Modeling Risk for Sexually Transmitted Infections in Women in a Court-Ordered Substance Treatment Program

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MODELING RISK FOR SEXUALLY TRANSMITTED INFECTIONS IN WOMEN IN A COURT-ORDERED SUBSTANCE TREATMENT PROGRAM

by

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ABSTRACT

Developing a comprehensive model of Sexually Transmitted Infection (STI) risk factors and their inter-relationships is vital to improving methods of risk identification and treatment delivery. The CDC posed three general categories that may serve as a framework for such a model: sexual network, individual behavior, and social/ structural risk. None of the extant risk models incorporate measures from all three categories. Additionally, none of these models, generally focused on individual behavior, use medical data on infection as their outcome variable. This is problematic because the ultimate outcome of infection is also influenced by sexual network and social/ structural variables, in addition to individual behaviors. Therefore the current study aimed to develop a comprehensive model of risk incorporating sexual network, individual behavior, and social/ structural risk variables, using medical data on infection status as the outcome variable. The sample consisted of 506 women in a court-ordered substance treatment program. An Exploratory Factor Analysis provided preliminary evidence for a three factor model corresponding to the CDC framework. However, a Confirmatory Factor Analysis failed to confirm this model. Additionally, a logistic regression suggested that this model has limited clinical utility for this sample. Future studies may more conclusively determine the importance of various STI risk variables, the relationships between them, and whether they mirror the CDC theoretical framework. With rates of infection still high in the United States, and even increasing among women for certain STIs, this is a critical public health issue that should continue to be examined.

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MODELING RISK FOR SEXUALLY TRANSMITTED INFECTIONS IN WOMEN IN A COURT-ORDERED SUBSTANCE TREATMENT PROGRAM

Each year, approximately 20 million individuals in the United States are newly infected with a sexually transmitted infection (STI) such as Human Immunodeficiency Virus (HIV), gonorrhea, or syphilis (Satterwhite et al., 2013). An estimated 49.5% of new STIs occur in females (Satterwhite et al., 2013). In fact, rates of infection in females appear to be increasing for several STIs (Hader, Smith, Moore, & Holmberg, 2001; "Sexually Transmitted Disease Surveillance 2011," 2012). Given that women are at particular risk for serious and long-lasting complications from STIs, including Pelvic Inflammatory Disease, ectopic pregnancy, infertility, and cervical cancer, it is important that individuals who are infected or at risk for infection receive timely interventions.

A vital aspect of STI treatment programs and preventive interventions is the identification of individuals who may have STIs or who are at risk of acquiring one. A survey of the literature shows a predominant focus on defining individual behaviors and traits that increase risk of acquiring an STI. Behavioral interventions have targeted various populations, deemed at high risk, including adolescents (Robin et al., 2004), African Americans (Darbes, Crepaz, Lyles, Kennedy, & Rutherford, 2008), drug users (Semaan et al., 2002), men who have sex with men (Herbst et al., 2005), and sex workers (Shahmanesh, Patel, Mabey, & Cowan, 2008). Many studies examine risk based on behaviors such as condom use or number of sexual partners (Capaldi, Stoolmiller, Clark, & Owen, 2002; De Vincenzi 1996). Other studies, specifically focused on measuring risk, have suggested that an individual's per act risk level may be quantified by taking into account the partner type, the route of exposure, and condom use (Boily et al., 2009; Varghese, Maher, Peterman, Branson, & Steketee, 2002). Individual traits such as sensation seeking have also been implicated as risk factors (Hendershot, Stoner, George, &

Norris, 2007). Though the use of individual traits and behavioral indicators is a convenient method of assessing risk, the lack of coherence in the literature is problematic given that interventions that may be effective for individuals with certain risk factors may not be effective for groups with other risk factors (Lin, Whitlock, O'Connor, & Bauer, 2008). A standardized system for assessing risk incorporating all of these factors is necessary to increase health care providers' abilities to provide interventions tailored to the individual's particular risk profile.

However, the various criteria typically used to target at-risk individuals may be inadequate for identifying a large proportion of people who are infected. In 1992, of the individuals screened at federally-funded testing sites who were found to be HIV-positive, 20 to 26% did not report any of the typically screened-for risk factors (Peterman, Todd, & Mupanduki, 1996). Similarly, when testing a sample of individuals who met typical high-risk criteria, Chen, Branson, Ballenger, and Peterman (1998) identified only 37% of the HIV-positive individuals in the sample. This mismatch between the reported risk criteria and the individuals actually infected suggests that many infected individuals do not fit with the typical profile of risk as it is currently conceptualized. A thorough understanding of risk factors for infection and their inter-relationships is critical to improving methods of risk identification and treatment delivery. However, the previous models of risk have several flaws.

Shortcomings of Extant Risk Models

For decades, the primary focus of models of STI risk was on individuals' risky behaviors and on predictors of those behaviors. The Health Belief Model (HBM), developed in the 1950s, was the first health behavior change model and was one of the first models used to examine HIV risk (Rosenstock, 1974). The HBM posits that individuals will change their behavior if they

perceive a disease as severe, if they perceive themselves as susceptible to that disease, and if they judge the benefits to outweigh the costs of change (Figure 1).

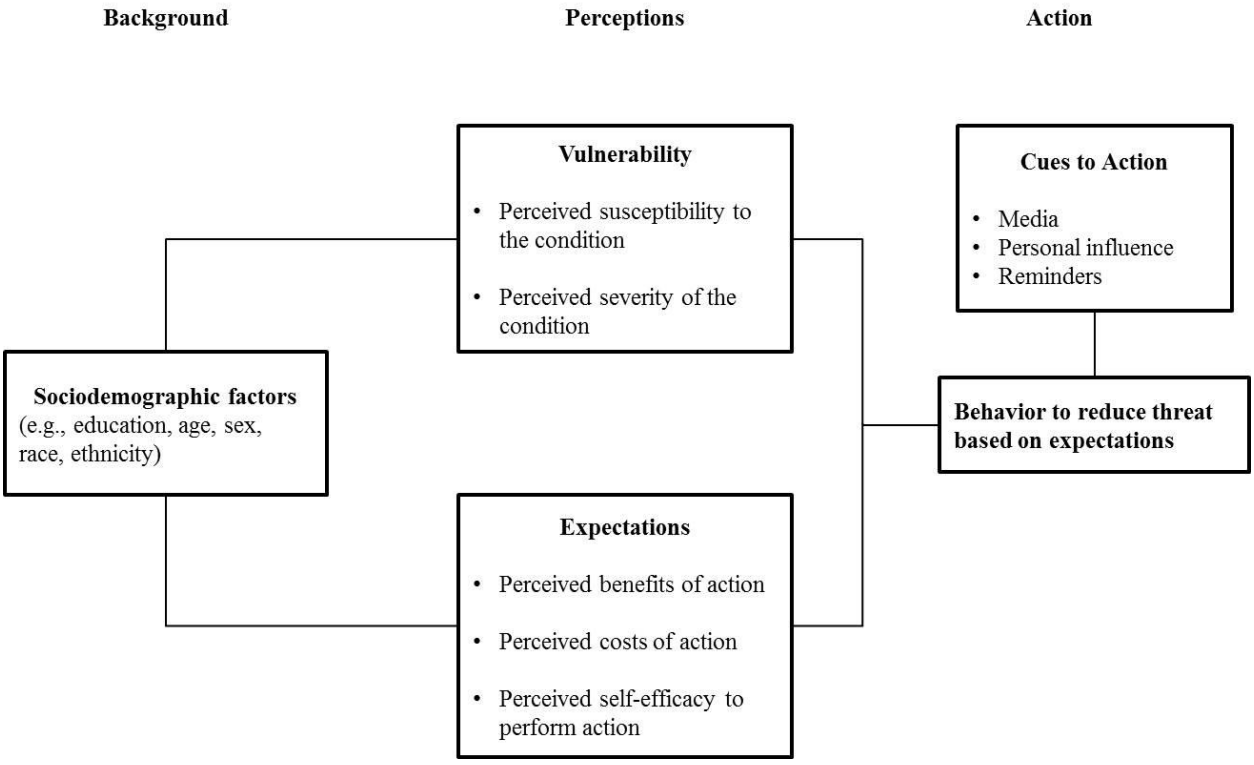

Figure 1. The Health Belief Model of Behavior Change. Adapted from "Social Learning Theory and the Health Belief Method," by I.M. Rosenstock, V.J. Stretcher and M.H. Becker, 1988, *Health Education Quarterly, 13*, 73-92.

Stage models, such as the AIDS Risk Reduction Model (ARRM; Catania, Kegeles, & Coates, 1990), have also been used to examine individual behavior risk. The ARRM theorizes that changes in behavior occur in three stages: the individual labels the behavior as risky, the individual commits to changing, and the individual acts on this commitment by seeking help or using self-help to engage in HIV preventive behavior (Figure 2). For a full discussion of individual behavior models of risk, see Fisher and Fisher (2000).

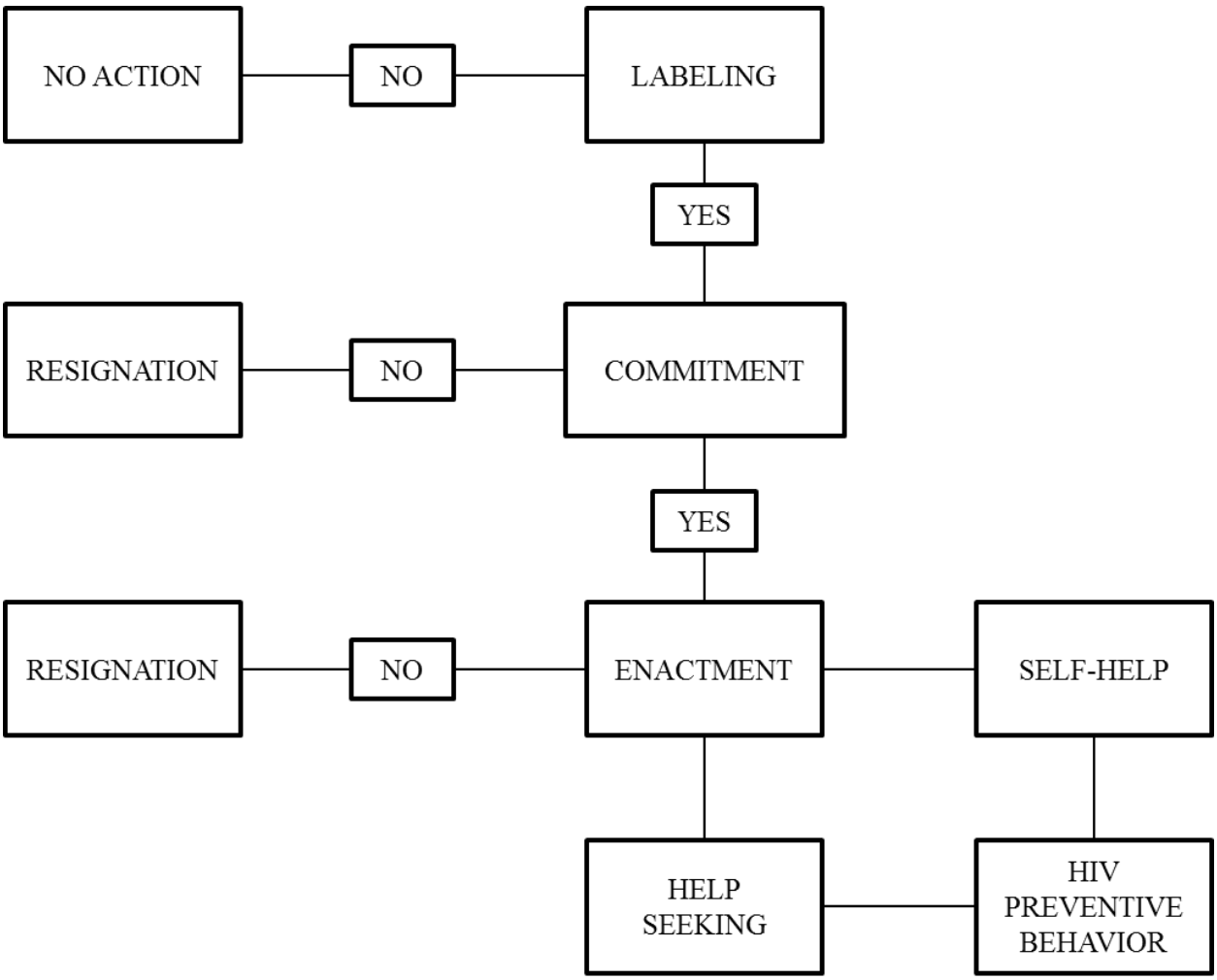

Figure 2. Stages of the AIDS Risk Reduction Model of HIV Preventive Behavior. Adapted from "Towards an understanding of risk behavior: an AIDS risk reduction model (ARRM)." by J. A. Catania, S. Kegeles and T. J. Coates, 1990, *Health Education Quarterly, 17*(1), 53-72.

While it is important to understand what may lead individuals to engage in risky behavior, this information is not sufficient for determining the risk of acquiring an STI (Fishbein & Jarvis, 2000). It should be noted that none of these models use medical data on infection as their outcome variable (see Table 1). This is problematic because the ultimate medical outcome of infection is also influenced by the characteristics of an individual's sexual partner(s) and social/structural factors such as poverty and public policy (Gupta, Parkhurst, Ogden, Aggleton, & Mahal, 2008). In addition, individuals' sexual networks play a large role in their risk. Sexual

networks are made up of individuals who are connected, either directly or indirectly, through sexual contact. Therefore, one individual, identical to and engaging in the same behaviors as another but within a different sexual network, may be at much greater risk of acquiring an STI (Koopman & Lynch, 1999).

Table 1
Individual Behavior Models of HIV and STI Risk

Theoretical Model	Elements of Model	Description/examples of element	Outcome Variable
Health Belief Model (HBM)	Sociodemographic factors	education, age, sex	Behavior to reduce threat based on expectations
	Vulnerability	perceived susceptibility to condition	
	Expectations	perceived benefits of action	
	Cues to Action	media, personal influence	
AIDS Risk Reduction Model (ARRM)	Labeling	Individual labels actions as risky	HIV Preventive Behavior
	Commitment	Individual commits to reducing risky behavior	
	Enactment	Self-help; help-seeking behavior	
Transtheoretical Model (TM)	Precontemplation	Individual does not intend to change behavior	Stage Change; Behavior Risk Reduction
	Contemplation	Individual intends to change behavior within 6 months; has considered pros/cons of change	
	Preparation	Individual seriously intends to take action to change within 1 month	
	Action	Individual has made some changes that have significantly reduced risk in the past 6 months	
	Maintenance	Begins after 6 months of consistent, effective behavior change; relapse prevention stage	

Theoretical Model	Elements of Model	Description/examples of element	Outcome Variable
Social Cognitive Theory (SCT)	Information	Increase knowledge of risk behaviors; persuade individuals of ability to change	Safer Behaviors
	Development of Social and Self-Regulatory Skills	Develop necessary skills to convert knowledge to safer behavior	
	Enhancement of Social and Self-Regulatory Skills	Increase skill level and associated feelings of self-efficacy	
	Peer Group Support	Involve social support network to encourage and maintain behavioral change	
	Perceived Vulnerability	Knowledge of risk associated with current behavior	
	Self-Efficacy	The feeling of being in control of one's behavior, motivation, and environment	
Theory of Reasoned Action (TRA)	Attitudes	Attitude toward engaging in preventive behavior; result of belief about consequences of behavior and evaluation of consequences	HIV Preventive Behavior
	Social Norms	Perception of whether others want the individual to engage in a behavior	
	Intentions	Behavioral intention to engage in risk prevention	
Theory of Planned Behavior (TPB)	Attitudes	(same as TRA)	HIV Preventive Behavior
	Social Norms	(same as TRA)	
	Perceived Behavioral Control	Individual's perception of the degree of difficulty of engaging in preventive behavior	
	Intentions	(same as TRA)	
Information-Motivation-Behavioral Skills Model (IMB)	HIV Prevention Information	Specific information about transmission and intervention that easily translates to individual behaviors	HIV Preventive Behavior
	HIV Prevention Motivation	Includes personal and social motivation as well as perception of individual risk of infection	
	HIV Prevention Behavioral Skills	Individual's objective and perceived ability to engage in preventive behaviors	

Note: The outcome variable and other elements of each of the individual behavior risk models that have been applied to HIV and other STIs are summarized and described. For a full discussion of these models and the empirical support for each, see Fisher and Fisher (2000).

In light of newer research on the importance of sexual networks, the focus of STI risk models has shifted toward the role that these networks play in infection. Sexual networks have been mathematically modeled in various ways in order to examine STI transmission and risk (see Koopman & Lynch, 1999). Some sexual network studies have focused on an individual and the characteristics of her partners (egocentric studies) while others have examined complete networks and the linkages between individuals (sociometric studies). For a more detailed review of sexual network study design, see Doherty, Padian, Marlow, and Aral (2005). Sexual network variables such as centrality within the network have been shown to predict individual infection risk (Friedman et al., 1997; Kottiri, Friedman, Neaigus, Curtis & DesMarlais, 2002). Additional sexual network measures such as dissortive mixing (partnerships among individuals with differential risk) and concurrent partnerships have been linked to higher risk of infection for HIV and other STIs (Catania, 1996; Gregson et al., 2002).

Both the individual behavior models and the sexual network models provide valuable insight into STI risk. Without integration, however, our understanding of the relationships among these factors is incomplete. None of the extant models incorporate measures of individual behavior, sexual network, and social/structural factors into one comprehensive model of risk. A better understanding of how various risk behaviors combine with partner characteristics and social/structural factors to contribute to the transmission and spread of STIs may suggest improved criteria for identifying at-risk individuals and even new avenues of intervention. Therefore, the aim of the proposed study is to develop and test a comprehensive predictive model of risk which accounts for individual behavioral risk, partner characteristics, and social/structural factors, and *which uses medical data on infections as the outcome variable*.

Theoretical Framework for the Current Study

A recent pilot study of a behavioral surveillance system for heterosexual HIV risk conducted by the Centers for Disease Control (CDC) posed three general categories into which risk factors for HIV fall: individual behavior risks, sexual network risks, and social/structural risks (DiNenno, Oster, Sionean, Denning, & Lansky, 2012). Individual behavior risks encompass any activities in which the individual engages that increase the chances of acquiring HIV. According to the CDC framework, such behaviors include, but are not limited to, engaging in unprotected sex, engaging in exchange sex, and having multiple partners (De Vincenzi, 1996; Koblin et al., 2006; Morris & Kretzschmar, 1997; Vuylsteke, Das, Dallabetta, & Laga, 2009). Sexual network risks are characteristics of an individual's sexual partner(s) that increase risk of infection in the individual. For example, an individual whose partner is known to be HIV-positive, has been incarcerated, or uses injection drugs is at higher risk (Chen et al., 1998; Koblin et al., 2006; Weinbaum, Sabin, & Santibanez, 2005). Social/structural risks include elements of an individual's community or environment that raise the risk of infection. Socioeconomic factors and local prevalence rates influence risk of infection and constitute social/structural risks (Adimora & Schoenbach, 2002; Gupta et al., 2008).

These categories, though originally posed as a structure for discussing various HIV risk factors, provide a logical framework for modeling the relationships among diverse behaviors and characteristics that influence risk. It is anticipated that these three types of risk may emerge as factors predicting STI status. If this is the case, the relationships among these categories of risk will be tested, and the direct and indirect influences on the outcome of infection will be examined.

Because STIs increase the risk of contracting HIV (see Galvin & Cohen, 2004), behaviors that increase the risk of contracting an STI may indirectly increase the risk of contracting HIV. There is also a direct link between the risk of HIV and other STIs because many of the same behaviors that increase the chances of contracting an STI also increase the chances of contracting HIV. In spite of this, most of the literature on risk factors for HIV is separate from that of other STIs. Consequently, most preventive services address HIV and other STIs separately. To remedy this problem, the CDC recently issued a call for the integration of preventive services for HIV and other STIs (Centers for Disease Control and Prevention, 2012). In light of this initiative for integration, the proposed model will use infection, including HIV and other STIs, as its outcome variable. The model will also incorporate risk factors for both HIV and other STIs, including individual behavior risks, sexual network risks, and social/structural risks. Such a model is necessary to improve our understanding of the interrelationships among these factors and may suggest the best avenues for integration of services.

Analytic Approach

Previous models of risk have primarily been theoretical in nature. While theory is important in guiding the formation of models, exploratory analyses can reveal relationships between variables that are unexpected and that may provide alternative perspectives on an issue. For this reason, three studies were conducted. In Study 1, the theoretical framework discussed above was used to guide an Exploratory Factor Analysis (EFA). The reliability of the model that emerged from this process was tested in Study 2 using a Confirmatory Factor Analysis (CFA). Finally, the clinical utility of this model was tested in Study 3 using logistic regression.

STUDY 1

The aim of Study 1 was to develop an initial model of STI risk using Exploratory Factor Analysis (EFA). A secondary aim was to compare this model to the CDC framework of risk to determine whether the indicators of risk fall into factors that are comparable to the CDC risk categories of individual behavior, sexual network, and social/structural risk.

Study 1 Methods

Participants and Procedure. Data used in this study were collected as part of a protocol, funded by the National Institute on Drug Abuse and approved by the university Institutional Review Board, to test HIV preventive interventions. Participants were court-ordered to receive substance abuse treatment and were recruited from a treatment facility at a Southeastern state hospital. Inclusion criteria were admission to the treatment facility, being at least 18 years of age, completion of detoxification, designation by facility staff as ready to participate in treatment program activities, and ability to provide informed consent. Exclusion criteria were exhibiting signs of psychosis or organic brain dysfunction prohibiting their participation in treatment group activities. Participants were assessed at intake, prior to intervention, and at 3- and 6-months post-intervention. Informed consent was obtained at intake and participants were compensated $10 for the initial assessment session.

The original sample consisted of 506 participants. Participants whose medical data were incomplete (e.g., participants not tested for all STIs) were excluded from analyses. Thus, participants included in analyses consisted of 434 women between the ages of 18 and 69 (M = 33.24, SD = 8.34). Of these participants, 36.6% identified as African-America, 60.4% as White, and 1.8% as Native America; 1.2% identified as members of any other racial group. The median and modal number of years of formal education was 12, with 33.6% of the participants

completing less than 12 years of education, and 28.3% completing more than 12 years of education. More than 36% of participants (*N* = 157) had been incarcerated for at least one month in their lifetimes. The mean duration of incarceration for these women was 10.35 months (*SD* = 14.68). Over 45% of participants (*N* = 196) had previously received treatment for drug abuse and over 37% had previously received treatment for alcohol abuse (*N*=163). Participant reports of recent and lifetime use of drugs and alcohol are summarized in Table 2.

Table 2
Recent and Lifetime Substance Use by Substance Type

Substance:	Recent Use		Lifetime Use	
	n	***M* (*SD*) days**	***n***	***M* (*SD*) years**
Alcohol (felt effects)	216	15.0 (11.1)	283	12.1 (7.6)
Cannabis	174	11.8 (11.6)	254	10.2 (7.0)
Cocaine	209	14.7 (11.3)	274	5.7 (4.8)
Opiates/Analgesics, Heroin, Methadone	69	6.0 (3.8)	99	2.8 (1.9)
Barbiturates, Sedatives/Hypnotics/Tranquilizers	70	7.3 (6.3)	105	3.8 (3.8)
Other Substances	59	5.3 (3.4)	120	1.9 (1.2)
>1 Substance (including alcohol)	233	12.9 (10.9)	307	8.1 (6.3)

Note: Recent use refers to use over the 30 day reporting period, as indicated on the Addiction Severity Index (ASI). Lifetime use refers to years of regular or problematic use, as defined on the ASI. N indicates the total number of individuals who reported at least one day of substance use in the reporting period or the total number of individuals who reported at least one year of regular or problematic use. M indicates the average number of days of substance use in the reporting period or the average number of years of regular or problematic substance use. SD indicates the standard deviation. Alcohol (felt effects) refers to alcohol consumption to the point of some impairment.

In order to perform an accurate validation of the factor structure obtained by the EFA in Study 1 through a CFA in Study 2, the sample was split in half (DeCoster, 1998). Half the sample (*n* = 217) was randomly selected to be included in the EFA in Study 1. A one-way ANOVA including descriptive variables, independent variables, and the dependent variable was

performed to examine potential differences between the two halves of the sample. No significant differences were found. Based on many guidelines for factor analysis, a sample size of 217 with a subject-to-variable ratio of 10 should be sufficient (Arrindell & van der Ende, 1985; Everitt, 1975; Guilford, 1954; MacCallum, Widaman, Zhang & Hong, 1999).

Risk Variables. The Addiction Severity Index and the Timeline Follow-Back are the measures that were used to derive the variables included in Study 1. These variables were chosen to represent individual behavior risk, sexual network risk, and social/structural risk. See appendix X for a table listing the variables and the measures from which they were derived.

Addiction Severity Index (ASI)-III. The ASI (McDermott, Alterman, Brown, Zaballero, Snider, & McKay, 1996) is a semistructured interview which assesses the severity of individuals' problems with employment, drugs and alcohol, family and social situations, and medical, psychiatric, and legal issues. A recent review of 37 studies examining the psychometric properties of the ASI suggests that the inter-rater and test-retest reliability of the severity ratings and composite scores on the ASI range widely across studies (Mäkelä, 2004). Despite flaws with the reliability of the severity ratings and composite scores, Mäkelä (2004) proposes that individual ASI items may still be used to measure change or as descriptors of clinical populations. Therefore, self-report responses to individual items from the ASI were examined in this study.

Participants' self-reported number of years of education completed, obtained from an item on the ASI, was used as a risk variable. Self-reported income from employment; unemployment compensation; public assistance or welfare; pension benefits or social security; and from mate, family, or friends, obtained in response to the ASI interview question "How much money did you receive from the following sources in the past 30 days?" were used as risk

variables. The number of months reported in response to the ASI interview question "How long was your longest full-time job?" was also used as a risk variable. During the ASI interview, participants reported on their employment pattern over the past 3 years by choosing the most representative option: full-time (40 hrs/wk), part-time (regular hours), part-time (irregular, day work), student, service, retired/ disability, unemployed, in controlled environment. A dichotomous employment pattern variable was created. Individuals who chose unemployed and in controlled environment received a '0' and all others received a '1.' Similarly, participants reported on their housing pattern by choosing the living arrangement most representative of the past 3 years: with sexual partner and children, with sexual partner alone, with children alone, with parents, with family, with friends, alone, controlled environment, no stable arrangements, or secondary treatment. A dichotomous housing pattern variable was created. Individuals who chose controlled environment, no stable arrangements, or secondary treatment received a '0' and all others received a '1.' A participant's responses to the ASI interview questions "How many months were you incarcerated in your life?" and "How many days in the past 30 have you engaged in illegal activities for profit?" were also used as risk variables.

Timeline Follow-Back (TLFB). The TLFB (Sobell & Sobell, 1992) is a calendar-based interview procedure that was used to gain information about individuals' sexual behavior and substance use over the 30-day period prior to entering the substance abuse treatment facility or other controlled environment. As part of the TLFB procedure, individuals were also asked to report on the characteristics of their three primary sexual partners from the 30-day reporting period. Details regarding activities with any partners other than these three were aggregated, and beyond the three primary partners, no details about partner characteristics were collected. The

TLFB procedure has been verified as both a reliable and valid measure of sexual behavior and substance use in previous research (Carey et al., 2001; Weinhardt, 1998).

As part of individuals' reports on the characteristics of their three primary sexual partners during the TLFB interview, participants indicated if they believed the partner was HIV-infected, and whether or not they perceived the partner to use crack cocaine or injection drugs. The number of partners reported to be HIV positive, the number of partners reported to use crack cocaine, and the number of partners reported to use injection drugs were used as risk variables. Because information on partner characteristics was only collected for participants' three primary partners, the range of each of these indicators is 0 to 3. The number of sexual partners and the number of times the participant engaged in exchange sex (i.e., sex was traded for alcohol, drugs, money, lodging, etc.), derived from participant reports during the TLFB interview, were also used as risk variables.

Additionally, the following numbers, derived from self-reports during the TLFB interview, were used as risk variables: number of times the individual engaged in unprotected vaginal sex, number of times the individual engaged in unprotected anal sex, number of times the individual engaged in unprotected oral sex, number of times the individual engaged in intravenous drug use, and number of times the individual engaged in crack cocaine use. For a summary of all study variables, see Appendix A.

Data Preparation. Data were screened for outliers using Mahalanobis distance, as described by Kline (2010). Any outliers not due to data entry error and greater than 3 standard deviations above the mean were replaced with the next most extreme value within 3 standard deviations of the mean (Kline, 2010). Data were screened for univariate normality by examining histograms, stem-and-leaf-plots, and box plots; skew and kurtosis indices were also calculated.

For skew indices greater than 3 or kurtosis indices greater than 10, appropriate transformations were made in an attempt to meet assumptions of normality (Kline, 2010). Because transformations resulted in data that remained significantly skewed, all analyses were performed on untransformed data.

Study 1 Results and Discussion

An EFA was performed in SPSS version 20 with half the sample (n = 217) on the 21 risk variables described above, chosen to represent individual behavior, sexual network, and social/structural risks. Eight factors with eigenvalues above 1 were extracted using principal components extraction with varimax rotation. This method was chosen to extract maximum variance, to simplify factors, and aid interpretability. Three of these factors emerged as theoretically meaningful and stable based on scree plots and successive analyses using alternative methods of extraction and rotation. A parallel analysis also confirmed a three factor solution (see Appendix B). With a cutoff of .45, 10 of the 21 variables did not load on any of these factors. Loadings of variables on the three factors, communalities, and percents of variance are shown in Table 3. Variables are ordered and grouped by size of loading to facilitate interpretation. Loadings under .45 (20% of variance) are replaced by zeros.

The factors that emerged which explain the sources of risk for STIs in women who abuse substances correspond fairly well with the three broad categories of risk posed by the CDC (Dinenno, Oster, Sionean, Denning, & Lansky, 2012). Factor 1 may be interpreted as a Sexual Network factor. This label is suggested by high loadings of the following variables: exchange sex, crack use, total number of partners, illegal activity, and partner crack use. Engaging in activity such as crack use and exchange sex exposes individuals to a more risky sexual network. This factor also accounts for the number of partners who use crack, a measure of

sexual network risk. Factor 2 may be interpreted as an Individual Behavior risk factor. This label is suggested by high loadings of the following variables: unprotected oral, vaginal, and anal sex. Unprotected sexual acts correspond to individual behavior risk. Factor 3 may be interpreted as a Social/Structural risk factor. This label is suggested by high loadings of the following variables: employment pattern, longest job, and education. These variables reflect social/ structural risk. Therefore, the EFA provides preliminary support of a three-factor model of risk (see Figure 3), corresponding to the categories of risk posed by the CDC.

Table 3

Factor Loadings, Communalities (h^2), and Percents of Variance for Principal Components Extraction and Varimax Rotation on all Risk Variables

Variable	F_1[a]	F_2	F_3	h^2
Exchange Partners	.83	.00	.00	.73
Crack Use	.74	.00	.00	.59
Total # Partners	.73	.00	.00	.60
Illegal Activity	.68	.00	.00	.54
Partner Crack Use	.56	.00	.00	.64
[+]Oral Sex	.00	.83	.00	.78
[+]Vaginal Sex	.00	.75	.00	.74
[+]Anal Sex	.00	.63	.00	.54
Employment pattern	.00	.00	.68	.59
Longest Job	.00	.00	.59	.42
Education	.00	.00	.51	.64
*Injection Drug Use	.00	.00	.00	.68
*Partner Injection Drug use	.00	.00	.00	.73
*Partner HIV status	.00	.00	.00	.66
*Lifetime Incarceration	.00	.00	.00	.65
*Income: unemployement	.00	.00	.00	.77
*Income: employment	.00	.00	.00	.57
*Income: public assistance	.00	.00	.00	.78
*Income: social security	.00	.00	.00	.67
*Income: mate	.00	.00	.00	.56
*Housing pattern	.00	.00	.00	.48
Percent of Variance	14.10	9.64	8.18	

[a]Factor labels: F_1 = Sexual Network; F_2 = Individual Behavior; F_3 = Social/Structural.

* denotes variables excluded from Study 2 and Study 3. [+]Oral, vaginal, and anal sex variables refer to number of unprotected sexual acts.

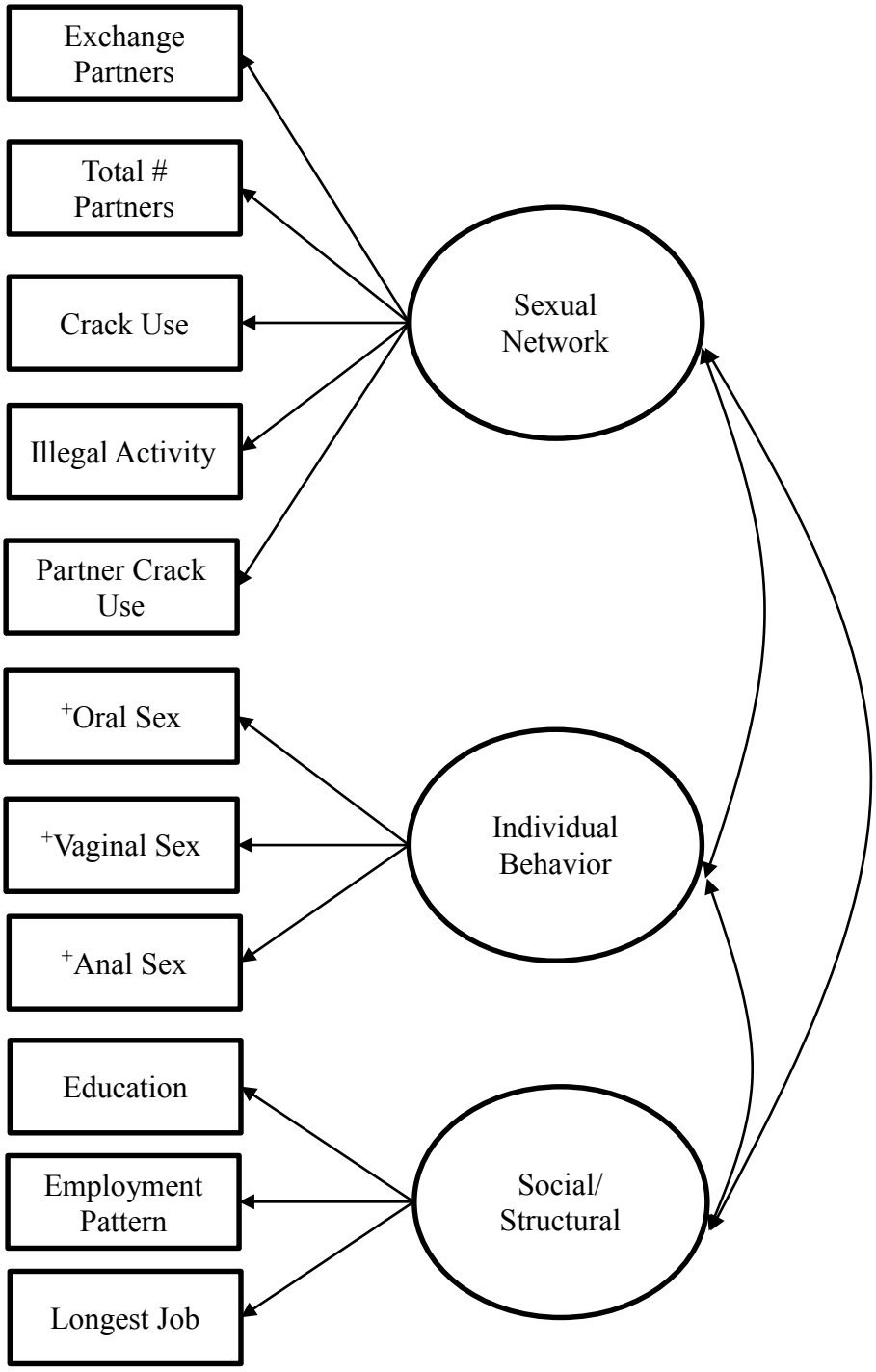

Figure 3. Measurement model of factor structure obtained in Study 1 EFA and submitted to CFA in Study 2. Relationships among the latent constructs Sexual Network, Individual Behavior, and Social/ Structural risk are free to vary. +Oral, vaginal, and anal sex variables refer to number of unprotected sexual acts.

STUDY 2

The aim of Study 2 was to use Confirmatory Factor Analysis (CFA) to refine the model developed in Study 1, identifying and correcting any model misspecifications.

Study 2 Method

The methods used in Study 2 were similar to those described in Study 1. The CFA in Study 2 was conducted with the participants excluded from Study 1 (n = 217). Additionally, indicators that did not load at the .45 level or higher on any of the three factors that emerged from the EFA in Study 1 were excluded from analyses in Study 2 (see Table 3).

Study 2 Results and Discussion

A CFA was performed in Mplus version 7.11 on the second half of the sample (n = 217) to test the reliability of the three factor measurement model (Figure 3) that emerged from the EFA in Study 1. Full information maximum-likelihood estimation was initially used to test the model. The model failed to converge using this method and was therefore tested using other methods of estimation. Secondary methods of estimation were selected based on appropriateness for the data; for example, generalized least squares estimation was used because it works well for data that violate assumptions of normality (Tabachnick & Fidell, 2007). The model still failed to converge using these alternative methods of estimation. This failure to converge may indicate poor reliability of the three factor model obtained in Study 1. Alternatively, it may be due to methodological limitations. Because the reason for nonconvergence was unclear, the model was submitted to a logistic regression to test its predictive validity.

STUDY 3

The aim of Study 3 was to test the clinical utility of the model obtained in Study 1. Logistic regression was used to test the model's ability to predict infection status.

Study 3 Method

The methods used in Study 3 were similar to those described in Study 1. Logistic regression in Study 3 was conducted with the same participants used in Study 2 (n = 217). Also similar to Study 2, indicators that did not load at the .45 level or higher on any of the three factors that emerged from the EFA in Study 1 were excluded from analyses in Study 3 (see Table 3). The remaining indicators were used as predictors for the outcome variable, infection status.

Outcome Variable. Individuals' medical records were examined to determine whether they were infected on admission to the substance treatment program with the following STIs: Chlamydia, Gonorrhea, Hepatitis B, HIV, and Syphilis. A dichotomous outcome variable for infection status was created indicating whether an individual had tested positive for one or more infections, or had not tested positive for any of these infection.

Study 3 Results and Discussion

Hierarchical logistic regression with blockwise entry was used to determine whether the three factor model obtained in Study 1 was able to effectively predict infection status. Sexual Network predictors were entered in the first block, Individual Behavior predictors in the second block, and Social/ Structural predictors in the third block, with dichotomous STI status as the outcome variable. Analysis was performed using SPSS Version 20. Three individuals with missing information were excluded from analyses for a sample of n = 214. A test of the full model with all 11 predictors against the constant-only model was statistically significant, χ^2 (11, n = 214) = 19.975, $p < .05$, indicating that the model reliably distinguished between infected and

uninfected women. However, the percentage of individuals correctly classified as having an STI increased only marginally from the constant-only model. See Table 4 for a comparison of percentage correct classifications.

Table 5 shows regression coefficients, Wald statistics, odds ratios, and 95% confidence intervals for odds ratios for each of the predictors. According to the Wald criterion, only crack cocaine use significantly predicted STI infection, $b = 0.04$, Wald $\chi^2(1) = 4.00$, $p < .05$. Each additional use of crack cocaine increased the odds of infection by 1.04. No other indicators significantly predicted STI status.

Table 4
Logistic Regression Classification Tables

Constant-only Model

Observed		Predicted		
		Infection status		Percentage
		0	1	Correct
Infection Status	0	156	0	100.0
	1	58	0	0.0
Overall Percentage				72.9

Full Model

Observed		Predicted		
		Infection status		Percentage
		0	1	Correct
Infection Status	0	149	7	95.5
	1	49	9	15.5
Overall Percentage				73.8

Note: Full Model includes Sexual Network, Individual Behavior, and Social/ Structural risk variables.

Table 5

Regression coefficients, Wald statistics, odds ratios, and 95% confidence intervals for odds ratios

		95% CI for Odds Ratio		
	***B* (SE)**	*Lower*	**Odds Ratio**	*Upper*
Block 1				
*(Constant)	-1.44 (0.22)		0.24	
Exchange Partners	0.16 (0.28)	0.68	1.18	2.04
Crack use	0.03 (0.02)	1.00	1.03	1.07
Illegal Activity	0.03 (0.05)	0.93	1.03	1.14
Total # Partners	0.03 (0.03)	0.98	1.03	1.08
Partner Crack Use	-0.04 (0.31)	0.53	0.96	1.75
Block 2				
(Constant)	-1.51 (1.10)		0.22	
Exchange Partners	0.15 (0.28)	0.67	1.16	2.03
*Crack use	0.04 (0.02)	1.00	1.04	1.08
Illegal Activity	0.04 (0.05)	0.94	1.04	1.15
Total # Partners	0.03 (0.03)	0.98	1.03	1.08
Partner Crack Use	0.00 (0.32)	0.53	1.00	1.88
[+]Oral Sex	-0.02 (0.02)	0.94	0.98	1.02
[+]Vaginal Sex	0.00 (0.02)	0.97	1.00	1.04
[+]Anal Sex	0.09 (1.07)	0.13	1.09	8.92

		95% CI for Odds Ratio		
	***B* (SE)**	*Lower*	**Odds Ratio**	*Upper*
Block 3				
(Constant)	-1.93 (1.35)		0.15	
Exchange Partners	0.09 (0.29)	0.62	1.09	1.93
*Crack use	0.04 (0.02)	1.00	1.04	1.08
Illegal Activity	0.04 (0.05)	0.94	1.04	1.16
Total # Partners	0.03 (0.03)	0.98	1.03	1.08
Partner Crack Use	0.01 (0.32)	0.54	1.01	1.89
[+]Oral Sex	-0.02 (0.02)	0.94	0.98	1.02
[+]Vaginal Sex	0.00 (0.02)	0.97	1.00	1.04
[+]Anal Sex	0.04 (1.08)	0.13	1.04	8.62
Employment Pattern	0.49 (0.35)	0.83	1.64	3.23
Longest Job	.01 (0.00)	1.00	1.01	1.02
Education	-0.01 (0.07)	0.87	1.00	1.14

Note: The Block 1 Model, including Sexual Network risk variables was significantly different from the constant-only model, χ^2 (5, n = 214) = 14.470, $p < .05$. The Block 2 Model, including Sexual Network and Individual Behavior risk variables was significantly different from the constant-only model, χ^2 (8, n = 214) = 15.930, $p < .05$. The Block 3 Model, including Sexual Network, Individual Behavior, and Social/ Structural risk variables was significantly different from the constant-only model, χ^2 (11, n = 214) = 19.975, $p < .05$. *Denotes variables that were significant, $p < .05$. [+]Oral, vaginal, and anal sex variables refer to number of unprotected sexual acts. CI = Confidence Interval. *B* = regression weights. SE = Standard Error.

GENERAL DISCUSSION

The aim of this study was to develop and test a comprehensive predictive model of risk which accounts for sexual network, individual behavior, and social/structural risk variables, using medical data on infections as the outcome measure. Medical data on infection status is often difficult to obtain for the population from which this sample was drawn. This group of women, for which medical data was available, provided a rare opportunity to model risk with infection status as the outcome variable.

The three factors that emerged from the EFA in Study 1 correspond well with the theoretical framework of risk posed by the CDC, providing preliminary support that the conceptualization of risk as stemming from Individual Behavior, Sexual Network, and Social/Structural risk factors is viable. Number of exchange partners, number of times an individual had unprotected oral sex, and employment pattern were the most robust variables of Sexual Network, Individual Behavior, and Social/Structural risk, respectively. Study 1 provides a good illustration of the correspondence between the obtained factor structure and the CDC framework. For example, number of exchange partners is a partner characteristic variable that offers some measure of sexual network risk. Exchange sex is directly linked to higher rates of STIs (Marx, Aral, Rolfs, Sterk & Kahn, 1990). It is also indirectly linked; individuals who engage in exchange sex with a larger number of partners have a larger sexual network, which is associated with higher rates of STIs (Johnson et al., 2003). While the obtained factor solution reflects the CDC framework, it is somewhat limited in that the Individual Behavior and Social/ Structural risk factors are only represented by three variables each. Additionally, some of these variables such as unprotected anal sex have a low frequency of occurrence within the sample, limiting their potential predictive power for many individuals.

The results of Study 2 were not supportive of the CDC model. A review of the literature shows that CFAs often fail to confirm the results of EFAs (Van Prooijen & Van Der Kloot, 2001). Van Prooijen and Van Der Kloot (2001) offer several methodological explanations for this. The first is that EFAs are often inadequately applied, which may lead to incorrect factor solutions. If inappropriate methods of extraction or rotation are used, the obtained solution may be invalid. Some authors note that principal components extraction can be problematic when used as the extraction method for factor analysis (Park, Dailey & Lemus, 2002; Schmitt, 2011). These authors also assert that oblique rotation is preferable over orthogonal rotation because few psychological variables are uncorrelated (Park, Dailey & Lemus, 2002; Schmitt, 2011). However, an EFA using principal axis factoring and promax rotation led to a similar three-factor solution, simply with fewer indicators reaching the .45 level on the Sexual Activity and SES factors; this solution also failed to converge when submitted to a CFA. Van Prooijen and Van Der Kloot (2001) also note that unsuitable criteria for determining the number of factors to retain can lead to invalid solutions. In Study 1, Kaiser's eigenvalue rule, scree plots, and parallel analysis were all used in the decision of number of factors to retain. Therefore, it is unlikely that the CFA failed to confirm the factor structure because of an improper EFA application.

Another possible explanation offered by Van Prooijen and Van Der Kloot (2001) is that EFA and CFA are not fully comparable, either because CFA is too conservative or EFA is too liberal. Van Prooijen and Van Der Kloot (2001) point out that EFA is data-driven, while CFA is theory driven. In EFA, the researcher is free to determine the number of factors to retain and variables are allowed to load on all factors, providing flexibility and choice. In CFA, on the other hand, the number of factors is determined by theory and variables are set to load on only

one factor, making this analysis method more restrictive. Therefore, this mismatch between the conservative nature of CFA and the liberal nature of EFA may lead to differences in the model because 1) small deviations from the model in CFA lead to rejection of the model or 2) due to the liberal methodology of EFA, the model that is retained may not reflect the "true" model (Van Prooijen & Van Der Kloot, 2001). In this study, then, the factor solution obtained through the EFA may be an inaccurate representation of the true structure of STI risk variables, or small deviations from this model in the CFA may have led to the failure to converge.

Alternatively the model may have failed to converge because of methodological issues with the study. Some variables in the study were ordinal or bivariate, which violates the normality assumption of estimation methods such as full information maximum likelihood and may have contributed to model non-convergence. However, the model failed to converge even when estimators that are robust to these conditions, such as mean- and variance-adjusted weighted least squares, were used. This can be interpreted in several ways. The data may violate the assumption of normality so severely as to make the use of parametric tests inappropriate. This may also be seen as evidence that the model is simply unreliable. Finally, other limitations in this study may have led to the failure to converge. For example, though the sample size (n = 205) used in the CFA was acceptable by some standards (Arrindell & van der Ende, 1985; Everitt, 1975; Guilford, 1954; MacCallum, Widaman, Zhang & Hong, 1999), it was not large enough by others (Cattell, 1978; Comrey & Lee, 1992). Additionally, the data were significantly non-normal, though this is to be expected for some variables in the study such as injection drug use and unprotected anal sex. The simplest explanation for non-convergence of the CFA in Study 2, however, is that the three-factor model derived from the EFA in Study 1 is

unreliable. It is difficult to determine with certainty which of these explanations is correct, making the results of Study 2 inconclusive.

The results of Study 3, however, are unequivocal, and call into question the clinical utility of this model in this setting and with this population. First, crack cocaine use was the only variable that significantly predicted STI infection when the model was submitted to logistic regression. Therefore, none of the other indicators of risk were useful in determining infection status in this sample, making the factor structure irrelevant. Second, and more importantly, using the model obtained from the EFA in Study 1 led to only a slight improvement in the rate of correct infection status classification over simply classifying all individuals as uninfected (73.8% vs 72.9%). Problematically, the number of false positives increased from 0 to 7, while only 15.5% of infected individuals were identified. This is worse than the 37% identification rate found in Chen et al. (1998). In sum, the three-factor model of risk was not useful in predicting STI status in this sample.

There is an important limitation to these studies that should be considered in the interpretation of the results. Because the variables were derived from a dataset collected as part of a project which was not originally designed to model risk, the range of indicators that could be examined was restricted. Therefore, the full spectrum of indicators in the areas of individual behavior, sexual network, and social/structural risk were not tested. The factor structure obtained in Study 1 may then be biased by the available indicators and may or may not be an accurate representation of the true structure of STI risk factors (Fitzgerald et al., 2003). Therefore, the results of this study should be interpreted with caution. The three categories of risk posed by the CDC may provide a stable, clinically useful, three-factor model if tested using

a broader range of indicators. A broader range of indicators may also provide an alternative, reliable solution that has some clinical utility.

While the available range of indicators was a limitation of the study, the use of this dataset for modeling STI risk was justified. As previously stated, it is often difficult to obtain medical data on infection status, even in high risk populations such as substance users. According to the National Survey of Substance Abuse Treatment Services (N-SSATS), conducted in 2007, infectious disease screening was available at less than half of reporting facilities (SAMHSA, 2010), despite the fact that The White House Office of National AIDS Policy (2010) recommends that HIV screening and prevention services be added to substance treatment programs. Only 29.7% of facilities screened for HIV, and even fewer screened for Hepatitis B and other STIs (22.2% and 21.3%, respectively). Additionally, according to Bachhuber and Cunningham (2013), the percentage of opioid treatment programs offering HIV and STI screening has decreased since 2007. While rates of screening were higher in facilities run by the Federal and State government (SAMHSA, 2010), the number of for-profit treatment centers, which are least likely to offer screening, is increasing (Bachhuber & Cunningham, 2013). Bachhuber has suggested that for-profit institutions may not offer screening in order to reduce costs, since many patients may have poor coverage or no insurance, and because it is not required by federal and state regulations (Radcliffe, 2013). Whatever the reason for the low screening rates, these figures are problematic and must be addressed, whether by mandating screening at a federal level or by providing compensation or other incentives to companies for offering screening. Given these low rates of screening, though, and the relatively low prevalence rates of these infections in the general population, it is unsurprising that none of the previous models of risk have been tested with medical data on infection status as the outcome variable.

However, testing risk models using medical data is necessary because behavioral measures such as unprotected sexual activity are not perfect proxies for infection status.

This gap in the literature must be addressed in order to provide an accurate picture of the various sources of risk for infection and the linkages between them. A precise understanding of the risk factors for HIV and STIs is critical to identifying and treating at-risk individuals. While the current study provides a preliminary step in addressing this issue, it is critical that a study be conducted that is specifically designed to develop and test a comprehensive model of infection risk. This study should encompass the full spectrum of individual behavior, sexual network, and social/structural variables and should use medical data on infection status as the outcome variable. Whether the CDC framework of risk is a useful model for predicting STI infection should also be investigated further. Overall, the results of the EFA provide preliminary support for the CDC theoretical framework of a three factor model of STI risk, while the results of the CFA are inconclusive, and the results of the logistic regression bring into question the clinical utility of the three factor model found through the EFA. Future studies may more conclusively determine the importance of various STI risk variables, the relationships between them, and whether they mirror the CDC theoretical framework. A comprehensive model of risk, tested with medical data on infection status, may suggest new avenues for STI screening and intervention. With rates of infection still high in the United States, and even increasing among women for certain STIs (Hader, Smith, Moore, & Holmberg, 2001; "Sexually Transmitted Disease Surveillance 2011," 2012), this is a critical public health issue that should continue to be examined.

APPENDIX A:
STUDY VARIABLES SUMMARY

Table A

Variables included in Study 1 with description and measure from which they were derived

Variable name	Measure	Variable description
[1]Exchange Partners	TLFB	Number of times participant engaged in exchange sex in the past 30 days
[1]Crack Use	TLFB	Number of times participant engaged in crack cocaine use om the past 30 days
[1]Total # Partners	TLFB	Number of male sexual partners in the past 30 days
[1]Illegal Activity	ASI	Self-reported number of days engaged in illegal activity in the past 30 days
[1]Partner Crack Use	TLFB	Number of primary sexual partners perceived to use crack cocaine; up to 3 partners
[2]Oral Sex	TLFB	Number of times participant engaged in unprotected oral sex with a male partner in the past 30 days
[2]Vaginal Sex	TLFB	Number of times participant engaged in unprotected vaginal sex with a male partner in the past 30 days
[2]Anal Sex	TLFB	Number of times participant engaged in unprotected anal sex with a male partner in the past 30 days
[3]Employment pattern	ASI	Dichotomized self-reported employment pattern over past 3 years; unemployed (unemployed, in controlled environment) or employed (full-time, part-time, student, service, retired/ disability)
[3]Longest Job	ASI	Self-reported longest full-time job, in months
[3]Education	ASI	Self-reported number of years of education completed
[*]Injection Drug Use	TLFB	Number of times participant engaged in injection drug use in the past 30 days
[*]Partner Injection Drug use	TLFB	Number of primary sexual partners perceived to use injection drugs; up to 3 partners
[*]Partner HIV status	TLFB	Number of primary sexual partners perceived to be HIV positive
[*]Lifetime Incarceration	ASI	Self-reported number of months incarcerated in lifetime
[*]Income: unemployement	ASI	Self-reported income from unemployment in the past 30 days
[*]Income: employment	ASI	Self-reported income from employment in the past 30 days

Variable name	Measure	Variable description
*Income: public assistance	ASI	Self-reported income from public assistance or welfare in the past 30 days
*Income: social security	ASI	Self-reported income from pension benefits or social security in the past 30 days
*Income: mate	ASI	Self-reported income from mate, family, or friends in the past 30 days
*Housing pattern	ASI	Dichotomized self-reported housing pattern over past 3 years; unstable (controlled environment, no stable arrangements, secondary treatment) or stable (with sexual partner and children, with sexual partner alone, with children alone, with family, with friends, alone)

Note: [1]Denotes variables included in Sexual Network risk factor. [2]Denotes variables included in Individual Behavior risk factor. [3]Denotes variables included in Social/ Structural risk factor. *Denotes variables included in Study 1 that did not load on one of the three factors. TLFB = Timeline Follow Back. ASI = Addiction Severity Index.

APPENDIX B:
PARALLEL ANALYSIS RESULTS

Table B

Three Factor Solution Parallel Analysis

Raw Data Eigenvalues	Critical Value Eigenvalues
3.82	1.69
2.23	1.55
1.59	1.49
1.36	1.41

Note: A Parallel Analysis with principal components extraction and random normal data generation was conducted in SPSS Version 20 using syntax from O'Connor (2000). Number of cases was 209, number of variables was 21, number of datasets was 40, and percentile was 95.

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