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Methamphetamine use drives decreases in viral suppression for people living with HIV released from a large municipal jail: Results of the LINK LA clinical trial

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ABSTRACT

Background: People living with HIV (PLWH) often experience decreases in HIV viral suppression (VS) after release from jail. The Linking Inmates to Care in LA (LINK LA) peer navigation intervention helped maintain VS 12 months after release from jail compared to standard of care. In this study, we analyzed correlates of substance use and tested whether substance use was an independent correlate of decreased VS in LINK LA participants.

Methods: We analyzed LINK LA data collected at baseline, 3, and 12 months. We defined high-risk drug use as any reported methamphetamine, cocaine, or opioid use in the 30 days prior to a study visit (or jail entry at baseline). We used generalized linear mixed models to test associations of sociodemographic variables with type of substance used, and we tested correlates of VS while controlling for time, the intervention, and their interaction.

Results: At baseline (n = 356), 71% of participants reported high-risk drug use: 58%, methamphetamine; 17%, cocaine; 7%, heroin; and 4%, prescription opioids. Non-Hispanic Whites and those younger than 35 were most likely to use methamphetamine; Blacks were most likely to use cocaine; people who inject drugs were most likely to use opioids. Participants who used high-risk drugs had 53% lower adjusted odds than non-users of maintaining VS (AOR 0.47, 95% CI 0.31–0.70, p < 0.001).

Conclusion: High-risk drug use, dominated by methamphetamine use, independently correlated with decreased VS among recently incarcerated PLWH. Improving HIV care continuum outcomes among populations leaving jail requires attention to efforts to address high-risk drug use.

1. Introduction

In the United States, viral suppression (VS) improved dramatically in the general population of people living with HIV (PLWH) following the introduction of convenient, highly active, and highly tolerable antiretroviral therapy regimens (Nance et al., 2018). Yet, PLWH who are outside of the HIV care continuum and not virally suppressed continue to be the major source of HIV transmission (Escudero et al., 2017;

Skarbinski et al., 2015) and preventable HIV-related morbidity and mortality (Kerr et al., 2014; 2012; Lesko et al., 2015). Disparities in engaging and retaining PLWH in the care continuum disproportionately affect PLWH who use substances (Korthuis and Edelman, 2018; Lazar et al., 2017), are involved in the criminal justice system (CJS) (Iroh et al., 2015), or are racial/ethnic minorities— especially Black and Hispanic PLWH (Lazar et al., 2017). Adequately engaging those who are not virally suppressed into the HIV care continuum is essential to

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reach goals of 90% of people leaving with HIV diagnoses, 90% of these in HIV medical care, and 90% of these virally suppressed (i.e., 90-90-90 goals) in the United States (Kay et al., 2016).

The transition period following release from correctional facilities can be marked by HIV viremia for PLWH due to medical care disruptions (Iroh et al., 2015). Linking Inmates to Care in LA (LINK LA) was a randomized controlled trial that was designed to test an intervention to improve linkage, retention, and antiretroviral therapy (ART) adherence among PLWH released from a large municipal jail with the goal of achieving or maintaining VS (Cunningham et al., 2018). LINK LA enrolled a racially diverse group of PLWH (42% Black, 31% Hispanic, 27% White) prior to release from the nation's largest municipal jail, with 78% reporting either high-risk drug (stimulants or opioids) or binge alcohol use. LINK LA examined a peer navigation intervention that maintained VS in 49% of the intervention group from baseline to month 12, compared to a decrease from 52% to 30% in the control group, for a significant difference-in-difference of 22%. Although high-risk drug use declined over time for all participants (20% decline in the intervention arm, 16% in the control arm), there was no statistically significant effect of the intervention on high-risk drug use, and there was no interaction between the intervention and high-risk drug use.

In observational studies, a co-existing substance use disorder has often been associated with decreases in VS or HIV care engagement after release from incarceration (Ammon et al., 2018; Chitsaz et al., 2013; Harawa et al., 2017; Palepu et al., 2004). Of the many previous studies of the connections between drug use and HIV outcomes, a large proportion have focused on injection drug use as a key marker of the deleterious effects of drug use. However, many fewer studies have examined the links of HIV continuum outcomes with the specific types of drug used (Lesko et al., 2017; Westergaard et al., 2013, 2011).

For the present study, we had 3 main goals: 1) to examine the sociodemographic and clinical characteristics correlated with use of specific types of drugs (including binge alcohol use) among participants in the LINK LA study at baseline; 2) to examine the sociodemographic and clinical predictors of using specific drug types over the 12 months following release from Los Angeles (LA) County Jail; and 3) to evaluate the associations of specific substance use types with VS, independent of the intervention effects for the 12 months of follow-up among men and transgender women living with HIV after release from incarceration in the LINK LA study. We hypothesized that participants who reported use of any high-risk drugs would be less likely to maintain VS over time, over and above known positive effects of the peer navigation intervention on VS.

2. Methods

2.1. Parent study

LINK LA was a randomized controlled trial conducted in LA, California between December 2012 and October 2016. A detailed description of the study, intervention, and findings have been published (Cunningham et al., 2018). In brief, LINK LA enrolled PLWH who had been released from LA County Jail. Participants were 1) adult, 2) men or transgender women, 3) living with HIV, 4) residents of LA County, 5) English speaking, 6) eligible for or receiving antiretroviral therapy, and 7) selected for HIV transitional case management prior to enrollment. The study randomized participants to one of two groups: 1) the intervention group: received LINK LA peer navigation and a 12-session intervention based on Social Cognitive Theory imparted by peers over 6-months; 2) the control group: received standard transitional case management. Participants in both arms received referrals for post-release housing, substance abuse treatment, and HIV care. These referrals were provided by peer navigators to participants in the intervention group and by case managers to participants in the control group. Participants were interviewed in-person by trained research assistants before release (baseline) then at months 3, 6, and 12. All study procedures

were reviewed and overseen by the LA County Department of Public Health institutional review board (IRB) and the UCLA IRB.

2.2. Measures

2.2.1. Substance use

Substance use was assessed by a standardized questionnaire that included questions for alcohol (use and intoxication), heroin, methadone, prescription opioids misuse (e.g., oxycodone or other opioids), crack, cocaine, and methamphetamine or amphetamines, among others. At baseline, participants were asked if they ever used a substance; if they answered yes, the participants were asked if the substance was used within the 30 days prior to arrest and the duration of use in years. At follow-up assessments, participants reported their use of the substance 30 days before the visits. There is extensive evidence to support the reliability and validity of self-reported substance use, when collected by trained interviewers, as in LINK LA (Dowling-Guyer et al., 2016; Johnson et al., 2000; Weiss et al., 1998). We created a composite variable, *high-risk drug use*, defined as any reported use of heroin, cocaine (powder or crack), methamphetamines or misuse of prescription opioids in the 30 days prior to being arrested (used at baseline) and 30-days prior to each follow-up assessment. We grouped the use of these substances, as they have the most consistently observed association with unsuppressed viral load in PLWH (Carrico et al., 2014; Qian et al., 2014; Rasbach et al., 2013). Binge alcohol use was defined as consuming 5 or more drinks on one occasion and also assessed for these periods.

2.2.2. Covariates

Covariates included age, reported gender/HIV risk group, race and ethnicity, individual annual income, Short Form-12 (SF-12), time, intervention (navigation, control), CD4 count, and the interaction of time and intervention. Age was dichotomized as 34 years or less or 35 years or more based on age-related differences in patterns of substance use and of risk behaviors leading to HIV transmission. We grouped participants into mutually exclusive categories based on gender identity and/or HIV behavioral risk. The risk/gender categories included men who have sex with men (MSM), transgender women (TGW), people who inject drugs (PWID) regardless of sexual orientation and gender identity, and people in none of the previous categories (i.e., heterosexual cis-males who did not inject drugs). Race/ethnicity was defined as Hispanic, non-Hispanic Black, and non-Hispanic White. Individual annual income was dichotomized as \$10,000 or above and under \$10,000. Two SF-12 summary scores—the physical health composite and the mental health composite—were derived from the eight domains in the SF-12 and standardized using a T-score normed to the United States general population with mean of 50 and standard deviation of 10. Higher scores indicate better health (Ware et al., 1996). The SF-12 has been shown to be reliable and valid in PLWH and people with a substance use disorder (Ion et al., 2011; Pyne et al., 2011). CD4 count was dichotomized at 500 or more cells/ μ L and less than 500 cells/ μ L.

2.2.3. HIV viral suppression

Viral load testing was performed at baseline, 3- and 12-months. Viral suppression (VS) was defined as an undetectable viral load or a quantitative value of less than 75 copies/mL. At baseline, the viral load was obtained from electronic medical records. At months 3 and 12, the viral load (HIV RNA) was obtained from blood samples analyzed using RealTime HIV-1 assays (Abbott Laboratories). Blood samples for testing were obtained by a staff phlebotomist.

2.3. Statistical analysis

We summarized baseline demographic characteristics and SF-12 composite scores by reported substance use as means and standard deviation or counts and percentages, where applicable. We modeled

outcomes using longitudinal logistic random intercept models, which are particular cases of generalized linear mixed models (GLMMs). Outcomes are VS and reported substance use (methamphetamine, cocaine, and opioids each individually and as the composite “high-risk drug use”). The intervention, interview assessment (baseline, 3- and 12-months), and their interaction were used as predictors in all models. We first fit models with each additional covariate singularly. Possible covariates were age, gender/HIV risk group, race/ethnicity, income, SF-12 composite scores, and CD4 count. If the *p*-value for the corresponding coefficient was less than 0.05, the covariate was retained in a final multivariable model. To further determine the longitudinal association of each type of substance use with VS, we fit bivariate longitudinal random intercept models to estimate the correlation between participants’ frequency of reporting each type of substance on the logit scale and the participants’ VS over all three time-point assessments (Hara et al., 2013; Weiss, 2005). GLMMs robustly handle missing data via maximum likelihood estimation and treated the missing data as missing at random. We used SAS Proc Glimmix software version 9.4 (SAS Institute Inc., Cary, NC, USA) for all analyses.

3. Results

3.1. Baseline characteristics by reported substance use

LINK LA enrolled and randomized 356 participants between 2012 and 2015. Baseline characteristics by study arm were described previously (Cunningham et al., 2018). In brief, mean age was 39.5 (standard deviation [SD] 10.4), 85% were men and 15% TGW, 42% were Black and 31% Latino. The mean SF-12 mental health composite score was 38 (SD 12), and the mean physical health composite score was 51 (SD 10). The reported gender/HIV risk groups were 56% MSM, 12% PWID, 15% TGW, and 17% other. The percentages of each substance used at baseline by sociodemographic and clinical variables are presented in Table 1. Younger participants (34 years or younger) were more likely than older participants (35 years or older) to recently use binge alcohol, methamphetamines, and marijuana. Older participants were more likely to use cocaine than younger participants. White participants were the most likely to use any high-risk drugs and the most likely to use methamphetamines, followed by Hispanic then Black participants. Black participants were the most likely to use cocaine followed by Hispanic then White participants. By gender/HIV risk group, MSM were the most likely to use high-risk drugs and methamphetamines; TGW were the most likely to use cocaine; PWID were the most likely to use opioids.

3.2. Predictors of substance use over time

Results of longitudinal modeling of drug use over the course of the study are summarized in Table 2. For high-risk drug use, Black participants had lower odds than White participants of ongoing high-risk drug use, while Hispanic participants had similar odds as White participants. MSM, TGW, and PWID all had higher odds of ongoing high-risk drug use than other participants. By individual drug, participants aged 34 years or less had more than twice the odds of methamphetamine use over time compared to those aged 35 years or older. Black participants had lower odds of methamphetamine use and higher odds of cocaine use than White participants. Again, MSM, TGW, and PWID all had higher odds of methamphetamine use than other participants. PWID were most likely to use any opioids.

3.3. Viral suppression

Fig. 1 shows the proportion of viral suppression in each arm and by high-risk drug use at study time points. In multivariable analysis, adjusted for the time-by-intervention interaction (Table 3), VS was independently predicted by baseline gender/HIV risk group, income, CD4

count, SF-12 mental health component score, and recent high-risk drug use. PWID was associated with higher odds of VS than participants in the other gender/HIV risk groups. Compared to those reporting a higher income, those reporting an income less than \$10,000 had lower odds of VS. Participants with a CD4 count lower than 500 cell/ μ L had lower odds of VS compared to those with a CD4 count over 500 cell/ μ L. SF-12 mental health composite score had a positive association with VS. As hypothesized, participants who used high-risk drugs at baseline had decreased odds of VS over time compared to those who did not use high-risk drugs (adjusted odds ratio 0.47, 95% confidence interval 0.31–0.70, $p < 0.001$).

The longitudinal correlation of average VS with average frequency of high-risk drug use over the three follow-up visits was -0.55 ($p = 0.001$). When examining associations of individual substances with VS, this correlation appears to be driven by stimulant use. The longitudinal correlations of average VS with use of individual substances were: methamphetamine use, -0.34 ($p = 0.03$); cocaine use, -0.30 ($p = 0.07$); opioid use, -0.19 ($p = 0.32$); and binge alcohol use, 0.33 ($p = 0.07$).

4. Discussion

The present study showed that the recent use of high-risk drugs, especially methamphetamines, was negatively associated with VS over 12 months in this population of PLWH released from a large municipal jail in Los Angeles. This longitudinal correlation was robust in analyses that adjusted for the significant effect of the intervention on VS over the same time period. The findings are important because efforts to end the HIV epidemic recognize the imperative of addressing the CJS, as gaps in care and loss of viral control occur frequently after release from correctional institutions (Iroh et al., 2015). Approximately 2.2 million Americans were estimated to be incarcerated in jails and prisons at the end of 2016, while an estimated 9 million are released from jails alone each year with a vastly disproportionate effect on Blacks and, to a lesser extent, Hispanics (Kaeble et al., 2018).

In the setting of the LINK LA clinical trial, which was conducted among PLWH released from the largest jail system in the US to test the effects of a theory-driven peer navigation intervention, we observed a close association of drug use with VS over and above the statistically significant effect of LINK LA on sustaining VS following release from custody. This longitudinal correlation highlights the importance of high-risk drug use as a barrier to sustained VS in PLWH after release from incarceration, even in the presence of supportive interventions. It also underscores the community reentry period as a time when individuals are at increased risk of substance use-associated harms. During this period substance use can disorganize health-oriented behaviors like seeking HIV medical care, maintaining ART adherence, and securing social determinants of health, such as stable housing (Wooditch et al., 2018), that support sustained VS. Given the additional negative and cumulative influences of incarceration experiences on ART adherence over the lifetime (Milloy et al., 2011; Nosyk et al., 2014), future linkage-to-care interventions for PLWH post-incarceration may be enhanced by devising additional strategies to mitigate substance use.

In this context, an important finding was that the prevalence of high-risk drug use overall in LINK LA was 71%. The prevalence of methamphetamines in particular was 58%—much greater in this CJS sample than that found in other recent studies of substance use and the continuum of care among PLWH in the US (Gardner et al., 2016; Nolan et al., 2017). In a number of other studies of drug use and HIV care in criminal justice settings, cocaine and opiates, especially injected opiates such as heroin, have predominated (Althoff et al., 2013; Chitsaz et al., 2013; Vagenas et al., 2016). Pharmacotherapy with long-acting opioid antagonists prior to release from custody has been shown to be effective for reducing the disorganizing influences of opioid and alcohol use disorders in PLWH (Springer et al., 2018a,b). However, in LINK LA, the

Table 1
Baseline characteristics prior to release from jail for participants in LINK LA by type of substance used (n = 356).

Characteristics	Total % (n)	High-Risk Drug Use ^b % (n)	Methamphetamine % (n)	Cocaine % (n)	Heroin % (n)	Prescription Opioids % (n)	Binge Alcohol % (n)
Total	100 (356)	71 (253)	58 (206)	17 (61)	7 (24)	4 (15)	25 (88)
Study Arm							
Intervention	51 (180)	67 (120)	58 (104)	14 (25)	8 (15)	6 (10)	23 (42)
Control	49 (176)	76 (133)	58 (102)	20 (36)	5 (9)	3 (5)	26 (46)
Age							
18-34 years	38 (137)	74 (101)	69 (95)**	10 (14)**	9 (13)	3 (4)	32 (44) ^a
35 or more	62 (219)	69 (152)	51 (111)	21 (47)	5 (11)	5 (11)	20 (44)
Race/ethnicity							
White, non-Hispanic	27 (95)	79 (75) [*]	74 (70)**	6 (6)**	7 (7)	7 (7) [*]	24 (23)
Black, non-Hispanic	42 (151)	63 (95)	40 (60)	26 (40)	4 (6)	1 (2)	23 (35)
Hispanic	31 (110)	75 (83)	69 (76)	14 (15)	10 (11)	5 (6)	27 (30)
Risk/gender group							
MSM	56 (201)	80 (160)**	70 (140)**	12 (24)**	4 (9)	3 (7)	22 (44)
PWID	12 (43)	70 (30)	51 (22)	23 (10)	21 (9)	7 (3)	30 (13)
TGW	15 (53)	77 (41)	58 (31)	32 (17)	9 (5)	6 (3)	30 (16)
None of the above	17 (59)	37 (22)	22 (13)	18 (10)	2 (1)	3 (2)	25 (15)
Educational attainment							
Less than high school	37 (131)	74 (97)	62 (81)	17 (22)	11 (14) [*]	2 (3)	30 (39)
High school or more	63 (224)	69 (155)	55 (124)	17 (39)	4 (10)	5 (12)	21 (48)
Annual income							
≤ \$10,000	42 (150)	69 (103)	55 (82)	19 (29)	8 (12)	1 (1)**	23 (35)
\$10,001 or more	58 (205)	73 (149)	60 (123)	16 (32)	6 (12)	7 (14)	25 (52)
Insurance							
Uninsured	55 (191)	70 (134)	58 (110)	18 (34)	8 (15)	4 (7)	28 (53)
Insured	45 (155)	72 (111)	57 (88)	17 (26)	5 (8)	5 (7)	22 (34)
Homeless							
Homeless	56 (198)	79 (156)**	64 (126) [*]	21 (41) [*]	10 (19) [*]	5 (10)	26 (52)
Not homeless	44 (158)	61 (97)	51 (80)	13 (20)	3 (5)	3 (5)	23 (36)
Reincarceration							
Reincarcerated	54 (192)	73 (141)	64 (123)	16 (31)	6 (12)	3 (6)	27 (51)
Number of times reincarcerated, mean (± SD)	1.3 (1.8)	1.3 (1.8)	1.4 (1.9)	1.3 (1.9)	1.3 (1.7)	1.1 (2.6)	1.2 (1.6)
Number of days per reincarceration, mean (± SD)	131 (147)	129 (150)	126 (151)	151 (138)	102 (86)	264 (222)	147 (177)
Treatment visits							
For substance use problems	15 (53)	81 (43)	60 (32)	28 (15)	6 (17)	6 (3)	23 (12)
For psychiatric/emotional problems	32 (112)	67 (75)	49 (55)	18 (20)	4 (5)	8 (9)	28 (31)
Short Form-12							
Mental health, mean (± SD)	38 (12)	38 (12)	37 (12)	38 (12)	34 (14)	35 (12)	34 (10)
Physical health, mean (± SD)	51 (10)	51 (10)	52 (9)	48 (11)	52 (9)	43 (13)	52 (10)
CD4 count (cell/μL) ^a							
< 500	51 (180)	72 (130)	55 (99)	18 (32)	7 (13)	6 (11)	27 (48)
500 or more	49 (175)	70 (122)	61 (106)	17 (29)	6 (11)	2 (4)	23 (40)
Viral suppression at baseline ^c							
Suppressed	52 (184)	68 (126)	55 (101)	17 (32)	4 (8)	4 (8)	27 (50)
Not suppressed	48 (172)	74 (127)	61 (105)	17 (29)	9 (16)	4 (7)	22 (38)

Abbreviations: MSM men who have sex with men; PWID people who inject drugs; TGW transgender women; SD standard deviation.

Chi-square test was used to test for statistically significant differences between users and non-users within each substance use type.

* $p \leq 0.05$.

** $p \leq 0.01$.

*** $p \leq 0.001$.

^a n = 355 due to missing values.

^b *High-risk drug use* was defined as any reported use of heroin, cocaine (powder or crack), methamphetamines or misuse of prescription opioids in the 30 days prior to being arrested (used at baseline) and 30-days prior to each follow-up assessment.

^c HIV viral suppression was defined as an undetectable viral load of less than 75 copies/mL.

prevalence of opiate use was fairly small, while methamphetamine use was common. Thus, it is unfortunate that no comparable pharmacotherapy for stimulant use is yet available (Bhatt et al., 2016; Castells et al., 2016) and surprising that PWIDs exhibited higher levels of viral suppression than other groups in our study. There is mixed support for agonist approaches to methamphetamine use disorder (Lee et al., 2018), but uptake may be limited in people involved with criminal justice systems. It is encouraging that contingency management is successfully being scaled up in treating stimulant use disorders in Veterans Affairs settings. This work provides key directions for research and programs targeting stimulant use during transitions into and out of jail settings (DePhilippis et al., 2018).

Our findings also point to discrete demographic and behavioral subgroups in Los Angeles populations with CJS involvement who use distinct types of high-risk drugs, including methamphetamine, cocaine, heroin, and prescription opioids. Many of the differences in overall high-risk drug use were driven by the high prevalence of methamphetamine use among White, MSM, and TGW participants, whereas cocaine use was most common in Blacks. This mirrors substance use patterns found in vulnerable PLWH in the general populations of Los Angeles (Aralis et al., 2018; Brecht, 2018; Reback and Fletcher, 2014). The higher rates of high-risk drug use in the White study participants exemplifies a distinct type of criminal justice disparity, documented in previous research, that results in higher likelihoods of incarceration and

Table 2
Multivariable analysis of substance use over 12 months in LINK LA.

Variable	High-Risk Drug Use ^a			Methamphetamine Use			Cocaine Use			Opioid Use		
	AOR	95% CI	P-value	AOR	95% CI	P-value	AOR	95% CI	P-value	AOR	95% CI	P-value
Age group												
34 or less				2.34	1.26–3.34	< 0.01						
35 or more (reference)												
Race/ethnicity												
Hispanic	0.74	0.39–1.39	0.35	0.45	0.20–0.98	0.04	2.11	0.75–5.92	0.16			
Black, non-Hispanic	0.52	0.28–0.96	0.04	0.17	0.08–0.37	< 0.001	5.44	2.04–14.5	< 0.001			
White, non-Hispanic (reference)												
Gender/HIV risk groups												
MSM	8.45	4.14–17.3	< 0.001	14.9	5.63–39.6	< 0.001				3.39	0.81–14.2	0.10
PWID	4.86	1.89–12.5	0.001	4.66	1.36–16.0	0.01				18.6	3.34–104	< 0.001
TGW	8.09	3.40–18.9	< 0.001	9.54	3.07–29.6	< 0.001				2.73	0.47–15.7	0.25
None of the above (reference)												

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; MSM, men who have sex with men; PWID, person who injects drugs; TGW, transgender women. All models adjusted for the intervention, time, and intervention by time interaction.

Variable that did not attain statistical significance ($p < 0.05$) in univariate analysis have been omitted.

^a High-risk drug use was defined as any reported use of heroin, cocaine (powder or crack), methamphetamines or misuse of prescription opioids in the 30 days prior to being arrested (used at baseline) and 30-days prior to each follow-up assessment.

longer sentences for Blacks than Whites arrested for similar charges (Iguchi et al., 2005; Rehavi and Starr, 2014; Steffensmeier et al., 2016). These disparities result in a concentration of Whites with more serious substance use in criminal justice settings. Previous research in vulnerable PLWH has also documented strong associations of type of substance use with access to the continuum of care for HIV (Sohler et al., 2007). Future interventions will need to accommodate racial differences in particular substance use patterns.

Mental health at baseline, as measured by the SF-12, was more than a full standard deviation below the US national norm, but better mental health scores independently predicted VS at 12 months. Mental health issues among PLWH in correctional settings are common. For example, in the EnhanceLink study— a cohort study of 878 PLWH leaving one of 20 jails— a high mental illness/emotional distress score as measured by Addiction Severity Index was found in 52.2% (Lincoln et al., 2015). In one study, PLWH who screened positive for depression prior to release from jail were more likely to anticipate needing income, housing, transportation, and assistance with adherence post-release than those who did not (Scheyett et al., 2010). In contrast to our findings, Loeliger et al. found that PLWH with higher severity scores of psychiatric need and untreated psychiatric illness during incarceration had higher levels of viral suppression than PLWH with a lower psychiatric need severity score over a 3-year period (Loeliger et al., 2018). Differences in measurements (SF-12 vs. psychiatric severity score) and study design (RCT vs. retrospective) make direct comparisons difficult. Yet, further study

in measuring psychiatric need and treatment is necessary, as on face value treatment of mental health problems in PLWH prior to and after release should be helpful in reducing both continued substance use and increasing PLWH's chances of achieving and maintaining VS in the community (Meyer et al., 2011; Peters et al., 2017). Although not specific to PLWH, in a recent meta-analysis of 37 RCTs conducted in prisons worldwide to test several behavioral (non-pharmacological) therapies for common psychological conditions (e.g., depression and anxiety), cognitive behavioral therapy and mindfulness-based therapies had modest effects and should be tested in PLWH with a co-existing mental health disorder (Yoon et al., 2017). In PLWH, pharmacotherapy for alcohol and opioid use have recently shown promise in people with a co-existing mental illness (Robertson et al., 2018a,b) reducing mental health hospitalizations and emergency department visits and improving psychotropic medication adherence after release from incarceration.

There were several limitations to this analysis. It was performed in the setting of a clinical trial with a behavioral intervention; hence, generalizability of findings to CJS settings without a linkage to care intervention may be limited. Nevertheless, both intervention and control participants were included in the analysis, and intervention assignment was controlled for. Due to small numbers of opioid users, we were underpowered to show significant associations with VS for this sub-group. Self-report bias was a possibility, as substance use data was collected via self-report and biologic testing was not performed. Additionally, we did not collect measures of diagnosis or severity of

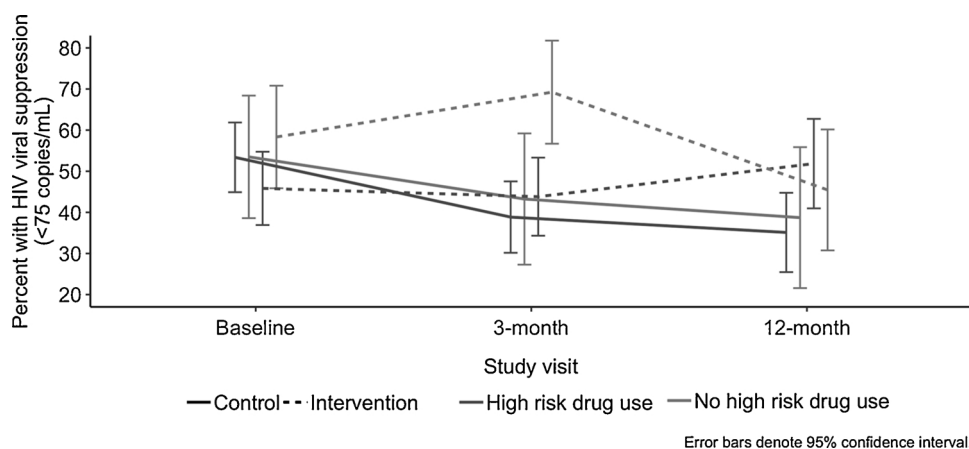


Fig. 1. Viral suppression by study arm and high-risk drug use over the course of the study.

Table 3
Univariate and multivariable predictors of HIV viral suppression^a over 12 months in LINK LA participants.

	Univariate GLMM models				Multivariate GLMM model			
	OR	95% CI		P value	AOR	95% CI		P value
		Lower	Upper			Lower	Upper	
Gender/HIV risk groups								
MSM	1.04	0.58	1.89	0.89	1.25	0.68	2.30	0.47
TGW	0.56	0.26	1.19	0.13	0.70	0.32	1.51	0.36
PWID	2.03	0.89	4.61	0.09	2.29	1.00	5.24	0.05
None of the above (reference)								
Income less than \$10,000								
Yes	0.53	0.34	0.82	< 0.01	0.57	0.37	0.89	0.01
No (reference)								
CD4 less than 500 cell/μL								
Yes	0.43	0.28	0.66	< 0.001	0.44	0.28	0.67	< 0.001
No (reference)								
SF-12 (per unit increase)								
Mental	1.03	1.02	1.05	< 0.001	1.02	1.01	1.04	< 0.01
Physical	1.03	1.01	1.04	< 0.01				
High risk drug use^b								
Yes	0.66	0.41	1.06	0.09	0.47	0.31	0.70	< 0.001
No (reference)								

Abbreviations: AOR, adjusted odds ratio; GLMM, generalized liner mixed models; MSM, men who have sex with men; OR, odds ratio; PWID, people who inject drugs; SF-12, 12-item Short Form Health Survey; TGW, transgender women.

Models were adjusted for the intervention, time and intervention by time interaction.

Variables that did not attain statistical significance ($p < 0.10$) in univariate analysis have been omitted.

^a HIV viral suppression was defined as an undetectable viral load of less than 75 copies/mL.

^b High-risk drug use was defined as any reported use of heroin, cocaine (powder or crack), methamphetamines or misuse of prescription opioids in the 30 days prior to being arrested (used at baseline) and 30-days prior to each follow-up assessment.

substance use disorders. We also acknowledge the potential for there to be many other factors between the relationship of high-risk drug use and viral suppression that include housing status, reincarceration, and therapy for drug use, among others. We did not control for these factors, as they are likely intermediates rather than confounders in the relationship between high-risk drug use and viral suppression. The strengths of this study include randomized controlled design with prospectively collected longitudinal, repeated measures, biological VS (HIV RNA) outcome data, and statistical methods to account for changes in substance use over time co-modeled with VS.

In summary, post-incarcerated PLWH who used high-risk drugs, especially methamphetamines, experienced decreased levels of VS over time, independent of peer navigation services that maintained levels of VS. In this population, efforts to curtail stimulant use are urgently needed, given the high prevalence of and negative association with use. Future intervention research to improve VS and the overall health of post-incarcerated PLWH should address geographical and racial/ethnic differences in substances used.

Contributors

Study concept and design: Goodman-Meza, Cunningham, Weiss, Shoptaw. Statistical analysis: Nakazono and Weiss. Drafting of the manuscript: Goodman-Meza, Cunningham, Weiss, Nakazono, Harawa. Critical revision of the manuscript for important intellectual content: Goodman-Meza, Cunningham, Weiss, Shoptaw, Harawa, Garland and

Takada. All authors reviewed and approved the final version of the manuscript.

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Declaration of Competing Interest

No conflict declared.

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