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Graded Response Item Response Theory in Scaling Suicidal Thoughts and Behaviors among Trauma-Exposed Women with Substance Use Disorders

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Abstract

Objective: The co-occurrence of substance use disorders (SUD) and trauma-exposure is a risk factor for suicidal thoughts and behaviors (STB). However, traditional methods of measurement for suicidal thoughts and behaviors are limited by an overreliance on dichotomous (i.e., yes or no) and averaged/summed scale score measurements. Further, among trauma-exposed individuals with SUD, it remains unclear which specific demographic factors, types of SUDs, and trauma sequelae (e.g., PTSD symptom clusters) may be associated with elevated STB. The present study utilized item response theory to a) generate empirically-derived STB severity scores and, b) examine which demographic factors, SUD diagnoses, and DSM-IV PTSD symptom clusters are associated with suicidality in a trauma-exposed sample with SUDs.

Methods: Female trauma-exposed participants with SUDs ($N = 544$) were recruited from community substance use treatment facilities in the National Drug Abuse Treatment Clinical Trials Network (CTN). Clinician-administered interviews assessed STB, SUDs, and PTSD symptoms.

Results: Results indicated that the unidimensional IRT model used to estimate latent STB severity scores fit well, with strong local reliability at higher levels of latent STB severity. Regression predictors of elevated STB severity included younger age, opioid dependence, and higher PTSD re-experiencing symptoms.

Conclusions: Clinicians are advised to screen for and target opioid use disorders and re-experiencing symptoms when addressing suicidal thoughts and behavior in trauma-exposed individuals with SUDs.

Keywords: Suicide; substance use disorders; posttraumatic stress disorder; trauma; item response theory

Public health significance statement: The presence of suicidal ideation and plans specifically may be particularly important in determining the overall severity of suicidal thoughts and behavior. In trauma-exposed women with substance use disorders, opioid use disorders, and higher PTSD re-experiencing symptoms, may signal a potentially elevated likelihood of suicidal thoughts and behaviors.

Graded Response Item Response Theory in Scaling Suicidal Thoughts and Behaviors among Trauma-Exposed Women with Substance Use Disorders

Approximately 35% of individuals who have made a suicide attempt have a substance use disorder (SUD; Borges et al., 2000), and SUDs are associated with elevated suicidal thoughts and behavior (STB; e.g., Cuomo et al., 2008; O'Neill et al., 2014). Further, ~72% of individuals with SUDs experience trauma (Clark et al., 2001), which also reliably associates with STB (e.g., Afzali et al., 2016; Arata et al., 2003). Given robust associations between SUD, trauma, and STB, it is essential to accurately estimate STB in trauma-exposed people with SUDs, and identify which clinical factors are associated with it.

STB Measurement

Sound measurement of STB is critical to suicidality assessment (e.g., Hasin et al., 1996), prevention and treatment (Brown, 2001; Range & Knott, 1997), and exclusion from non-suicide-focused clinical trials (e.g., Brady et al., 2001; Mills et al., 2012). The severity of STBs is not equivalent to actual suicide *risk* (i.e., a metric of individuals who are more or less likely to attempt or die by suicide). However, the assessment of the severity of STBs is often a central part of suicide risk assessment.

Although many clinicians use their own judgement in weighing various STB constructs to determine STB severity, several clinical practices and clinical trials use assessment tools. However, like other psychological constructs, STB assessment tools have been limited by a heavy reliance on either dichotomous questions assessing the presence or absence of STB (e.g., Anestis et al., 2012; Barman-Adhikari et al., 2019; Barr et al., 2017) or averaged/summed scale scores (e.g., Allan et al., 2019; Chapman & Ford, 2008; Clements-Nolle et al., 2009). Dichotomous “yes/no” STB measures fail to capture meaningful variability in STB severity,

obfuscating understanding of who is at more or less risk of suicide. Indeed, clinicians may match the intensity of their approach to managing STBs with perceived severity (e.g., minimal intervention versus safety planning versus hospitalization; Weber et al., 2017; Zalsman et al., 2016). Dichotomous measurement approaches do not provide information about such gradations in STB to inform critical decisions. Alternatively, averaged/summed scale scores overcome the limitations of dichotomous measures but may mischaracterize latent severity of STB. With averaged/summed scores, items are assumed to have equal weight in the overall score when they may not (e.g., assuming passive thoughts about death and a suicide plan and intent are weighted equivalently in determining suicide risk; Andrich, 1978; Curran et al., 2008). Despite this, clinicians and researchers often rely on averaged/summed scores to (a) determine who may be at high or low “suicide risk” (e.g., Farabaugh et al., 2015), or (b) as outcomes in both PTSD (e.g., Resick et al., 2017) and SUD (e.g., Morley et al., 2014) clinical trial research. Such a reliance on average/summed scores is particularly problematic in the context of STB where conventional risk assessment is premised upon the notion that some forms of STB (e.g., planning with lethal means) escalate suicide risk more than others (e.g., thoughts of death; American Psychiatric Association, 2016). Indeed, the weight of specific items in STB measures do not impact overall severity equally (Harris et al., 2015). Accurately estimating STB thus requires analytic methodologies that can accommodate items having distinct weights in order to, in turn, accurately factor STB severity into a more comprehensive suicide risk assessment.

Item response theory (IRT; Embretson & Reise, 2000) is similar to factor analysis and offers such an innovation because it utilizes individual items to create an estimate of an underlying latent trait. Accordingly, the relative weight of individual items is allowed to vary, and their differential weights can be used to construct a particularly precise estimate of STB.

Using IRT to determine how different STB items should be weighted to yield a more accurate estimate of STB severity has multiple potential benefits. First, it allows a more accurate assessment of the relationship between STB severity and a range of predictors or correlates. Second, it can guide researchers and clinicians in differentially weighing STB measure items to yield a more accurate STB severity estimate for the purposes of guiding risk assessment, clinical decision making, outcome monitoring, and inclusion/exclusion in research studies. Although IRT has been used to construct estimates of STB in other populations (e.g., Bevens et al., 2012; Harris et al., 2015), no studies to our knowledge have utilized IRT in this way in a trauma-exposed population with SUDs or with STB measures designed for such a group.

STB Correlates

Variability in demographics and common psychopathology arising from substance use (i.e., SUD type) and trauma (i.e., posttraumatic stress disorder (PTSD) pathology) results in considerable heterogeneity in trauma-exposed people with SUDs, which may influence STB. However, few studies have examined which demographic or clinical characteristics are associated with STB in trauma-exposed people with SUDs. Such information is pertinent to identifying which individuals are likely to experience severe STB and intervene accordingly.

Specific SUDs

A few studies have examined whether SUDs are linked to STB by focusing on one or only a few specific SUDs with variable findings. For example, studies suggest that American Indians and Alaska Natives with substance use problems who report regular opioid use (Rieckmann et al., 2012), and adolescents in residential SUD treatment who use methamphetamine (Dixson et al., 2018), are more likely than their counterparts who do not to have STB histories. Similarly, those with polysubstance use disorders are more likely to have a

history of suicide attempts and have more severe suicidal ideation than those with a single SUD (Martinotti et al., 2009). Although meaningful, these studies did not compare STB severity across multiple SUD types. As such, it is unclear if they specifically and uniquely associate with STB relative to other substances or SUD. In a different study among homeless young adults, individuals who misused prescription opioids were more likely than others to report suicidal thoughts, but individuals who misused prescription stimulants and sedatives were not (Barman-Adhikari et al., 2019). Although these findings suggest that chronic opioid use specifically may be a correlate of STB, this study focused on nonmedical use of prescription drugs, rather than SUDs broadly. Thus, it remains unclear which specific SUDs are associated with STB.

It is also unclear which SUDs are associated with STB in trauma-exposed samples. Many trauma survivors engage in substance use to self-medicate trauma-related symptoms (e.g., Leeies et al., 2010; Sheerin et al., 2016). However, distinct substances have variable associations with impulsivity, disinhibition, and mood, which also may be differentially related to STB.

Accordingly, a study in military personnel (some of whom were trauma-exposed and had elevated PTSD symptoms) at suicide risk showed that higher levels of cannabis use, but not opioids or alcohol, were associated with a greater likelihood of suicidal ideation (Allan et al., 2019). Further, greater cannabis use was linked to a higher likelihood of suicidal behavior for individuals with elevated PTSD symptoms. These authors concluded that the use of cannabis to cope with PTSD symptoms may increase suicide risk (Allan et al., 2019). Alternatively, as these relationships were non-causal in nature, people with higher STBs may use cannabis to cope with PTSD symptoms. Regardless of directionality, the sample in this study did not necessarily have a trauma history or SUD, and although substance use was examined as a STB correlate, specific SUDs were not. Another study involving 65 women with comorbid PTSD and SUD found that

opioid, alcohol, or polysubstance SUD diagnoses did not differentially associate with suicidal or self-injurious behavior (Harned et al., 2006). However, Harned and colleagues (2006) did not examine whether cannabis SUDs were associated with STB which, based on Allan and colleagues' work (2019), may be particularly important in samples that have trauma exposure histories. Furthermore, Harned and colleagues' (2006) focus on women with comorbid PTSD and SUD, rather than the broader category of *trauma exposure* and SUD, neglects variability in PTSD symptoms post-trauma (Atwoli et al., 2015).

PTSD symptom clusters

Although, research clearly indicates that higher general PTSD severity is linked to elevated STB in those with SUD (Bornovalova et al., 2011; Moylan et al., 2001; Neupane et al., 2017), it remains unclear what specific clusters of PTSD symptoms escalate STB. There are three DSM-IV PTSD symptom clusters: re-experiencing, hyperarousal, and avoidance/numbing (APA, 2000). In DSM-5, avoidance/numbing was split into two clusters: avoidance and negative changes in mood/cognitions. Although DSM-5 allows for more nuance in differentiating avoidance/numbing symptoms, DSM-IV criteria can still reveal critical information about how PTSD clusters generally affect STB. Regardless of organization, PTSD symptom clusters are highly heterogeneous and individuals may experience elevations in some but not others, thereby appearing to have lower global PTSD severity while still experiencing significant PTSD symptoms that may inform STB (Galatzer-Levy & Bryant, 2013). Probing PTSD symptom clusters to understand which ones are associated with STB may provide a more precise understanding of who is likely to develop STB after trauma-exposure. Indeed, in trauma-exposed SUD samples, hyperarousal and re-experiencing PTSD symptom clusters are particularly associated with suicide attempts (Anestis et al., 2012), perhaps because they involve greater

distress-related arousal. However, whether these symptom clusters are associated with elevations in a STB latent estimate that accounts for differential item weights has not been investigated.

In sum, the extant literature is limited by a lack of analytic procedures that accommodate potentially distinct weights in determining an estimate of STB for trauma-exposed people with SUDs. Further, it remains unclear which demographic and clinical variables (e.g., type of SUD, PTSD symptom clusters) are associated with STB in trauma-exposed individuals with SUD using such analytic procedures. This information is pertinent for identifying which individuals require targeted suicide intervention. Moreover, it is particularly important to examine how to measure, and what associates with, STB among women with histories of trauma and SUD for two reasons. First, compared to their male counterparts, women show an increased risk for trauma exposure and PTSD (Olf et al., 2007) and lower engagement in SUD treatment (Greenfield et al., 2007). Women with SUD also show more comorbid psychiatric disorders and poorer functioning than men with SUD, suggesting a more severe presentation overall, which may increase STB severity (McHugh et al., 2018; Nock et al., 2008). Second, although men show more completed suicide attempts than women, women with and without PTSD and SUD show an equal to greater amount of non-fatal STBs than men (Nock et al., 2008; Ronzitti et al., 2019). Indeed, some research has found that being female and having multiple psychiatric comorbidities are risk factors for STB (Nock et al., 2008). These findings indicate that trauma-exposed women with SUD may exhibit unique types of STBs compared to men. Therefore, studying STB measurement properties and identifying which specific variables are associated with them in this specific population is germane. The current study, therefore, aimed to address these issues by (a) utilizing IRT to develop an empirically-derived estimate of STB that accommodates varying item weights, and (b) identifying whether specific demographic

variables, SUDs, and PTSD symptom clusters are associated with heightened risk for STB in a trauma-exposed sample with SUDs and varying levels of PTSD symptoms. Given the sparse and mixed literature in this area, we consider the analysis on SUDs relating to elevated STB to be hypothesis-generating. However, based on Anestis et al (2012), we hypothesized that hyperarousal and re-experiencing clusters would be associated with elevated STB.

Method

Participants and Procedure

This study is a secondary analysis of a subset of participants from a randomized controlled trial (see Hien et al., 2009) comparing the efficacy of Seeking Safety (Najavits, 2002) and an active control group, Women's Health Education, for women with full or sub-threshold PTSD and substance dependence. Female participants were recruited across seven community-based substance use treatment programs participating in the National Drug Abuse Treatment Clinical Trials Network (NIDA CTN). Sites were located in the West ($n = 1$), Midwest ($n = 1$), Northeast ($n = 2$), and Southeast ($n = 3$) of the United States. They were representative of a mix of urban ($n = 5$) and suburban ($n = 2$) community treatment facilities.

Participants first completed a brief pre-screening via telephone with a research assistant, followed by a more comprehensive, in-person screening to determine eligibility for the parent study. Inclusion criteria for this stage included being aged 18 to 65; having used substances (including alcohol) in the past six months; and having experienced a traumatic event consistent with the DSM-IV definition of Criterion A (APA, 2000). Exclusion criteria included having an advanced medical disease; hospitalization in past two months due to psychosis or STB; active psychosis in the past two months; serious and specific suicide plan or attempt in the past six months (note that participants requiring further assessment in these domains were allowed to

continue onto the next screening appointment); or pending legal actions involving PTSD. In the parent study, participants were subsequently screened in greater depth for these and other inclusion and exclusion criteria (including elevated STBs using standardized suicide assessment). For the purposes of the present study of assessing how PTSD symptom clusters and type of SUD were associated with STB, we included participants who provided data at the in-person screening stage during which they received a thorough standardized assessment of STB. This led to a total of $N = 544$ trauma-exposed women with substance dependence in this study. Full study procedures are reported elsewhere (Hien et al., 2009) and were approved by relevant Institutional Review Boards. All participants provided informed consent.

Measures

Assessments were completed by research assistants and independent assessors.

Demographics

Age and race/ethnicity were collected at the in-person screening assessment, and education and marital status was assessed for participants who remained eligible following the screening eligibility assessment. Consequently, 32% of the sample was missing education level and marital status data (see data analytic section for more information).

Suicidal Thoughts and Behaviors

STB was assessed by the STB module in the Psychiatric Research Interview for Substance and Mental Disorders (PRISM; Hasin et al., 1996). The PRISM is a semi-structured, clinician-administered interview for individuals who use substances, with a focus on suicidality within the past 6 months. Four of the questions (i.e., thoughts of death, suicide ideation, suicide plan, and suicide gestures) have three categories for item rating options: absent (1), subthreshold (2), and present (3). The fifth item (i.e., previous suicide attempt) has two response options

(absent or present). While these questions were used as indicators of underlying latent STB, two of the items were also used to group participants who were excluded from the RCT based on suicidal intent: participants indicating either a plan or a suicide attempt in the past 6 months were coded ‘1’ while all others (i.e., RCT-eligible participants, participants excluded from the RCT for reasons other than suicidality) were coded ‘0’.

PTSD symptoms

The Clinician Administered PTSD Scale (CAPS; Blake et al., 1995) for DSM-IV was used to assess for exposure to lifetime Criterion A traumatic events and the frequency and severity of PTSD symptoms in the past 30 days. The CAPS is a structured clinical interview where symptoms fall into three clusters or subscales: Re-Experiencing, Avoidance/Numbing, and Hyperarousal. PTSD scale scores were derived using both (a) conventional subscale scores based on summing the frequency and intensity of symptoms, and (b) IRT-derived scale scores previously scored for this subsample in prior analyses (Morgan-López et al., 2020a, 2020b; Saavedra et al., 2021).

Substance use disorders

The Composite International Diagnostic Interview (CIDI; Robins et al., 1988) for *DSM-IV* was used to assess lifetime psychiatric and substance dependence diagnoses based on the presence or absence of substance dependence. The CIDI is a structured interview assessing alcohol, cannabis, cocaine, stimulants, opioids, sedatives, PCP, psychedelics, inhalants, and other substance dependence.

Data Analysis

Item Response Theory

SAS Proc IRT (SAS Institute, 2013) was used to fit a graded response IRT model under marginal maximum likelihood for the generation of expected a posteriori (EAP) IRT scores to capture latent severity in STB with the PRISM STB module. First, in order to test for unidimensionality of the five PRISM STB items, a 1-factor categorical confirmatory factor analysis model was estimated under robust weighted least squares (rWLS; Flora & Curran, 2004) to obtain a general sense of fit from conventional model fit metrics that are often unavailable in IRT software; assessment on unidimensionality would then be supplemented by assessment of the number of eigenvalues > 1 in SAS Proc IRT output.

The final graded response IRT scoring model would then take into account differences in (a) conditional proportions in each category for each suicide-related item (i.e., item thresholds/difficulties) and (b) the strength of the relation between each symptom and all other symptoms (i.e., item slope/discrimination); these slope/discrimination parameters function as symptom “weights”, with those with larger slopes receiving greater weight on PRISM IRT scores (Andrich, 1978; Curran et al., 2008; Morgan-López et al., 2020a). Often, IRT scores are set to a z-score metric (i.e., to have mean = 0 and variance = 1), but this metric is arbitrary (Blanton & Jaccard, 2006) and, more importantly, unfamiliar. To place the IRT scores in a more familiar metric, as is often done in educational testing with t-scores (e.g., mean = 50, SD = 10), the mean and variance of the IRT scores was set to the sample mean and variance of the PRISM suicidality *total* scores; this maintains the scores in a metric familiar to clinicians while also retaining the proper weighting of each symptom in relation to underlying suicidal thoughts and behaviors.

Local Reliability

Under classical test theory (CTT), the most common measure of reliability used in practice is Cronbach's α . Under CTT, α presumes that the reliability of a score is constant throughout the range of the construct, which is often unrealistic in practice. In IRT, the concept of reliability is "local", or specific to different levels of the construct (Embretson & Reise, 2000); for health outcomes research, a measure is ideally at its maximum reliability at the level of the construct at which a diagnostic decision is made (Chiesi et al., 2017; Morgan-López et al., 2020b). In order to calculate and graph local reliability (LR) for our proposed PRISM IRT-derived scale, test information function (TIF) values are output, where TIF values are the expected value of the inverse of the error variances for each estimated value of the latent construct score. Then, the TIF values are converted to LR values using $1 - (1/(TIF))$ for each specific value of the latent construct score.

Multilevel Regression

After generation of PRISM scale scores under IRT, a multiple regression model with a random intercept structure (to accommodate site-level clustering) was performed with the IRT scores as outcomes and baseline substance dependence diagnoses as primary predictors (with CAPS PTSD subscale scores and demographics as covariates). Multiple imputation using SAS Proc MI was used for accommodating covariate missingness on education and marital status. Twenty imputed datasets were used in accordance with recommendations by Graham et al. (2007); inferences across all 20 datasets, taking into account within- and between-imputation variance, were combined using SAS Proc MIANALYZE.

Multiple Imputation Diagnostics

The adequacy of the multiple imputation model that was used, where all variables listed in Table 1 were used in the estimation of missing observations under SAS Proc MI, was assessed

using multiple imputation diagnostics. The logic underlying multiple imputation diagnostic methodology is that the distribution of the observed values for a given variable should equal the distribution of the imputed values, after conditioning on the probability that the datum was imputed (Bondarenko & Ragnathan, 2016; Nguyen, Carlin & Lee, 2017); this is the exact articulation of the missing-at-random assumption (Schafer & Graham, 2002). Thus, a series of univariate propensity score models (within each imputed dataset) are fit in order to estimate the probabilities that a datapoint was imputed or observed, conditional on the variables that were a part of the imputation model; while general purpose software does not yet have this process automated (e.g., SAS, SPSS, Stata), the R package ‘mice’ has graphical evaluation of differences in the conditional distributions of the observed and imputed variables. For any given variable, the imputation model is deemed adequate if, after controlling for the propensity score, the differences between the imputed and observed distributions of the variable of interest are non-significant in at least 60% of the MI datasets (Bondarenko & Ragnathan, 2016).

Results

IRT Model Fit and Item Parameters

Demographics are in Table 1 while tetrachoric correlations between substance use disorder diagnoses are in Table 2. Rates of PRISM item endorsement are in Table 3. The initial unidimensional categorical CFA model was estimated under robust weighted least squares (rWLS; Flora & Curran, 2004) for a general sense of single-factor model fit. The initial model was judged as essentially unidimensional (Millsap, 2012) based on (a) the Comparative Fit Index (CFI) value from the categorical CFA model (CFI = .996) and (b) the second eigenvalue of the PRISM items being considerably less than 1 (.439).

The item parameters for the final STB scoring model are in Table 4. Of the four symptoms with absent, subthreshold, or present responses, suicide gestures indicate the greatest severity, requiring a latent risk score around .75 SDs above the mean before participants would endorse subthreshold suicide gestures. Suicide gestures also had the lowest endorsement rate, with 73.4% of the sample as ‘absent’. The two symptoms with the largest slopes/discrimination parameters, indicative of the symptoms that are most highly correlated with all other symptoms, and thus receiving greater ‘weight’ in estimation of the PRISM IRT score, were suicide ideation and suicide plan. The PRISM IRT STB severity score had a mean of 0 (SD = .88), prior to post-processing transformation. To facilitate interpretation, IRT scores were transformed to have a mean of 7.89 (SD = 3.94) - the same mean and SD as the PRISM STB *sum* scores.

Local Reliability

Local reliability was assessed for the PRISM IRT STB severity scores based on conversion of the test information function values (Chiesi et al., 2017; Morgan-López et al., 2020a). Figure 1 shows that the local reliability values remain above .85 throughout the practical range of the PRISM (between 0 SDs and +1.5 SDs), with the maximum reliability of .95 around +.75 SDs above the mean which, incidentally, approximates the estimated level of latent STB corresponding to a transition from subthreshold to present for all symptoms; +.75 SDs also translates to a total score equivalent value of 10.84, very close to the empirical cutscore value (10.70) distinguishing the severe STB group from the rest of the sample. The PRISM STB IRT scores are thus maximally reliable at the point of greatest clinical concern: the transition from ‘subthreshold’ to ‘present’.

Multilevel Receiver Operating Characteristic Curve (mROC)

To assess the extent to which using the IRT score maximally distinguishes severe STB, an ROC analysis was conducted. First, an empirical cutpoint was established on the rescaled PRISM STB IRT scores that distinguished participants that were originally excluded from the RCT due to severe STB ($n = 31$) and all other participants using the general formula for the weighted mean of two distributions (see Jacobson & Truax, 1991, p.13) as adapted for use under IRT (Morgan-López et al., 2020b; Saavedra et al., 2021):

$$(1) \frac{(\sigma_{Severe} \times \text{Mean}_{Non-Severe}) + (\sigma_{Non-Severe} \times \text{Mean}_{Severe})}{(\sigma_{Severe} + \sigma_{Non-Severe})}$$

Given the mean and SD for the severe STB group (mean = 13.41, SD = 1.35) and all other participants (mean = 7.59, SD = 3.26), the weighted midpoint/cutpoint between these distributions was 11.70.

Next, a random intercept logistic regression model was fit under SAS Proc GLIMMIX, where the severe STB group status was the dependent variable and whether each person was above or below the empirical cutpoint was the predictor; this was for the purpose of extracting predicted probabilities of severe STB that were adjusted for site-level clustering, and then using those predicted probabilities to estimate ROC curves and area under the curve (AUC) values in SAS Proc Logistic (Kiernan, 2018). Both the AUC values for models with the PRISM IRT scale score (AUC = .954 [CI: .935, .974]) and a grouping based on the empirical cutscore (AUC = .941 [CI: .916, .965]) suggest high “diagnostic” accuracy with predicting severe STB, even in cases where neither a plan nor a previous attempt in the past 6 months was evident. The AUC values are largely consistent with the proportions of participants who would have been misclassified as a) not having severe STB using the sum score cutoff but were classified as severe using the IRT cutoff and b) vice-versa; 5.5% of participants would have been misclassified. This may reflect a smaller proportion of participants than would typically

constitute significant “practical misclassification” under IRT (Morgan-López et al., 2020b; Saavedra et al., 2021; Sinharay & Haberman, 2014) but for outcomes as serious as STB, precision is even more paramount with regard to reducing the proportion of patients who “fall through the cracks” (Gibbons et al., 2017).

Multilevel Regression

Table 5 shows the full set of results for the multiple predictor multilevel regression model in addition to the p -values for each predictor examined separately prior to inclusion in multiple predictor model. Within separate, single predictor models, variables that were related to higher STB severity included being of Asian descent ($p = .04$), younger age ($<.001$), alcohol dependence ($p = .01$), cannabis dependence ($p = .001$), opioid dependence ($p = .01$), and all three sub-dimensions of PTSD ($ps = .018$ or less); being of African American descent was related to a lower STB severity in a single predictor model ($p = .005$). Of these effects, among substance dependence indicators, only opioid dependence remained significant in the multiple predictor model ($b = .697 (.329)$, $t = 2.12$, $p = .03$, Cohen’s $d = .19$) even after controlling for other substance dependence diagnoses and demographics. Across key covariates, increased STB were observed among younger women ($b = -.037 (.017)$, $t = -2.14$, $p = .03$, Cohen’s $d = .19$), and women high in reexperiencing PTSD symptoms ($b = .082 (.025)$, $t = 3.17$, $p = .002$, Cohen’s $d = .27$).

Multiple Imputation Diagnostics

While most of the variables in the model had no missingness, MI diagnostics were assessed on education and marital status (which had 33.3% missingness) and the PTSD criterion scores (which each had 16% missingness). We assessed the proportion of datasets where a) the observed and imputed values for that variable remained significant after controlling for the

probability that the datapoint was observed or generated under MI (i.e., observed versus imputed main effects) and b) whether the observed/imputed difference depended on whether the probability of the datum being an imputed value was higher or lower (i.e., observed/imputed x propensity score interactions). In no greater than 5% of datasets were observed/imputed differences significant and in no greater than 20% of the datasets were there observed/imputed differences that depended on the level of the missingness propensity score (with the threshold of significant differences in 40% or greater of the datasets indicating an inadequate multiple imputation model; Bondarenko & Rangunathan, 2016; Nguyen et al., 2017).

Discussion

Although suicidal thoughts and behaviors (STBs) and suicide risk are distinct—the latter reflecting a more comprehensive construct that weighs STB severity against several other demographic, clinical, and situational factors—STBs are nonetheless critically important to assess and target among individuals with substance dependence and/or trauma exposure. Unfortunately, systematic exclusion of patients with STBs in research thwarts understanding of how to best identify and treat these individuals. Overreliance on dichotomous or averaged/summed scale scores in STB measurement further compounds this issue. The current study is innovative in its use of statistical analyses that mirror how clinicians may weight, rather than add, STB variables during suicide risk assessment. Such an approach offers a more precise method of estimating STB severity using a common STB assessment tool to guide clinical practice and STB research.

Consistent with clinical practice guidelines suggesting that clinicians consider suicide risk to be elevated in the presence of suicidal ideation and plans (e.g., Perlman et al., 2011), the current study found that suicide ideation and plans had the highest weight in determining the

overall STB severity. It is notable that the PRISM measures current suicidal thoughts, and thus current endorsement of suicidal ideation and plans may be the key determinant of severity of current STBs. Although a past suicide attempt is a clear risk factor for future attempts (e.g., Asarnow et al., 2017), its historical focus may not reflect the severity of present-moment STB to the same extent as current suicidal ideation and plans. The current study found that suicidal ideation was weighted higher in the overall measure compared to thoughts of death, suggesting that actively contemplating suicide (e.g., “I would like to kill myself”) does indicate greater STB severity than contemplating death (e.g., “I wish I weren’t here”). Notably, the present study examined how these factors contribute to overall STB severity, not suicide *risk* (i.e., prediction of a future attempt), per se. A key future directive of this research is to examine the IRT-derived scale in predicting the occurrence, timing, and lethality of future suicidal behavior.

Correlates of STB

Using the IRT-derived measure, the present work also aimed to identify the demographic, substance dependence type, and PTSD symptom cluster characteristics that are associated with elevated STB. Younger age was associated with higher severity of STB. This finding is consistent with research showing that the rank of suicide as a cause of death decreases in women as their ages increase (Heron, 2015).

Specific substance dependence diagnoses

Individuals with alcohol, cannabis, and opioid dependence exhibited higher levels of STB in single predictor models. However, in multiple predictor models, only opioid dependence was associated with higher STB after controlling for the presence of other substance dependence diagnoses and demographics. The link between STB and cannabis dependence in the single predictor models is consistent with Allan and colleagues (2019) who found increased cannabis

use was associated with higher rates of suicidal ideation, and interacted with PTSD symptoms to predict suicidal behavior, while other substances did not. However, that this predictor became non-significant when other variables (including other substance dependence diagnoses) were included in the model suggests that general comorbidity of substance dependence diagnoses may be particularly predictive of STB, rather than cannabis or alcohol dependence per se. On the contrary, opioid dependence remained a robust correlate of STB even after accounting for such comorbidity. The finding that opioid dependence was associated with greater STB is consistent with previous findings suggesting that, among people who misuse substances, opioid use is specifically associated with more severe STB (Barman-Adhikari et al., 2019; Rieckmann et al., 2012). Although our study assessed opioid dependence rather than use, individuals with this disorder may be using heavily in a way that increases STB. Indeed, this substance may be associated with psychopathologies such as depression or psychosocial stressors that may also increase STB over time. Unlike stimulants and alcohol, which may be frequently used in social settings, individuals may be more likely to use opioids by themselves. Opioid dependence may therefore increase social isolation— a known predictor of STB (Calati et al., 2019). However, it is important to note that our findings do not illuminate causal relationships. Indeed, it is also possible that, given its sedating qualities, opioids may be frequently used to cope with trauma-related distress or STB. Moreover, given that suicidal behavior is also conceptualized as a maladaptive coping strategy (e.g., Linehan, 1993), a general tendency to escape aversive inner experiences may increase proclivity towards opioid dependence and STB. As well, opioids are used to self-medicate chronic pain (Vowles et al., 2015), a phenomenon that is associated with STB (Tang & Crane, 2006). Chronic pain may be a common underlying variable that accounts for linkages between these opioid dependences and STB.

PTSD symptoms

STB were most associated with PTSD re-experiencing symptoms. A national epidemiologic study showed that the PTSD symptom clusters of re-experiencing and avoidance are significantly associated with suicide attempts (OR 1.34 and 1.27, $p < .01$, respectively). Specifically, individuals endorsing physiologic reactions when reminded of trauma had a 2.53 increased likelihood of a suicide attempt post-PTSD diagnosis. The authors suggested that the combination of autonomic limbic arousal and perception of defeat from ongoing threat may enhance catastrophic cognitions which could lead to STB (Selaman et al., 2014). Indeed, if individuals experience a rise in STBs to escape distress, this may be particularly the case in response to re-experiencing symptoms that remind them of their distressing traumas.

Clinical Implications

The findings of this study have several important clinical implications as they indicate who may be in need of additional suicide risk assessments and interventions and ways to increase the accuracy of inclusion and exclusion criteria for clinical trials. First, best practice guidelines recommend that clinicians use brief suicide screeners to guide decisions regarding whether further suicide risk assessment is necessary (e.g., Bryan et al., 2009; The Assessment and Management of Suicide Risk Work Group, 2019). Several screening tools rely on scale averages or summed scores (e.g., the Suicidal Behavior Questionnaire-Revised; Osman, 2001), which clinicians and researchers may then utilize to determine who is at “high” or “low” suicide risk (e.g., Farabaugh et al., 2015). Summed/averaged STB scale scores are also frequently utilized as an outcome measure in both PTSD (e.g., Resick et al., 2017) and SUD (e.g., Morley et al., 2014) clinical trials to monitor changes in STB severity. However, the current findings suggest that, at least for some STB measures, not all items are created equal and that re-

weighting scale scores to emphasize suicidal ideation and plans may yield a more accurate estimate of STB severity. Second, there is valid concern regarding whether “active” (i.e., suicidal ideation, e.g., “I am thinking about killing myself”) and “passive” (i.e., thoughts of death, e.g., “Sometimes I wish I weren’t here”) forms of suicidal thinking actually reflect differential STB severities or reflect an arbitrary distinction (e.g., Baca-Garcia et al., 2011; May et al., 2015). Our findings suggest that, although all STB components (e.g., thoughts of death, past attempts), should be considered when determining an individual’s STB severity, suicidal ideation (compared to thoughts of death) and the presence of plans may be particularly indicative of the severity of STB.

Further, the current findings have implications for clinical trial exclusion criteria. Excluding participants from clinical trials on the basis of singular STB items (e.g., a recent past suicide attempt) may result in the exclusion of some individuals whose actual underlying severity of STB is comparable to those who are not excluded. These results therefore demonstrate that assessing STB for the purposes of study inclusion would be more appropriate if multiple STB components with different weights that are determined by IRT analyses were considered. With regard to specific types of SUD and PTSD symptoms, the current findings indicate that individuals with opioid dependence and high re-experiencing symptoms may warrant additional suicide risk assessment and management procedures. Moreover, identifying and targeting potentially common functions of opioid use and STB may prove useful in decreasing both substance use and STB. Importantly, the study highlights that targeting re-experiencing symptoms may be critical to reducing STB in trauma-exposed individuals with substance dependence. Research suggests that trauma-focused treatments such as Prolonged Exposure therapy may be particularly efficacious in reducing re-experiencing symptoms of

intrusive memories (Schnurr & Lunney, 2019). However, if, akin to research studies in PTSD and SUD populations, such individuals are excluded from participation until their suicidal risk decreases (alternately referred for suicide safety treatment), their re-experiencing symptoms may not have the opportunity to diminish through clinical treatment targeting PTSD symptoms. Future research is needed to elucidate the extent to which reducing re-experiencing symptoms reduces STB and whether additional intervention directly targeting STB may be needed.

Limitations and Future Directions

The present study has several limitations. Most notably, the data examined are cross sectional in nature, and we were therefore unable to elucidate causal relationships. Future studies that examine these relationships overtime may be more useful in establishing temporal precedence. In addition, the sample consisted of treatment-seeking women and the findings may not generalize to men or non-treatment seeking trauma-exposed samples with SUD. Furthermore, although we analyzed data from the point of study participation that occurred prior to possible exclusion for potentially severe STBs, some participants with particularly severe and imminent suicide plans or a recent suicide attempt may have been excluded at a pre-screen prior to the stage at which they were assessed in the present study. Thus, the present findings may not generalize to participants with particularly apparent and severe STBs, although participants who required further assessment in STB domains were allowed to continue to the point at which they provided the information used in the present study. Also, the version of the CIDI and CAPS used to determine diagnostic criteria was based on DSM-IV and not DSM-5. Consequently, both SUD and PTSD diagnoses were based on DSM-IV. Despite similarity between re-experiencing symptom clusters in DSM-IV (APA, 2000) and DSM-5 (APA, 2013), the findings regarding which symptom clusters are associated with STB may not be fully generalizable to those with

PTSD per DSM-5 (APA, 2013). However, the fact that the re-experiencing cluster was associated with STB is likely relevant for those with DSM-5 PTSD since this symptom cluster remained consistent across the two versions, as did the hyperarousal cluster. Furthermore, given that the diagnoses in the present study reflected substance dependence as defined by the DSM-IV, rather than SUD as defined by DSM-5, study relationships may only generalize to those who exhibit “higher severity” indicators of DSM-5 SUD diagnoses. Finally, it remains unclear which aspects of opioid dependence (e.g., regular use of the substances, impacts of these substances, specific withdrawal syndromes, or other elements of the pathology,) are associated with STB, and future researchers are advised to disentangle this.

Conclusions

Despite the critical importance of understanding, assessing, and identifying STB in trauma-exposed populations with SUDs, research methodologies that measure these variables are limited. The present study utilized an innovative statistical analytic methodology to examine STB in a way that mirrors the weighting of various factors in suicide risk assessment. The findings highlight that trauma-exposed women with substance dependence who are younger, have opioid dependence, and/or have higher re-experiencing symptoms may warrant focused suicide risk assessment and management strategies. Future work to elucidate the mechanisms through which these relationships operate would be beneficial.

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Table 1
Demographic Characteristics (N = 544 women)

Variables	<i>M (SD) or n (%)</i>
Age	39.28 (9.00)
Education ^a	
Less than High school	216 (59.02%)
Some College	108 (29.51%)
College	42 (11.48%)
Race	
Hispanic	9 (1.65%)
Black	203 (37.32%)
Asian	4 (.74%)
White	262 (48.16%)
Mixed	62 (11.41%)
Other	4 (.74%)
Ethnicity	
Hispanic/Latino	46 (8.5%)
Non-Hispanic/Latino	498 (91.5%)
Married ^a	64 (11.8%)
Re-experiencing symptoms	15.31 (7.70)
Avoidance symptoms	23.99 (10.95)
Hyperarousal symptoms	18.85 (8.41)
Total PTSD severity	58.06 (22.47)
Substance Dependence Diagnoses (% yes)	
Alcohol	417 (76.65%)
Cannabis	250 (45.96%)
Stimulants	74 (13.60%)
Sedatives	156 (28.68%)
Opioids	217 (39.89%)
Cocaine	433 (79.60%)
PCP	4 (.74%)
Psychedelics	16 (2.94%)
Inhalants	1 (.18%)
Other	5 (.92%)

^a *n* = 366

Note. *M* = mean; *SD* = standard deviation; PCP = Phencyclidine. PCP, inhalants, and other drug categories were not included in primary study analyses due to low cell sizes.

Table 2*Tetrachoric Correlations between Substance Use Disorder Diagnoses*

Variable	Alcohol	Cannabis	Stimulants	Sedatives	Opioids	Cocaine	PCP	Psychedelics	Inhalants	Other
Alcohol	1.00	0.35	0.45	0.33	0.17	0.08	1.00	0.35	0.87	1.00
Cannabis	0.35	1.00	0.28	0.22	0.11	0.25	0.28	0.20	1.00	0.14
Stimulants	0.45	0.28	1.00	0.31	0.30	0.09	0.16	0.49	-0.89	0.10
Sedatives	0.33	0.22	0.31	1.00	0.64	0.05	0.97	0.32	-0.88	0.12
Opioids	0.17	0.11	0.30	0.64	1.00	0.09	0.10	0.33	0.93	0.39
Cocaine	0.08	0.25	0.09	0.05	0.09	1.00	-0.02	0.32	0.87	-0.18
PCP	1.00	0.28	0.16	0.97	0.10	-0.02	1.00	0.69	-0.71	-0.82
Psychedelics	0.35	0.20	0.49	0.32	0.33	0.32	0.69	1.00	-0.89	-0.84
Inhalants	0.87	1.00	-0.89	-0.88	0.93	0.87	-0.71	-0.89	1.00	1.00
Other	1.00	0.14	0.10	0.12	0.39	-0.18	-0.82	-0.84	1.00	1.00

Note. PCP = Phencyclidine.

Table 3*Suicidal Thoughts and Behaviors from the PRISM (N = 543)*

Variables	n (%)
Thoughts of Death	
Absent	257 (47.33%)
Subthreshold	142 (26.15%)
Present	144 (26.52%)
Suicidal Ideation	
Absent	326 (60.04%)
Subthreshold	98 (18.05%)
Present	119 (21.92%)
Suicidal Plan	
Absent	383 (70.53%)
Subthreshold	38 (7.00%)
Present	122 (22.47%)
Suicidal Gesture	
Absent	400 (73.66%)
Subthreshold	33 (6.08%)
Present	110 (20.26%)
Suicidal Attempts	
Absent	407 (74.95%)
Present	136 (25.05%)

Table 4
PRISM Graded Responses IRT Parameters

Symptom	Threshold (Absent to Subthreshold)	Threshold (Subthreshold to Present)	Slope
Recurrent thoughts of death	-0.05	0.75	2.81
Recurrent suicidal ideation	0.29	0.85	5.64
Specific suicide plan	0.58	0.82	5.60
Suicide gesture	0.76	0.99	2.55
Suicide attempt		.79*	3.15

Note. * Threshold for Absent to Present

Table 5
Multilevel Regression Model Estimates

Predictor	Estimate	SE	t	Multiple Predictor Model p-values	Single Predictor Model p-values
Intercept	6.26	1.49	4.21	<.001	X
High School or Less	-0.10	0.52	-0.20	0.84	0.750
Some College	0.42	0.52	0.80	0.42	0.610
Married	0.62	0.51	1.23	0.22	0.410
Hispanic	0.09	0.57	0.15	0.88	0.790
Asian	3.31	1.76	1.88	0.06	0.040
Black	-0.49	0.35	-1.43	0.15	0.005
Other	0.27	0.59	0.46	0.64	0.760
Age	-0.04	0.02	-2.14	0.03	<.001
Alcohol Dependence	0.60	0.36	1.65	0.10	0.014
Cannabis Dependence	0.59	0.31	1.89	0.06	0.001
Stimulant Dependence	0.31	0.45	0.68	0.50	0.090
Sedative Dependence	-0.62	0.36	-1.70	0.09	0.700
Opioid Dependence	0.70	0.33	2.12	0.03	0.012
Cocaine Dependence	0.49	0.39	1.25	0.21	0.260
PTSD Reexperiencing	0.08	0.03	3.17	0.002	<.001
PTSD Avoidance	-0.01	0.02	-0.45	0.65	0.018
PTSD Hyperarousal	0.03	0.02	1.39	0.16	0.002

Note: Parameter estimates, standard errors and t-values are for the multiple predictor model. For Education Level, College Degree+ is the reference group. For race/ethnicity, Whites are the reference group.

Figure 1

Local Reliability Plot: PRISM Suicidality IRT Scores

