HHS Public Access

Author manuscript

Int J Drug Policy. Author manuscript; available in PMC 2017 January 01.

Published in final edited form as:

Int J Drug Policy. 2016 January ; 27: 56–64. doi:10.1016/j.drugpo.2015.09.006.

The micro-social risk environment for injection drug use: An event specific analysis of dyadic, situational, and network predictors of injection risk behavior

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Abstract

Background—This study explores the risk environment for drug use by examining injection risk behavior during specific injection episodes. By leveraging multiple observations of injection episodes of participants, the study attempts to move beyond global assessment of environmental variables to simultaneously model within (i.e., event level) as well as between (i.e., individual level) predictors of injection risk. Furthermore, gender is also explored as a potential moderator of the relationship between the association of specific partner characteristics (e.g., having an injection partner who is also a sexual partner) and injection risk behavior.

Methods—Data is used from the Sexual Acquisition of Transmission of HIV Cooperative Agreement Study (SATHCAP). Multilevel structural equation modeling is utilized to predict within and between variations in underlying injection risk behavior as measured using four indicators of injection risk.

Results—Results indicated that a number of partner level characteristics (i.e., being emotionally close with the partner, sexual partnership, being a first time partner) and one social situational (i.e., the number of non-injectors present at the injection episode) characteristic predicted event level injection risk behavior. However, the impact of partner characteristics also appears to be moderated by gender of the participants. More specifically, sharing a sexual partnership with an injection partner was more strongly associated with injection risk among females as compared to males and females indicated higher levels of risk when injecting with other females while the partner's gender showed no significant association with risk for male injectors.

Conclusion—These results suggest that people who inject drug do report varying levels of risk during different injection episodes and this variation can be explained by partner and situational characteristics. Improved understanding of the social processes surrounding injection episodes is required to further refine harm reduction approaches.

Keywords

injection drug use; risk environment; HIV prevention; event level data

Background

Despite gains in reducing the burden of HIV among people who injection drugs (PWID) in the United States (Strathdee & Stockman, 2010), the risk of acquiring HIV still remains elevated in this population. For example, between 2009 and 2012, injection drug use was involved with 12% of infections among males and 24% of new infections among females in the United States (CDC, 2013). Given that an estimated 1% of the US population is estimated to use injection drugs each year (USDHHS, 2013), this suggests that PWIDs continue to contribute disproportionally to the new incidence of HIV in the United States. Furthermore, PWIDs also remain at high risk for hepatitis C virus (HCV) (Nelson et al., 2011).

HIV/HCV prevention research has increasingly focused on the "risk environment" for injection drug use such as neighborhoods, networks, and norms (Latkin, German, Vlahov, & Galea, 2013; Rhodes, 2009) in effort to explain the persistence of these health burdens. However, only a small number of studies have examined setting characteristics for *specific injection episodes* (i.e., event level data) and how these characteristics may impact injection risk behavior (Latkin et al., 2013).

Each injection "episode" takes place during a specific time, in a specific place, and, when not injecting alone, with specific people. The characteristics of these settings (both social and physical) likely impact the level of risk observed during each episode. Yet, despite the importance of the specific characteristics surrounding an injection event, studies that have examined setting characteristics often rely on global assessments of injection risk behavior (i.e., frequency of risk behavior during the past 6 months) or only examine behavior during a single injection episode. Inference of associations in studies using global assessments of injection risk behavior are limited given the potential for individual level confounding factors and the lack of direct connection between the behavior and the predictors. Even with event-level data, examining only a single event also limits inference because within person variation in risk behavior is not observed and therefore individual level characteristics may still confound observed associations (Leigh & Stall, 1993).

Previous research into social settings suggests that setting level outcomes are dependent on characteristics such as the availability of resources, the distribution of these resources, and social processes in the settings (Tseng & Seidman, 2007). During injection episodes, these resources may include injection equipment, the time available to inject, and the level of knowledge of hygienic injection practices. For example, previous research has indicated greater levels of syringe coverage are associated reduced injection risk behavior (Abdul-Quader et al., 2013) and that the time available to inject is associated with the ability of injectors to engage in harm reducing activities (Cooper, Moore, Gruskin, & Krieger, 2005). However, as noted, these variables are infrequently measured at the event level despite the fact that the availability of resources during specific episodes (e.g., how many sterile

syringes are available immediately prior to injecting) likely drives the impact of these variables on risk behavior.

Furthermore, if multiple injectors are present, these resources may be distributed more or less equally among multiple injectors. For example, providing the drugs during a specific episode may place an individual at a privileged position of risk during the injection episode, such as the order of injection (Maher, 2002). The distribution of these resources may also be explained by the social processes that exist in this setting such as social networks of injectors, norms of sharing equipment, and disparities in power among injectors. For example, a growing number of studies that document how gender impacts injection risk behavior (Frajzyngier, Neaigus, Gyarmathy, Miller, & Friedman, 2007; Syvertsen et al., 2014) and the importance of gender inequities in understanding the risk environment for injection drug use (Strathdee et al., 2010). The current study specifically focuses on gender as a possible moderator of the association between dyad level characteristics and injection risk behavior given that previous studies have indicated that gender may moderate the relationship between risk behavior and setting or partner factors such as police presence (Cooper et al., 2005) or injecting with sexual partners (Harris & Rhodes, 2013).

Accordingly, the current study is intended to expand upon preliminary investigations of the micro-social risk environment for injection drug use and further explore situational, dyadic, and network characteristics associated with injection risk behavior by using even-specific data on up to four different injection episodes nested within each participant. In addition, the study incorporates latent variable measurement of injection risk behavior in effort to improve the measurement characteristics of this behavior (Janulis, 2014). Therefore, multilevel structural equation modeling is used in effort to examine the following research questions 1) what characteristics of injection partners and social/physical environment explain within person variation in injection risk behavior, and 2) what network and individual characteristics explain between person variation in injection risk behavior and 3) does gender explain variation in the association between dyadic characteristics and injection risk behavior?

Method

This US focused study uses a subset of data from the Sexual Acquisition and Transmission of HIV Cooperative Agreement Program (SATHCAP; Compton, Normand, & Lambert, 2009) obtained via the National Addiction and HIV Archive Program (NAHDAP, 2015). SATHCAP included three U.S. sites (i.e., Chicago, IL; Los Angeles, CA; and Raleigh Durham, NC), and one international site (i.e., St. Petersburg, Russia). However, only data from the three U.S. sites that is publicly available through the National Addiction and HIV Archive Program will be used in this study. The recruitment of participants for all SATHCAP sites utilized respondent driven sampling and full details on recruitment procedures can be found elsewhere (Iguchi et al., 2009).

Inclusion Criteria—The total sample of SATHCAP participants at these three sites was 4688. However, the current study utilized a subsample of PWIDs from the larger sample collected in the SATHCAP study. Participant were included in the current study if they

injected with at least one person during the last 6 months ("with" means, "people who injected drugs at the same place and time as you"). This inclusion criterion was necessary because individuals who have not injected in the same place and time as another individual did not provide data on specific injection episodes. This criterion included 835 total participants with 55 providing data on four injection episodes, 391 providing data on three injection episodes, 207 providing data on a two injection episodes, and 182 providing data on a single injection episode leading to a total. IDU participants had a mean age of 42.6 (SD = 10.8) and were majority male (67.5%). As for racial/ethnic identification, the majority identified as African American (53.5%), followed by white (34.7%), Hispanic/Latino (24.1%), and other (2.0%). After removing participants missing on one or more independent variables or all dependent variables, the final sample included 782 participants reporting on 1674 injection episodes.[1]

Measures

The measures used in this study can be broadly organized into two groups: level 2 (i.e., individual) measures and level 1 (i.e., injection episode) measures. Level 2 measures include demographics, drug use, and personal network characteristics. These variables do not change across injection episodes. Level 1 measures included situational characteristics (i.e., characteristics of the injection episode), dyadic characteristics (i.e., characteristics that depend on the participant and the injection partners), and injection risk behaviors. These variables are injection episode specific and therefore can have variability within individual participants.

Level 2 (Individual) Measures

Level 2 variables indicated characteristics of the individual that were constant throughout all injection episodes. The following demographic variables were included in the study: age, gender, race, ethnicity, homelessness (i.e., identify as homeless during the previous year). Participants were be coded using their currently identified gender. Race was coded as White, African American, and Other given the small cell counts of non-African American or non-White identified participants. Two variables indicated the frequency of crack/cocaine and opioid/heroin use. Number of years injecting drugs was also assessed. Finally, the injection network size was measured by the participant's response to the following question: "About how many different people did you inject drugs within the past 6 months? (By "with", we mean people who injected drugs at the same place and time as you.)".

Level 1 (Injection Episodes) Measures

Level 1 measures are specific to each injection episode. Data on one to four injection episodes were elicited from each participant. Those who had injected with at least one individual were asked to provide the initials of up to three individuals they had "recently injected with". In addition, participants were also asked if one of these named partners was the partner with whom they most frequently inject. If none of the previously named partners

[1]Given the computationally demanding nature of the data analysis, it was infeasible to utilize more advanced treatment of missing data such as multiple imputation. However, missing variable dummy codes were introduced for categorical variables in effort to utilize as many cases as possible in the data analysis.

were their most frequent partner, information was also elicited on their most recent injection episode with the most frequent partner. This created the possibility of four episodes being observed (i.e., if the participant named three partners and none of them were their most frequent partner). For each individual named, the participants provided information about the characteristics of those individuals and the most recent situation in which they injected with that individual.

Dyadic Characteristics—Several variables examined the dyadic characteristics between the participant and the injection partner. First a variable indicated if the participants identified as the same gender. Two dummy codes indicated the perceived concordance of HIV status between the participant and the partner with HIV-discordance (i.e., indicating the participant believes they do not share the same serostatus) used as the reference category. Therefore, one variable will indicate if they are of unknown concordance (i.e., the participant is unsure about their own or the partners HIV status) while another variable will indicate if the participant believes the partner to be HIV-concordant. One variable indicated if the participant and the injection partner identified as the same gender. Another dyadic variable indicated if the injection partner is also a sex partner. Finally, a categorical variable indicated the length of injection partnership between the partners.

Situational Characteristics—Two characteristics of the physical environment of the injection episode will be included in the analysis. First, the location of the injection episode was categorized using an indicator identifying if the participant injected in their home or injected in another location. Second, the location was categorized if it was the most common location the participant injects at with that partner. Two additional variables examined the social environment of the injection episode. The first measured how many other individuals were injecting at the same site. The second measured how many other individuals where using drugs at the same site but not injecting.

Injection Risk Behavior—Injection risk behavior will be measured with four variables. One indicator was ordinal while the other three indicators were binary. As will be discussed further in the analysis section, these variables were measured as a single continuous latent variable. The three-point ordinal indicator will measure if the participant engaged in receptive syringe sharing and, if they did, whether they used bleach to clean the syringe before injecting (0 = No receptive sharing, 1 = receptive sharing with bleach 2 = receptive sharing no bleach). The first binary indicator will measure if the participant used a used syringe to mix, measure, or divide the drugs. The second binary indicator will measure if the participant shared any other non-syringe injection paraphernalia. The third binary variable will indicate if the participant engaged in distributive syringe sharing.

Analytic Approach

The current study used a model that includes a latent factor dependent variable measured by the four indicators as well as multiple observed predictors (Figure 1). This measurement model will be briefly discussed before moving on to discuss the modeling approach.

Measurement Model—As discussed, the measurement model includes four indicators (i.e., receptive syringe sharing, dividing drugs, paraphernalia sharing, and distributive syringe sharing) and models these variables as a single factor. While distributive syringe sharing is not a direct causal risk factor for the participant to contract viral diseases (i.e., because it only places the partner at risk), this variable has shown to be a good indicator when measuring injection risk behavior using a latent variable approach (Janulis, 2014) and may reflect a willingness to engage in risk of other unmeasured variables. Accordingly, distributive syringe sharing was included as an indicator of injection risk behavior given the limited number of observed indicators for injection risk behavior in the current dataset and the previously observed strong factor loading of this indicator in similar factor models.

Model Fit—For the estimator, maximum likelihood with robust standard errors (MLR) was used because this is the only estimator that allows for categorical indicators in multilevel structural equation modeling with random slopes (Muthen & Muthen, 2012).[2] Unfortunately, there is currently no method for estimating a multilevel random slope model with categorical indicators that includes global measures of fit such as Chi-square, RMSEA, CFI, or TLI (Geiser, Bishop, Lockhart, Shiffman, & Grenard, 2013). Although global fit indices are not available when using MLR with random slopes, an iterative approach is possible to examine if nested models significantly improve fit using the Wald test of nested models. Accordingly, the modeling process will be an iterative process that progressively frees different parameters of the model to examine if freeing these parameters significantly improves model fit. The first model (i.e., *Model 1*) included the full model absent of random slopes with factor loadings constrained to be equal across the within and between levels of the model. *Model 2* was the same model with all factor loadings freed across levels (except for the fixed loading for identification). Using the best fitting model as the reference, *Model 3* freed the random slope for *gender concordance* and *Model 4* freed the slope for *sexual partner multiplexity*. Finally, the last model (*Model 5*) included *gender* as a predictor of both slopes.

Results

Descriptives

The majority of episodes did not include receptive syringe sharing (77.4%) with the remaining episodes being roughly split between episodes where the participant shared a syringe after using bleach to clean the syringe (11.6%) or shared without using bleach (10.9%). Similarly, the minority of episodes included mixing, measuring, or dividing drugs (31.5%) or shared non-syringe paraphernalia (37.5%). However, distributive syringe sharing was reported in over half of injection episodes (52.6%).

Model Comparison

As noted, models were tested using an iterative approach beginning with the most constrained model and examining if freeing parameters significantly improved model fit,

[2]For all models, the standard integration technique was used with 7 integration points used for Models 1–4 and the default number of integration points, 15, used to run the final model as suggested for computationally demanding modeling.

using Wald's test (Bentler, 1990) for nested models. Results for all models can be found in Table 1. Beginning with the first two models that excluded all random slopes, freeing the factor loadings across the within and between levels (Model 2) did not improve fit over the fully constrained model (Model 1), $W = 5.56$, df = 3, $p = 0.135$. Therefore, the null model (i.e., Model 1) was retained and all subsequent models included factor loadings constrained to be equal across the between and within levels of the model. Next, Model 3 freed the random slope for the effect of *gender concordance* on injection risk behavior. Model 3 significantly improved fit over Model 1 ($W = 27.91$, df = 1, $p < 0.001$) suggesting that the relationship between *gender concordance* and injection risk behavior did vary across individuals. This was also confirmed by the significance of the variance for the random slope ($\sigma^2_{s1} = 2.86$, $p = 0.008$). Model 4 significantly improved the fit of the model over Model 3 by freeing the slope for *sexual partnership* ($W = 24.22$, df = 1, $p < 0.001$), again corresponding with a significant variability in this slope parameter ($\sigma^2_{s2} = 0.49$, $p = 0.014$). Finally, Model 5 also significantly improved model fit over Model 4, ($W = 11.62$, df = 2, $p = 0.003$), by including the participant's *gender* as a predictor of both the random slopes for *gender concordance* as well as *sexual partnership*. Accordingly, all hypotheses were examined using Model 5 with both random slopes freed and gender used as a predictor of these slopes. Accordingly, Model 5 was used to examine all path coefficients between the independent variables and the latent variables, either injection risk behavior or the random slopes. Parameter estimates and standard errors for all hypotheses can be found under Model 5 in the far right column of Table 1.

Dyadic Predictors

As discussed, two estimates (i.e., one for females and one for males) were examined for the relationship between injection risk behavior and gender concordance as well as sexual partnership. For males, *gender concordance* was not a significant predictor of injection risk behavior ($\gamma = -0.51$, $p = 0.060$) while *sexual partnership* was positively associated with risk behavior ($\gamma = 1.07$, $p < 0.001$). For females, both *gender concordance* ($\gamma = 1.10$, $p = 0.001$) and *sexual partnership* ($\gamma = 2.21$, $p < 0.001$) were significantly positively associated with injection risk behavior. As suggested by the simple slopes, female participants had significantly more positive slopes for both *gender concordance* ($\gamma = 1.60$, $p < 0.001$) and *sexual partnership* ($\gamma = 1.14$, $p = 0.014$) as assessed by the path coefficient between *gender* and each random slope. This indicated that females with injection partners that were female or sexual partners tended to engage in higher levels of risk behavior. Finally, while significant residual variability remained in the random slope for gender concordance ($\sigma^2_{s1} = 2.64$, $p = 0.028$), no significantly variability remained in the random slope for sexual partnership after accounting for *gender* as a predictor ($\sigma^2_{s2} = 0.80$, $p = 0.317$). Moving to other dyadic variables, length of injection partnership was not significantly associated with injection risk behavior when comparing the first ($\gamma = 0.28$, $p = 0.315$), second ($\gamma = 0.10$, $p = 0.731$), and third ($\gamma = -0.04$, $p = 0.902$) quartile of injection partnership to episodes in the lowest quartile of injection partnerships. However, injecting with a first time partner was negatively associated with injection risk ($\gamma = -1.28$, $p = 0.008$). Perceived closeness was significantly positively associated with injection risk behavior ($\gamma = 0.21$, $p < 0.001$). There was also no evidence of serosorting as dyads with unknown concordance ($\gamma = 0.14$, $p =$

0.814) and those that were perceived as sero-concordant ($\gamma = -0.35$, $p = 0.578$) showed no significant differences in level of risk as compared to those with known discordance

Network and Situational Predictors

Injection network size was not significantly associated with injection risk ($\gamma = 0.00$, $p = 0.606$). While the number of injectors at the injection episode was not associated with risk behavior ($\gamma = 0.01$, $p = 0.727$), the number of non-injection drug users was positively associated with risk behavior ($\gamma = 0.10$, $p = 0.013$). However, there was no significant interaction between the number of injectors and the non-injectors present during the injection episode ($\gamma = 0.00$, $p = 0.630$). Finally, neither injecting at one's own home ($\gamma = -0.18$, $p = 0.430$) or injecting at the participant's most common injection location ($\gamma = -0.60$, $p = 0.111$) were significantly related to injection risk behavior

Discussion

Given the continued burden of HCV and HIV among PWIDs, understanding the social processes associated with the spread of these diseases remains an important goal of public health research. This study attempted to overcome limitations in previous research by exploiting data with multiple observations of drug use episodes for each participant in effort to examine within person variation of injection risk behavior.

Contradicting previous research showing higher risk among gender discordant partnerships (Hahn, Evans, Davidson, Lum, & Page, 2010; Johnson, Gerstein, Cerbone, & Brown, 2002) or male-male partnerships (Gyarmathy et al., 2010), female-female injection partners tended to have higher levels of injection risk behavior. These findings may suggest that norms surrounding female-female injection partnerships may facilitate increased levels of risk behavior (Latkin, Kuramoto, Davey-Rothwell, & Tobin, 2010) or that skills and resources (e.g., injection equipment) imbalances may especially burden female-female injection partnerships in the current sample. For example, previous research has indicated that females may have lower level of access to injection equipment or may have less experience self-injecting (Roberts, Mathers, & Degenhardt, 2010), two factors that may lead to higher risk (i.e., more sharing or requiring assistance injecting) among female-female dyads as compared to gender discordant dyads.

However, there was a positive association between sexual partnership and injection risk behavior for both males and females, as suggested by previous studies (Morris et al., 2014). Furthermore, the association between sexual partnership and injection risk behavior was significantly more positive for female injectors as compared to males. This concurs with findings from several studies indicating that sexual partners were at increased likelihood for engaging in injection risk behavior for both male and female injectors (Bailey et al., 2007; Hottes, Bruneau, & Daniel, 2011). Furthermore, this may suggest that the resource imbalances or gender norms may enhance the potential risk of sexual partnerships for female injectors. This finding also concurs with results from a number of smaller studies indicating sexual partnerships may be more detrimental, in terms of injection risk, to female injectors as compared to males (Choi, Cheung, & Chen, 2006). However, by using event specific data, the current study confirms that it is not merely individuals that inject with sexual

partners that are at higher risk, but the specific injection episodes with sexual partners that are related to heighted risk. For example, females' sexual partners may be responsible for obtaining drugs (El-Bassel, Shaw, Dasgupta, & Strathdee, 2014) and, due to this responsibility, may subsequently retain greater control over the injection process (e.g., injecting first with the same equipment to be used by the female sexual partner).

Furthermore, no significant relationship between size of the participant's injection network and injection risk behavior was observed. This may suggest that the size of injection networks may have little effect on injection risk behavior, as found in some previous studies (Paquette, Bryant, & De Wit, 2011; Shaw, Shah, Jolly, & Wylie, 2007). While several studies have found a positive association between network size and injection risk (Cepeda et al., 2011; Thiede et al., 2007), differences in the current study from most previous studies (e.g., the current study used sampling population linked to MSM and statistical models that controlled for episode specific variables) could explain why the current findings differ from those in the past. The non-significant relationship between injection network size and risk behavior may also be inaccurate due to the inherent difficulty of recalling the number of injectors in the "same place and time" in the last 6 months among individuals who frequently inject drugs. Accordingly, this instrument could introduce measurement error that may have attenuated the relationship between injection network size and risk behavior. Finally, the addition of factors not included in previous analysis (e.g., number of injectors present during the episode) or the included covariates such as gender and frequency of drug use may have attenuated a potential relationship between network size and risk behavior.

Moving onto the social and physical circumstances of injection episodes, the number of injectors at an episode had no relationship and the number of non-injectors was positively associated with injection risk behavior. Finally, no significant relationship was observed between injecting at home and risk behavior. Previous studies that have compared specific types of injection locations (e.g., home vs. shooting gallery vs. outdoors) have found mixed results with some finding significant associations (Bailey et al., 2007; Latkin et al., 1994) while others found no relationship between injecting location (Johnson et al., 2002). Accordingly, the association between injection location and injection risk behavior continues to remain unclear. Studies examining this association would benefit by explicitly including assessment of possible mediating variables (e.g., resources and social processes) at these locations to clarify the impact of injecting location on injection risk behavior. In addition, the locations of injection episodes are likely associated with other variables such as the gender of the injector (Cooper et al., 2005) and a more nuanced analysis may provide greater insight to how these variables interact.

Given the novel approach of the current study that allows estimation of within person variability across partners and settings, a particularly noteworthy finding that was that significant variability was observed in injection risk behavior across injection episodes. This indicates that participants in the current study did experience different levels of injection risk behavior across injection episodes. More specifically, in a null model with no within-level predictors (results not shown), 13.2% (ICC = 0.132) of the unexplained variability in injection risk behavior took place at the within-person level indicating that a sizable percentage of variability existed across different injection episodes. This finding suggests

that partner and setting level characteristics are important factors in determining the observed level of risk behavior for specific drug use episodes. Furthermore, the significant variability of the within-level latent factor in the final model (i.e., Model 5) suggests that significant variability continued to exist across injection episodes after accounting for all the included explanatory variables at the within level and the included partner and setting level independent variables were not sufficient to account for all setting level variability. More generally, only a single setting variable (i.e., number of non-injection drug users) was significant while several dyadic variables were significant at the within level. Clearly, much remains unknown about setting specific variables that may impact injection risk.

Limitations

The following limitations should be considered when interpreting the current study findings. First, the current study used pre-existing data that was not primarily designed to assess episode specific variability in injection risk behavior or to test the theoretical application of social setting theory to injection episodes. Accordingly, this analysis primarily focused on dyadic characteristics rather than other important setting level variables related to injection risk behavior that were not measured in the current study. For example, the control over the drugs used to inject (i.e., if the participant obtained the drugs themselves), the time available to inject, and injection norms of the setting are all important variables related to injection risk behavior not available in the current analysis. Second, measurement of event specific data is somewhat unique and the approach of the current study (i.e., collecting data on injection episodes up to 6 months prior to the data collection) is prone to potential biases. For example, participants may suffer recall bias or other forms of measurement error due to the difficulty of remembering injection specific information that may have occurred weeks or months before the questionnaire is completed. While similar approaches have been used in previous studies of sexual risk behavior and substance use, the novelty of this approach being applied to injection risk behavior makes the validity and reliability of this measurement process uncertain. Third, in contrast to most multilevel studies, this study has small cluster sizes (n 4) but a large number of clusters (n = 782). Accordingly, the study likely had substantial power to detect between person associations but less statistical power to detect within person associations. Fourth, while there are substantial benefits in using latent variable measurement of injection risk behavior, the clinical importance of observed associations is unclear given that no study has yet established the level of decline in composite risk required to observe reductions in incidence of HIV or HCV. Fifth, the impact of micro-social characteristics on injection risk behaviors almost certainly differs across geographic regions and cultures. While the current study did utilize a sample of participants that are somewhat diverse geographically (i.e., across the 3 US sites), the impact of this variability was not explicitly modeled and more detailed analysis of these factors would likely provide greater insight into how certain setting level factors may be more or less important in certain regions (e.g., rural versus urban).

Future Directions

Given the new insights into injection settings provided by the current study and these acknowledged limitations, this study suggests a number of avenues for future research examining injection settings and the social processes associated with injection risk behavior.

First, significant within person variability in injection drug risk behavior remained unexplained after all predictors were included in the final model. Accordingly, uncovering variables that more accurately explain this variability remains an important area for future research. This work could be particularly important in identify the mediating social processes relevant to the impact of syringe exchange programs and behavioral interventions among PWIDs. For example, previous studies (Latkin et al., 2010) have utilized measures of descriptive (i.e., perceived prevalence of behavior) and injunctive (i.e., perceived approval) norms among injection drug users. More explicitly measuring these norms during specific injection episodes would likely clarify the processes and mechanisms at play in these settings. As noted in the limitation section, one challenge with collecting event specific data is implementing valid and reliable measurement techniques. However, ecological momentary assessment or other real-time data collection techniques such as coded ethnography may facilitate measurement of complex setting characteristics such as social norms during injection episodes. Similarly, these approaches may also improve upon the discussed measurement issues inherent in a study that inquires about specific injection episodes up to 6 months prior to the data collection. Furthermore, these methods would allow for researchers to easily obtain a large number of observations per participant and therefore overcome the limitation of low statistical power at the within participant level.

Implications for HIV/HCV Prevention Interventions

The findings of the current study also have practical implications for PWID preventive interventions. As discussed, the significant variability across different episodes suggests that partner and setting factors impact the level of risk behavior at each event. In the current study, participants injecting with sexual partners or non-first time partners were more likely to engage in risk behavior. Accordingly, behavioral interventions may benefit from targeting these relationships as particularly important for reducing risk behavior. For example, previous interventions have attempted to increase communication about and promote self-efficacy to engage in harm reduction practices through skill building exercises with sexual partners (Jiwatram-Negrón & El-Bassel, 2014). While PWID interventions have begun to explore the targeting of intimate partner relationships and communication between sexual partners (El-Bassel et al., 2011), this approach has been much more widely utilized in other areas such as sexual health interventions (Jiwatram-Negrón & El-Bassel, 2014). Accordingly, the full utility of this approach has yet to be extended to injection related interventions. Similarly, female injectors indicated higher levels of risk when injecting with gender concordant partners and sexual partners. Accordingly, gender specific programming may also be beneficial in order to target circumstances that may place female injectors at unique or increased level of risk (Magnus et al., 2012).

Conclusion

Continued refinement of harm reduction approaches is required in the US given the continued disproportionate burden of HIV and HCV among PWID. This preliminary study found that partner and situational characteristics were significant predictors of injection risk behavior during specific injection episodes and suggested that gender continues to play an important role in moderating the association between partner characteristics and risk

behavior. More specifically, having an injection partner who was also a sexual partner and injecting in a gender concordance dyad was more detrimental for females compared to males. These findings highlight the increasingly nuanced understanding of the impact of gender on injection risk behavior emerging in this literature. However, this analysis is necessarily reductive given the somewhat limited scope and variables captured in the current study. Accordingly, much remains unknown about the complexity of gender and the intertwined associations between gender, norms, power dynamics, and resource imbalances surrounding injection episodes. Future research should continue to increase our understanding of these effects in effort to improve existing environmental, situational, network, partner, and individual interventions. Finally, given the methodological advantages of event specific data, this study's findings should also encourage the continued pursuit of event level data and development of data capture and analysis methods appropriate for such data.

Acknowledgments

This work was supported by the National Institute on Drug Abuse (T32DA021129) and by Michigan State University. The content is the sole responsibility of the authors and does not necessarily represent the official views of Michigan State University, the National Institute on Drug Abuse, or the National Institutes of Health.

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Highlights

- Event level data is used to model the risk environment for injection drug use
- Dyadic and situational factors are associated with injection risk behavior
- Association between sexual partnership and injection risk is moderated by gender
- Association between gender concordance and injection risk is moderated by gender

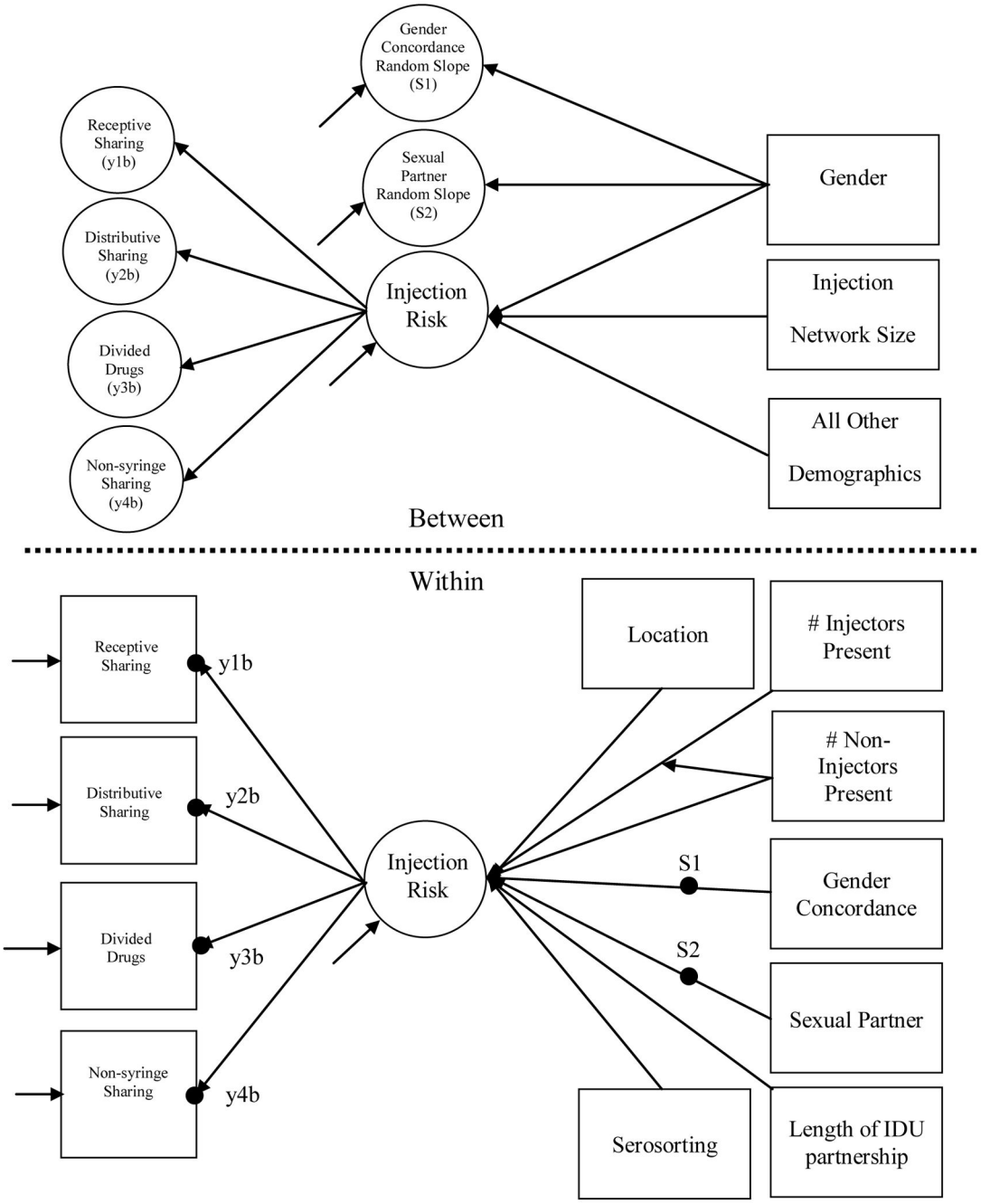

Figure 1.
Model Path Diagram

Table 1

Model Parameters for Models 1 through 5

	Model 1	Model 2	Model 3	Model 4	Model 5
Model Fit					
Loglikelihood	−3067.56	−3057.622	−3062.19	−3062.13	−3056.17
Scaling Correction Factor	1.20	1.26	1.18	1.15	1.17
AIC	6211.12	6197.24	6202.39	6204.27	6196.34
BIC	6417.20	6419.59	6413.89	6421.17	6424.10
Wald Test	-	5.56, p = 0.135	27.91, p < 0.001	24.22, p < 0.001	11.6, p = 0.003
Parameters					
Within					
Factor Loadings[a]					
Receptive Sharing	1.00	1.00	1.00	1.00	1.00
Distributive Sharing	**1.15 (0.19)**	**1.25 (0.22)**	**1.15 (0.19)**	**1.52 (0.19)**	**1.17 (0.19)**
Divide Drugs	**0.68 (0.11)**	**0.86 (0.19)**	**0.68 (0.11)**	**0.68 (0.11)**	**0.67 (0.11)**
Non-syringe sharing	**0.53 (0.08)**	**0.92 (0.24)**	**0.53 (0.08)**	**0.53 (0.08)**	**0.53 (0.08)**
Path Coefficients					
Gender Concordance	0.41 (0.21)	0.28 (0.18)	0.22 (0.23)	0.22 (0.22)	−0.43 (0.29)
Female (Simple Slope)	-	-	-	-	**1.11 (0.35)**
Missing	0.08 (0.53)	0.10 (0.42)	0.06 (0.51)	0.04 (0.51)	−0.12 (0.51)
Sexual Partner	**1.67 (0.28)**	**1.15 (0.33)**	**1.68 (0.28)**	**1.68 (0.28)**	**1.08 (0.49)**
Female (Simple Slope)	-	-	-	-	**2.24 (0.45)**
Closeness	**0.21 (0.05)**	**0.15 (0.05)**	**0.20 (0.05)**	**0.21 (0.05)**	**0.18 (0.05)**
Partnership Length					
New Partner	**−1.15 (0.48)**	**−0.90 (0.38)**	**−1.26 (0.48)**	**−1.26 (0.49)**	**−1.28 (0.48)**
1st Quartile (Reference)	-	-	-	-	-
2nd quartile	0.33 (0.28)	0.38 (0.23)	0.31 (0.27)	0.31 (0.28)	0.28 (0.27)
3rd quartile	0.14 (0.29)	0.27 (0.25)	0.09 (0.28)	0.08 (0.28)	0.10 (0.28)
4th quartile	−0.01 (0.30)	0.27 (0.28)	−0.06 (0.29)	−0.06 (0.30)	−0.04 (0.29)
HIV Concordance					
Discordant (Reference)	-	-	-	-	-

	Model 1	Model 2	Model 3	Model 4	Model 5
Unknown Concordance	0.17 (0.66)	0.21 (0.55)	0.27 (0.61)	0.29 (0.61)	0.14 (0.60)
Concordant	−0.36 (0.68)	−0.16 (0.58)	−0.29 (0.63)	−0.28 (0.62)	−0.35 (0.63)
Missing	0.14 (0.65)	0.17 (0.54)	0.26 (0.60)	0.28 (0.60)	0.18 (0.60)
# of people injecting	0.02 (0.04)	−0.02 (0.03)	0.01 (0.03)	0.01 (0.04)	0.01 (0.04)
# non-injectors using drugs	**0.10 (0.04)**	**0.08 (0.03)**	**0.10 (0.04)**	**0.10 (0.04)**	**0.10 (0.04)**
# of injectors * # of non-injectors	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.04)
Inject at home	−0.15 (0.24)	−0.19 (0.19)	−0.17 (0.23)	−0.15 (0.23)	−0.18 (0.23)
Location is Common Location	−0.77 (0.38)	−0.54 (0.31)	−0.65 (0.38)	−0.66 (0.38)	−0.60 (0.38)
Missing	−0.24 (0.41)	−0.39 (0.32)	−0.17 (0.41)	−0.17 (0.41)	−0.20 (0.41)
Residual Variance - Within					
Injection Risk (Latent)	**1.95 (0.54)**	**1.35 (0.47)**	**1.38 (0.50)**	**1.37 (0.51)**	**1.29 (0.46)**
Between					
Factor Loadings[a]					
Rec. Share	1.00	1.00	1.00	1.00	1.00
Dist. Share	**1.15 (0.19)**	**1.06 (0.19)**	**1.15 (0.19)**	**1.52 (0.19)**	**1.17 (0.19)**
Divide Drugs	**0.68 (0.11)**	**0.59 (0.11)**	**0.68 (0.11)**	**0.68 (0.11)**	**0.67 (0.11)**
Non-syringe sharing	**0.53 (0.08)**	**0.42 (0.08)**	**0.53 (0.08)**	**0.53 (0.08)**	**0.53 (0.08)**
Thresholds					
Rec. Share					
Shared - used bleach	**6.01 (1.24)**	**5.25 (1.03)**	**5.85 (1.18)**	**5.91 (1.27)**	**4.91 (1.18)**
Shared - did not use bleach	**7.99 (1.31)**	**7.27 (1.36)**	**7.82 (1.24)**	**7.89 (1.34)**	**6.88 (1.24)**
Dist. Share	**6.54 (1.58)**	**5.65 (1.53)**	**6.39 (1.51)**	**6.45 (1.46)**	**5.36 (1.44)**
Divide Drugs	**2.79 (0.80)**	**2.45 (0.84)**	**2.69 (0.77)**	**2.72 (0.77)**	**2.05 (0.77)**
Other equipment	1.15 (0.62)	1.28 (0.72)	1.08 (0.60)	1.11 (0.60)	0.59 (0.50)
Path Coefficients					
Injection Network Size	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)
Female	0.50 (0.31)	0.59 (0.96)	0.41 (0.30)	0.41 (0.30)	−0.81 (0.51)
Age	−0.04 (0.02)	−0.06 (0.03)	−0.04 (0.02)	−0.04 (0.02)	−0.04 (0.02)
Race					
Black	**1.01 (0.38)**	**1.21 (0.45)**	**0.94 (0.37)**	**0.95 (0.37)**	**0.95 (0.38)**
Race - Other/Multiple	0.20 (0.56)	0.26 (0.65)	0.27 (0.55)	0.25 (0.55)	0.21 (0.38)

	Model 1	Model 2	Model 3	Model 4	Model 5
Hispanic	0.28 (0.52)	0.35 (0.61)	0.24 (0.51)	0.26 (0.51)	0.28 (0.55)
Homeless	**1.88 (0.37)**	**2.22 (0.45)**	**1.89 (0.36)**	**1.88 (0.37)**	**1.85 (0.36)**
Drug Use					
Crack/Cocaine Frequency	−0.01 (0.01)	−0.01 (0.02)	−0.01 (0.01)	−0.01 (0.01)	−0.01 (0.01)
Heroin/Opioids Frequency	**−0.04 (0.02)**	**−0.05 (0.02)**	**−0.04 (0.01)**	**−0.04 (0.01)**	**−0.04 (0.01)**
Injection Frequency	−0.00 (0.01)	−0.03 (0.01)	−0.00 (0.01)	−0.00 (0.01)	−0.02 (0.01)
Injection Duration	**0.05 (0.02)**	**0.06 (0.02)**	**0.05 (0.02)**	**0.05 (0.02)**	**0.05 (0.02)**
Random Slopes Predictors					
Gender Concordance					
Female	-	-	-	-	**1.54 (0.45)**
Sexual Partnership					
Female	-	-	-	-	**1.08 (0.49)**
Residual Variance - Between					
Injection Risk (Latent)	**10.15 (2.43)**	**13.34 (3.52)**	**9.17 (2.13)**	**9.01 (2.22)**	**8.64 (1.18)**
Gender Concordance	-	-	**2.86 (1.08)**	**2.87 (1.10)**	**2.64 (1.20)**
Sexual Partnership	-	-		**0.49 (0.20)**	0.80 (0.60)

Note. Bold values indicate p-value of less than 0.05.

[a] Factor loadings for the first factor indicator were fixed at 1 for identification purposes.

Int J Drug Policy. Author manuscript; available in PMC 2017 January 01.