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THE INTERACTION AND PROGRESSION OF ADOLESCENT SUBSTANCE USE AND CO-OCCURRING MENTAL HEALTH PROBLEMS AND SOCIAL SUPPORT: A LATENT GROWTH MODELING APPROACH

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BY

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DISSERTATION

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ABSTRACT

Background: Few studies have examined a reciprocal parallel process longitudinal trajectory of adolescent substance use and mental health problems simultaneously, and none have described this parallel process for adolescents receiving outpatient substance use treatment. No studies have examined how social support may account for deviations outside the overall trajectories for substance use or mental health problems. **Method:** Secondary data analysis examined a longitudinal parallel process latent growth model between mental health and substance use problems among adolescents who received outpatient substance use treatment. **Results:** Findings suggest that mental health and substance use problems are associated both initially and longitudinally, and the effects are reciprocal in nature. Covariates differentially influence the associations between these parallel processes. The reciprocal parallel process was strongest in the combined co-morbid group compared to the other co-morbid groups. Social support significantly predicted mental health problem deviations from the overall

trajectory at intake and the 6-month follow-up timepoint. **Discussion:** This study appears to be the first to identify a reciprocal parallel process relationship between mental health and substance use disorders within a diverse adolescent substance use treatment sample. The combined co-morbid group demonstrated the strongest parallel process relationship. Social support played a minimal role in predicting deviations from the overall trajectory for mental health problems. This study highlights the importance of not assuming that treatment of one disorder should be prioritized over the other, as well as the need for an integrated approach to intervention that begins with adequate screening and assessment of co-occurring problems.

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Chapter 1 Introduction

All of the ways in which adolescents develop: cognitively, physically, socially, and emotionally, prepare them to experiment with new behaviors as they transition from childhood to adulthood (APA, 2005). One of these new behaviors is substance use. In fact, adolescence tends to be the peak time period for the introduction of substance use (Degenhardt, Stockings, Patton, Hall, & Lynskey, 2016). Initiation of alcohol use earlier in adolescence predicts many social and health problems (Agrawal et al., 2006; Clark, Cornelius, Kirisci, & Tarter, 2005; Grant & Dawson, 1997; Hingson, Heeren, & Winter, 2009). Substance misuse during this vulnerable period may result in interference with normative developmental tasks, damaged social relationships, increased deviant peer associations, and addiction (Baumrind & Moselle, 1985; Kuntsche et al., 2013; Maggs & Schulenberg, 2005; Marsiglia et al., 2019; Pei et al., 2020; Warner & White, 2003). Neurological development at this time increases adolescents' vulnerability to the effects of substance use, the development of a substance use disorder, and the co-occurring development of a substance use and mental health disorder (Degenhardt et al., 2016; Squeglia & Gray, 2016). Importantly, the likelihood for substance misuse and dependence decreases 4-5% for adolescents 13-21 years of age for each year that substance use initiation is delayed (Grant, 1997).

Racial/Ethnic Identity Perspectives in Adolescent Substance Use Research

Examining the predictors, correlates, and outcomes of adolescent substance use and co-occurring mental health disorders is crucial to reduce racial/ethnic health disparities in these areas through innovative approaches and policies. Although current work has been addressing predictors of treatment initiation and engagement for racial/ethnic minorities

(Acevedo et al., 2012), a discussion about the complexity of racial/ethnic identity development and its connection to substance misuse is needed to contextualize this type of research.

For most studies, self-reported race/ethnicity is usually recorded into a categorical scheme that includes whites, blacks, Asians, Hispanics, and American Indians (National Research Council, & Committee on Population, 2004). It is often assumed that self-reported race/ethnicity is a static construct that does not change over the life course. For adolescents, ethnic identify (affiliation, attachment, and pride) is a fluid construct that matures through their associations with family, peers, and socio-environmental interactions (Phinney & Ong, 2007). The strength of racial/ethnic identify for minority youth has been associated with improved psychological outcomes (Brown et al., 2021; Phinney & Chavira, 1992; Romero & Roberts, 2003) and lower substance use (Marsiglia, Kulis, Hecht, & Sills, 2004)

Co-Occurring Substance Use and Mental Health Disorders

Adolescents with co-occurring substance use and mental health problems are becoming the norm rather than the exception (Roberts & Corcoran, 2005; Tiburcio et al., 2021). Among youth with a substance use disorder (SUD), it is estimated that 50-75% also experience a co-occurring mental health disorder (MHD; Armstrong & Costello, 2002; Chan, Dennis, & Funk, 2008; Essau & de la Torre-Luque, 2019; Hawkins, 2009; Merikangas et al., 2010). A national survey from the Substance Abuse and Mental Health Services Administration (SAMHSA) reported that adolescents with a current mental health disorder are likely to have a concurrent substance use disorder compared to adolescents without a current mental health disorder (Substance Abuse and Mental Health Services Administration [SAMHSA], 2020). Regarding age of first substance use, a recent longitudinal study revealed

that adolescents who experience alcohol intoxication before the age of 12 are significantly more likely to experience future psychiatric disorders (Antti et al., 2021).

For those adolescents in addiction treatment who have a co-occurring MHD, more than half of them actually have three or more co-occurring psychiatric disorders (Dennis et al., 2004). The most common comorbid psychiatric disorders among youth in addiction treatment include conduct problems (60%-80%), attention-deficit/hyperactivity disorder (ADHD; 30%-50%), mood disorders (major depressive disorder; 24%-50%), and trauma-related symptoms (Bukstein, Glancy, & Kaminer, 1992; Grella, Hser, Joshi, & Rounds-Bryant, 2001; MacPherson et al., 2021; Riggs, Levin, Green, & Vocci, 2008). At the time of entry into substance use treatment, adolescents with co-occurring disorders show an overall elevated problem severity level compared to adolescents with SUDs alone, especially if the former have both an internalizing and an externalizing disorder (De Hert et al., 2015; Grella, Hser, Joshi, & Rounds-Bryant, 2001; Shane, Jasiukaitis, & Green, 2003).

Previous studies have shown that adolescents with a SUD and another MHD have worse treatment outcomes compared to adolescents with a SUD alone (Ercan, Coskunol, Varan, & Toksöz, 2003; Humfleet, Prochaska et al., 2005; Villagrana & Lee, 2020; White, Jordan, & Schroeder, 2004). Not only are youth with co-occurring problems more likely to relapse after treatment than are youth with SUDs only (Grella et al., 2001), but the relapse usually occurs more quickly (Tomlinson, Brown, & Abrantes, 2004; Winters et al., 2008). Thus, the need for early intervention for these issues is paramount for adolescent populations.

Treatment for Co-Occurring Disorders in Adolescents

It is important to treat adolescents with co-occurring disorders (CODs) with a program that integrates treatments for each condition, because it yields better outcomes

compared to programs that only treat the SUD (Belendiuk & Riggs, 2014; Spencer et al., 2021; Tanner-Smith, Wilson, & Lipsey, 2013; Tripodi, Bender, Litschge, & Vaughn, 2010; Waldron & Turner, 2008). Unfortunately, while most treatment programs (92%) accept adolescents with CODs, only half of these programs address mental health issues (Mark et al., 2006; SAMHSA, 2019). A recent national service utilization survey found that less than 10% of adolescents who might benefit from substance use treatment actually receive it, and even fewer receive an integrated treatment for CODs (DiCola, Gaydos, Druss, & Cummings, 2013; Spencer et al., 2021).

To date, at least 10 programs have shown promising evidence for treating adolescents with SUDs and co-occurring MHDs (Bender, Springer, & Kim, 2006; Bukstein & Horner, 2010; Hawkins, 2009; Spencer et al., 2021; Torrens, Rossi, Martinez-Riera, Martinez-Sanvisens, & Bulbena, 2012). Importantly, when working with adolescents with an SUD and a co-occurring MHD, previous research recommends the following key intervention components (Godley et al., 2014): (1) Assessments that simultaneously assess substance use and mental health problems (Bender, Springer, & Kim, 2006; Couwenbergh et al., 2006; Riggs, 2003); (2) Approaches to engagement and retention procedures that are non-confrontational (Lamps, Sood, & Sood, 2008; Riggs, 2003); (3) Adaptive treatment plans that incorporate participant input (Bender, Springer, & Kim, 2006); (4) Family and community resources incorporated into treatment plans (Riggs, 2003); (5) Treatment that is developmentally sensitive and culturally and linguistically appropriate (Armstrong & Costello, 2002; Bender, Springer, & Kim, 2006); (6) Flexibility in addressing client-specific domains as necessary for emotion regulation, executive function skills for problem solving and decision-making, and issues with impulsivity and interpersonal relationships (Bender,

Springer, & Kim, 2006; Couwenbergh et al., 2006; Libby & Riggs, 2005; Riggs, 2003); (7) Assigning appropriate and relevant homework (Bender, Springer, & Kim, 2006); and (8) Combining medication management and adherence protocols, as necessary (Riggs, 2003; Riggs, Levin, Green, & Vocci, 2008).

The Adolescent Community Reinforcement Approach (A-CRA) is directly aligned with the aforementioned key intervention components, which makes it a suitable treatment for adolescents with a SUD and a co-occurring MHD. A-CRA is a behavioral intervention that seeks to increase the family, social, and educational/vocational reinforcers of an adolescent to support recovery from substance misuse and dependence. Adapted from the adult Community Reinforcement Approach (CRA; Azrin, Sisson, Meyers, & Godley, 1982; Hunt & Azrin, 1973), A-CRA subsequently was manualized and clinically tested for use with adolescents (Dennis et al., 2004; Godley et al., 2001; Slesnick, Prestopnik, Meyers, & Glassman, 2007).

Social Support and Treatment Outcomes

Adolescents with stronger family relationships tend to have lower substance use (Kapetanovic et al., 2020; Piko, 2000; Resnick et al., 1997; Yap et al., 2017). A perceived lack of familial and peer support (Williams & Chang, 2000) and peer pressure to use substances (Godley, Passetti, Funk, Garner, & Godley, 2008; Myers & Brown, 1996) have been found to be strong determinants for relapse after treatment for adolescents. Low family cohesion also was a predictor for treatment nonresponse for adolescents with depression and a co-occurring SUD (Rohde et al., 2018). Interestingly, while most adolescents eventually relapse after treatment (Chung & Maisto, 2006, Godley, Kahn, Dennis, Godley, & Funk,

2005; Marks & Leukefeld, 2018), there seem to be distinct differences in relapse triggers for adolescents versus adults.

For adolescents, the most common reasons for relapse are social and peer pressures, whereas for adults, relapses occur mostly due to internalized psychological or interpersonal issues (Chung & Maisto, 2006). This distinction between adolescent and adult relapse triggers is important to consider when planning how and when social support could be bolstered during more vulnerable periods during and after treatment. Furthermore, within the context of mental health, functional support (quality of support provided or perceived) rather than structural support (quantity of support) has been shown to be more important for adolescents (Chu, Saucier, & Hafner, 2010; Rueger, Malecki, Pyun, & Coyle, 2016). To date, there is only one study that has investigated social support within the context of co-occurring substance use and MHDs for adolescents. The authors of this 2021 study found that parenting processes (e.g., parental monitoring) predicted the depression trajectory (slope), with higher levels of parental monitoring predicting a steeper rate of change (decline) in depression over one year (MacPherson et al., 2021). This study did not demonstrate a predicted rate of change in substance use symptoms. The present study aimed to examine these associations of social support with depression and substance use symptoms in more detail.

While the aforementioned aspects of social support seem fairly straight forward, family dynamics can complicate the influence of social support. Specifically, if adolescents are receiving social support from the same family members who encourage or approve of their substance use, the positive effects of social support may be attenuated by these factors.

The proposed study examined the associations between social support and negative family and peer influences to determine the strength of this relationship.

Longitudinal Co-Development of Co-Occurring Disorders

The high prevalence of comorbidity between substance use disorders (SUDs) and other mental health disorders (MHDs) does not suggest that one causes the other. Other studies suggest that shared or common genetic and/or environmental risk factors (e.g., chronic maltreatment) may increase the risk for both MHDs and SUDs (Felitti & Anda, 2010; Fergusson & Lynskey, 1997; Young, Rhee, Stallings, Corley, & Hewitt, 2006). Towards this end, additional research is needed to enhance our understanding of the co-occurring relationship between MHDs and SUDs, as it may substantially influence prevention and intervention programs. This research would entail determining which differing categories of co-occurring disorders, such as externalizing (i.e., attention-deficit/hyperactivity disorder, conduct disorder, oppositional defiant disorder) and internalizing disorders (i.e., major depressive disorder, generalized anxiety disorder, traumatic stress), might necessitate different approaches for intervention (Hawkins, 2009). Previous work has focused more attention on adolescents with co-occurring SUDs and externalizing disorders compared to co-occurring SUDS and internalizing disorders. This emphasis is somewhat surprising, given that the efficacy of treatments is stronger for internalizing disorders relative to those for externalizing disorders (O'Neil, Conner, & Kendall, 2011).

Earlier investigations of internalizing/externalizing disorders and SUDs generally have taken the form of correlational studies (e.g., correlating depression levels with substance use). Fleming and colleagues (2008) suggested examining the association between

changes in SUDs and MHDs (latent constructs) as a function of co-development across a period of time (longitudinal focus), with the primary focus being that of developmental growth trajectories. Examination of this approach is conducted using latent growth curve modeling (LGCM), which allows one to predict the longitudinal growth of one construct from the growth of another construct to characterize how both constructs influence each other over time.

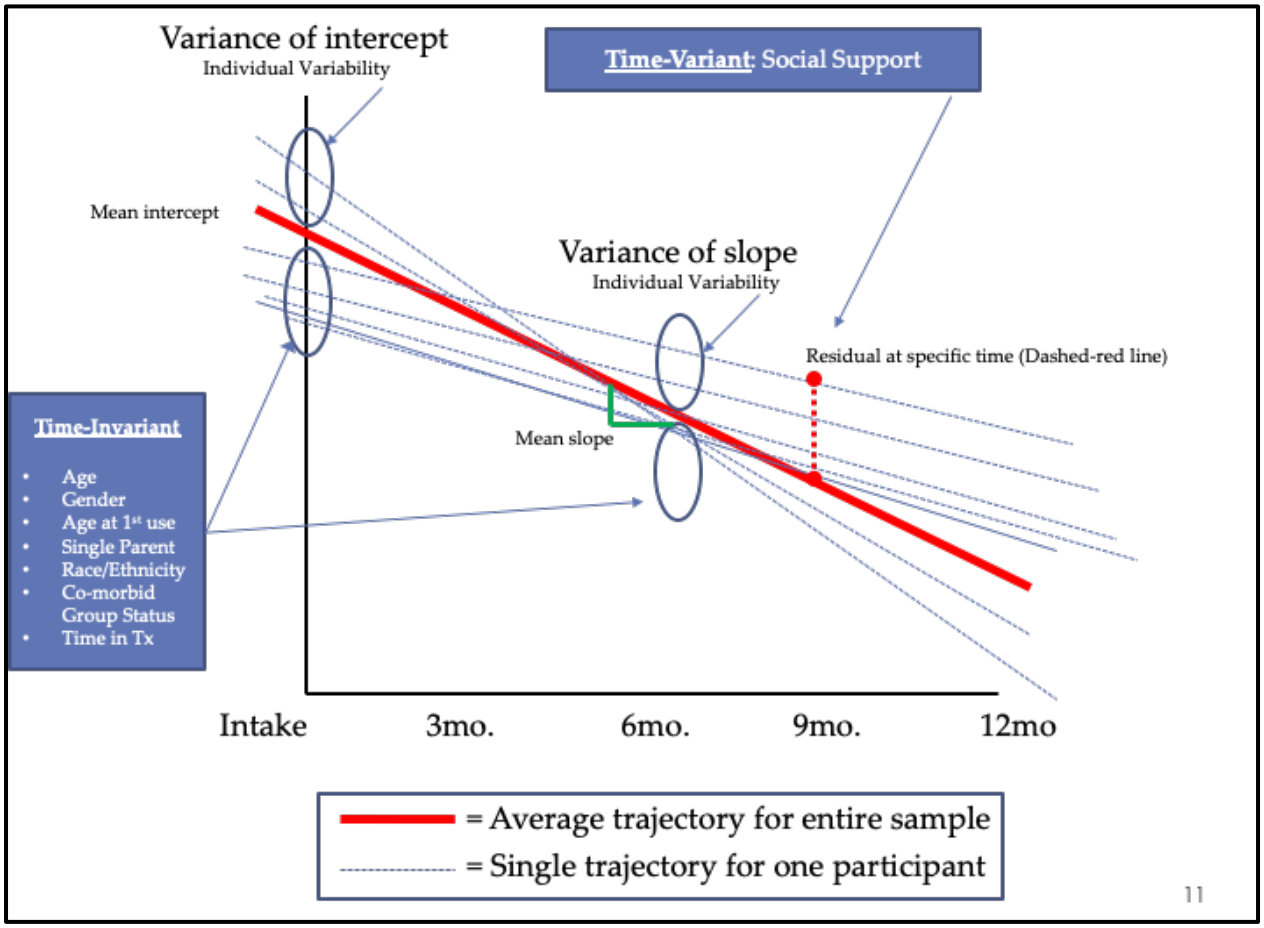
The primary advantage of using LGCM is that multiple growth processes (parallel process) can be modeled simultaneously using longitudinal data. These models also can include covariates that vary with time (time-varying) and those that do not vary by time (time-invariant) as illustrated in Figure 1. This means that while we observe an overall average trajectory for an entire sample, the time-invariant predictors (e.g., age, race/ethnicity, gender) can determine which participants will start higher or lower on mental health and substance use outcomes at baseline, and examine rates of change that may differ based on group identification (e.g., age, race/ethnicity, gender). For example, assume that gender is a significant predictor at baseline, such that being female predicts higher levels of initial substance use and mental health problems. This would suggest that clinicians should be aware that an escalation in substance use problems for young women would likely be accompanied by an escalation in mental health problems, even if they are not readily observable by teachers or family members.

The use of time-varying predictors (e.g., social support) makes it possible to identify time-specific instances in which individuals experience higher or lower substance use or mental health symptoms (before returning to their predicted long-term trajectories) that is associated with social support (see Figure 1). This specific association would provide

evidence to suggest that a predictor variable could be an intervention target at the time during development when it is predictive.

Figure 1

General Latent Growth Model Diagram to Illustrate Model Features

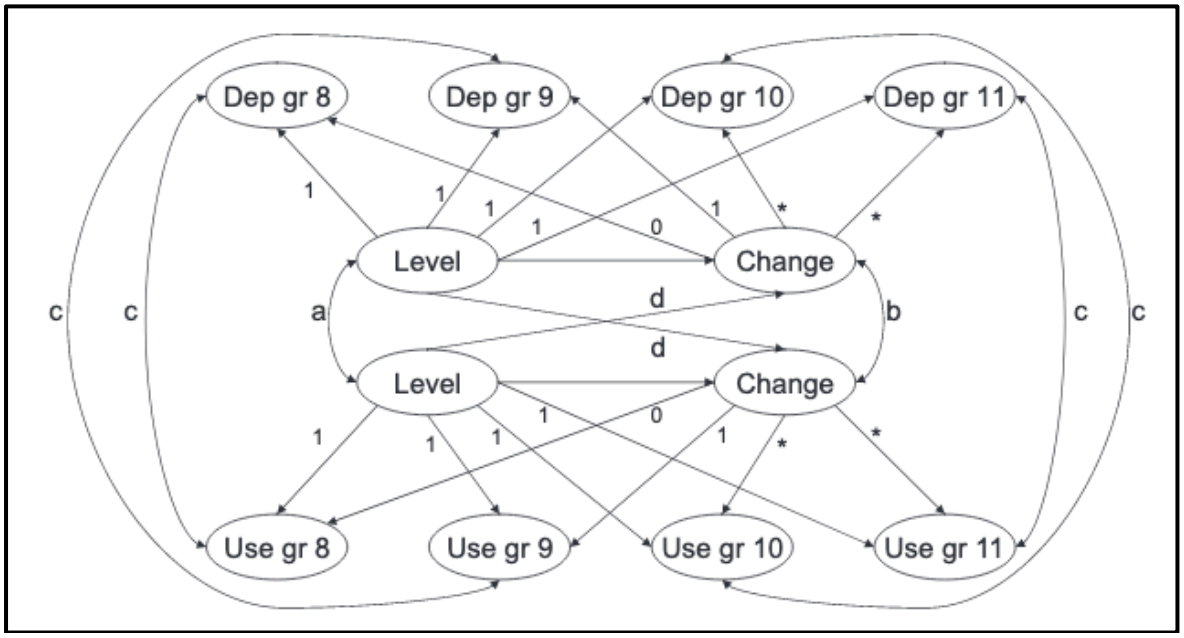


The simultaneous estimation of growth curve models for both substance use and mental health symptoms, and the relationships between the different types of variation observed in these models (see Figure 2), enable an examination of the following (Fleming, Mason, Mazza, Abbott, & Catalano, 2008) in a structural equation framework (SEM):

1. Associations in levels at a particular time point (represented by Path A in Figure 2);
2. Associations in concurrent change over multiple time points (Path B in Figure 2);
3. Associations in episodic expressions of the two variables, which are assessed as deviations from expected values of the growth trajectory (Paths C in Figure 2); and
4. Predictive relationships between levels and change (Paths D in Figure 2).

Figure 2

Descriptive Parallel-process Growth Model



Few studies have attempted to model the trajectory of adolescent substance use and mental health problems simultaneously, and none appear to have successfully modeled this co-occurring parallel process trajectory for adolescents in a substance use treatment setting. Previous studies have explored the separate individual growth trajectories of MHDs (i.e.,

depression; Cortes, Fleming, Catalano, & Brown, 2006; Garber, Keiley, & Martin, 2002) and SUDs (e.g., Bryant, Schulenberg, O'Malley, Bachman, & Johnston, 2003; Hussong, Hicks, Levy, & Curran, 2001; Jackson, Sher, & Wood, 2000).

Interestingly, Godley and colleagues (2014) examined separate trajectories of substance use and mental health symptoms across one SUD only group (non-comorbid) and three different comorbid groups: Internalizing group, Externalizing group, and Internalizing + Externalizing group (Combined). The sampled used for the Godley et al. (2014) study is a subset of the sample used for the current study. At the time they conducted their analyses, data from participants were still being collected; the current study used a sample that contained data from the complete study. Using a descriptive latent growth model, Godley and colleagues found that the combined group reported more substance use and mental health problems at intake compared to the other co-morbid groups. With respect to trajectories of treatment outcomes, the externalizing and combined groups showed the greatest decreases in substance use problems compared to the non-comorbid group from intake to the 3-month follow-up assessment. For mental health problems, all co-morbid groups demonstrated larger rates of improved mental health symptoms (from intake to the 3-month follow-up assessment) compared to the non-comorbid group. The combined group demonstrated the largest effect size difference. The authors suggested that while there were mental health improvements over the 12-month time period, some persisting mental health problems remained.

Fleming and colleagues (2008) were unable to find predictive relationships across mental health and substance use constructs, except for a higher baseline level of depressive symptoms in early adolescence predicting a decreasing rate of change in alcohol use.

However, they believed that their non-treatment sample presented with a low level of severity in terms of depressive symptoms and substance use variance, which may have prevented their discovery of reciprocal predictive associations (Path D, Figure 2). Windle and Windle (2001) argued that the predictive associations (Path D, Figure 2) might be present when mental health and substance use symptoms are in the more severe range, as in substance use treatment samples. Fortunately, the Godley and colleagues' study (Godley at al., 2014) provides a foundation to examine the reciprocal relationship between substance use and mental health symptoms, as their study used a treatment sample with higher mental health and substance use symptoms in the more severe range at intake.

Chapter 2 Current Study

For the current study, a secondary data analysis was conducted which examined standard latent growth models (LGM) and multivariate latent growth models (MLGM) of a dual-process growth model between mental health and substance use symptoms. The study used longitudinal data originating from a Substance Abuse and Mental Health Services Administration (SAMHSA) dissemination project of A-CRA with substance use treatment agencies collected over a time period of 12 months. The one-year data collection timeframe for adolescents who were part of this study was as follows: (1) Adolescents were given A-CRA outpatient treatment for 12 weeks (3 months); (2) Followed by 12 weeks (3 months) of Assertive Continuing Care (ACC); and (3) Followed by another 6 months of follow-up assessment (Godley, Garner, Smith, Meyers, & Godley, 2011). The current study used insights gained from the Godley et al. (2014) and Fleming et al. (2008) studies to support the dual-process growth model approach, while accounting for the influence of social support at time-specific instances.

While a previous study has taken a more descriptive approach toward investigating separate growth models for different co-morbid groups (Godley et al., 2014), the current study used an inferential approach to examine how group membership in one of the co-morbid groups would predict a unique trajectory compared to the other co-morbid groups on substance use and mental health symptoms. For the current study, substance use and mental health symptom severity were expected to be at their highest level at baseline, with a proposed decreasing trajectory across the entire sample over the five follow-up time points. Fleming et al. (2008) suggested that using a treatment sample with a higher symptom

severity may help predict the dual-process predictive effects between substance use and mental health symptoms.

To date, no other dual-process growth model studies appear to have examined how social support (time-varying predictor) may account for deviations outside the overall developmental trajectories for substance use or mental health. In other words, individuals would have time periods characterized by high or low levels of mental health and substance use symptoms before returning to their longer-term trajectories for these variables. It could be the case that during these deviations, levels of social support would account for some of this observed variance, over and above the variance accounted for by intake predictors (time-invariant). For those studies that have examined the role of social support within a single latent growth model for substance use or mental health, social support usually was included as an intake predictor and not as a time-varying predictor that might influence the deviations from the longer-term trajectories (Duncan, Duncan, & Strycker, 2000; Stice, Ragan, & Randall, 2004).

Research Question and Hypotheses

Research Question 1

According to previous research, predictors like age, gender, age at first use of a substance, single parent household, and race/ethnicity play an important role in the onset and course of substance use and mental health across development (Felton, Kofler, Lopez, Saunders, & Kilpatrick, 2015). While these predictors have been examined extensively, little is known about how membership in a specific co-morbid group at intake is associated with changes in substance use and mental health over time in a substance use treatment population. The current study addressed this research question.

Research Question 2

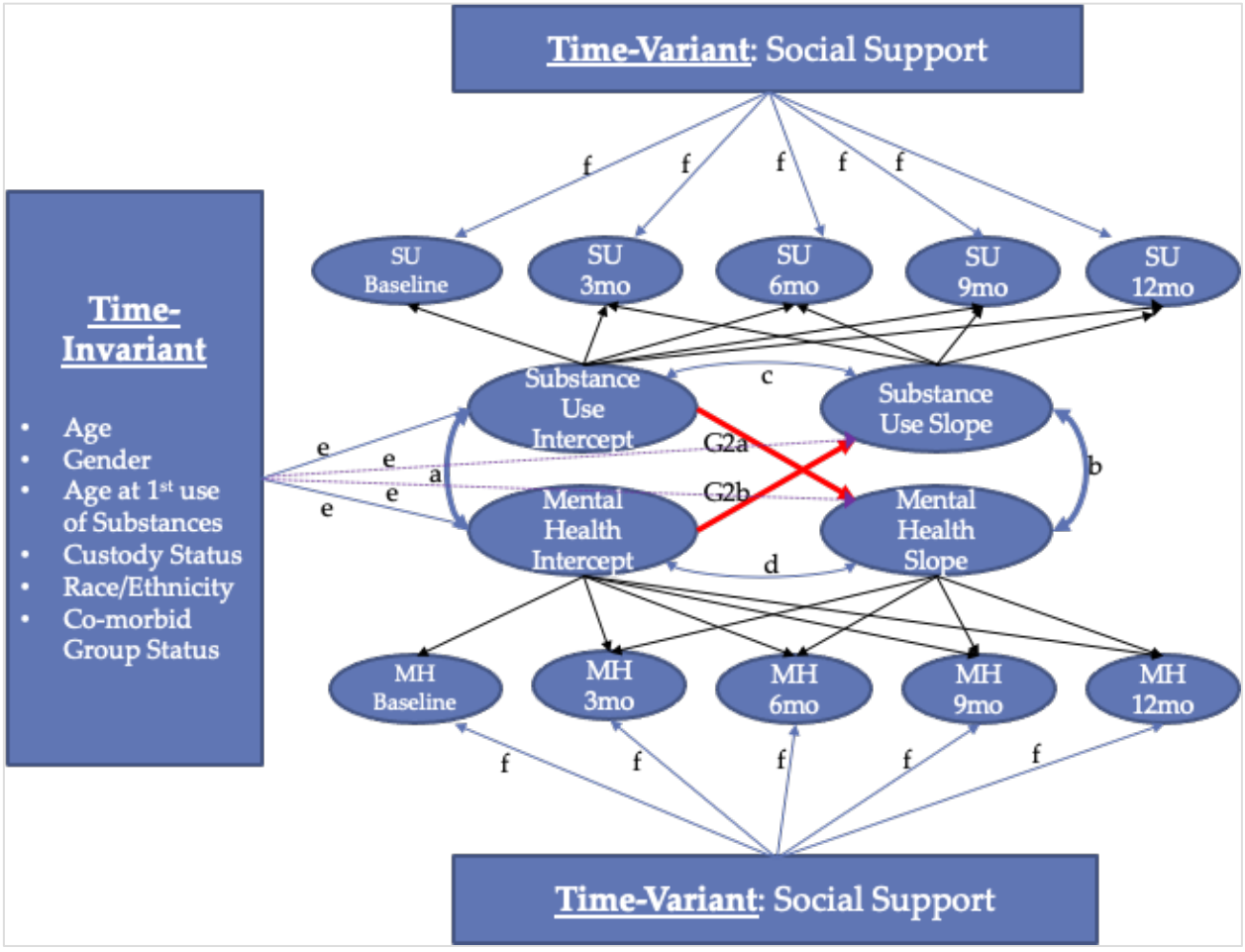
The current study examined the dual-process growth model between mental health and substance use symptoms. Little is known about these associations, and deviations from the long-term trajectories potentially were better accounted for by social support, over and above the variance already accounted for by the intake predictors.

Hypotheses

The current hypotheses were modeled on Figure 3 in paths E, and F, and G, though not every lettered path was used to test a specific hypothesis:

Figure 3

Dual-process Growth Model for Substance Use and Mental Health Outcomes



Hypothesis 1 (Path G2, Figure 3).

1. Simultaneous temporal predictions (intercept predicting slope) between substance use and mental health symptoms during the treatment phase (A-CRA + ACC; first 6 months):
    a. H1a: Higher levels of mental health symptoms at intake will predict greater decreases in substance use during the treatment phase (A-CRA + ACC; first 6 months) (Red Path G2b, Figure 3).
    b. H1b: Higher levels of substance use at baseline will predict greater decreases in mental health symptoms during the treatment phase (A-CRA + ACC; first 6 months) (Red Path G2a, Figure 3).

    Support for these hypotheses would provide evidence for the directional and causal relationship between mental health and substance use symptoms during the treatment phase (A-CRA + ACC; first 6 months). Clinically, this finding would reinforce the need to use treatments that simultaneously targeted co-occurring substance and mental health disorders. This prediction was based on the belief that there would be higher symptom severity during the treatment phase, which Windle and Windle (2001) argue is necessary to reveal the causal predictive effects of the dual-process growth model.

Hypothesis 2.

2. Co-morbid group status predicting a unique parallel process growth trajectory base on simultaneous temporal predictions from H1 during the treatment phase (A-CRA + ACC; first 6 months):

a. Based on the findings from H1, the combined co-morbid group status, when compared to the other two co-morbid groups, was predicted to show a unique dual-process growth trajectory during the treatment phase (A-CRA + ACC; first 6 months).

Support for this prediction would demonstrate that the co-occurring relationship between substance use and mental health symptoms is more strongly intertwined for the combined group compared to the other co-morbid groups during the treatment phase. This prediction was based on previous research using A-CRA implementation data that revealed more severe separate trajectories for the combined co-morbid group on mental health and substance use symptoms (Godley et al., 2014). Separate trajectories for both mental health and substance use symptoms show the greatest rate of decline during the treatment phase (first 6 months), which is the shorter time frame that includes the higher symptom severity range, as advocated by Fleming et al. (2008).

Hypothesis 3 (Path F, Figure 3) Social Support:

a. The current study predicted that social support would account for additional variance during the treatment phase (first 6 months). We expected to see higher levels of social support to account for an improvement in substance use and mental health symptoms after accounting for baseline (time-invariant) predictors, such as age, age of first use of substances, gender, race/ethnicity, and custody status.

Support for this prediction after accounting for the effects of the time invariant predictors would reveal that increased social support may play a supportive role

for improving co-occurring problems. If supported, social support may play a stronger role for the combined co-morbid group.

Chapter 3 Methods

Sites

This study is a secondary analysis of data from a large dissemination project of A-CRA across 78 SUD treatment agencies. The original project was funded by the Substance Abuse and Mental Health Services Administration's (SAMHSA) Center for Substance Abuse Treatment (CSAT). Data were collected as a requirement of each agency's grant for local program evaluation under their respective voluntary consent procedures. Data were de-identified prior to any analyses. All agencies who received funding to implement A-CRA had their clinicians participate in the same standardized training, cross-site supervision, and certification process based on individualized review and feedback provided by the treatment developers throughout the grant period. The one year data collection timeframe for adolescents who were part of this study is as follows: (1) Adolescents were given A-CRA outpatient treatment for 12 weeks (3 months); (2) Followed by 12 weeks (3 months) of Assertive Continuing Care (ACC); and (3) Followed by another 6 months of follow-up assessment (Godley, Garner, Smith, Meyers, & Godley, 2011).

Participants and Procedure

Co-occurring Problem Group Categories

Participants were categorized into four mutually exclusive groups based on their endorsed DSM-IV-R symptoms from the GAIN at intake. The four groups were as follows: (1) Substance use only; (2) Substance use + Internalizing; (3) Substance use + Externalizing; and (4) Substance use + combined internalizing/externalizing. Group 2 (“Internalizing”) includes participants who endorsed symptoms used to indicate a substance use disorder *and* generalized anxiety, major depression, or traumatic stress. Group 3 (“Externalizing”)

includes participants who endorsed symptoms used to indicate a substance use disorder *and* conduct disorder or attention deficit hyperactivity disorder (ADHD). Group 4 ("Combined") includes participants who endorsed symptoms for a substance use disorder *and* at least one externalizing *and* one internalizing problem. These groups were chosen to enable comparisons to other co-occurring problem studies, such as that by Godley and colleagues (2014).

Previous research demonstrated that the substance use disorder scale, and both the internalizing and externalizing disorder scales from the full GAIN-I, have a high agreement with the more extensive clinical diagnostic criteria that directly map onto the relevant DSM-IV disorders. For example, internalizing disorders map onto depression, anxiety, and traumatic stress, and externalizing disorders map onto conduct disorder and attention deficit hyperactivity disorder (Dennis, Chan, & Funk, 2006). The scales use past year counts on 1 of 5 criteria, with 1 or 2 counts indicating a moderate level and 3 or more counts indicating a high level of severity. Both levels have high agreement with having a diagnosis. The substance use disorder, internalizing, and externalizing scales each require greater than 1 count to be categorized into each disorder group. The combined group requires at least one count from both the internalizing and externalizing categories (Dennis, Feeney, & Stevens, 2006).

Participants

Participants were selected from the data collected at all 78 A-CRA sites. Three of the five follow-up time points were used: baseline, 3 months (3mo), and 6 months (6mo). To maximize the sample size for analyses over the three time points for the criterion variables (mental health and substance use), participants who completed their 12-month follow up

assessments were included. The focus of the study was on the active phase of treatment (first 6 months), which emphasized the importance of selecting participants with as much complete data as possible. Participants who had complete data on the time-invariant and time-variant variables during the treatment phase (first 6 months) were included in this study. Only those measures relevant to the current analyses are described below. This study included male and female participants within the age range of 10 years old to 17 years old, and who self-identify as African American, Hispanic, Caucasian, American Indian/Alaska Native, Asian, and mixed race.

Measures & Scales

Global Appraisal of Individual Needs (GAIN-I) (Dennis, Titus, White, & Hodgekins, 2003)

This study used the GAIN, a standardized instrument administered for research purposes and to support clinical decision making for diagnosis, placement, treatment planning, and service use. The instrument has been used with both adolescents and adults (Dennis, Scott, Godley, & Funk, 1999; Dennis, Chan, & Funk, 2006). The GAIN has eight sections covering background information, substance abuse, physical health, risk behaviors, mental health, environment, legal issues, and vocational information. It includes more than 1,500 questions and 100 scales. The GAIN's measures (indices and scales) have been validated with collateral reports, urine tests, follow-up methods, and treatment records (Dennis, Chan, & Funk, 2006; Dennis, Ives, White, & Muck, 2008; Garner, Godley, & Funk, 2008). Three measures from the GAIN intake and follow-up interviews (0, 3, 6, 9, and 12 months) were used for outcome analysis (and are different measures than the ones used for group classification).

Criterion Variables

Mental health outcomes (dependent variables) were estimated using the Emotional Problem Scale (EPS), derived from the larger GAIN-I Instrument. The EPS is calculated as the proportional average of items measuring the recency (e.g., 1–3 months ago, 1– 4 weeks ago, 3–7 days ago, past 2 days) and number of days (during the past 90) of: a) being bothered by or kept from responsibilities because of emotional problems, b) being disturbed by memories, and c) having problems paying attention or with self-control (Cronbach's alpha = .79; 7 items; ranges from 0 to 1). Cut points for severity have been empirically derived to aid clinical interpretation of this scale: low = 0 to .13 (less than weekly problems); moderate = .14 to .50 (weekly problems); and high = .51 to 1.00 (daily problems). Scores greater than .13 indicate a degree of severity that warrants consideration in treatment planning (GAIN Coordinating Center, 2011).

Substance use outcomes (dependent variables) were estimated using: (1) The Substance Problems Scale (SPS), derived from the larger GAIN-I Instrument. This scale is a count of past month symptoms of substance abuse, dependence, and substance-induced health and psychological disorders based on DSM-IV criteria (Cronbach's alpha = .90; 16 items; ranges from 0 to 16); (2) Percent of days abstinent (dependent variable also derived from the larger GAIN-I instrument) is a self- report of the proportion of days not using any alcohol or other drugs (excluding tobacco) while in the community out of the past 90 days. This outcome variable was selected as it is commonly used in major treatment outcomes studies. Adolescent self-report measures of substance use from the GAIN have been shown to be consistent with collateral reports (kappa = .69–.92 and agreement = 90%–98%) and urine testing (kappa = .75–.90 and agreement = 88%–95%; Godley, Godley, Dennis, Funk, &

Passetti, 2002); and (3) the Substance Frequency Scale (SFS), derived from the larger GAIN-I instrument, is a self-report of the average percent of days (out of the past 90) of alcohol or other drug use. Higher scores represent increasing frequencies of substance use in terms of days, with a cut off score of 0.14 or higher indicating considerable difficulty stopping without significant assistance.

Time-Invariant Covariates

Time-invariant covariates are variables that were assessed at only one time point in the study, in this case, at the baseline. Gender was determined as 'male' or 'female'. Race/ethnicity contained the following categories: Hispanic, Caucasian (non-Hispanic), Mixed ethnicity, African American, Native American/Alaskan Native and Asian. Age was coded as <12, 12-14, or 15-17 years of age. Age at first use of substances was measured by a single item: "How old were you when you first got drunk or used any drug?" Age of first use was coded into three age groups: <10, 10-14, and 15-17. Single parent status was measured by a single item: "Who has legal custody of you?" with the following response categories (1= Foster care, 2= Institutional care, 3= Out of home placement, 4=With parents*)*. Comorbid group status contained the following categories: (1) Substance use only; (2) Substance use + Internalizing; (3) Substance use + Externalizing; and (4) Substance use + combined internalizing/externalizing.

Time-Varying Covariates

Time-varying covariates were variables that were measured and could presumably change across the five assessment periods in this study. The current study used social support, which was defined as the types of people available for emotional/instrumental/informational support. It was measured using items from the Social

Connectedness Scale (SCS), an 8-item scale that is transformed into a binary variable (0 = no social support/social connectedness, 1 = experiencing social support/social connectedness). This scale is defined as any self-help attendance, any days of structured activities without AOD use, having anyone in their living, vocational or social environment that has been in treatment or is in recovery in the past 90 days.

The General Social Support Index was originally considered for use as a time-varying covariate, but it was later determined to have too much missing data at various time-points, thus it was not used in any of the analyses.

Data Analysis Strategy

One useful method in the study of change over time is MLGM with parallel process latent models. MLGM is a branch of structural equation modeling that allows the study of individual variation of behavior over time and allows for the modeling of interactions among related factors. This modeling approach includes the ability to account for measurement error by using latent repeated measures and handle missing data. MLGM also allows for the modeling of covariates on temporal relations and can test whether certain factors predict the intercept (the starting point of the trajectory) and slope (change over time). MLGM has the added advantage of allowing the researcher to model the interrelationships between constructs that change over time, and model predictors of these changes. This is a particularly useful analytical tool given the aims of the current study were to examine the longitudinal relations between mental health and substance use problems and test specific predictors (Wang & Wang, 2019). Modeling the interactions of two repeated-measure latent constructs across time allows for the investigation of causal relationships between the two latent

constructs as these models allow for the inclusion of directional paths among growth factors (Preacher et al., 2008).

The following outlines the steps in the development of MLGM with parallel processes (Muthén & Muthén, 2010). The first step required fitting each growth model to the mental health and substance use variables separately and examining the trajectory shape of each process. An initial examination of mean changes across time points was conducted to guide the trajectory shape specification within each separate model. Goodness of fit indices were examined. Model modifications were made as appropriate to improve fit. Growth was first tested to be linear in nature (slope specified as 0, 1, and 2). The second step involved examining both processes jointly and fitting a model whereby intercepts and slopes could correlate. Model fit was re-examined, and modifications made as appropriate. In the third step, to examine whether initial levels in one construct predict change in another (between processes), slopes were regressed onto intercepts. In the fourth step, time-invariant covariates were added to the model and the intercept and slopes of each process were regressed on these covariates. Examination of regression coefficients and their significance (z- score values ± 1.96 or greater indicating significance), as well as direction of effects, determined the contributions of each covariate. In the fifth step, time-varying covariates were added to the model and regressed onto their repeated-measure outcome variables.

Model fit was evaluated by looking at overall model fit (absolute, parsimony, and comparative fit), strain and strength of effects. Absolute fit was indicated by chi-square with a non-significant p-value suggesting good model fit and the standard root mean square residual examined the average difference between the observed and model implied correlations (values < 0.05 suggesting good fit). Model parsimony was determined by the

root mean square error of approximation (RMSEA) (RMSEA values < 0.06 indicate good fit) that assessed "the extent to which a model fits reasonably well in the population" (Brown, 2006 p. 83). The Tucker-Lewis index (TLI) and the Comparative Fit Index (CFI) assessed comparative fit with values > 0.95 indicating adequate model fit. Reliance alone on chi-square testing has been questioned given its tendency to be inflated by sample size (Chueng & Rensvold, 2000).

Missing data were managed by maximum-likelihood estimation (ML) under the assumption of missingness at random (Allison, 2003; Raykov, 2005). This approach is efficient and creates less biased parameter estimates than other methods such as mean/regression imputation, or pairwise or listwise deletion strategies (Schäfer & Graham, 2002). To determine feasibility of model testing, patterns of missing data were examined in Mplus, and the percentage of data coverage was assessed. Muthén and Muthén (2010) suggest that Mplus will reject models with less than 10% data coverage.

Chapter 4 Results

Normality analyses and descriptive statistics are provided. The full sample (N = 3218) was used to model a series of latent growth models that tested Hypotheses 1 through 3.

Normality Analysis

All variables were examined for normality, linearity, univariate and multivariate outliers, and multicollinearity. As shown in Table 1, several variables evidenced significant skewness and kurtosis, with acceptable skewness values -2 and +2; and acceptable kurtosis values between -7 and +7 (Bryne, 2010; Hair et al., 2010). Data coverage in the sample for the mental health and substance use indicators ranged from 38% - 100%, with the majority of missing data originating from the General Social Support (GSSI) index variables. Coverage of the covariates ranged from 81.9-100%. Together, these findings support the use of the robust maximum likelihood estimator to handle non-normally distributed data and missingness.

Table 1

Zero Order Correlations Among Covariates, Mental Health Problems, Substance Use Problems, and Social Support at Baseline, 3 Month Follow-Up, and 6 Month Follow-Up. *Means, Standard Deviations and other Descriptive Statistics (N=3218).*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Gender	-	-.028	-.054**	.227**	.023	.061**	-.070**	.058**	.069**	.060**	.060**	.066**	.063**	.044*	.015	.021	.046**	.017	.021	.039*	-.002	.024	.057**	-.023	-.033	-.021	.214**	.193**	.148**	.067**	.074**	.051**	.096**	.017	.030
Race/ Ethnicity		-	-.014	.058**	-.045*	.025	.089**	.093**	.053**	.050**	.092**	.043**	.032	.037*	.056**	.028	.038*	.058**	.027	-.004	.001	.012	-.013	.031	.036*	.022	.037*	.013	.029	-.005	.012	.020	-.019	-.046	.007
Age Groups			-	.020	.253**	-.053**	.027	.179**	.183**	.171**	.109**	.092**	.079**	.071**	.067**	.029	.064**	.060**	.033	-.118**	-.067**	-.057**	-.107**	.098**	.080**	.079**	.034	.031	.011	.037*	.000	-.065**	-.119**	-.239**	-.206**
Co-morbid Status				-	-.191**	.043*	-.092**	.470**	.391**	.372**	.460**	.378**	.345**	.309**	.172**	.167**	.309**	.188**	.183**	-.257**	-.187**	-.170**	-.249**	.244**	.145**	.130**	.648**	.431**	.383**	.139**	.107**	.095**	.115**	-.051	-.028
Age of First Use					-	.013	.086**	-.207**	-.155**	-.151**	-.177**	-.132**	-.113**	-.104**	-.096**	-.108**	-.094**	-.097**	-.102**	.187**	.145**	.131**	.170**	-.114**	-.116**	-.078**	-.156**	-.142**	-.119**	-.026	-.012	-.032	-.062*	-.022	.040
Session Count						-	.024	.010	.038*	.060**	.016	.044*	.041*	.018	-.018	-.014	.015	-.024	-.010	.016	.051**	.069**	.036*	.016	-.078**	-.063**	.052**	.091**	.118**	.035	.095**	.097**	.023	.036	.070*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Custody Status							-	-.055**	-.054**	-.030	-.012	.020	.051*	.038	-.004	.013	.052**	.009	.018	.081**	.109**	.118**	.019	.068**	.022	.000	-.099**	-.074**	-.033	-.025	-.007	-.010	-.046	-.027	.045
Substance Use Dependence (Lifetime) Baseline								-	.687**	.645**	.888**	.563**	.509**	.436**	.249**	.232**	.410**	.255**	.240**	-.445**	-.253**	-.271**	-.407**	.322**	.208**	.215**	.381**	.292**	.283**	.180**	.118**	.059**	.121**	-.088**	-.090**
Substance Use Dependence (Lifetime) 3 MO FU									-	.745**	.622**	.826**	.589**	.312**	.333**	.223**	.304**	.322**	.231**	-.387**	-.281**	-.268**	-.345**	.271**	.218**	.187**	.332**	.361**	.302**	.162**	.146**	.120**	.077**	-.042	-.091**
Substance Use Dependence (Lifetime) 6 MO FU										-	.586**	.620**	.803**	.284**	.267**	.301**	.277**	.271**	.292**	-.362**	-.284**	-.320**	-.308**	.240**	.206**	.215**	.288**	.333**	.361**	.144**	.149**	.121**	.068**	-.070*	-.072*
Substance Use Dependence (Past Year) Baseline											-	.601**	.535**	.512**	.255**	.234**	.486**	.264**	.245**	-.447**	-.232**	-.248**	-.439**	.388**	.221**	.216**	.368**	.278**	.260**	.156**	.112**	.064**	.117**	-.046	-.050
Substance Use Dependence (Past Year) 3 MO FU												-	.661**	.377**	.406**	.254**	.383**	.397**	.265**	-.368**	-.309**	-.276**	-.361**	.359**	.283**	.226**	.325**	.362**	.307**	.140**	.146**	.123**	.073**	-.004	-.048
Substance Use Dependence (Past Year) 6 MO FU													-	.354**	.333**	.389**	.362**	.343**	.384**	-.333**	-.327**	-.372**	-.320**	.350**	.286**	.297**	.286**	.322**	.380**	.112**	.136**	.133**	.064*	-.021	-.040
Substance Use Dependence (Past Month) Baseline														-	.316**	.246**	.966**	.327**	.271**	-.388**	-.250**	-.165**	-.408**	.607**	.322**	.233**	.324**	.195**	.193**	.038*	.055**	.024	.022	-.062*	-.063*
Substance Use Dependence (Past Month) 3 MO FU															-	.432**	.323**	.964**	.453**	-.244**	-.404**	-.348**	-.256**	.282**	.600**	.400**	.186**	.272**	.224**	.037*	.050	.023	-.004	-.056*	-.102**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Substance Use Dependence (Past Month) 6 MO FU																-	.247**	.439**	.963**	-.184**	-.272**	-.377**	-.195**	.242**	.389**	.583**	.169**	.185**	.288	.022	.045*	.022	.031	-.049	-.130**
Substance Problem Scale Baseline																	-	.341**	.276**	-.397**	-.263**	-.165**	-.427**	.629**	.344**	.246**	.326**	.193**	.19**1	.046**	.057**	.029	.024	-.062*	-.057*
Substance Problem Scale 3 MO FU																		-	.475**	-.264**	-.430**	-.371**	-.280**	.306**	.633**	.470**	.198**	.283**	.234**	.041*	.056**	.030	-.009	-.074**	-.106**
Substance Problem Scale 6 MO FU																			-	-.203**	-.288**	-.408**	-.218**	.263**	.413**	.621**	.185**	.197**	.305**	.017	.051**	.030	.021	-.057	-.136**
Days Abstinent (Past 90) Baseline																				-	.441**	.352**	.876**	-.687**	-.344**	-.286**	-.229**	-.182**	-.179**	-.044*	-.037*	-.007	-.073**	.058*	.111**
Days Abstinent (Past 90) 3 MO FU																					-	.604**	.372**	-.349**	-.724**	-.387**	-.176**	-.234**	-.215**	-.039*	-.033	-.039*	-.020	.118**	.140**
Days Abstinent (Past 90) 6 MO FU																						-	.291**	-.239**	-.444**	-.673**	-.139**	-.219**	-.283**	-.048**	-.034	-.036	-.045	.090**	.149**
Days Abstinent (Intake)																							-	-.723**	-.370**	-.311**	-.228**	-.158**	-.153**	-.024**	-.049**	-.013	-.033	.066*	.100**
Substance Frequency Scale Baseline																								-	.426**	.343**	.266**	.176**	.165**	-.002	.028	-.007	-.010	-.066*	-.088**
Substance Frequency Scale 3 MO FU																									-	.532**	.159**	.222**	.186**	-.001	.017	.001	-.012	-.103**	-.112**
Substance Frequency Scale 6 MO FU																										-	.128**	.164**	.230**	.012	.020	.006	.025	-.085**	-.129**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Emotional Problems Scale Baseline																											-	.497**	.436**	.116**	.081**	.084**	.130**	-.033	-.044
Emotional Problems Scale 3 MO FU																												-	.579**	.098**	.106**	.080**	.059*	-.032	-.065*
Emotional Problems Scale 6 MO FU																													-	.090**	.084**	.107**	.066*	-.064*	-.072*
Social Support Intake																														-	.189**	.123**	.184**	.076**	.027
Social Support 3 MO FU																															-	.304**	.055*	.098**	.091**
Social Support 6 MO FU																																-	.045	.094**	.131**
General Social Support Index Intake																																	-	.332**	.238**
General Social Support 3 MO FU																																		-	.371**
General Social Support 6 MO FU																																			-
Mean	1.29	4.37	2.03	1.47	2.13	15.96244	3.79	5.28	5.14	4.99	4.56	4.15	3.84	1.61	0.93	0.75	2.87	1.69	1.37	46.87	64.3	64.22	50.53	12.61	6.86	6.26	26.09	20.85	18.84	0.82	0.79	0.78	6.33	7.07	7.17
Standard Deviation	0.452	1.139	0.573	1.273	0.54	9.505366	0.662	3.656	3.747	3.836	3.619	3.689	3.759	2.59	2.063	1.897	3.756	3.073	2.818	33.578	32.01	33.384	33.818	14.332	11.25	11.109	19.95	18.063	17.107	0.383	0.406	0.416	2.386	2.139	2.167

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Skewness	0.953	-0.67	0.002	0.09	0.411	0.96	-3.313	0.069	0.127	0.165	0.296	0.458	0.566	1.765	2.681	3.149	1.462	2.289	2.666	-0.1	-1.009	-0.99	-0.237	1.187	2.147	2.33	0.932	1.211	1.252	-1.676	-1.437	-1.333	-0.876	-1.193	-1.279
Kurtosis	-1.093	0.772	0.046	-1.666	1.07	2.618	10.709	-1.313	-1.321	-1.374	-1.225	-1.119	-1.085	2.267	7.039	10.111	1.356	5.065	7.278	-1.563	-0.532	-0.662	-1.55	0.745	5.118	6.22	0.561	1.466	1.464	0.811	0.064	-0.225	-0.13	0.825	0.991

*Correlation is significant at the 0.01 level (2-tailed).

**Correlation is significant at the 0.05 level (2-tailed).

Descriptive Analyses

Table 1 also presents means, standard deviations, variance estimates, and zero-order correlations for mental health and substance use indicators, and all covariates are presented for the full sample of N=3218. Full sample characteristics are shown in Table 2. The sample had the largest number of adolescents from the age range group of 15-17 years old (67.2%). The sample was 71.5% male, and as far as race/ethnicity, it was: 39.7% Hispanic, 33% Non-Hispanic White, 15% African American, 15% Mixed-race/ethnicity, 9.1% Native American/Alaskan Native, and 1% Asian. Examining the means over time, mental health symptoms (measured by the Emotional Problems Scale; EPS) decreased from an intake mean of 26.09 (SD - 19.95) to the 6-month follow-up time point mean of 18.84 (SD - 17.11). The substance use outcome means (measured by the Substance Problems Scale; SPS) also decreased over time, from an intake mean of 2.87 (SD – 3.76; Range 0-16) to the 6-month follow-up time point mean of 1.37 (SD – 2.82; Range 0-16). At intake, 40% of the sample were not experiencing problems with their substance use, which increased to 60.3% not experiencing problems with their substance use at the 6-month follow-up timepoint. The wide range of scores suggests that some adolescents were experiencing multiple problems with their substance use at each of the follow-up time points.

Table 2

Client Demographics for Full AAFT Sample (n=3218)

Variable	N	%
Totals	3218	100%
Gender		
Male	2300	71.5%
Female	917	28.5%

Race/Ethnicity		
Native American/Alaskan Native	292	9.1%
Asian	33	1%
African American	475	15%
White	1054	33%
Hispanic	1278	39.7%
Mixed	465	15%
Age		
<12	2	0.1%
12-14	485	15.1%
15-17	2161	67.2%
Comorbid psychiatric		
Internalizing disorder (MDD, GAD, trauma-related distress) + SU Disorder	318	10%
Externalizing disorder (ADHD/conduct disorder) + SU Disorder	695	22%
Any Co-morbid disorder + SU Disorder	1136	35%
Substance Use Disorder ONLY	1067	33%
Age of first use		
<10	248	8%
10-14	2203	72%
15-17	598	19%
Legal Custody		
Foster care	109	4%
Institution	19	1%
Other out of home	197	8%
With Parents	2294	87%

Session Count		
Average	16	
Range	0-79	
Std Deviation	9.5	
25th Percentile	9	
50th Percentile	15	
75th Percentile	22	

This study exclusively focused on examining the data timepoints across intake, the 3-month follow-up, and the 6-month follow-up. This was to intentionally focus on the active phase of treatment. The next series of analyses addressed hypotheses 1 through 3. The modeling process followed these general steps: (1) Fitting the parallel process unconditional model without covariates; (2) Fitting the unconditional parallel process model without directional regression paths and covariates; (3) Fitting the parallel process model with directional regression paths and time-invariant covariates; and finally (4) Fitting the parallel process model with directional regression paths and time-invariant and time-varying covariates.

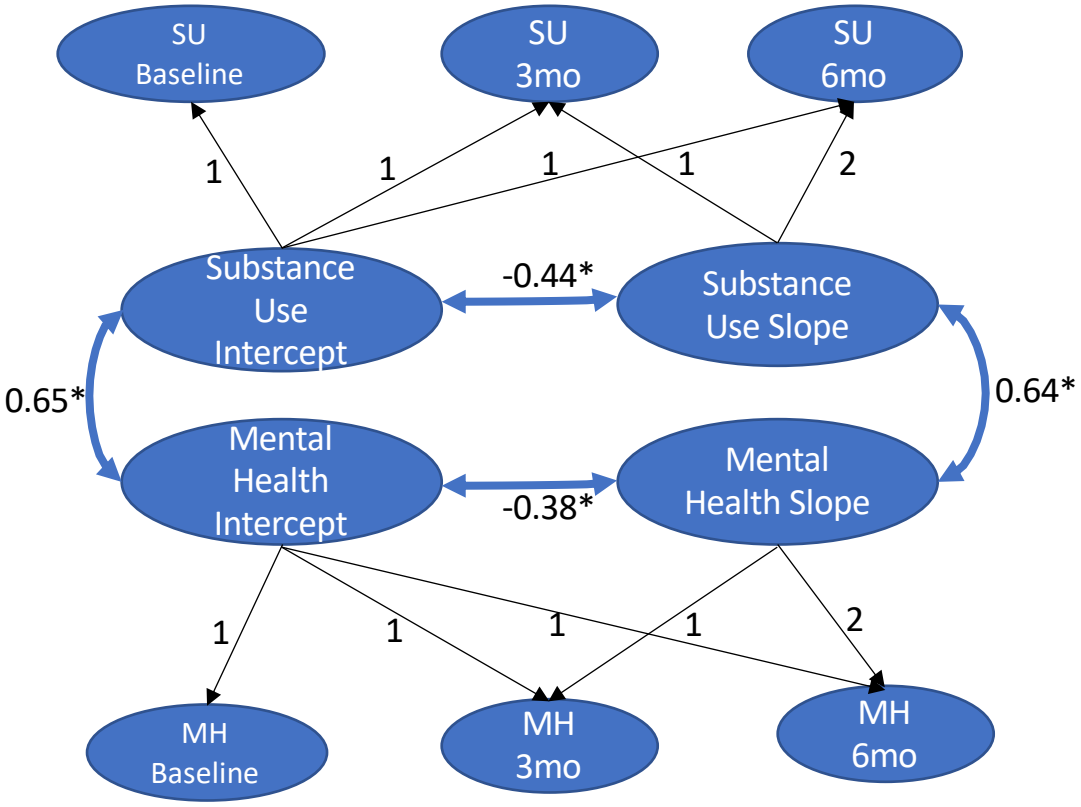
Parallel-Process Model without Covariates

Results of the Unconditional Parallel Process Model without Directional Regression Paths and without Covariates (Figure 4)

The model was fit to the data and demonstrated adequate fit, $\chi 2$ (7, n = 3218) = 206.47, p=0.01; RMSEA = 0.09; CFI = 0.95; TLI = 0.89; SRMR = 0.03 (Table 3). Examination of standardized residuals and modification indices indicated that no areas of significant strain were present.

Figure 4

Unconditional Parallel Process Model without Directional Regression Paths and Covariates.



Note: Standardized estimates shown. SU = Substance use outcomes, MH = mental health outcomes. Baseline = baseline (Time Point 1), 3mo = 3 month follow-up (Time Point 2), 6mo = 6 month follow-up (Time Point 3). Model fit: $\chi 2$ (7, n = 3218) = 206.47, p=0.01; RMSEA = 0.09; CFI = 0.95; TLI = 0.89; SRMR = 0.03. * = $p < 0.01$

Table 3

Unconditional Parallel Process Model Without Directional Regression Paths and Without Covariates (n=3218)*. Standardized Estimates.*

Variable	Estimate (β)	S.E.	Est./S.E.	P-value
Factor: Intercept of Mental Health Problems (IM)				
Emotional Problem Scale Baseline	0.726	0.017	41.971	0.000
Emotional Problem Scale 3 MO FU	0.794	0.018	44.074	0.000
Emotional Problems Scale 6 MO FU	0.845	0.025	34.023	0.000
Factor: Slope of Mental Health Problems (SM)				
Emotional Problem Scale Baseline	0.000	0.000	999.00	999.000
Emotional Problem Scale 3 MO FU	0.306	0.023	13.481	0.000
Emotional Problems Scale 6 MO FU	0.650	0.052	12.532	0.000
Factor: Intercept of Substance Use Problems (IS)	0.598	0.021	27.849	0.000
Substance Use Problems Scale Baseline	0.721	0.025	28.385	0.000
Substance Use Problems Scale 3 MO FU	0.795	0.032	24.721	0.000
Substance Use Problems Scale 6 MO FU				
Factor: Slope of Substance Use Problems (SS)				
Substance Use Problems Scale Baseline	0.000	0.000	999.00	999.000
Substance Use Problems Scale 3 MO FU	0.343	0.025	13.742	0.000
Substance Use Problems Scale 6 MO FU	0.756	0.058	13.006	0.000
Intercept of Substance Use (IS)				
WITH Intercept of Mental Health (IM)	0.657	0.036	18.441	0.000
WITH Slope of Mental Health (SM)	-0.397	0.055	-7.195	0.000
WITH Slope of Substance Use (SS)	-0.444	0.048	-9.345	0.000
Slope of Substance Use (SS)				
WITH Slope of Mental Health (SM)	0.641	0.083	7.732	0.000
WITH Intercept of Mental Health (IM)	-0.399	0.050	-8.052	0.000
Slope of Mental Health (SM)				
WITH intercept of Mental Health (IM)	-0.375	0.043	-8.698	0.000
Residual Variances				
Substance Use Problems Scale Baseline	0.643	0.026	25.038	0.000
Substance Use Problems Scale 3 MO FU	0.582	0.013	43.454	0.000
Substance Use Problems Scale 6 MO FU	0.330	0.037	8.892	0.000
Emotional Problem Scale Baseline	0.472	0.025	18.787	0.000
Emotional Problem Scale 3 MO FU	0.457	0.012	37.847	0.000
Emotional Problems Scale 6 MO FU	0.275	0.030	9.109	0.000

Note. IM = Mental health symptoms intercept, SM = Slope of mental health symptoms, IS = Substance use symptoms intercept, SS = Slope of substance use symptoms, Estimate. = standardized coefficient, z-value = Est./S.E. values > ± 1 .96 = p <.05. SRMR =

standardized root-mean square residual, RMSEA = root-mean square error of approximation, TLI = Tucker-Lewis index, CFI = comparative fit index. Model fit: $\chi 2$ (7, n = 3218) = 206.47, p=0.01; RMSEA = 0.09; CFI = 0.95; TLI = 0.89; SRMR = 0.03.

The intercepts of both processes were specified to correlate in Figure 4. Data revealed a significant positive correlation between the initial level of mental health problems and substance use problems (r = 0.65, p = < 0.01). This suggests that at baseline (Time Point 1), higher initial levels in one domain were associated with higher initial levels in another. Thus, adolescents with higher initial mental health problems evidenced greater substance use problems.

The slopes of both processes were specified to correlate. Data revealed a significant positive correlation between the mental health problems slope and the substance use problems slope (r = 0.64, p = <0.01). This suggests that change over time in one domain was associated with change over time in the other domain. More specifically, given that both slopes were negative (i.e., mental health problems and substance use problems both declined over time), a decrease in mental health problems was associated with a decrease in substance use problems.

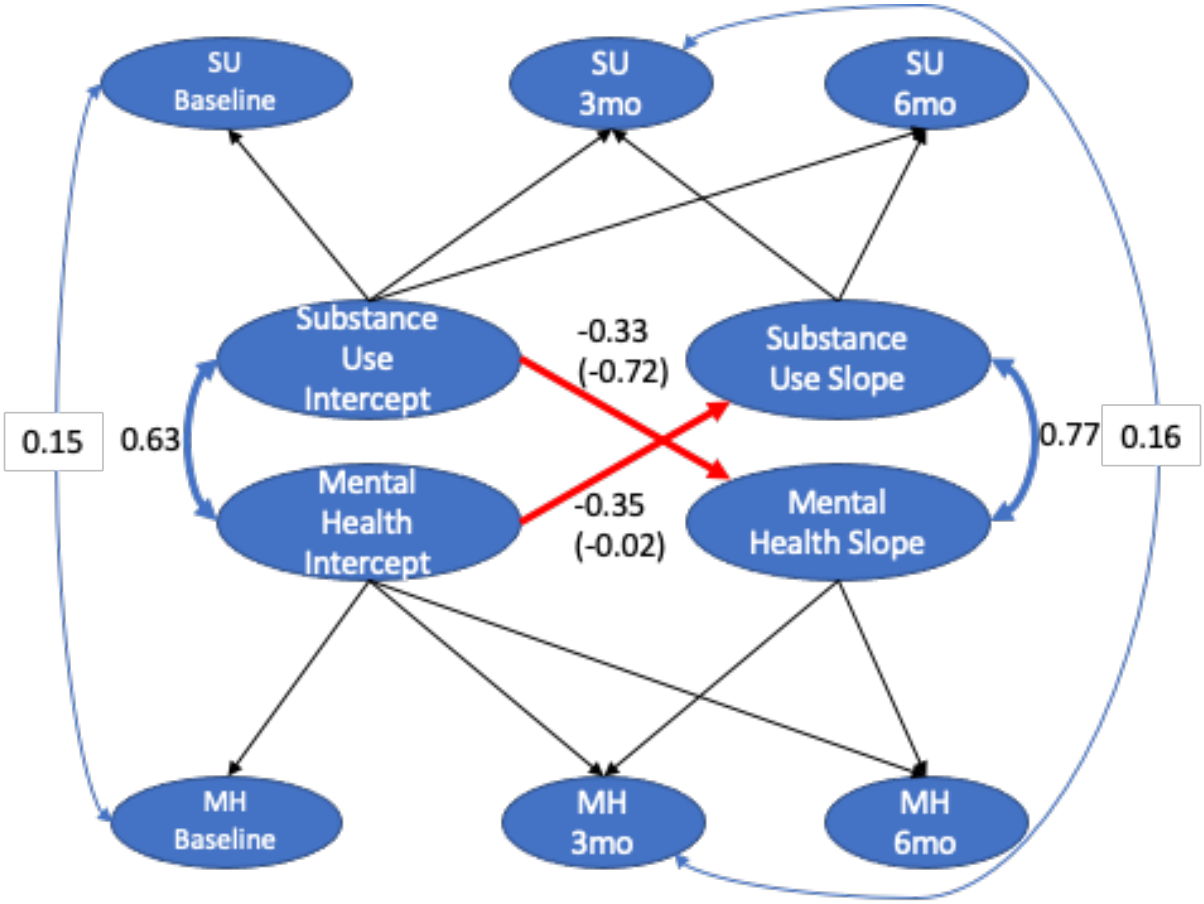
The intercepts of both processes were specified to correlate with their respective slopes. Data revealed a significant negative correlation between the mental health problems intercept and mental health problems slope (r = -0.44, p = <0.01), and a significant negative correlation between the substance use problems intercept and substance use problems slope (r = -0.38, p = < 0.01). A negative correlation between the intercept and slope factors suggests that individuals with greater values at baseline (Time Point 1) tended to have lower slope scores; namely, less positive growth in mental health and substance use problems over time.

Results of the Unconditional Model <u>with</u> Directional Regression Paths and without Covariates (Figure 5)

The model was fit to the data and demonstrated adequate fit, $\chi 2$ (7, n = 3218) = 137.75, p=0.01; RMSEA = 0.08; CFI = 0.97; TLI = 0.93; SRMR = 0.03 (Table 4). Examination of standardized residuals and modification indices indicated an area of significant strain was present. To reduce the significant strain and improve model fit, the intake mental health and substance use variables were correlated, and the 3-month follow-up mental health and substance use variables were also correlated. In the final model, adding these modification indices improved model fit by reducing $\chi 2$ from 206.47 (Table 3) to 137.75 (Table 4). Results regarding Hypothesis 1a and 1b are discussed below.

Figure 5

Unconditional Parallel Process Model with Directional Regression Paths and without Covariates.



Note: Standardized estimates shown. SU = Substance use outcomes, MH = mental health outcomes. Baseline = baseline (Time Point 1), 3mo = 3 month follow-up (Time Point 2), 6mo = 6 month follow-up (Time Point 3), Parenthesis = Unstandardized estimate. Model fit: $\chi 2$ (7, n = 3218) = 206.47, p=0.01; RMSEA = 0.09; CFI = 0.95; TLI = 0.89; SRMR = 0.03. * = $p < 0.01$.

Table 4

Unconditional Parallel Process Model with Directional Regression Paths and without Covariates (n=3218)*. Standardized Estimates.*

Variable	Estimate (β)	S.E.	Est./S.E.	P-value
Factor: Intercept of Mental Health Problems (IM)	0.676	0.015	46.322	0.000
Emotional Problem Scale Baseline	0.747	0.016	45.835	0.000
Emotional Problem Scale 3 MO FU	0.779	0.020	38.972	0.000
Emotional Problems Scale 6 MO FU				
Factor: Slope of Mental Health Problems (SM)				
Emotional Problem Scale Baseline	0.000	0.000	999.000	999.000
Emotional Problem Scale 3 MO FU	0.237	0.023	10.355	0.000
Emotional Problems Scale 6 MO FU	0.493	0.049	10.034	0.000
Factor: Intercept of Substance Use Problems (IS)				
Substance Use Problems Scale Baseline	0.523	0.016	33.440	0.000
Substance Use Problems Scale 3 MO FU	0.637	0.020	32.281	0.000
Substance Use Problems Scale 6 MO FU	0.693	0.023	30.482	0.000
Factor: Slope of Substance Use Problems (SS)				
Substance Use Problems Scale Baseline	0.000	0.000	999.000	999.000
Substance Use Problems Scale 3 MO FU	0.267	0.020	13.259	0.000
Substance Use Problems Scale 6 MO FU	0.581	0.045	12.931	0.000
Slope of Substance Use (SS)				
REGRESSED ON Intercept of Mental Health (IM)	-0.345	0.063	-5.447	0.000
Slope of Mental Health (SM)				
REGRESSED ON Intercept of Substance Use (IS)	-0.334	0.071	-4.689	0.000
Intercept of Substance Use (IS)				
WITH Intercept of Mental Health (IM)	0.633	0.034	18.365	0.000
Slope of Substance Use (SS)				
WITH Slope of Mental Health (SM)	0.768	0.107	7.209	0.000
Emotional Problem Scale Baseline				
WITH Substance Use Problems Scale Baseline	0.155	0.030	5.142	0.000
Emotional Problem Scale 3 MO FU				
WITH Substance Use Problems Scale 3 MO FU	0.162	0.023	6.947	0.000
Means				
Intercept of Mental Health Problems	1.883	0.053	35.700	0.000
Intercept of Substance Use Problems	1.346	0.053	25.518	0.000
Residual Variances				
Substance Use Problems Scale Baseline	0.726	0.016	44.306	0.000
Substance Use Problems Scale 3 MO FU	0.597	0.014	43.674	0.000

Variable	Estimate (β)	S.E.	Est./S.E.	P-value
Substance Use Problems Scale 6 MO FU	0.358	0.035	10.332	0.000
Emotional Problem Scale Baseline	0.543	0.020	27.564	0.000
Emotional Problem Scale 3 MO FU	0.460	0.013	35.926	0.000
Emotional Problems Scale 6 MO FU	0.313	0.028	11.234	0.000
Slope of Mental Health Problems	0.889	0.048	18.690	0.000
Slope of Substance Use Problems	0.881	0.044	20.094	0.000

Note. IM = Mental health symptoms intercept, SM = Slope of mental health symptoms, IS = Substance use symptoms intercept, SS = Slope of substance use symptoms, EPS7P = Emotional Problems Scale, SPSM = Substance Use Problems Scale, Estimate. = standardized coefficient, z-value = Est./S.E. values > ± 1 .96 = p <.05. SRMR = standardized root-mean square residual, RMSEA = root-mean square error of approximation, TLI = Tucker-Lewis index, CFI = comparative fit index. Model fit: $\chi 2$ (7, n = 3218) = 137.75, p=0.01; RMSEA = 0.08; CFI = 0.97; TLI = 0.93; SRMR = 0.03.

Hypothesis 1a: Higher Levels of Mental Health Problems at Intake Will Predict Greater Decreases in Substance Use Problems during the Treatment Phase (A-CRA + ACC; first 6 months).

The slope of substance use problems was regressed onto the intercept of mental health problems. Hypothesis 1a was supported. Holding initial levels of substance use problems constant, there was a significant direct effect of the mental health problems intercept predicting a negative slope (decreasing growth over time) of substance use problems (-0.35, S.E. = 0.06, z = -5.45, p = <0.01, *Unstandardized estimate = -0.02*). This suggests that adolescents with a higher initial level of mental health problems evidenced a significantly steeper decrease in substance use problems over time when compared to youth with lower initial mental health problems (Figure 5).

Hypothesis 1b: Higher Levels of Substance Use Problems at Baseline Will Predict Greater Decreases in Mental Health Problems during the Treatment Phase (A-CRA + ACC; first 6 months).

The slope of mental health problems was regressed onto the intercept of substance use problems. Hypothesis 1b was supported. Holding initial levels of mental health problems constant, there was a significant direct effect of the substance use problems intercept predicting a negative slope (decreasing growth over time) of mental health problems (-0.33, S.E. = 0.07, z = -4.69, p = <0.01, *Unstandardized estimate = -0.73*). This suggests that adolescents with a higher initial level of substance use problems evidenced a significantly steeper decrease in mental health problems over time when compared to youth with lower initial substance use problems (Figure 5).

Conditional Parallel Process Model with Directional Regression Paths and Time-Invariant Covariates

Hypothesis 2: The Combined Co-morbid Group Status (substance use + internalizing disorder and externalizing disorder), When Compared to the Other Two Co-morbid Groups, Will Predict a Unique Parallel-process Growth Trajectory during the Treatment Phase (A-CRA + ACC; first 6 months).

Testing of the covariates was conducted in separate models in line with experimental Hypothesis 2. Here, age, gender, race/ethnicity, comorbid status, age of first substance use, and custody status were regressed onto the baseline conditional model to determine if they were predictive of initial level (intercept) and change over time (slope) (Table 5, Figure 6).

Table 5

Conditional Parallel Process Model with Directional Regression Paths and Time-Invariant Covariates (n=3218). *Standardized Estimates.*

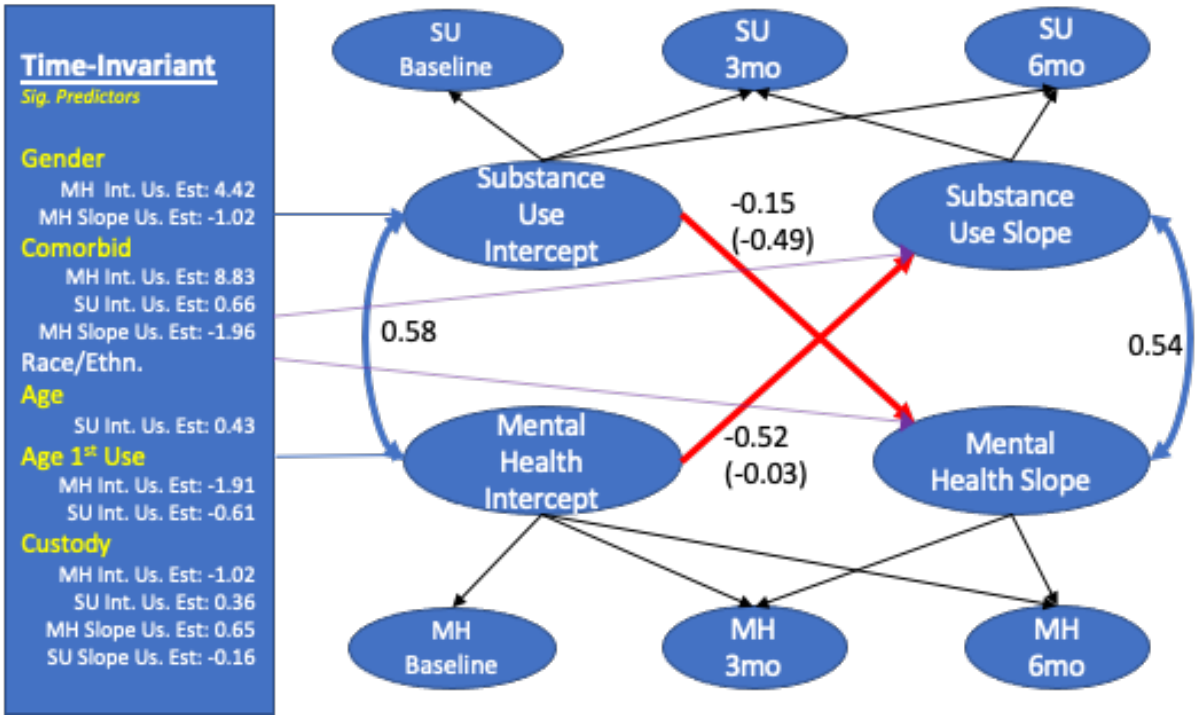
Variable	Estimate (β)	S.E.	Est./S.E.	P-value
Factor: Intercept of Mental Health Problems (IM)				
Emotional Problem Scale Baseline	0.773	0.010	73.872	0.000
Emotional Problem Scale 3 MO FU	0.812	0.015	54.137	0.000
Emotional Problems Scale 6 MO FU	0.889	0.021	43.136	0.000
Factor: Slope of Mental Health Problems (SM)				
Emotional Problem Scale Baseline	0.000	0.000	999.000	999.000
Emotional Problem Scale 3 MO FU	0.342	0.013	26.029	0.000
Emotional Problems Scale 6 MO FU	0.749	0.030	24.922	0.000
Factor: Intercept of Substance Use Problems (IS)				
Substance Use Problems Scale Baseline	0.548	0.016	34.538	0.000
Substance Use Problems Scale 3 MO FU	0.647	0.020	32.002	0.000
Substance Use Problems Scale 6 MO FU	0.690	0.023	29.686	0.000
Factor: Slope of Substance Use Problems (SS)				
Substance Use Problems Scale Baseline	0.000	0.000	999.000	999.000
Substance Use Problems Scale 3 MO FU	0.293	0.020	14.573	0.000
Substance Use Problems Scale 6 MO FU	0.625	0.044	14.257	0.000
Slope of Substance Use (SS)				
REGRESSED ON Intercept of Mental Health (IM)	-0.516	0.109	-4.731	0.000
Slope of Mental Health (SM)				
REGRESSED ON Intercept of Substance Use (IS)	-0.154	0.057	-2.684	0.007
Slope of Substance Use (SS)				
REGRESSED ON				
Gender	0.082	0.047	1.727	0.084
Race/Ethnicity	0.002	0.044	0.053	0.958
Age	-0.011	0.044	-0.257	0.798
Comorbid Status	0.132	0.097	1.358	0.174
Age of First Substance Use	0.000	0.046	0.005	0.996
Custody Status	-0.117	0.044	-2.643	0.008
Slope of Mental Health (SM)				
REGRESSED ON				
Gender	-0.074	0.031	-2.384	0.017
Race/Ethnicity	0.037	0.031	1.223	0.222
Age	0.000	0.031	0.016	0.987
Comorbid Status	-0.397	0.044	-8.987	0.000
Age of First Substance Use	-0.031	0.032	-0.970	0.332
Custody Status	0.070	0.031	2.273	0.023

Intercept of Mental Health (IM)				
REGRESSED ON				
Gender	0.134	0.020	6.796	0.000
Race/Ethnicity	0.012	0.019	0.611	0.541
Age	0.002	0.019	0.081	0.935
Comorbid Status	0.752	0.015	50.524	0.000
Age of First Substance Use	-0.063	0.020	-3.176	0.001
Custody Status	-0.046	0.019	-2.362	0.018
Intercept of Substance Use (IS)				
REGRESSED ON				
Gender	-0.014	0.033	-0.412	0.680
Race/Ethnicity	0.047	0.032	1.473	0.141
Age	0.085	0.032	2.632	0.008
Comorbid Status	0.429	0.031	13.790	0.000
Age of First Substance Use	-0.153	0.033	-4.675	0.000
Custody Status	0.122	0.032	3.799	0.000
Intercept of Substance Use (IS)				
WITH Intercept of Mental Health (IM)	0.558	0.043	12.963	0.000
Slope of Substance Use (SS)				
WITH Slope of Mental Health (SM)	0.537	0.074	7.234	0.000
Residual Variances				
Substance Use Problems Scale Baseline	0.700	0.017	40.206	0.000
Substance Use Problems Scale 3 MO FU	0.600	0.015	39.779	0.000
Substance Use Problems Scale 6 MO FU	0.370	0.038	9.620	0.000
Emotional Problem Scale Baseline	0.403	0.016	24.906	0.000
Emotional Problem Scale 3 MO FU	0.468	0.013	36.528	0.000
Emotional Problems Scale 6 MO FU	0.234	0.032	7.360	0.000
Intercept of Mental Health Problems	0.338	0.020	17.133	0.000
Slope of Mental Health Problems	0.741	0.031	24.213	0.000
Intercept of Substance Use Problems	0.757	0.028	27.017	0.000
Slope of Substance Use Problems	0.837	0.043	19.362	0.000

Note. IM = Mental health symptoms intercept, SM = Slope of mental health symptoms, IS = Substance use symptoms intercept, SS = Slope of substance use symptoms, Estimate. = standardized coefficient, z-value = Est./S.E. values > ± 1 .96 = p<.05. SRMR = standardized root-mean square residual, RMSEA = root-mean square error of approximation, TLI = Tucker-Lewis index, CFI = comparative fit index. Model fit: $\chi 2$ (21, n = 3218) = 212.75, p=0.01; RMSEA = 0.06; CFI = 0.96; TLI = 0.90; SRMR = 0.03.

Figure 6

Conditional Parallel Process Model with Directional Regression Paths and Time-invariant Covariates.



Note: Standardized estimates shown. SU = Substance use outcomes, MH = mental health outcomes. Baseline = baseline (Time Point 1), 3mo = 3 month follow-up (Time Point 2), 6mo = 6 month follow-up (Time Point 3), Parenthesis = Unstandardized estimate. Model fit: $\chi 2$ (21, n = 3218) = 212.75, p=0.01; RMSEA = 0.06; CFI = 0.96; TLI = 0.90; SRMR = 0.03. * = $p < 0.01$

Comorbid Status Predictor of Intercept and Slope

A dummy code for comorbid status was created (0 = Substance use disorder only, 1 = Substance use disorder + Externalizing disorder, 2 = Substance use disorder + Internalizing disorder, 3 = Substance use disorder + Externalizing & Internalizing Disorder). This covariate was combined with the other time-invariant covariates in the same model, as research has determined that these time-invariant covariates have been predictive in prior

studies. More emphasis was applied to the comorbid status covariate, and a multigroup analysis was conducted to examine the effect in more detail. The overall model fit the data adequately, $\chi 2$ (21, n = 3218) = 212.75, p=0.01; RMSEA = 0.06; CFI = 0.96; TLI = 0.90; SRMR = 0.03 (Table 5). Examination of standardized residuals and modification indices suggested that no areas of significant strain were present. Hypothesis 2 was supported.

Comorbid status significantly predicted higher initial levels of mental health problems (0.75, S.E. = 0.02, z = 50.52, p = < 0.01, *Unstandardized Est: 8.83*) and substance use problems (0.42, S.E. = 0.03, z = 13.79, p = <0.01, *Unstandardized Est: 0.66*). This indicates that mean initial mental health problem scores were 0.75 standardized units higher for co-morbid adolescents compared to the substance use only group, and that the mean initial substance use problem scores were 0.42 standardized units higher for the co-morbid adolescents compared to the substance use only group. Comorbid status significantly predicted a decreasing change over time (decreasing rate of change = negative slope) in mental health problems (-0.40, S.E. = 0.04, z = -8.99, p = <0.01, *Unstandardized Est: -1.96*), and was not predictive of a change over time (slope) in substance use problems.

Mental health problem intercept means for each comorbid group were as follows: (1) Substance use only group = 1.46 (n = 1067, SD = 2.32); (2) Substance use + Externalizing group = 2.72 (n = 695, SD = 3.15); (3) Substance use + Internalizing group = 2.87 (n = 318, SD = 3.58); and (4) Substance use + Both Internalizing/Externalizing = 4.30 (n = 1135, SD = 4.6).

Substance use problem intercept means for each comorbid group were as follows: (1) Substance use only group = 10.14 (n = 1067, SD = 10.15); (2) Substance use + Externalizing group = 24.96 (n = 695, SD = 12.37); (3) Substance use + Internalizing group = 25.11 (n =

318, SD = 15.23); and (4) Substance use + Both Internalizing/Externalizing = 42.04 (n = 1136, SD = 19.44).

Covariate Predictors of Mental Health Problem Intercept

Considering the time-invariant covariates other than comorbid group status for predicting mental health problems, the variables for gender, age of first use of substances, and custody status were predictive of higher initial levels of mental health problems (Table 5). This indicates the following: (1) mean initial mental health problem scores for females were 0.13 units higher compared to males (0.13, S.E. = 0.02, z = 6.80, p = <0.01, *Unstandardized Est: 4.42*); (2) mean initial mental health problem scores were higher for adolescents who used their first substance at a younger age (-0.06, S.E. = 0.02, z = -3.18, p = <0.01, *Unstandardized Est: -1.91*); (3) mean initial mental health problem scores were higher for adolescents who were currently living in foster care or another form of institutionalized care compared to those adolescents living with parents (single, multi, adopted; -0.05, S.E. = 0.02, z = -2.36, p = <0.05, *Unstandardized Est: -1.02*).

Covariate Predictors of Substance Use Problem Intercept

Considering the time-invariant covariates other than comorbid group status for predicting substance use problems, the variables for age, age of first use, and custody status were significantly predictive of higher initial levels of substance use problems (Table 5). This indicates the following: (1) mean initial substance use problem scores were higher for older age adolescents (0.09, S.E. = 0.03, z = 2.63, p = 0.01, *Unstandardized Est: 0.43)*; (2) mean initial substance use problem scores were higher for adolescents who used substances at a younger age (-0.15, S.E. = 0.03, z = -4.68, p = <0.01); and (3) mean initial substance use problem scores were higher for adolescents who were currently in an out-of-home placement

(other family, emancipated, runaway) or with parents (single, multi, adopted) compared to adolescents living in foster care or another form of institutionalized care (0.12, S.E. = 0.03, z = 3.80, p = <0.01, *Unstandardized Est: 0.36*).

Covariate Predictors of Mental Health Problem Change Over Time (Slope)

Considering the time-invariant covariates other than comorbid group status for predicting mental health problem change over time (slope), both gender and custody status were significantly predictive of mental health problem change (slope), but in different directions. Gender significantly predicted a decreasing change over time (decreasing rate of change = negative slope) in mental health problems (-0.07, S.E. = 0.03, z = -2.38, p = 0.02, *Unstandardized Est: -1.02*), while custody status significantly predicted an increasing change over time (increasing rate of change = positive slope) in mental health problems (0.07, S.E. = 0.03, z = -2.362, p = 0.02, *Unstandardized estimate = 0.65*). This suggests that males exhibited a steeper declining rate of change, while adolescents living with parents or non-institutionalized form of care exhibited a less steep rate of change of mental health problems over time.

Covariate Predictors of Substance Use Problem Change Over Time (Slope)

Custody status was the only time-invariant covariate to significantly predict substance use problem change over time (slope). Custody status significantly predicted a decreasing change over time (decreasing rate of change = negative slope) in substance use problems (-0.12, S.E. = 0.03, z = -2.362, p = 0.02, *Unstandardized estimate = 0.65*), such that adolescents living in foster care or another form of institutionalized care exhibited a decreasing rate of change of substance use over time.

Multigroup Analysis by Comorbid Status

Comorbid status significantly predicted the intercepts of mental health and substance use problems, and it significantly predicted the slope of mental health problems but not substance use problems. Multigroup analysis was conducted to determine which comorbid group demonstrated a stronger co-occurring relationship between substance use and mental health symptoms during the treatment phase.

Results indicated that the parallel predictive process model was only statistically significant for the substance use + internalizing & externalizing disorder group (Combined group; Table 6). For this group (n=869), the mental health problems intercept significantly predicted the substance use problems slope (-0.37, S.E. = 0.10, z = -3.68, p = <0.01, *Unstandardized estimate = -0.04*), and the substance use intercept significantly predicted the mental health problems slope (-0.22, S.E. = 0.09, z = -2.28, p = 0.02, *Unstandardized estimate = -0.61*).

Table 6

Multiple Group Analysis by Comorbid status for the Conditional Parallel Process Model with Directional Regression Paths and Time-Invariant Covariates (n=2497)

Comorbid Group	N	B (Unstand.)	SE	Z	P
Substance Use Only Group	808				
Intercept of MH on Slope of SU		-0.17 (-0.02)	0.13	-1.33	0.19
Intercept of SU on Slope of MH		-0.22 (-1.07)	0.13	-1.72	0.09
SU + Externalizing Group	599				
Intercept of MH on Slope of SU		-0.23 (-0.02)	0.21	-1.09	0.28
Intercept of SU on Slope of MH		-0.03 (-0.10)	0.12	-0.25	0.81

SU + Internalizing Group	221				
Intercept of MH on Slope of SU		-0.24 (-0.02)	0.23	-1.04	0.30
Intercept of SU on Slope of MH		0.03 (0.09)	0.16	0.19	0.85
SU + Internalizing & Externalizing Group	869				
Intercept of MH on Slope of SU		-0.37 (-0.04)	0.10	-3.68	0.000
Intercept of SU on Slope of MH		-0.22 (-0.61)	0.09	-2.28	0.02

Note. MH = Mental Health Problems, SU = Substance Use Problems. B = Standardized Estimate (Unstandardized estimate), z-value = Est./S.E. values > ± 1 .96 = p<.05. SRMR = standardized root-mean square residual, RMSEA = root-mean square error of approximation, TLI = Tucker-Lewis index, CFI = comparative fit index. Model fit: $\chi 2$ (21, n = 3218) = 212.75, p=0.01; RMSEA = 0.06; CFI = 0.96; TLI = 0.90; SRMR = 0.03.

Comparing the combined group to the overall model, this specific comorbid group demonstrated a stronger predictive relationship of the substance use problems intercept predicting mental health slope (-0.22 vs -0.15). This specific comorbid group demonstrated a weaker predictive relationship of the mental health problems intercept predicting substance use problems slope (-0.37 vs -0.52) compared to the overall model. This suggests that the reciprocal parallel process relationship was more similar in strength for the combined group compared to the overall model. In the overall model, mental health problems at baseline (intercept) were driving the reduction of substance use over time (slope).

Final Parallel Process Model with Time-Invariant and Time-Varying Covariates

Hypothesis 3: The Proposed Study Predicts That Social Support Will Account for Additional Variance during the Treatment Phase (first 6 months).

It was expected that higher levels of social support would account for an improvement in substance use and mental health symptoms after accounting for intake (time-invariant) predictors (Table 7, Figure 7).

Table 7

Conditional Parallel Process Model with Directional Regression Paths and Time-Invariant and Time-Varying Covariates (n=3218).

Variable	Estimate (β)	S.E.	Est./S.E.	P-value
Factor: Intercept of Mental Health Problems (IM)				
Emotional Problem Scale Baseline	0.762	0.012	65.708	0.000
Emotional Problem Scale 3 MO FU	0.800	0.016	49.962	0.000
Emotional Problems Scale 6 MO FU	0.871	0.022	40.504	0.000
Factor: Slope of Mental Health Problems (SM)				
Emotional Problem Scale Baseline	0.000	0.000	999.000	999.000
Emotional Problem Scale 3 MO FU	0.343	0.013	26.191	0.000
Emotional Problems Scale 6 MO FU	0.746	0.030	25.254	0.000
Factor: Intercept of Substance Use Problems (IS)				
Substance Use Problems Scale Baseline	0.554	0.017	32.814	0.000
Substance Use Problems Scale 3 MO FU	0.646	0.021	30.543	0.000
Substance Use Problems Scale 6 MO FU	0.694	0.024	28.575	0.000
Factor: Slope of Substance Use Problems (SS)				
Substance Use Problems Scale Baseline	0.000	0.000	999.000	999.000
Substance Use Problems Scale 3 MO FU	0.301	0.019	15.620	0.000
Substance Use Problems Scale 6 MO FU	0.647	0.042	15.264	0.000
Slope of Substance Use (SS)				
REGRESSED ON Intercept of Mental Health (IM)	-0.498	0.113	-4.404	0.000
Slope of Mental Health (SM)				
REGRESSED ON Intercept of Substance Use (IS)	-0.151	0.061	-2.488	0.013
Slope of Substance Use (SS)				
REGRESSED ON				
Gender	0.084	0.048	1.767	0.077
Race/Ethnicity	-0.016	0.043	-0.370	0.712
Age	-0.022	0.044	-0.503	0.615

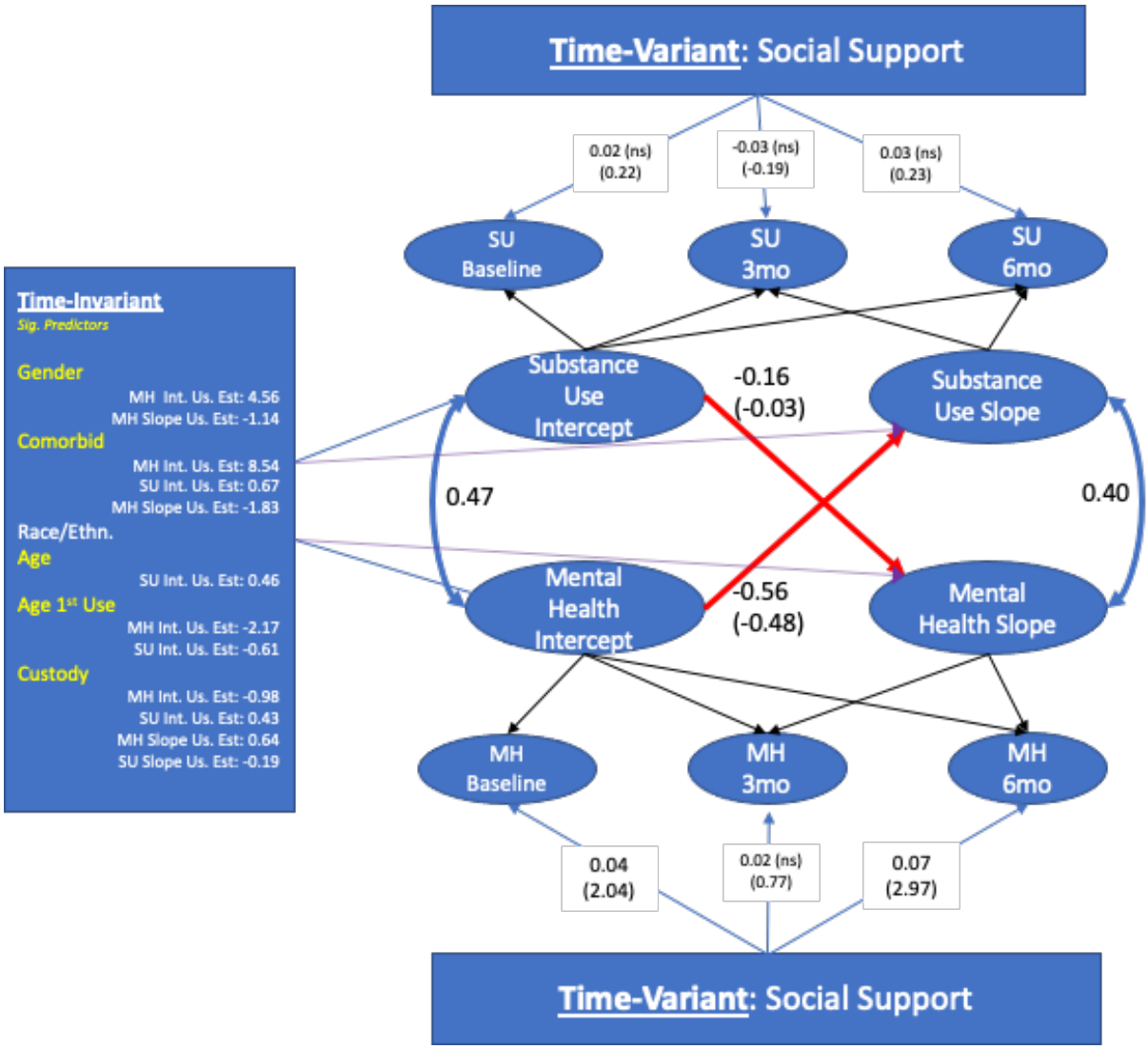
Variable	Estimate (β)	S.E.	Est./S.E.	P-value
Comorbid Status	0.127	0.099	1.279	0.201
Age of First Substance Use	0.009	0.046	0.191	0.849
Custody Status	-0.137	0.044	-3.118	0.002
Slope of Mental Health (SM)				
REGRESSED ON				
Gender	-0.083	0.032	-2.585	0.010
Race/Ethnicity	0.047	0.031	1.497	0.134
Age	-0.016	0.032	-0.493	0.622
Comorbid Status	-0.374	0.045	-8.365	0.000
Age of First Substance Use	-0.009	0.033	-0.279	0.780
Custody Status	0.067	0.032	2.082	0.037
Intercept of Mental Health (IM)				
REGRESSED ON				
Gender	0.142	0.021	6.678	0.000
Race/Ethnicity	0.004	0.021	0.191	0.849
Age	0.011	0.021	0.518	0.604
Comorbid Status	0.746	0.016	46.065	0.000
Age of First Substance Use	-0.073	0.021	-3.412	0.001
Custody Status	-0.044	0.021	-2.140	0.032
Intercept of Substance Use (IS)				
REGRESSED ON				
Gender	-0.020	0.035	-0.590	0.555
Race/Ethnicity	0.061	0.033	1.830	0.067
Age	0.092	0.034	2.711	0.007
Comorbid Status	0.429	0.033	13.100	0.000
Age of First Substance Use	-0.151	0.034	-4.423	0.000
Custody Status	0.142	0.033	4.270	0.000
Mental Health Problems (Baseline) REGRESSED ON Social Support at Baseline	0.041	0.014	2.826	0.005
Mental Health Problems (3 MO FU) REGRESSED ON Social Support at 3 MO FU	0.017	0.011	1.505	0.132
Mental Health Problems (6 MO FU) REGRESSED ON Social Support at 6 MO FU	0.072	0.017	4.355	0.000
Substance Use Problems (Baseline) REGRESSED ON Social Support at Baseline	0.023	0.017	1.339	0.180
Substance Use Problems (3 MO FU) REGRESSED ON Social Support at 3 MO FU	-0.025	0.014	-1.849	0.064

Variable	Estimate (β)	S.E.	Est./S.E.	P-value
Substance Use Problems (6 MO FU)				
REGRESSED ON Social Support at 6 MO FU	0.033	0.018	1.787	0.074
Intercept of Substance Use (IS)				
WITH Intercept of Mental Health (IM)	0.545	0.048	11.414	0.000
Slope of Substance Use (SS)				
WITH Slope of Mental Health (SM)	0.520	0.072	7.211	0.000
Mental Health Problems (3 MO FU)				
WITH Substance Use Problems (3 MO FU)	0.192	0.025	7.699	0.000
Residual Variances				
Substance Use Problems Scale Baseline	0.690	0.019	37.007	0.000
Substance Use Problems Scale 3 MO FU	0.597	0.015	38.859	0.000
Substance Use Problems Scale 6 MO FU	0.340	0.038	8.894	0.000
Emotional Problem Scale Baseline	0.410	0.017	23.689	0.000
Emotional Problem Scale 3 MO FU	0.472	0.013	35.785	0.000
Emotional Problems Scale 6 MO FU	0.223	0.031	7.132	0.000
Intercept of Mental Health Problems	0.341	0.021	15.930	0.000
Slope of Mental Health Problems	0.758	0.031	24.319	0.000
Intercept of Substance Use Problems	0.751	0.030	25.186	0.000
Slope of Substance Use Problems	0.841	0.043	19.348	0.000

Note. IM = Mental health symptoms intercept, SM = Slope of mental health symptoms, IS = Substance use symptoms intercept, SS = Slope of substance use symptoms, Estimate. = standardized coefficient, z-value = Est./S.E. values > ± 1 .96 = p<.05. SRMR = standardized root-mean square residual, RMSEA = root-mean square error of approximation, TLI = Tucker-Lewis index, CFI = comparative fit index. Model fit: $\chi 2$ (32, n = 3218) = 109.94, p=<0.01; RMSEA = 0.03; CFI = 0.98; TLI = 0.96; SRMR = 0.02.

Figure 7

Conditional Parallel Process Model with Directional Regression Paths and Time-Invariant and Time-Varying Covariates.



Note: Standardized estimates shown. SU = Substance use outcomes, MH = mental health outcomes. Baseline = baseline (Time Point 1), 3mo = 3 month follow-up (Time Point 2), 6mo = 6 month follow-up (Time Point 3), Parenthesis = Unstandardized estimate. Model fit: $\chi 2$ (32, n = 3218) = 109.94, p=<0.01; RMSEA = 0.03; CFI = 0.98; TLI = 0.96; SRMR = 0.02.

Testing of the time-invariant covariates (TICs) and time-varying covariates (TVCs), in the same model, was conducted in a separate model in line with experimental Hypothesis 3. Age, gender, race/ethnicity, comorbid status, age of first substance use, and custody status were regressed onto the baseline conditional model as time-varying covariates. As to the effects of the time-varying covariates, relations between changes in substance use and mental health problems, and changes in social support, were modeled using techniques described by Bollen and Curran (2006). First, six additional paths were defined to represent the effects of changes in social support on both substance use and mental health problems. Social support was only determined by each newly added path within that given period. For example, the two added paths for Timepoint 1 were only related to Timepoint 1 substance use problems and mental health problems, respectively. These paths were regressed onto the six corresponding repeated measures of substance use and mental health problems.

The overall model fit the data adequately, $\chi 2$ (32, n = 3218) = 109.94, p=<0.01; RMSEA = 0.03; CFI = 0.98; TLI = 0.96; SRMR = 0.02. (Table 7). Examination of standardized residuals and modification indices suggested an area of significant strain was present. Timepoint 3 for both substance use problems and mental health problems was correlated, which resulted in improved model fit. The final model with all TVCs and TICs continued to demonstrate decreasing trajectories in substance use and mental health problems for the overall group (Figure 8, Figure 9). Hypothesis 2 was partially supported.

Figure 8

Latent Trajectory of Overall Sample for Mental Health Problems

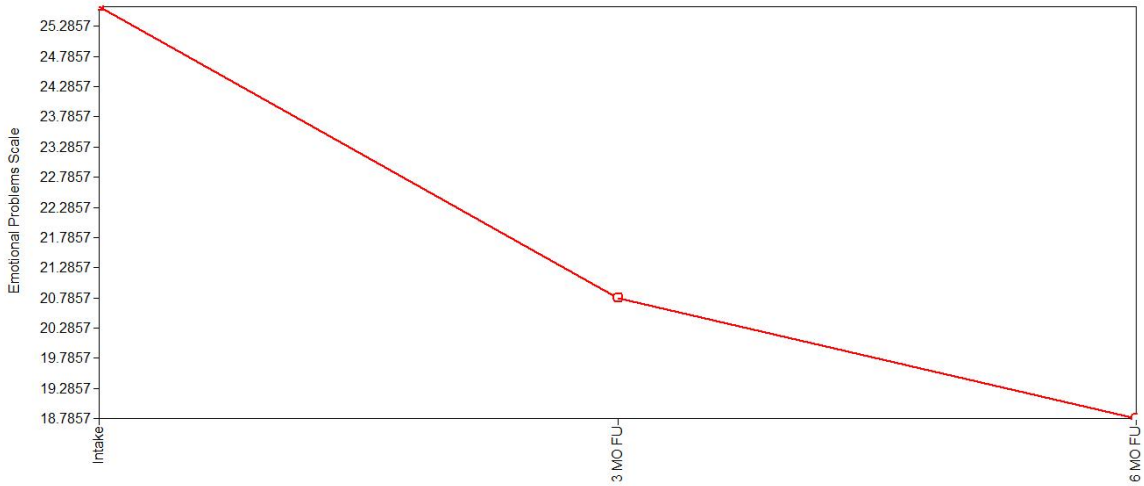
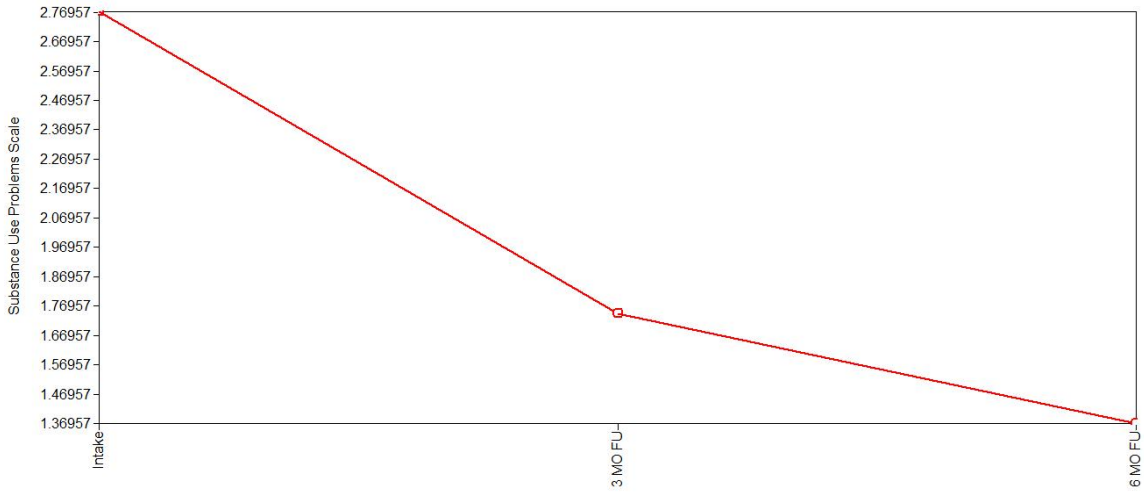


Figure 9

Latent Trajectory of Overall Sample for Substance Use Problems



Time-Invariant Predictors of Intercept and Slope

Although the results already addressed the influence of TICs in the prior model in the previous section, the prior model only included TICs; it did not include TVCs. In this section,

the new model included both TICs and TVCs, as this can influence the estimates of the TICs, as well as change some from being significant to non-significant and vice-versa.

In this final model that included TVCs, TICs predicted the intercept and growth factors of substance use problems and mental health problems, and the TVCs predicted Timepoint 1 and Timepoint 3 repeated measures of mental health problems but did not significantly predict any of the repeated timepoint measures of substance use problems. For covariate effects on slopes, gender predicted decreasing mental health problems over time (-0.08, S.E. = 0.03, z = -2.58, p = 0.01, *Unstandardized estimate = -1.14*), comorbid status predicted decreasing mental health problems over time (-0.37, S.E. = 0.04, z = -8.36, p = < 0.01, *Unstandardized estimate = -1.83*), and custody status predicted increasing mental health problems over time (0.07, S.E. = 0.03, z = 2.08, p = 0.04, *Unstandardized estimate = 0.63*) and decreasing substance use problems over time (-0.14, S.E. = 0.04, z = -3.12, p = <0.01, *Unstandardized estimate = -0.19*). This suggests that being a male and being an adolescent without a co-morbid condition predicted decreasing mental health problems over time. Being an adolescent living with parents or out-of-home care predicted an increase in mental health problems over time, while being an adolescent living in foster care/institutionalized care predicted decreasing substance use problems over time.

For covariate effects on intercepts, gender significantly predicted baseline mental health problems (0.14, S.E. = 0.02, z = 6.68, p = <0.01, *Unstandardized estimate = 4.56*), but not substance use problems. Age significantly predicted baseline substance use problems (0.09, S.E. = 0.03, z = 2.71, p = <0.01, *Unstandardized estimate = 0.46*), but not mental health problems. Comorbid status significantly predicted baseline mental health problems (0.75, S.E. = 0.02, z = 46.07, p = <0.01, *Unstandardized estimate = 8.54*) and baseline

substance use problems (0.43, S.E. = 0.03, z = 13.10, p = <0.01, *Unstandardized estimate = 0.67*). Age of first substance use significantly predicted baseline mental health problems (-0.07, S.E. = 0.02, z = -3.41, p = <0.01, *Unstandardized estimate = -2.17*) and baseline substance use problems (-0.15, S.E. = 0.03, z = -4.42, p = <0.01, *Unstandardized estimate = -0.61*). Custody status significantly predicted baseline mental health problems (-0.04, S.E. = 0.02, z = -2.14, p = 0.03, *Unstandardized estimate = -0.98*) and baseline substance use problems (0.14, S.E. = 0.03, z = 4.27, p = <0.01, *Unstandardized estimate = 0.43*). For the final model, being a female, having a comorbid disorder, being younger when first using any substance, and living in foster care/institutionalized care predicted baseline higher levels of mental health problems. Additionally, being an older age adolescent, having a comorbid disorder, being younger when first using any substance, and living with parents/out-of-home placement predicted baseline higher levels of substance use problems.

Time-Varying Covariate Effects

In the final model that included all covariates, the effects of TVCs indicated that only two regression paths (Timepoint 1 and Timepoint 3 of repeated measures of mental health problems) were significantly and positively associated with changes in mental health problems over time (β's of 0.04 at T1 and 0.07 at T3, all p <0.01), but were not predictive for Timepoint 2 of mental health problems (3 month follow-up) or any of the repeated measures for substance use problems (Table 7). These positive coefficients indicated that deviations from the overall trajectory for mental health problems were associated with changes in social support at baseline and at the 6 month follow up timepoints. Hypothesis 3 was only partially supported, and only for mental health problems, not for substance use problems.

The results also suggested that regardless of when a participant's social support changed, those who had social support at baseline and at the 6-month follow-up timepoint would experience a slightly faster decrease in mental health problems compared to participants who did not experience social support at two of the three time points.

Multigroup Analyses by Comorbid Status

After accounting for the effects of the time invariant predictors, the time-varying predictors revealed that increased social support may play a supportive role for improving co-occurring problems. However, social support only demonstrated a stronger role for the combined co-morbid group. As demonstrated by the individual trajectories of each comorbid group for mental health and substance use problems, the combined group demonstrated the larger decreases in substance use and mental health problems over time compared to the other comorbid groups (Figure 10, Figure 11).

Results indicated that the parallel predictive process model was only statistically significant for the substance use + internalizing & externalizing disorder group (Combined co-morbid group; Table 8). For this group (n=764), the mental health problems intercept significantly predicted the substance use problems slope (-0.34, S.E. = 0.10, z = -3.68, p = <0.01, *Unstandardized estimate = -0.03*), and the substance use intercept significantly predicted the mental health problems slope (-0.24, S.E. = 0.09, z = -2.70, p = 0.01, *Unstandardized estimate = -0.68*). Social support was only statistically significant for mental health problems at the 6-month follow-up timepoint (0.13, S.E. = 0.03, z = 4.38, p = <0.01, *Unstandardized estimate = 6.71*), and not for any of the repeated measure timepoints for substance use problems.

Figure 10

Latent Trajectory of Mental Health Problems by Comorbid Group Status

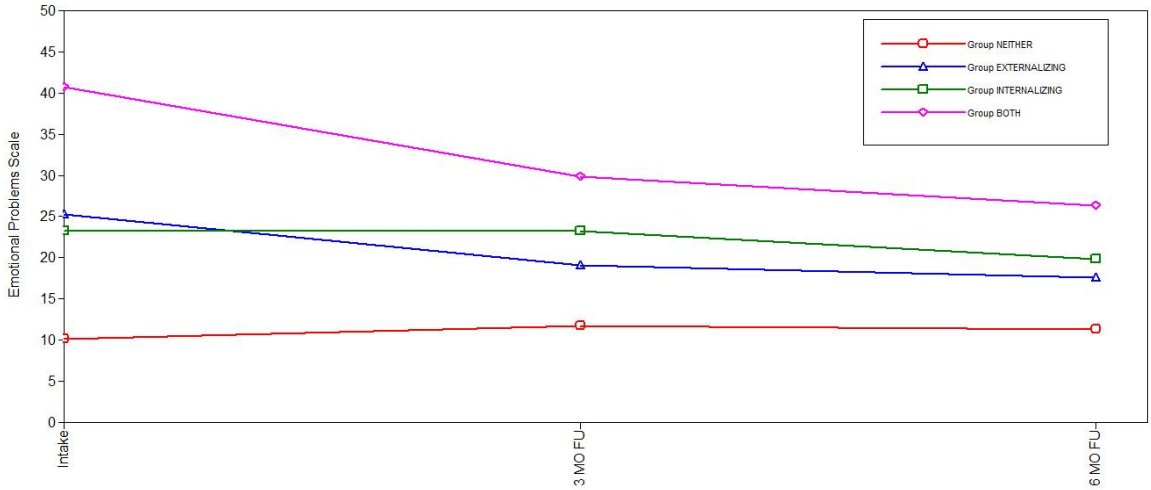
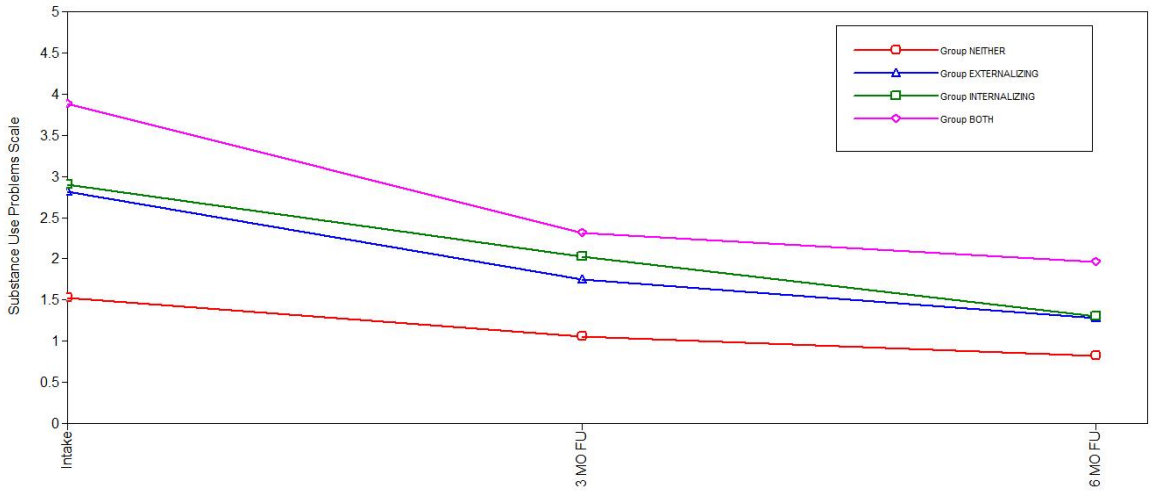


Figure 11

Latent Trajectory of Substance Use Problems by Comorbid Group Status



Comparing the combined co-morbid group to the overall sample, this specific comorbid group demonstrated a stronger predictive relationship of the substance use problems intercept predicting mental health slope (-0.24 vs -0.16). This specific comorbid

group demonstrated a weaker predictive relationship of the mental health problems intercept predicting substance use problems slope (-0.34 vs -0.55) compared to the overall model.

Table 8

Multiple Group Analysis by Comorbid Status for the Conditional Parallel Process Model with Directional Regression Paths and Time-Invariant and Time-Varying Covariates (n=2188).

Comorbid Group	**N**	**B (Unstand.)**	**SE**	**Z**	**P**
Substance Use Only Group	712				
Intercept of MH on Slope of SU		-0.06 (-0.01)	0.14	-0.42	0.67
Intercept of SU on Slope of MH		-0.04 (-0.21)	0.14	-0.27	0.78
Baseline Social Support on MH Problems		0.05 (1.20)	0.03	1.58	0.11
3-MO Social Support on MH Problems		0.09 (2.28)	0.02	3.68	0.00
6-MO Social Support on MH Problems		0.03 (0.67)	0.03	0.79	0.43
Baseline Social Support on SU Problems		0.04 (0.22)	0.03	1.26	0.21
3-MO Social Support on SU Problems		-0.01 (-0.05)	0.03	-0.40	0.69
6-MO Social Support on SU Problems		-0.01 (-0.02)	0.03	-0.16	0.87
SU + Externalizing Group	517				
Intercept of MH on Slope of SU		-0.33 (-0.03)	0.21	-1.59	0.11
Intercept of SU on Slope of MH		-0.05 (-0.18)	0.11	-0.49	0.63
Baseline Social Support on MH Problems		0.09 (3.02)	0.04	2.37	0.02
3-MO Social Support on MH Problems		0.01 (0.23)	0.03	0.23	0.82
6-MO Social Support on MH Problems		0.09 (3.20)	0.04	2.39	0.02
Baseline Social Support on SU Problems		-0.03 (-0.25)	0.04	-0.78	0.43
3-MO Social Support on SU Problems		-0.04 (-0.30)	0.03	-1.49	0.14
6-MO Social Support on SU Problems		0.06 (0.41)	0.04	1.71	0.09
SU + Internalizing Group	195				
Intercept of MH on Slope of SU		-0.24 (-0.03)	0.27	-0.90	0.37
Intercept of SU on Slope of MH		0.10 (0.31)	0.17	0.59	0.55

Comorbid Group	**N**	**B (Unstand.)**	**SE**	**Z**	**P**
Baseline Social Support on MH Problems		-0.03 (-1.20)	0.06	-0.51	0.61
3-MO Social Support on MH Problems		0.05 (2.06)	0.04	1.11	0.27
6-MO Social Support on MH Problems		0.03 (0.95)	0.06	0.43	0.67
Baseline Social Support on SU Problems		-0.00 (-0.04)	0.06	-0.08	0.94
3-MO Social Support on SU Problems		-0.02 (-0.14)	0.04	-0.43	0.67
6-MO Social Support on SU Problems		-0.01 (-0.04)	0.06	-0.12	0.91
SU + Internalizing & Externalizing Group	764				
Intercept of MH on Slope of SU		-0.34 (-0.03)	0.10	-3.68	0.000
Intercept of SU on Slope of MH		-0.24 (-0.68)	0.09	-2.70	0.01
Baseline Social Support on MH Problems		0.04 (2.28)	0.03	1.28	0.20
3-MO Social Support on MH Problems		0.00 (0.21)	0.02	0.18	0.86
6-MO Social Support on MH Problems		0.13 (6.71)	0.03	4.38	0.000
Baseline Social Support on SU Problems		0.04 (0.55)	0.03	1.39	0.17
3-MO Social Support on SU Problems		-0.02 (-0.22)	0.02	-0.92	0.35
6-MO Social Support on SU Problems		0.04 (0.42)	0.03	1.39	0.17

Note. MH = Mental Health Problems, SU = Substance Use Problems. B = Standardized Estimate (Unstandardized estimate), z-value = Est./S.E. values > ± 1 .96 = p<.05. SRMR = standardized root-mean square residual, RMSEA = root-mean square error of approximation, TLI = Tucker-Lewis index, CFI = comparative fit index. Model fit: $\chi 2$ (32, n = 3218) = 109.94, p=<0.01; RMSEA = 0.03; CFI = 0.98; TLI = 0.96; SRMR = 0.02.

Chapter 5 Discussion

This study was guided by three broad goals. The first goal was to investigate a parallel process model of prospective associations between mental health problems and substance use problems in a sample of adolescents undergoing substance use treatment using a specific treatment modality (Adolescent Community Reinforcement Approach; A-CRA). The second goal of the study was to extend our understanding of whether certain covariates were predictive of initial severity and/or time course change of mental health problems and substance use problems over time. More specifically, the interest was in determining how membership in a particular co-morbid group might predict a unique parallel process relationship between mental health and substance use problems, compared to the other comorbid groups. The third goal was to examine how deviations from the long-term trajectory of the parallel process model of mental health problems and substance use problems were better accounted for by social support, over and above the variance already accounted for by the intake predictors.

Using a diverse sample of adolescents from multiple substance use treatment settings across the country, the results from this study add to prior research by identifying significant predictive reciprocal associations in the parallel process modeling of mental health problems and substance use problems over time for the overall sample, even after including all time-varying and time-invariant covariates. The stronger of the two reciprocal associations was mental health problems at intake (intercept) predicting a steeper decline in substance use (slope) over time, compared to substance use problems at intake predicting the slope of mental health problems. Additionally, with the exception of race/ethnicity, all baseline predictors (age, gender, age of first substance use, custody status, and comorbid group status)

differentially predicted baseline status at intake and/or the rate of change in mental health and substance use problem slopes. When considering all baseline predictors, custody status was the only variable to significantly predict both intercepts and both slopes. Comorbid group status was the strongest predictor of baseline status for both mental health and substance use problems, as well as the strongest predictor for the rate of change of mental health problems over time. Furthermore, custody status was the only significant predictor of the rate of change of substance use problems over time. The details of these covariate predictors are discussed later.

Social support as a time-invariant predictor significantly predicted deviations from the overall trajectory of mental health problems at baseline and the 6-month follow-up time points. Social support did not significantly predict deviations from the overall trajectory for substance use problems. Results suggest that social support had a minimal, but positive effect on the parallel process relationship between mental health and substance use problems. Including social support as a time-invariant covariate minimally increased the strength of the parallel process relationship. This is discussed in more detail in a later section.

In multigroup analyses by comorbid group status (including all time-varying and time-invariant covariates), the study demonstrated that this parallel process model of mental health and substance use problems remained significant only for the substance use + internalizing & externalizing group. This too is discussed again in an upcoming section.

Prospective Associations

Results suggest that mental health problems and substance use problems were associated both initially and longitudinally. Specifically, as seen in Figure 4, the significant correlation of intercepts of mental health and substance use problems ($r = 0.47$) suggests that

adolescents with higher initial mental health problems evidenced greater substance use problems at intake. The moderately correlated intake rates of co-occurring mental health and substance use problems are not surprising in this substance use treatment sample, considering the expansive literature demonstrating this phenomenon (Chan, Dennis, & Funk, 2008; Essau & de la Torre-Luque, 2019; Kaminer & Bukstein, 2008).

In addition, significantly associated slope trends suggest that mental health problems and substance use problems were associated prospectively. The rate of decline in both mental health problem and substance use problem slope trends indicated that overall, adolescents receiving A-CRA treatment demonstrated improved outcomes within the observed period from intake to the 6-month follow-up time point. This study's findings are similar to the findings from Godley et al. (2014), who used a subset of adolescents from the same data source as this study. The significant positive correlation between the rate of change (slope) of mental health problems and the rate of change (slope) of substance use problems (correlation of slopes; $r = 0.40$) suggested that change over time in one domain was associated with change over time in the other domain. More specifically, given that both slopes were negative (i.e., mental health problems and substance use problems both declined over time), a decrease in mental health problems was associated with a decrease in substance use problems. While correlated slopes do not offer any evidence of causal effects of one variable influencing the other, they suggest that these domains are linked developmentally over time for this sample. This finding may be better understood by considering the shared common risk factors (i.e., shared biopsychosocial determinants) that can contribute to both mental health and substance use problems (Kelly & Daley, 2013; Pelayo-Teran et al., 2012). This may suggest that for treatment samples similar to those found in the current study, changing

the developmental course of one domain could affect the developmental course in the other domain. This should prompt clinicians to be attentive to changes in substance use, as it might signal that a change in mental health status is likely, despite not necessarily being readily observable at the time.

Directionality In the Reciprocal Parallel Process Model

In examining the directional paths (regression paths) of the reciprocal parallel process model of mental health and substance use problems, adolescents who entered treatment with a higher level of mental health problems at intake evidenced a steeper decrease in their substance use problems over time compared to adolescents with lower levels of mental health problems at intake. In reciprocal fashion, adolescents who experienced higher levels of substance use problems at intake evidenced a steeper decrease in their mental health problems over time compared to adolescents with lower levels of substance use problems at intake. To our knowledge, this is the first study to demonstrate this reciprocal parallel process relationship for mental health problems and substance use problems using longitudinal data. The current study adhered to recommendations to use longitudinal data from a treatment sample with a higher clinical severity (Fleming, 2008) and with shorter periods of follow-up assessment (less than one year follow-up time points; Windle & Windle, 2001), and it therefore seems likely that these methodological changes contributed to our findings that support Hypothesis 1.

For the overall sample, the strength of the directional relationship was stronger for the path of MH intercept → SU slope (-0.56; → = predicting) compared to the path of the SU intercept → MH slope path (-0.16), which suggests that early elevated mental health problems were driving a substantially stronger decrease in substance use over time compared

to the reciprocal path of early elevated substance use problems driving a decrease in mental health problems over time. This suggests that adolescents in this sample were better able to respond to the emotional/social/vocational distress in their lives and reduce the need to use substances as a self-regulation strategy.

The next two sections will discuss each directional pathway and how the current findings (using a combined model) are consistent or inconsistent with prior studies that have investigated these prospective relationships separately or as a combined model. Studies using treatment samples are very limited, which will reduce the number of available comparisons. Furthermore, comparisons of findings may be difficult to generalize as most prospective latent growth models of CODs tend to use non-intervention community samples, where the primary purpose is to determine the etiological joint development of substance use problems and mental health problems over time (Duperrouzel et al., 2018; Measelle, Stice, Hogansen, 2006; Windle and Windle, 2001).

Mental Health Problem Intercept Predicting Substance Use Problem Slope Over Time

The current finding that adolescents who experienced an increased severity of mental health problems at intake evidenced a steeper decrease in their substance use problems over time compared to adolescents with lower levels of mental health problems at intake, is consistent with other adolescent treatment/intervention studies examining prospective relationships (Fleming et al., 2008; McKowen et al., 2013). A *community* sample demonstrated a similar finding when it reported that high levels of internalizing problems at intake were prospectively associated with lower levels of substance use two years later (Colder et al., 2013). Although this study had a different follow-up timeframe, it supported earlier studies that found that internalizing problems were associated with a lower risk of

substance use (Costello et al., 1999, Kaplow et al., 2001, 2002). Since adolescent substance use tends to occur within the context of peers as a social behavior (Kobus, 2003), and knowing that social withdrawal tends to accompany internalizing problems, conceivably these internalizing problems protect adolescents from the social pressures that normally accompany substance use (Fite et al., 2006). To the contrary, a meta-analysis revealed a prospective relationship whereby depression symptoms at first time measurement predicted higher levels of alcohol use and alcohol related problems over time (Conner, Pinquart, & Gamble, 2009). While this finding may be more applicable to studies where the primary substance use of choice is alcohol, the current study sample tended to use more marijuana compared to alcohol.

Substance Use Problem Intercept Predicting Mental Health Problem Slope Over Time

The current study found that adolescents who showed an increased severity of substance use problems at intake evidenced a steeper decrease in their mental health problems over time compared to adolescents with lower levels of substance use problems at intake. A recent treatment study with a similar prospective relationship between substance use and mental health (internalizing) problems found that substance use at intake predicted decreases in depressive symptoms over time (Dyar et al., 2020). These study participants, who ranged in age from 16-29, represented a diverse sample of high-risk adolescents and young adults. When examining *adult* treatment studies, the current findings are similar to those studies that investigated this prospective relationship in a population living with HIV who also had a co-occurring substance use and mental health disorder (Delaney et al., 2018), and for a study that determined that baseline cannabis use predicted decreased anxiety and depression (Hser et al., 2017).

Multigroup Analyses by Comorbid Group Status

Based on the findings from Hypothesis 1 (predicting a reciprocal parallel process model), this study also sought to investigate whether the combined co-morbid group, when compared to the other two co-morbid groups and the single non-comorbid group (substance use disorder only), would demonstrate a unique reciprocal parallel process growth trajectory during the treatment phase (A-CRA + ACC; first 6 months). Initially this study used co-morbid group status as a baseline predictor to determine if it would predict baseline levels at intake (intercept) and rates of change over time (slope) in both mental health and substance use constructs. In the final model that included all covariates, co-morbid status predicted both intercepts and only the slope of mental health (Step 1 toward confirming Hypothesis 2). The multigroup analysis was then conducted to determine which co-morbid group demonstrated the reciprocal parallel process relationship and its directional strength compared to the overall group model (Step 2 toward confirming Hypothesis 2).

Based on the results from the final model that included all time-varying and time-invariant covariates (Table 8), the combined co-morbid group was the only group to demonstrate the reciprocal parallel process relationship between mental health and substance use problems. These findings are similar even for the reciprocal parallel process model that only included the baseline predictors (time-invariant covariates; Table 6).

The results suggest that this study was able to demonstrate this relationship in the combined co-morbid group because it was the group that entered treatment with the highest mental health and substance use problems. While this group demonstrated significant decreases in mental health and substance use problems over time compared to other groups, the observed relationship of the reciprocal parallel process in this particular group could

possibly be attributed to both the persisting emotional problems and elevated substance use problems that were still elevated at the 6-month time point. It could be that the mental health problems take longer to resolve, or the social determinants (external factors in the social environment) of the mental health problems continue to persist and may be unlikely to change during the course of treatment for this sample.

The elevated mental health and substance use problems are similar to the results from Shane et al. (2003) and Rowe et al. (2004), in as much as adolescents with combined co-morbid disorders entered treatment with higher levels of substance use problems and left treatment with lower, but still elevated substance use compared to the other co-morbid groups at discharge. The findings also are similar to those from the Godley et al. (2014) study that conducted HLM trajectories for each co-morbid group for mental health problem and substance use problems. As a reminder, the Godley et al. study used a subset of the current study's dataset.

Although it is harder to generalize findings from this study to other empirically supported treatments (ESTs) mostly due to the lack of a control group using other ESTs, it is still worth noting that A-CRA, when practiced with fidelity, can produce reductions in substance use and mental health problems for this high severity co-morbid group in treatment settings (Campos-Melady et al., 2017). A review by Brewer et al. (2017) described the availability of other ESTs that can be used by themselves or in combination with other approaches for the simultaneous treatment of co-occurring disorders.

Influence of Time-Varying and Time-Invariant Covariates

Data from the present study found that certain covariates were associated uniquely with mental health problems and substance use problems. In general, predicting initial status

(intercept) was easier than predicting change over time (slope) as there was more inter-individual variance around initial status compared to the decreasing inter-individual variance of change over time for both processes. First, the shared predictors of the reciprocal parallel process model will be discussed. This will be followed by separate discussions about intercept-only predictors, and then slope-only predictors.

Reciprocal Parallel Process Shared Time-Invariant Predictors

In the final model with both time-invariant and time-varying covariates, the time-invariant variable that predicted both mental health problem and substance use problem intercept and slope was custody status The variable in the dataset for custody status provided the following options: 1= Foster care; 2= Institutional care; 3= Out of home placement; 4=With parent (single or both). This variable offered the opportunity to determine which type of custody placement would predict higher initial status and slope of both processes. For the overall model, custody status did not predict the same type of placement for all intercepts and slopes.

Living in foster care, or another institutionalized care setting, at intake predicted higher levels of mental health problems and decreasing substance use problems over time. Living in an out-of-home placement or with parents at baseline predicted a higher initial status of substance use problems and decreasing mental health problems over time. To the study author's knowledge, no other LGM studies have reported custody status findings as a predictor of initial status or slope. The differential predictions of initial status and slope could be further teased out by conducting latent class analyses to determine profiles of adolescents based on custody status to examine common demographic characteristics for each custody group. However, these analyses are beyond the scope of this paper.

Adolescents with a co-occurring disorder and being a younger age when first using any substances both predicted higher mental health problems and substance use problem at intake. For study participants who exhibited the reciprocal parallel relationships between mental health and substance use, it is plausible that they would have a co-occurring disorder with elevations in both domains, since most adolescents who enter substance use treatment present with co-occurring problems (Mason & Posner, 2009). Consistent with prior research, younger age of first substance use is a consistent predictor of future substance use disorders (Donoghue et al., 2017) and co-morbid mental health problems (Behrendt et al., 2009; Chen & Anthony, 2009; Dawson, Grant, & Li, 2007). Factors that determine early age of first substance include childhood traumatic experiences (Darke & Torok, 2014), early age major depression (Sintov et al. 2009), and bipolar disorders (Lagerberg et al., 2011). These additional factors could be introduced in future studies as moderating variables.

Differential Time-Invariant Predictors of Each Intercept and Slope

Outside of the common predictors for the reciprocal parallel process model, differential predictors of each intercept and slope from both processes will be discussed. For gender, being female predicted higher intake levels of mental health problems compared to males. Being male predicted a steeper decreasing rate of change for mental health problems over time compared to females. Consistent with this study's findings, while males tend to be overrepresented in substance use treatment settings, females tend to present with higher mental health problems (Godley, Hedges, & Hunter, 2011). In the current study, males entered treatment with significantly lower mental health problems and had significantly lower mental health problems at the 6-month follow-up; considerably lower than females. This finding is consistent with the findings from Godley et al. (2011) In terms of age, being

an older adolescent was predictive of higher intake levels of substance use compared to younger adolescents. This is consistent with prior research showing that older adolescents with co-occurring disorders experience more substance use problems compared to younger-aged adolescents (Lubman et al., 2007; McKowen et al., 2013).

Time-Varying Effects of Social Support on the Reciprocal Parallel Process Model

Including social support as a time-varying covariate in the overall reciprocal parallel process model increased model fit but did not substantially impact the reciprocal parallel process model. Social support significantly predicted mental health problems at baseline and at the 6-month follow-up time points but was not predictive of substance use problems. Hypothesis 3 was only partially supported, and only for mental health problems (not for substance use problems).

The results also suggested that regardless of when a participant's social support changed, those who had social support at baseline and at the 6-month follow-up timepoint were more likely to report lower scores of mental health problems compared to participants who did not experience social support at two of the three time points. These results are similar to findings from MacPherson et al. (2021) in terms of increased social support predicting a decline in depression symptoms over time. Interestingly, social support was the highest at intake and began to decrease over each follow-up timepoint. The high levels of social support at intake may be related to the high degree of implementation of A-CRA for this study sample. As reported in a prior study utilizing this specific sample, adolescents received high and equivalent treatment initiation, engagement, and retention rates (Godley, Hedges, & Hunter, 2011). High quality implementation could have led treatment sites to engage family members early in the treatment process, which is a standard part of the A-

CRA process. The early higher levels of social support could have decreased as the adolescents in the sample improved in their outcomes, which may have influenced caregivers to reduce their support as it may not have been needed as much when the adolescents were improving during the course of treatment.

Additionally, the influence of social support on each of the predictive pathways of the parallel process model was minimal. The slight increase of the negative estimate for each of the regression paths indicates that the inclusion of social support slightly increases the rate of reduction of substance use and mental health problems over time. The lack of significant associations between social support and the repeated substance use measures could be the result of reduced variance to account for among the substance use variables. Another reason may have been the weak correlations between the social support and substance use variables (r's range of 0.02 – 0.06). Importantly, although this dataset contained another variable for social support, the General Social Support Index, it was not considered for analysis due to high levels of missing data. While this study may have been constrained by the current social support variable, in that it did not specifically allow the study to determine specific types of social support (instrumental, emotional, or informational), longitudinal investigations of social support remain an important area of investigation for treatments involving adolescents with co-occurring disorders.

Conclusion and Clinical Recommendations

This study appears to be the first to identify a reciprocal parallel process relationship between mental health and substance use disorders within a diverse adolescent substance use treatment sample. While it is important to demonstrate the reciprocal parallel process model for the overall sample, it is also clinically useful to identify the strength and direction of this

reciprocal relationship for each of the co-morbid groups through multiple group analysis. The latter can help determine whether different treatment considerations should be made depending on the identified co-morbid group. The multigroup analysis revealed that this reciprocal parallel process relationship was only significant in the combined co-morbid group. This group accounted for 1/3 of the treatment sample and presented with higher clinical acuity at baseline. Contrary to expectations, social support did not adequately account for additional variance or have a substantial impact on the predicted pathways of the reciprocal parallel process model. After accounting for all covariates in the final model, the reciprocal parallel process remained significant and thus strengthened the conclusion that this relationship was not an artifact of the presence of other associated covariates.

According to the 2019 National Survey on Drug Use and Health (NSDUH), of the 397,000 adolescents ages 12-17 who had CODs in the past year, 33 percent did not receive treatment for both disorders (SAMHSA, 2020). The significant reciprocal relationship of the parallel process model highlights the importance of not assuming that the treatment of one disorder should be prioritized over the other. Furthermore, there is the associated need for an integrated approach to intervention that begins with adequate screening and assessment of co-occurring problems (Morojele, Saban, & Seedat, 2012; Mueser & Gingerich, 2013). Although best practice recommendations have been made for screening and assessment of CODs (SAMHSA, 2020), a report on available treatment access for adolescents revealed that comprehensive screenings and assessments were not readily used in psychiatric or primary care settings (Sterling et al., 2010).

During the screening process for co-occurring disorders, it is a fairly common practice for clinicians to use separate screeners for substance use disorders (ie., AUDIT,

CAGE, MAST; SAMHSA, 2020) and separate screeners for mental health disorders (ie., PHQ9, GAD7; SAMHSA, 2020). At the clinic or agency level, barriers such as time constraints, level of training, adherence to standard practice guidelines, and familiarity with different screeners can determine when and how clinicians screen for their co-occurring problems (Dennis & Davis, 2021). In order to reduce the burden of having to use many screeners to detect the presence of co-occurring disorders, there are effective integrated screeners such as the ASSIST (Hides et al., 2009), the Psychiatric Diagnosis Screening Questionnaire (Zimmerman & Mattia, 2001), and the GAIN Short Screener (Dennis, Chan, & Funk, 2006), that can simplify the screening for CODs. While many screeners can take as little at 10-20 minutes, some full-length screeners can take an hour or more to conduct. Since there are already time constraints placed on clinicians, efforts are already underway to make COD screeners even shorter, while still being effective and accurate.

A recent study by Dennis and Davis (2021) attempted to address this situation by creating a shorter co-occurring problem screener (GAIN-Q3) from a larger screening instrument (the GAIN-I). The new GAIN-Q3 only takes 10-15 minutes to complete. The authors of this study tested the ability of the GAIN-Q3 to screen for multiple co-occurring problems for nine clinical problems. They were able to demonstrate that the GAIN-Q3 had good convergent and discriminant validity relative to the full-length scales, as well as other scales assessed in the GAIN-I (Dennis & Davis, 2021). Although this is one commendable instance of creating valid shorter screening instruments, it is possible that The Mental Health Parity and Addiction Equity Act and the Affordable Care Act will mandate increased availability for appropriate screening, assessment, and treatment for co-occurring disorders and their associated problems (Mental Health Parity & Addiction Equity Act, 2008; Patient

Protection & Affordable Care Act, 2010). The combined co-morbid group in the current study uniquely demonstrated the reciprocal parallel process of mental health problems and substance use problems. This same group was identified by Godley et al. (2014) as demonstrating the largest reductions in mental health and substance use problems while receiving A-CRA treatment compared to the other co-morbid groups. Despite these considerable reductions in co-occurring problems, adolescents from this combined group still reported higher elevated problems at the 6-month follow-up timepoint compared to the other co-morbid groups. Welsh et al. (2011) used a similar sample of A-CRA implementation adolescents in their study and found similar declines in mental health and substance use problems for a defined group of adolescents who had an Opioid Use Disorder plus a combined externalizing and externalizing disorder. This "combined" group is similar in terms of elevated substance use and mental health problems at baseline and reductions in problems during treatment. By the end of treatment this "combined" group still had elevated mental health and substance use problems compared to another co-morbid group (Marijuana and Alcohol defined group) at the 12-month follow-up.

Although these are somewhat promising findings for providers as far as treating individuals with CODs, the field requires considerably more attention to the refinement of treatments. Furthermore, it is important to consider that the adolescent sample used in this study (and in Godley et al., 2014) was part of a rigorous implementation study that utilized A-CRA with fidelity-extensive training and supervision for participating clinicians. For clinicians/agencies who often treat adolescents from this specific combined group, it is imperative that sufficient training time and resources be devoted so that clinicians can become competent to deliver A-CRA or a comparable EST (Campos-Melady et al., 2017).

The field of implementation science can provide informed practices to implement and sustain ESTs in real world settings, such as through training and consultation (Liddle et al., 2006), or funding or financial incentivization for EST adoption (Jaramillo et al. 2019; Scudder et al., 2017).

Huang et al. (2017) studied the comprehensive assessment of A-CRA sustainment for professionals utilizing this treatment by developing an A-CRA sustainment measure to capture provider-level and organizational-level sustainment factors. Of the 10 identified treatment core elements in the measure, their factor analysis results revealed two composite assessments of A-CRA sustainment. The first composite domain measured treatment staffing and delivery elements, while the second domain measured clinical supervision elements. Their findings corroborated the importance of providing good quality clinical supervision to ensure the proper implementation of ESTs like A-CRA (Martino, 2010; Miller et al., 2004; Schoenwald, Shiedow, & Chapman, 2009).

Strengths, Limitations, & Future Studies

There are inherent limitations of any secondary data analysis study. Since the author of this study did not have control over what was contained in the data set, this can limit the analysis of certain variables. For example, although the current dataset had another measure of social support, there was too much missing data across the timepoints to allow its inclusion in current analyses. Imputation techniques could have been utilized for missing values, and yet those techniques were beyond the scope of this project. Also, given that the social support variable in the current study did not include any detail about the type of social support received (i.e., instrumental or emotional), the interpretation of these findings is somewhat limited.

Another limitation of secondary data sets is the number of available follow-up timepoints and the length of time between measurements. While the current study was able to demonstrate a significant reciprocal parallel process model, the lack of shorter timepoints between measurements would have allowed the researcher to possibly identify a more specific time period that more strongly demonstrates this reciprocal parallel process.

General limitations of the current study also include a reduced ability to generalize findings from this study to other adolescent treatment populations using a different EST other than A-CRA as the current study did not include a control or comparison treatment group using another EST. While this study had the benefit of using data from the GAIN-I measurement instrument that demonstrated good test/re-test reliability as well as being able to reliably approximate DSM-IV diagnoses (Dennis, Chan, & Funk, 2006; Dennis, Feeney, & Stevens, 2006), there was no opportunity to corroborate the GAIN with DSM-IV diagnostic interviews for each of the disorders. In a related fashion but concerning mental health and substance use problems, most of the data were collected by self-report from participants and there were no collateral reports from parents/caregivers/family members to corroborate the extent of the substance use and mental health problems at each timepoint.

The limitations lend some insight into suggestions for future studies. While most adolescent studies exclusively assess self-reported race/ethnicity at baseline and thereby treat it as a static factor in analyses, research has demonstrated that racial/ethnic identities *shift* over time (Saperstein, 2012, 2013). This shifting of identities may be particularly relevant for research involving adolescent populations, as they are still undergoing physical and psychological development. Saperstein (2012) suggests that researchers utilize multiple currently available measures of racial/ethnic identity to capture a more accurate

representation of racial/ethnic identify complexity. To inform this approach, Roth (2016) has outlined the types of measures researchers may use to capture the multiple dimensions of race/ethnicity and the outcomes for which each measure may be appropriate.

The covariates studied were not exhaustive, and it is possible that other covariates may play an important role in predicting change over time in both processes, or by moderating the effects of the current baseline predictors. Future studies could look at other potential moderators in this reciprocal parallel process relationship, such as impulsivity and emotion dysregulation (Felton et al., 2020), given that the adolescents in the combined co-morbid group continued to display elevated emotional problems at the end of the follow-up period. Other moderators could include a focus on traumatic distress/PTSD, as it is represented in adolescents with co-occurring disorders at rates of 14-39% (Chan et al., 2008). Adolescents who enter substance use treatment with a history of trauma exposure present with elevated problem severity, which is also more likely if they have a combined presentation of substance use disorder + internalizing & externalizing disorders (combined; Grella et al., 2001; Shane, Jasiukaitis, & Green, 2003).

One major strength of this study is the use of a large representative diverse racial/ethnic adolescent treatment sample. The large sample size proved adequate to examine a significant reciprocal parallel process model and conduct multigroup analyses to tease out the directional strength of this relationship within co-morbid groups. The study size and refined co-morbid status variable made it possible to investigate prospective relationships within a high severity combined co-morbid group, well beyond the co-morbid groups in other studies that tended to focus on co-morbid internalizing or co-morbid externalizing groups. The benefit and continued availability of this diverse adolescent dataset to researchers

supports the need to continue adolescent health disparity research. Additionally, the strength of conducting this type of secondary data analysis with a very hard to reach population means that additional time, energy, and resources do not have to be devoted to another phase of research.

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