duration (>10 years(median))	1.55 (-1.80-4.90)	0.365	1.03 (-2.51-4.56)	0.569	0.75 (-3.64-5.14)	0.738
# of sex acts (by client type)						
Non regular	**0.63 (0.58-0.67)**	**<0.001**	-	-	-	-
Regular	-	-	**0.74 (0.69-0.78)**	**<0.001**	-	-
Spouse/ steady partner	-	-	-	-	**0.99 (0.96-1.02)**	**<0.001**
# of clients (by client type)						
Non regular	**0.18 (0.03-0.32)**	**0.020**	**1.21 (1.06-1.37)**	**<0.001**	0.22 (-0.04-0.48)	0.094
Regular	**0.58 (0.53-0.64)**	**<0.001**	**0.18 (0.09-0.27)**	**<0.001**	0.01 (-0.12-0.14)	0.937
Condom use covariates						
Self-efficacy (composite score - coming)	**-2.66 (-4.36--0.97)**	**0.002**	**-2.69 (-4.64--0.75)**	**0.007**	-1.72 (-4.30-0.86)	0.191

Table 3.3 Continued: Results of bivariate linear regression using GEE of unprotected vaginal sex acts by partner type among FSW-IDU in Tijuana

	Non-regular clients (n=265)		Regular clients (n=270)		Partners (n=196)	
	Coeff. (95% CI)	P-value	Coeff. (95% CI)	P-value	Coeff. (95% CI)	P-value
Outcome expectancy (composite score – coming)	**-4.49 (-6.24--2.73)**	**<0.001**	**-7.09 (-9.37--4.81)**	**<0.001**	-1.21 (-3.73-1.30)	0.344
Hormonal contraceptive use (always vs. less than always)	**4.84 (1.66-8.02)**	**0.003**	**4.84 (1.08-8.60)**	**0.012**	2.26 (-1.76-6.28)	0.271
Free access to condoms (always vs less than always)	**-6.07 (-10.32--1.83)**	**0.005**	**-11.60 (-16.71--6.50)**	**<0.001**	-2.42 (-7.82-2.98)	0.380
Afford to buy your own condoms (Yes vs. No)	**-5.31 (-8.33--2.28)**	**0.001**	**-9.86 (-13.40--6.33)**	**<0.001**	**-5.65 (-9.66--1.65)**	**0.006**
Drug use covariates						
Injection frequency (more than 1 time daily vs. once daily or less)	**7.15 (0.81-13.50)**	**0.027**	6.09 (-1.31-13.50)	0.107	-0.23 (-8.03-7.58)	0.955
Methamphetamine use (Y vs. N)	**3.87 (0.52-7.23)**	**0.024**	3.23 (-0.67-7.13)	0.105	0.58 (-4.01-5.16)	0.806
Alcohol use before sex w/ client (always/often/sometimes vs. never)	2.77 (-0.57-6.11)	0.104	**5.49 (1.84-9.13)**	**0.003**	-0.04 (-3.53-3.45)	0.983
Drug use before sex w/ client	**5.42 (0.48-10.36)**	**0.032**	**6.03 (1.90-10.16)**	**0.004**	3.68 (-0.70-8.05)	0.100

Table 3.3 Continued: Results of bivariate linear regression using GEE of unprotected vaginal sex acts by partner type among FSW-IDU in Tijuana

	Non-regular clients (n=265)		Regular clients (n=275)		Partners (n=196)	
	Coeff. (95% CI)	P-value	Coeff. (95% CI)	P-value	Coeff. (95% CI)	P-value
Social living environment variables						
Have spouse/steady partner	**-2.94 (-6.18-0.29)**	**0.074**	**-5.79 (-9.40--2.18)**	**0.002**	-	-
Have children <18 at home	-1.62 (-5.30-2.06)	0.388	-2.83 (-6.93-1.26)	0.175	-1.65 (-6.26-2.96)	0.483
Inject drugs at home	**-3.46 (-6.69--0.23)**	**0.036**	**-3.58 (-7.36-0.19)**	**0.063**	-2.81 (-7.22-1.60)	0.212
Structural living environment						
Housing movement (worsened vs. no change)	-2.93 (-6.64-0.79)	0.122	0.00 (-4.41-4.41)	0.999	4.69 (-1.87-11.24)	0.161
(improved vs. no change)	-1.33 (-5.56-2.89)	0.536	**-5.25 (-9.91--0.58)**	**0.027**	-1.97 (-7.33-3.39)	0.471
Current housing (unstable vs stable)	1.03 (-2.92-4.99)	0.609	**4.40 (-0.05-8.84)**	**0.053**	**4.92 (0.59-9.24)**	**0.026**
(inadequate/homeless vs. stable)	-1.43 (-7.03-4.17)	0.617	0.74 (-5.58-7.06)	0.819	4.27 (-3.29-11.83)	0.268

Table 3.4: Factors independently associated with unprotected vaginal sex acts by partner type among FSW-IDU in Ciudad Juarez

Ciudad Juarez	Non-regular clients (n=299)		Regular clients (n=299)		Partners (n= 185)	
	Coeff. (95% CI)	P-value	Coeff. (95% CI)	P-value	Coeff. (95% CI)	P-value
Individual level						
# of vaginal sex acts with:						
Non-regular clients	0.48 (0.46-0.51)	<0.001	-	-	-	-
Regular clients	-	-	0.52 (0.49-0.56)	<0.001	-	-
Spouse/steady partner	-	-	-	-	1.00 (0.98-1.01)	<0.001
Duration of sex work (Ref = >10 years)	-2.41 (-5.10-0.27)	<0.001	-	-	-	-
Condom use self-efficacy scale (standardized)	-3.47 (-4.68--2.26)	0.006	-1.86 (-2.66--1.06)	<0.001	-	-
Condom use positive outcome expectancy scale (standardized)	-1.76 (-3.00--0.51)	0.023	-0.70 (-1.54-0.14)	0.102	-0.37 (-0.79-0.06)	0.091
Hormonal contraceptive use (always vs. less than always)	3.02 (0.42-5.63)	0.020	1.93 (0.22-3.64)	0.027	-	-
Able to afford to buy condoms (Yes vs. No)	-2.23 (-4.87-0.41)	0.098	-	-	-	-
Age (<25 vs. GE 25)	-	-	-2.42 (-4.51--0.33)	0.023	-1.46 (-2.73--0.19)	0.025
Social living environment						
Child(ren) < 18 yrs living at home	-	-	-	-	-0.34 (-1.36-0.68)	0.519
Structural environment						
Housing movement						
worsening	-	-	-	-	0.47 (-0.76-1.69)	0.457
improving	-	-	-	-	-1.11 (-2.22-0.01)	0.052

Table 3.4 Continued: Factors independently associated with unprotected vaginal sex acts by partner type among FSW-IDU in Ciudad Juarez

[a] forward stepwise selection of variables was performed for non-regular and regular clients, backwards stepwise was performed for partner models due to a lack of significant bivariate associations

[b] hierarchical analysis was performed in the order of individual, social and structural-level covariates. Insignificant values in the multivariate models are a result of locking hierarchical-levels during analysis and were significant at an earlier level.

[C] clustering of observations by individual accounted for using GEE and an exchangeable correlation structure

[d.] models adjusted for intervention group and days since baseline

Table 3.5: Factors independently associated with unprotected vaginal sex acts by partner type among FSW-IDU in Tijuana

	Non-regular clients (n=260)		Regular clients (n=271)		Partners (n=179)	
	Coeff. (95% CI)	P-value	Coeff. (95% CI)	P-value	Coeff. (95% CI)	P-value
Individual level						
# of vaginal sex acts with:						
Non-regular clients	0.55 (0.51-0.60)	<0.001	-	-	-	-
Regular clients	-	-	0.74 (0.68-0.79)	<0.001	-	-
Spouse/steady partner	-	-	-	-	0.98 (0.95-1.01)	<0.001
# of regular clients	-	-	-0.22 (-0.35--0.08)	0.002	-	-
Income (0= greater than or equal to the 3500 pesos per month vs. 1= less than 3500)	3.71 (1.80-5.63)	<0.001	4.19 (2.05-6.32)	<0.001	-	-
Condom use self-efficacy scale (standardized)	-1.02 (-2.08-0.03)	0.056	-	-	-	-
Positive outcome expectancy of condom use scale (standardized)	-2.59 (-3.78--1.41)	<0.001	-3.24 (-4.56--1.93)	<0.001	-	-
Hormonal contraceptive use (always vs. less than always)	2.09 (0.12-4.06)	0.038	-	-	-	-
Access to free condoms (always vs. less than always)	-3.80 (-6.40--1.21)	0.004	-	-	-1.92 (-3.30--0.54)	0.006
Any meth use	-	-	-	-	1.62 (0.40-2.84)	0.009
Alcohol use prior to sex w/ client (any vs never)	-	-	2.90 (0.81-4.98)	0.006	-	-
Drugs use prior to sex w/ client (any vs. never)	-	-	2.35 (-0.84-5.54)	0.149	-	-

Table 3.5 Continued: Factors independently associated with unprotected vaginal sex acts by partner type among FSW-IDU in Tijuana

	Non-regular clients (n=260)		Regular clients (n=271)		Partners (n=179)	
	Coeff. (95% CI)	P-value	Coeff. (95% CI)	P-value	Coeff. (95% CI)	P-value
Social living environment						
Have a spouse/steady partner (Yes vs. No)	-1.86 (-3.79--0.07)	0.058	-	-		
Injected at home	-	-	-	-	-1.13 (-2.17--0.08)	0.035
Structural environment						
Housing category (REF=stable)						
Unstable	-	-	-2.21 (-4.72-0.31)	0.085	-	-
Inadequate/homeless	-	-	0.03 (-3.47-3.52)	0.988	-	-

[a] forward stepwise selection of variables was performed for non-regular and regular clients, backwards stepwise was performed for partner models due to a lack of significant bivariate associations

[b] hierarchical analysis was performed in the order of individual, social and structural-level covariates. Insignificant values in the multivariate models are a result of locking hierarchical-levels during analysis and were significant at an earlier level.

[C] clustering of observations by individual accounted for using GEE and an exchangeable correlation structure

[d.] models adjusted for intervention group and days since baseline

Table 3.6: The association between housing variables and unprotected vaginal sex acts by client type, adjusted for respective covariates from multivariate models presented in tables 3.4 and 3.5[a]

	Non-regular clients		Regular clients		Spouse/steady partner	
	Coeff	p-value	Coeff	p-value	Coeff	p-value
Tijuana						
Housing Category (ref=stable)						
Unstable	-1.05 (-3.38-1.28)	0.38	-2.21 (-4.72-0.31)	0.085 [b]	0.60 (-0.61-1.81)	0.33
Inadequate/homeless	-0.68 (-3.98-2.63)	0.69	0.03 (-3.47-3.52)	0.988	1.00 (-0.99-2.99)	0.32
Housing movement between categories (ref=no change)					Model did not converge	
Worsening	-2.11 (-5.06-0.84)	0.16	-0.83 (-4.31-2.64)	0.64		
Improving	-0.33 (-3.71-3.05)	0.85	0.63 (-3.28-4.53)	0.75		
Ciudad Juarez						
Housing Category (ref=stable)						
Unstable	-1.31 (-3.82-1.20)	0.31	-0.79 (-2.41-0.83)	0.34	0.19 (-0.66-1.04)	0.67
Inadequate/homeless	4.80 (-2.13-11.73)	0.17	0.35 (-4.81-5.50)	0.89	0.56 (-1.72-2.85)	0.63
Housing movement between categories (ref=no change)						
Worsening	-0.60 (-3.69-2.49)	0.71	-0.79 (-2.60-1.01)	0.39	0.47 (-0.76-1.69)	0.46
Improving	0.19 (-3.06-3.44)	0.91	-0.82 (-2.78-1.14)	0.41	-1.11 (-2.22-0.01)	0.052 [b]

[a] each housing variable was forced into final adjusted multivariate models separately
[b] Entered adjusted multivariate model unforced

References

1. Mathers BM, Degenhardt L, Phillips B, Wiessing L, Hickman M, Strathdee SA, et al. Global epidemiology of injecting drug use and HIV among people who inject drugs: a systematic review. Lancet 2008;372(9651):1733-45.

2. Rhodes T. The 'risk environment': a framework for understanding and reducing drug-related harm. International Journal of Drug Policy 2002;13(2):85-94.

3. Weir BW, Bard RS, O'Brien K, Casciato CJ, Stark MJ. Uncovering patterns of HIV risk through multiple housing measures. AIDS and behavior 2007;11(6 Suppl):31-44.

4. Aidala AA, Lee G, Garbers S, Chiasson MA. Sexual behaviors and sexual risk in a prospective cohort of HIV-positive men and women in New York City, 1994-2002: implications for prevention. AIDS education and prevention : official publication of the International Society for AIDS Education 2006;18(1):12-32.

5. Elifson KW, Sterk CE, Theall KP. Safe living: the impact of unstable housing conditions on HIV risk reduction among female drug users. AIDS and behavior 2007;11(6 Suppl):45-55.

6. Kidder DP, Wolitski RJ, Pals SL, Campsmith ML. Housing status and HIV risk behaviors among homeless and housed persons with HIV. Journal of acquired immune deficiency syndromes 2008;49(4):451-5.

7. Surratt HL, Inciardi JA. HIV risk, seropositivity and predictors of infection among homeless and non-homeless women sex workers in Miami, Florida, USA. AIDS care 2004;16(5):594-604.

8. 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. Social science & medicine 2011;72(5):710-6.

9. UNAIDS. Global report: UNAIDS report on the global AIDS epidemic 2010.; 2010.

10. Patterson TL, Mausbach B, Lozada R, Staines-Orozco H, Semple SJ, Fraga-Vallejo M, et al. Efficacy of a brief behavioral intervention to promote condom use among female sex workers in Tijuana and Ciudad Juarez, Mexico. American journal of public health 2008;98(11):2051-7.

11. Munoz FA, Pollini RA, Zuniga ML, Strathdee SA, Lozada R, Martinez GA, et al. Condom access: Associations with consistent condom use among female sex workers in two northern border cities of Mexico. AIDS education and prevention : official publication of the International Society for AIDS Education 2010;22(5):455-65.

12. Morris MD, Case P, Robertson AM, Lozada R, Vera A, Clapp JD, et al. Prevalence and correlates of 'agua celeste' use among female sex workers who inject drugs in Ciudad Juarez, Mexico. Drug and alcohol dependence 2011.

13. Strathdee SA, Philbin MM, Semple SJ, Pu M, Orozovich P, Martinez G, et al. Correlates of injection drug use among female sex workers in two Mexico-U.S. border cities. Drug and alcohol dependence 2008;92(1-3):132-40.

14. Patterson TL, Semple SJ, Staines H, Lozada R, Orozovich P, Bucardo J, et al. Prevalence and correlates of HIV infection among female sex workers in 2 Mexico-US border cities. The Journal of infectious diseases 2008;197(5):728-32.

15. El-Bassel N, Terlikbaeva A, Pinkham S. HIV and women who use drugs: double neglect, double risk. Lancet 2010;376(9738):312-4.

16. Ulibarri MD, Strathdee SA, Patterson TL. Sexual and drug use behaviors associated with HIV and other sexually transmitted infections among female sex workers in the Mexico-US border region. Current opinion in psychiatry 2010;23(3):215-20.

17. Katsulis Y, Durfee A. Prevalence and correlates of sexual risk among male and female sex workers in Tijuana, Mexico. Global public health 2012;7(4):367-83.

18. Lindsay RR, G; Martinez, G; Vera, A; Lindsay, SP ; Strathdee, SA; Rusch, ML. Determining housing instability in a longitudinal study of female sex workers that inject drugs along the northern Mexico border. TBD In production.

19. Vera A, Abramovitz D, Lozada R, Martinez G, Rangel MG, Staines H, et al. Mujer Mas Segura (Safer Women): A combination prevention intervention to reduce sexual and injection risks among female sex workers who inject drugs. BMC public health 2012;12(1):653.

20. Gupta GR, Parkhurst JO, Ogden JA, Aggleton P, Mahal A. Structural approaches to HIV prevention. Lancet 2008;372(9640):764-75.

21. Blankenship KM, Friedman SR, Dworkin S, Mantell JE. Structural interventions: concepts, challenges and opportunities for research. Journal of urban health : bulletin of the New York Academy of Medicine 2006;83(1):59-72.

22. Suglia SF, Duarte CS, Sandel MT. Housing Quality, Housing Instability, and Maternal Mental Health. Journal of urban health : bulletin of the New York Academy of Medicine 2011.

23. Mizuno Y, Purcell DW, Zhang J, Knowlton AR, De Varona M, Arnsten JH, et al. Predictors of current housing status among HIV-seropositive injection drug users (IDUs): results from a 1-year study. AIDS and behavior 2009;13(1):165-72.

24. Evans GW, Wells NM, Chan HY, Saltzman H. Housing quality and mental health. Journal of consulting and clinical psychology 2000;68(3):526-30.

25. Calsyn RJ, Winter JP. Social support, psychiatric symptoms, and housing: A causal analysis. Journal of Community Psychology 2002;30(3):247-259.

26. Strathdee SA, Lozada R, Semple SJ, Orozovich P, Pu M, Staines-Orozco H, et al. Characteristics of female sex workers with US clients in two Mexico-US border cities. Sexually transmitted diseases 2008;35(3):263-8.

27. de la Torre A, Havenner A, Adams K, Ng J. Premium sex: Factors influencing the negotiated price of unprotected sex by female sex workers in Mexico. Journal of Applied Economics 2010;13(1):67-90.

28. Worth D. Sexual decision-making and AIDS: why condom promotion among vulnerable women is likely to fail. Studies in family planning 1989;20(6 Pt 1):297-307.

29. Amaro H. Love, sex, and power. Considering women's realities in HIV prevention. The American psychologist 1995;50(6):437-47.

30. Krishnan S, Dunbar MS, Minnis AM, Medlin CA, Gerdts CE, Padian NS. Poverty, gender inequities, and women's risk of human immunodeficiency virus/AIDS. Annals of the New York Academy of Sciences 2008;1136:101-10.

31. El-Bassel N, Witte SS, Wada T, Gilbert L, Wallace J. Correlates of partner violence among female street-based sex workers: substance abuse, history of childhood abuse, and HIV risks. AIDS patient care and STDs 2001;15(1):41-51.

32. 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.

33. Shannon K, Strathdee SA, Shoveller J, Rusch M, Kerr T, Tyndall MW. Structural and environmental barriers to condom use negotiation with clients among female sex workers: implications for HIV-prevention strategies and policy. American journal of public health 2009;99(4):659-65.

34. 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. Sexually transmitted diseases 2010;37(10):608-14.

35. Wood MM, Tortu S, Rhodes F, Deren S. Differences in condom behaviors and beliefs among female drug users recruited from two cities. Women & health 1998;27(1-2):137-60.

36. Jamner S, Wolitski RJ, Corby NH, Fishbein M. Using the theory of planned behavior to predict intention to use condoms among female sex workers margaret. Psychology & Health 1998;13(2):187-205.

37. Victora CG, Huttly SR, Fuchs SC, Olinto MT. The role of conceptual frameworks in epidemiological analysis: a hierarchical approach. International journal of epidemiology 1997;26(1):224-7.

38. Aidala A, Cross JE, Stall R, Harre D, Sumartojo E. Housing status and HIV risk behaviors: implications for prevention and policy. AIDS and behavior 2005;9(3):251-65.

39. Rugpao S. Women's reports of condom use in Thai couples under intensive and regular STI/HIV risk reduction counseling. AIDS and behavior 2008;12(3):419-30.

40. Wand H, Ramjee G. The effects of injectable hormonal contraceptives on HIV seroconversion and on sexually transmitted infections. AIDS 2012;26(3):375-80.

41. Urada LA, Malow RM, Santos NC, Morisky DE. Age Differences among Female Sex Workers in the Philippines: Sexual Risk Negotiations and Perceived Manager Advice. AIDS research and treatment 2012;2012:812635.

CHAPTER 4: The association between lifetime, active and passive smoking and latent tuberculosis infection in adults and children in the United State: results from NHANES

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Abstract

Previous studies assessing the relationship between smoking, especially passive smoking, and tuberculosis have underutilized biomarkers to measure smoke exposure. We used the latest available US National Health and Nutrition Examination Survey (NHANES) dataset with latent tuberculosis infection (LTBI) testing to determine the association between cotinine-confirmed active and passive smoking and LTBI among adults ages ≥20 years (n=3843) and children 3-19 years (n=3205). We also assessed the relationship between self-reported current, former and lifetime smoking (pack-years) and LTBI among adults. LTBI prevalence in 1999-2000 among cotinine-confirmed active, passive, and non-smoking adults and children was 6.0%, 5.2%, 3.2% and 0.3%, 1.1%, 1.5%, respectively. This corresponds with 3,402,000 active and 3,391,000 passive smoking adults who were LTBI+ in the US civilian non-institutionalized population in 1999-2000. Similarly, 3,216,000 current and 3,515,000 former smoking adults were LTBI+. Using

weighted multivariate logistic regression, adult active smokers were significantly more likely to test positive for LTBI (AOR=1.93 95% CI 1.12-3.31) but not adult passive smokers (AOR 1.63 95% CI 0.95-2.81), compared with adult non-smokers. Self-reported current smoking was also associated with LTBI (AOR 1.55 95% CI 1.04-2.31), but not former smoking (AOR 1.57 95% CI 0.70-3.51) or pack-years among current smokers (AOR 0.99 95% CI 0.99-1.00) or former smokers (AOR 1.00 95% CI 1.00-1.00) compared to never-smokers. Models controlled for age, gender, socioeconomic status, race, birthplace (US vs Foreign-born), household size, and having ever lived with someone w/ TB. After stratification by birthplace, both active (AOR 2.64; 95%CI 1.22-5.72) and passive smoking (AOR 2.39 95% CI 1.12-5.10) were significantly associated with LTBI among foreign-born adults. LTBI testing and treatment should be recommended among foreign-born active and passive smokers. Targeted smoking prevention and cessation programs in the United States and globally should be included in comprehensive national and international TB control efforts.

Introduction

Tuberculosis (TB), remains a major global health problem, with 8.8 million incident cases globally in 2010[1]. Smoking, though declining in the US, is still a major cause of morbidity and mortality in the US and worldwide. Smoking has consistently been shown to be a risk factor for poor TB outcomes including activation of latent TB, progression of active TB, and TB-related

mortality[2-4]. While current smoking has been associated with increased risk of latent TB infection (LTBI)[5-8], evidence is still limited[4]. Few studies have investigated the association between passive smoking (environmental or secondhand smoke exposure) and TB infection in adults[9-13] or children[14-19], which may contribute to the household spread of TB. Neither the association of active nor passive smoking with LTBI has been investigated on a nationwide, representative sample in the United States.

In almost all studies on the relationship between smoking and TB, researchers have relied on self-reported smoking status to assess risk; this measurement can be subject to significant underreporting bias. Cotinine, a metabolite of nicotine, may be measured in a variety of body fluids and is considered the gold-standard for assessing nicotine exposure.[20] While self-reported current smoking status is 80-90% concordant with measured serum cotinine levels in national studies in the United States[21], there is less concordance between biologic assessment of smoking status and self-report among adolescents, among whom smoking may be more sporadic and where embarrassment or fear may lead to under-reporting of current or passive smoking[22].

Assessing possible dose-response relationships between smoking and TB among self-reported current smokers can be complicated by recall bias with respect to the number of cigarettes smoked per day or additional

unreported passive smoke exposure. In fact, exposed non-smokers tend to underestimate their exposure compared with serum cotinine levels.[23]

Two studies have used cotinine levels to assess the relationship between smoking and TB. The first used urinary cotinine to confirm passive smoking status among adolescent pulmonary TB contacts in Spain and found that contacts of TB patients that became infected with TB had higher average urinary cotinine levels than those who were not infected[24]. The second study, conducted in South Africa, found no association between serum cotinine-determined current smoking status and LTBI or active TB infection among adults[25].

A limitation of using serum cotinine to assess the association between smoking and LTBI is that its half-life is 18-20 hours. Temporality is an important criterion for establishing a causal relationship between current or passive smoking and LTBI. Thus, an ideal study would involve a cohort analysis that would identify onset of smoking, onset of LTBI, and length and intensity of exposure as antecedents to LTBI. However, estimating past exposure to smoking is also useful in establishing an overall association between smoking and LTBI. For this reason, lifetime exposure of smoking, typically measured in self-reported pack-years, is often used to evaluate this association. A benefit of using self-reported pack-years is that both current *and former* smokers can have lifetime smoke exposure estimations and a dose-response relationship can be assessed.

We sought to determine the association between active, passive, and lifetime smoking and LTBI in a nationally representative US population using cotinine verification of smoking status as well as self-reported life time exposure measures. In this paper, we first quantify the association between cotinine-confirmed active and passive smoking and LTBI among US adults and children; we then measure the association between self-reported current and former adult smokers and LTBI, and then evaluate the association between self-reported lifetime pack-years of smoking and LTBI among current and former US adult smokers.

Methods

Data source

The National Health and Nutrition Examination Survey (NHANES) is administered in 2 year cycles through the Centers for Disease Control and Prevention's (CDC) National Center for Health Statistics (NCHS) and comprises a nationally representative sample of the US civilian (non-institutionalized) population ≥ 1 year of age, with oversampling of persons aged ≥60 years and minority racial/ethnic groups. The 1999-2000 NHANES survey administered home interviews and subsequent physical examinations during which biomarkers including serum cotinine were collected and Tuberculin Skin Tests (TST) were placed. Respondents returned to have TST read 48-72 hours after placement. The unweighted sample size of adults for the home interview was 4880 (response rate = 76.2%) and for the examination

was 4444 (response rate = 69.4%). For children 1-19, 4612 were interviewed (response rate 88.0%) and 4388 examined (response rate 83.8%). Among adults and children, 97% of those who had a physical examination returned to have their TST read[26]. The NHANES Institutional Review Board (IRB), which is part of NCHS, reviewed and approved all study protocols. Though serum cotinine is gathered each year as part of the examination, the 1999-2000 survey is the latest available NHANES dataset that includes both this measure and TST data among respondents.

TB and smoking exposure classification

After placement of TST, induration was measured by trained NHANES TST readers at 48-72 hours. Induration ≥10mm was considered a positive result for LTBI. For those with evidence of Bacillus Calmette-Guérin (BCG) vaccination (determined by the presence of a scar on the upper arm during the medical examination), ≥15mm was considered positive. There were 39 adults and 4 children that were BCG-vaccinated and had induration between 10-15mm.

Participants were classified as non-, passive, or active smokers using information from both the interviews and the laboratory results using CDC definitions[27]. Persons with serum cotinine levels <0.05ng/mL (0.05ng/mL being the minimum level of detection (LOD) for the 1999-2000 survey) who did not report smoking within the past 30 days or using any product containing nicotine within the 5 days prior to their physical examination were classified as

non-smokers. Those who reported no smoking/nicotine use but had serum cotinine levels of 0.05-10ng/mL were classified as passive smokers. Individuals with serum cotinine levels >10ng/mL who had smoked in the previous 30 days were considered active smokers. Persons who reported smoking in the previous five days on at least two questionnaire items and had serum cotinine levels ≥0.05ng/mL- <10ng/mL (adults n=90, children ≥12 yrs n=63) were considered active smokers, albeit likely occasional smokers[21]. Those with cotinine levels ≥10ng/mL with at least two interview questions indicating they did not smoke (adults n=45, children ≥12 yrs n=29) were considered passive smokers. Individuals with cotinine levels above 0.05ng/mL who did not indicate smoking but used chewing tobacco or snuff in the five days previous to the lab testing (adults n=61, children ≥12 yrs n=11) were categorized as non-smokers. Where there were discrepant responses regarding current smoking in both the home and lab interview questions (adults n=28, children ≥12 yrs n=100), or both interview questions were missing we then used the above mentioned serum cotinine cutoff points to assign smoking exposure. Children aged 3-12 yrs (n=1,163) were not interviewed regarding smoking and were assigned to exposure categories using only serum cotinine levels. Children aged 3-12 yrs with cotinine levels ≥10ng/mL were considered passive smokers.

Lifetime exposure to cigarette smoke was determined using home interview questions only. Participants who had smoked ≥100 cigarettes in their

lifetime and who reported currently smoking “every day” or “some days” were categorized as current smokers. Those who had smoked ≥100 lifetime cigarettes and did not report currently smoking were considered former smokers. The total number of cigarettes smoked per day multiplied by the total number of years of smoking provided a cigarette-year dosage estimate of exposure. Pack-years were then calculated by dividing cigarette years by 20 (20 cigarettes per pack). Pack-years was calculated for both current and former smokers.

Covariates of interest included age at time of examination (approximately 4-6 weeks after the home interview), gender, race/ethnicity (a known confounder of smoking and TB status), nation of birth (United States, Mexico, Other foreign-born), poverty income ratio (<1 indicates below the poverty line, adjusted by year), level of education, the number of persons living in the same household, and whether the participant had ever lived with somebody with active TB.

Statistical Analysis

Adults ≥20 years of age and children ≥3-20 were analyzed separately as children are thought to be more susceptible to the effects of passive smoking on their immature respiratory and immune systems[28,29]. Additionally, adults and children (aged 13-19) received different questionnaires assessing smoking behaviors. Weighted analyses were used to account for oversampling of the elderly and other race/ethnicity groups. To account for non-response for

those without a complete TST lab result, the two-year Taylor series weights provided by the NCHS for NHANES were adjusted according to Bennett et al. (see online supplement) [26] and permission was provided for us to use them in our analysis. Chi-square and t-tests were used to calculate differences between smoking measures and LTBI status. Nationwide prevalence estimates of LTBI among those with personal or household smoking behaviors were calculated using weighted proportions for survey data. Associations between smoking measures and LTBI were explored using weighted bivariate analyses and multivariate logistic regression (α=0.05).

Results

Of the 3843 adults and 3205 children who had TST results, 202 adults (unweighted proportion 5.3%) and 240 children (unweighted proportion 7.5%) had complete TST readings but were without serum cotinine lab results; these subjects were excluded from final models. Among adults with complete LTBI results, nine (unweighted proportion 0.2%) were excluded from models of current and former smokers due to missing home interview questions regarding smoking status.

Prevalence of smoking

Among adults, nearly a quarter (24.9%; 95% CI 21.9%-28.0%), or 3,216,318 individuals were self-reported current smokers and nearly another quarter (24.6% ; 95% CI 22.3%-26.9%) were self-reported former smokers in the United States in 1999-2000. Using serum cotinine to confirm smoking

status and after weighting, 29.3% (95% CI 25.9%-32.7%) of adults and 9.4% (95% CI 6.8%-12.0%) of children aged 3-19 were active smokers; 34.1% (95% CI 31.2%-37.0%) of adults and 59.2% (95% CI 55.2%-63.2%) of children aged 3-19 were passive smokers; and 36.6% (95% CI 31.7%-41.6%) of adults and 31.4% (95% CI 26.0%-36.7%) of children aged 3-19 were non-smokers.

Prevalence of LTBI

In 1999-2000, prevalence of LTBI was 4.6% (95% CI 3.4%-5.9%) for adults and 1.1% (95% CI 0.4%-1.9%) for children aged 3-12 (Table 4.1). The prevalence of LTBI among adults was 6.0% (95% CI 3.9-8.2) for active smokers , or 3,402,181 individuals, and 5.2% (95% CI 2.9-7.5) for passive smokers or 3,390,797 individuals in the civilian, non-institutionalized population in 1999-2000.

Sociodemographic correlates of LTBI

Respondents with LTBI were more likely to have been born outside the United States, to report having lived with someone with active TB, and have lower household income than those who did not have LTBI (Table 4.2). Among adults, LTBI+ respondents were more likely to be older, male, of minority race/ethnicity, with less than high school education, and living in larger households than LTBI- respondents. Among children, age, gender, race/ethnicity and household size did not significantly differ by LTBI status. Among adults there were no differences in the mean number of pack-years for current or former smokers according to LTBI status (p=0.53 and p=0.31

respectively, T-test). Overall, there was no difference in LTBI status based on BCG vaccination (p=0.50 for adults and p=0.60 for children, Pearson's Chi-square).

Active and passive smoking and LTBI

Adults with cotinine-confirmed active smoking status were almost two times as likely to be LTBI+ (OR 1.93, 95% CI 1.12-3.31) compared to non-smokers (Table 4.3). After adjusting for age, gender, poverty income ratio, race, education, birthplace, household size, and having ever lived with somebody with TB, the OR for the association between active smoking and LTBI among adults was 2.32 (95% CI 1.21-4.45) (Table 4.4). The adjusted OR for LTBI among cotinine-confirmed passive smoking among adults was 2.03 (95% CI 0.89-4.62). Unexpectedly, the unadjusted OR for LTBI among active smoking children (aged 3-19) was 0.20 (95% CI 0.04-0.96), but this protective effect lost significance after adjustment for covariates (AOR 0.13, 95% CI 0.01-1.45). Passive smoking was not associated with LTBI in bivariate or multivariate models.

Self-reported current and former smoking and LTBI

In both bivariate and multivariate analyses, self-reported current smoking among adults was associated with an approximate 50% increased risk of LTBI (AOR 1.55, 95% CI 1.04-2.31) compared to those who had never smoked. There was no association between self-reported former smoking and LTBI.

Pack years and LTBI

Higher number of reported pack-years smoking among adults (both current and former smokers) was not associated with LTBI.

The strongest correlate of LTBI for both adults and children in this sample was foreign-born status (Table 4.3). Therefore, we tested the association of smoking and LTBI among adults and children stratifying by US vs. foreign-born status (Table 4.4). After stratifying by place of birth, the relationship of TB and smoking among us-born was reduced. However, among foreign-born adults, the association between active and passive smoking and LTBI appeared to be stronger than for US-born adults for both active and passive smoking. However, US and foreign-born children who were active smokers as well as children exposed to passive smoking in the US were less likely to have LTBI. When stratified by birthplace, an increase in one pack-year was associated with a very small increase in the likelihood of LTBI among former adult smokers in the US.

Discussion

Our study of the non-institutionalized US population reports a strong positive association between active smoking and LTBI when identified either by self-report or serum cotinine. This is the first study to use cotinine confirmation of active and passive smoking status in assessing risk for LTBI. Although the association between passive smoking and LTBI was only marginally significant among adults in our sample, other studies have found an

increased risk for active TB among exposed passive smokers (albeit a small risk).[9-13]

As might be expected, the risk of LTBI due to active smoking was greater among those born outside of the United States. There was no association between active smoking and LTBI among US-born subjects. Passive smoking was marginally associated with LTBI among US-born respondents and significantly associated with LTBI among the foreign-born population. This difference in the risk of LTBI for passive smoking may be due to a difference in the prevalence of *Mycobacterium tuberculosis* circulating in the community. In other words, there may be higher risk of LTBI due to passive smoking in populations with a higher prevalence of TB.

It is noteworthy that the majority of active TB cases in the United States arise from activated LTBI and not through de-novo transmission in the community after arrival[30,31]. Therefore, tobacco control programs targeting foreign-born populations and their contacts in the United States may be critical in reducing activation of LTBI even though they may not have a large effect on pre-existing LTBI. Active and passive smoking in immigrants' home countries along with higher prevalence of *M. tuberculosis* may be an important determinant of the US TB burden. Furthermore, higher prevalence of smoking may continue for many ethnic groups in the United States after immigration[32].

We did not observe passive smoking to be associated with increased risk for LTBI among children, in contrast to other studies which did find such

an association for LTBI[15-18] and active TB[14,19] among children. This lack of association could simply be due to the small number of LTBI cases among children in the NHANES 1999-2000 study. However, all other studies were conducted among contacts of TB patients or in high TB incidence areas and used self-reported smoking measures, which could affect risk estimates. Two of these studies reported an association between passive smoking and TB infection among children living in the home of a TB patient[15,18]. Du Preez et al. reported a dose-response relationship between passive smoke exposure and TB infection in a high TB-incidence area.[16] In the only other study of passive smoking and LTBI among children conducted in the United States, Kuemmerer did not exclude active smokers or control for confounders; in addition TB prevalence and smoking prevalence were much higher at the time of his study (1963) than in 1999-2000. We therefore suspect that our differing results may be attributable to the low prevalence of LTBI in the US population (especially among children), differences in measurement of passive smoke exposure, and even in the difference in passive smoke exposure in the US population of 1999-2000 and other studied populations. More research is needed among adults and children using cotinine-confirmed measures of passive smoking in settings with diverse TB exposures.

Since smoking has been associated with poor adherence to LTBI treatment[33] and given our approximation of nearly 6.8 million adults who were either active or passive smokers and were LTBI+ in the US in 1999-2000,

current efforts to treat LTBI in the US may be hindered without special attention to tobacco control and smoking cessation. With recent changes in treatment guidelines for LTBI[34], more research is needed to determine if there is an association between LTBI treatment failure under new guidelines and active and passive smoking.

Our finding that former smokers were not more likely to be LTBI+ than never-smokers suggests that improvements in smoking cessation interventions among susceptible populations could prevent incident cases of LTBI as well as progression to active TB. Whereas former smokers have been shown to have increased risk for LTBI compared to never-smokers in other studies[8,35], most of these studies have shown lower risks for TB disease for former smokers compared to current smokers.[2,3]

We observed no evidence of a dose response relationship between more pack-years of smoking and increased risk of LTBI among current and former smokers. Other studies have shown such and association with TB infection[5,8,36] and disease.[37,38] It may be that under-reporting of previous smoking history interferes with this measurement; a longitudinal study with careful tobacco exposure measurements would be more useful in assessing the dose-response relationship between tobacco use and TB outcomes.

Limitations

We used a cutoff point of 10-15ng/mL to distinguish active smokers from non-smokers; however, some researchers have recommended even

lower cutoff points, ranging from 1-6 ng/mL depending on age and race[39] to ascertain current smoking status. Our cutoff point of 10 ng/mL may have misclassified some active smokers as passive smokers. However, those with at least two interview responses affirming smoking status were considered active smokers regardless of cotinine levels and were likely light smokers if cotinine levels were < 10ng/mL at the time of testing. Since we triangulated cotinine-levels with interview questions, any misclassification of smoking status using the cutoff point of 10ng/mL would have been among those with discrepant or missing interview responses. Discrepant or missing interview responses were few among adults and more common among children, especially those 3-12 years of age who were not interviewed.

A challenge of investigating the association between smoking and LTBI in the US population is the low prevalence of LTBI. This may have especially affected our estimates among children, and as a result the confidence limits around our risk estimates for LTBI were quite wide. In addition, with the TST as our diagnostic TB outcome, we were only able to investigate the association between smoking and LTBI and not active TB. Further discussion of the limitations of the TST test and confounders of LTBI in the NHANES study can be found elsewhere[26]. While TST may have overestimated the LTBI in the population, we had a more strict definition of LTBI using a criterion of ≥ 15mm skin induration (instead of 10mm) for infection for those who had been vaccinated with BCG. In addition, we employed a cross-sectional design with

LTBI status determined from TST administered at a single time point. Therefore, we were unable to determine the temporality between smoking exposure and incident LTBI. Furthermore, while we controlled for potential confounders, it is possible that the apparent associations between smoking and LTBI in our study are due to residual confounding. Future comparisons and estimations of LTBI prevalence, active TB, and the association of smoking on both latent and active TB will be possible with the ongoing 2011-2012 NHANES, which will utilize both the TST test and the more specific QuantiFERON®-TB diagnostic blood test.

Conclusion

While the effects of lifetime, active and passive smoking on LTBI in the United States across age and national birthplace are not consistent in the 1999-2000 NHANES, active or current smoking determined by both serum cotinine levels and self-reported smoking were strongly associated with LTBI. Tobacco control efforts among the general US population and especially targeting the immigrant population will likely decrease the prevalence of LTBI in the United States and elsewhere. The independent associations between both active and passive smoking and LTBI were strongest among foreign-born adults representing a subpopulation in need of comprehensive active and passive smoking prevention and cessation efforts. Further research using cotinine-confirmed smoking exposure assessment, especially for passive smoking, in areas of higher TB prevalence would help to more accurately

determine the specific TB burden due to tobacco use. Cigarette smoking exposure has been recommended as a criterion for treatment of LTBI [40] and has been incorporated into guidelines in the United States[41] and Canada[42], yet only Canada recommends smoking as a criterion for TB testing among immigrants. The United States should also recommend TB testing for immigrants that actively smoke or are exposed to passive smoke, and support global tobacco control efforts to reduce morbidity and mortality associated with TB.

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Table 4.1. Estimated prevalence of LTBI according to smoking characteristics in the US among adults and children, 1999-2000

	Adults			Children		
Characteristics	Weighted LTBI prevalence	Population with characteristic	Estimated no. with LTBI	Weighted LTBI prevalence	Pop. w/ characteristic	Estimated no. with LTBI
	% (95% CI)	No. x 1,000	No. x 1,000 (95% CI)	% (95% CI)	No. x 1,000	No. x 1,000 (95% CI)
All participants	4.65 (3.41-5.88)	192491	8943 (6559,11328)	1.13 (0.36,1.89)	69423	783 (251,1315)
Smoking						
Non-smokers	3.23 (2.10,4.35)	70523	2276 (1484,3068)	1.48 (0.21,2.75)	21771	321 (46,596)
Active	6.03 (3.85,8.22)	56385	3402 (2171,4633)	0.30 (0,0.73)	6550	20 (0,49)
Passive	5.17 (2.86,7.48)	65583	3391 (1877,4905)	1.08 (0,2.20)	41102	442 (0,904)
Self-reported smoking						
Never	3.70 (2.14,5.26)	97145	2611 (1512,3710)	-	-	-
Current	5.70 (3.56,7.85)	48012	3216 (2009,4423)	-	-	-
Former	5.36 (3.04,7.68)	47334	3515 (1993,5037)	-	-	-

Table 4.2. Latent TB Infection among US non-institutionalized adults (aged ≥20 years) and children (aged 3-19 years) by sociodemographic correlates and smoking status, 1999-2000

	Adults			Children		
	LTBI- unweighted n=3543 (weighted %)	LTBI+ unweighted n=300 (weighted %)	P (Pearson's Chi-square)	LTBI- unweighted n=3140 (weighted %)	LTBI+ unweighted n=65 (weighted %)	P
Smoking status			0.036			<0.001
Non-smoker	1387 (37.1)	106 (25.1)		995 (31.3)	32 (41.1)	
Passive smoker	1,168 (33.9)	91 (37.4)		1627 (59.2)	23 (56.4)	
Active smoker	802 (28.9)	87 (37.5)		284 (9.5)	4 (2.5)	
Self-reported smoking status			0.183			-
Never	1886 (51.0)	118(40.5)		-	-	
Current	713 (24.7)	83(30.9)		-	-	
Former	938(24.4)	96(28.6)		-	-	
Pack years						
Active			0.144			-
Weighted mean	14.8	10.5		-	-	
Former			0.317			-
Weighted mean	23.1	30.1		-	-	
Age (years)			0.047			0.897
Weighted mean	44.9	48.7		11.4	11.6	
Male sex	1617 (47.0)	186 (61.7)	0.010	1624(53.3)	38 (54.3)	0.947
Race/Ethnicity			<0.001			0.055
Non-Hispanic White	1721 (73.0)	39 (30.3)		647 (58.3)	5 (50.5)	
Mexican American	885 (5.8)	146 (17.2)		1295 (11.3)	50 (31.7)	

Table 4.2 Continued. Latent TB Infection among US non-institutionalized adults (aged ≥20 years) and children (aged 3-19 years) by sociodemographic correlates and smoking status, 1999-2000

	Adults			Children		
	LTBI- unweighted n=3543 (weighted %)	LTBI+ unweighted n=300 (weighted %)	P (Pearson's Chi-square)	LTBI- unweighted n=3140 (weighted %)	LTBI+ unweighted n=65 (weighted %)	P
Non-Hispanic Black	642 (10.0)	76 (21.2)		921 (15.2)	8 (11.1)	
Other Hispanic/Multiracial/Other	295 (11.3)	39(31.3)		277 (15.3)	2 (06.7)	
Birthplace			<0.001			<0.001
USA	2715 (85.2)	128 (41.6)		2738 (92.0)	23 (27.8)	
Mexico	480 (3.3)	116 (15.2)		294 (2.0)	33 (22.0)	
Other foreign born	345 (11.6)	56 (43.2)		107 (5.9)	9 (50.2)	
Ever lived with someone with active TB	148 (3.3)	35 (12.5)	<0.001	44 (0.7)	5 (2.8)	0.023
BCG scar	501 (12.7)	35 (17.3)	0.495	44(0.8)	1(0.5)	0.595
Education			<0.001			-
< High School graduate	1,283 (23.1)	201 (49.6)		-	-	
High school graduate/GED or more	2251 (76.9)	98 (50.4)		-	-	
Poverty Income Ratio <1	620 (15.4)	74 (27.4)	0.020	1054 (27.2)	33 (83.4)	<0.001
Household size (persons)			0.001			0.563
Weighted mean	3.0	3.5		4.4	4.7	

Table 4.3: Smoking status and LTBI according to sociodemographic correlates, United States, 1999-2000.

	Adults (≥ 20) n= 3843		Children (3-19) n=3205	
	OR (95% CI)	P-value	OR (95% CI)	P-value
Cotinine confirmed smoking status (Ref=non-smokers)				
Passive smokers	1.63 (.95-2.81)	0.072	0.72 (0.18-2.87)	0.623
Active smokers	1.93 (1.12-3.31)	0.021	0.20 (0.04-0.96)	0.045
Self-reported smoking status (ref=never smokers)				
Current	1.57 (1.12-2.06)	0.003	-	-
Former	1.47 (0.71-3.04)	0.270	-	-
Pack years (interval=1 year)				
(active n=692)	0.99 (0.96-1.02)	0.402	-	-
(former n=920)	1.00 (1.00-1.00)	0.233	-	-
Age (5-year intervals for adults, 2-year intervals for children)	1.07(1.00-1.14)	0.041	1.01 (0.80-1.29)	0.897
Male sex	1.82(1.18-2.80)	0.010	0.96 (0.27-3.36)	0.947
Race/ethnicity (ref=non-Hispanic white)				
Mexican American	7.09 (3.87-12.99)	<.0001	3.25 (0.94-11.23)	0.061
Non-Hispanic Black	6.66 (3.37-13.14)	<.0001	0.84 (0.20-3.55)	0.795
Other Hispanic/multiracial/Other	5.13 (2.72-9.72)	<.0001	0.51 (0.07-3.90)	0.487
Education (ref= Beyond High School)				
< High school graduate	3.27 (2.15-4.99)	<.0001	-	-
Poverty income ratio < 1	2.07(1.13-3.80)	.022	13.44 (4.31-41.90)	<0.001
Birthplace (Ref=born in USA)				
Mexican-born	9.56(6.85-13.35)	<.0001	36.03 (10.86-119.52)	<0.001
Foreign-born	7.65(4.40-13.27)	<.0001	27.95 (5.32-146.85)	0.001
Size of household (unit=1 person)	1.26(1.14-1.38)	<.0001	1.18 (0.64-2.18)	0.562
Ever lived w/ someone w/ active TB	1.14(1.04-1.25)	0.008	3.81 (1.13-12.80)	0.033

Table 4.4: LTBI risks* by age, birthplace, and self-reported cigarette pack-years, United States, 1999-2000

	All Adults (n=3069)		All Children (n=2580)		U.S. born adults (n=2304)		U.S. born children (n=2240)		Foreign born Adults (n=765)		Foreign born children (n=305)	
	Adjusted OR	p-value	Adjusted OR	p-value	Adjusted OR	p-value	Adjusted OR	p-value	Adjusted OR	p-value	Adjusted OR	p-value
Model 1 Cotinine confirmed smoking status (Ref=non-smokers)												
Passive smokers	2.03 (0.89-4.62)	0.085	0.41 (0.08-2.16)	0.272	1.76 (0.90-3.43)	0.091	0.07 (0.01-0.45)	0.008	2.39 (1.12-5.10)	0.027	1.35 (0.43-4.33)	0.574
Active smokers	2.32 (1.21-4.45)	0.015	0.13 (0.01-1.45)	0.090	1.44 (0.62-3.38)	0.370	0.24 (0.07-0.84)	0.028	2.64 (1.22-5.72)	0.018	0.06 (0.00-0.70)	0.028
Model 2 (Ref=never smoker)					N=2408				N=818			
Current	1.55 (1.04-2.31)	0.035	-	-	1.22 (0.69-2.16)	0.468	-	-	1.83 (0.78-4.28)	0.149	-	-
Former	1.57 (0.70-3.51)	0.182	-	-	1.53 (0.73-3.21)	0.236	-	-	1.68 (0.58-4.90)	0.313	-	-
Model 3 Ref=never smoker)												
Pack years (active) n=585	0.99 (0.99-1.00)	0.562	-	-	0.99 (0.97-1.02)	0.568	-	-	NA	NA	-	-
Pack years (former) n=765	1.00 (1.00-1.00)	0.177	-	-	1.00 (1.00-1.00)	0.003	-	-	NA	NA	-	-

*All models for adults were adjusted for age, gender, poverty income ratio, race, education, household size, and having ever lived with someone with TB (except when stratified by birthplace). Models for children were adjusted using the same variables as for adults except for education.

References

1. WHO. Global tuberculosis control 2011. In. Geneva: WHO; 2011.

2. Bates MN, Khalakdina A, Pai M, Chang L, Lessa F, Smith KR. Risk of tuberculosis from exposure to tobacco smoke: a systematic review and meta-analysis. Arch Intern Med 2007;167(4):335-42.

3. Lin HH, Ezzati M, Murray M. Tobacco smoke, indoor air pollution and tuberculosis: a systematic review and meta-analysis. PLoS Med 2007;4(1):e20.

4. Slama K, Chiang CY, Enarson DA, Hassmiller K, Fanning A, Gupta P, et al. Tobacco and tuberculosis: a qualitative systematic review and meta-analysis. Int J Tuberc Lung Dis 2007;11(10):1049-61.

5. Anderson RH, Sy FS, Thompson S, Addy C. Cigarette smoking and tuberculin skin test conversion among incarcerated adults. American journal of preventive medicine 1997;13(3):175-81.

6. Plant AJ, Watkins RE, Gushulak B, O'Rourke T, Jones W, Streeton J, et al. Predictors of tuberculin reactivity among prospective Vietnamese migrants: the effect of smoking. Epidemiology and infection 2002;128(1):37-45.

7. Solsona J, Cayla JA, Nadal J, Bedia M, Mata C, Brau J, et al. Screening for tuberculosis upon admission to shelters and free-meal services. European journal of epidemiology 2001;17(2):123-8.

8. den Boon S, van Lill SW, Borgdorff MW, Verver S, Bateman ED, Lombard CJ, et al. Association between smoking and tuberculosis infection: a population survey in a high tuberculosis incidence area. Thorax 2005;60(7):555-7.

9. Alcaide J, Altet MN, Plans P, Parron I, Folguera L, Salto E, et al. Cigarette smoking as a risk factor for tuberculosis in young adults: a case-control study. Tuber Lung Dis 1996;77(2):112-6.

10. Ariyothai N, Podhipak A, Akarasewi P, Tornee S, Smithtikarn S, Thongprathum P. Cigarette smoking and its relation to pulmonary tuberculosis in adults. The Southeast Asian journal of tropical medicine and public health 2004;35(1):219-27.

11. Dong B, Ge N, Zhou Y. [Smoking and alcohol consumption as risk factors of pulmonary tuberculosis in Chengdu: a matched case-control study]. Hua Xi Yi Ke Da Xue Xue Bao 2001;32(1):104-6.

12. Leung CC, Lam TH, Ho KS, Yew WW, Tam CM, Chan WM, et al. Passive smoking and tuberculosis. Arch Intern Med 2010;170(3):287-92.

13. Tekkel M, Rahu M, Loit HM, Baburin A. Risk factors for pulmonary tuberculosis in Estonia. The international journal of tuberculosis and lung disease : the official journal of the International Union against Tuberculosis and Lung Disease 2002;6(10):887-94.

14. Altet MN, Alcaide J, Plans P, Taberner JL, Salto E, Folguera LI, et al. Passive smoking and risk of pulmonary tuberculosis in children immediately following infection. A case-control study. Tuber Lung Dis 1996;77(6):537-44.

15. den Boon S, Verver S, Marais BJ, Enarson DA, Lombard CJ, Bateman ED, et al. Association between passive smoking and infection with Mycobacterium tuberculosis in children. Pediatrics 2007;119(4):734-9.

16. du Preez K, Mandalakas AM, Kirchner HL, Grewal HM, Schaaf HS, van Wyk SS, et al. Environmental tobacco smoke exposure increases Mycobacterium tuberculosis infection risk in children. The international journal of tuberculosis and lung disease : the official journal of the International Union against Tuberculosis and Lung Disease 2011;15(11):1490-6, i.

17. Kuemmerer JM, Comstock GW. Sociologic concomitants of tuberculin sensitivity. The American review of respiratory disease 1967;96(5):885-92.

18. Singh M, Mynak ML, Kumar L, Mathew JL, Jindal SK. Prevalence and risk factors for transmission of infection among children in household contact with adults having pulmonary tuberculosis. Archives of disease in childhood 2005;90(6):624-8.

19. Tipayamongkholgul M, Podhipak A, Chearskul S, Sunakorn P. Factors associated with the development of tuberculosis in BCG immunized children. The Southeast Asian journal of tropical medicine and public health 2005;36(1):145-50.

20. Cummings SR, Richard RJ. Optimum cutoff points for biochemical validation of smoking status. American journal of public health 1988;78(5):574-5.

21. Caraballo RS, Giovino GA, Pechacek TF, Mowery PD. Factors associated with discrepancies between self-reports on cigarette smoking and

measured serum cotinine levels among persons aged 17 years or older: Third National Health and Nutrition Examination Survey, 1988-1994. American journal of epidemiology 2001;153(8):807-14.

22. Caraballo RS, Giovino GA, Pechacek TF. Self-reported cigarette smoking vs. serum cotinine among U.S. adolescents. Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco 2004;6(1):19-25.

23. Max W, Sung HY, Shi Y. Who is exposed to secondhand smoke? Self-reported and serum cotinine measured exposure in the U.S., 1999-2006. International journal of environmental research and public health 2009;6(5):1633-48.

24. Altet MN, Alcaide J, Plans P, Taberner JL, Salto E, Folguera LI, et al. Passive smoking and risk of pulmonary tuberculosis in children immediately following infection. A case-control study. Tubercle and lung disease : the official journal of the International Union against Tuberculosis and Lung Disease 1996;77(6):537-44.

25. Brunet L, Pai M, Davids V, Ling D, Paradis G, Lenders L, et al. High prevalence of smoking among patients with suspected tuberculosis in South Africa. The European respiratory journal : official journal of the European Society for Clinical Respiratory Physiology 2011;38(1):139-46.

26. Bennett DE, Courval JM, Onorato I, Agerton T, Gibson JD, Lambert L, et al. Prevalence of tuberculosis infection in the United States population: the national health and nutrition examination survey, 1999-2000. Am J Respir Crit Care Med 2008;177(3):348-55.

27. Vital signs: nonsmokers' exposure to secondhand smoke --- United States, 1999-2008. MMWR Morb Mortal Wkly Rep 2010;59(35):1141-6.

28. Krishnan S, Dunbar MS, Minnis AM, Medlin CA, Gerdts CE, Padian NS. Poverty, gender inequities, and women's risk of human immunodeficiency virus/AIDS. Annals of the New York Academy of Sciences 2008;1136:101-10.

29. Cook DG, Strachan DP. Health effects of passive smoking-10: Summary of effects of parental smoking on the respiratory health of children and implications for research. Thorax 1999;54(4):357-66.

30. Chin DP, DeRiemer K, Small PM, de Leon AP, Steinhart R, Schecter GF, et al. Differences in contributing factors to tuberculosis incidence in U.S. -born and foreign-born persons. American journal of respiratory and critical care medicine 1998;158(6):1797-803.

31. Geng E, Kreiswirth B, Driver C, Li J, Burzynski J, DellaLatta P, et al. Changes in the transmission of tuberculosis in New York City from 1990 to 1999. The New England journal of medicine 2002;346(19):1453-8.

32. Constantine ML, Rockwood TH, Schillo BA, Alesci N, Foldes SS, Phan T, et al. Exploring the relationship between acculturation and smoking behavior within four Southeast Asian communities of Minnesota. Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco 2010;12(7):715-23.

33. Lavigne M, Rocher I, Steensma C, Brassard P. The impact of smoking on adherence to treatment for latent tuberculosis infection. BMC Public Health 2006;6:66.

34. 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. Social science & medicine 2011;72(5):710-6.

35. McCurdy SA, Arretz DS, Bates RO. Tuberculin reactivity among California Hispanic migrant farm workers. American journal of industrial medicine 1997;32(6):600-5.

36. Nisar M, Williams CS, Ashby D, Davies PD. Tuberculin testing in residential homes for the elderly. Thorax 1993;48(12):1257-60.

37. Chang KC, Leung CC, Tam CM. Tuberculosis risk factors in a silicotic cohort in Hong Kong. The international journal of tuberculosis and lung disease : the official journal of the International Union against Tuberculosis and Lung Disease 2001;5(2):177-84.

38. Hnizdo E, Murray J. Risk of pulmonary tuberculosis relative to silicosis and exposure to silica dust in South African gold miners. Occupational and environmental medicine 1998;55(7):496-502.

39. Benowitz NL, Bernert JT, Caraballo RS, Holiday DB, Wang J. Optimal serum cotinine levels for distinguishing cigarette smokers and nonsmokers within different racial/ethnic groups in the United States between 1999 and 2004. American journal of epidemiology 2009;169(2):236-48.

40. Chan ED, Keane J, Iseman MD. Should cigarette smoke exposure be a criterion to treat latent tuberculous infection? American journal of respiratory and critical care medicine 2010;182(8):990-2.

41. Mazurek GH, Jereb J, Vernon A, LoBue P, Goldberg S, Castro K. Updated guidelines for using Interferon Gamma Release Assays to detect Mycobacterium tuberculosis infection - United States, 2010. MMWR. Recommendations and reports : Morbidity and mortality weekly report. Recommendations and reports / Centers for Disease Control 2010;59(RR-5):1-25.

42. Updated recommendations on interferon gamma release assays for latent tuberculosis infection-2010 update. An Advisory Committee Statement (ACS). Canada communicable disease report = Releve des maladies transmissibles au Canada 2010;36(ACS-5):1-21.

CHAPTER 5: Discussion

Summary of results

The residential environment is an important aspect of structural and social risk environments. This chapter will highlight characteristics of the residential environment that were shown in this dissertation to influence transmission of HIV and TB.

The first manuscript (Chapter 2) found that more than 75% of FSW-IDU in Tijuana and Ciudad Juarez, Mexico were living in traditionally unstable/inadequate housing at baseline; nearly half of FSW-IDU (40%) were living in rented rooms. A trend was observed with a greater increase in housing instability associated with higher proportions of receptive needle sharing at baseline, which has been noted elsewhere among populations that inject drugs[1,2]. Changes in housing types over 4 months were frequent and often occurred across housing stability categories; at each follow up visit fewer than half of FSW-IDU were in the same housing category as their previous visit. This is concerning given that residential transience has been independently associated with increased drug use and sharing needles [3,4]. The inconsistency of housing indicates the importance of longitudinal instead of cross-sectional studies in characterizing housing stability among subpopulations that frequently change their primary place of residence. As we considered housing stability categories among FSW-IDU in Tijuana and

Ciudad Juarez, we used longitudinal housing consistency to inform how to categorize housing types. We found that 1) living in a parent's or spouse/sexual partner's house reflected stable housing comparable to living in own home/apartment; and 2) living in rented rooms denoted a unique housing group with high stability but at higher sexual risk for HIV comparable to those in inadequate housing. Of the three housing stability categories that we tested, these results lent support for a culturally-adapted housing stability category (adaptation #1). The paper concluded that cultural context is important when considering housing stability categories. The inconsistency in housing and high proportion of FSW-IDU moving into more unstable housing over time highlights the importance of promoting programs that ensure housing stability among groups at high risk for HIV.

The second manuscript (chapter 3) used the same dataset as the first, and explored the association between housing stability measures and unprotected condom use among the same sample of FSW-IDU along the northern Mexico border. Contrary to our hypotheses, we did not find an association of social living or housing measures with unprotected sex acts among FSW after controlling for individual level variables. Housing, whether measured by current housing categories or longitudinal movement between housing categories, did not consistently affect levels of unprotected sex among FSW-IDU across study site nor client type. This was unexpected given the consistency of the direction and magnitude of association of many of the

bivariate associations between housing measures and unprotected sex. In the presence of individual-level risk factors, previous studies on unstable housing and unprotected sex have been mixed, with some reporting an association[5,6] while others have not[7-9]. This study indicated that several individual risk factors are still independently associated with unprotected sex, including condom use self-efficacy, outcome expectancy, hormonal contraceptive use, and income.

The association between passive smoking and LTBI among adults, which was the focus of the third manuscript (chapter 4), was marginally significant among the general US adult population and not significantly associated with TB among children. However, foreign-born status modified the effect of smoking and LTBI in our study. The effect of active smoking on LTBI was greater among those born outside of the US. After stratification, passive smoking among adults was still marginally associated with LTBI among US-born respondents and was significantly associated with LTBI among the foreign-born population. This underscores the need for changes in US policies to increase LTBI testing and treatment among those exposed to passive smoke.

We did not observe passive smoking to be associated with an increase in risk for LTBI among children, in contrast to others who have found an association between passive smoking and LTBI[10-13] or active TB[14,15] among children. This could be attributed to the small number of LTBI cases among

children in the NHANES 1999-2000 study or differences in passive smoking measurement. Manuscript three also described a strong positive association between both active and current smoking, when determined either by self-report or combined with serum cotinine results, and LTBI among adults after controlling for known confounders of TB.

Since smoking has been associated with LTBI treatment failure[16] and given our approximation of nearly 6.8 million adults who were either active or passive smokers and were LTBI+ in the US in 1999-2000, current efforts to treat LTBI in the US may be hindered without special attention to tobacco control and smoking cessation. With recent changes in treatment guidelines for LTBI[6], more research is needed to determine if there is an association between LTBI treatment failure under new guidelines and active and passive smoking.

Limitations

This dissertation has important limitations, including the potential for misclassification of our variables of interest and biases, which could have impacted our results and could be improved upon with future research.

Misclassification

In chapters 2 and 3, we relied on one self-reported housing question that captured the primary place of residence over the previous 4 months to categorize housing stability and calculate consistency and movement. Furthermore, follow-up visits in the same housing type do not necessarily

denote living in the exact locale as the previous visit, which we were unable to disentangle. Therefore we likely underestimated the true number of changes in housing in our consistency measure, particularly among the most common housing types such as rented rooms – nevertheless, there was a high degree of movement, even with this conservative measure.

In chapter 4, we used a cutoff point of 10-15ng/mL to distinguish active smokers from non-smokers, a cutoff which is widely reported in the literature; however, some have recommended even lower cutoff points ranging from 1-6 ng/mL depending on age and race[17]. Our cutoff point of 10 ng/mL may have misclassified active smokers as passive smokers. However, those with at least two interview responses affirming smoking status were considered smokers regardless of cotinine levels and were likely light smokers if cotinine levels were < 10ng/mL at the time of the interview. Since we triangulated cotinine-levels with interview questions, any misclassification of smoking status using the cutoff point of 10ng/mL would have been among those with discrepant or missing interview responses. Discrepant or missing interview responses were few among adults and more common among children and adolescents, especially since children 3-12 years of age did not receive interview questions regarding smoking behavior.

A challenge of investigating the association between smoking and LTBI in the US is the low prevalence of LTBI. This may have overestimated the

association found among children, and as a result the standard error of our LTBI prevalence and regression estimates were wide.

With the TST TB diagnostic test, we were only able to investigate the association between smoking and TB infection and not active TB. Further discussion of the limitations of the TST test such as the inability to distinguish between latent and active TB and confounders of LTBI in the NHANES study such as individuals with BCG vaccination can be found elsewhere[18]. While TST may have overestimated the LTBI prevalence, we used a more strict definition of TB by using a larger cutoff of ≥ 15mm skin induration (instead of 10mm) for those BCG-vaccinated since BCG-vaccination can result in false-positive test results.

Biases

In chapters 2 and 3, given that having recent unprotected sex and injection drug use were part of the inclusion criteria, the ability to generalize to broader groups of FSW is reduced. Self-reported sexual behavior may have resulted in recall bias; participants were asked questions regarding many behaviors, including the number of vaginal sex acts by client type and the number of vaginal sex acts that were protected. As with all longitudinal studies, loss to follow-up could have been a source of bias affecting our outcomes. However our retention rates were high (85.9%) considering a hard-to-reach and often transient population. Those who were lost to follow-up were

not significantly different in their housing measurements or rates of unprotected sex at baseline compared to those who remained in the study.

Since many of our independent variables of interest as well as outcome variables are behavioral, social-desirability or recall bias likely affected our results, especially since respondents are asked to state the number of clients, number of sex acts and number of protected sex acts in MMS. However, the participants of the MMS sample trade sex regularly making estimates of frequency less difficult to recall. Also it is unknown whether recall bias would overestimate or underestimate estimates of clients. Social desirability bias may inflate the reporting of risk reduction behaviors such as condom use. However, a research team with experience among FSW and IDU population in Tijuana and Ciudad Juarez used trained peer interviewers to minimize these biases.

FSW-IDU in Tijuana and Ciudad Juarez constitute a specific high-risk subpopulation, which may limit the generalizability of the findings to broader FSW populations; however, having a sample of FSW-IDU from two unique cities on the northern border of Mexico will strengthen generalizability.

Strengths

There are also considerable strengths to the datasets that we used in exploring the effect of the residential environment on HIV and TB. The MMS

dataset used for manuscripts 1 and 2 had a large sample size for a hard-to-reach population of women who both traded sex and injected drugs. The longitudinal data included 3 follow-up visits with good retention that allowed us to assess the frequency of changing housing categories over a period of 18 months. To our knowledge, this type of housing detail has not yet been published among FSW-IDUs, an important subpopulation in Mexico's efforts to overcome a concentrated epidemic of HIV. With the longitudinal data, we were able to have multiple measures of housing stability including movement between categories as well as housing stability categories. Also, recruitment from two study sites allowed for comparisons between cities, and increases generalizability of our findings to FSW-IDU in these cities.

In manuscript 3, the NHANES dataset had clinical measures of both outcome and exposure variables. Analysis of smoking and TB using a combination of serum cotinine measures along with TST test of tuberculosis infection have rarely been published, making this one of the first studies to employ the use of serum cotinine to assess passive smoking exposure. Various studies have found an increased risk for active TB among self-reported passive smokers[19-23], although none showed a particularly strong association. This is the first study to report a confirmed association between active and passive smoking and LTBI among adults. Also, NHANES is a nationally representative sample of the civilian, non-institutionalized population in the United States. Most studies reporting an association between smoking

and TB have been conducted in clinical settings or among contacts of TB patients.

Implications

For FSW-IDU in Tijuana and Ciudad Juarez, the mechanisms by which inconsistent and unstable housing effect HIV risk behaviors need more study. Regardless of whether there is a direct impact between housing instability and unprotected sex, which we were unable to detect, housing conditions among FSW-IDU in Tijuana and Ciudad Juarez warrant efforts to assist in the procurement of stable housing. Findings from manuscript 2 suggest that condom use self-efficacy, outcome expectancy and contraceptive use are associated with condom use with both regular and non-regular clients.

The independent associations between both active and passive smoking and LTBI were strong among foreign-born adults representing a subpopulation in need of comprehensive active and passive smoking prevention and cessation efforts. Cigarette smoke exposure has been recommended as a criterion for treatment of LTBI [24] and has been incorporated into guidelines in the United States[25] and Canada[26], yet only Canada recommends smoking as a criterion for TB testing among immigrants. The United States should also recommend TB testing for immigrants that actively smoke or are exposed to passive smoke.

It is possible that passive smoking only impacts LTBI to a significant degree where there is a prevalence threshold of *Mycobacterium tuberculosis*

circulating in the community. However, the majority of active TB cases in the US arise from activated LTBI and not through transmission in the community post-arrival in the US[27,28]. Therefore, smoking cessation programs among foreign-born populations and their contacts in the United States are essential to reduce activation of LTBI, but may not have a large effect on incident LTBI. Instead, exposure to smoke through active and passive smoking, if indeed causal, and exposure to *Mycobacterium tuberculosis*, likely occurred in their birth nation. Since smoking habits continue for many ethnic groups in the United States after immigration[29], global tobacco control efforts could have an impact on LTBI rates in the United States and worldwide.

Directions for future research

Using regression models, we only assessed one outcome, unprotected sex, among FSW-IDU. Further modeling to describe the associations between these housing measures and other HIV risk outcomes, including receptive needle sharing and risk reduction behaviors (i.e. sex work or injection reduction or cessation) would be informative. Asking specifically about the number of moves since the last visit, and reasons for moving (including reasons for not moving) would have been informative in understanding housing consistency. Since having control over one's living space is an important component of housing stability, future studies should describe the leasing process for FSW who rent housing; more information is needed specifically on the frequency with which leasing contracts are used when

renting diverse housing types in Northern Mexico. If formal leases are used by FSW, the terms of a leasing contract, how often terms are negotiated, and with whom contracts are negotiated (pimps, bar owners, etc.) would be helpful in determining if there is a gendered power structure and other elements that may impact stability. For much of the above mentioned research, qualitative studies would be necessary to provide context and improve understanding of housing instability among FSW-IDU in Mexico.

For comparison with the results of manuscript three, more studies are needed investigating cotinine-confirmed passive smoking and LTBI among adults and children in settings with higher TB incidence. Longitudinal studies of passive smoke exposure using reliable measurements of exposure over time would assist in understanding the relationship between passive smoking and LTBI, since passive smoking is typically measured using self-reported current exposure. Longitudinal studies that employ smoking histories or medical records that recorded smoking behavior would provide insight into the relationship between longer term passive smoking and LTBI. Ideally, a longitudinal history using a biomarker test capturing nicotine exposure could provide a more accurate assessment of lifetime smoke exposure and LTBI. Future comparisons and estimations of LTBI prevalence, active TB, and the association of smoking on both latent and active TB will be possible with the ongoing 2011-2012 NHANES, which will utilize both the TST test and the more specific QuantiFERON®-TB diagnostic blood test.

Conclusions

The influence of the residential environment is an important part of the structural and social environment. Measuring the impact of the residential environment is complex and improvements are needed in measuring the influence of the residential environment on transmission of HIV and TB.

While FSW-IDU experience inconsistent and unstable housing, the influence of housing stability on unprotected sex is less clear. Interventions that reduce risk behaviors at the individual level among FSW that do not inject drugs have proven less effective for FSW-IDU. As housing stability is a top priority reported by female sex workers themselves, further understanding of the HIV/STI risks that are influenced by the residential environment will assist in further advocacy for improved housing among FSW-IDU.

Passive smoking appears to play role in the transmission of TB among the foreign-born population in the US, independent of individual risk factors. The United States should recommend TB testing and treatment for immigrants that actively smoke or are exposed to passive smoke. Global tobacco control efforts, including efforts to reduce passive smoke exposure in the home, would likely reduce morbidity and mortality associated with TB.

References

1. Topp L, Iversen J, Baldry E, Maher L. Housing Instability among People Who Inject Drugs: Results from the Australian Needle and Syringe Program Survey. Journal of urban health : bulletin of the New York Academy of Medicine 2012.

2. Andia JF, Deren S, Kang SY, Robles RR, Colon HM, Oliver-Velez D, et al. Residential status and HIV risk behaviors among Puerto Rican drug injectors in New York and Puerto Rico. The American journal of drug and alcohol abuse 2001;27(4):719-35.

3. German D, Davey MA, Latkin CA. Residential transience and HIV risk behaviors among injection drug users. AIDS and behavior 2007;11(6 Suppl):21-30.

4. Rosenthal D, Rotheram-Borus MJ, Batterham P, Mallett S, Rice E, Milburn NG. Housing stability over two years and HIV risk among newly homeless youth. AIDS and behavior 2007;11(6):831-41.

5. Surratt HL, Inciardi JA. HIV risk, seropositivity and predictors of infection among homeless and non-homeless women sex workers in Miami, Florida, USA. AIDS care 2004;16(5):594-604.

6. 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. Social science & medicine 2011;72(5):710-6.

7. Elifson KW, Sterk CE, Theall KP. Safe living: the impact of unstable housing conditions on HIV risk reduction among female drug users. AIDS and behavior 2007;11(6 Suppl):45-55.

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. Aidala A, Cross JE, Stall R, Harre D, Sumartojo E. Housing status and HIV risk behaviors: implications for prevention and policy. AIDS and behavior 2005;9(3):251-65.

10. den Boon S, Verver S, Marais BJ, Enarson DA, Lombard CJ, Bateman ED, et al. Association between passive smoking and infection with Mycobacterium tuberculosis in children. Pediatrics 2007;119(4):734-9.

11. du Preez K, Mandalakas AM, Kirchner HL, Grewal HM, Schaaf HS, van Wyk SS, et al. Environmental tobacco smoke exposure increases Mycobacterium tuberculosis infection risk in children. The international journal of tuberculosis and lung disease : the official journal of the International Union against Tuberculosis and Lung Disease 2011;15(11):1490-6, i.

12. Kuemmerer JM, Comstock GW. Sociologic concomitants of tuberculin sensitivity. The American review of respiratory disease 1967;96(5):885-92.

13. Singh M, Mynak ML, Kumar L, Mathew JL, Jindal SK. Prevalence and risk factors for transmission of infection among children in household contact with adults having pulmonary tuberculosis. Archives of disease in childhood 2005;90(6):624-8.

14. Tipayamongkholgul M, Podhipak A, Chearskul S, Sunakorn P. Factors associated with the development of tuberculosis in BCG immunized children. The Southeast Asian journal of tropical medicine and public health 2005;36(1):145-50.

15. Altet MN, Alcaide J, Plans P, Taberner JL, Salto E, Folguera LI, et al. Passive smoking and risk of pulmonary tuberculosis in children immediately following infection. A case-control study. Tuber Lung Dis 1996;77(6):537-44.

16. Lavigne M, Rocher I, Steensma C, Brassard P. The impact of smoking on adherence to treatment for latent tuberculosis infection. BMC Public Health 2006;6:66.

17. Benowitz NL, Bernert JT, Caraballo RS, Holiday DB, Wang J. Optimal serum cotinine levels for distinguishing cigarette smokers and nonsmokers within different racial/ethnic groups in the United States between 1999 and 2004. American journal of epidemiology 2009;169(2):236-48.

18. Bennett DE, Courval JM, Onorato I, Agerton T, Gibson JD, Lambert L, et al. Prevalence of tuberculosis infection in the United States population: the national health and nutrition examination survey, 1999-2000. Am J Respir Crit Care Med 2008;177(3):348-55.

19. Alcaide J, Altet MN, Plans P, Parron I, Folguera L, Salto E, et al. Cigarette smoking as a risk factor for tuberculosis in young adults: a case-control study. Tuber Lung Dis 1996;77(2):112-6.

20. Ariyothai N, Podhipak A, Akarasewi P, Tornee S, Smithtikarn S, Thongprathum P. Cigarette smoking and its relation to pulmonary tuberculosis in adults. The Southeast Asian journal of tropical medicine and public health 2004;35(1):219-27.

21. Dong B, Ge N, Zhou Y. [Smoking and alcohol consumption as risk factors of pulmonary tuberculosis in Chengdu: a matched case-control study]. Hua Xi Yi Ke Da Xue Xue Bao 2001;32(1):104-6.

22. Leung CC, Lam TH, Ho KS, Yew WW, Tam CM, Chan WM, et al. Passive smoking and tuberculosis. Arch Intern Med 2010;170(3):287-92.

23. Tekkel M, Rahu M, Loit HM, Baburin A. Risk factors for pulmonary tuberculosis in Estonia. The international journal of tuberculosis and lung disease : the official journal of the International Union against Tuberculosis and Lung Disease 2002;6(10):887-94.

24. Chan ED, Keane J, Iseman MD. Should cigarette smoke exposure be a criterion to treat latent tuberculous infection? American journal of respiratory and critical care medicine 2010;182(8):990-2.

25. Mazurek GH, Jereb J, Vernon A, LoBue P, Goldberg S, Castro K. Updated guidelines for using Interferon Gamma Release Assays to detect Mycobacterium tuberculosis infection - United States, 2010. MMWR. Recommendations and reports : Morbidity and mortality weekly report. Recommendations and reports / Centers for Disease Control 2010;59(RR-5):1-25.

26. Updated recommendations on interferon gamma release assays for latent tuberculosis infection-2010 update. An Advisory Committee Statement (ACS). Canada communicable disease report = Releve des maladies transmissibles au Canada 2010;36(ACS-5):1-21.

27. Chin DP, DeRiemer K, Small PM, de Leon AP, Steinhart R, Schecter GF, et al. Differences in contributing factors to tuberculosis incidence in U.S.-born and foreign-born persons. American journal of respiratory and critical care medicine 1998;158(6):1797-803.

28. Geng E, Kreiswirth B, Driver C, Li J, Burzynski J, DellaLatta P, et al. Changes in the transmission of tuberculosis in New York City from 1990 to 1999. The New England journal of medicine 2002;346(19):1453-8.

29. Constantine ML, Rockwood TH, Schillo BA, Alesci N, Foldes SS, Phan T, et al. Exploring the relationship between acculturation and smoking behavior within four Southeast Asian communities of Minnesota. Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco 2010;12(7):715-23.