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Expanding outcomes when considering the relative effectiveness of two evidence-based outpatient treatment programs for adolescents

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Abstract

The current study seeks to advance understanding about how to address substance use and co-occurring mental health problems in adolescents. Specifically, we compared the effectiveness of two evidence-based treatment programs (Motivational Enhancement Treatment/Cognitive Behavior Therapy, 5 Sessions [MET/CBT5] and Adolescent Community Reinforcement Approach [A-CRA]) for both substance use and mental health outcomes (i.e., crossover effects). We used statistical methods designed to approximate randomized controlled trials when comparing nonequivalent groups using observational study data. Our methods also included an assessment of the potential impact of omitted variables. We found that after applying balancing weighting to ensure similarity of the baseline samples (given the nonrandomized study design), both groups significantly improved on the two substance use outcomes (days abstinent and percent of youth in recovery) and on the two mental health outcomes (PTSD symptoms and general emotional problems). Youth in A-CRA were significantly more likely to be in recovery at the 3-month follow-up compared to youth in MET/CBT5, but the size of this effect was very small. Youth

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receiving MET/CBT5 appeared to show significantly more improvement in the two mental health measures compared to youth in A-CRA, though these effect sizes were also very small. The findings indicate that adolescents with co-occurring substance use and mental health problems improve on both substance use and mental health outcomes with both treatments even though they are not specifically targeting mental health problems.

Keywords

Adolescent; Substance use treatment; Mental health; Causal inference; Omitted variable

1. Introduction

In 2016, approximately 4.4 percent (1.1 million) of adolescents aged 12 to 17 were in need of substance use (SU) treatment (i.e., had a substance use disorder [SUD] or received SU treatment in the past year) (Substance Abuse and Mental Health Services Administration, 2017). Evidence shows that substance abuse during adolescence elevates risk for addiction later in life (Agrawal et al., 2006; Everett et al., 1999; Khuder et al., 1999; King & Chassin, 2007), whether the substance is legal like alcohol and cigarettes, or illegal (Agrawal et al., 2006; Everett et al., 1999; King & Chassin, 2007). Furthermore, the majority of adolescents with SU problems (as many as 90%) also suffer from mental health (MH) problems, such as depression, anxiety, post-traumatic stress, conduct problems, and attention deficit hyperactivity disorder (ADHD) (Chan et al., 2008). For example, about one third of youth in SU treatment meet criteria for post-traumatic stress disorder (PTSD) (Turner et al., 2004), whereas the lifetime prevalence of PTSD in the adolescent general population is only about 5% (McLaughlin et al., 2013). Adolescents with co-occurring SU and MH problems are at particularly high risk for a range of poor outcomes, including suicide and academic problems (Brewer et al., 2017; Lewinsohn et al., 1995). When they do access services, youth with co-occurring SU and MH problems have worse treatment outcomes than those with a SU or MH problem only (Brewer et al., 2017; Hawkins, 2009; Rowe et al., 2004). For example, youth with co-occurring problems are more likely to relapse soon after SU treatment (Grella et al., 2001; Tomlinson et al., 2004). Therefore, it is important for research to identify treatments that can not only reduce SU but also address MH problems.

Unfortunately, while both are considered to be psychiatric problems under the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) (American Psychiatric Association, 2013), substance abuse and MH concerns are typically treated separately, in two different systems with different billing structures, certification and licensure processes, and overall philosophies (Hawkins, 2009). While there is increasing agreement that integrated treatment for co-occurring disorders is the gold standard, there are few evidence-based adolescent treatments that follow such a model (Godley, Hunter, et al., 2014; Hawkins, 2009; Hogue et al., 2018). Fortunately, there is some promise for crossover effects, where treatment intended to impact one problem (e.g., substance abuse) also addresses another (e.g., MH) (Connell et al., 2016; Godley, Hunter, et al., 2014; Reider & Sims, 2016). Interventions that address risk factors common to both types of problems (e.g., problematic thinking styles, maladaptive coping, and emotion regulation techniques) may hold the most promise for potential

crossover effects. For example, Kerr and colleagues (2014) examined whether an intervention designed to decrease delinquency, substance use, and risky sexual behavior among girls in the juvenile justice system might also affect depression. The intervention (Multidimensional Treatment Foster Care [MTFC]) has been found effective in reducing delinquency and teenage pregnancy, among other related outcomes (Chamberlain et al., 2007; Kerr et al., 2009). Although not specifically designed or intended to address depression or other MH concerns, MTFC focused on addressing problems that are risk factors for depression, such as emotion regulation, managing anger and irritability, enhancing social support from prosocial adults and peers, and increasing a sense of belongingness. Indeed, the authors found that MTFC significantly decreased depressive symptoms and suicidal thoughts above and beyond the changes observed in the treatment-as-usual group (Kerr et al., 2014).

There are many evidence-based treatment approaches that could theoretically be effective in reducing both SU and MH problems, because the two types of problems overlap so much in etiology (Hawkins, 2009). It can be difficult to examine such crossover effects, however, because SU treatment trials often exclude individuals with co-occurring MH problems or do not report MH outcomes. One landmark study of adolescent SU treatment that sheds a great deal of light on treatment approaches for this population did include youth with MH problems: the Cannabis Youth Treatment (CYT) study (Diamond et al., 2002). In this randomized controlled trial (N=600), youth with a cannabis use problem were randomized to one of five interventions. Overall, youth in all of the conditions improved on SU outcomes, but two interventions—the Adolescent Community Reinforcement Approach (A-CRA) (Godley et al., 2001) and Motivational Enhancement Treatment/Cognitive Behavior Therapy, 5 Sessions (MET/CBT5) (Sampl & Kadden, 2001)—were particularly cost-effective (Dennis et al., 2004). A-CRA consists of 10 individual sessions with the adolescent, four sessions with caregivers including two with the entire family, and case management throughout the treatment period. A-CRA is adapted from the Community Reinforcement Approach (CRA) for adults (Azrin et al., 1982; Meyers & Smith, 1995) and applies elements of operant conditioning to increase prosocial behavior, skills training, and social systems approaches. MET/CBT5 includes two individual MET sessions, followed by three group CBT sessions. A course of treatment lasts approximately 6 to 7 weeks. Both A-CRA and MET/CBT5 use therapeutic approaches (i.e., cognitive-behavioral and behavioral) to reduce adolescent substance abuse that have been shown to be effective in addressing a variety of MH problems as well (Bisson et al., 2007; Hofmann et al., 2012; Thomas & Zimmer-Gembeck, 2007). This finding, along with their demonstrated cost effectiveness (Dennis et al., 2004), makes these therapeutic approaches particularly worthy of further investigation with respect to addressing MH problems among youth with co-occurring SUDs. Furthermore, initial research supports the use of several A-CRA procedures to treat SU and commonly co-occurring psychiatric disorders (Godley, Hunter, et al., 2014).

Unfortunately, the CYT trial did not examine differences between A-CRA and MET/CBT5 in MH outcomes. In a related study, Ramchand and colleagues (Ramchand et al., 2011) compare youth who received MET/CBT5 with a sample of propensity score weighted youth who participated in a heterogeneous set of “exemplary” adolescent substance abuse treatment programs (Ramchand et al., 2011). Here, the propensity score weights served to

create a pseudorandomized study whereby the groups of youth receiving MET/CBT5 were made to look similar to the youth receiving “exemplary” on 17 pretreatment variables that might confound the treatment effect estimates. They found that youth who received MET/CBT5 demonstrated greater reductions in SU, but there were no group differences in MH outcomes at 12-month follow-up. The heterogeneity of the comparison group, however, makes it difficult to determine the extent to which the findings may have been influenced by particularly strong or weak comparison group programs. For A-CRA, Godley and colleagues (2014) examined differences between youth with and without co-occurring SU and psychiatric problems on rates of treatment engagement, retention, and satisfaction, as well as SU and emotional problem outcomes among youth receiving A-CRA. While youth with co-occurring problems had higher mean levels of SU and emotional problems at each follow-up, they had greater rates of improvement over time than youth with no co-occurring problems (Godley, Hunter, et al., 2014). To our knowledge, MET/CBT5 and A-CRA have not yet been directly compared to determine whether one particular treatment has a greater impact on MH problems.

The current study seeks to build on the prior literature and advance understanding about how to address SU and co-occurring MH problems in adolescents. We had three primary objectives: (1) to compare youth receiving MET/CBT5 and A-CRA on SU outcomes, in an attempt to replicate the aforementioned CYT findings using a larger, more representative sample; (2) to compare these evidence-based treatments’ impact on MH problems (i.e., crossover effects), specifically PTSD, given its high prevalence in this population (Turner et al., 2004), and overall psychopathology; and (3) to apply state-of-the-art statistical methods designed to approximate randomized controlled trials when comparing nonequivalent groups that include an assessment of the potential impact of omitted variables. We hypothesized that we would replicate CYT findings, specifically that the two treatments would not differ on SU-related outcomes at 3 months, but that A-CRA would have advantages over MET/CBT5 on MH outcomes due to its longer length of treatment and resultant opportunity to address such problems.

2. Methods

Our study used a quasi-experimental design involving balancing weights (akin to propensity score weighting) and omitted variable sensitivity analyses to robustly compare MH and SU outcomes for youth receiving A-CRA versus MET/CBT5. More specifically, we analyzed longitudinal observational data from adolescents receiving SUD treatment, who were administered the Global Appraisal of Individual Needs (GAIN) biopsychosocial assessment instrument (Dennis et al., 2003). One-hundred and seventy-eight adolescent SUD treatment sites that the Center for Substance Abuse Treatment (CSAT) funded between 1997 and 2012, including the sites in our A-CRA and MET/CBT5 groups, routinely collected the GAIN. Clinicians interviewed adolescents receiving services at those sites up to four times over the course of 12 months using the GAIN (intake and 3-, 6-, and 12-months postintake). In the current study, we focus primarily on the 3-month outcomes given evidence from prior studies that the most change tends to happen for youth between the baseline and 3-month follow-ups in the GAIN data (Dennis et al., 2004). Outcomes from the 6-month follow-up are provided for descriptive purposes and sensitivity analyses.

2.1. A-CRA intervention

We drew youth receiving A-CRA from four cohorts of the Assertive Adolescent and Family Treatment Initiative (AAFT; CSAT RFA TI-06–007) (Garner et al., 2009). AAFT1, AAFT2, AAFT3, and AAFT4 included a sample of adolescents who received A-CRA from one of 80 different treatment programs located across the country including locations such as San Francisco, CA; Pinellas Park, FL; Chicago, IL; New York, NY; and Laredo, TX. CSAT funded fifteen sites as part of AAFT1 in September 2006, 17 in 2007, 14 in 2009, and 34 in 2010 as part of AAFT2, AAFT3, and AAFT4, respectively. Most sites implemented A-CRA as an outpatient intervention with durations of 12 to 14 weeks, followed by another 12 to 14 weeks of in-home assertive continuing care (ACC), during which clinicians used A-CRA procedures, home visits, and case management to stress rapid initiation of services after discharge from treatment that promote recovery and prevent relapse (Godley et al., 2006). CSAT provided free training and technical assistance via a training and technical assistance contract awarded to Chestnut Health Systems (Garner et al., 2009).

There were 4,968 youth aged 12–17 in the A-CRA group who were eligible to have 3- and 6-month follow-up interviews during the study funding period, of whom 4,369 (87.5% of the eligible A-CRA sample) completed the 3-month follow-up interview and 4,101 (82.5%) completed the 6-month follow-up. For our primary analysis examining the relative effectiveness of MET/CBT5 versus A-CRA on 3-month outcomes, we restricted the final sample for the outcome analyses to only those youth who had the relevant outcome measure. However, we note that we used the full sample (4,968) when doing the multiple imputation of incomplete data (described below) and that we account for nonresponse rates at 3-months by estimating balancing weights that account for nonresponse (see Appendix A).

2.2 MET/CBT5 intervention

We drew youth receiving MET/CBT5 from the Effective Adolescent Treatment (EAT; TI03-007) program initiative, which CSAT launched in 2003 and which provided support for 37 community-based programs across the U.S. to adopt MET/CBT5 to treat adolescent cannabis use. EAT included locations such as Burlington, VT; Pinellas Park, FL; Pontiac, MI; Laredo, TX; and Santa Barbara, CA. CSAT funded the first cohort in 2003 ($n = 22$ sites) and the second cohort in 2004 ($n = 15$ sites), with grant funding supporting a three-year period and including training and technical assistance in delivering the therapy (MET/CBT5) and in implementing the GAIN assessment tool. The support for the therapy and assessment tool included didactic training and active role plays followed by a certification process whereby program staff had audiotaped practice sessions (for the therapy or assessment) that an expert reviewed and provided feedback (Dennis et al., 2004; Sampl & Kadden, 2001). The EAT request for applications (RFA) encouraged MET/CBT5 applicants to add additional services to their clients above and beyond the standard 5 sessions, resulting in many grantees adding therapeutic services, including family sessions and MH services (Belur et al., 2014).

There were 5,184 youth in the MET/CBT5 sample who were eligible to have 3-month and 6-month follow-up interviews during the study funding period, of whom 3,834 (74.0% of the eligible MET/CBT5 sample) completed the 3-month follow-up interview and 3,610 (69.6%)

completed the 6-month follow-up. As noted, we restricted the final sample for the outcome analyses to only those youth who had the relevant outcome measure at 3-months, accounting for nonresponse directly in our balancing weights estimation step.

2.3. Measures

As noted, staff obtained data on pretreatment client characteristics (measured at intake) and treatment outcome measures at 3- and 6-months from the same biopsychosocial instrument, the GAIN (Dennis et al, 2003). The GAIN has eight sections assessing background and demographic characteristics (asked at baseline only); substance use; physical health; risk behaviors; mental health; environment; and legal and educational/vocational problem areas. It includes more than 100 symptom counts, change scores, and service utilization indices, most with Cronbach alphas over .85 (Dennis et al, 2003).

2.3.1 Pre-treatment characteristics.—To adjust for observed pretreatment heterogeneity between A-CRA and MET/CBT5, we used balancing weights (Hainmueller, 2012) to balance the two groups on 27 pretreatment variables that experts have been identified as important potential predictors of treatment assignment for adolescents and SUD (Grant et al., 2019) and that the literature has identified as key potential predictors of outcomes in this sample (Griffin et al., 2012; Griffin et al., 2014; Griffin et al., 2011; Ramchand, Griffin, Hunter, et al., 2014; Ramchand, Griffin, Slaughter, et al., 2014; Ramchand et al., 2011; Schuler et al., 2014). The full list of pretreatment characteristics used in this study are shown in Table 1.

2.3.2. Outcomes.—Given the goal of the current study to examine the effectiveness of A-CRA and MET/CBT5 for MH problems among adolescents in SUD treatment, we examined two domains of outcomes in our data. In the first domain, we examined two SU-related outcomes using the same two primary outcomes in the CYT. Namely, we examined total days abstinent together with a binary indicator of whether a youth was in recovery (meaning living free in the community and with no use 30 days prior to the follow-up interview). Concurrently, we examined two MH-related outcomes: the EPS (Emotional Problems Scale) and the TSS (Traumatic Stress Scale). The EPS assesses a range of internalizing and externalizing problems using seven items where adolescents report the recency and number of days for which they experienced such problems; it ranges from zero to one (Cronbach's alpha=0.78). EPS cut points for clinical decision-making are low (0–.13 less than weekly problems), moderate (.14–.50 weekly problems), and high (.50–1.00 daily problems), where scores in the moderate-to-high range indicate need for treatment planning (GAIN Coordinating Center, 2013). The TSS is a 13-item measure of PTSD symptoms in which adolescents report (yes or no) whether they were bothered by different symptoms over the past 90-day monitoring period; it ranges from zero to 13 (Cronbach's alpha=0.92). TSS cut points for clinical decision-making are low (0 problems), moderate (1–4 problems), and high severity (5–13 problems), where scores in the moderate-to-high range indicate need for treatment planning (GAIN Coordinating Center, 2012). We standardized continuous outcomes so that we could report final treatment effect estimates on an effect size scale.

We note that our work is part of a larger study whose goal is to better understand the role of PTSD for substance using youth. As such, we had a prior interest in understanding the relative effectiveness of A-CRA versus MET/CBT5 on PTSD (as measured by the TSS). Since we also wanted to compare these treatments on MH problems more generally, we also included the EPS as a second MH outcome to our analyses. EPS is a general scale that includes both internalizing and externalizing MH symptoms. We selected our SU outcomes to match the two primary outcomes measured as part of the CYT trial.

2.3.3 Missing data.—The mean rate of missingness on baseline covariates was less than 1.0 percent while the mean rate of missingness on 3-month outcomes ranged from 0.2% (emotional problem scale) to 36.9% (traumatic stress scale). We handled missingness using multiple imputation by way of the bootstrap EM algorithm, as implemented in the R package Amelia (Honaker et al., 2010). To specify the number of imputed datasets we took the maximum missingness rate of the union of outcomes and covariates (61.2%) and used Bodner’s formula (Bodner, 2008). The linear interpolation suggests 90 imputed datasets. We imputed missing values for all youth eligible for 3-month and 6-month follow-up interviews, treating the 3-month and 6-month data as missing for youth not responding to either of those waves. We used outcomes in the imputation to ensure that correlation among our predictors, treatment variable, and outcomes are properly considered, but we dropped individuals for whom we do not observe the outcome of interest from final analyses, after incorporating their covariate information into nonresponse weights.

2.4. Statistical analyses

2.4.1 Balancing weights.—We designed our analytic approach to answer the following question: *When disseminated to a set of community-based outpatient programs, what is the relative effectiveness of MET/CBT5 versus A-CRA for SU- and MH-related outcomes?* To answer this question, we used balancing weights to compare the outcomes of youth receiving MET/CBT5 in the EAT initiative with those of similar youth receiving A-CRA at the AAFT sites. The use of balancing weights, which are akin to propensity score weighting, is an increasingly popular method to estimate treatment effects for longitudinal, observation study data (like the GAIN data) in which individuals are not randomized to the treatments under consideration. We chose balancing weights so that the weighted average of the values for each covariate in either group (A-CRA or MET/CBT-5) equal the corresponding average for the combined sample of both groups. This way the weighted average of the values for covariate in one group (A-CRA) equal weighted averages in the other group (MET/CBT-5). For this reason, a study that applies balancing weights can be considered a “pseudo-randomized” trial comparing A-CRA against MET/CBT5 by creating comparable treatment groups on key pretreatment characteristics that might confound treatment effect estimates if the groups were not made comparable.

We estimated the balancing weights for this analysis using entropy balancing (Hainmueller, 2012), which computes weights that optimally “balance” the exposure groups and that can be modified to account for nonresponse. See Appendix A for extensive details on our weighting method. In brief, we targeted the weights to ensure balance on the first three moments (e.g., mean, variance, skewness) of the empirical distribution of each pretreatment

covariate between the two groups and adjusted the weights for nonresponse to ensure that our final weighted sample was representative of the original baseline sample. We implemented the estimation of the weights using the “entbal” package in R (R Development Core Team) and we assessed balance between the treatment groups across a number of criteria (Ridgeway et al., 2013).

To show how comparable the A-CRA and MET/CBT5 groups were after applying the balancing weights, we report the pre- and postweighting standardized mean difference (SMD) for each variable used to create the weights. The SMD is estimated by:

$$\frac{\hat{\mu}_t - \hat{\mu}_c}{\hat{\sigma}}$$

Here, $\hat{\mu}_j$ denotes the estimated mean value for the treatment and control conditions ($j = t$ and c , respectively); $\hat{\sigma}$ denotes the estimated standard deviation for the variable in question using the average of the standard deviations from each group (unweighted and weighted accordingly). Values of 0 for an SMD represent no difference in means while values of ± 1 represent one standard deviation difference between the two groups. Since standardized differences of 0.10 are considered to be small effect size differences, we denote group differences to be notable when the absolute SMD is greater than 0.10. In evaluating the full performance of the weights, we also additionally calculated the log-ratio of the weighted standard deviations and the weighted Kolmogorov-Smirnov statistics for each variable to capture how well the weights balanced the second and higher moments in our analysis (Imbens & Rubin, 2015; Ridgeway et al., 2013).

2.4.2. Outcome analyses.—We estimated the treatment effect for each of our outcomes separately at 3-months postintake by computing the adjusted mean difference between the weighted youth receiving MET/CBT5 and those receiving A-CRA, along with corresponding 95% confidence intervals (CI), using a linear model for the outcome as a function of treatment and the pretreatment covariates reported in Table 1 and simultaneously weighting each youth’s data by the youth’s balancing weight. By combining regression modeling with the balancing weights, we aim to reduce bias over just weighting alone. We fit separate models for each outcome. Given the variable response rates on each outcome (80.6% for EPS, 51.0% for TSS, 80.2% for days abstinent, 80.6% for in recovery), we opted to estimate different balancing weights for each outcome analysis to ensure the analytic sample used in a specific outcome model had optimal weights that would minimize bias from the observed pretreatment covariates used in the balancing weights model. Finally, we standardized the outcomes so that the estimated treatment effects represent effect sizes (Cohen’s d) and consider effects under 0.2 to be small, between 0.2 to 0.4 to be moderate, and above 0.4 to be large.

2.4.3. Omitted variable sensitivity analyses—A key assumption in estimating the difference in the effects of the two treatment programs is that we have not left out any potential confounders when estimating the balancing weights. Such an assumption is impossible to test in practice. However, it is critical to understand how sensitive findings

from observational studies might be when considering the effect of omitted confounders. As such, we designed a series of graphical tools that describe how sensitive both treatment effect estimates and statistical significance (as measured by the p-value) will be to an unobserved covariate (Burgette, Griffin, Pane et al., forthcoming; Pane et al., forthcoming). We applied those tools here to assess the sensitivity of our findings to omitted variables.

3. Results

3.1 Sample characteristics.

Table 1 demonstrates how well the final balancing weights balanced the pretreatment covariates between the A-CRA and MET/CBT5 groups using the entropy balancing procedure and the TSS outcome (the outcome with the highest nonresponse rate). Before weighting, the groups were notably different (i.e., $SMD > 0.1$) on 17 out of 27 of the pretreatment confounders included in the analysis. In particular, youth in the A-CRA group were older (15.6 vs 15.4) and that group had a much greater proportion of minority youth compared to the MET/CBT5 group (68% vs 49%). They also had higher mean levels of SU (SFS = 11.9 vs 10.4) and greater rates of past SU treatment (8.0 vs 1.4 on the SATI). A-CRA youth also had greater rates of MH problems (EPS = 0.3 vs 0.2) and higher rates of prior MH treatment (0.3 vs 0.2). After weighting, the groups look much more similar with no lingering imbalance. The balance statistics were not only consistent across imputations but also subsets of the data defined by missingness on each outcome; additional tables in Appendix B show balance tables for the other outcomes. There were no variables that had an SMD in absolute value greater than 0.1 after accounting for nonresponse and weighting for any of the outcomes.

3.2 Outcome trends over time

Figure 1 emphasizes that overall, youth SU improved over the course of the follow-up, as evidenced by the increase in number of days abstinent. Furthermore, MH problems (i.e., EPS and TSS) decreased over time. The largest changes in both SU and MH occurred from baseline to 3-months, with smaller changes observed from 3 to 6 months. As per the design of this study, there were no notable differences in outcome means at baseline because the balancing weights are designed to balance the two groups on baseline values for all outcomes being examined.

3.3 Treatment effects

Table 2 shows balancing weighted outcome means at baseline and 3 months for each group as well as treatment effect estimates from our fully adjusted regression models. As shown by the weighted means, youth in both groups improve on average over the course of the study. For SU outcomes, the percentage of days youth abstained increased from 51% to 66% for both groups and the percentage in recovery more than doubled from 20% to more than 40% for both groups. For MH outcomes, both groups decreased on EPS and TSS, suggesting a reduction in emotional problems and PTSD-specific symptoms over the course of the first 3 months.

We note that most treatment effect size estimates are small, ranging from 0.01 to 0.14, suggesting minimal differences between the groups. While youth in both groups improved over time, youth receiving A-CRA are more likely to be in recovery at 3 months compared to MET/CBT5 (estimated effect size difference = 0.10; 95% confidence interval = 0.05, 0.14). Conversely, there is no statistically significant evidence that either group has an advantage with respect to reported days of abstinence at 3 months (estimated effect size difference = 0.01; 95% confidence interval = -0.04, 0.06). For MH outcomes at 3 months, there is evidence that youth in MET/CBT5 are doing slightly better on average symptom reduction compared to youth in A-CRA, with estimated effect sizes of 0.14 for emotional problems (EPS) and 0.07 for PTSD symptoms (i.e., TSS). Appendix Table C1 shows treatment effect estimates for each outcome at 6 months, which served as a sensitivity analysis to the 3-month estimates; the results were consistent.

3.4 Omitted variable sensitivity analyses

A key assumption for our estimates to reflect causal effects is that we have observed all pretreatment variables that are associated with the outcome of interest and the probability of being in the A-CRA versus MET/CBT5 study arm. To understand how sensitive the findings reported in Table 2 might be to the impact of unobserved confounders that we did not measure in our sample (e.g., family history of SUD and/or MH problems), we used a series of sensitivity analyses that allow us to explore how strongly correlated an omitted factor might have to be with both the reported outcome and the likelihood of being in A-CRA versus MET/CBT5 to significantly change the reported results shown in Table 2.

Figure 2 illustrates the sensitivity analyses for the EPS, where the estimated treatment effect size was 0.14 and the corresponding p-value was less than 0.001. Figure 2 shows how both the estimated treatment effect (solid contours) and p-value (dashed contours) would change as a function of an unobserved confounder whose association with the treatment indicator is expressed through an effect size or SMD (x-axis), and whose relationship with the outcome is expressed as a correlation (y-axis). The solid contours report the adjusted treatment effect estimate that would result as we increase the relationship between the omitted variable and the outcome and treatment group indicator (A-CRA vs. MET/CBT5). As shown, the estimated treatment effect gets larger as we move to the right from zero along the x-axis and decreases as we move left from zero. The dashed contours show how statistical significance of our result is impacted. As shown, an unobserved confounder would need a correlation with the outcome greater than 0.20 and would need to differ between the A-CRA and MET/CBT5 groups with an SMD of greater than 0.20 to change our finding to have a non-statistically significant p-value > 0.05. Additionally, the plot shows (via the black dots) the observed correlations and effect sizes observed in our data for a relevant subset of the 27 pretreatment confounders that we used in the balancing weights. As shown in Figure 2, among these observed pretreatment confounders, only the baseline value of EPS is correlated with the outcome at greater than 0.20 and had an unweighted SMD of greater than 0.20. Generally, when a post-treatment outcome is also measured at baseline, the pretreatment measure is more strongly related to the post-treatment measure than other variables. Thus, relative to the observed variables, the omitted variable would need to have a very strong relationship with both the outcome and the treatment group to change our

findings regarding the beneficial effect of MET/CBT5 vs. A-CRA on emotional problems. This sensitivity analysis suggests that even if there are omitted variables, it is unlikely that, had we been able to control for them, our findings for emotional problems would change, and we conclude our results are robust to unobserved confounding for EPS.

Appendix D shows the same graphics for the traumatic stress scale (Figure D1), days abstinent in the past 90 (Figure D2), and recovery (Figure D3). In general, the conclusions are consistent, and our findings show relative robustness on MH and SU outcomes. The only notable exception is for TSS, where we see that our findings are highly sensitive to a potential unobserved confounder. An unobserved confounder would only need a correlation with the outcome greater than 0.05 and would need to differ between the A-CRA and MET/CBT5 groups with an SMD of greater than -0.03 to change our finding to have a non-statistically significant p-value > 0.05 .

4. Discussion

In this study, we estimated the change in SU and MH problems over time in a relatively large sample of adolescents in SU treatment. Specifically, we examined whether either of two evidence-based treatments for adolescent SU, A-CRA and MET/CBT5, outperformed the other on either SU or MH outcomes. Overall, we found that after applying balancing weighting to ensure similarity of the baseline samples (given the nonrandomized study design), both groups significantly improved on the two SU outcomes (days abstinent and percent of youth in recovery) and on the two MH outcomes (PTSD symptoms and general emotional problems). Youth in A-CRA were significantly more likely to be in recovery at the 3-month follow-up compared to youth in MET/CBT5, but the size of this effect was very small. Youth receiving MET/CBT5 appeared to show significantly more improvement in the two MH measures compared to youth in A-CRA, but, again, the effect sizes were very small. Indeed, the size of all group differences—even the significant ones—were less than a Cohen's d of 0.2, which is a commonly accepted cutoff for a small effect size (Cohen, 1992).

This study is the first, to our knowledge, to compare two active youth SU treatments to determine whether one has an advantage in terms of addressing MH problems. Our findings provide the field with a fuller picture of how evidence-based treatments designed to address drug and alcohol use can also help to alleviate MH symptoms that co-occur in the vast majority of youth engaged in such treatments.

While the aforementioned findings suggest that A-CRA may have an advantage when it comes to youth remaining in recovery at 3 months, we are reluctant to draw many conclusions given the small effect size ($d=0.10$). Nevertheless, clinical directors, parents, and policy-makers may find the 5-percentage point difference between A-CRA and MET/CBT5 relevant as it resulted in approximately 196 additional youth in recovery in the A-CRA group. Also, it is difficult to determine whether this finding is caused by more treatment sessions in the A-CRA treatment compared to MET/CBT5 as opposed to some qualitative difference in treatment content or that A-CRA included additional services beyond the primary treatment sessions that extended past the 3-month follow-up. On the

other hand, this finding is consistent both in direction and effect size with nonsignificant trends in the CYT trial, where a greater percentage of youth receiving A-CRA were in recovery at the 12-month follow-up compared to those receiving MET/CBT5 (Dennis et al., 2004). That this effect may have persisted at the 12-month follow-up in the smaller CYT study suggests that this may be a robust, though small, finding that we were able to detect in the current study due to our larger sample size.

MET/CBT5 appears to have outperformed A-CRA in its impact on PTSD symptoms (TSS) and emotional problems (EPS) at 3-month follow-up, contrary to our expectations. Prior research has been mixed, with some studies showing SU treatments do not have crossover effects on MH symptoms (Ramchand, Griffin, Slaughter, et al., 2014; Ramchand et al., 2011) and others showing promise for reducing MH symptoms (Kerr et al., 2014; Liddle et al., 2009; Reider & Sims, 2016). However, no prior study has directly compared these two evidence-based treatments, A-CRA and MET/CBT5, or examined impact on PTSD symptoms specifically. That said, these effect sizes are small (effect sizes of 0.14 and 0.07) and should, therefore, be interpreted cautiously. Additionally, while our findings for emotional problems were robust to unobserved confounding, our findings for PTSD symptoms were highly sensitive to the potential impact of an unobserved confounder, suggesting it is easy to wipe away differences between the two groups on this outcome. The sensitivity of our findings on PTSD are likely driven in large part by the higher rate of missingness on the TSS (36.9% at the 3-month follow-up), which was an optional scale at the follow-ups for sites collecting GAIN data. Our methods aim to handle this issue in three key ways. First, we used multiple imputation to help address the amount of uncertainty that exists by creating 90 imputed datasets to be used in our analysis. Second, we used unique balancing weights for each outcome that ensure our responders on a given outcome generalize to the original baseline sample of youth used in our study. Finally, we used our unobserved sensitivity analyses to additionally highlight how outcomes like TSS, which have higher rates of missingness, can be more sensitive to the impact of unobserved confounders given the smaller sample size available for estimation of the relative treatment effect of A-CRA versus MET/CBT5. Still, it is possible that additional services encouraged by the EAT RFA, which included family sessions (similar to or identical to A-CRA family services) and MH services (see Table 2 in Belur et al., 2014) might have contributed to the MH outcome findings in favor of MET/CBT5. However, we do not have the needed data on other types of services received to determine the frequencies at which such services were accessed by adolescents. It is also possible that youth used the strategies taught by MET/CBT5 for SU problems and more easily applied them to address their MH symptoms. In particular, CBT is the gold standard intervention for many MH conditions including PTSD, depression, and anxiety (David et al., 2018), so the approaches to addressing problematic thinking and behaviors within the context of drug or alcohol use/cravings are directly translatable to dealing with similar (potentially the same) thinking styles that perpetuate MH symptoms.

While youth in both treatments had reductions in their PTSD and emotional problem symptoms at 3-month follow-up, in neither group did the average of the emotional problem scale scores fall into the low or subclinical range. Perhaps more specific targeting of MH symptoms by these treatments would result in further symptom reduction, but additional

research is needed to answer this question. It is noteworthy that both treatments are associated with means closer to the low range (average for both groups <1 symptom) at 3-month follow-up for PTSD symptoms. Future research should examine specific components of each treatment that may be common and linked to TSS symptom improvement and compared to evidence-supported trauma interventions such as Trauma-Focused Cognitive Behavioral Therapy (Cohen et al., 2012).

Our study applies a modern approach to assess the sensitivity of our results to unobserved confounding variables. The application of omitted variable analyses in most studies involving observational data is rare in the field of addiction (Schmidt et al., 2012; Watkins et al., 2016). Nonetheless, such analyses are critical to understanding the potential bias in study findings that might arise when using observational rather than randomized trial data and that, we believe, should become standard practice. As noted, a key assumption in any analysis with balancing or propensity score weights is that no key potential unobserved confounders have been left out when estimating the weights (Hainmueller, 2012; Rosenbaum & Rubin, 1983). Such an assumption is impossible to test empirically (Weitzen et al., 2005). Thus, in practice, it is critical that researchers use weighting together with omitted variable sensitivity analyses to assess how robust findings from the study might be and to help assess the quality of the evidence from the observational study relative to a randomized control trial, which will balance on both observed and unobserved confounders (VanderWeele & Ding, 2017). We note that our balancing weights, estimated via entropy balancing, did an excellent job creating almost equivalent groups of youth in the two treatments groups (A-CRA versus MET/CBT5) on the 27 observed pretreatment covariates. Additionally, the omitted variable sensitivity analyses showed findings from the study for the SU outcomes (days abstinent and percent of youth in recovery) and on one MH outcome (general emotional problems) are highly likely to be robust to omitted variable bias, meaning that potential unmeasured confounders would not be likely to change the findings (had we measured them). In contrast, the findings on PTSD symptoms are highly sensitive to unobserved confounding, suggesting that those findings are not robust. The tools used in the omitted variable sensitivity analysis are readily available (Pane et al., Under Review) and can easily be adopted by others in the field engaged in research to estimate causal effects from observational study data.

It is important to note the study's limitations. First, the study lacks a no-treatment or treatment-as-usual control group, so it is not possible to determine whether the observed improvements in MH and SU would have occurred naturally over time or within the context of usual care. Second, we only examined changes over a relatively short follow-up period. While youth in this study sample have follow-ups at 6 and 12 months, the response rates for these follow-ups is low (e.g., TSS at 6 months is 45.6%) and the majority of the change as shown in Figure 1 occurs from baseline to 3 months. Thus, we did not analyze these outcomes in depth, though we present 6-month outcome analyses in Appendix C, and they are consistent with the results of the 3-month outcomes in that A-CRA has a larger effect on recovery, but MET/CBT-5 has larger effects on PTSD symptoms and emotional problems. We also did not examine trajectories of change over time; it is possible that each of the two treatments functions differently in terms of when youth are most likely to exhibit symptom reduction, and how sustainable such effects may be. Finally, the results of the study apply only to the specific regimes we studied: A-CRA plus the extended Assertive Continuing

Care services and MET/CBT-5 that encourages participants to seek additional services. We cannot determine the contributions of the primary A-CRA treatment or the extended Assertive Continuing Care services that extended past the 3-month follow-up and potentially throughout the entire 6-month follow-up period. Similarly, we cannot separate the contributions of the specific MET/CBT-5 services from any additional services youth sought as a result of the encouragement of the EAT study. Moreover, the impact of encouraging youth to seek additional services could be sensitive to the availability of other services and funding for them. We do not have data on those factors in the context of the current study, and they might not hold in other settings, which possibly limits the generalizability of our results.

Taken together, this study's findings replicate previous reports showing that both A-CRA plus the extended Assertive Continuing Care services and MET/CBT-5 that encourages participants to seek additional services yielded improvements in SU outcomes (Dennis et al., 2004), with A-CRA showing a small advantage over MET/CBT5 in the recovery outcome measure. MET/CBT5 showed a slight advantage over A-CRA in the two MH measures, although the reasons for this are not entirely clear. As noted in the description of the interventions in the Methods section, MET/CBT5 clinicians were encouraged to augment the intervention with other services and it is possible that the slight advantage of MET/CBT5 is primarily due to those added services. However, our findings indicate that adolescents with co-occurring MH problems appear to benefit from both treatments even though they are not specifically targeting MH problems. This finding may reassure clinicians that youth with co-occurring SUD and MH problems—who make up the majority of youth SUD clients—are likely to find benefits in either of these two evidence-based treatments. All else being equal, MET/CBT5 plus encouragement for additional services may be the better choice for adolescents with co-occurring PTSD or other MH problems, but the relatively small sized effects on these outcomes should be weighed against other considerations. For instance, A-CRA clinicians, rather than retraining to an augmented MET/CBT5 approach, should target specific A-CRA procedures to MH symptoms that their clients present. Prior research has identified A-CRA procedures that have significant overlap with empirically supported interventions for adolescent MH treatment (Godley, Smith, et al., 2014). This has led to practice recommendations for clinicians to target A-CRA procedures to specific MH symptoms (Godley, Smith, et al., 2014). More research is needed to better understand these effects, including potential moderators of these effects. Such work should examine whether the findings might be further improved by matching procedures of each model to specific MH problems identified through broad-spectrum assessment of client functioning.

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5. Appendix A:: Technical Details on Weighting Method

We estimated the balancing weights for this analysis using entropy balancing that computes weights that optimally “balance” the exposure groups and that can be modified to account for nonresponse. More specifically, the method of entropy balancing estimates a set weights that ensure that a weighted empirical distribution is similar to a target distribution over which inference is required. The target distribution is typically represented by a set of moments from a joint distribution X that represents the (sub)population for which inference is required, e.g., $\mu_j^p = E[X_j^p]$ where μ_j^p is the p^{th} noncentral moment of the random variable X_j from X . The weights are then chosen such that the moments of the weighted empirical

distribution matches these targets, i.e., $\frac{\sum_i w_i x_{ij}^p}{\sum_i w_i} \approx \mu_j^p$ for all j, p . In our application, we

considered the first three moments ($p = 3$) and we selected the targets to be the empirical sample moments of the distribution *prior to nonresponse*, i.e., all eligible participants from both programs. Then we weighted *only responders* to this target population of individuals before attrition due to loss to follow-up; this removes potential confounding due to nonresponse. The problem of selecting the weights for entropy balancing is posed as an optimization procedure and entropy balancing is from a class of optimization balancing procedures, compared with more traditional propensity score estimation methods. We implemented the estimation of the weights using the “entbal” package in R (R Development Core Team) and we assessed balance between the treatment groups across a number of criteria (Ridgeway et al., 2013).

To evaluate how comparable the A-CRA and MET/CBT5 groups were after weighting the observations, we used the balancing weights to weight the distributions and we assessed estimates of characteristics of the target population both pre- and postweighting. In particular, we calculated the standardized mean difference (SMD), the log-ratio of the weighted standard deviations, and the weighted Kolmogorov-Smirnov statistics for each variable used to evaluate the weights (see Imbens & Rubin, 2015; Ridgeway et al., 2013). The SMD evaluates performance on balancing the first moment, the log-ratio of the sample standard deviations compares the second moment, and the KS statistics compare higher moments. We only report the SMD in the paper; the log-ratio and KS are available upon request. Typical advice is that standardized differences of 0.10 are considered to be small effect size differences, and it is common to denote group differences as notable when any of these measures is greater than 0.10 (Cohen, 1992). In addition, we calculated the effective sample size after weighting, demonstrating the reduction in information due to the weighted sample and to ensure our effective sample sizes were reasonable for the final outcome analyses (also available upon request).

Appendix B:: Balance details for each outcome

Table B1:

Balance on Emotional Problem Scale at 3-months: A-CRA vs. MET/CBT5

	Unweighted: A-CRA Mean	Unweighted: MET/CBT5 Mean	Weighted: A-CRA Mean	Weighted: MET/CBT5 Mean
Gender: Female	26.8%	29.9%	28.3%	28.3%
Age	15.6	15.4 *	15.5	15.5
Race: White/Caucasian	31.9%	50.8% *	41.5%	41.5%
Race: Other	20.5%	16.6% *	18.5%	18.5%
Race: Black/African-American	15.9%	10.1% *	13.0%	12.9%
Substance Frequency Scale	11.9	10.4 *	11.1	11.1
In Detoxification Program or Not (past 90 days)	3.1%	1.0% *	2.0%	2.0%
Current Withdrawal Scale-Past Week	1.0	1.4 *	1.2	1.2
Needle Use	2.1%	0.9%	1.5%	1.4%
Worsening Physical Health Due to SU	0.7	0.7	0.7	0.7
Cognitive Impairment Screen	3.6	3.5	3.5	3.5
Depressive Symptom Scale	2.8	2.6	2.7	2.7
Mental Health Treatment (past 90 days)	0.3	0.2 *	0.3	0.3
Homicidal Suicidal Thought Scale	0.2	0.2	0.2	0.2
General Conflict Tactic Scale	3.2	2.9 *	3.0	3.0
Continued Substance Use Despite Prior Tx	11.0%	8.8%	9.8%	9.9%
Substance Abuse Tx Index	8.0	1.4 *	4.7	4.6
Substance Use Dependence (past year)	4.4	3.6 *	4.0	4.0
Living Environmental Risk Index	10.8	10.3 *	10.5	10.5
Social Environmental Risk Index	13.2	12.8	13.0	13.0
Recovery Environment Risk Index	19.6	25.2 *	22.3	22.4
Parent Activity Index	3.3	3.6 *	3.4	3.4
Adjusted Days Abstinent (past 90 days)	47.8	55.1 *	51.5	51.5
In recovery	24.7%	24.9%	24.8%	24.7%
Internal Mental Distress Scale	8.5	7.5 *	8.0	8.0
Behavior Complexity Scale	11.0	9.6 *	10.3	10.3
Traumatic Stress Scale	2.3	1.8 *	2.0	2.0
Emotional Problems Scale	0.3	0.2 *	0.2	0.2
Comorbidity Disorder/Problem: Internal Only	8.1%	6.1%	7.0%	7.1%
Comorbidity Disorder/Problem: External Only	23.6%	25.9%	24.7%	24.9%
Comorbidity Disorder/Problem: Both	33.9%	29.9%	31.8%	32.0%

* Absolute value of SMD > 0.1 when comparing A-CRA to MET/CBT5

Note: Balance statistics were nearly identical across the 90 datasets

Table B2:

Balance on Days Abstinent at 3-months: A-CRA vs. MET/CBT5

	Unweighted: A-CRA Mean	Unweighted: MET/CBT5 Mean	Weighted: A-CRA Mean	Weighted: MET/CBT5 Mean
Gender: Female	26.8%	29.9%	28.3%	28.3%
Age	15.6	15.4 *	15.5	15.5
Race: White/Caucasian	31.9%	50.8% *	41.5%	41.5%
Race: Other	20.5%	16.6% *	18.5%	18.5%
Race: Black/African-American	15.9%	10.1% *	13.0%	12.9%
Substance Frequency Scale	11.9	10.4 *	11.1	11.1
In Detoxification Program or Not (past 90 days)	3.1%	1.0% *	2.0%	2.0%
Current Withdrawal Scale-Past Week	1.0	1.4 *	1.2	1.2
Needle Use	2.1%	0.9%	1.5%	1.4%
Worsening Physical Health Due to SU	0.7	0.7	0.7	0.7
Cognitive Impairment Screen	3.6	3.5	3.5	3.5
Depressive Symptom Scale	2.8	2.6	2.7	2.7
Mental Health Treatment (past 90 days)	0.3	0.2 *	0.3	0.3
Homicidal Suicidal Thought Scale	0.2	0.2	0.2	0.2
General Conflict Tactic Scale	3.2	2.9 *	3.0	3.0
Continued Substance Use Despite Prior Tx	11.0%	8.8%	9.9%	9.9%
Substance Abuse Tx Index	8.0	1.4 *	4.7	4.6
Substance Use Dependence (past year)	4.4	3.6 *	4.0	4.0
Living Environmental Risk Index	10.8	10.3 *	10.5	10.5
Social Environmental Risk Index	13.2	12.8	13.0	13.0
Recovery Environment Risk Index	19.6	25.2 *	22.3	22.4
Parent Activity Index	3.3	3.6 *	3.4	3.4
Adjusted Days Abstinent (past 90 days)	47.8	55.1 *	51.5	51.5
In recovery	24.7%	24.9%	24.8%	24.7%
Internal Mental Distress Scale	8.5	7.5 *	8.0	8.0
Behavior Complexity Scale	11.0	9.6 *	10.3	10.3
Traumatic Stress Scale	2.3	1.8 *	2.0	2.0
Emotional Problems Scale	0.3	0.2 *	0.2	0.2
Comorbidity Disorder/Problem: Internal Only	8.1%	6.1%	7.0%	7.1%
Comorbidity Disorder/Problem: External Only	23.6%	25.9%	24.7%	24.9%
Comorbidity Disorder/Problem: Both	33.9%	29.9%	31.8%	32.0%

* Absolute value of SMD > 0.1 when comparing A-CRA to MET/CBT5

Note: Balance statistics were nearly identical across the 90 datasets

Table B3:

Balance on In recovery at 3-months: A-CRA vs. MET/CBT5

	Unweighted: A-CRA Mean	Unweighted: MET/CBT5 Mean	Weighted: A-CRA Mean	Weighted: MET/CBT5 Mean
Gender: Female	26.8%	29.9%	28.3%	28.3%
Age	15.6	15.4 *	15.5	15.5
Race: White/Caucasian	31.9%	50.8% *	41.5%	41.5%
Race: Other	20.5%	16.6% *	18.5%	18.5%
Race: Black/African-American	15.9%	10.1% *	13.0%	12.9%
Substance Frequency Scale	11.9	10.4 *	11.1	11.1
In Detoxification Program or Not (past 90 days)	3.1%	1.0% *	2.0%	2.0%
Current Withdrawal Scale-Past Week	1.0	1.4 *	1.2	1.2
Needle Use	2.1%	0.9%	1.5%	1.4%
Worsening Physical Health Due to SU	0.7	0.7	0.7	0.7
Cognitive Impairment Screen	3.6	3.5	3.5	3.5
Depressive Symptom Scale	2.8	2.6	2.7	2.7
Mental Health Treatment (past 90 days)	0.3	0.2 *	0.3	0.3
Homicidal Suicidal Thought Scale	0.2	0.2	0.2	0.2
General Conflict Tactic Scale	3.2	2.9 *	3.0	3.0
Continued Substance Use Despite Prior Tx	11.0%	8.8%	9.8%	9.9%
Substance Abuse Tx Index	8.0	1.4 *	4.7	4.6
Substance Use Dependence (past year)	4.4	3.6 *	4.0	4.0
Living Environmental Risk Index	10.8	10.3 *	10.5	10.5
Social Environmental Risk Index	13.2	12.8	13.0	13.0
Recovery Environment Risk Index	19.6	25.2 *	22.3	22.4
Parent Activity Index	3.3	3.6 *	3.4	3.4
Adjusted Days Abstinent (past 90 days)	47.8	55.1 *	51.5	51.5
In recovery	24.7%	24.9%	24.8%	24.7%
Internal Mental Distress Scale	8.5	7.5 *	8.0	8.0
Behavior Complexity Scale	11.0	9.6 *	10.3	10.3
Traumatic Stress Scale	2.3	1.8 *	2.0	2.0
Emotional Problems Scale	0.3	0.2 *	0.2	0.2
Comorbidity Disorder/Problem: Internal Only	8.1%	6.1%	7.1%	7.1%
Comorbidity Disorder/Problem: External Only	23.6%	25.9%	24.8%	24.9%
Comorbidity Disorder/Problem: Both	33.9%	29.9%	31.8%	32.0%

* Absolute value of SMD > 0.1 when comparing A-CRA to MET/CBT5

Note: Balance statistics were nearly identical across the 90 datasets

Appendix C:: 6-month outcome sensitivity analyses

Table C1:

Estimated treatment effects for 6-month outcomes

Substance Use/ Mental Health	Treatment Group	Outcome	Baseline PS Weighted Mean	6-month PS Weighted Mean	Effect Size	95% CI
Substance Use	A-CRA	Days Abstinent (Past 90)	51.50	65.69	0.05	(0.00, 0.10)
	MET/CBT5		51.48	63.49		
	A-CRA	In Recovery	24.81%	50.77%	0.09	(0.04, 0.14)
	MET/CBT5		24.74%	46.01%		
Mental Health	A-CRA	Emotional Problem Scale	0.23	0.18	0.14	(0.10, 0.19)
	MET/CBT5		0.23	0.15		
	A-CRA	Traumatic Stress Scale	2.02	0.76	0.11	(0.05, 0.18)
	MET/CBT5		2.02	0.70		

Appendix D:: Omitted variable sensitivity analysis for other outcomes

Figure D1: Sensitivity analyses for the traumatic stress scale

Variable Definitions (baseline measures): Substance abuse treatment index (**sati**); Adjusted days abstinent (**ada**); Substance use dependence past year (**sud_sy**); Emotional problem scale (**eps7p**); Parent activity index (**pai**); Recovery environment index (**reri**); In

detoxification program during past 90 days (**detox90**); Behavior complexity scale (**bcs**); Living environment index (**lri7**); Traumatic stress scale (**tss**); Substance frequency scale (**sfs8p**); Internal mental distress scale (**imds**); General conflict tactic scale (**gcts**); Mental health treatment (**mhtrt**); Current withdrawal scale past week (**cws**); Used needle or not (**nps**); Depressive symptom scale (**dss9**); Social environmental risk index (**sri7**); Cognitive impairment screen (**cis**); Continued substance use despite prior treatment (**csudptx**); Homicidal suicidal thought scale (**hsts2**); Categorization of internal and/or external problems (**codis4**); Worsening physical health due to substance use (**wphsu**); In recovery (**recov**) – Note: *imds* ($\rho = .41$) and *tss* ($\rho = .39$) had correlations shifted to 0.35 for visual purposes

Figure D2: Sensitivity analyses for days abstinent

Variable Definitions (baseline measures): Substance abuse treatment index (**sati**); Adjusted days abstinent (**ada**); Substance use dependence past year (**sud_sy**); Emotional problem scale (**eps7p**); Parent activity index (**pai**); Recovery environment index (**reri**); In detoxification program during past 90 days (**detox90**); Behavior complexity scale (**bcs**); Living environment index (**lri7**); Traumatic stress scale (**tss**); Substance frequency scale (**sfs8p**); Internal mental distress scale (**imds**); General conflict tactic scale (**gcts**); Mental health treatment (**mhtrt**); Current withdrawal scale past week (**cws**); Used needle or not (**nps**); Depressive symptom scale (**dss9**); Social environmental risk index (**sri7**); Cognitive impairment screen (**cis**); Continued substance use despite prior treatment (**csudptx**);

Homicidal suicidal thought scale (**hsts2**); Categorization of internal and/or external problems (**codis4**); Worsening physical health due to substance use (**wphsu**); In recovery (**recov**) – Note: *ada* ($\rho = .45$) had correlation shifted to 0.4 for visual purposes

Figure D3: Sensitivity analyses for youth in recovery

Variable Definitions (baseline measures): Substance abuse treatment index (**sati**); Adjusted days abstinent (**ada**); Substance use dependence past year (**sud_sy**); Emotional problem scale (**eps7p**); Parent activity index (**pai**); Recovery environment index (**eri**); In detoxification program during past 90 days (**detox90**); Behavior complexity scale (**bcs**); Living environment index (**lri7**); Traumatic stress scale (**tss**); Substance frequency scale (**sfs8p**); Internal mental distress scale (**imds**); General conflict tactic scale (**gcts**); Mental health treatment (**mhtrt**); Current withdrawal scale past week (**cws**); Used needle or not (**nps**); Depressive symptom scale (**dss9**); Social environmental risk index (**sri7**); Cognitive impairment screen (**cis**); Continued substance use despite prior treatment (**csudptx**); Homicidal suicidal thought scale (**hsts2**); Categorization of internal and/or external problems (**codis4**); Worsening physical health due to substance use (**wphsu**); In recovery (**recov**)

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Highlights

- Compared the mental health impacts of two adolescent substance use treatments
- A-CRA showed a small advantage over MET/CBT5 in reducing substance use at 3-months
- MET/CBT5 showed a small advantage over A-CRA in decreasing mental health symptoms
- Omitted variable analysis showed unmeasured confounders unlikely to change results

Figure 1: Outcome Trends Overtime

Figure 2: Sensitivity analyses for the emotional problem scale

Variable Definitions (baseline measures): Substance abuse treatment index (**sati**); Adjusted days abstinent (**ada**); Substance use dependence past year (**sud_sy**); Emotional problem scale (**eps7p**); Parent activity index (**pai**); Recovery environment index (**reri**); In detoxification program during past 90 days (**detox90**); Behavior complexity scale (**bcs**); Living environment index (**Iri7**); Traumatic stress scale (**tss**); Substance frequency scale (**sfs8p**); Internal mental distress scale (**imds**); General conflict tactic scale (**gcts**); Mental health treatment (**mhtrt**); Current withdrawal scale past week (**cws**); Used needle or not (**nps**); Depressive symptom scale (**dss9**); Social environmental risk index (**sri7**); Cognitive impairment screen (**cis**); Continued substance use despite prior treatment (**csudptx**); Homicidal suicidal thought scale (**hsts2**); Categorization of internal and/or external problems (**codis4**); Worsening physical health due to substance use (**wphsu**); In recovery (**recov**) – Note: *dss9* ($\rho = .43$), *imds* ($\rho = .49$), *bcs* ($\rho = .41$), *tss* ($\rho = .41$), and *eps* ($\rho = .52$) had correlations shifted to 0.4 for visual purposes

Table 1:

Balance between A-CRA vs. MET/CBT5 for Analyses of the Traumatic Stress Scale at 3-months:

	Unweighted: A-CRA Mean	Unweighted: MET/CBT5 Mean	Weighted: A-CRA Mean	Weighted: MET/CBT5 Mean
Gender: Female	26.8%	29.9%	28.3%	28.4%
Age	15.6	15.4 *	15.5	15.5
Race: White/Caucasian	31.9%	50.8% *	41.5%	41.6%
Race: Other	20.5%	16.6% *	18.5%	18.5%
Race: Black/African-American	15.9%	10.1% *	12.9%	12.9%
Substance Frequency Scale	11.9	10.4 *	11.1	11.1
In Detoxification Program or Not (past 90 days)	3.1%	1.0% *	2.0%	2.0%
Current Withdrawal Scale-Past Week	1.0	1.4 *	1.2	1.2
Needle Use	2.1%	0.9%	1.4%	1.5%
Worsening Physical Health Due to SU	0.7	0.7	0.7	0.7
Cognitive Impairment Screen	3.6	3.5	3.5	3.5
Depressive Symptom Scale	2.8	2.6	2.7	2.7
Mental Health Treatment (past 90 days)	0.3	0.2 *	0.3	0.3
Homicidal Suicidal Thought Scale	0.2	0.2	0.2	0.2
General Conflict Tactic Scale	3.2	2.9 *	3.0	3.0
Continued Substance Use Despite Prior Tx	11.0%	8.8%	9.9%	9.9%
Substance Abuse Tx Index	8.0	1.4 *	4.7	4.7
Substance Use Dependence (past year)	4.4	3.6 *	4.0	4.0
Living Environmental Risk Index	10.8	10.3 *	10.5	10.5
Social Environmental Risk Index	13.2	12.8	13.0	13.0
Recovery Environment Risk Index	19.6	25.2 *	22.4	22.4
Parent Activity Index	3.3	3.6 *	3.4	3.4
Adjusted Days Abstinent (past 90 days)	47.8	55.1 *	51.5	51.5
In recovery	24.7%	24.9%	24.8%	24.8%
Internal Mental Distress Scale	8.5	7.5 *	8.0	8.0
Behavior Complexity Scale	11.0	9.6 *	10.3	10.3
Traumatic Stress Scale	2.3	1.8 *	2.0	2.0
Emotional Problems Scale	0.3	0.2 *	0.2	0.2
Comorbidity Disorder/Problem: Internal Only	8.1%	6.1%	7.1%	7.1%
Comorbidity Disorder/Problem: External Only	23.6%	25.9%	24.8%	24.8%
Comorbidity Disorder/Problem: Both	33.9%	29.9%	31.9%	31.9%

* Absolute value of SMD > 0.1 when comparing A-CRA to MET/CBT5

Note: Balance statistics were nearly identical across the 90 datasets

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Table 2:

Estimated treatment effects for 3-month outcomes

Substance Use/ Mental Health	Treatment Group	Outcome	Baseline PS Weighted Mean	6-month PS Weighted Mean	Effect Size	95% CI
Substance Use	A-CRA	Days Abstinent (Past 90)	51.50	65.85	0.01	(-0.03, 0.06)
	MET/CBT5		51.48	65.52		
	A-CRA	In Recovery	24.81%	46.54%	0.10	(0.05, 0.14)
	MET/CBT5		24.74%	42.03%		
Mental Health	A-CRA	Emotional Problem Scale	0.23	0.19	0.14	(0.09, 0.18)
	MET/CBT5		0.23	0.17		
	A-CRA	Traumatic Stress Scale	2.02	0.72	0.07	(0.01, 0.14)
	MET/CBT5		2.02	0.58		