Published in final edited form as:

AIDS Behav. 2016 August ; 20(8): 1646–1657. doi:10.1007/s10461-016-1394-x.

Modeling a theory-based approach to examine the influence of neurocognitive impairment on HIV risk reduction behaviors among drug users in treatment

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Abstract

Although it is well established that people who use drugs (PWUDs) are characterized by significant neurocognitive impairment (NCI), there has been no examination of how NCI may impede one's ability to accrue the expected HIV prevention benefits stemming from an otherwise efficacious intervention. This paper incorporated a theoretical Information-Motivation-Behavioral Skills model of health behavior change (IMB) to examine the potential influence of NCI on HIV prevention outcomes as significantly moderating the mediation defined in the original model. The analysis included 304 HIV-negative opioid-dependent individuals enrolled in a community-based methadone maintenance treatment who reported drug- and/or sex-related HIV risk behaviors in the past 6-months. Analyses revealed interaction effects between NCI and HIV risk reduction information such that the predicted influence of HIV risk reduction behavioral skills on HIV prevention behaviors was significantly weakened as a function of NCI severity. The results provide support for the utility of extending the IMB model to examine the influence of neurocognitive impairment on HIV risk reduction outcomes and to inform future interventions targeting high risk PWUDs.

Resumen

Aunque esta bien establecido que personas que utilizan drogas (PWUDs) se caracterizan significativamente por un deterioro neurocognitivo (NCI), no se a encontrado pruebas de cómo el

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Conflict of Interest

The authors declare that they have no conflict of interest.

Compliance with Ethical Standards

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

deterioro neurocognitivo puede impedir la habilidad de obtener la prevención de VIH esperada y sus beneficios o de otra manera su intervención eficaz. Este trabajo incorpora la teoría, información-motivación-habilidades conductuales del modelo de salud y cambio de comportamiento (IMB) para examinar la influencia del NCI en VIH y resultados de prevención como se define en el modelo original. El análisis incluye 304 individuos VIH negativo dependientes a opioide inscritos en un tratamiento de mantenimiento con metadona basado en la comunidad que reportaron comportamientos de riesgo a VIH por uso de drogas y/o sexo en los pasados 6 meses. Los análisis revelaron efectos de interacción entre NCI y la información para reducir el riesgo de VIH que predijo la influencia de la reducción de los comportamientos y conductas para la prevención del VIH fue significativamente debilitado en función de la severidad de NCI. Los resultados dan apoyo para utilizar el modelo IMB para examinar la influencia del deterioro neurocognitivo en la reducción de riesgos del VIH y para informar futuras intervenciones dirigidas PWUDs.

Keywords

Neurocognitive impairment; HIV risk reduction; IMB model; drug users; moderated mediation

Introduction

According to the Centers for Disease Control and Prevention (CDC), the estimated incidence of HIV in the United States has remained stable over the past decade, at about 50,000 new infections per year (1). Although the number of diagnosed HIV infections attributed to people who use drugs (PWUDs) has decreased in recent years (1), they still remain a priority population for the prevention of HIV because they represent a critical conduit for new HIV infections, and because this occurs through preventable drug-related (e.g., needle sharing) and sex-related (e.g., inconsistent condom use) HIV risk behaviors (2–6). As a result of chronic drug use, related lifestyle experiences, and relatively poor health (7–17), a disproportionate percentage of PWUDs experience neurocognitive impairment (NCI) to the extent that it may interfere with their ability to fully participate in treatment (18–20). It is well documented that HIV-infected PWUDs may experience cognitive impairment associated with the disease process (AIDS-related dementia) (14–17, 19, 21–27), but HIV- PWUDs also demonstrate levels of NCI that may be disruptive to their participation in treatment services (18, 28–31). Numerous primary and secondary HIV prevention approaches exist (see <https://effectiveinterventions.cdc.gov/> <http://www.nrepp.samhsa.gov/ProgramProfile.aspx?id=11>) (32) but no studies have examined how NCI may influence intervention or treatment outcomes among PWUDs. Thus, it is crucial to better understand and accommodate NCI among PWUDs in the intervention approaches we use to prevent HIV transmission and other illnesses.

An increasing number of evidence-based HIV prevention approaches have been developed for high risk populations, including PWUDs (32). These evidence-based interventions (EBIs), however, do not fully address the unique drug- and sex-related HIV risk-reduction needs that are characteristic of PWUDs, and such EBIs have not been widely disseminated and adopted in the context of addiction treatment programs, such methadone maintenance

programs (MMPs) (32, 33). This is critical since PWUDs frequently report engaging in high risk behaviors across both sexual- (e.g., trading sex for drugs; inconsistent or no condom use with multiple partners) and drug-related (e.g., needle sharing; improper needle cleaning) domains. An application of health behavior change theory to HIV prevention among PWUDs can help researchers to identify the critical dynamics of this particular population HIV risk behaviors in need of targeted intervention efforts, and to empirically evaluate the ability of these theories to predict and promote prevention behavior. The theoretical approach used for this analysis is the Information-Motivation-Behavioral Skills model of health behavior change (IMB) (34, 35) – a theoretical model, which has been successfully applied to the design and evaluation of a wide range of intervention approaches targeting various patient populations and diseases (14, 36–41).

In brief, the model asserts that HIV risk reduction information, motivation, and behavioral skills are key determinants of HIV risk reduction behavior (Figure 1) (34). The model specifies that HIV risk reduction information and motivation primarily act on HIV risk reduction behavioral skills to influence HIV preventive behavior. Thus, the effects of HIV prevention information and motivation are expressed as a result of using HIV risk reduction behavioral skills that are applied in the initiation and maintenance of HIV risk reduction behavior. The model also specifies that HIV risk reduction information and motivation may have direct effects on risk reduction behavior, particularly when complex or novel behavioral skills are not necessary to influence HIV risk reduction outcomes. For example, while in drug treatment, an individual may be relatively motivated to avoid becoming HIV-infected and to withdraw from social interactions that have previously led to risk behavior until he/she learns the risk reduction skills needed to operate more safely in such situations. Importantly, information and motivation are regarded as generally independent constructs in the model. Thus, even well-informed individuals are not necessarily highly motivated to practice risk reduction, and highly motivated individuals are not presumed to be well informed about HIV risk reduction (34, 38). The IMB model's constructs are regarded as highly generalizable determinants of HIV preventive behavior across risk populations and across HIV-risk reduction behaviors (34, 38, 42–47).

It is well established that some risk populations (e.g., PWUDs) are characterized by significant NCI, such that neurocognitive may play a substantial role in how they are able to respond to HIV risk reduction interventions (14–20, 25–27, 29, 30, 33). To date, however, there has been no examination of how NCI may impede one's ability to accrue the expected HIV prevention benefits stemming from an otherwise efficacious intervention. More importantly, no studies have incorporated a theoretical framework, such as the IMB model, to examine the potential influence of NCI on HIV prevention outcomes, as defined in the original model. In the present study, we therefore sought to examine whether HIV risk reduction behavioral skills mediate the influence of HIV risk reduction information and motivation on HIV prevention outcomes as a function of the NCI, as measured by the Brief Inventory of Neuro-cognitive Impairment (BINI) (48). Because behavioral intervention approaches require at least a moderate level of cognitive processing, we hypothesized that NCI would disrupt the expected flow of the IMB constructs.

Methods

The present study was a secondary analysis of data from a randomized controlled trial (RCT) of the Community-friendly Health Recovery Program (CHRP) (<https://clinicaltrials.gov/ct2/show/NCT01741350>) (49). The CHRP is an evidence-based behavioral HIV-risk reduction intervention that is designed to reduce HIV transmission risk behavior among high-risk drugs users (<http://www.nrepp.samhsa.gov/ProgramProfile.aspx?id=11>). The protocol of the study was approved by the Investigational Review Board (IRB) at the University of Connecticut, the Human Investigation Committee at Yale University, and received board approval from the APT Foundation MMP, Inc.

Participants

This study involved analysis of data from HIV-negative opioid-dependent individuals ($N=304$, 147 males) who were newly enrolled, though not necessarily first-time methadone patients, in a community-based methadone maintenance treatment (MMT) (49). Inclusion criteria included a diagnosis of opioid dependence (DSM-V) seeking MMT, and reporting drug- and/or sex-related HIV risk behaviors in the past 6-months. For inclusion into the study, participants' HIV status was assessed using a self-report measure. They were asked about the result of their most recent HIV test, in which, all of them reported that they were HIV-negative. Furthermore, participants' past drug- and sex-related risk behaviors were assessed using several items from the Risk Assessment Battery (50).

Measures

IMB Measure—Consistent with the IMB model of health behavior change (34, 38), participants completed an audio computer assisted structured interview (ACASI) assessment that covered the following domains: drug- and sex-related HIV risk reduction knowledge (information component), personal and social motivation to reduce HIV risk behavior (motivation component), behavioral skills component, and HIV risk behavior (HIV prevention behavior component). Measures for the current study were adapted from previous HIV prevention work (50–52). Responses were analyzed as continuous measures, or dichotomized into an IMB strengths/deficits-based approaches. All responses were re-coded so that higher values indicated higher levels of information, motivation, and behavioral skills. Each IMB construct was made with several associated observable variables that can be directly measured. Structural equation modelling (SEM) was used to estimate the structural coefficients between constructs or latent variables. The IMB model constructs are described below:

Information: Participants' HIV risk reduction knowledge about safer sex and safer injection drug use was measured with seven items with “yes”, “no” or “do not know” as answers (e.g., “If an HIV+ person only has sex with another HIV+ person, they don't need to use condom”; “If an HIV+ person shared needles with another HIV+ person, they don't need to clean the needles”).

Motivation: Twelve items examined participants' motivation to use condoms and clean needles, intentions to engage in safer sexual activity and safer injection drug use practices,

and perception of significant others' beliefs about the importance of using condoms and using clean needles (e.g., "I plan not to have sex during the next 3 months", "I plan not to shoot up during the next 3 months", "Most people important to me think I should clean needles before sharing, during the next 3 months"). Answers for motivation items were constructed on a five-point Likert scale (0 "very true" and 4 "very untrue").

HIV behavioral skills: Four items assessed participants' behavioral skills in the form of their self-efficacy about abstaining from sexual activity and using a condom and about abstaining from injecting drugs and using clean needles (e.g., "How hard would it be for you to abstain from oral, vaginal, or anal sex?", "How hard would it be for you to abstain from injecting drugs?", "How hard would it be for you to always use condoms or latex protection if you have oral, vaginal, or anal sex?", and "How hard would it be for you to always clean your needles with bleach if you shared them?"). Answers for these items were constructed on a five-point Likert scale (0 "very hard to do" and 4 "very easy to do").

Additionally, participants were asked to demonstrate the steps necessary to properly clean a needle/syringe and to demonstrate the steps necessary to properly select and apply a male and female condom using replicas, as in prior randomized controlled trials (53, 54). Ratings of audio-taped demonstrations of these procedures by staff blind to treatment assignment have shown excellent inter-rater reliability in our prior trials (inter-rater reliability = 0.98) (54). Using standardized skills rating forms (53, 54), each participant's demonstrated needle cleaning and male and female condom application skills were blindly rated by trained research assistants under the supervision of a licensed clinical psychologist.

HIV preventive behaviors: Several items from the Risk Assessment Battery (RAB) were used to assess participants' sex- and drug-related HIV risk behavior (50). The scale required participants to categorize and quantify their drug use and sexual activity during the prior week. Drug-use related items included how they used drugs, whether they used new syringes or cleaned syringes and, if so, how they cleaned them, and whether they shared syringes, rinse water, cooker, or cotton. Sexual activity-related items assessed whether they had used a condom and, if not, whether it was due to abstinence from sexual activity.

Neurocognitive Impairment (NCI)—NCI was measured using the Brief Inventory of Neuro-cognitive Impairment (BINI), which is a brief, self-report measure of neuropsychological symptoms optimized for use among PWUDs in drug treatment (48). The BINI was developed as a rapid and convenient way to elicit diagnostically relevant information about both general NCI and specific symptoms areas (i.e., attention, memory, linguistic functioning, etc.). It includes a diverse set of factors with excellent overall reliability ($\alpha=0.97$). Factors include Global Impairment (e.g., "I have difficulty paying attention" and "I get lost easily"), Academic-related (e.g., "I count with my fingers" and "I have trouble learning new things"), Language-related (e.g., "My words get mixed up"), Memory-related (e.g., "I have trouble remembering people's names"), Psychomotor/physical (e.g., "I am very clumsy"), Psychomotor/perceptual (e.g., "I have trouble with the left side of my body"), Anger-related (e.g., "I have urges to break and smash things"), Pain-associated (e.g., "I have severe headaches"), and Traumatic Head Injury-related (e.g., "I have been knocked unconscious"). The reliability of the 9 factors ranged from excellent to good (by

factor: F1 $\alpha=0.97$; F2 $\alpha=0.89$; F3 $\alpha=0.82$; F4 $\alpha=0.76$; F5 $\alpha=0.79$; F6 $\alpha=0.75$; F7 $\alpha=0.75$; F8 $\alpha=0.74$; F9 $\alpha=0.73$) (48). All the subscales were analyzed as a continuous variable, with a higher score indicating a higher degree of NCI.

Procedure

The procedures for this study have been previously described in detail (49), and are briefly described here. All opioid-dependent patients entering a MMT were screened for participation within one week of receiving the first methadone dose. Patients who met inclusion criteria, and who were willing to participate as subjects, were provided a description of the study and invited to provide informed consent, followed by a baseline assessment, which took approximately 120 minutes to complete. Participants were assessed using an ACASI process that has demonstrated sound psychometric properties in prior studies (51, 55) and controlled trials (56), using an event-level sex-and drug-related HIV risk behavior assessment approach. All participants were reimbursed for the time and effort required to participate in the study.

Data analysis

All IMB items were rescored and evaluated for missing data. All available data were included via maximum likelihood estimation, a preferred method for handling missing data when assumed missing-at-random (57). Analyses were carried out in Mplus Version 7.31 (58), which includes the capability to test models using a full information (direct) maximum likelihood estimator to account for missing data (59).

Measurement models—First, latent variable structural equation analysis (confirmatory factor analysis, CFA) was used to test the fit of the IMB constructs, including HIV prevention behaviors (outcome variables). Model fit was assessed with the χ^2 , the comparative fit index (CFI) (60), the Tucker-Lewis index (TLI) (61), and the root mean square error of approximation (RMSEA) (62). Values of 0.95 or greater for the CFI and TLI and 0.08 or below for the RMSEA are indicative of good fit (63).

For each measurement model, the best fitting model was assessed by evaluating a single latent construct for each information, motivation, and behavioral skills construct, including HIV preventive behaviors. The full item set of each construct was then loaded on to its respective latent variables. Individual items were removed from the scale if they had a non-significant factor loading ($p>.05$) or the unstandardized factor loading estimate was $<.40$. Individual error variances were correlated if they had a modification index >10 and they were from theoretically related items. This process of excluding items and correlating errors was iteratively repeated until the best fitting measurement model was obtained (i.e., non-significant χ^2 , CFI $>.95$, RMSEA $<.5$). If the factor loadings of the initial CFA model demonstrated a pattern of theoretically related items that were not systematically loading onto the latent construct (e.g., motivation), those items were flagged, and subsequently evaluated as an independent latent factor using the previously described CFA procedures.

Structural model test—Analyses were structured to address two overarching research questions: (a) consistent with the IMB model, whether the effects of HIV risk reduction

information and motivation (Independent Variables: IVs) on HIV prevention behaviors (Dependent Variable: DV) were mediated by HIV risk reduction behavioral skills (Mediator: Me); and (b) whether NCI (Moderator: Mo) moderated the effects of these proximal variables (IVs) on HIV prevention behavior (DV). In order to test whether the indirect effect depended on the level of NCI (Mo), coefficients were estimated in two regression analyses. First, HIV risk reduction behavioral skills (Me) was regressed on HIV risk reduction information and motivation (IVs). Subsequently, HIV preventive behavior (DV) was regressed on HIV risk reduction information and motivation (IVs), HIV risk reduction behavioral skills (Me), NCI (Mo), and the interaction between NCI and HIV risk reduction information, motivation, and behavioral skills. The total effect of the IVs was determined to be mediated if the direct effects of IVs on the DV became nonsignificant or somewhat reduced after controlling for Me. A significant interaction effect on the DV is indicative of a moderated mediation effect.

In order to proceed with an evaluation of the model, an extended IMB model-based measure of neurocognitive impairment (nciIMB model) among high risk drug users was developed. The nciIMB items were constructed to be reflective of the population-based IMB model (34). Variables (i.e., years of injection drug use) that did not have a significant correlation with NCI were excluded from the overall nciIMB models. Consistent with the development of previous IMB-based measures, all IMB items were fitted in the model. Since the drug-related and sex-related HIV risk reduction variables were measured separately, we tested separate SEMs for each domain, as described below.

Results

Sample Characteristics

The current sample averaged 33.8 years of age ($SD = 9.5$) and was mostly Caucasian (74.7%), never married (66.8%), unemployed (73%), English-speaking (94.7%), and had a significant other (70.1%), with a median of 12 years of education. Of the total participants, almost two-thirds reported injecting drugs within the past six months. All participants were maintained on a stable dose of methadone, with an average daily dose of 57.72 mg ($SD = 25.5$ mg).

Measurement model

The estimated CFA with parameters and tests of significance of the IMB model domains are shown in Table 1. In fitting the initial constructs of the IMB model, the CFA indicated theoretically consistent adjustments to improve the fit of the model. Modifications to the IMB model constructs yielded a reduced number of items for each of the measures, which resulted in an improved model fit. The CFA model for all the original information items (7 items), did not yield a good fitting model ($\chi^2 = 134.49$, $p < .001$; CFI = .236, RMSEA = 0.159), but after retaining a total of 3 items on a single construct, a good fitting model was found for the information construct ($\chi^2 = 39.94$, $p < .001$; CFI = 1.00, RMSEA = 0.00). The motivation latent measurement model yielded a good fitting model by retaining 6 items on a single latent construct ($\chi^2 = 13.07$, $p = .004$; CFI = 1.00, RMSEA = 0.00). Factor loadings for the initial CFA of a single behavioral skills measurement model, which included self-efficacy, drug-

related (e.g., needle cleaning skills) and sex-related (e.g., male and female condom application) skills items, demonstrated poor fit. Specifically, the patterns observed amongst the vast majority of items with the lowest unstandardized factor estimates were self-efficacy components related to behavioral skills. Therefore, the behavioral skills constructs were separated for drug-related (e.g., needle cleaning skills) and sex-related (e.g., male and female condom application) behavioral skills, and also excluded self-efficacy items. Similarly, the CFA model for HIV preventive behavior yielded a good fitting model for drug-related (clean needle use; $\chi^2=18.64$, $p=.002$; CFI=0.943, RMSEA=0.09) and sex-related (condom use; $\chi^2=112.30$, $p<.001$; CFI=1.00, RMSEA=0.00) behaviors when organized by separate latent constructs.

Path model

The IMB model-based measure of neurocognitive impairment (nciIMB models) were examined separately for drug- and sex-related outcomes in order to explore the process leading to corresponding improved risk reduction behaviors among study participants.

Drug risk reduction nciIMB model—The path analysis of drug risk reduction outcomes (e.g., clean needle use) that we used to examine the nciIMB model resulted in good fitting indices (Figure 2). The good CFI (0.95), TLI (~0.95), and RMSEA values (<0.05) suggested that this model explained the nciIMB model well. The moderated mediation hypothesis was tested by regression analyses. First, needle cleaning skills was predicted by HIV risk reduction information ($\beta=0.12$) and motivation ($\beta=0.23$). In addition, clean needle use was predicted by HIV risk reduction information ($\beta=0.11$), motivation ($\beta=0.17$), needle cleaning skills ($\beta=0.10$), and the information $\times$ NCI interaction ($\beta=-0.25$). The significant interaction effect we observed in the drug-risk reduction model supported the assumption of moderated mediation exerted by NCI.

Sex risk reduction nciIMB model—For the purpose of our analyses, we modelled male condom (Figure 3) and female condom (Figure 4) skills separately. The path analysis of sex risk reduction outcomes (e.g., condom use) that we used to examine the nciIMB model also resulted in good fitting models for both the male and the female condom application skills, with good CFI (~0.95), TLI (~0.95), and RMSEA values (<0.05). As earlier, male condom application skills was predicted by HIV risk reduction information ($\beta=0.15$) and motivation ($\beta=0.29$). Additionally, male condom use was predicted by HIV risk reduction information ($\beta=0.12$), motivation ($\beta=0.19$), male condom application skills ($\beta=0.12$), and the information $\times$ NCI interaction ($\beta=-0.30$). Similarly, female condom application skills was predicted by HIV risk reduction information ($\beta=0.11$) and motivation ($\beta=0.20$). In addition, female condom use was predicted by HIV risk reduction information ($\beta=0.08$), motivation ($\beta=0.12$), female condom application skills ($\beta=0.09$), and the information $\times$ NCI interaction ($\beta=-0.15$). The significant interaction effects that we observed in both sex-risk reduction models supported the assumption of moderated mediation exerted by NCI within each model.

Discussion

This study is the first to establish whether the expected mediation effect that HIV risk reduction behavioral skills has on HIV risk reduction information, motivation, and HIV preventive behaviors – as well described in the IMB model of health behavior change – may vary as a function of NCI among PWUDs. The results provide support for the utility of the moderated mediation nciIMB framework of HIV risk reduction to inform future interventions targeting high risk PWUDs.

The results of the drug risk reduction nciIMB model portray the importance of HIV risk reduction knowledge, motivation, and behavioral skills (i.e., needle cleaning skills) for behavior change (i.e., clean needle use), as all of these variables had significant associations with clean needle use (Figure 2). They tend to work best, however, in orchestration: HIV risk reduction knowledge and motivation enhance clean needle use via an individual's needle cleaning skills. That is, greater HIV risk reduction knowledge and motivation was related to greater needle cleaning skills. Greater needle cleaning skills, in turn, were associated with improvement in reported drug risk reduction behavior (i.e., clean needle use). Further, the mediation effect of needle cleaning skills in the relationship between information and clean needle use was moderated by NCI, indicating that the higher the levels of NCI, the less risk reduction information (knowledge) participants accrued and, thus, a relatively lower level of behavioral skill development, which was then associated with lower clean needle use behavior.

A similar pattern was shown in the models examining male and female condoms application skills. The effect of HIV risk reduction knowledge and motivation on condom use was mediated. That is, greater HIV risk reduction knowledge and motivation was associated with greater condom application skills. Greater condom application skills, in turn, was related to improvement in reported sex risk reduction behavior (i.e., condom use). Further, the mediation effect of condom application skills on information and condom use was significantly moderated by NCI. Thus, participants with higher levels of NCI tended to show less risk reduction knowledge and skill development, which was associated with less consistent condom use behavior.

Overall, the results provide further support for the IMB model of HIV prevention behavior (36, 38, 42). The findings confirm the model's central proposition that both information and motivation work through behavioral skills to affect HIV prevention behavior (34). This indicates that enhancement of HIV risk reduction information and motivation positively influences their HIV behavioral skills. A higher degree of HIV behavioral skills, in turn, was associated with better HIV prevention outcomes, such as consistent condom use and clean needle use.

As an extension of previous research, we also found a significant moderating effect on the translation of HIV risk reduction knowledge and motivation into HIV preventive behaviors via HIV risk reduction behavioral skills. In both the drug-related and sex-related HIV risk reduction domains that we modelled, the strength of the partial mediation effect decreased in conjunction with levels of NCI: HIV risk reduction behavioral skills (demonstrated needle

cleaning and condom application) tended to translate gains in information and motivation into HIV preventive behavior (clean needle use and condom use), particularly among individuals without high levels of NCI, as they appeared more likely to benefit from the information and skills components that were conveyed by the intervention (18, 19). Hence, this pattern of findings might at least partially explain the variation in prior studies regarding the mediating role of behavioral skills between HIV risk reduction information, motivation, and HIV preventive behavior (36–38, 42, 43, 45, 49, 64).

The indirect effects shown in the models represent a facilitating process: PWUDs with higher levels of HIV risk reduction information and motivation tended to have greater HIV risk reduction behavioral skills and, thus, were more likely to engage in effective HIV preventive behaviors (34, 49). By examining the moderated mediation effect reported here, however, we now assert that this automatic process works differentially for subgroups of individuals: Individuals characterized by higher levels of NCI are less likely to benefit from the HIV risk reduction information conveyed by the intervention and, hence, are less likely to engage in HIV preventive behaviors. Because a significant proportion of PWUDs are characterized by NCI (14–20, 25–27, 29, 30, 33), our findings point toward the need for future studies to develop and test intervention strategies to better accommodate the potentially disruptive influence of NCI on key intervention outcomes.

Study limitations

This study has a number of potential limitations that should also be acknowledged. First, the use of self-report measures may have reduced our ability to precisely detect some outcomes (e.g., NCI, sexual and drug use behaviors) due to participants' reluctance to self-report socially undesirable behaviors (65). In addition, the data may have been subject to potential biases associated with the desire to misrepresent levels of awareness about particular items on the questionnaire. This may have been diminished, however, by the use of the ACASI assessment approach, which provided participants with a relatively higher level of privacy than, for example, a face-to-face interview. Second, the measure of behavioral skills used in the study focused on enactment of behaviors necessary for cleaning needles and applying condoms to male and female replicas. The IMB theory specifies that perceived efficacy in performing these skills is also part of the behavioral skills construct (34); thus, it is not clear how the omission of efficacy judgments from our measures influenced the results. Third, this study made use of baseline data (cross-sectional in nature) to examine the nciIMB model. Thus, this limits the ability to detect causal relationships between IMB constructs and NCI over time. Fourth, the study was conducted in the context of a MMT clinic setting among newly enrolled individuals. It is likely that methadone may have exerted some effect on opioid use and related HIV risk behaviors (66–69), and may have restricted our ability to detect intervention effects across all participants. Fifth, the inclusion of participants meeting specific eligibility criteria may limit our ability to generalize the findings to other risk populations such as non-drug involved populations, non-treatment settings, or to persons not willing to participate in an intervention study. In addition, the majority of the sample was Caucasian, thus possibly limiting the generalizability of the results to more ethnically diverse individuals.

Conclusions

The current study provides additional support for the IMB model as HIV risk reduction behavioral skills were found to mediate the influence of HIV risk reduction information and motivation on HIV prevention behaviors (i.e., clean needle use and consistent condom use). In an extension of existing research, we found interaction effects between NCI and HIV risk reduction information such that the predicted mediating influence of HIV risk reduction behavioral skills on HIV prevention behaviors was significantly weakened as a function of NCI severity. This test of an extended version of the IMB model, a prevailing theoretical model of health behavior change (34), provides evidence as to the utility of the extended IMB model for situations (e.g., intervening with certain risk populations) in which NCI may function as a moderator of intervention outcomes predicted by the original model. It therefore makes an important contribution to our understanding of the applicability of theoretically-grounded models of HIV prevention behavior for persons who may be characterized by some degree of NCI. Because of the relatively higher rates of NCI among PWUDs (18, 28) and the negative influence of NCI on HIV prevention behaviors (18, 19), future interventions should take into account the disruptive impact that NCI may have on some participants' ability to fully benefit from otherwise efficacious interventions.

Acknowledgments

Funding

Funding to support the study was provided by a National Institute on Drug Abuse (NIDA) Grants (R01-DA022122; K02DA033139) to Michael M. Copenhaver. NIDA had no role in the study design, collection, analysis or interpretation of the data, writing the manuscript, or the decision to submit the paper for publication.

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Figure 1.
The information–motivation-behavioral skills model (IMB) of HIV preventive behavior
(Fisher & Fisher, 1994)

Figure 2.

The IMB model-based measure of neurocognitive impairment (nciIMB model) for clean needle use among high risk drug users

Figure 3.
The IMB model-based measure of neurocognitive impairment (nciIMB model) for male condom application among high risk drug users

Figure 4.
The IMB model-based measure of neurocognitive impairment (nciIMB model) for female condom application among high risk drug users

Table 1

Constructs for HIV risk reduction Information, Motivation, and Preventive Behaviors

Constructs	Items	N	β	p	SE	Mean	SD	Mean Score	CFS/T LI	RMSE A	α
Information (0–3)	If an HIV+ person has sex with another HIV+ person, they don't need condoms	304	0.708	0.017	0.297	0.91	0.29				
	If an HIV+ person shares with another HIV+ person, they don't need to clean needles	304	0.662	0.026	0.297	0.97	0.18	2.76	1.000 / 1.000	0.000	0.561
	If HIV+ person is on HIV meds, can't give HIV	304	0.101	0.251	0.088	0.90	0.30				
Motivation (0–6)	I do not plan to have sex in the next 3 months.	304	0.172	0.115	0.109	2.79	1.49				
	I plan to not shoot up during the next 3 months	304	0.727	0.094	0.434	0.37	0.83				
	I plan to always use clean needles in next 3 months.	304	0.256	0.119	0.164	0.17	0.53				
	People important to me think I should always use condoms in the next 3 months.	304	0.423	<0.001	0.112	0.29	0.77	4.37	1.000 / 1.000	0.000	0.715
	Most people important to me think I should clean needles before sharing in the next 3 months	304	0.973	<0.001	0.192	0.38	0.95				
Condom use (0–3)	Always cleaning needles w/ bleach before sharing in the next 3 months would be:	304	0.471	<0.001	0.115	0.38	1.04				
	Do you use condoms every time you have sex?	304	0.539	<0.001	0.075	0.05	0.22				
	Have you had oral, anal, or vaginal sex without using a condom or other latex protection in the past six months?	304	0.036	<0.001	0.115	0.15	0.35	0.12	1.000 / 1.000	0.000	0.615
HIV Preventive Behaviors	Do you inconsistently (sometimes or never) use condoms or other latex protection for vaginal sex?	304	0.708	<0.001	0.057	0.15	0.36				
	Did you inject illicit drugs in the past 7 days?	304	0.526	<0.001	0.040	0.67	0.47				
Clean needle use (0–5)	If you injected drugs last week, how many times have you shared rinse	304	0.861	<0.001	0.045	0.87	0.33	3.53	0.943/0.885	0.090	0.79

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Constructs	Items	N	β	p	SE	Mean	SD	Mean Score	CFS/T LI	RMSE A	α
	water?										
	If you injected drugs last week, how many times have you shared a cooker?	304	0.884	<0.001	0.043	0.89	0.31				
	If you injected drugs last week, how many times have you shared cotton?	304	0.941	<0.001	0.030	0.89	0.31				
	When was the last time you used an unclear needle or syringe after someone else used it?	304	0.205	<0.001	0.039	0.34	0.48				