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Loneliness, Risky Beliefs and Intentions about Practicing Safer Sex among Methamphetamine Dependent Individuals

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Abstract

Background: Methamphetamine use is a known predictor of riskier sexual behaviors, which can have important public health implications (e.g., HIV-transmission risk). Loneliness also is associated with riskier sexual behaviors, though the relationship between loneliness and beliefs and/or intentions to practice safer sex has not been examined among people dependent on methamphetamine.

Materials and Methods: Individuals who met DSM-IV criteria for lifetime methamphetamine dependence and current (18-months) methamphetamine abuse or dependence (METH+ $n = 56$) were compared to those without severity and recency of methamphetamine use (METH- $n = 59$). These groups did not differ on social network size or proportion of people with HIV (~58% HIV+). Participants completed the NIH Toolbox Loneliness Scale and the Sexual Risks Scale's "Norms" and "Intentions" subscales.

Results: METH+ individuals were significantly lonelier than METH- controls ($t(113) = 2.45, p = .02$). Methamphetamine dependence remained significantly associated with greater loneliness, after controlling for HIV status and other relevant covariates (e.g., neurocognitive impairment, history of mood disorder, social network size; $F = 3.70$, Adjusted $R^2 = 0.18, p = .0009$).

Loneliness, above and beyond the aforementioned covariates, was significantly associated with riskier beliefs and intentions to practice safer sex among METH+, but not METH-, individuals ($\beta = 2.92, p = .02$).

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E.E.M., the Principal Investigator of the current research study, aided in the development of the design of the current study. M.A.H. performed the data analysis and interpretation for the current study under the supervision of E.E.M. M.A.H. drafted the manuscript and E.E.M., N.S.-S., J.L.M., J.E.I., R.K.H. and I.G. provided critical revisions. I.G. developed the larger study concept for the parent Translational Methamphetamine Research Center (TMARC), and serves as its Director.

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Disclosure of interest

The authors declare that they have no conflict of interest. The authors alone are responsible for the content and writing of the article

Conclusions: Loneliness is prevalent among individuals dependent on methamphetamine, and is uniquely associated with riskier beliefs and intentions regarding practicing safer sex. Findings may aid in identifying individuals at-risk of engaging in riskier sexual behaviors and guide risk prevention strategies.

Keywords

Loneliness; Methamphetamine dependence; risky sexual behavior; norms; HIV

1. Introduction

Methamphetamine is a highly addictive, psychomotor stimulant. It is estimated that approximately 1.1 million Americans 12 years or older meet criteria for methamphetamine use disorder and 205,000 individuals initiated methamphetamine use in 2018 (Substance Abuse and Mental Health Services Administration, 2019). Methamphetamine is associated with hypersexuality, and its use is predictive of riskier sexual behaviors (Mansergh et al., 2006; Semple et al., 2004) such as higher frequencies of unprotected sexual intercourse (Hittner, 2016), as well as needle sharing (Marshall et al., 2011), which can lead to increased risk of HIV-transmission (Corsi & Booth, 2008), among other infections.

While engagement in substance use treatment may decrease sexual risk behaviors and subsequent adverse health outcomes, less focus has been placed on precipitating and perpetuating factors of methamphetamine use and sexual risk behaviors. For example, loneliness is linked to increased sexual risk behaviors in the general population (Efrati & Gola, 2018; Stickley et al., 2014). Loneliness is a common human experience with nearly half of Americans reporting feeling lonely “sometimes” to “always” (Bruce et al., 2019). Loneliness is defined as a feeling that accompanies the perception that one’s social needs are not being met by the quantity, or especially the quality of one’s social relationships (Hawkley & Cacioppo, 2010). Thus, loneliness is the *perception* of being alone, rather than objective social isolation. It has been linked to a myriad of adverse mental and physical health outcomes including depression (Drageset et al., 2012), anxiety (Muyan et al., 2016), anger (Karababa, 2020), suicide (Stravynski & Boyer, 2001), cognitive decline (J. T. Cacioppo & Cacioppo, 2014), Alzheimer’s disease (Sundstrom et al., 2019; Wilson et al., 2007), poor cardiovascular health (Hawkley et al., 2003; 2010), and type II diabetes (Otto, 2020). These negative health outcomes are a consequence of, and/or exacerbated by, poor health behaviors that may arise from loneliness.

Mechanistically, feeling alone is instinctually related to feelings of being unsafe, which in turn increases sympathetic activation, according to one loneliness model (Fees et al., 1999). Chronic hypervigilance, coupled with cognitive biases that the world is a threatening place and other negative social expectations, may lead to behaviors that further isolate and exacerbate loneliness (i.e., behaviors that perpetuate the social circumstances in which the subjective feeling of loneliness arose). Being engrossed in this self-fulfilling prophecy has significant impacts on health-related behaviors. Furthermore, emotion regulation as well as other types of self-control behaviors become compromised when someone feels lonely (Kearns & Creaven, 2017).

Inadequate self-regulation may contribute to the relationship between loneliness and substance abuse. This relationship is likely bidirectional: some individuals may self-medicate with methamphetamine use in response to distressing feelings of loneliness (Semple et al., 2002), whereas others may first engage in methamphetamine use and subsequently find themselves unable to participate in activities that maintain positive social relationships, leading to feelings of social isolation (Beller & Wagner, 2018a, 2018b). Intuitively, this feedback loop between methamphetamine use and loneliness could have direct or indirect effects on increased sexual risk behaviors and successive adverse health outcomes. Previous work has shown that loneliness (Golub et al., 2010; Hart et al., 2016; Hubach et al., 2012; 2015; Munoz-Laboy et al., 2009; Stickley et al., 2014) and methamphetamine use (Hittner, 2016) are independently associated with riskier sexual behaviors. Loneliness, together with methamphetamine use, may confer additive risk for engaging in riskier sexual behaviors. That is, a lonely individual who turns to methamphetamine to cope with feelings of loneliness may be more likely to engage in riskier sexual behaviors, given the hypersexuality and impulsivity that accompany methamphetamine use. Moreover, a methamphetamine user whose social network has eroded to a point of experiencing loneliness may lack the opportunities (or skills) to engage in safer alternatives to risky sex.

Generally, attitudes and norms about health behaviors are linked to concurrent and future intentions, and engagement in those health behaviors (Geber et al., 2021; Sheeran et al., 2016) including sexual risk behaviors (Sheeran & Orbell, 1998; Sheeran & Taylor, 1999; White et al., 1994). Individuals who use methamphetamine, and perhaps particularly those who are lonely, may have different assessments of risk and consequences in relation to safe sex than those who do not use methamphetamine. If true, addressing beliefs and intentions to practice safer sex in this particularly vulnerable population may be an important treatment focus with critical public health implications.

The goal of this study was to compare the prevalence rates of loneliness between individuals who are dependent on methamphetamine and those who are not dependent on methamphetamine, and evaluate the impact of loneliness on risky sexual beliefs (i.e., poor norms of practicing safer sex) and poor intentions to practice safer sex. We hypothesized that individuals who are dependent on methamphetamine would have higher rates of loneliness than those not dependent on methamphetamine. Furthermore, we hypothesized that loneliness would be associated with riskier beliefs and riskier intentions about sex, such that individuals with high rates of problematic loneliness would endorse poorer personal norms about practicing safer sex and poorer intentions to practice safer sex, particularly among methamphetamine dependent individuals.

2. Materials and methods

2.1. Design

The study was conducted at the University of California San Diego (UC San Diego) Translational Methamphetamine AIDS Research Center (TMARC) from June 2014 to June 2017 after receiving approval from its Institutional Review Board. The current study was conducted as a substudy of a large, center-wide project examining the intersection of

methamphetamine and HIV on the central nervous system (CNS) and behavior, particularly given the established independent effects of methamphetamine and HIV on the CNS (Soontornniyomkij et al., 2016), as well as the link between methamphetamine use and HIV risk (Colfax & Shoptaw, 2005). This larger project sought to study individuals whose methamphetamine use exceeded a particular exposure-threshold to methamphetamine (defined below in Section 2.2); however, recruitment was kept broad to best generalize findings. Therefore, participants were not required to be in a particular stage of their addiction to participate (i.e., active use, treatment-seeking, etc.). Rather, participants were recruited from the greater San Diego community, a primarily an urban city located near the southwest U.S. border. Specific recruitment locations included substance abuse treatment programs, HIV clinics, and the broader community. Recruitment methods included hosting community education events, using social marketing to promote the research study, and engaging in a wide range of community outreach venues (e.g., major community events, networking with care clinics and service providers, and sharing flyers, brochures and posters within the community). After providing written, informed consent, participants underwent a comprehensive, standardized neurobehavioral and neuromedical assessment. Inclusion criteria were broad and encompassed any individuals aged 18 or older from the local community who were able to complete in-person study assessments. Exclusion criteria included prior histories of neurological (e.g., seizure disorders) or severe psychiatric (e.g., schizophrenia) conditions that are independent of methamphetamine and/or HIV infection.

2.2. Participants

Participants included 115 English-speaking adults (> 18 years of age) stratified by whether or not they met the *Diagnostic and Statistical Manual of Mental Disorders* 4th edition (DSM-IV; APA, 1994) criteria for lifetime methamphetamine dependence and methamphetamine abuse or dependence < 18-months prior to study enrollment (METH+; $n = 56$). If individuals did not meet both these criteria, then they were placed in the control group: (METH-; $n = 59$). The DSM-IV was used to assess participants instead of the DSM-5 in order to maintain protocol consistency with other ongoing research projects that were being conducted at our center and had already been developed and executed prior to DSM-5 publication. Thus, the use of DSM-IV allowed for comparisons between other center-wide studies and their cohorts. Criteria for the METH+ group were chosen in order to capture individuals who experienced both severity *and* recency of methamphetamine use-related problems. An 18-month time frame for classifying recent/current methamphetamine abuse or dependence was selected to match DSM-IV's clinical diagnostic time frame (12-month) as closely as possible, while also balancing the feasibility of participant recruitment.

Three individuals in the METH- group reported limited and/or remote methamphetamine use, which did not meet DSM-IV criteria for abuse or dependence. All three individuals were older adults (> 50 years) with at least a high school education. Two of the three individuals were Black (the other being White, non-Hispanic), two were HIV-, and two were male. The age of first methamphetamine use among these three individuals ranged from 30–41 years (median = 35 years), their time since last methamphetamine use ranged from about 1-month to > 25 years (median = about 6-months), their total lifetime methamphetamine use ranged from about 3- to 9-months (median = about 6-months), and

their total lifetime quantity of methamphetamine use ranged from about 6 g to 1.8 kg (median = 13 g).

Individuals meeting criteria for non-methamphetamine substance dependence (e.g., cocaine, opioids) could have been enrolled in the study if they last met criteria > 5 years prior to study enrollment. Similarly, individuals meeting non-methamphetamine substance abuse criteria could have been enrolled in the study if they last met criteria > 12-months prior to study enrollment. Due to high prevalence of alcohol and cannabis use histories in our overall sample (90.4% and 71.3%, respectively), individuals meeting criteria for alcohol or cannabis abuse or dependence were enrolled, provided that criteria for dependence had last been met > 12-months prior to study enrollment. Per these criteria, only one person in each METH- and METH+ group met criteria for current, non-methamphetamine substance use disorder (in both cases, cannabis use disorder). In the overall sample, 58% were people with HIV, which was established by self-report and confirmed by the Miriad HBc/HIV/HCV finger stick point-of-care test (MedMira, Nova Scotia, Canada). Table 1 summarizes other relevant participant characteristics in each METH group, and Table 2 summarizes the DSM-IV-TR diagnostic criteria for methamphetamine abuse and dependence.

2.3. Measures

2.3.1. Loneliness scale—Participants were administered the Loneliness Scale of the NIH Toolbox Emotions Battery (Salsman et al., 2013). This 8-item scale measures perceptions that one is alone, lonely, or socially isolated from others (e.g., “In the past month, please describe how often... I feel alone and apart from others”). Item responses use a Likert-type scale from 1 (never) to 5 (always), with higher scores reflecting greater loneliness. Scores on this scale were also converted to *T*-scores using published norms. Problematic levels of loneliness, suggestive of the potential need for psychological support, was defined as *T*-scores > 60 (Babakhanyan et al., 2018).

2.3.2. Sexual risks scale—This 38-item self-report measure (DeHart & Birkimer, 1997) assesses attitudes about safer sex (e.g., “Condoms ruin the natural act”), personal normative beliefs (e.g., “My friends talk a lot about ‘safer’ sex”), intention to practice safer sex (e.g., “If I were going to have sex, I would take precautions to reduce my risk of HIV/AIDS”), expectations about the feasibility of safer sexual activity (e.g., “If a sexual partner didn’t want to use condoms, we would have sex without using condoms”), and perceived susceptibility to HIV/AIDS (e.g., “I may have had sex with someone who was at risk for HIV/AIDS”). A total score comprised of all the subscales represents current sexual risk. However, this study specifically examined the subscales that assessed personal normative beliefs and intentions to practice safer sex. Item responses used a Likert-type scale from 1 (strongly disagree) to 5 (strongly agree), with higher scores representing greater personal norms toward practicing safer sex and greater intentions to try to practice safer sex.

2.3.3. Substance use and mood assessment—The Composite International Diagnostic Interview (CIDI) version 2.1 (Kessler & Ustun, 2004; Wittchen, 1994) was administered to assess for the presence of current and lifetime substance abuse and dependence, as well as mood disorders (i.e., major depressive disorder, dysthymia, and

bipolar I and II) based on the DSM-IV criteria (APA, 1994). Participants completed a modified self-report methamphetamine use timeline follow-back (TLFB) assessment (Rippeth et al., 2004). In this adapted approach, participants' quantities and frequencies of substance use were assessed across different participant-identified periods of use in their lifetime (e.g., from age 22 to 30, age 34 to 42, etc.) beginning with their age of first use. An estimate of total lifetime days of use and total lifetime quantity of use was calculated by summing reported estimates across these periods. Variables collected from this modified TLFB method included age of first use, lifetime cumulative quantity (grams), lifetime cumulative frequency (days), density of use (average grams per day; cumulative grams divided by cumulative days), and recency of use (days since last use). This approach has shown sensitivity to capturing differences in substance use characteristics between those with and without a substance use disorder, despite reliance on self-report and rough estimates across the lifetime (Cherner et al., 2010; Paolillo et al., 2019).

2.3.4. Neurocognitive impairment—Participants completed a comprehensive neuropsychological test battery assessing seven neurocognitive domains; details are described in Heaton et al. (2010). A global deficit score (GDS) ranging from 0 (normal) to 5 (severe) was created, which is described in detail in Carey et al. (2004). Individuals with a GDS of ≥ 0.5 were classified as neurocognitively impaired. The reading subtest of the Wide Range Achievement Test – Fourth Edition (WRAT-4; Wilkinson & Robertson, 2006) was administered as an estimate of pre-morbid verbal IQ.

2.3.5. Sarason social support scale—This 27-item questionnaire measures an individual's perceived social support network and their satisfaction with that support (Sarason et al., 1983). Participants are asked to list the number of family members and friends in their social network, excluding themselves, whom they can rely on during different situations (e.g., "How many people can you really count on to distract you from your worries when you feel under stress?"). Participants are also asked to rate their satisfaction with the overall social support that they receive in each situation using a Likert-type scale (1 = Very Dissatisfied to 6 = Very Satisfied). Higher scores reflect larger social support networks, or greater satisfaction with their received support.

2.3.6. Sexual risk behavior subscale—The Sexual Risk Behavior Subscale is a component of the 24-item Risk Assessment Battery (Navaline et al., 1994), which assesses an individual's self-reported risk behaviors related to drug use and risky sexual practices. Participants were asked to rate the frequency of engaging in these behaviors during and prior to the past 6-months (e.g., "How often did you use condoms when you had sex?"). Item responses are summed and range from 0 to 22. Higher scores indicate more frequent engagement in past risky sexual behaviors.

2.3.7. Impulsivity/disinhibition—Impulsivity/disinhibition was measured using a validated *T*-score composite approach comprised of the following scales: 1) the Disinhibition subscale of the Frontal Systems Behavior Scale (FrSBe) self-report (Grace & Malloy, 2001), 2) the Urgency and Lack of Premeditation subscales of the UPPS Impulsive Behavior Scale (Whiteside & Lynam, 2003), and 3) the Barratt Impulsiveness

Scale (BIS-11) total score (Patton et al., 1995). Details of the composite *T*-score approach are described in detail in Marquine et al. (2014). Higher scores represent greater impulsivity/disinhibition.

2.4. Statistical analyses

Demographic characteristics and scores on the aforementioned behavior scales were compared between the METH-/+ groups using *t*-tests for continuous variables and Pearson χ^2 tests, or Fisher's Exact Test (for small cell frequencies, i.e., $n < 20$) for dichotomous or nominal variables. Non-parametric Spearman's ρ was used to examine univariable associations with loneliness given the non-normal distribution of scores.

Multivariable linear regression was used to investigate the association between loneliness and METH-/+ groups, as well as the association between loneliness and sexual risk norms and intentions. Participant characteristics from Table 1 were selected as covariates in the multivariable regression if they significantly differed between METH-/+ groups using a critical α -level of .05 (e.g., age, education, premorbid verbal IQ, lifetime history of other substance use disorders). Lifetime history of mood disorder and social support network were also considered as covariates given their significant associations (at a critical α -level of .01) with the primary outcome variables (e.g., loneliness and/or sexual risk norms and intentions). Due to high collinearity between premorbid verbal IQ and years of education, the former was selected as the model covariate given its robustness to other potential confounds (e.g., quality of education). Though HIV serostatus and neurocognitive impairment were unrelated to loneliness in our overall sample, they were selected as covariates because of prior literature supporting their associations with loneliness (Abell et al., 2019; Yoo-Jeong et al., 2020). In our overall sample, people with HIV also were more likely to have engaged in riskier sexual behaviors over the past 6-months and prior to the past 6-months compared to HIV- individuals. Additionally, although 98.5% of people with HIV were on antiretroviral therapies (ART; 90% of whom were adherent to ART) and 82.3% had undetectable viral loads that were unassociated with poorer norms or poorer intentions to practice safer sex, HIV+ serostatus was associated with poorer intentions to practice safer sex in the whole sample, thereby providing support to include HIV serostatus as a covariate during analyses. Statistical significance was determined using a critical α -level of .05 for all analyses.

3. Results

3.1. Prevalence rates of loneliness in METH- and METH+ individuals

Both the continuous loneliness *T*-score and the proportion of individuals with potentially problematic loneliness (*T*-score > 60) were significantly higher in METH+ than METH- individuals (METH+: $M = 59.63$, $SD = 10.99$; METH-: $M = 54.30$, $SD = 12.32$; $t(113) = 2.45$, $p = .02$; see Figure 1). Of the characteristics listed in Table 1, lifetime history of mood disorder and smaller social support network were significantly associated with greater loneliness in the whole group at the univariable level ($p < .01$), and therefore included as covariates in the subsequent multivariable regression. Despite covariate inclusion, METH+ remained significantly associated with greater loneliness ($\beta = 2.92$, $p = .02$; $F = 3.70$, Adj

$R^2 = 0.18, p = .0009$). Other significant covariates predicting loneliness included HIV+ serostatus ($\beta = 2.20, p = .047$), total number of people in social support network ($\beta = -0.09, p = .001$), and premorbid verbal IQ ($\beta = 0.18, p = .02$).

3.2. Univariable associations with loneliness within METH-/+ groups

The Spearman ρ correlations between loneliness and continuous variables in METH- and METH+ groups are listed in Table 3, as well as results of one-way ANOVAs comparing loneliness across categorical variables. There was a significant, omnibus difference in loneliness across people of different ethnicities in the METH-, but not in the METH+ group. Among METH- individuals, Black participants reported the highest loneliness ($M = 61.84, SD = 9.62$), while other/Hispanic participants were the least lonely ($M = 56.32, SD = 12.13$). Those with a lifetime history of mood disorder reported significantly higher loneliness ($M = 59.66, SD = 11.18$) compared to those without ($M = 51.55, SD = 12.09$), but only within the METH- group. In the METH+ group, people with HIV ($M = 62.10, SD = 8.10$) were significantly lonelier than HIV- individuals ($M = 56.09, SD = 13.57$); there was no HIV effect on loneliness in the METH- group. The only non-methamphetamine use disorder that was associated with loneliness was lifetime history of opioid use disorder; however, this association was only noted in the METH+ group. Specifically, those in the METH+ group with a lifetime history of opioid use disorder reported lower loneliness relative to METH+ individuals without lifetime history of opioid use disorder. Greater norms about practicing safer sex and greater intentions to practice safer sex were each significantly associated with lower current sexual risk in both groups (ρ s = 0.65 to 0.82).

3.3. Multivariable association between loneliness and beliefs, intentions to practice safer sex

In a multivariable regression with only METH+ individuals, potentially problematic levels of loneliness ($\beta = -2.21, p = .02$) and neurocognitive impairment ($\beta = 1.70, p = .046$) remained significantly associated with poorer beliefs about practicing safer sex after controlling for age, HIV serostatus, lifetime history of mood disorder, lifetime history of other substance use disorder, age of first methamphetamine use, and total number of people in social support network ($F = 2.41, \text{Adj } R^2 = 0.20, p = .03$). In METH- individuals, this model (excluding age of first methamphetamine use) was not significant. Findings remained unchanged when lifetime history of other substance use disorders was replaced with the more specific lifetime history of opioid use disorder variable. In addition, our results held regardless of the recency of participants' methamphetamine use, which could also serve as a proxy for recruitment source (i.e., participants who were recruited at a substance use treatment center vs. those recruited from a community flyer would likely have had more recent methamphetamine use).

In METH+ individuals, potentially problematic levels of loneliness ($\beta = -2.65, p = .03$) and HIV+ serostatus ($\beta = -3.00, p = .009$) remained significantly associated with poorer intentions to practice safer sex after controlling for age, neurocognitive impairment, premorbid verbal IQ, lifetime history of mood disorder, lifetime history of other substance use disorders, age of first methamphetamine use, and total number of people in social support network ($F = 2.63, \text{Adj } R^2 = 0.25, p = .02$). In METH- individuals, this model

(excluding age of first methamphetamine use) was not significant. Again, findings remained unchanged when lifetime history of other substance use disorders was replaced with lifetime history of opioid use disorder, and when recency of methamphetamine use was considered.

3.4. Effect of impulsivity/disinhibition, loneliness, and methamphetamine status on beliefs and intentions to practice safer sex

Given prior literature suggesting the role of impulsivity/disinhibition in the relationship between loneliness and sexual risk behavior (Torres & Gore-Felton, 2007), the effect of impulsivity/disinhibition on poorer beliefs about and intentions to practicing safer sex was also considered. In the overall sample, higher impulsivity/disinhibition was associated with having potentially problematic levels of loneliness ($t = 3.60$, $df = 105$, $p = .0005$), regardless of methamphetamine status. However, impulsivity/disinhibition did not reach statistical significance when predicting beliefs about practicing safer sex ($F = 3.38$, $Adj R^2 = 0.10$, $p = .007$) or intentions to practice safer sex ($F = 7.94$, $Adj R^2 = 0.25$, $p < .0001$) after controlling for HIV serostatus, methamphetamine status, potentially problematic loneliness, and the interaction between methamphetamine status and potentially problematic loneliness.

The interaction between methamphetamine status and potentially problematic loneliness was a significant contributor of both beliefs about practicing safer sex ($\beta = 5.37$, $p = .03$) and intentions to practice safer sex ($\beta = 6.09$, $p = .03$). HIV-positive serostatus was also a significant contributor of poorer intentions to practice safer sex ($\beta = -4.71$, $p = .0009$), but not beliefs about practicing safer sex. There was no significant interaction between HIV and methamphetamine status on intentions to practice safer sex. Figures 2 and 3 illustrate the interactive effect between potentially problematic loneliness and methamphetamine on norms and intentions to practice safer sex.

4. Discussion

Our findings indicate that individuals with methamphetamine use disorders reported higher levels of loneliness than those in a METH⁻ comparison group, consistent with prior reports (Semple et al., 2002), although previous work is limited. Our cross-sectional results cannot disentangle directionality of this relationship, but it is presumed to be bidirectional: loneliness may predispose people to methamphetamine use, and methamphetamine use may have severe social consequences that contribute to loneliness. Increased loneliness in METH⁺ compared to METH⁻ individuals held despite comparable levels of exposure to factors associated with loneliness (e.g., age, depression, social network size, and HIV serostatus). In fact, 50% of the METH⁺ group met criteria for problematic levels of loneliness, highlighting a potential need for psychological intervention, compared to about 30% in the METH⁻ group. The presence of loneliness also may result in poorer personal norms and intentions about practicing safer sex, possibly as a means of emotional pain and distress avoidance (stemming from perceived social isolation or perceived social rejection) through pleasure-seeking behaviors, resulting in the potential to engage in unsafe sexual behaviors. As such, loneliness can have indirect, downstream public health implications in a population already at high risk for engaging in riskier behaviors (e.g., riskier sexual practices).

In the general population, loneliness is a significant risk factor for many negative health consequences such as cognitive decline (Abell et al., 2019; J. T. Cacioppo & Cacioppo, 2014; Child & Lawton, 2019; Wilson et al., 2007) and cardiovascular risk (Christensen et al., 2020; Hawkey et al., 2003; 2010). In people with HIV, loneliness has been associated with poorer immune function (Rendina et al., 2019), more depressive symptoms (Yoo-Jeong et al., 2020), and lower CD4+ count (Straits-tröster et al., 1994). Recent work has highlighted the association between loneliness and substance use and dependence such as opioid use disorder (McDonagh et al., 2020; Pedrero-Perez et al., 2020; Polenick et al., 2019), alcohol use disorder (Munoz-Laboy et al., 2017; Pinedo Gonzalez et al., 2021; Rodriguez et al., 2010), and co-occurring addictive disorders such as gambling and internet addiction (Savolainen et al., 2020).

Our study extends this research to illustrate that among individuals who are dependent on methamphetamine, loneliness is also associated with riskier beliefs and intentions about practicing safer sex, above and beyond the impact of other pertinent factors. The higher prevalence of loneliness in methamphetamine users, and its association with riskier beliefs and intentions about practicing safer sex, may be explained by some of the following aspects specific to methamphetamine addiction (Newton et al., 2009): positive reinforcement (“pleasure seeking”), negative reinforcement (“pain avoidance”), inhibitory control dysfunction (“impulsivity”), incentive salience (“craving”), and stimulus response learning (“habits”). Newton et al. (2009) found that positive reinforcement through pleasure-seeking behaviors was the primary motivator for most METH+ individuals, however, pain avoidance was also an important, non-overlapping factor. Thus, people may engage in methamphetamine use and subsequent riskier sexual behaviors as coping methods to avoid the emotional pain associated with loneliness and/or rejection, particularly if they have poor inhibitory control.

Torres and Gore-Felton (2007) proposed this type of paradigm, which they called the Loneliness and Sexual Risk Model (LSRM), that posits that the relationship between loneliness and sexual risk behavior is mediated by substance use and impulsive behavior. In our sample, individuals who experienced potentially problematic levels of loneliness reported significantly higher impulsivity/disinhibition than those who reported loneliness within normal limits across both METH-/+ groups, providing initial support for the LSRM model. However, in separate multivariable regression models with beliefs and intentions to practice safer sex as outcome variables, the interaction between potentially problematic loneliness and methamphetamine status was statistically significant while impulsivity/disinhibition was not, suggesting that an individual who is methamphetamine dependent *and* lonely has worse beliefs and intentions to practice safer sex than their lonely METH- counterparts, regardless of their impulsivity/disinhibition level.

Polysubstance use is an important aspect in methamphetamine dependence that was also considered in our cohorts (Ellis et al., 2018; Timko et al., 2018). Of the three non-methamphetamine lifetime substance use disorders that were examined (alcohol, cocaine, and opioid), there was a significant association between loneliness with lifetime opioid use disorder. This association was found in only the methamphetamine dependent group, but occurred in the opposite direction than what was to be expected. However, given the

relatively low prevalence of positive lifetime opioid use disorder in the whole sample, as well as within the methamphetamine dependent group (only 8 of 56 individuals), these findings may have been driven by a skewed sample. Even when DSM-IV substance use disorder criteria were not considered, the number of individuals reporting *any* lifetime opioid use was low (one person in METH– group and 13 people in METH+ group), again suggesting a skewed, non-representative sample of opioid users. By contrast, alcohol and cannabis were the substances that had the most number of people reporting any lifetime use (90.4% and 71.3% in the whole sample, respectively). Post-hoc analyses found that both cumulative densities of alcohol and cannabis were significantly higher in the METH+ than the METH– group, suggesting that methamphetamine dependent individuals consumed larger quantities of these substances over shorter periods of time relative to individuals who were not methamphetamine dependent. However, neither alcohol density or cannabis density predicted loneliness, beliefs about practicing safer sex, or intentions to practice safer sex. Rather, methamphetamine dependence consistently predicted these variables above and beyond alcohol use, cannabis use, and other covariates such as age and HIV status, indicating its robust effects on both loneliness and the potential of engaging in riskier sexual behaviors.

Our study did not find a link between poorer norms and intentions to practice safer sex among people with HIV who had undetectable viral loads, suggesting that they are equally as concerned about taking part in unsafe sex compared to people with HIV who were detectable for the virus. However, people with HIV *are* more likely to engage in riskier sexual behaviors in the past 6 months and prior to the past 6 months than HIV– individuals. We did not find an association between loneliness and self-reported, past sexual risk behaviors (e.g., frequency of condom use during sex) in the whole sample. However, given the cross-sectional nature of our study, it may be inappropriate to link current feelings of loneliness with past risky sexual behaviors. Rather, it may be more informative to investigate the factors that have been shown to be significantly associated with future sexual risk behaviors in the literature such as attitudes, personal norms, and intentions of engaging in safer sex (Sheeran & Orbell, 1998; Sheeran & Taylor, 1999; White et al., 1994). Indeed, our data confirmed that beliefs and intentions of engaging in safer sex were significantly associated with lower *current* sexual risk.

Findings from this study have potential, important public health implications related to identifying and treating individuals who may be at-risk for engaging in HIV-transmission risk behaviors. Prior work has shown that methamphetamine use is a predictor of riskier sexual intentions (Darke et al., 2008) and riskier sexual practices (Loza et al., 2020; Mausbach et al., 2009). However, changing drug use behavior may not be a realistic goal, or sufficient target in sexual risk reduction interventions; rather, addressing maladaptive coping due to emotional distress may be more successful (Semple et al., 2004). Thus, identification of lonely individuals who are dependent on methamphetamine, and whom we found were more likely to report poorer personal norms and intentions to engage in safer sex practices, allows us to capture an at-risk group and consider alternative approaches that could be integrated into substance use treatment programs to reduce riskier sexual behaviors. Increased opportunities for social contact (e.g., social recreation intervention), one-on-one or group interventions based on mutual aid, enhanced social support (e.g., through mentoring

programs, Buddy-care program, conference calls), improving social skills (e.g., speaking on the phone, giving and receiving compliments, enhancing nonverbal communication skills), and addressing maladaptive social cognitions (e.g., cognitive behavioral therapy) may all be important target areas to reduce the prevalence of loneliness in this at-risk population.

Though this study provides preliminary evidence for the importance of identifying those with high feelings of loneliness, and its implications on future attitudes and beliefs about engaging in potentially risky behaviors, it is not without limitations. First, our data are cross-sectional, so we cannot assume directionality or claim that loneliness influences riskier personal norms and intentions to practice safer sex. It is entirely possible that a bidirectional relationship may exist. Our selection criteria were developed such that they focused on studying methamphetamine effects while minimizing the potential confounding effects of other substances. By doing so, generalizability of findings to poly-substance users becomes more limited. Similarly, recruitment from HIV clinics may introduce some confounding factors that may not have been fully accounted for by controlling for HIV status, thus potentially limiting generalizability to non-HIV populations. Though results from our recruited sample suggest that the relationship between loneliness and riskier beliefs and intentions about practicing safer sex are theoretically relevant to many kinds of individuals (i.e., active methamphetamine users, those seeking treatment, and recently abstinent former methamphetamine users), future work should specifically examine whether there are particularly risky periods of methamphetamine addiction in which loneliness more strongly influences riskier beliefs and intentions about safer sex practices, which could be investigated by evaluating the specific recruitment sources (e.g., substance use treatment centers, HIV clinics, community flyers). Furthermore, given the discrepancy between average age of first methamphetamine use (22 years) relative to the average age in the METH+ sample (40 years), a potential survival bias may exist, which may skew findings. Of note, the proportion of individuals with HIV in the METH- and METH+ groups were nearly identical (57.6% vs 58.9%, respectively), suggesting that if survival bias is present, it is more likely specific to methamphetamine-related characteristics rather than HIV-related selective survival bias. Our current design also did not query further into the dimensions of loneliness (e.g., intimate loneliness, relational loneliness, collective loneliness) that an individual may be encountering (S. Cacioppo et al., 2015). Additionally, although our sample was large enough to see robust effects, it was relatively small, especially considering the number of potentially important covariates. This research would ideally be replicated in a larger sample of METH- and METH+ individuals. Further work should also investigate how loneliness may differentially influence attitudes about sex among individuals with different partner statuses (e.g., married, single, polyamorous relationships, etc.), as well as among sexual and gender minorities, especially given important considerations raised by Bryant et al. (2018) and Race et al. (2017) regarding the role of controlled drug use and safer sex in facilitating community, building identity, and responding to marginalization in such minority groups.

Despite these limitations, our findings highlight the high prevalence of loneliness among individuals with methamphetamine use disorder, and explores the potential impact of loneliness among those who are typically at-risk of engaging in HIV-related risk behaviors by finding a unique association between loneliness and riskier beliefs and intentions

regarding the practice safer sex. These results suggest potential areas of intervention, including promotion of adaptive beliefs and intentions to engage in safer behaviors. In addition, findings from this study are highly relevant during the current COVID-19 pandemic, as individuals have been required to engage in unprecedented social distancing and may be experiencing the effects of prolonged social isolation. Consequently, feelings of loneliness and mental health problems could be elevated (Killgore et al., 2020), and may contribute to engagement in riskier behaviors such as practicing poorer safer sex in order to feel social connection, pleasure, and avoid emotional pain.

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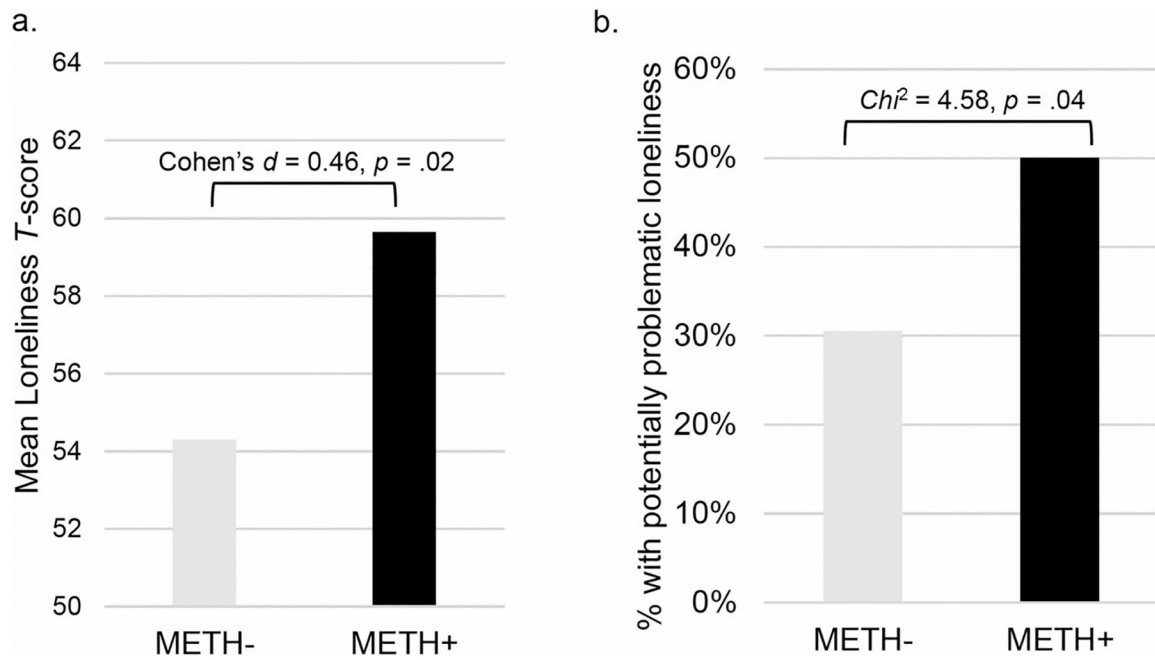


Figure 1.

(a) Mean loneliness T -scores between METH – and METH+ groups. b) Percent of individuals reaching potentially problematic levels of Loneliness ($T > 60$) in METH – and METH+ groups.

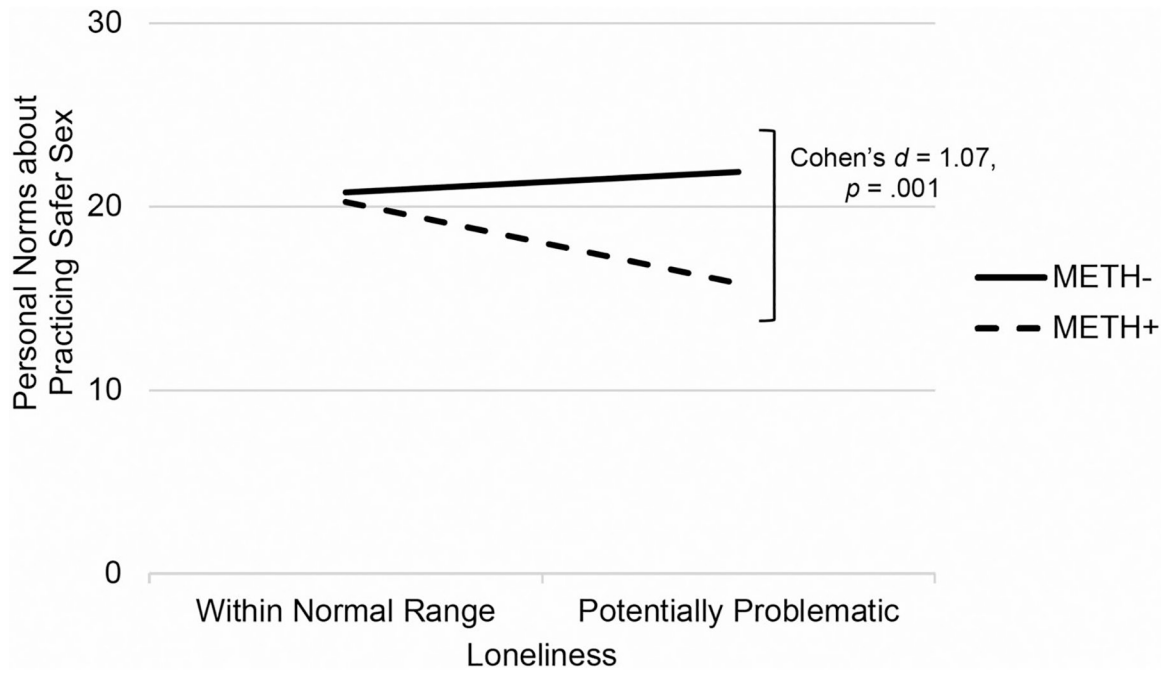


Figure 2. The interaction between the degree of loneliness (within normal range and potentially problematic) and methamphetamine status (METH – and METH+) on personal beliefs and norms about practicing safer sex.

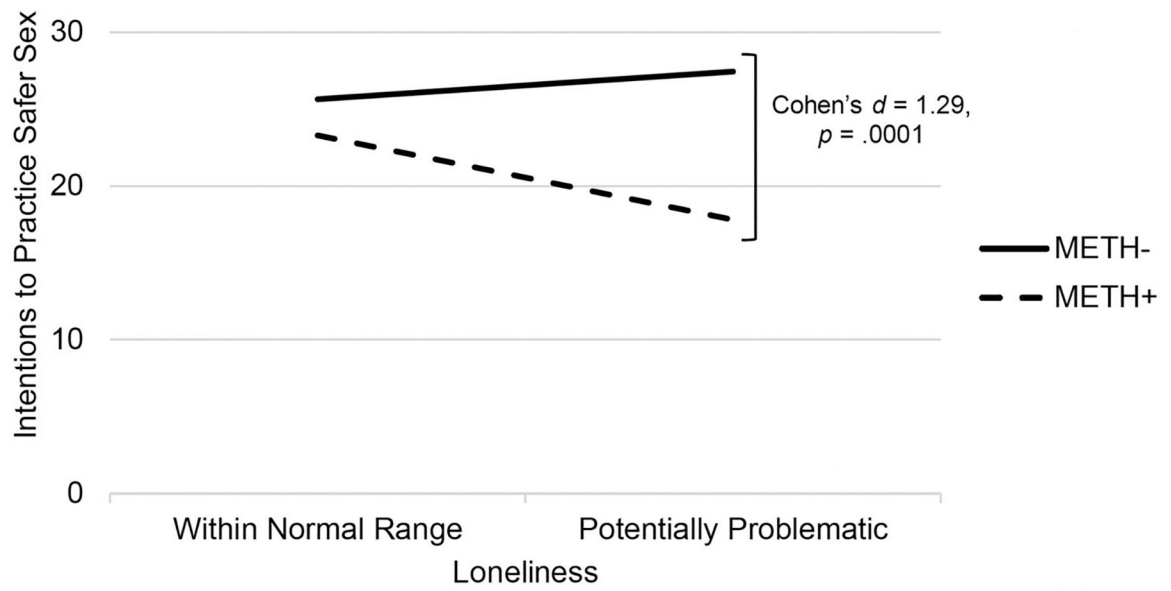


Figure 3. The interaction between the degree of loneliness (within normal range and potentially problematic) and methamphetamine status (METH – and METH+) on intentions to practice safer sex.

Table 1.

Participant demographics and descriptive statistics.

	METH- (n = 59)	METH+ (n = 56)	p
<i>Demographics</i>			
Age (years)	48.6 (14.0)	40.0 (10.6)	.0004
Education (years)	15.1 (2.3)	13.0 (2.5)	<.0001
Sex/Gender (% male)	79.3%	74.1%	.65
<i>Ethnicity</i>			
% White, non-Hispanic	56.9%	40.7%	.09
% Hispanic	17.0%	37.5%	.02
% Black	18.6%	8.93%	.18
% Other ^a	6.8%	10.7%	.52
HIV status (% HIV+)	57.6%	58.9%	.89
<i>Neuropsychiatric characteristics</i>			
Premorbid Verbal IQ ^b	105.4 (15.3)	99.8 (13.5)	.04
Neurocognitive Impairment (% impaired)	34.5%	35.2%	.94
Lifetime Mood Disorder ^c (% yes)	33.9%	44.6%	.24
Lifetime Other ^d Substance Use Disorder (% yes)	28.8%	69.6%	<.0001
Lifetime Alcohol Use Disorder (% yes)	28.6%	72.2%	<.0001
Lifetime Cocaine Use Disorder (% yes)	1.8%	27.8%	<.0001
Lifetime Opioid Use Disorder (% yes)	1.8%	14.8%	.02
<i>Methamphetamine use characteristics (Median [IQR])</i>			
Age of first use	–	22.0 [18.0, 30.0]	–
Lifetime cumulative quantity of use (grams)	–	1300.7 [374.8, 3112.5]	–
Lifetime cumulative frequency of use (days)	–	2212.5 [716.5, 3732.3]	–
Density of use (grams/days)	–	0.9 [0.5, 1.5]	–
Recency of use (days since last use)	–	32.7 [4.8, 152.2]	–
<i>Sarason social support scale</i>			
Total # people in overall network	43.7 (45.3)	36.0 (33.8)	.35
Average # people in overall network	3.5 (3.5)	2.8 (2.6)	.26

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	MEIH- (n = 59)	MEIH+ (n = 56)	p
Overall satisfaction with network	29.7 (6.5)	27.4 (7.1)	.09
Average satisfaction with network	4.9 (1.1)	4.6 (1.2)	.09
<i>Sexual risks scale</i>			
Beliefs regarding practicing safer sex	21.1 (6.3)	17.9 (5.8)	.008
Intention to practice safer sex	26.2 (7.4)	20.4 (7.3)	.0001
<i>Risk assessment battery</i>			
Sexual Risk Behavior Subscale (≤ 6 mo)	5.7 (2.9)	7.3 (4.0)	.02
Sexual Risk Behavior Subscale (> 6 mo)	7.2 (3.3)	10.1 (3.8)	<.0001
Impulsivity/disinhibition composite (T)	53.6 (9.1)	69.6 (12.8)	<.0001

Note.

^a Asian, Native Hawaiian/Pacific Islander, American Indian/Alaska Native, or did not identify with any ethnicities;

^b WRAT-4 Reading score;

^c Major Depressive Disorder and/or Bipolar I/II;

^d Alcohol, Cocaine, Opioid.

Table 2.

Summarized DSM-IV-TR diagnostic criteria for substance abuse and substance dependence (APA, 1994).

	Abuse	Dependence
Criteria	1 symptom(s) in a 12-month period	3 symptoms in the same 12-month period (or 1 symptom[s] if dependence criteria was previously in one's lifetime)
Symptoms	<ul style="list-style-type: none"> • Recurrent substance-related legal problems • Recurrent substance use in situations where it is physically hazardous • Recurrent substance use resulting in a failure to fulfill major role obligations at work, school, or home • Continued substance use despite having persistent or recurrent social or interpersonal problems caused or exacerbated by the effects of the substance 	<ul style="list-style-type: none"> • Substance is taken in larger amounts or over a longer period than was intended • Persistent desire or unsuccessful efforts to cut down or control substance use • Great deal of time is spent in activities necessary to obtain the substance, use the substance, or recover from its effects • Substance use is continued despite knowledge of having a persistent or recurrent physical or psychological problem that is likely to have been caused or exacerbated by substance use • Important social, occupational, or recreational activities are given up or reduced because of substance use • Tolerance, as defined by either: (1) a need for markedly increased amounts of substance to achieve intoxication or desired effect or (2) a markedly diminished effect with continued use of the same amount of the substance • Withdrawal, as defined by either: (1) the characteristic withdrawal syndrome for the substance or (2) the substance (or a similar substance) is taken to relieve or avoid withdrawal symptoms

Table 3.

Univariable associations with loneliness within METH-/+ groups.

	METH- (n = 59)	METH+ (n = 56)	Statistical association ^a	Risk direction (higher loneliness)	Statistical association ^a
Demographics					
Age	-	-	-	Older age	$\rho = .28^{**}$
Education	-	-	-	More educated	$\rho = .29^{**}$
Sex/Gender	-	-	-	-	-
Ethnicity	-	-	-	-	-
White, non-Hispanic vs non-White	-	-	-	-	-
Hispanic vs non-Hispanic	-	-	-	-	-
Black vs non-Black	Black	-	$F = 5.46^*$	-	-
Other ^b vs White, Hispanic, Black	-	-	-	-	-
HIV status	-	-	-	HIV+	$F = 4.29^*$
Neuropsychiatric characteristics					
Premorbid Verbal IQ ^c	-	-	-	-	-
Neurocognitive Impairment	-	-	-	-	-
Lifetime Mood Disorder ^d	Hx of mood disorder	-	$F = 6.25^*$	-	-
Lifetime Other ^e Substance Use Disorder	-	-	-	-	-
Lifetime Alcohol Use Disorder	-	-	-	-	-
Lifetime Cocaine Use Disorder	-	-	-	-	-
Lifetime Opioid Use Disorder	-	-	-	No lifetime opioid dx	$F = 4.79^*$
Methamphetamine Use Characteristics ^f					
Age of first use	-	-	-	Older age	.32 ^{**}
Lifetime cumulative quantity of use	-	-	-	-	-
Lifetime cumulative frequency of use	-	-	-	-	-
Density of use	-	-	-	-	-

	METH-	METH+
	(n = 59)	(n = 56)
	Risk direction (higher loneliness)	Risk direction (higher loneliness)
	Statistical association ^a	Statistical association ^a
Recency of use	-	-
Sarason Social Support Scale		
Total # people in overall network	Less total people	Less total people
Average # people in overall network	Less average people	Less average people
Overall satisfaction with network	Less satisfied overall	Less satisfied overall
Average satisfaction with network	Less satisfied on avg	Less satisfied on avg
Sexual Risks Scale		
Beliefs regarding practicing safer sex	-	Poorer beliefs
Intention to practice safer sex	-	Poorer intentions
Risk Assessment Battery		
Sexual Risk Behavior Subscale (6 mo)	-	-
Sexual Risk Behavior Subscale (> 6 mo)	-	-
Impulsivity/disinhibition composite (T)	More impulsive/disinhibited	More impulsive/disinhibited
	$\rho = -.48$ ***	$\rho = .26$ *

Note.

^aIf univariable association with loneliness is significant, then Spearman's ρ (correlation between loneliness and continuous variables), or *F*-statistic (one-way ANOVA determining whether loneliness differs across categorical variables) will be noted;

^bAsian, Native Hawaiian/Pacific Islander, American Indian/Alaska Native, or did not identify with any ethnicity;

^cWRAT-4 Reading score;

^dMajor Depressive Disorder and/or Bipolar I/II;

^eAlcohol, Cocaine, Opioid;

^fIn subset of METH+ individual (N = 56).

* $p < .10$;

** $p < .05$;

*** $p < .001$.