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MARKERS OF ALCOHOL USE DISORDER OUTPATIENT TREATMENT
OUTCOME: PREDICTION MODELING OF DAY ONE TREATMENT

A Dissertation Presented

by

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ABSTRACT

Background: Alcohol use disorders (AUD) affect health and wellbeing, and have broad societal costs (Bouchery, Harwood, Sacks, Simon, & Brewer, 2011; Rehm et al., 2009; Sudhinaraset, Wigglesworth, Takeuchi, & Tsuker, 2016). While treatments have existed for decades, they are limited in success and expensive to administer. As such, understanding which factors best predict who will benefit most from treatment remains a laudable goal. Prior attempts to predict factors associated with positive treatment outcome are limited by methodology including statistical methods that lead to poor predictive power in new samples. This study aims to use a data-driven approach to clarify the predictors of AUD treatment success (Objective 1) accompanied by a theory-driven analysis assessing the mediation of treatment outcomes through psychological distress (Objective 2). **Methods:** One hundred forty-five patients seeking treatment for alcohol use problems at the Day One Intensive Outpatient Treatment Program (part of UVM Medical Center) between June 2011 and June 2012 were examined. Variables were extracted through chart review and were categorized using the Bronfenbrenner Ecological Model. First, 20% of the sample was set-aside for model testing, and the remaining 80% was used in an Elastic Net Regularized linear regression, with 10-fold cross validation. Models were tested on the set-aside sample to yield estimates of out-of-sample prediction and repeated models were compared to ensure generalizability. Next, a theoretical model was tested examining a model of psychological distress mediating the relationship between individual predictors and treatment outcome. **Results:** The models developed from the Elastic Net Regularization approach demonstrated consistency in model strength (mean=0.32, standard deviation=0.03) with models ranging from 14 to 31 included variables. Across the models, 15 variables occurred in >75% of the models, and an additional 7 variables were included in 25% - 75% of the models. Some of the strongest predictors included treatment non-compliance ($\beta=-0.92$), ASI Alcohol Composite ($\beta=0.63$), treatment dosage ($\beta=-0.36$), and readiness to change ($\beta=-0.95$). The results of the theory-driven mediation analysis demonstrated several strong direct predictors of outcome frequency of alcohol use, including readiness to change ($\beta=-0.59$), initial frequency of alcohol use ($\beta=0.27$), and access to a primary care physician ($\beta=-2.20$). The theoretical model found that none of the mediation pathways (testing psychological variables) were significantly different from the direct models. **Conclusions:** This study used both data-driven and theory-driven methods to examine factors affecting treatment of AUDs. The application of data-driven methods provided several predictors of outcome that can guide treatment efforts within Day One IOP treatment, as well as generalized to other abstinence-based treatment settings. For example, focusing on treatment attendance and using motivational interviewing to enhance readiness to change are methods supported by this study. Demographic variables that have been shown to predict treatment outcome in small studies, without cross-validation were not identified by the elastic net regression (e.g., age and gender). It is suspected that this is due to model overfitting in prior studies supporting the importance of using generalizable statistical methods to understand predictors of treatment outcome. This notion is supported by the results of the theory-driven model, which did not yield a strong model of treatment success. Taken together, the results support the use of strong analytic techniques which will guide theory in the future.

DEDICATION

To my loving and supportive husband, friends and scholarly community, without whom I would never have been able to persist through struggle.

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Introduction, Research Questions, and Hypotheses

With approximately 15.7 million people diagnosed with an Alcohol Use Disorder (AUD) in the United States alone, the development of effective treatments has remained an issue of national importance. The financial costs of AUDs have included health related expenses, with severe patterns of alcohol use worsening other chronic health conditions (Rehm et al., 2009), as well as added stress on finances, interpersonal relationships, housing and educational/career progression. Additionally, there have been numerous societal costs due to loss of productivity, increased demand on the criminal justice system, and intentional/accidental damage to persons or property associated with AUDs (Bouchery et al., 2011; Sudhinaraset et al., 2016). These costs have driven research aimed at understanding AUD treatment, including reduction of the severity of current alcohol use and ultimately long-term remission from use.

Many treatments exist, and although research has indicated a significant reduction in use following an array of treatments, relapse has remained a central problem affecting between 40% and 60% of treatment completers. Recurrence of use has varied widely with a range of factors across psychological and sociological domains being shown to influence the success and failure of treatment. Adamson, Sellman, and Frampton (2009) have found factors that consistently predict treatment outcomes, including demographic (gender, employment, SES), substance-use (motivation to change and severity of use), and psychological (rating of anxiety, rating of depression, and overall psychiatric severity) variables. In addition, literature examining the impact of an individual's social context on treatment outcome has supported several additional predictors, including

general family social support, general friend social support, and changes in specific social support for alcohol use (Best & Lubman, 2017; McCutcheon et al., 2013).

Despite these advancements in predicting an individual's likelihood of successful treatment, notable limitations have remained in the consistency and generalizability of predictors. The inconsistencies in predictive variables found in Adamson et al.'s (2009) meta-analysis suggest that past analytical methods have relied too heavily on the relationship between variables within a single study sample (overfitting). The problem of representativeness is impacted by frequent utilization of "clean samples" of patients (i.e. alcoholics without comorbid psychiatric disorders) and "ivory tower" treatment protocols (i.e., highly regulated and reimbursed) that have limited predictive utility within the setting of community-based treatment. Even within studies that have utilized a community sample, research generally has focused on a single treatment approach, such as Alcoholics Anonymous, that fails to reflect the multi-modal approach available in most community based treatment programs (Blonigen, Timko, Finney, Moos, & Moos, 2011; Blonigen, Timko, & Moos, 2013). A final limitation of the current research has been a sparsity of clinically meaningful models of the process of recovery. There has been clear support from the literature for an impact of multiple forms of psychological distress (e.g., anxiety, impulsivity, and personality features) on treatment engagement and completion (Burns, Teesson, & Neill, 2005; Glass, Williams, & Bucholz, 2014; Grant, Goldstein, Saha, Chou, Jung, Zhang, Pickering, Ruan, Smith, Huang, Hasin, et al., 2015). As such, examining theoretically derived predictors within a community sample may help

to identify and understand the role of mental health in the process of recovery for patients in community-based treatment.

The proposed study aims to utilize an alternative analytic method (the Elastic Net Regularization approach) to accurately identify predictors of treatment success in a sample of clients who have sought treatment for alcohol use disorders at an outpatient treatment clinic. The Day One clinic, associated with the University of Vermont Medical Center, has utilized an integrated, intensive outpatient treatment model providing evidence-based interventions for both alcohol use and other highly co-occurring disorders. Further, we aimed to examine the concordance of a theoretically-driven model that supported the prediction of treatment effectiveness among individuals seeking treatment for abnormal alcohol use.

Objective 1: This study has employed a data-driven methodology to examine the predictors of AUD treatment outcome within a community sample representative of outpatient treatment facilities within Vermont. Demographic, substance-use, sociological, and psychological variables have been used to identify significant predictors of reductions in the frequency of alcohol use. The Elastic Net Regularization approach in combination with cross-validation acts to prevent model overfitting by estimating the accuracy of ‘significant’ variables and strength of generalizability to other treatment samples.

Objective 2: Based on the strong relationships between psychological distress and treatment outcome seen in the literature, we have additionally tested a theoretical model of successful treatment. (Figure 2). We expect this theory-driven analysis to demonstrate

psychological distress as a mediator of the relationship between treatment outcome and baseline characteristics of the individual, microsystem, mesosystem, and macrosystem.

Literature Review

Our societal conceptualization of alcohol use disorders (AUDs) has shifted from a view that alcohol problems reflect a person's character (e.g. "moral failure"); to a medical model of a disease process (Stolberg 2006). These beliefs have been reflected in treatment approaches. For example, beliefs based on moral failure led to treatments that segregated patients from society (e.g., inebriate asylums typically employed pre-1800s), while a belief in the biological underpinnings of addiction led to the public's susceptibility to 'sham' cures (e.g., the infamous Keely Cure in the late 1890s). Keeley's cure consisted of injections of bichloride of gold, and he claimed that drunkenness "is a disease and I can cure it" (p. 68; Tracy, 2005), "unless [patients re-created] it by returning to their use, thus re-poisoning [their] nerve cells," (Hanson, 2011). Current treatments have reflected a belief that alcoholism remains a chronic illness which can be treated with a combination of lifestyle changes and medical treatments. Though attempts to segregate patients in recovery away from society still occur (i.e. long-term hospitalization), the integration of treatment into the community has become the norm, including short-term residential alcohol treatment facilities and the integration of screening/treatment into the primary medical care setting (Rehm et al 2016). However, treatments have remained less than fully effective, with broad estimates of success being only 40-60% of clients (NIDA, 2012). This lack of success has led to AUD treatment research focused on identifying sub-groups of problem drinkers (i.e. females, adolescents, the elderly, and those with certain comorbid illnesses) who have benefitted from tailored treatment.

For example, Project Matching Alcoholism Treatment to Client Heterogeneity [MATCH], attempted to identify individual characteristics that predict treatment success (Arch, 1998). The Project MATCH collaborative study group collected information across ten client characteristics shown to impact alcohol use. These included: severity of alcohol involvement, cognitive impairment, client conceptual level, gender, meaning seeking, motivational readiness to change, psychiatric severity, social support for drinking and/or abstinence, sociopathy, and pattern of alcohol use. However, this landmark study found that the randomization of characteristics of clients to treatment type did not significantly improve treatment outcome (Longabaugh & Wirtz, 2001). A provocative meta-analysis examined 55 trials for patient characteristics related to treatment success. They found the number of statistical tests for interactions was the only significant predictor of the number of significant associations found in a study (Moyer, Finney, Elworth, & Kraemer, 2001). This was consistent with the observation of Whelan and Garavan (2014), that model overfitting has greatly limited the predictive utility of much of the current literature. Thus, despite years of research aimed to improve outcomes, the effectiveness of AUD treatment has not improved.

The AUD treatment literature has remained full of studies containing methodological flaws that inherently limit generalizability. For example, Sugarman and colleagues (2013) used a path analysis to assess the predictors of change in use (mean number of drinks per day) within a sample of 99 individuals. They initially hypothesized a mediational model, with marital status, gender, drinking severity, educational level, depression, and history of sexual abuse working through self-efficacy and social support

to predict changes in use. Though the hypothesized model was shown not to be significant, the researchers included an additional path through education level that ultimately improved the model fit. This post-hoc model adjustment would exemplify the issue of over-fitting a statistical model within a single study sample. Hypothesis pre-registration has been suggested as one step that can be taken to reduce Type I (false positive) errors in clinical trials (Kaplan & Irvin, 2015). Kaplan and Irvin (2015) reported that following the requirement of hypothesis pre-registration, positive findings in studies of treatment for heart disease fell from 57% to 8%. In addition, challenges to replication and generalizability has led to the development of analytic techniques to improve the rigor of predictive modeling, including bootstrapping, permutation, and cross-validation. Each of these techniques have included explicit tests of generalizability by either resampling the data or testing the model on a set-aside portion of the original data.

The current study has used a data-driven approach to identify variables that affect the success of outpatient treatment for Alcohol Use Disorders (AUDs). Treatment outcomes from one year of patients seen at the University of Vermont's Day One clinic – an outpatient clinic for the integrated treatment of substance use and comorbid psychiatric problems – were examined such that factors predicting treatment outcomes were identified. In addition to this bottom-up model derivation, we have tested a (pre-specified) theoretically-driven predictive model which examined the influence of psychological distress on treatment outcomes.

Prior to examining the trajectories of patients through treatment, several areas of background literature need to be examined. First, to better understand psychological

disorders, such as AUDs, this paper presents a review of relevant frameworks and discusses the selected model which supports heterogeneity within etiology, a hallmark of AUDs. Second, this framework was used to review factors that influence the initiation of unhealthy alcohol use. Third, the literature on factors impacting treatment outcomes was reviewed. Finally, this paper has applied this theoretical model, hypothesizing the relationship between psychological distress and treatment outcome, keeping in mind the context of several barriers to generalization (e.g., single treatment and single cohort).

Frameworks within psychology

Recognition of the complexity of factors contributing to unhealthy alcohol use has led to broad theoretical frameworks such as the bio-psycho-social model (Engel, 1980). The bio-psycho-social model has assumed three basic principles in the process of having integrated multiple levels of information about behavior. These three principles were: 1) abnormal behavior was complex, 2) one theoretical model would be insufficient, and 3) integration of information was necessary (Griffiths, 2005). Though various fields of research have had greater and lesser success incorporating multiple levels of information, Griffiths (2005) suggested that within the field of AUD, “research and clinical interventions are best served by a biopsychosocial approach that incorporates the best strands of contemporary psychology, biology and sociology.” As such, there has been a call for research to begin uniting these fields in order to develop a working, integrated model of problematic alcohol use.

In the field of AUDs, a strong background literature has been developed within each discipline (biology, psychology and sociology). For example, research on the biological mechanisms of AUDs has provided insight into the heritability (Kreek, Nielsen, Butelman, & LaForge, 2005; Kreek, Nielsen, & LaForge, 2004; Pinto & Anseau, 2009; Verhulst, Neale, & Kendler, 2015) and neurobiological alterations that may have been specific to AUDs (Porjesz & Rangaswamy, 2007; Whelan et al., 2014). However, recognizable limits to integrating the biological, psychological and sociological factors related to AUDs have remained. These have included a simple lack of interdisciplinary efforts, wide variability in defining patterns of “abnormal” alcohol use, disagreement surrounding causality, and even inconsistency in the definition of successful treatment for AUDs.

Research on the initiation of alcohol use has long examined the psychological and sociological factors that contribute to the development of an AUD. Studies have examined factors within the individual that have contributed to alcohol use, including alcohol-related beliefs, motivations for use, and behaviors associated with use. Additionally, it has been acknowledged that the choices of an individual are commonly impacted by their immediate environment, social relationships (peers and family, particularly) and beliefs about alcohol use held by societal/cultural groups. As is common across psychological disorders, no single predictor has been associated with a ‘tipping point’ into the development of problematic use. Instead, individual components have been shown to increase the likelihood of patterns of use that eventually contribute to problematic use. However, to organize the delivery of each of the relevant constructs

Bronfenbrenner's ecological model was used as a framework (Figure 1). This paper has expanded on the work of Sudhinaraset, Wigglesworth, & Takeuchi (2016). This model breaks down factors that have influenced complex behavior as occurring at different levels. Relevant to alcohol use, this has included psychological processes (Individual level), the influence of the immediate environment and relationships (Microsystem level), the influence of community-level beliefs and practices (Mesosystem level), and the wider impacts of society (Macrosystem level).

Bronfenbrenner's ecological model was selected for examining factors contributing to abnormal alcohol use for several reasons. First, the degree of overlap with Engel's (1980) Bio-Psycho-Social model signified symmetry in understanding. Secondly, both models have suggested that the understanding of a complicated problem, such as initiation of abnormal alcohol use, involves examination at each level of the system. Finally, this model has allowed for multiple points of contact, or non-linear paths, between each level of the system. Thus, it has the capacity to accommodate the complex interactions within and between levels seen in the literature. This paper has addressed the ongoing need for research that initiates a conversation about how personal, interpersonal, community, and systems-level factors impact alcohol use as it relates directly to the treatment outcomes of individuals suffering with alcohol use disorders.

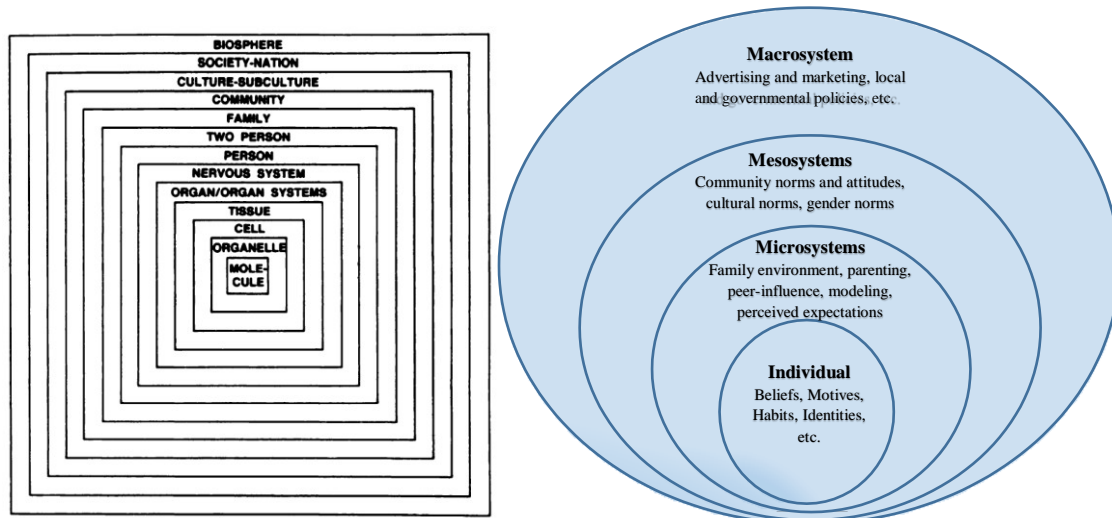


Figure 1: Engel's representation of the Bio-Psycho-Social Model (Engel, 1980) and Bronfenbrenner's ecological model (Hardcastle, Byrnes, Bartlett, Denton, & Walsh, 1981)

Epidemiology of Alcohol Use Disorders: Overview

According to the 2015 National Survey on Drug Use and Health (NSDUH; Center for Behavioral Health Statistics and Quality, 2016) there were 138.3 million current (past 30 day) alcohol users (representing 51.7% of the population) in the United States. Of these, 48.2% reported binge-use (4+ or 5+ drinks on one occasion for females and males, respectively) that became ongoing high levels of use in 17.3 million individuals. The high occurrence of use and tendency towards problematic patterns of use has led to 15.7 million individuals diagnosed with an AUD in the past year (Center for Behavioral Health Statistics and Quality, 2016).

From this data, many trajectories of drinking behavior have become apparent. This has included time-limited periods of alcohol use (e.g., adolescent experimentation and young adult binge-use), maintained limited use, and uncontrolled use commonly associated with AUDs (Chassin & Sher, 2013; Sher, Grekin, & Williams, 2005). Among

those with an AUD, a range of predictors (social, psychological, and biological) have contributed to both the initiation of problematic use and the remission of an AUD. Below, we have reviewed the literature for factors associated with developing an AUD, and then the limited research on factors that have influenced the likelihood of engaging in and completing treatment. Prior to this review, the definition of several key terms relevant to this literature have been presented.

Definition of Terms:

The substance use field has used many terms to describe patterns of alcohol use (e.g., abnormal use, concerning use, problematic use, binge drinking, alcohol abuse, alcohol dependence, and alcohol use disorder). Each of these terms has represented significant differences in the description of an individual's pattern of alcohol use; however, the plethora of terms continues to limit the ability to communicate effectively to a wider audience. As this paper has focused on individuals seeking treatment for a wide range of patterns of ongoing alcohol use, we have selected to utilize the term "unhealthy" alcohol use' to encompass abnormal/concerning/problematic use, binge drinking, and alcohol abuse/dependence/disorder (see Table 1 within Saitz, 2005).

Similarly, several terms have been used to express changes in alcohol use (e.g., remission, partial abstinence, full abstinence, lapse, relapse, and controlled drinking). Again, these terms have been used to describe separate trajectories as individuals attempt to reduce or eliminate alcohol use. In addition, they inherently integrate criteria required for a diagnosis of alcoholism. This includes the amount of use, frequency of use, impact

on functioning (e.g., social, work, etc.), and recovery goals (e.g., abstinence, harm-reduction, etc.). This paper has selected ‘recovery from use’ to incorporate reductions in alcohol use, moderated use, abstinence, engagement in services, and improvement in overall functioning. These terms have been employed generally unless a need for greater specificity was clearly identified.

Because a wide variety of “yardsticks of success” have been used in the assessment of treatment for alcohol use (Sobell, Sobell, Connors, & Agrawal, 2003), we have critically examined how the field defines and measures successful treatment. Sobell, Sobell, Connors, & Agrawal (2003) summarized that capturing abstinence and improvement over time in “acute alcohol-related problems” were of utmost importance. Anton & Randall (2005) also acknowledged the merit of, “...outcome measures [which] reflect both abstinence and some evaluation of relapse to heavy daily drinking.” Despite recommendations from the National Institute on Alcohol Abuse and Alcoholism (NIAAA) to use the percentage of heavy drinking days, researchers have made their own arguments for a variety of other outcome variables (Allen, 2003). For example, Anton and Randall (2005) assessed percentage of days abstinent and time to first heavy drinking day, Stevens and colleagues (2014) used engagement in treatment and level of use, and Newton-Howes, Foulds, Guy, Boden, & Mulder (2017) employed several metrics, including time to relapse, drinks per drinking day (DDD), percentage of days drinking (PDD) and percentage of days with heavy drinking (PHDD). Despite recommendations for outcome variables like PHDD (Allen, 2003), an official consensus has not yet been achieved.

The methods of measuring drinking behavior have continued to evolve, which has contributed to indecision in variable selection. Sobell and colleagues (2003) noted a dramatic increase in reliability following a shift from self-reported retrospective estimates of alcohol use (e.g., Quantity-Frequency and Lifetime drinking methods) to validated self-report measures and/or structured interviews. Newer methods that have assessed both the amount and frequency of alcohol use include concurrent recall (CR) and daily drinking estimation (DDE). The CR protocol collected alcohol use information during or shortly after use, which would result in more accurate reporting than DDE measures of use over the recent past (Time-Line Follow-Back [TLFB] and Form 90). Both methods have provided an accurate depiction of use, which allowed researchers to operationalize outcome variables.

In recognition of the complexity of treatment outcomes, researchers such as Cisler & Zweben (1999) have developed composite measures which incorporated continuous variables (e.g., frequency and amount of use) with measures of function (problems associated with unhealthy alcohol use). Zweben and Cisler's (2003) brief assessment via the 8-item, Form 90-Quick (Miller, 1996) and the 15-item, Short Index of Problems (Miller, Tonigan, & Longabaugh, 1995) have resulted in the successful categorization of patterns of unhealthy alcohol use (abstinent, moderate use with problems, heavy use or problems, and heavy use with problems). This approach has been useful in grouping individuals following the completion of treatment associated with remission (abstinence or non-problematic moderate drinking) status (30% that remitted, 36% non-remitted, and 34% unstably remitted), and noting the joint impact of alcohol use and alcohol-related

problems (Zweben & Cisler, 2003). Categorical outcome variables have been problematic because: 1) functioning challenges included in the measure likely confound the influence of psycho-social problems on alcohol use behaviors and 2) they provided no better differentiation on the trajectories of recovery following treatment (i.e. 70% with unstable or non-remitted status). Therefore, a metric of success reflecting alcohol consumption, such as the quantity and/or frequency of use, has remained a preferred way to evaluate treatment outcomes.

Thus, the primary outcome variable selected for this study was the frequency of alcohol use when treatment was terminated (number of drinks/month during the month prior to discharge). Though the data was not collected using a standardized measure (e.g., concurrent recall or timeline follow-back), a standardized assessment was conducted by a trained clinician in alignment with Vermont requirements for reporting patient outcomes (i.e., description of use of alcohol within the past month). It is notable that several alternative outcome variables have been collected within this dataset (including metrics of treatment engagement, overall functioning at outcome, etc.). We believe, however, that this co-assessment by client and clinician of the frequency of use (e.g., None, 1-3/month, 1-2/week, 3-6/week, and daily use) represented the most reliable indicator of treatment outcome which has remained consistent with metrics utilized within past literature.

Psychological and sociological predictors of the initiation of alcohol use and abuse

INDIVIDUAL

The first level of the Bronfenbrenner model focuses on individual characteristics related to (in this case) patterns of unhealthy alcohol use. This section has reviewed several factors that contribute to the development of these patterns of use. These factors have spanned across the internal sensations associated with alcohol use, the cognitions regularly used to reinforce use, the emotional states (temporary and ongoing) that become paired with use behaviors, and the demographic variables which have gently reinforced use. The ultimate goal of this section was to develop a sense of the internal world for individuals engaging in alcohol use.

From the moment alcohol has been ingested it begins to influence the individual with both stimulating and depressant effects that depend both on the dose of alcohol consumed and the length of time since consumption (Brabant, Guarnieri, & Quertemont, 2014). Individuals with greater sensitivity to the stimulating effects and reduced sensitivity to the sedating effects of alcohol have been shown to be at risk for unhealthy alcohol use (King, McNamara, Hasin, & Cao, 2014). This concept has consistency with the first portion of the Hedonic Hypothesis which suggested that the pleasurable effects of alcohol initially motivate use. This influence has the ability to change with time, however, and eventually becomes replaced by a need to relieve/prevent the experience of withdrawal, particularly the experience of negative affect (Cheetham, Allen, Yücel, & Lubman, 2010; Robinson & Berridge, 2003; Sher et al., 2005).

Baker and colleagues (2004) suggested that early withdrawal symptoms bias information processing, via subconscious processing of the environment, towards alcohol and drug-related stimuli. Use becomes facilitated by these stimuli as a result of an

increased likelihood of drinking in response to early withdrawal, ultimately leading to negative reinforcement (Breese, Sinha, & Heilig, 2011; Fox, Bergquist, Hong, & Sinha, 2007; Ryan, 2002). The influence on attentional biases have also been shown to be moderated by an individual's emotional experiences separate from occasions of use. Increased negative affect and difficulty regulating affective states both contribute to internalizing symptoms. Further, internalizing symptoms have been associated with an increased likelihood of unhealthy alcohol use (Pandina, Johnson, & Labouvie, 1992). As such, both the experience of and immediate response to negative affect (either subconscious enhancement of drinking-related cues or conscious activation of beliefs related to use) have been identified as key contributors to unhealthy alcohol use.

Motivations for drinking have also helped in understanding the pathways to unhealthy drinking (Cox & Klinger, 1988). The currently accepted model identified four motivations for drinking that are cross-validated on an international stage, including alcohol use for enhancement (drinking to enhance mood), coping (drinking to suppress withdrawal symptoms), social (drinking as a social lubricant), and conformity (drinking to fit social expectations) motivations (Kuntsche, Stewart, & Cooper, 2008). The first two motivations can be fitted within Bronfenbrenner's individual level; social and conformity motivations have been considered in the discussion of the microsystem level of the model.

Both enhancement and coping have been shown to be predictive of the, "number of drinking occasions and the frequency of drunkenness in the last 30 days" (Kuntsche & Kuntsche, 2009). Unlike those who have drunk to address/relieve negative affect (coping

motives), those with enhancement motives hold a connection between alcohol use and rewards, often including positive emotional states. Beliefs associated with enhancement motivation (i.e., “drinking makes me happy”) have predicted greater positive outcomes associated with alcohol use. In addition, individuals who have tended towards impulsivity during positive affective states (a trait known as positive urgency) have increased frequency of alcohol use and problematic use (Coskunpinar, Dir, & Cyders, 2013; Cyders et al., 2007; Cyders & Smith, 2008). Additionally, impulsive action during negative emotions (negative urgency) has been associated with both unhealthy and disordered alcohol use, consistent with coping motivations (Coskunpinar et al., 2013). Further, results within a college sample suggested that both enhancement and coping motivations interact with the traits of positive and negative urgency in the association with unhealthy alcohol use (M. A. Cyders et al., 2007). In other words, as unhealthy alcohol use was developing, drinking supported a cycle enhancing desired emotional states (positive reinforcement via enhancement motives) while diminishing undesirable ones (negative reinforcement via coping motives). Interestingly, these pathways have been empirically examined in great depth and thus we will consider the evidence independently.

The trajectory for developing enhancement motivations for alcohol use begins with the initial experiences of use and are influenced as use continues. Using a longitudinal approach, Warner, White, & Johnson (2007) examined trajectories of use across five time points from age 12 to 31. They found that those who endorsed unhealthy alcohol use had higher frequency of experiencing drunkenness (subjective experience of being “high or drunk”) during their first use of alcohol, though there was no difference

between the groups in reporting a positive first use experience. This suggests that despite meeting an expectation of the first use being rewarding, individual outcomes of first use (drunkenness) predicted future problematic use. Whether these differences in drunkenness relate to the amount consumed during first use and/or expectations for how drinking would make them feel (i.e., intoxicated, dizzy, high, etc.) remains uncertain. However, other studies have shown that subjective reports of heightened stimulating effects of alcohol predict greater AUD symptomology (King et al., 2014). Jester and colleagues (2015), found both the first occasion of drunkenness and binge use were longitudinally predicted by parental alcoholism and enhancement expectancies of use (neither cognitive improvement nor coping expectancies were predictive). In addition, they found that growth in one's enhancement expectancy was best modeled by the combination of fixed effects (parental alcoholism, age, and gender) and random effects of age at onset of use and time since onset. Therefore, the modification or growth of enhancement motives has signified the conjoint influence of known 'risk factors' and indicated a divergent, and potentially unhealthy, group of alcohol users.

Changes in the way alcohol has been used to regulate emotional states, and/or to cope with withdrawal symptoms (coping motives) has represented another possible risk factor for unhealthy alcohol use development. Drinking to avoid these states has been traditionally known as the self-medication model (Bandura, 1969; Colder, 2001; Greeley & Oei, 1999). In testing this model, Colder (2001) confirmed that an emotion induction, viewing aversive images, led to an exacerbation of respiratory sinus arrhythmia (RSA). As RSA has been associated with self-regulation during emotional situations, it was not

surprising that the change in RSA had a modest direct impact on alcohol use for coping reasons. Most interestingly, Colder (2001) identified significant indirect effects such that stress led to drinking to cope only for individuals that experienced high reactivity to the emotion induction, as measured by skin conductance. Studying a parallel process, Heilig and colleagues (2010) examined negative affect occurring within alcohol withdrawal and relapse. They reported that shifts in emotional processing following alcohol use greatly impacts relapse potential, particularly enhanced reactivity to stressors. In both models, drinking related to a coping motivation was greater in those with higher emotional reactivity. Thus, it would be reasonable to conclude that for some individuals a conscious or sub-conscious activation of a “drinking to cope” belief would mediate drinking behavior during disruptive emotional experiences.

Given the evidence for patterns of drinking being related to emotional regulation, it would follow that comorbid psychiatric diagnoses frequently co-occur in individuals with unhealthy alcohol use. Mounting evidence has suggested a relationship with both internalizing (i.e. mood and anxiety) disorders (Bell & Britton, 2014; Brière, Rohde, Seeley, Klein, & Lewinsohn, 2014; Holahan, Moos, Holahan, Cronkite, & Randall, 2001; Schneier et al., 2011; Zimmermann et al., 2003), and externalizing (i.e. conduct and disruptive behavior) disorders (Edwards, Gardner, Hickman, & Kendler, 2016; Farmer et al., 2016; King, Iacono, & McGue, 2004). Further, research has found broadly-defined, psychological distress (i.e., the experience of any form of emotional or behavioral disturbance [Hill & Angel, 2005]) and the interaction between externalizing and internalizing symptoms to be associated with increased alcohol use (Colder et al., 2017).

Indeed, latent class analyses have suggested that there are patterns of psychological symptoms/disorders that differentiate individuals with pathological alcohol use (Glass et al., 2014; Kessler, Chiu, Demler, & Walters, 2005; McCutcheon et al., 2013). For example, Glass and colleagues (2014) found four distinct classes within Alcohol Use Disorder (AUD): AUD alone, AUD + internalizing, AUD + externalizing, and AUD with both internalizing and externalizing disorders. A complicated dynamic has long existed in the development of unhealthy alcohol use, between an individual's internal/emotional experience (particularly increasing psychological distress) and the way that they have interpreted and responded to the events occurring around them (i.e., emotional regulation). In a similar way, demographic variables which have defined the individual have been seen to influence the initiation and trajectories of alcohol use.

Among the variety of factors that described an individual, the ones that have proved most influential in determining the likelihood of unhealthy alcohol use include sex/gender, race/ethnicity, and specific sub-components of socioeconomic status (SES; i.e., educational attainment). As of 2015, adult men in the U.S. were identified to have a prevalence of AUD nearly twice that of women, 9.8 and 5.3 million, respectively (NSDUH, 2016). Clear biological differences have existed between the sexes in the processing of alcohol (e.g., males able to consume greater quantities with fewer physical consequences), and this certainly has contributed to the increased likelihood of alcohol use problems among males (Grant, Goldstein, Saha, Chou, Jung, Zhang, Pickering, Ruan, Smith, Huang, & Hasin, 2015; Nolen-Hoeksema, 2004). In addition to metabolic differences between males and females, differences have been found in the rates of

associated psychological and behavioral patterns (including impulsive personality [Dick et al., 2010; Kaiser et al., 2016; Mitchell, 2011; Nolen-Hoeksema, 2004; Stautz & Cooper, 2013], impulse control disorders [Ernst et al., 2006; King et al., 2004; Sartor, Lynskey, Heath, Jacob, & True, 2007], and use of other substances [Grant et al., 2015; Hasin, Stinson, Ogburn, & Grant, 2007]).

While the gender gap has remained large, cohort studies have revealed the difference to be shrinking, with women's patterns of unhealthy use showing increases over time (Keyes, Li, & Hasin, 2011; Keyes & Grant, 2008). In their review of the literature, Keyes et al. (2011) identified several possible explanations for the changing gender gap. These have included changes in the economic and workplace setting following the 1970s, greater financial independence for females, and changes in gender norms and values surrounding alcohol use which has resulted in more permissiveness attitudes (Keyes et al., 2011). Lyons & Willott (2008) began a conversation to examine how women understood increases in drinking among females. Before discussing their findings, it should be recognized that many have suggested that the influence on drinking behaviors has more to do with gendered behaviors, e.g., aggression and dominance, rather than biological sex. In support of this notion, Visser & Smith (2007) found that among young men masculine identity has been uniquely associated with alcohol use patterns. Specifically, high levels of alcohol consumption (particularly beer drinking) was commonly associated with masculinity, which was equivalent to other forms of masculinized behaviors (i.e., sports performance, sexual competence, etc.). Further examinations of masculinity, by Clinkinbeard and Barnum (2017) found that the specific

gendered trait of Dominance Masculinity (e.g., being aggressive and forceful) was linked with more frequent binge drinking and negative consequences regardless of gender identity. Lyons & Willott (2008) similarly found that drinking among women required a fine balance between reinventing dominance masculinity while holding onto traditional feminine roles (e.g., drinking in groups, sending drunk women home, and maintaining the caregiver role). As such, Likis-werle and Borders' (2017) examination of a small sample of women found that high risk drinkers were more likely to hold values of being both a powerful woman and feminine.

Further, Clinkinbeard and Barnum (2017) found that holding gendered self-concepts that opposed the individual's gender identity (i.e., a man with traditionally feminine beliefs or female with non-dominant masculine beliefs) was protective against the consequences of alcohol use. The same protective effects were found among young men with beliefs associating masculinity to rationality, health, integrity, free thought, resisting social pressure, and religious beliefs (Visser & Smith, 2007). As such, the risk for having initiated alcohol use and developed problematic patterns of use may not only be impacted by explicit biological contributions but also by societal (or sub-group) beliefs regarding the use of alcohol to establish a dominant masculine identity. Therefore, while male gender has been associated with greater drinking problems, sociocultural influences likely contribute to the changing risk for unhealthy alcohol use regardless of gender identity.

Race and ethnicity have also been associated with differences in the initiation of alcohol use and patterns of early use. This could be related to biological differences

between racial groups, including differences in the functionality of enzymes that break down alcohol into its component parts, i.e. alcohol dehydrogenase (ADH) and aldehyde dehydrogenase (ALDH). The presence of the ADH1B*2, ADH1B*3 and ALDH2*2 genes have been indicated to be protective against the progression towards alcohol related problems, particularly within individuals of Asian and perhaps African descent (Crabb, Matsumoto, Chang, & You, 2004; Wall, Luczak, & Hiller-Sturmhofel, 2016). The rate of aldehyde production from alcohol (completed by ADH) and subsequent elimination rate of aldehyde (by ALDH) could impact the likelihood of developing use related problems; a pathway that can be strongly impacted by the ALDH deficiency seen in ALDH2*2 homozygotes. However, the relative protection provided by being heterozygous for ALDH2*2 has been suggested to also be impacted by sociocultural changes in alcohol use (Higuchi et al., 1994). Indeed, Wall and colleagues (2016) have reported multiple individual and community factors that have directly or indirectly impacted the protective effects of the ALDH2*2 & ADH1B*2 genotypes. These have included: ethnicity (primarily across Asian ethnic groups), behavioral control, childhood adversity, family environment, culture, and religion. Therefore, it has been suggested that the genotypic variation across racial groups as well as environmental differences contribute to the trajectory of alcohol use. Notably, acculturation into American society of individuals from both Asian (Wall et al., 2016) and Hispanic descent (Wahl & Eitle, 2010) has been associated with an increase in alcohol use, binge drinking, and alcohol related problems.

It has also been observed that the likelihood of past month and lifetime use of alcohol differs between racial/ethnic groups within the United States. Hispanic

adolescents were found to be more likely and Asian adolescents less likely to have drunk a full alcoholic beverage compared to Caucasian and African American adolescents while controlling for grade, sex and family structure (Shih et al., 2010). These patterns of use were determined to be moderated by differences in individual, family and peer influences, which would suggest that use can be impacted by a wider socio-cultural belief which was tied to racial/ethnic differences.

Finally, individuals are defined by their status within society which has been globally defined as SES; however, the sub-components of SES have clearly described variables at Bronfenbrenner's individual level. Variables that have been used to describe SES include occupational status, educational attainment, and income levels. Casswell et al. (2003) followed a group of New Zealand young adults from 18 to 26 years and found that the frequency of alcohol use was only significantly impacted by income levels (both occupation and education were non-significant), with higher income associated with more occasions of use. In contrast, Barr and colleagues (2016) recently validated a causal relationship between educational attainment and alcohol use frequency/intoxication within a cohort of Finnish twins (12-26 years old). The results found educational attainment moderated individual environmental factors such that those with increased education were less impacted by their individual environment (controlling for shared environment and genetic components). The authors further suggested these findings were likely conservative when considering samples in the United States (Barr et al., 2016). When considering an individual's quantity of use, educational attainment was the only sub-component found to be significant, with greater education predicting lower levels of

use (Caswell et al., 2003). Finally, when considering women in particular, unemployment and low SES were associated with more frequent use throughout young adulthood and greater amounts of use until age 26 at which point use sharply declined (Caswell et al., 2003). As can be surmised from these results, a need for clarity has remained in the determination of the effect of sub-components of SES on the initiation of use. Further, all of the above individual elements are likely to have been influenced by the situations, people and places (their microsystem) present throughout development.

MICROSYSTEMS

Looking beyond the internal experiences of the individual, Bronfenbrenner's second level – the microsystem – led to consideration of the impact an individual's immediate environment throughout development on alcohol use. Research has strongly supported the impact of an individual's family history of alcohol dependence on the development of use-related problems (Beseler, Aharonovich, Keyes, & Hasin, 2008; Warner et al., 2007). Indeed, family history has been shown to contribute to unhealthy alcohol use via biological (genetic and neurological) and psychological (modeling of norms and expectations for alcohol use) mechanisms (Beseler et al., 2008; Kuperman et al., 2013). Because of the limitations of the current dataset (lacking biological predictors), this paper has been focused on the influence the environment has on the individuals' psychological development. This narrowed lens more closely approximated the factors assessed within the Day One outpatient treatment setting.

Nash, McQueen, & Bray (2005) examined the longitudinal impact of a positive family environment (as measured by parental attention, monitoring and communication) on adolescent alcohol use. Families with a positive environment and strong parental disapproval for alcohol predicted less frequent teen alcohol use, as well as lower alcohol consumption and fewer alcohol related problems. In addition, in comparison to adolescents of parents with low or no disapproval, strongly disapproving families showed, “more positive family environments (acceptance, monitoring, and communication), greater self- efficacy for avoiding alcohol use, fewer peers and friends that drank alcohol, less approval for alcohol use among close friends, and less alcohol use and associated problems” (Nash et al., 2005). The work of Nash and colleagues (2005) suggested a supportive environment to be generally beneficial; explicitly expressed parental attitudes played an important role in reducing alcohol use. In fact, Campbell & Oei (2010) proposed that both parental behaviors and stated pro-alcohol beliefs (i.e., “Alcohol is a great way to relax after work”) had a strong influence on the child’s expectations for the use of alcohol, as well as their ability to resist use. Other family factors identified in Ryan, Jorm, & Lubman's (2010) review of longitudinal studies included explicitly stated disapproval, moderate discipline, parental monitoring, parent-child relationship quality, and parental support/involvement/communication. They found that these factors resulted in delayed alcohol initiation or decreased alcohol use in adolescents. Further, they determined that parental modeling of drinking behaviors (e.g., normalization of alcohol use via modeling of use) resulted in earlier initiation of alcohol use, a finding supported by Merline and colleagues’ (2008) examination of the

Monitoring the Future study. It is useful to identify that, though a limited subset of these parental behaviors have been specifically related to alcohol, a large majority have shown protective effects shared with overall risk for negative outcomes (Smokowski, Bacallao, Cotter, & Evans, 2014; Vassallo, Edwards, Renda, & Olsson, 2014; Yap, Pilkington, Ryan, Kelly, & Jorm, 2014).

In addition to the influence of parents, peers have been found to strongly impact both the initiation and continuation of use, even with problematic outcomes. Nash and colleagues (2005) identified that nearly half of the variability in alcohol use in adolescents was predicted by the influence of an adolescent's peer-groups. The effect was moderated by positive family environment which in turn was affected by parental alcohol expectations (reviewed above). A large body of research has shown that deviant behaviors occurring within a peer group (e.g., truancy, theft, and property damage) increased the likelihood of initiation, the amount of, and problems associated with alcohol use (Merline et al., 2008). Further, research demonstrated that something broader than the deviant acts or the presence of deviant others has influenced alcohol use; positive beliefs about alcohol use within their peer group(s) – social motivations – strongly contributed to an individual's drinking (Merline et al., 2008).

While striking consistency in drinking behavior has been seen within peer groups, the mechanisms by which this occurs have been debated among experts of Social Learning Theory. Drinking attitudes and behavior could have been directly modified by peer influence through modeling, imitation and reinforcement (i.e. socialization model). Alternatively, adolescents could have selected peers on the basis of similarities in beliefs

and behaviors that become mutually reinforced over time (the selection model: Bandura, 1977). The work of D'Amico & McCarthy (2006) has shown that selection may be a potent factor early in development, with middle school youth being influenced by the perception of their peers' beliefs surrounding alcohol use. Results have suggested adolescents were more likely to initiate and maintain alcohol use even if they wrongly believe that peers hold a positive view of alcohol use (D'Amico & McCarthy, 2006). A longitudinal study (Trucco, Colder, & Wieczorek, 2011) showed that perceptions of use had an effect on the initiation of alcohol use which strengthened across time points. This would suggest that peer-initiated beliefs developed and became reinforced throughout the period of adolescence. The socialization model has also been supported from the perspective of an individual's motivations for the use of alcohol. As shown by Kuntsche & Kuntsche (2009), significant relationships have been found between social drinking motivations and alcohol use, including drunkenness. In addition, Cheetham and colleagues (2010) have argued for an overlap between use for enhancement and social motives as these components co-occur during occasions of celebration (i.e., parties, holidays, etc.). Unfortunately, it has remained unclear whether the perception of other's alcohol use directly influences an individual's internal motivations (enhancement, coping, social or conformity) or acts through an alternative mechanism for initiating, maintaining, or increasing alcohol use. Though no concrete pathways have been established, Newton, Barrett, Swaffield, and Teesson (2014) found that a reduction in awareness of the consequences of deviant acts and a reduced ability to say no to peers, resulted in greater alcohol use over a period of 18 months. Thus, an interaction between

social acceptability and enhancement expectancies of use was necessary to lead to unhealthy use. Taken together, at the microsystem levels variables including family environment, parental beliefs and behaviors, and peer beliefs and behaviors have been related to an adolescent's drinking behavior and outcomes.

MESOSYSTEMS & MACROSYSTEMS

The final two levels of the Bronfenbrenner model were used to examine how a person's community and broader societal influences impact drinking behavior. Factors included from the mesosystem and macrosystem address areas such as community structure (e.g., ease of access to alcohol within the community [Nargiso, Friend, & Florin, 2013]) and socioeconomic status (SES). In addition, differential cultural expectations surrounding alcohol use ("drinking cultures") have been shown to vary across national samples (e.g., Argentina, Mexico, Poland and the United States [Borges et al., 2010]). As a number of these factors are regularly utilized within current studies (particularly the examination of mediation and moderation based on SES), a general overview of broadly contributing factors, as well as differential effects across groups, have been presented.

The relationship with alcohol use can be communicated by a community in many ways, including passive communications. Community norms have been reflected to the individual through the accessibility and location of alcohol retailers, as well as the perceived permissibility of alcohol use (via modeling, direct communication or indirect communication [e.g., advertising] of appropriate use behavior) (Ahern, Galea, Hubbard,

Midanik, & Syme, 2008; Nargiso et al., 2013; Sudhinaraset et al., 2016). Some researchers have suggested that the density of alcohol outlets contributes to use independently (Ahern, Margerison-zilko, Hubbard, & Galea, 2013), while others have claimed that specific aspects of the community influence risk, particularly the structural conditions of the neighborhood (Sudhinaraset et al., 2016). Observed dilapidation, disrepair, and unresponsiveness within the community, has been termed 'neighborhood disorder'. It has been identified as a stressor associated with greater prevalence of alcohol use (Hill and Angel 2005). Duprey, Oshri, and Caughy (2017) found that neighborhood disorder moderated the relationship between early childhood maltreatment and late adolescence substance use via psychological distress. They examined moderated mediation (neighborhood disorder X internalizing symptoms) and found highly internalizing adolescents were more likely to engage in some form of substance use (alcohol, marijuana or cigarettes) when their neighborhood was less disordered. As other researchers (Hill & Angel, 2005) have found increased use among individuals with externalizing disorders, the impact of neighborhood disorder may depend on the expression of distress (presentation of internalizing or externalizing symptomology). Jitnarin and colleagues' (2015) closer examination of neighborhood disorder identified that it could represent a marker of social disadvantage, particularly for Midwestern men. Together neighborhood disorder, the density of alcohol outlets, and perceived community permissiveness have created social expectations both about alcohol use behaviors and about the social advantages and disadvantages of group membership (i.e. identifying with the community of drinkers).

Similar to the broad influence of the community, socioeconomic status (SES) has been assumed to impact the likelihood of developing unhealthy alcohol use. The field remains in debate regarding whether SES has a significant impact on the frequency and quantity of alcohol use (Bonevski, Regan, Paul, & Baker, 2014; Intarut & Pukdeesamai, 2017; Lee et al., 2015; Patrick, Wightman, Schoeni, & Schulenberg, 2012; Wiles et al., 2007). More recent research has focused on determining relationships between alcohol use and components of SES, including occupational status, educational attainment, and income levels. As described in the individual section, even these sub-components of SES have been suggested to influence differential patterns of alcohol use that pertain to the socioeconomic status of an individual, particularly their income and educational attainment.

Finally, unexplained patterns of use would suggest a wider socio-cultural belief. Though a commonly held societal or cultural alcohol use belief has been difficult to quantify, inherent differences in drinking cultures have been documented, even among countries in the European Union (Gordon, Heim, & MacAskill, 2012). For example, Gordon and colleagues (2012) suggested the overall contribution to differences in problematic drinking cultures – between France, Germany, Sweden, Spain, and the United Kingdom – may be marked by three factors. These factors were: 1) the degree of hedonism (regularity and extent of use for the pursuit of pleasure), 2) the general function (social, ritual, enhancement, coping), and 3) the degree of social controls which surround alcohol use. More research, utilizing longitudinal and/or development frameworks, has been called for in order to understand these larger cultural influences on the initiation and

development of unhealthy alcohol use. The current work has suggested global influences – including community influences, sub-components of SES, and drinking culture – to have motivated and/or delimited alcohol use.

SUMMARY

As reviewed above, research supported a complex and interacting web of psychological and sociological factors which contributed to unhealthy alcohol use. The Bronfenbrenner model provided a useful framework, both to group predictors of alcohol use and to posit the way these factors influenced the development of patterns of unhealthy alcohol use. The differential trajectories of alcohol use appeared to be influenced by an individual's immediate response to alcohol, their level of psychological distress and their beliefs in alcohol's ability to modify their current (generally emotion-related) experience. Further, the initiation of use was found to be influenced by individual differences in sex/gender, racial/ethnic group, acculturation status, and components of SES such as income-level and educational attainment. Many of these individual variables were also influenced by the environment within which the person develops, primarily via sociological factors. Most notably, family members and peers demonstrated marked influence on the development of beliefs about the permissibility and motivations for alcohol use. The inherent instructions about the permissibility of alcohol use were further impacted at the level of an individual's community. The differential trajectories in use behaviors caused by neighborhood disorder and mediated by psychological distress provided an excellent example of a communities' influence. Finally, the most diffuse

factors on an individual's alcohol use behaviors were those related to societal expectations, including SES, acculturation, and drinking cultures. Together each of Bronfenbrenner's levels identified a cascade of risk factors that influence both the likelihood of initiating alcohol use and the development of unhealthy use. Given the longitudinal effects of the factors reviewed, we have examined the influence of these factors on an individual's treatment outcomes, when they engage in outpatient treatments for unhealthy alcohol use.

Treatment of Unhealthy Alcohol Use

In order to examine predictors of treatment effectiveness, we have presented content such that current treatments for unhealthy alcohol use and how people access these treatments was understood. Since the late 80s, there has been an increased focus on supporting individuals in accessing effective treatments. A summary of the research by Bien, Miller, & Tonigan (1993) identified that utilization of brief interventions (e.g., identification of a problem, advice for remission, and follow-up) was generally effective across drinkers of different levels of severity and racial/ethnic groups. However, they also noted that individual characteristics contributed to differential success in treatment. As a result, the matching hypothesis was introduced (Donovan & Mattson, 1994; M. E. Mattson, 1994). This identified that individualized characteristics (gender, alcohol use severity, etc.) would be predictive of the effectiveness of a particular format of treatment relative to others, e.g., Bien and colleagues (1993) study of gender. This led to Project MATCH, one of the largest nationally funded studies ever conducted (fully described in

Barbor & Del Boca, 2002). As mentioned previously in this literature review, Project MATCH examined differential treatment effectiveness as predicted by ten client characteristics (severity of alcohol involvement, cognitive impairment, client conceptual level, gender, meaning seeking, motivational readiness to change, psychiatric severity, social support for drinking versus abstinence, sociopathy, and typology). The effects of these predictors were examined within two separate setting arms (outpatient and inpatient/aftercare) with three treatment types: Cognitive Behavioral Therapy (CBT), Motivational Enhancement Therapy (MET), and Twelve-Step Facilitation Therapy (TSF).

The Project MATCH Research Group's study showed a general benefit of treatment within both setting arms and limited differences between any of the treatment types, despite validation of treatment integrity (Allen et al., 1997; Connors et al., 1998). However, Allen and colleagues (1997) found several interesting interaction effects between the treatment setting and either: (1) treatment type (TSF showing slight advantages in the outpatient setting) or (2) individual character predictors (complex influences of meaning seeking, typology, psychiatric severity and motivation depending on setting, treatment type and duration of treatment). Retrospective analyses have identified additional differences between groups, including slight racial differences in frequency of drinking (black clients less frequently than white, but not Hispanic, clients [Tonigan, 2003]) and participant self-selection effects on treatment outcome (those attending a single session had worse initial and outcome data than either full 12-week or zero week attendance [Cutler & Fishbain, 2005]). Although attempts to identify more

effective treatment models have yielded similarly inconclusive results, consistencies have appeared across treatments which has supported the current level of effectiveness (Imel, Wampold, Miller, & Fleming, 2008). These commonalities focus on the benefits of therapeutic alliance, specific therapeutic skills and eliciting change talk from the client, across therapeutic treatment formats for unhealthy alcohol use (Feldstein Ewing, Filbey, Sabbineni, Chandler, & Hutchison, 2011; Magill et al., 2016; Morgenstern et al., 2012). In other words, it matters more that patients have engaged in treatment in a way that encourages continued self-examination of recovery from use.

Though the literature has grown, including emphases on personalized medicine (Litten et al., 2015), many of the theoretically supported models have yet to be implemented within the outpatient treatment setting. McLellan and Meyers (2004) found that 90% of specialty treatments focus on models of treatment that have shown limited effectiveness. In response to ongoing limitations in treatment, several groups have identified the need to describe the advances in research within a conceptual framework that integrates psychological and social factors that could be applied across treatment settings. Thus, the remainder of this literature review has been targeted towards two goals: 1) having examined the evidence surrounding the effect of psychosocial predictors on treatment outcome, via the utilization of the Bronfenbrenner model, and 2) having considered the structural relationship between variables in order to develop a testable model of each individual's pathway to recovery from use.

Psychological and Sociological Predictors of Treatment Outcome

Barriers to Treatment Engagement

Prior to having reviewed the factors predicting treatment outcome, we recognized that the whole population of individuals with unhealthy alcohol use would not be represented within the literature. This was because some patients experience barriers while initiating treatment. Storbjork and Room (2007) reported two distinct types of unhealthy alcohol users: treatment-seeking individuals with heightened severity of alcohol use (tending to be middle-aged males with complicated functional and/or psychological impairments) and treatment-avoidant individuals with moderate to mild unhealthy use. Descriptive categories of treatment engagement have failed to define why, for what nuanced reason(s), individuals have opted out of treatment for unhealthy patterns of alcohol use. After completing a qualitative study in unhealthy drinkers (measured by AUDIT-C and 3+ dependence criteria), Wallhed Finn, Bakshi, and Andréasson (2014) reported three primary barriers to treatment engagement: felt stigmatization, held beliefs of independently gained success (i.e., precontemplation, denial or overconfidence), and held uncertainties surrounding treatment.

The internal experience of ambivalence has been influenced by stigma, both in the decision-making process and engagement in treatment for alcohol use. The experience of stigma (i.e. labels such as “the socially-deprived alcoholic”) was negatively related to an individual’s engagement in treatment, particularly among males, individuals with low SES (education and income, specifically), and certain racial/ethnic groups (Keyes et al., 2010; Wallhed Finn et al., 2014). Other identified barriers included resistance to having alcohol use labeled as a problem and difficulty in the process of building confidence to

make a change in use independently. Though Bishop (2018) demonstrated a marked ability for unhealthy users to engage in change independently (~11% have lifelong use), the 16 year half-life of alcohol dependence suggested that, “addiction [was] ambivalent drug use, which eventually involve[d] more costs than benefits (otherwise why quit?)” (Heyman, 2013). This idea paralleled the redefinition of unhealthy alcohol use as both compulsive (e.g., influenced by urges to use) and susceptible to changes in processing (i.e., motivated beliefs, self-deception, and cognitive deficits) of the incentives available within the environment (Henden, Melberg, & Røgeberg, 2013; Pickard, 2016). Finally, non-treatment seekers were clear that, were they to engage in treatment, two primary aspects would have been essential (Keyes et al., 2010): confidence in the care provider (experience, expertise, supportiveness) and attractiveness of treatment (easy access, high autonomy, maintenance of daily life). Though potential patients were certain that treatment could support identifying the “underlying reasons [for use] that have to be dealt with,” many were genuinely uninformed of the expectations, options for, and content of treatment (Wallhed Finn et al., 2014). As such, the experience of barriers within any of these content areas (and likely others) has contributed to the experience of real or imagined barriers to change and thus impacted the patients ability to have engaged in or maintained treatment (Cutler & Fishbain, 2005).

INDIVIDUAL

To understand factors affecting treatment, it was useful to reflect on factors that impacted the initiation of use (reviewed above). Some of the strongest influences were drinking motivations and factors that reinforced drinking behavior. As such, this paper

first focused on the utilization of positive forms of motivation for recovery from use. Given the high rate of treatment failure, and the nature of being immediately rewarded by alcohol consumption, financial contingencies have been one strategy for enhanced motivation and improved treatment outcomes. Petry, Martin, Cooney, and Kranzler (2000) found that utilizing financial reinforcement for confirmed abstinence (negative breathalyzers) was effective for improving treatment engagement and outcomes over an 8-week course, when compared to treatment as usual. The long-term effectiveness of this approach has not been determined. Similarly, motivational enhancement/interviewing approaches have been shown to be effective by identifying and bolstering an individual's motivations and readiness for change in use, i.e. motivational readiness (Ilgen, McKellar, Moos, & Finney, 2006; Miller & Rollnick, 2002). The concept of motivation for change was strongly influenced by the Stages of Change model (DiClemente & Prochaska, 1998). Though clinically interpreted as a fluid transition through the stages of precontemplation, contemplation, action, and maintenance, research has continued to question the best model of the process of recovery (Littell & Girvin, 2002; Zeng & Ajzen, 2014). Very early on, DiClemente and Hughes (1990) identified that these categories were important markers of a balance between an individual's confidence in their ability to change (self-efficacy) and concern for the risk of relapse (temptation). This would suggest motivational readiness (assessed by stages or continuously) represented a balance between supporting confidence in change, as well as identifying and countering the reasons for relapse, an area of research heavily contributed to by Marlatt (1996). Together these results suggested that positive reinforcement was essential

in beginning the process of modifying drinking behaviors (particularly an internal sense of motivational readiness).

Among individuals beginning to decrease or quit alcohol use, Zywiak, Connors, Maisto and Westerberg (1996) identified positive affect/social factors as one of three primary triggers of relapse (also negative affect and degree of withdrawal/desire to drink). The results of their study indicated that males may be more likely to experience challenges in recovery from use for positive affect/social reasons, such as “I was with others having a good time and we felt like getting drunk together” (Zywiak et al., 1996). However, many studies have either not reported the relationships between drinking/relapse motives (Canale, Vieno, Santinello, Chieco, & Andriolo, 2015) or found no relationship between positive affect/social motives and treatment outcomes (Elliott, Aharonovich, O’Leary, Wainberg, & Hasin, 2014). Further, the related behavioral predictor of positive urgency (engaging in impulsive acts during the experience of heightened positive emotions) has not been shown to relate to differences in treatment outcomes or to be indirectly impacted by treatment (Hershberger, Um, & Cyders, 2017). Thus, the influence of positive emotional experiences on recovery from use has remained debatable and may ultimately have little impact on the outcome of treatment.

On the other side of the equation, the effects of negative reinforcement were found to contribute to continued engagement in patterns of unhealthy alcohol use via reduced withdrawal symptoms, including associated negative affect, and the completion of relapse behaviors (Baker et al., 2004; Breese et al., 2011; Cheetham et al., 2010; Fox et al., 2007; Robinson & Berridge, 2003; Ryan, 2002; Sher et al., 2005). Indeed, Zywiak

and colleagues (1996) found that negative affect was a primary reason for relapsing to unhealthy alcohol use, and led to greater amounts of use and longer duration of relapse, particularly among women. Following a 60-day motivational intervention, drinking to cope with negative affect was shown to relate to the amount of alcohol consumed per drinking day and likelihood of meeting criteria for alcohol dependence (Elliott et al., 2014). These results would suggest a stable trait influencing alcohol use behaviors.

Treatments have been developed that target negative affect in order to reduce the impact on recovery from use. Anker, Kushner, Thuras, Menk, and Unruh (2016) utilized Cognitive Behavioral Therapy techniques (psychoeducation, cognitive restructuring and coping during a stress-inducing imaginal exposure) which supported patients with heightened baseline emotionality in reducing alcohol use at a four-month follow-up. A pilot study which added Affect Regulation Training, led to significant benefits over CBT alone (Gulliver, Gudleski, & Bole, 2014). Notably, patients were significantly more satisfied by the combined treatment which may also enhance treatment retention. Further, longitudinal studies of individuals who attended Alcoholics Anonymous have shown enhanced coping with emotional states to be associated with the duration of participation. Interestingly, this effect was mediated through a reduction in impulsivity, particularly in adults less than 25.4 years of age (Blonigen et al., 2011, 2013).

Naturally, these results have led researchers to examine factors underlying recovery from unhealthy alcohol use, particularly if ability to cope with emotion or retrain impulsive tendencies influenced outcome. In order to examine this question, Maisto and colleagues (2017) studied both the trait-like and situational factors that

contribute to the occurrence and degree of a relapse in alcohol use. They found that the trait-like, cumulative impacts of greater reactivity to social challenges (as measured by systolic blood pressure) and situational feelings of stress (measured by daily electronic momentary assessment) both contribute to the occurrence and amount drunk during a relapse (Maisto et al., 2017). These results paralleled the finding that negative urgency, which integrates both trait reactivity within states of negative affect, interfered with treatment outcomes and decreased only a limited amount during treatment (Hershberger et al., 2017). The integration of these studies has supported a vital role of negative affect in recovery from use with more concrete roles of individual variability in ability to tolerate negative emotional states and engage in non-impulsive responses. Interestingly, some studies have suggested a moderating effect of demographic variables for ability to evoke change in each of these factors as therapeutic targets, female gender and younger age, respectively.

An individual's experience of serious mental health symptoms was another perceived barrier to making a change in patterns of alcohol use (McCallum, Mikocka-Walus, Gaughwin, Andrews, & Turnbull, 2016). Surprisingly, within a nationally representative sample (Epidemiological Catchment Area study), the presence of comorbidity (i.e., more than one clinical diagnosis) occurred in nearly half (47%) of those meeting criteria for an alcohol use disorder (Helzer & Pryzbeck, 1988). Other studies have suggested that the occurrence of a comorbidity may range from .14 to .75 (Burns et al., 2005; Mellentin, Nielsen, Stenager, & Nielsen, 2015; Schuckit et al., 1997). Johnson, Cloninger, Roache, Bordnick, and Ruiz (2000) compared sub-groups based on the age of

onset within a sample of outpatient treatment seeking patients; they found a heightened level of psychological and social distress within individuals who initiated alcohol use prior to 20 years of age (relative to onset after 25 years old). Though they determined age of onset not to be a reliable indicator of homogeneity among those with unhealthy alcohol use, it has provided insight into possible ‘types’ of drinking groups. Regardless, comorbid mental health problems are associated with greater severity of alcohol use behaviors (Burns et al., 2005; Glass et al., 2014; Kaufmann, Chen, Crum, & Mojtabai, 2014; Mellentin et al., 2015; Newton-Howes et al., 2017). Though there are contradictions to the impact of psychological severity (Maisto et al., 2017), the consideration of differential trajectories based on the class of psychological distress (i.e., internalizing, externalizing, combined) has provided even greater clarity.

First, the influence of co-occurring internalizing disorders was examined with the most common disorders being mood and anxiety (major depression, dysthymia, and bipolar; generalized anxiety, social anxiety and agoraphobia: Burns et al., 2005; Glass et al., 2014). Within studies of individuals with comorbid anxiety and/or depression, general themes have included increased baseline severity of alcohol use, both frequency and amount, as well as equivalent recovery from use with moderate to large effects of treatment (effect sized ranged from 0.58 to 1.35: Burns et al., 2005; Kaufmann et al., 2014; Mellentin et al., 2015). Of interest, past reports indicated the occurrence of comorbidity was more common in women (65% versus 44% in men), particularly for a co-occurring anxiety or depression diagnosis (Helzer & Pryzbeck, 1988). Individuals with comorbid depression/anxiety utilized services as much (Mellentin et al., 2015), if

not more frequently (Kaufmann et al., 2014) when compared to individuals with unhealthy alcohol use alone. Despite also reporting similar treatment satisfaction, Kaufmann and colleagues (2014) found that individuals with comorbid anxiety or depression were more likely to have an unmet need for treatment and greater number of barriers to treatment, particularly attitudinal and financial. Of note, discussion of specific internalizing diagnoses should be considered preliminary as nuances have only begun to be explored within sample sizes that are far too limited to provide generalizable results (e.g., Kushner et al., 2005).

With this qualification, specific impacts have begun to be established dependent on the type of internalizing disorder. Within those individuals experiencing comorbidity between alcohol use and depressive disorders, Karl Mann, Hintz, and Jung (2004) found a lower percentage of relapse specifically among the women of this group at 12 month (which has also been seen within samples of mixed anxiety/depression comorbidity [Sánchez-Peña, Alvarez-Cotoli, & Rodríguez-Solano, 2012]). When researchers compared three groups of individuals based on maintenance of abstinence through treatment (early relapse vs. late relapse vs. abstainers), it was found that those with comorbid anxiety disorders (particularly social anxiety and agoraphobia) were more likely to be in the early relapse group (Schellekens, de Jong, Buitelaar, & Verkes, 2015). Further, the examination of two-month follow-up data indicated that the presence of an anxiety disorder was predictive of increased risk for persistence of alcohol use, particularly for social anxiety and panic/agoraphobia, but not for those with depressive disorders (Kushner et al., 2005). Schellekens and colleagues (2015) attributed this

difference to increased craving among those with comorbid alcohol use and anxiety, which has been supported by previous research (Johnston, Thevos, Randall, & Anton, 1991). Therefore, even within the internalizing disorders, differences in the trajectory of recovery from use were apparent, with individuals experiencing comorbid anxiety (and perhaps specifically interpersonally avoidant disorders such as social anxiety and agoraphobia) had increased likelihood of relapse when compared to those with co-occurring depression.

As described above, those individuals who have experienced comorbid externalizing disorders were also noted to modify the trajectory of recovery, of which antisocial personality disorder (ASPD) and co-morbid substance use have been most frequently documented (Glass et al., 2014; Grant, Goldstein, Saha, Chou, Jung, Zhang, Pickering, Ruan, Smith, Huang, Hasin, et al., 2015; Helzer & Pryzbeck, 1988). The prevalence of ASPD co-occurrence with unhealthy alcohol use ranged from 15-41%. It has been associated with earlier age of onset of alcohol use, greater legal/physical/social problems, more concurrent substance use, less likelihood of speaking to a provider about the occurrence of unhealthy alcohol use, and greater alcohol use at treatment onset (Helzer & Pryzbeck, 1988; Newton-Howes et al., 2017). Through meta-analysis of the impact of comorbid personality disorders on treatment for unhealthy alcohol use, Newton-Howes et al. (2017) determined relapse and retention issues to be more of an issue when compared to patients with a personality disorder. However, the amount and frequency of alcohol use showed similar changes between these groups, despite greater frequency of use at baseline for the personality disorder group. Researchers noted an

overall low quality of data within the utilized studies, particularly in the use of treatment completer analyses which they noted as a potential source of bias for the results (Newton-Howes et al., 2017).

The prevalence rates for comorbid substance use were found to vary widely between studies, which could reflect differences in the substance focused on and the demographics of the sample, particularly age, race/ethnicity, and gender (Gilder, Stouffer, Lau, & Ehlers, 2016; Grant et al., 2015; Malcolm, Hesselbrock, & Segal, 2006). Across studies, the occurrence of multiple substance use disorders (versus unhealthy alcohol use alone) was associated with lower education, greater frequency of drop out from school, greater occurrence of internalizing (major depressive episodes, panic disorder, and social and specific phobias) and externalizing (ASPD/CD) diagnoses, earlier onset of alcohol use, greater severity of alcohol problems, and – despite more frequent treatment attempts – less frequent recovery from unhealthy alcohol use (Gilder et al., 2016; Grant et al., 2015). Thus, individuals who have used multiple substances demonstrated greater impairment, particularly in the realm of psychological distress. Within a sample of Alaskan Natives, Malcolm et al. (2006) found the co-occurrence of an opioid use disorder predicted earlier onset, greater alcohol problems, and more severe withdrawal when compared to co-occurring marijuana or cocaine use disorders. Therefore, the class of substances could be suggested to influence the degree of psychological distress. Altogether, externalizing disorders were shown to impair the efficacy of treatment with both general (level of externalizing) and specific effects (co-occurring use disorders). Indeed, researchers have demonstrated that highly externalizing

drinkers had greater severity of unhealthy alcohol use (Colder et al., 2017; Glass et al., 2014) and poorer treatment outcomes (Grant and colleagues (2015)). However, no studies could be found which examined the effects (categorically or continuously) of higher levels of psychological distress on the treatment of unhealthy alcohol use.

Finally, demographic characteristics of the individual have been shown to influence the trajectory of recovery both due to the effectiveness of treatments within a specific sub-population, as well as barriers to having been able to engage in treatment. Though there were discrepancies across analyses, Adamson and colleagues' (2009) meta-analysis of studies identified that gender (being female identified), employment, and socioeconomic status (particularly higher income) were consistently predictive of recovery from unhealthy alcohol use. These results were supported via the naturalistic, longitudinal (1, 3, 8, and 16 year) observation of a group of individuals who, at the initial visit, had not sought treatment despite a recognized problem with alcohol use (Moos & Moos, 2006). Within this study they examined differences in outcomes for those who sought help (professional treatment and/or self-help groups) and identified predictors of short-term remission (at 3 years) and long-term relapse (at 16 years). Moos and Moos (2006) found help seeking behaviors facilitated recovery. Regarding short-term remission, they found female gender and higher educational attainment were significant predictors. They also reported that lower educational attainment and unemployed status at the 3-year follow-up was predictive of individuals who experienced recurrence of alcohol use at year twelve (Moos & Moos, 2006). The more favorable trajectory for women in the treatment of alcohol use problems could be associated with other factors – discussed

above – which have been shown to relate to treatment outcomes such as the severity of baseline alcohol use (generally lower), co-occurrence of internalizing psychological disorders, and responsiveness to standard treatment approaches (Litt, Kadden, & Tennen, 2015; Mann et al., 2004; McCutcheon et al., 2014). Further, a predictive model developed by Sugarman et al., (2013) suggested that the impact of gender on treatment-related drinking outcomes may be partially mediated through educational attainment. Altogether it would appear that females have better outcomes when engaged in a process of recovery.

Unlike the clear evidence of differences based on gender, race and/ethnicity has impacted recovery from unhealthy alcohol use in ways that have varied widely. Though Adamson et al. (2009) found no specific race/ethnicity differences in treatment outcomes, Priester and colleagues (2016) described numerous barriers specific to racial/ethnic minorities. Barriers occurred across several areas, including insurance/policy barriers (lack of insurance for men of color), service provision (cultural insensitivity/incompetence), and service availability (lack of specialized treatment or transportation to treatment in the community). The authors also expressed that, "societal oppression [could] contribute to differential, inaccurate, and under diagnosis of individuals who [were] racial/ethnic, gender, or sexual minorities." The influence of these diagnostic discrepancies could compound the experience of being dually-stigmatized (i.e., being a member of a group marginalized due to cultural and psychological stigmas).

Though much can still be learned about the impact of these barriers on treatment engagement and completion, several studies have confirmed a marked disparity in

treatment utilization and outcome for black and Latino/a individuals (Guerrero, Marsh, Khachikian, Amaro, & Vega, 2013; Saloner, Carson, & Lê Cook, 2014). Guerrero and colleagues (2013) identified notable differences in the occurrence of unhealthy alcohol use based on region of origin, age of emigration, and level of acculturation, as well as differences in the demographics of individuals entering treatment. They reported that having "young, less-educated, and treatment-naïve Latinos entering [treatment would] have significant implications for health literacy and intervention tolerability, fidelity, and acceptability." In their examination of disparities in treatment completion across racial/ethnic groups, Saloner and colleagues (2014) noted that black and Hispanic youths experienced several individual-level protective factors (e.g., substance use history, living and schooling arrangements, and referral pathways). These protective factors prevented these groups from having experienced a widening of disparity in treatment outcomes when compared to white youth. It should be noted that broader influences within an individual's social relationships, community and society influence each of these individual factors both directly and indirectly. As such, we have continued outward to review how these external factors have contributed to patterns of unhealthy alcohol use.

MICROSYSTEMS

An individual's recovery from unhealthy alcohol use was investigated from the perspective of possible contributors from their social environment, including specific impacts of family members and the general influences of peers. An individual's family history of use predicted both the initiation and trajectory of alcohol use over time.

Capaldi, Feingold, Kim, Yoerger, and Washburn (2013) determined that more widespread family history of alcohol use significantly differentiated individuals with high, though desisting, levels of problems associated with alcohol use. Interestingly this group of individuals were also likely to have high and decreasing amounts of use, which suggests that family history may predict a worse course of unhealthy alcohol use (Capaldi et al., 2013). Indeed, having a family history of alcoholism, particularly male alcoholics, has been associated with a younger age of onset for alcohol use (Johnson et al., 2000). However, as predictors of treatment effectiveness, Adamson, Sellman, and Frampton (2009) stated, “onset age of alcohol misuse, alcohol-related problems, and family history of alcohol or drug problems were all poor predictors of outcome.” Thus, these factors have been considered as proxy risk factors (i.e., related to but not causal of), which stood in for the correlated factors of greater psychosocial stressors, craving, or, most likely, baseline alcohol consumption (Johnson et al., 2000). Given that family history was non-specific, more focus has been placed on the relationship between an individual’s alcohol use and their family relationship.

To capitalize on the focus on family relationships, many treatments have been developed that utilized an individual’s family members to support treatment. Individuals that have engaged in one of these models of treatment, community reinforcement (CR) supports (CR-Training prior to treatment or CR-Approach during treatment), were found to be more likely to initiate treatment, as well as greater levels of abstinence at 6-month and 2-year follow-ups (Edwards & Steinglass, 1995). The combination of these approaches in community reinforcement and family training (CRAFT) were suggested to

be particularly effective for individuals who have been resistant to treatment. Miller, Meyers, and Tonigan (1999) found that treatment resistant drinkers were significantly more likely to engage in treatment (assessment and at least one session) at both 6 months and 1 year after group randomization, when family members were trained in CRAFT versus Al-anon or family intervention models. As stated by Edwards & Steinglass (1995), “involving the spouse in the [treatment compliance] as well as providing communication skills training appear to be the significant components of treatment success.” Indeed, the experience of high social support from an individual’s social network (e.g., family and friends) has been shown to be predictive of longer engagement in treatment and greater reductions in unhealthy alcohol use (Dobkin, De Civita, Paraherakis, & Gill, 2002; Mavandadi, Helstrom, Sayers, & Oslin, 2015).

Engagement in CRAFT was not always shown to be ideal, as individuals with limited social support were found to have significantly less effectiveness in CR, when compared to individual treatment (Edwards & Steinglass, 1995). Within this group, a standard brief informational intervention proved more advantageous for changes in alcohol use, notably even compared to individuals with high social support who engaged in standard care (Mavandadi et al., 2015). Though CR treatments assisted those with strong family support in becoming motivated for treatment, both the type of intervention and social context of the individual undergoing treatment matters in the determination of outcomes.

Variability in the number of supports, types of supports (e.g., family or friends), and format of support (e.g., general sense of wellbeing, specific support for abstinence, or

specific support for alcohol use) has made the ability to fully understand the social context of recovery difficult (described by Groh, Jason, Davis, Olson, & Ferrari, 2007). When the type and form of support within a recovery model (i.e., the Oxford House) was more closely examined, the factors of length of stay, general friend support, and their interaction were found to be significant predictors of less alcohol use at follow-up. Indeed, it appeared that low general friend support was a risk factor for individuals that was mitigated after a six month stay in the recovery environment (Groh et al., 2007). This was supported by a naturalistic five year follow-up of a sample of at-risk drinkers that differentiated two separate types of recovery profiles: low-risk drinking and abstinence (McCutcheon et al., 2014). The low-risk group were more commonly women undergoing changes in roles (e.g., first child during the five-year period), generally experienced lower severity of unhealthy alcohol and drug use at baseline, and experienced higher general levels of family support. Alternatively, the abstinent group had higher baseline severity in unhealthy alcohol use, greater losses of relationships, and lower family support, but engaged in more treatment (e.g., AA and specialist therapy) and had higher general support from friends. Therefore, it can be deduced that the path to recovery from use may naturally be different for individuals who have experienced general support from family, as compared to general support from friends.

Families involvement has demonstrated marked influence on a patients motivation for changes in alcohol use, yet the impact of friendships have remained unclear. Best & Lubman (2017) showed that within an adolescent sample, treatment had little effect on the number of friends an individual had, but a marked impact on the

proportion of their current friends that were using drugs or alcohol. This resulted in changed dynamics within their friendships and families (i.e., less conflict and overall social dysfunction), as well as modified behavioral patterns of substance use and criminal activities. Therefore, the engagement in treatment supported changes both in general relational engagement and specific support for abstinence within an individual's friendship group. Litt, Kadden, and Tennen (2015) found that a specific treatment which focused on the development of a social network supportive of abstinence was beneficial in the process of recovery for men, but not women. Interestingly, they found that women generally had more currently using friends, as well as greater mental health concerns and lower self-efficacy, and thus were unable to expand their social network or enhance self-efficacy during treatment (Litt et al., 2015). Additional factors may have influenced the ability of patients to have engaged in re-establishing a peer network supportive of abstinence (e.g., gender, psychological distress or self-efficacy), but these results have validated the influence of both family and friend support on recovery from unhealthy alcohol use. Though social support was not directly assessed within the study, Best and Lubman's (2017) results have suggested that distress occurring within social relationships could be a relevant proxy risk factor relevant to the current study.

MESOSYSTEMS & MACROSYSTEMS

As the focus has shifted outwards, a sparsity of literature was notable for factors within an individual's mesosystem (community) and macrosystem (social groups and society) which have described an influence on the outcomes of treatment for unhealthy

alcohol use. This area of research has been understudied, perhaps due to the difficult nature of controlling community and society level variables.

At the level of the mesosystem specifically, communities have been considered for their influence on effectiveness of and access to treatment services. Elliott and colleagues (2016) were among the few who have directly examined the impact of the community. They found that community-wide permissibility of alcohol use influenced recovery from heavy use within a sample of HIV-infected adults (Elliott et al., 2016). Specifically, they found that motivational interviewing was more effective at reducing drinks per drinking day among individuals with communities that had a permissive attitude about drinking, as compared to an educational control (Elliott et al., 2016). The specificity of the study sample has limited the generalizability of the result; however, this study would suggest changes in the setting of treatment were more common when the community wasn't already supporting changes in use.

The majority of the available literature has examined the potential for access to support for individuals within a community setting, such as a sober living community. Mericle, Karriker-Jaffe, Gupta, Sheridan, and Polcin (2016) found that the presence of Sober Living Houses was associated with community demographics; however, the affordability of sober living was impacted by the community as well. While all facilities were more commonly co-located with treatment and self-help facilities, affordable facilities (\$300-1450/month) also tended to be in areas with more unemployment and a greater presence of drinking venues. Though sober living houses have been shown to be effective (Groh et al., 2007), the specific impact on treatment outcomes, relative to these

differences in community setting, could not be determined. However, Mericle et al. (2016) found that communities with a greater proportion of Hispanic and Asian American individuals tended to have fewer Sober Living Houses and thus decreased access.

Though there have not been studies which directly assessed impacts of living in a culturally diverse community, researchers have discussed societally-held beliefs about treatment engagement (see stigmatization above) and societally-influenced structural barriers to successful completion of treatment which are influenced by race/ethnicity. Indeed, Saloner and colleagues (2014) identified variables at the macrosystem level which led to lower rates of treatment completion for black and, particularly, Hispanic youth. These included fewer available services, lower financial accessibility, and greater concentration of minorities within the community. Further, Guerrero et al.'s (2013) found that, among individuals of Latino/a ethnicity, differential treatment outcomes could be addressed by structural modifications making treatment more responsive to the needs of this ethnic group. Modifications to treatment which were found to increase engagement and success of treatment included culturally competent treatment (e.g., language concordance), longer residential stays, greater co-occurring disorder training for staff, and participation in after-care outpatient treatment (Guerrero et al., 2013). Of course, these disparities in access and outcome of treatments for unhealthy alcohol may have resulted from interactions between factors at the level of the individual, mesosystem and macrosystem which have yet to be uncovered.

Priester and colleagues (2016) identified a full range of individual (discussed above) and structural barriers to accessing or completing treatment. Structural barriers

included: poor provider training (only 10% of providers feel prepared and many are underqualified), limitations in service availability (wait-lists), inadequately provided services (provider biases and unclear best-practices), coverage issues for insurances/policies, racial/ethnic disparities in access/utilization of services, and under-identification of comorbidities (Priester et al., 2016). Even once an individual has accessed treatment within their community the effectiveness of treatment generally relies on the adequate provision of evidence-based treatments for unhealthy alcohol use. Poor performance could be attributed to both the experience and interpretation of clinical indicators of treatment outcome (e.g., base rate of risk predictors and treatment-unrelated regression toward the mean [Adamson et al., 2009]). However, optimal treatment outcome could also depend on influences both within and outside the therapeutic setting.

An example of a structural change having occurred outside of the therapeutic setting included the use of continuing care interventions, such as the Alcohol Therapeutic Interactive Voice Response (ATIVR: Rose, Skelly, Badger, Ferraro, & Helzer, 2015). This approach used daily call-ins over four months which supported daily monitoring, provided feedback on progress, and engaged patients in their use of coping skills. Following a Cognitive Behavioral Therapy treatment, ATIVR was more effective in maintaining a low frequency of drinking over the four months of implementation (though no differences at the one-year follow-up) within those who were abstinent at the end of treatment (Rose et al., 2015). This is one example of an intervention made at the level of the community care model; however, many other changes could be made to intervene in patient education, access of services, and continuity of care for patients struggling to

change unhealthy patterns of alcohol use. Accordingly, continued learning about the influence of the community has yet to have provided clarification of the specific effects of community support on alcohol use, community-wide access to alcohol use, and specific supports/barriers to treatment within a community setting.

As researchers have strived to better understand the impact of local communities on an individual's patterns of alcohol use, this paper has attempted to explore factors constructed socially and culturally which have impacted recovery from unhealthy alcohol use. As the field has grown to examine larger factors that attempt to classify similar groups of individuals, researchers have increased their emphasis on data-analytic strategies. These data-driven methodologies have supported inferences of homogeneity within a classification, be it an individual-, community- or societal-level factor, and focus, ultimately, on causality to an identified outcome. As such, the remainder of this paper has been focused on implementation of multiple analytic methods (data-driven and theory-driven) in order to have continued the burgeoning literature that has focused evidenced-based treatments for the recovery from unhealthy alcohol use.

The Current Study

This study addressed two aims: 1) having used a data-driven approach to identify predictors (across the levels of the Bronfenbrenner model (Sudhinaraset et al., 2016) of AUD treatment outcome and 2) having confirmed a model of recovery from use driven by the above literature. The study sample consisted of individuals who attended Day One (a community-level intensive outpatient treatment center associated with the University

of Vermont Medical Center) from June 2011 – June 2012. As Day One has recently celebrated 30 years of providing treatment for co-occurring substance use and mental health disorders, it was timely to have examined the outcomes of Day One clients. A retrospective data set has been compiled (by the author) that includes multiple variables, many of which directly overlapped with factors identified above, others which have adequate proxy variables, and still others that represent additional constructs yet to formally assessed.

Despite the advances which have occurred within the field of alcohol treatment, uncertainty has remained surrounding the definition of successful recovery from use, effective measures of alcohol use outcomes, reliable predictors of treatment outcome, and ability to generalize predictors of outcome across communities experiencing unhealthy alcohol use. In terms of generalizability, Grant and colleagues (2015) stated that samples of patients with alcohol dependence (AD) alone have been, “most typically represented in clinical trials of AD interventions, since they are a “clean” clinical trial population for whom the clearest inferences may most readily be drawn.” However, this group identified that individuals with AD alone represented only a portion of the community who have experienced unhealthy alcohol use, and may have increased likelihood of having remitted from use independently or with limited treatment (Grant et al., 2015; Mccutcheon et al., 2014; Storbjork & Room, 2007). Thus, this study has examined the predictors of treatment outcome within a sample of patients which has not limited, via inclusion/exclusion criteria, the variability in levels of baseline alcohol use and comorbid mental health and/or substance use diagnoses.

Further, the current study has used both a data-driven approach to identifying predictors of treatment outcome, and subsequently a theory-driven approach to consider if a model of recovery could be substantiated within a community treatment program. Whelan and Garavan (2014) stated that within, “the general linear model, optimism [the degree of overfitting to the sample increased] as a function of the decreasing number of participants and the increasing number of predictor variables in the model.” Though optimism could be assessed by a number of means (as described by Whelan and Garavan 2014), the utilization of nested cross-validation, as occurs within the Elastic Net Regularization approach, supported the identification of predictors that were statistically shown to relate to treatment outcomes, a marker of consistency and – perhaps – generalizability. In addition to the Elastic Net Regularization approach, we employed cross-validation which ensured optimization of the outcome variables and nested cross-validation to adequately define the model metrics (e.g., alpha and lambda). Using randomly generated 10-fold cross-validation, a model was developed within a sub-sample of participants (90% of the study group [e.g., the training set]) and tested for accuracy within a completely independent sub-sample (the remaining 10% [e.g., the testing set]). As this process was repeated, such that each 10% sample has been the “testing set,” the degree of over-fitting between each proven model was compared. Simultaneously, the penalties within the Elastic Net Approach were optimized within the training set via nested cross-validation. This paper used this novel approach to the analytic method, as it has provided greater clarity about the factors that *reliably* predicted outcomes for the treatment of unhealthy alcohol use.

The first objective of this study was the use of data-driven methodology to have examined the predictors of AUD treatment outcome within a community sample representative of outpatient treatment facilities within Vermont. Demographic (gender, employment, SES), substance-use (motivation to change and severity of use), sociological (general family social support, general friend social support, and changes in specific support for alcohol use), and psychological (rating of anxiety, rating of depression, and overall psychiatric severity) variables were used to identify significant predictors of reduced frequency of alcohol use following treatment. The Elastic Net Regularization approach prevented model overfitting by having estimated the accuracy of ‘significant’ variables and strength of generalizability to other treatment samples. Having collected data within a longitudinal sample of treatment seeking clients in a community clinic has aided this goal of obtaining generalizable results.

The second objective of this study was to determine the feasibility of applying theory-driven variables in having predicted changes in an individual’s frequency of unhealthy alcohol use following an abstinence-based treatment (e.g., the recovery model; Figure 2). This second hypothesis asserted the level of psychological symptoms would mediate the relationship between treatment outcome and baseline characteristics of the individual (including individual, microsystem, mesosystem, and macrosystem level variables). The literature has supported the development of a theoretically-driven psychosocial model, first proposed in this article. This model was used to examine the predictors of treatment outcome assessed at the initiation of treatment. Variables which

represented individual, microsystem, mesosystem, and macrosystem predictors, as well as psychological symptoms, were used to model alcohol treatment outcome.

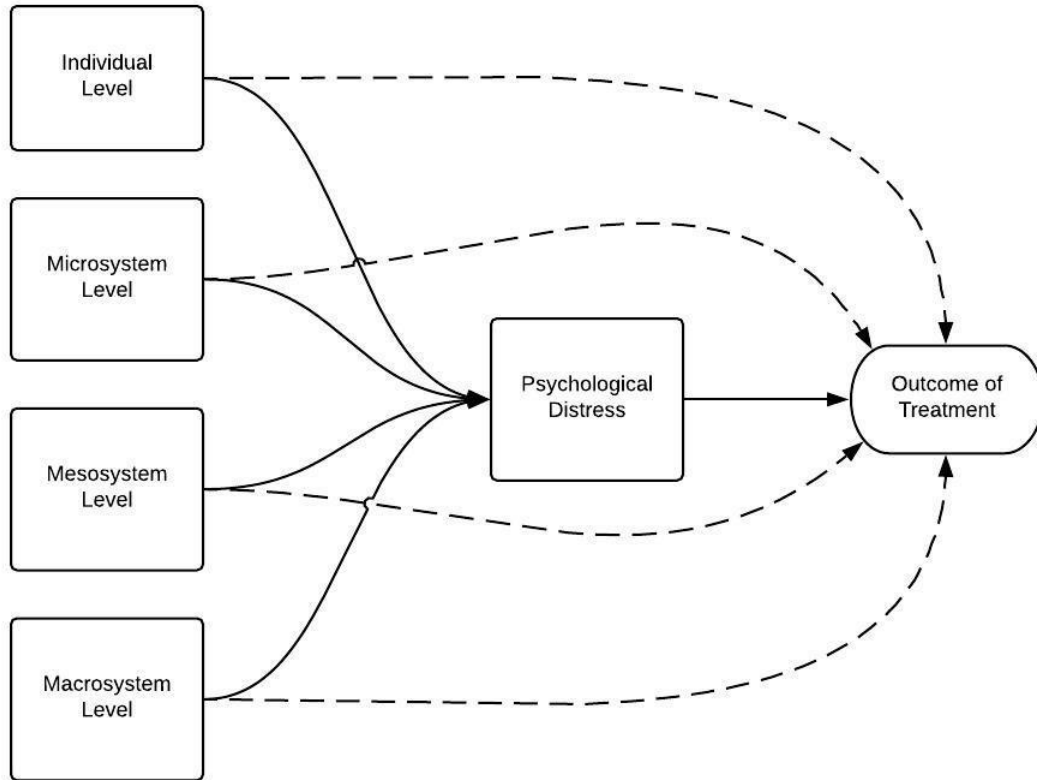


Figure 2: Theoretically-driven mediational model, demonstrating the impact of Individual, Microsystem, and Macrosystem level predictors being mediated through psychological distress to predict outcomes of treatment for unhealthy alcohol use.

Methods

Collection of Retrospective Data:

Records were reviewed from patients seen at Day One from June 2011 - June 2012. First, 250 variables were identified by the study team for inclusion in the research database. Prior to collecting this information, protocol exemption was finalized with the Committees on Human Subjects (CHRMS: 16-009) due to the plan to complete a routine de-identification step. Data coding was performed both to protect the identity of the patients included in the dataset and to minimize researcher bias during the analytic process. Each patient's data was double-entered from paper charts, and data quality was assessed by identifying discrepancies between the two entries and resolving these with the paper (source) record.

Inclusion Criteria:

Inclusion criteria were minimal and included having completed an intake appointment and identifying alcohol use as a primary or secondary treatment target. Figure 3 shows the 323 total referrals (or self-referrals) during the study period; and the exclusions resulting in a final sample of 145 subjects who met inclusion criteria. For patients who began treatment more than once during the study period (N=7) only their first entry into the program was included. Other reasons for exclusion included: missing files (N=31; at referral [n=26] or post-intake [n=5]) and cancelled/missed intake appointments (N=43). Of the 145 patients seeking treatment for unhealthy alcohol use 121 identified alcohol as a primary issue and 24 as a secondary issue.

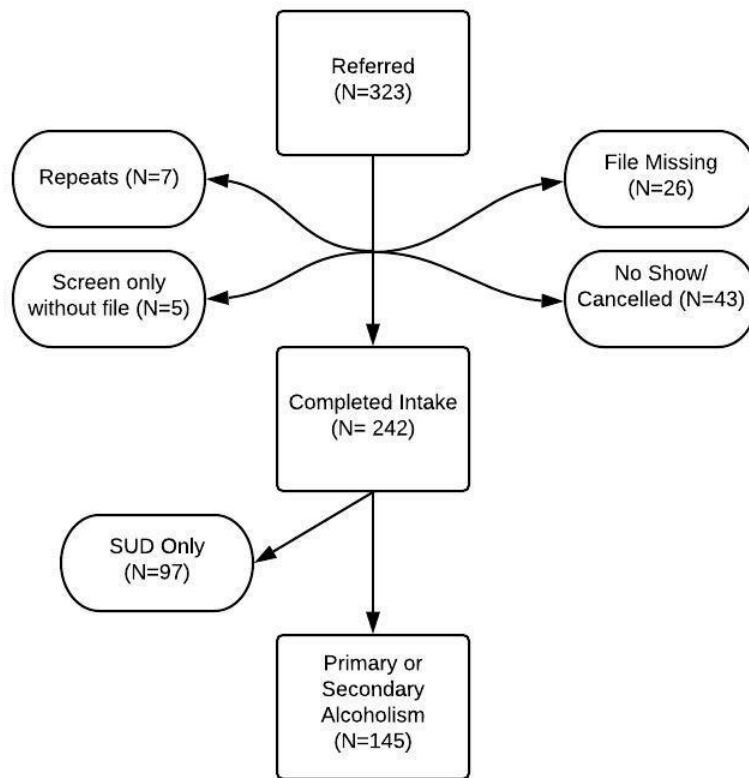


Figure 3: Flow chart of inclusion from referral to final research database.

Outpatient Treatment Setting:

A full description of the Day One outpatient treatment setting is provided in *Appendix 1* (Messina, Keithcart, Brown, Dees, and Reed ; unpublished). The Day One program is a long-standing division of the University of Vermont Medical Center’s (UVM-MC) Psychiatry department, which supports the treatment of co-occurring substance use and mental health disorders within an outpatient treatment setting. Treatment at Day One involves customization of treatment intensity (from one to three sessions per week), integration of comorbidity treatment, psychiatric intervention, and other treatment group specialties. These services are provided by four Licensed Alcohol

and Drug Counselors (LADCs) along with a psychiatrist. Together the team provides an ongoing assessment of active substance-related and mental health concerns and provides therapeutic groups, individual sessions, and medical interventions to support abstinence-based recovery.

Data Collection:

Data were collected at five points: phone screen, intake assessments, in-person interview, in-session measures, and treatment termination summary (Table 1). A description of the patient's experience while engaging in these assessments can be garnered from Messina et al. (*Appendix 1*).

The Phone Screen identified the current substance use and mental health concerns of patients and determined if Day One services were appropriate (e.g., appropriate level of care and ability to meet expectations for treatment). Appropriate patients were scheduled to visit the facility to complete an intake assessment packet.

The Intake Assessments were a series of self-report and computerized measures, completed at Day One, that assesses a wide array of information across substance use, mental health, demographic, and social domains. Following the completion of these documents, patients were scheduled for an in-person session with one of the counselors.

The goals of the In-person Interview were to: 1) obtain informed consent for Day One clinical services and 2) develop a collaborative treatment plan based on American Society of Addiction Medicine (ASAM) criteria. During the interview clinicians collected patient motivation for treatment, stage of change, urine drug screen, and a strengths-based description of treatment goals. Prior to the initiation of treatment, all

patients were described to the clinical team who collaboratively assigned an appropriate level of care to the patient according to clinical best-practices.

In Session Measures were completed by both the clinicians and patients addressing attendance, patterns of use, and changes in level of service. At each session, clinicians recorded attendance (attended, cancelled, no-showed) and maintenance of abstinence. When patients were in attendance, they were regularly requested to report their success with maintaining abstinence since the last attended session. Further, patients were requested to complete urinalysis, influenced by patterns of non-abstinence, which provided confirmation of both alcohol and illicit substance use.

A Treatment Termination Summary was completed via formal assessment between the patient and clinician. This included treatment duration and completion, current alcohol and substance use and overall functioning. The clinicians prepared a discharge summary including mental health diagnoses, treatment attendance, and details of discharge. In collaboration with the Day One treatment team, several metrics of treatment dosage were developed from content collected at termination, including months in treatment, relative measures of treatment engagement (i.e., dosage, compliance, non-compliance), and grouping into a measure of completer status (Attendance Grouping).

Table 1: Summary of the timeline of variable collection according to the point in which each measure was completed by client and/or mental health clinician. Red Variables were removed from the dataset due to missingness, or issues with data quality.

Phone Screen	Intake Assessment - Continued	Interview	During Treatment	Termination - Continued
Demographics	Initial Substance Use Status	Demographics	Outcome Substance Use Status	Outcome Substance Use Status
· Age	· ASI Alcohol Severity	· Education	· Clean Samples	· Reason for discharge
· Gender	· ASI Drug Severity	· Employment Status	· Unclean Samples	· Pattern Frequency improvement
	· ASI Alcohol Composite	· Living Situation	· Percent Clean Urine Drug Test	· Overall Functioning
Initial Substance Use Status	· ASI Drug Composite	· Arrests at Onset	· Abstained Sessions	· Route Alcohol
· # of days abstained from alcohol	· Family History of substance use		· Non-abstinence Sessions	· Outcome Frequency of Alcohol use
· # of days abstained from drug	· Previous Treatment	Initial Substance Use Status	· SR Non-Abstinence	· Outcome Social Connectedness Alcohol
		· Age of Onset Alcohol	· SR Abstinence	· Route Secondary Substance
		· Route Alcohol	· SR Missing	· Frequency Secondary Substance
Intake Assessment	Psychological Status	· Initial Frequency of Alcohol use	Treatment Dosage	· Alcohol Change Score
Demographics	· Beck Anxiety Inventory	· Initial Social Connectedness Alcohol	· Scheduled Sessions	· Secondary Substance Change Score
· Race	· Beck Depression Inventory - II	· Age of Onset Secondary Substance	· Attended Sessions	
· Ethnicity	· Beck Scale for Suicide Ideation	· Route Secondary Substance	· Cancelled Sessions	
· Relationship Status	· ASI Psychiatric Severity	· Frequency Secondary Substance	· No-show Sessions	Treatment Dosage
· ASI Employment Severity	· ASI Psychiatric Composite	· Social Connectedness Secondary Substance	· Transition Service	· Months in Treatment
· ASI Legal Severity		· Relapse Risk	· Number of Identified Goals	· Attendance Grouping
· ASI Family/Social Severity		· Relapse Risk Code		· Percent Planned Sessions
· ASI Employment Composite	Health Status	· Readiness to Change	Termination	· Treatment Dosage
· ASI Legal Composite	· ASI Medical Severity		Psychological Status	· Treatment Compliance
· ASI Family/Social Composite	· ASI Medical Composite	Psychological Status	· Final AxisI Diagnosis	· Treatment NonCompliance
· Onset psychiatric services	· Care Access	· Initial AxisI Diagnosis	· Final AxisII Diagnosis	· Discharge Date
· Onset therapeutic services	· Insurance Coverage	· Initial AxisII Diagnosis	· Final AxisIII Diagnosis	· Clinician Reported Sessions Attended
· Onset primary care physician	· Transportation Difficulties	· Initial AxisIII Diagnosis	· Final AxisVI Diagnosis	· Aftercare plan
· Financial Struggle	· Other Access problems	· Initial AxisVI Diagnosis	· Final AxisV Diagnosis	· Total progress
· Financial Struggle Degree	· AIDS Risk	· Initial AxisV Diagnosis	· Change AxisV (GAF)	· Progress towards goals

Nested Variables:

Using the Bronfenbrenner model, variables were reviewed according to when they were collected (Table 1), and which level (individual, microsystem, and mesosystem/macrosystem) they represented in the model (Table 2).

Individual Level Variables: At the level of the individual, four classes of data were collected: substance use status (pre- and post-treatment), psychological status, health status, and demographic variables.

Baseline measures of alcohol and drug use severity were assessed via the Addiction Severity Index (ASI) during the initial intake assessment. The ASI is an interview-based instrument that assesses for potential problems among domains commonly impacted by substance use. These include: Medical, Employment/Support Status, Alcohol, Drug, Legal, Family/Social, and Psychiatric domains. Within the Day One program a multimedia version of the ASI was used, which allowed patients to complete the assessment at their own pace. Number of days abstained from alcohol and drug were collected during the initial phone intake and the remainder of the variables assessing baseline substance use status were collected during the screening interview. These included a description of all substances used (including substance class, age at onset, route of administration, and frequency of use), readiness to change use, previous treatment, and a clinician-assessed risk of relapse. Among the substance use variables were data collected during and after treatment completion. Those variables collected during treatment included clinician and self-reported abstinence and non-abstinence sessions. Post-treatment variables focused on the changes in secondary substances, including route, frequency, relative pre-post change in use.

Among the psychological variables, the majority were assessed in the initial intake material. Self-reports were completed, including the Beck Anxiety Inventory (BAI: Beck & Steer, 1993), Beck Depression Inventory – Second Edition (BDI II: Beck & Brown, 1996), Beck Scale for Suicide Ideation (BSS: Beck & Steer, 1991), and a measure of psychiatric severity via the ASI (McLellan et al., 1992). The BAI is a 21-item self-report measure which allows patients to describe subjective, somatic, and/or panic-

related symptoms of anxiety on a scale from zero to three. Similarly, the BDI-II allows patients to self-report via 21-items on their experience of symptoms of depression with ratings made on a scale from zero to three. Finally, the BSS assesses for a patient's suicidal intent via self-report on five screening items and sixteen follow-up items each with scales from zero to three. In addition, each patient completed a psychological assessment during the screening interview to determine diagnoses according to each of the Diagnostic and Statistical Manual of Mental Disorders – 4th edition (DSM-IV: APA, 2013) axes (i.e. Axis I-V). All the variables assessing health were collected within the initial intake paperwork and interview. Patients self-reported AIDS risk, and overall medical severity via the ASI. Finally, patients reported a range of demographics in the initial intake paperwork, including their age, gender, race, ethnicity, educational attainment, and employment status.

Microsystem Level Variables: At the level of the patients' microsystem (Table 2), data was characterized primarily by demographic variables collected from the initial intake paperwork. This level targeted the influence of the patients' immediate social influences; those individuals – may also be influences of objects or symbols – who participated in the life of the developing person on a fairly regular basis over an extended period of time (Hardcastle, Byrnes, Bartlett, Denton, & Walsh, 1981; pg. 22). The most direct assessment of these influences came from the ASI wherein patients report the level of distress/impairment within their family/social network. Additionally, patients provided a report of their relationship status (single, married, missing) and living situation. Finally,

each patient reported their family history of substance use prior to the initiation of treatment, within the initial intake paperwork.

Mesosystem Level Variables: At the mesosystem level, variables addressed the relationships that exist between two or more settings/microsystems (Hardcastle et al., 1981; pg. 25) and covered four classes of data: treatment dosage, demographics, substance use status (pre- and post-treatment), and health status variables. Patient-specific data was collected throughout treatment and after termination regarding patient's engagement and process of treatment. These included measures of attendance (e.g., scheduled, attended, cancelled, and no-show sessions), relative dosage of treatment, compliance and non-compliance, duration of treatment, and progress towards their goals. Many of the factors assessing duration of patient engagement were adjusted based on each patients' level of engagement, including percent planned sessions (attended/individual session goal), treatment dosage (attended/scheduled sessions), treatment compliance ([attended + cancelled sessions]/scheduled sessions), treatment non-compliance (no show/scheduled sessions), and progress towards treatment goals (number of identified goals/achieved goals at termination of treatment).

Demographic variables addressed participant's involvement with the legal system (number of arrests and ASI-assessed problems), employment concerns, and community treatment engagement (e.g., utilization of psychiatric, psychological and medical care). Each patient was also assessed, via interview, for their substance-specific social engagement for both alcohol and secondary substances prior to treatment initiation and for alcohol alone after treatment completion. Most patients provided a reason for

terminating treatment (completed, client left against medical advice, terminated by facility, transferred to another substance abuse treatment program, incarcerated, death, and other) and completed urine drug screens as determined to be necessary by the treating clinician. Finally, patients provided a dichotomous report, in the initial intake paperwork, of challenges they were experiencing surrounding access to care, insurance coverage, transportation difficulties, and other access problems.

Macrosystem Level Variables: The processes between two or more settings (at least one without the individual) which indirectly contribute to their development, are identified as the macrosystem variables (Hardcastle et al., 1981; pg. 25). These include two discrete variables which assessed the degree of financial struggles each patient was experiencing, both via Yes/No and Likert-scale scores. This data was collected in the intake assessment.

Table 2: Variables extracted from Day One client records

Individual Level Factors	Individual Level Factors	Microsystem Level Factors	Mesosystem Level Factors	Macrosystem Level Factors
Psychological Status	Pre-Tx Substance Use Status	Pre-Tx Substance Use Status	Demographics	Demographics
BAI	Days Abstain Alcohol	Family History	ASI Legal Severity	Financial Struggle
BDI II	Days Abstain Drug	Demographics	ASI Family/Social Severity	Financial Struggle Degree
BSS	ASI Alcohol Severity	Relationship Status	ASI Legal Composite	
ASI Psychiatric Severity	ASI Drug Severity	ASI Employment Severity	ASI Family/Social Composite	
ASI Psychiatric Composite	ASI Alcohol Composite	ASI Employment Composite	Psychiatrist	
Initial AxisI Diagnosis	ASI Drug Composite	Living Situation	Therapist	Outcome Variables
Initial AxisII Diagnosis	Alcohol Age of Onset		PCP Intake	
Initial AxisIII Diagnosis	Alcohol Route	Mesosystem Level Factors	Arrests Onset	Total progress
Initial AxisVI Diagnosis	Alcohol Frequency	Treatment Dosage		Progress towards goals
Initial AxisV Diagnosis	Secondary Substance Age of Onset	Months in Treatment	Post-Tx Substance Use Status	
	Secondary Substance Route	Scheduled Sessions	Reason for discharge	Post-Tx Substance Use Status
	Secondary Substance Frequency	Attended Sessions	Alcohol Social Connectedness	Pattern Frequency improvement
Health Status	Relapse Risk	Attendance Grouping	Clean Samples	Overall Functioning
ASI Medical Severity	Relapse Risk Code	Cancelled Sessions	Unclean Samples	Alcohol Route
ASI Medical Composite	Readiness to Change	Noshow Sessions	Percent Clean UDT	Alcohol Frequency
Aids Risk	Previous Treatment	Percent Planned Sessions		Alcohol Freq Change
		Tx Dosage	Health Status	Alcohol_changescore
		Tx Compliance	Care Access	
	Post-Tx Substance Use Status	Tx NonCompliance	Insurance Coverage	
Demographics	Secondary Substance Route	Transition Service	Transportation Difficulties	Final AxisV Diagnosis
Age	Secondary Substance Frequency	Discharge Date	Other Access problems	Change GAF
Gender	Secondary Substance changescore	Clinician Reported Sessions Attended		Change Education
Race	Abstained Sessions	Aftercare plan	Pre-Tx Substance Use Status	Change Employment
Ethnicity	Nonabstinence Sessions	#Identified Goals	Alcohol Social Connectedness	Change Living Situation
Education	SR NonAbstinence	Treatment Plan Duration	2 Substance Social Connectedness	
Employment Status	SR Abstinence	Treatment Plan Sessions		
	SR Missing			

Treatment Outcome Variables

From the data collected, there were a number of variables that could have been utilized as a potential outcome variable (Table 2). As described in the Definition of

Terms section (page 10), the metrics for assessing a recovery-oriented treatment outcome has been debated. For this study, the assessment of the frequency of alcohol use at the termination of treatment was selected as it was consistently recorded in a standard manner and is generally consistent with recommendations from the literature (Allen, 2003; Anton & Randall, 2005; Sobell et al., 2003), e.g., focused on a measure of the amount and/or frequency in alcohol use. Of note, variables that measure other indicators of successful treatment including progress made towards treatment goals, global metrics of functioning, and measures of wellbeing are clinically important changes; however, a metric directly related to alcohol use was selected as the outcome variable for this study.

Data Analysis:

Objective 1 Analysis: Elastic Net Regularized Linear Regression

In accordance with the primary objective of this study, a novel, data-driven methodology was employed to identify factors which predicted the frequency of alcohol use. The Elastic Net Regularization Approach was selected for the ability to enable shrinkage of the model, automatic selection of significant predictors, and independent selection of highly correlated variables (Zou & Hastie, 2005). The Elastic Net Regularization approach allows correlated variables to remain in the regression model, which is a desirable characteristic given the inter-correlations among the variables in Table 2. A ten-fold cross-validated regression framework was used for model building and to improve out-of-sample prediction. Within this study, the approach assessed the

predictors of the frequency of unhealthy alcohol use following engagement in substance abuse treatment via the Day One Intensive Outpatient Program.

Prior to any data analysis, 25 subjects (approximately 17% of the sample) were selected as a “set-aside” sample. This group was not used in model building, but rather was an independent test set in which the final model was tested. The set-aside sample was stratified on subject age (Control= 37.96 [StDev=15.5255]; Testing= 38.3167 [StDev=12.4509]), gender (Control= 40% female; Testing= 36.7% female), and education (Control= 13.48 [StDev=2.4685]; Testing= 13.8583 [StDev=2.4402]).

The remainder of the data was used in the development of a model using the elastic net regularization approach and 10-fold cross-validation. This approach included two essential components: 1) k-fold cross-validation of the regression model within the “outer-fold” and 2) nested, k-fold tuning of the parameters (alpha and lambda) within the “inner-fold.”

Within the outer-fold, 10-fold cross validation was used to develop a series of models from which the predictive strength of each variable was assessed. Within this approach a “training” set (k-1 of the folds; [n=108]) was used to develop a model of regression coefficients for each variable in relation to its prediction of the outcome variable (outcome frequency of Alcohol use). Finally, the model was tested for accuracy in the remaining data (the “testing” set, comprised of the last fold [n=12]). The predictive utility of this model was assessed by computing a receiver operator characteristic (ROC) curve and was summarized as the area under the curve (AUC). This process was repeated such that each fold was used as a testing set. The following 10 models were then utilized

to identify every variable which had shown significant predictive utility in a given model within the outer-fold analysis. This process was repeated ten times with each fold serving as the testing data once.

Within the inner-fold, 9-fold nested-cross-validation of the “training” set was used to tune the optimal values of the parameters (alpha and lambda). Similar to the outer-loop, the process used a k-fold strategy that examined a series of ten values for alpha (between zero and one) and lambda (logarithmic scale), which resulted in a parameter grid with 100 possible values. The models for each of these possible sets were developed on eight of the folds (n=96) and tested on the 9th fold (n=12). The AUC of these models was used to determine the optimal parameter set for the training set, which occurs independently for each of the ten outer-loops. These parameters added penalties to an ordinary least squares regression which optimized the variables included in the final model. It did so by managing the balance between the lasso penalty (influence on variable reduction) and the ridge penalty (degree of constraining correlated variables) as a function of the selected alpha, as well as the weight of the shrinkage/constraint these penalties had on the model as a function of lambda. In addition, the nested cross-validation approach removed cross-contamination that would have otherwise unduly increased the generalizability of the study (described further in Whelan & Garavan, 2014).

Following the development of these models, the variables that were identified as sufficiently predictive of outcome were remodeled on the sample of 120 individuals which enhanced the accuracy of the model coefficients, using parameters of alpha and

lambda that were specifically optimized for the full test sample. This optimized model, including the parameters, was tested on the set-aside group which assessed the generalizability (via AUC) of the final model to a separate group of data.

Objective 1: Data Cleaning

Prior to the completion of the elastic net regularized regression the data was assessed for missingness, and variables with more than 20% missingness were removed (see Data Cleaning below). Given that this data was from patient records, a certain amount of missing data was expected, thus a cutoff of 20% missingness within a subject was applied, which did not result in removal of any subjects. Variables were tested for normality and skewness and/or kurtosis was recorded such that the impact on outcomes could be considered. Because of the strength of the elastic net regression and preference for interpretability, only limited data transformations were completed (see the results section). Outliers were defined as greater than 2.5 standard deviations above the variable mean and again recorded for interpretation of effect on the study results.

Objective 2: Application of a Theoretically Derived Model

The second objective of this study was to test a theory-driven model of predictors of treatment outcome. Variables were selected as they applied to the reviewed literature for predictors of the initiation and maintenance of unhealthy alcohol use (Table 3). We expected psychological symptoms to mediate the impact of individual, microsystem, mesosystem, and macrosystem level predictors on treatment outcome (as depicted in

Figure 2). Variables were limited to those collected before treatment began (i.e. baseline characteristics) as mental health variables were only collected at one time point. First, variables were assessed for a significant correlation to the outcome variable to determine the appropriateness of inclusion into the regression model. To reduce redundancy, where two variables represented the same construct both theoretically and statistically (correlation >0.5), one of the variables was removed. Path analysis was performed to test the theoretical model (Figure 2). All analyses were conducted using the SPSS System's PROCESS macro, version 3.2 (Hayes, 2017). These analyses used maximum likelihood estimation and were performed on the variance-covariance matrix. Due to the relatively small sample size, the results of the path analysis should be considered exploratory.

Table 3: Theory-driven variables selected from Day One retrospective data collection and described in relation to predictors of initiation and maintenance of unhealthy alcohol use within the literature

Individual Factors	Description of influence from the literature
Readiness to Change	Contribution of initial sensitivity of alcohol use and ongoing influence of motivational readiness, or the balance between self-efficacy and temptation (Positive Reinforcement)
ASI Alcohol Severity	Development of tolerance and withdrawal avoidance in the early stages of addiction and ongoing increased risk for maintenance and relapse for individuals with high severity of alcohol use
Alcohol Frequency	Development of tolerance and withdrawal avoidance in the early stages of addiction and ongoing increased risk for maintenance and relapse for individuals with high severity of alcohol use
Relapse Risk	A conglomeration of factors contributing to the occurrence of relapse likely to include stress reactivity, emotional impulsivity, motivations for use, and barriers to treatment engagement
Microsystem Factors	
ASI Family/Social Severity	Initial influences of motivations for social conformity and ongoing difficulties managing distress within their social support setting
Mesosystem Factors	
PCP Intake	Initial influences of social disadvantage and bio-psycho-social consequences as well as ongoing structural inequalities in the availability, adequacy and comprehensiveness of available treatments
Psychological Distress	
Beck Depression Inventory - II	Predisposition for psychological distress and ongoing disruption individually and interpersonally in the individuals functioning

Data Cleaning

As described above, variables were assessed for missingness and removed using an 80% cut-off rule (no more than 20% missingness). This resulted in several variables being removed from the dataset (Table 1). These included all of the variables assessing a tertiary substance use concern, as well as details of drug use behaviors, baseline relationship status, creation of an aftercare plan, and clinician rated relapse risk. For patients reporting a secondary substance concern (n=58) substance use frequency pre/post was retained in the data set as 80% of the sub-set had complete data. Data on secondary substance use was re-coded to include all subjects (i.e. a new category was generated (coded as 0), indicating no history of reported unhealthy use). For the variable of days since last substance use, non-users were given a maximum value of the age of the patient in days. All missingness was corrected utilizing basic imputation strategies which were based on the format of the variable, as well as metrics of normality. For categorical variables and those with distribution issues (skewness or kurtosis), the median value of the variable was used. For continuous variables with normal distribution the mean of the variable was used. Finally, several variables were excluded as not relevant to the analysis (i.e. discharge date, route of alcohol use), or because they were not able to be meaningfully coded (mental health diagnoses, treatment plan sessions, reason for discharge, termination summary, change in demographics during treatment).

Missingness was also assessed at the level of the participant, and no records were removed (i.e. no subject had >20% missingness). Sixteen variables were found to include outliers, defined as greater than 2.5 standard deviations above the variable mean. These

were not removed as the analytic method is robust to outliers, and none of the variables could be determined to be invalid. Three variables had 4 or more outliers AIDS Risk (5 outliers); Clean Urine Samples (4 outliers); Self-Reported Non-Abstinence (4 outliers). Though no corrections were made for these variables, they are noted to aid in considering the potential influences on the data analysis.

Results

Study Sample:

Demographics of the 145 subjects included are presented in Table 4, including characteristics of co-morbid substance use and other mental health concerns. Referral sources included the legal system, substance use treatment programs (residential, outpatient, and dual diagnosis), mental health services (outpatient, IOP, inpatient), primary care providers, student health, employee assistance programs, and self-referrals.

Table 4: Demographics of the patient sample

Gender		Racial Identity		Co-Morbid Disorders	
Male	91 (63%)	Caucasian	140 (97%)	None	51 (35%)
Female	54 (37%)	American Indian	1 (1%)	Substance Use Disorder(s)	34 (23%)
Age		Black/African American	3 (2%)	Mental Health Disorder(s)	34 (23%)
18-29	45 (31%)	Bi-racial	1 (1%)	SU & MH Disorders	26 (19%)
30-45	51 (35%)	Ethnicity		Attendance	Avg (StDev)
46-60	42 (29%)	“Non-Hispanic”	145 (100%)	Attended Sessions	12.1 (13.25)
60+	7 (5%)	Outcome frequency of Alcohol use		Cancelled Sessions	2.4 (3.01)
Marital Status		None	89 (61%)	No-Show Sessions	1.6 (2.59)
Married	34 (23.5%)	1-3/month	37 (26%)	Time to Initiation	Avg (StDev)
Single	77 (53%)	1-2/week	11 (8%)	Days to Intake	18 (45.54)
Not Reported	34 (23.5%)	3-6/week	4 (3%)	Days to Treatment	11 (20.62)
		Daily use	4 (3%)		

The gender distribution (37% Female) was consistent with national prevalence rates (NSDUH, 2016). Age appeared evenly distributed with an average of 38.26 years (SD=12.97). The racial diversity of the patient sample was consistent with that of the

demographic area, including when the sample was compared to government estimates for Chittenden county ($X^2=2.034$, $p=0.565$: US Census Bureau, 2016). However, the sample notably did not include any patients of Latino/a ethnicity. Most of the sample was single (53.1%), though marital status had the largest degree of unreported data (23.45%). On average, it took a little over two weeks (18 days) from referral to completion of the intake assessment, and 11 days from intake to beginning treatment. Once engaged in treatment, patients completed an average of 12 sessions, with 2.4 cancelled and 1.6 no-show sessions. Treatment resulted in 61% of participants reporting abstinence at the end of treatment (Table 4).

Objective 1:

Prior to the initiation of the Elastic Net Regularization approach, four multi-level, categorical variables were transformed to continuous variables to capture the full variance of patient responses. For example, the initial frequency of alcohol use was originally an ordinal variable (levels 1 through 5) and was transformed to be a quantitative measure of occurrences of alcohol use within the past month (0, 2, 6, 18, 28). Variables that were transformed included initial frequency of alcohol use, social connectedness (i.e. having a recovery community) both at the start and end of treatment, and onset secondary substance use frequency. Alcohol frequency at the end of treatment (the outcome variable) was kept categorical due to wide variation between participants (Mean = 2.30, St.Dev. = 5.41) and the non-normality of the resulting distribution (skewness = 3.70 and kurtosis = 13.80).

To contend with issues of generalizability and model overfitting, (as noted by (Whelan & Garavan, 2014), the full analysis (detailed below) was run 9 times using different random seeds for randomization of subjects into the k-fold structures. The results were assessed for the overall consistency of the predictive models via two types of data: 1) model performance (e.g., the variability in the degrees of freedom and % variance explained by each model) and 2) variable consistency (e.g., frequency of occurrence in the final model).

The set of nine models demonstrated fairly wide variation in the number of predictors (degrees of freedom) and a great deal of consistency in explanatory power. As seen in Table 5, the number of variables for each model ranged from 14 to 31. This suggested that the characteristics of the group influenced variable selection at the sub-run level. Interestingly, these models were relatively consistent in the amount of variance explained (average adjusted $R^2 = 0.316 \pm 0.025$; range 0.264 to 0.345). The stability of model performance suggests a strong underlying model with several variables that were impacted by the particular patients randomized into a given fold.

Table 5: Replication of Final Restricted Model for the prediction of outcome frequency of Alcohol use following abstinence-based treatment

Run	DOF	R ²
1	19	0.32635
2	19	0.32635
3	31	0.34488
4	26	0.26416
5	23	0.31251
6	19	0.33045
7	18	0.28475
8	23	0.32678
9	14	0.32509
AVG (StDev)	21.33333 (5.02549)	0.315702 (0.0253)

The second metric of the generalizability of the elastic net models was variability across runs. In the examination of the 9 final restricted models, a total of 40 variables were present in at least one of the models (Table 6). Variables were categorized based on the consistency of inclusion within a model across the 9 models, which resulted in a frequency of a variables occurrence ranging from 0%-100%. This data was used to categorize variables into high (>75% of models), medium (between 25% and 75% of models), and low (<25% of models) frequency groups. Across the nine runs there were 15 high frequency, 7 medium frequency, and 8 low frequency variables. As depicted in Table 6, variables indicated as predictive within fold-based models were found to be significant in an average of approximately four final, restricted models. In addition, 10 variables were only predictive at the level of the folds within a run (e.g., produced no significant coefficient in a final, restricted model). The most consistent variables were individual patient characteristics and treatment process variables; however, social systems and societal level variables were also present.

Table 6: Variables reported across the nine runs to be predictive of the frequency of alcohol use following abstinence-based treatment

Final Variables	Variable occurrence within final model		Models
	# of models	% of models	
INDIVIDUAL			
ASI Drug Severity	0	0%	None
ASI Medical Composite	0	0%	None
Employment Status	0	0%	None
Initial Axis I Diagnosis	0	0%	None
Self-Reported Abstinence	0	0%	None
Age	1	11%	3
Number of days abstained from drug use	1	11%	3
Race	1	11%	3
Number of days abstained from alcohol	2	22%	3, 8
ASI Inconsistency	4	44%	1-4
ASI Drug Composite	4	44%	3-5, 8
AIDS Risk	4	44%	3-6
Onset age of Alcohol use	5	56%	3-5, 7, 8
ASI Skipped	5	56%	3-6, 8
Secondary Substance Change score	9	100%	1-9
Non-abstinence Sessions	9	100%	1-9
Outcome Secondary Substance Frequency	9	100%	1-9
Beck Depression Inventory - II	9	100%	1-9
Readiness to Change	9	100%	1-9
Initial Alcohol Frequency	9	100%	1-9
ASI Alcohol Composite	9	100%	1-9
MICROSYSTEM			
Family History of substance use	2	22%	3, 8
Living Situation	2	22%	3, 4
MESOSYSTEM			
Onset therapeutic services	0	0%	None
Arrests at Onset	0	0%	None
Transportation Difficulties	0	0%	None
Scheduled Sessions	0	0%	None
Percent Planned Sessions	0	0%	None
Treatment Compliance	2	22%	1, 2
Percent Clean Urine Drug Test	2	22%	3, 4
Outcome Alcohol Social Connectedness	6	67%	1-5, 8
Treatment Non-Compliance	7	78%	3-9

Table 6 (Continued)

MESOSYSTEM (continued)			
Onset psychiatric services	8	89%	1-8
Primary Care Physician at Onset	8	89%	1-8
ASI Legal Severity	8	89%	1-8
Attended Sessions	9	100%	1-9
Months in Treatment	9	100%	1-9
Treatment Dosage	9	100%	1-9
Attendance Grouping	9	100%	1-9
MACROSYSTEM			
Degree of financial struggle	3	33%	3-5

The content and form of the nine generated models has been illustrated through the detailing of a representative, example model. In the process of generating this final representative model, ten folds were completed to establish a set of variables predictive of outcome frequency of alcohol use. We examined the consistency of variable inclusion across folds in order to recognize the potential contribution of participant randomization within the process of model generation. Examining the results of the ten folds within this model, there was notable variation in the number of variables (with degrees of freedom ranging from 7 to 24 [mode=10]) and in the regression coefficients within each of the ten fold-based models (ranging from -0.45608 to 0.46353 [mean=0.190693]). This representative model had 23 total variables, including 100% of the high frequency variables (>75% of models), 57% of the medium frequency variables (25% - 74%), and 11% of the low frequency variables (<25%).

Seventy-five percent of the fold-based models identified ASI alcohol composite, readiness to change, initial alcohol frequency, attendance grouping, Beck Depression Inventory - II, dosage of treatment, change in the level of secondary substance use at the

end of treatment, and clinician reported non-abstinence sessions which demonstrated striking consistency of the strongest predictors. Variables that appeared less consistently in the models (ranging from 40 to 10% of the fold-based models) included: treatment duration (in months), clinician-reported session attendance, relative amount of no-show sessions, ASI legal severity, ASI metric of the possibility of change in drug use problems, onset psychiatric services, days of pre-treatment alcohol abstinence, inconsistency in ASI reports, pre-treatment primary care physician, onset age of Alcohol use, family history of substance use, outcome engagement with social groups supportive of alcohol recovery, percent of the prescribed treatment completed, and the pre-post change in substance use. The strength of the regression coefficients for the predictive variables (Table 7) ranged from +/- 0.00019 to 0.92 (mode=-0.17).

Overall, the model shows that treatment non-compliance is the strongest predictor of outcome (greater non-compliance related to a worse outcome), and that variables included in the final model were represented across most of the levels of the Bronfenbrenner model.

Table 7: Representative Model of the predictors of alcohol frequency following an outpatient abstinence-based treatment program

<i>Restricted Model (minMSE+1) Variables</i>	<i>Coefficient</i>	<i>Frequency across Folds</i>
Individual		
Non-Abstinence Sessions	0.066	80%
Outcome Secondary Substance Frequency	0.02	90%
Secondary Substance Change score	0.011	10%
ASI Alcohol Composite	0.63	100%
ASI Drug Composite	0.25	20%
Initial Alcohol Frequency	0.022	100%
Beck Depression Inventory – II	0.00091	90%
Number of days abstained from alcohol	-0.00019	10%
Onset age of Alcohol use	-0.0043	10%
ASI Skipped	-0.018	10%
Readiness to Change	-0.095	100%
Microsystem		
Family History of substance use	-0.026	10%
Mesosystem		
Onset psychiatric services	0.079	20%
Outcome Alcohol Social Connectedness	-0.0019	10%
Attended Sessions	-0.005	30%
Months in Treatment	-0.0085	40%
ASI Legal Severity	-0.025	20%
Attendance Grouping	-0.17	90%
Primary Care Physician at Onset	-0.17	10%
Treatment Dosage	-0.36	90%
Treatment Non-Compliance	-0.92	30%

At the individual level, readiness to change (internalized motivations for abstinence) was consistently included (100% of the ten folds) as a negative predictor (i.e., the higher the readiness to change the lower the alcohol use at the end of treatment). In addition, initial frequency of alcohol use and the composite measure of alcohol use from the ASI were constant, positive predictors (i.e., the amount and challenges with alcohol

use directly related to greater frequency of alcohol use at outcome). Other variables in the model measured the history and degree of alcohol and drug use (i.e. duration of abstinence from alcohol and age of drinking onset), baseline depression, and alcohol use during treatment among others (Table 7). Both baseline variables and individual factors measured throughout treatment were included in the model. In summary, several individual level variables were found to be important predictors of outcome.

At the level of the microsystem, only one variable (family history of substance use) significantly contributed to the prediction of outcome. Interestingly, the direction of the relationship was that having a positive family history of substance use was predictive of a *better* treatment outcome (a greater decrease in alcohol use frequency). Further examination of this dichotomous variable using a Chi-Square analysis with Yates correction, indicated that the frequency of alcohol use at the outcome of treatment was not significantly impacted by a patients family use histories ($X^2[4, N=145] = 5.80, p = 0.22$). As presented within Table 8, there appears to be somewhat of an influence for patients having reported high frequency of use within the past month, though the sample sizes are much too small to provide conclusive evidence.

Table 8: Chi-square table demonstrating the relationship between family history of substance use and post-treatment frequencies of alcohol use.

EXPECTED NULL HYPOTHESIS Outcome Frequency of Alcohol Use	Family History of substance use	
	Yes	No
None	60 (58.3)	29 (30.7)
Mild Frequency of Use	23 (24.2)	14 (12.8)
Moderate Frequency of Use	9 (7.2)	2 (3.8)
High Frequency of Use	0 (2.6)	4 (1.4)
Severe Frequency of Use	3 (2.6)	1 (1.4)

At the level of the mesosystem, several variables remained in the final, restricted model predicting a reduction in use. These included variables related to engagement in treatment (greater engagement related to better outcome), variables related to being part of a recovery community, and baseline characteristics such as having a primary care physician or legal problems. Interestingly, while having a primary care physician was related to better outcomes, having a psychiatrist at onset predicted a worse outcome. Given the surprising finding regarding having an outpatient psychiatrist, this was further explored. The results of a Chi-Square analysis with Yates correction indicated a non-significant relationship between outcome frequency of Alcohol use and engagement in outpatient psychiatric services ($X^2[4, N=145] = 3.78, p = 0.44$). As can be seen in Table 9, there are very slight indications of underperformance of treatment for those with psychiatric outpatient services (e.g., less in the none and more in the mild and moderate frequency groups). In summary, it appears that the context of a patient's environment –

particularly medical and legal, duration of treatment attendance, and respective engagement in treatment (maybe even particularly when noncompliant) have a marked impact on changes in the frequency of alcohol use.

Table 9: Chi-square table demonstrating the relationship between Onset psychiatric services and post-treatment frequencies of alcohol use.

EXPECTED NULL HYPOTHESIS Outcome Frequency of Alcohol Use	Onset psychiatric services	
	Yes	No
None	11 (15.3)	78 (73.7)
Mild Frequency of Use	9 (6.4)	28 (30.6)
Moderate Frequency of Use	4 (1.9)	7 (9.1)
High Frequency of Use	0 (0.7)	4 (3.3)
Severe Frequency of Use	1 (0.7)	3 (3.3)

Objective 2:

The second aim of this study was to test a predictive model of recovery from alcohol use (Figure 2) using theoretical constructs taken from the literature. We hypothesized that psychological symptoms would mediate the relationship between treatment outcome and baseline characteristics of the individual (including individual, microsystem, mesosystem, and macrosystem level variables). All of the 41 predictor variables (grounded in the recovery literature) were assessed prior to the patients engagement in treatment services, as follows:

Individual factors (14 variables assessed): Readiness to Change, ASI
Alcohol Severity/Composite, Number of days abstained from alcohol,

Alcohol Frequency, Relapse Risk, Onset age of Alcohol use, secondary substance frequency, Onset age of secondary substance use, ASI Drug Severity/Composite, Previous Treatment, Education, Age, Gender, and Race.

Microsystem factors (8 variables assessed): Family History of substance use, Initial Alcohol Social Connectedness, Initial Secondary Substance Social Connectedness, Relationship Status, ASI Legal Severity/Composite, Arrests at Onset, ASI Family/Social Severity/Composite.

Mesosystem factors (11 variables evaluated): Insurance Coverage, Transportation Difficulties, Other Access Problems, Degree of financial struggle, Employment Status, ASI Employment Severity/Composite, Onset psychiatric services, Onset therapeutic services, and Onset primary care clinician.

Macrosystem factors (4 variables assessed): Care Access, Identified Goals, Treatment Plan duration and Treatment Plan sessions.

Psychological distress (4 variables assessed): Beck Anxiety Inventory, Beck Depression Inventory – Second Edition, Beck Scale for Suicide Ideation, and ASI Psychiatric Severity/Composite.

We first examined correlations between the identified predictor variables and the outcome (change in frequency of alcohol use). Nine variables were significantly correlated with the outcome variable at the end of abstinence-based treatment (Table 10). These variables were examined for potential collinearity by examining the correlation coefficients between the independent variables, employing a stringent threshold of 0.75 due to concerns of the sample size (previous research employed a 0.95 threshold [Zainodin & Yap, 2013]). The theoretical implications of the severity of alcohol use was the driving force for removal of two, highly-correlated, variables (Table 10), and the final inclusion of 7 variables in the model.

Table 10: Treatment predictors correlation to the outcome frequency of alcohol use, including removed variables.

Individual Factors	
Readiness to Change	-0.336** (p=0.000036)
ASI Alcohol Severity	0.219** (p=0.008214)
ASI Alcohol Composite	0.340** (p=0.000029)
Initial Frequency of Alcohol Use	0.438** (p=3.4994E-8)
Relapse Risk	0.174* (p=0.037)
Microsystem Factors	
ASI Family/Social Severity	0.198* (p=0.016931)
ASI Family/Social Composite	0.205* (p=0.013514)
Mesosystem Factors	
Onset primary care physician	-0.203* (p=0.014254)
Macrosystem Factors	
None	
Psychological Distress	
Beck Depression Inventory - II	0.204* (p=0.013948)

The restricted variables were systematically entered into mediation analyses using the SPSS macro PROCESS (Hayes, 2017) with frequency of alcohol use at the end of treatment as the outcome and Beck Depression Inventory - II as the mediator (Table 11). As depicted in Figure 4, the analysis tested the direct relationships between baseline characteristics and psychological distress (a-paths), psychological distress and outcome (path b), baseline characteristics and outcome (c-paths), as well as mediation through psychological distress of baseline characteristics on outcome frequency of alcohol use (c'-paths). On the a-path, ASI Family/Social Severity significantly predicted higher BDI-II scores ($B=3.55$, $SE=0.5023$, $t=7.0723$, $p<0.001$). Notably, the b-path between psychological distress and treatment outcome was non-significant ($B=0.0556$, $SE=0.8863$, $t=1.7013$, $p=0.0911$) when controlling for the other predictors.

The results of the c-path indicated a number of variables which significantly predicted the outcome variable. Among the individual variables, readiness to change ($B=-0.5908$, $SE=0.1532$, $t=-3.8572$, $p=0.0002$) and initial frequency of alcohol use ($B=0.2706$, $SE=0.05175$, $t=4.7054$, $p<0.001$) were found to be predictive of treatment outcome when controlling for the other predictors. While the microsystem variable approached significance, ASI Family/Social Severity ($B=0.2572$, $SE=0.1941$, $t=1.8413$, $p=0.0677$), the mesosystem variable was found to significantly predict the outcome frequency of alcohol use, onset primary care physician ($B=-2.1956$, $SE=0.8842$, $t=-2.4833$, $p=0.0142$).

The results of the c'-path also demonstrated several variables which maintained significant predictive power for the outcome variable when mediated by psychological

distress. As can be observed within Table 11, these included readiness to change (B=-0.5732, SE=0.1525, t=-3.7593, p=0.0003), initial frequency of alcohol use (B=0.2721, SE=0.0571, t=4.7637, p<0.001), and primary care physician at onset (B=-2.4, SE=0.8863, t=-2.7078, p=0.0076). The results of these analyses determined that within this subject group there were no significantly mediated pathways through psychological distress, as noted by all indirect effects overlapping zero (Table 11).

Table 11: Mediation Analyses (N=145)

a path (X→M, controlling for otherbaseline predictors)						c path (X→Y, controlling for other baseline predictors)					
X	M	B	SE	T	p	X	Y	B	SE	t	p
ASIAS	BDI-II	-0.21	0.5	-0.41	0.6797	ASIAS	OFAU	0.16	0.19	0.84	0.4016
FoAU	BDI-II	-0.03	0.15	-0.18	0.8539	FoAU	OFAU	0.27	0.06	4.71	<0.001***
RR	BDI-II	1.69	1.49	1.13	0.261	RR	OFAU	-0.25	0.58	-0.44	0.6608
ASIFSS	BDI-II	3.55	0.5	7.07	<0.001***	ASIFSS	OFAU	0.26	0.19	1.84	0.0677*
PCP	BDI-II	3.68	2.29	1.61	0.1104	PCP	OFAU	-2.2	0.88	-2.48	0.0142*

c' path (X→M→Y, controlling for other baseline predictors)							Indirect effects			
X	M	Y	B	SE	T	p	Effect	SE *	LLCI *	ULCI *
ASIAS	BDI-II	OFAU	0.17	0.19	0.91	0.3663	-0.01	0.03	-0.09	0.05
FoAU	BDI-II	OFAU	0.27	0.06	4.76	<0.001***	-0.002	0.01	-0.03	0.02
RR	BDI-II	OFAU	-0.35	0.58	-0.6	0.5472	0.09	0.11	-0.07	0.38
ASIFSS	BDI-II	OFAU	0.16	0.23	0.71	0.4784	0.2	0.12	-0.03	0.44
PCP	BDI-II	OFAU	-2.4	0.89	-2.71	0.0076**	0.2	0.17	-0.07	0.58

Note. X=independent variable (Initial Predictors: Readiness to Change [RtC], ASI Alcohol Severity [ASIAS], initial Frequency of Alcohol Use [FoAU], Relapse Risk [RR], ASI Family/Social Severity [ASIFSS], and Onset primary care physician [PCP]). M=mediator (Psychological Distress: Beck Depression Inventory - II). Y=dependent variable (Outcome of Treatment: outcome frequency of Alcohol use). SE=standard error; CI=confidence interval. All models are ordinary least squares regressions controlling for other baseline predictors.

* estimated on 5000 bootstrap samples and 95% confidence intervals (CI)

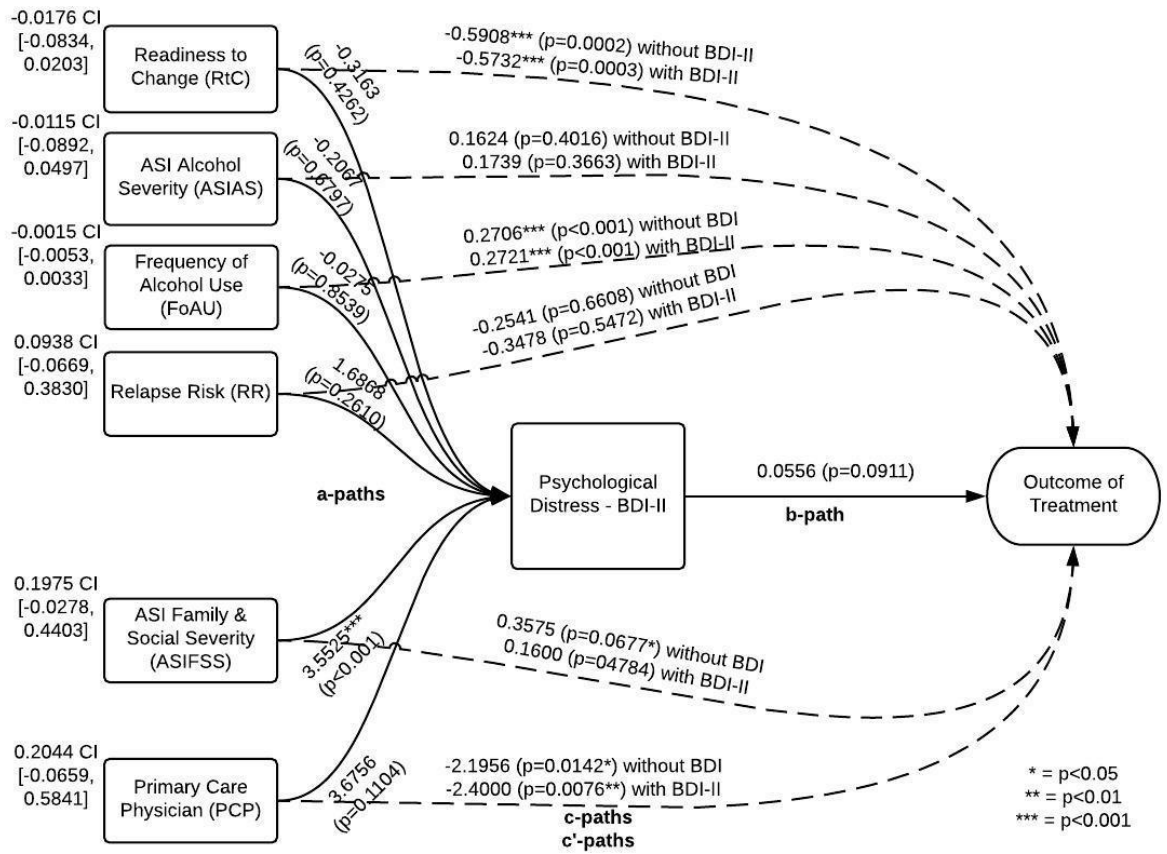


Figure 4: Completed model of the prediction of the frequency of alcohol use at outcome of treatment via theory-driven regression analysis using PROCESS within SPSS.

Discussion

The Day One Intensive Outpatient Program was effective with 61% of the sample reporting no alcohol use (within the past month) at the end of treatment. This success rate is consistent with treatment outcome literature described by (Moos & Moos, 2006). The goal of this study was to advance knowledge of the predictors of treatment success using both data-driven and theory-driven analytic methods. The results are summarized below separately and together to guide future research efforts.

Objective I:

The data-driven, Elastic Net Regularized regression was used to identify predictors of the primary outcome, frequency of alcohol use at the end of treatment. Five categories of variables found to consistently predict the frequency of alcohol use (e.g., the high and medium frequency variables) are presented below. These variables were identified in the out-of-sample test set, and thus are representative of both this sample and the wider population of patients in abstinence-based recovery. As such, these concepts may have importance in the process of assessment and throughout treatment.

The first set of constructs are measurements of alcohol use at the beginning of treatment (initial frequency of alcohol use) and associated problems in functioning (ASI Alcohol Composite). These two variables were represented in 100% of models and have a positive relationship with the outcome variable frequency of alcohol use (i.e. more alcohol use at intake is related to more alcohol use at the end of treatment; a worse outcome) with moderate and weak correlational strength, respectively. These results provide an important reminder that assessing the starting point for a patient's recovery is

important for understanding the outcome of treatment. This also suggests that a harm-reduction model – that is strategies for reducing alcohol use – may be a useful precursor to successful abstinence-based treatment.

The second set of constructs which consistently predict outcome are co-occurring mental health conditions, particularly depressive symptoms, and onset therapeutic services. Both variables were found in the majority of final models. Those patients with fewer depressive symptoms at intake had lower alcohol use at the end of treatment.

Paradoxically, those who reported having an outpatient psychiatrist had higher alcohol use at the end of treatment. It may be that having an outpatient psychiatrist at intake is a proxy for the severity of the mental illness, or for treatment resistance (as their addiction was not treated in the course of outpatient psychiatric treatment). These results provide information supporting the known impact of mental illness on addiction (Burns et al., 2005; Gilder et al., 2016; Glass et al., 2014; Grant, Goldstein, Saha, Chou, Jung, Zhang, Pickering, Ruan, Smith, Huang, Hasin, et al., 2015; Helzer & Pryzbeck, 1988; Johnston et al., 1991; Kaufmann et al., 2014; Kushner et al., 2005; Malcolm et al., 2006; Mann et al., 2004; McCallum et al., 2016; Mellentin et al., 2015; Newton-Howes et al., 2017; Sánchez-Peña et al., 2012; Schellekens et al., 2015). In addition, these results support integrated treatment addressing mental health and addiction in a coordinated manner.

The third construct related to treatment outcome is readiness to change, as greater initial motivation to change is related to lower alcohol use at the end of treatment. While this variable was identified in 100% of the models, it has a very weak correlation with outcome. This may suggest that motivation is necessary though not sufficient for

benefitting from treatment. However, a large literature demonstrates the effectiveness of motivational interviewing (Elliott et al., 2014; Miller & Rollnick, 2002; Morgenstern et al., 2012), and this finding further supports treatments that integrate efforts to support patients in developing and sustaining motivation for change, including enhancing self-efficacy and directly addressing risks for relapse.

The fourth construct consistently identified is substance use during treatment, both lapses of alcohol use and the frequency of using other substances during treatment. Fewer lapses were associated (weakly) with a positive treatment outcome in every model. Interestingly the weak relationship of lapses to treatment outcome suggests that even in abstinence-based treatment lapses do not preclude successful treatment. This is consistent with treatment literature demonstrating alcoholism as a relapsing and remitting disease (Allen et al., 1997; Heyman, 2013; Heyman & Mims, 2010; Marlatt, 1996; Moos & Moos, 2006; Pickard, 2016; White, Scott, Dennis, & Boyle, 2005; Zywiak et al., 1996). As such, the treatment process of re-committing to goals and strengthening motivation to change after a lapse may be beneficial. The use of other substances at the end of treatment was associated with greater alcohol use (a worse outcome) in 100% of the final models. This suggests that considering all substance use during treatment is paramount to treatment of problematic alcohol use. Stated a different way, the attitude that using marijuana (53% of the reported secondary substance), does not affect drinking and/or is somehow preferable to using alcohol, is not supported by this study. Though not directly assessed in this study, there may be different treatment trajectories related to the profile of co-occurring disorders (substance alone [23%] or with mental health concerns [19%]).

Further studies addressing how the level and/or duration of treatment within the intensive outpatient program, or how collaboration with additional treatments (e.g., medication assisted treatment, mental health counseling, Narcotics Anonymous, etc.) works for patients with different diagnostic profiles will be important.

The fifth and final essential construct is the patient's engagement in treatment. While this is an intuitive finding, it is one with nuanced clinical implications. For example, this study found that the absolute amount of treatment (months in treatment and/or number of sessions) predicted better outcomes, as did consistent treatment attendance (attended/scheduled sessions and no-show/scheduled). However, the number of sessions that were cancelled or that the client "no-showed" did not predict treatment outcome. Clinical interpretation of patterns of non-attendance typically include lower motivation or commitment in patients who "no show" to sessions, and the reverse for "appropriately cancelled sessions", and this would be assumed to be related to treatment outcome. This has direct clinical implications for encouraging a patient's efforts to attend sessions even if they are inconsistent. Further this finding supports treatment program efforts to reduce barriers for engagement in treatment and to work on enhancing motivation for recovery. Questions in our field remain regarding the variables which best predict decision making within the course of each patients' recovery treatment, including when treatment may be unhelpful, when to transition patients to a different type/level of treatment, and when is it appropriate to administratively discharge patients. For example, White and colleagues (2005) review the rationale for "kicking out patients" and suggest alternatives for administrators and clinicians. This finding falls in line with the suggestion

of enhancing efforts to sustain patient engagement and limiting the interpretation of missed sessions.

While the 5 constructs above are the most consistent factors found across the predictive models, each model demonstrated variability in significant predictors which suggests an impact at the level of the individuals included in model development. For example, the presence of a family history of substance use (a microsystem level variable) was a weak predictor of alcohol use at the end of treatment, such that having a family history of substance use predicted better outcomes. While much literature associates family history of substance use with poorer outcome (Capaldi et al., 2013), it has been suggested that family history may serve as a proxy risk variable which may be better measured by other variables, including psychosocial stressors, craving or baseline alcohol consumption (Adamson et al., 2009; Johnson et al., 2000). Thus, utilizing information about an individual's family history of substance use within treatment may end up being helpful in predicting modifiable patterns of use and motivations for recovery which are well suited to change within IOP treatment.

At a societal level, a person's degree of financial struggle was a weak, positive predictor of outcome in several models (i.e. less financial struggle was associated with less alcohol use at the end of treatment). Interestingly, several studies have demonstrated differential trajectories of treatment engagement and success as a result of the interaction of socioeconomic status and racial group, with worse outcomes observed for low SES, Black- and Hispanic-identified patients (Lewis, Hoffman, Garcia, & Nixon, 2018; Saloner & Cook, 2013). A comprehensive approach to treatment, including case

management & peer-supports, could aid in addressing issues of poverty, employment, and access to services. As a result, patient's treatment attendance would be enhanced, leading to a more positive outcome. This study was not able to provide clarity on the mechanisms by which financial struggles impact treatment success. Future research will be needed to determine the overlapping influences of financial stability, employment opportunities, coverage of treatment costs and other aspects of treatment which may impact recovery.

The results of this study have important implications for several variables which are believed to be clinically meaningful, including age, gender, and psychological distress. Within this study, age was not supported as a predictor of treatment outcome, however, the age of first drink was. Thus, perhaps for alcohol treatment, "age is just a number," while early drinking behavior is a meaningful predictor of difficulties in recovery. Of interest, this falls in line with Johnson, et al.'s (2000) conclusion that age of onset may provide insight into possible 'types' of drinking groups.

An additional, surprising finding was that gender did not predict treatment outcome. This is in contrast to literature demonstrating that females are more likely to have short-term remissions in alcohol use (Adamson et al., 2009; Moos & Moos, 2006). Given the strong representation of females (37%) it is unlikely that this finding is due to a lack of statistical power in the current sample. Thus, (at least) three potential explanations are possible. First, perhaps Day One differentially enhances male-specific recovery. This is unlikely, given that several modifications to Day One IOP treatment were more likely to benefit the recovery of females, including access to a female clinician, a group for

expectant mothers, and a weekly women's group. The second alternative, could be the presence of reduced disparity between men and women, including many which have previously been suggested to influence gender-based differences in treatment outcome. These could include severity of baseline alcohol use, co-occurrence of internalizing psychological disorders, educational attainment, and responsiveness to treatment (Litt et al., 2015; Mann et al., 2004; McCutcheon et al., 2014; Sugarman et al., 2013). Finally, it is possible that gender no longer effectively measures the underlying trait which predicts engagement/disengagement from alcohol use behaviors. Women's integration of dominance masculinity (e.g., being aggressive and forceful) and men learning to hold opposing gendered self-concepts (i.e., traditionally feminine beliefs) may result in more equivalent patterns of use and, likely, recovery (Clinkinbeard & Barnum, 2017; Likiswerle & Borders, 2017; Lyons & Willott, 2008). As such, these results could suggest that it may be time to let go of gender-based beliefs within recovery and seek for a deeper level of understanding.

Based on abundant literature, it was surprising that while specific measures of depression and anxiety were related to treatment outcome; suicidality and the broader measure of psychiatric severity within the Addiction Severity Index were notably absent. This suggests that refined measures of specific psychological symptoms may be a more useful approach than a broad measure of psychological distress. Given the strength of psychological distress as a predictor in the literature (Colder et al., 2017; Hill & Angel, 2005), it may be that the Addiction Severity Index isn't a sufficient measure, perhaps because it measures addiction related pathology rather than mental health symptoms

more generally. Thus, in future studies it will be useful to examine specific diagnostic groups (e.g., assessing Panic Disorder, OCD, ADHD, Anger/Aggression/Anti-social Personality Disorder, etc.) or to measure psychological distress not related to substance use problems.

Taken together, the data-driven analysis of the Day One Intensive Outpatient treatment program, highlights the importance of characteristics of the individual when they begin treatment (their level of alcohol use, anxiety and depressive symptoms, comorbid substance use, and motivational stage) as well as their engagement during treatment. Alternatively, decreasing attention to specific demographics, non-specific mental health measures, and reasons for non-attending treatment sessions will likely support all patients' ability to utilize the effectiveness of IOP services.

Strengths and Weaknesses of the Elastic Net Regularized Regression Approach

The Elastic Net Regularization approach, in combination with cross-validation was selected to identify predictors of the treatment outcome while preventing model overfitting and enhancing generalizability. In this approach, a sub-set of the data is set-aside, so that final model testing occurs on a new set of patients who were never used in model generation. This is a significant advantage over traditional approaches which are known to have poor replicability and generalizability (Whelan & Garavan, 2014; Zou & Hastie, 2005).

In order to test the replicability of the results generated with the Elastic Net Regularization approach, multiple models were generated and evaluated in selecting the most important predictors. We chose to evaluate the frequency of predictor variables as a

measure of their importance (i.e. those variables that were important in every model are presumably better predictors than those that are only identified in 10% of the models). Rationale for this choice comes from recognition that the number of variables in a model did not generally increase its' power (for example a model with 31 variables had only slightly better explanatory power than a model with 14 predictors - regression coefficients of 0.34488 and 0.32509, respectively).

There was considerable variability in the explanatory power and number of included variables within the fold-based runs. One potential explanation for this is our sample size. Though 120 subjects is somewhat representative (Lo Coco et al., 2019), 108 subject were used to train the model, which was then tested on 12 subjects. Thus, it is apparent that the predictors cannot be evenly distributed during the randomization of patient's into testing sets. Indeed, heterogeneity characterizes individuals engaged in patterns of unhealthy alcohol use, a primary reason for studies like Project MATCH (Allen et al., 1997; Connors et al., 1998; Pagano, Friend, Tonigan, & Stout, 2004; Project Match Research Group, 1998). As such, increased sample size might have yielded an even stronger model.

Another potential to consider are the similarities and differences in the patterns of variables that appear within the final models, with a focus on a conceptual framework of recovery. It is possible to consider this concept via, at least, two different interpretations. The first being Johnson and colleagues' (2000) concept of a proxy risk variable, that the predictors identified within this study are actually imperfectly measuring a broader concept. Given the assumption of inclusion of all relevant variables within the study,

performance of factor analysis could support the identification of conceptual parity. The second consideration follows from difficulty assuring the assumption of having completely assessed all variables which may contribute to the course of recovery. The need to return to the literature for possibly missing content will be further addressed within the limitations section, below.

Objective II:

The second objective tested a theoretically-derived model of factors to predict treatment outcome. The model of recovery depicted in Figure 2 posits that factors from all levels of the Bronfenbrenner model are important, and that psychological distress will mediate the relationship of the variables to treatment outcome. Results showed significant direct effects of readiness to change, initial frequency of alcohol use, and having a primary care physician. As the influence of the first two variables have been previously discussed, we will focus on the implications of having a primary care physician. The contribution of a primary care physician to improve treatment outcomes suggests that some level of engagement with medical treatment may be beneficial. There is also the potential that this is a proxy risk factor, perhaps representing the individual's stability within their community or their socioeconomic status.

The finding that psychological distress did not mediate the relationship between any of the predictors and outcome was surprising. This may be because of the limited number of variables which were significantly related to psychological distress. Though not a requirement for mediation, this would indicate some weakness within the model structure. However, the lack of a significant relationship between psychological distress

and treatment outcome is a true weakness in the theoretical model. Given the relatively weak correlation prior to analysis, it may be suggested that this single measure of depression is insufficient for the demands of mediation. An alternative strategy could be to derive a psychological distress variable using factor analysis, which may be both more effective and theoretically-consistent (Hill & Angel, 2005). However, there are not enough psychological variables in the dataset for this to be feasible. The indirect effects are also problematic in that while they are statistically significant, for readiness to change, initial frequency of alcohol use, and access to a primary care physician, each has confidence intervals which overlap zero. This demonstrates that the relationships are weak (i.e. the mediational path does not improve prediction over the direct path). Therefore, the results of this analysis should be interpreted with great caution, and alone cannot advance our understanding of recovery within the field.

Taken together, the results of the theoretically aligned mediational analysis suggest limited benefit for improving a general understanding of recovery from alcohol use disorder for several reasons. First, the process of variable selection (though consistent with general practices) is biased by removal of non-correlated variables which are thus not accounted for in the final analysis. Secondly, this method generates results that are inherently specific to the sample of patients included in this study, resulting in overfitting of the model, making application to wider populations untenable.

Integration of Data- and Theory-Driven Research:

The final consideration of this study is the comparison between analytic methods. Notably, the direct comparison between a modified regression analysis, such as the Elastic Net Regularization approach with cross-validation, and the mediation model results in elements which are not directly relatable. There are, however, several overlapping results across the two analytical methods. It may be that these represent a “true” relationship as they are supported by both theoretically and data-derived analyses. Alternatively, it may be that these variables represent a specific effect of the study’s sample, though the Elastic Net Regularization methods makes this unlikely. The significant predictors in objective two (readiness to change, initial frequency of alcohol use, and access to a primary care physician at onset) were also in the high frequency group of predictors for the primary analysis with the same direction of effect, which would imply an inherent relationship. Finally, three variables are noted to lack a significant relationship to treatment outcome, which again aligns with the development of a model with some level of generalizability. The results do, however, demonstrate some overfitting to the study sample, occurring in the increased strength of the coefficients for the significant variables within the mediation analysis, including readiness to change (Objective I: -0.095; II: -0.591), initial frequency of alcohol use (I: 0.022; II: 0.271), and primary care physicians (I: -0.170; II: -2.196). Overall, these results demonstrate the marked benefits of implementing a data-driven approach, including an enhanced capacity for demonstrating significant predictors of treatment outcome and improvements in the

perceived ability to apply these results to the broader community of patient's recovery from unhealthy alcohol use.

Limitations/Future Directions

As noted above, there are several areas within this study which could benefit from further examination to strengthen generalizability of our results to the field of recovery. These include decisions made in the analytic process and limitations in the selection and measurement of the variables that were collected. In terms of the analytic approach, the decision to complete a simple replacement of missing variables according to the mean/median of the sample could be a concern. An alternative approach of utilizing multiple imputation may have benefitted the results by increasing the individual-specific variability for each piece of missing data rather than relying on the central tendencies of the group. Given the relatively limited amount of missingness (particularly after variable exclusion), the amount of impact that this manipulation would have on our results cannot be easily determined. Similarly, it should be noted that when using data-driven methods, there are choices made in setting up the framework which affect the results. For example, while the choice of a 10-fold cross validation is well-represented within the field (Zou & Hastie, 2005), an argument could be made for using 5-fold (to increase sample size in each fold) and/or a 20-fold (to improve replicability) cross validation setups. Thus, in the absence of clear evidence for the optimal structure, we chose to use methods that have been demonstrated to be robust in similar sample sizes.

Within the second objective, we noted the potential utility of using factor analysis to detect latent variables. This is particularly relevant in the context of defining

psychological distress – as a latent variable may better capture variability in mental health profiles when compared to a unitary measures of depression, anxiety (which were collected using the Beck instruments), and substance-related mental health issues (as done on the ASI). Unfortunately, there were not enough mental health items collected in this study to use this method. Considering the best-practices for selecting which variables are entered into a model will likely require a balance of taking from the literature and examining the influences of the collected data, a goal of future work.

In this dataset, there were several limitations which are associated with the data itself. First, as Day One provides services primarily to Chittenden County in Vermont, the demographics reflect those of its' residents. With Vermont being reported by the United States Bureau (2016) to be primarily Caucasian (93.1%), racial diversity may be the largest influence on our study sample. Additionally, the sample of participants is influenced by the patient's level of need and the accessibility of other local treatment facilities. At the time the data was collected, alternative services for the treatment of unhealthy alcohol or substance use primarily included inpatient and peer-support based treatment (i.e., AA). In addition, the sample of patients may be impacted by the focus on an abstinence-based model of care within Day One. This suggests that individuals in immediate withdrawal, those swayed toward a peer recovery process, and those disinterested in abstinence-based recovery may not be included in this study sample.

The choice of selecting patients who initiated treatment within a single year may also impact the results. Though this study used retrospective data from 2011 to 2012, the landscape of drug and alcohol use and treatment has changed dramatically in the last 8

years. Influences of the opioid epidemic include a strain on treatment center resources, a change in the patient population at Day One, and a higher rate of co-morbid alcohol and drug problems. Therefore, it is unknown if the results of this study will be the same for those seeking treatment today. However, the inclusion of subjects with all types of co-occurring drug use and mental health problems; as well as the use of cross-validation strengthen the generalizability of these findings

The source data came from patient clinical records. This is a strength in that the data is directly relevant and feasibly collected in community-based treatment centers. However, there were limits to variables that were available including inconsistent sampling of urine toxicology. In the context of treatment at Day One, urine drug tests are ordered for clinical reasons. Therefore, patients are not equally assessed, with those who were successfully abstinent being tested less often than those who experienced lapses. Further, Alessi, Petry, & Barnett (2019) provide data that self-reporting use and UDTs may be out of date, with information that transdermal measurement of alcohol use can provide an accurate and timely measurement of use that may enhance and direct interventions.

There is always a trade-off between the ideal research assessments and the ideal clinical assessments (with the research assessments usually being longer and more expensive than is feasible clinically). However, the study results would be strengthened by standardized measures assessing patterns of substance use (i.e., Timeline Follow-Back and/or Concurrent Recall; Sobell et al., 2003), components of socioeconomic status (Townsend Index and/or Duncan's Socioeconomic Index; Shavers, 2007) and

psychological distress (Psychological Distress Manifestations Measurement Scale; Masse, 2000). The standardized measures that were used, i.e. the Addiction Severity Index, may influence the information provided by the sub-components of family/social distress, health status, and employment status given the overall focus on assessing the impacts of substance use.

Finally, this study followed the clinical treatment course, which included data collected at clinical time points (i.e. intake assessment, in-person interview, during treatment, etc.), and there were different durations between these timepoints between participants. This may have been particularly relevant for our second objective as the psychological variables were collected once during the intake paperwork. Ideally this would have been collected after the initial predictors and at multiple timepoints to assist in determining an influence through the mediator and possible changes over time. Many of the other variables included in this study are not stagnant and will demonstrate significant and important change throughout treatment, i.e., readiness to change. As such, focus on advancing the clinical utilization of assessment throughout IOP treatment will be important for future research.

It is also important to consider the variables that were and those that were not measured. First, we will consider general aspects of the initiation of and engagement in treatment that facilitates recovery. The process of self-selection into treatment may be important to acknowledge (e.g., Cutler & Fishbain's [2005] attending zero sessions has better outcomes than one session). It is difficult to measure the inherent elements of the therapeutic skills demonstrated by frontline-clinicians, including the examination of

stigma, pros/cons of independent recovery, uncertainties surrounding treatment engagement, development of therapeutic alliance, evocation of change talk, and flexibility with barrier to change. Below we discuss variables that could be considered in future studies using the Bronfenbrenner model, including variables at the level of the individual, microsystem, mesosystem, and macrosystem.

At the level of the individual there are several variables that would have been ideal to include. For example, measures assessing the underlying elements of gender, such as Dominance Masculinity (Bem Sex-Role Inventory; Clinkinbeard & Barnum, 2017), will likely aid in clarifying the aspects of gender that are connected to differences in recovery outcomes within the literature more broadly. Similarly, the development of contextual knowledge about the specific motivations for drinking (Kuntsche et al., 2008) and maintaining use of alcohol (Relapse Motivations [Zywiak et al., 1996]) would add important context to an individual's trajectory of recovery. An increased focus on integration between the fields of psychology and biology has begun to open the door for the assessment of both emotional reactivity and emotional regulation via variables like respiratory sinus arrhythmia and skin conductance (Colder, 2001; Heilig, Thorsell, et al., 2010). While these are not typically collected clinically, they would add rich data that might be useful in predicting treatment outcome as they are rooted in neurobiology.

Future research will also benefit from understanding how the social environment and relationships influence recovery. The literature suggests marked and separate influences for both family support (Dobkin et al., 2002; Edwards & Steinglass, 1995; Miller et al., 1999) and friend/social support (Best & Lubman, 2017), which may differ

based on characteristics of the individual (Groh et al., 2007; Litt et al., 2015; Mavandadi et al., 2015; McCutcheon et al., 2014). Such complexity may contribute to confusion in what to measure and how to consider these factors within treatment. It appears that the most consistent components to assess would be beliefs about alcohol use perpetuated by family/friends, general family/friend support, and specific family/friend support for recovery. As these are assessed in future work, further clarity is likely to be identified in patient responsive to specific interventions relative to the source (family versus friend), type (general vs. specific) and degree of social support.

Finally, the broadly-based contributions of the community and society could be measured with variables such as neighborhood disorder and community-wide permissibility of use. Inclusion of these factors may help to understand systemic barriers to treatment. Further, assessment of the influences of societally-held beliefs about the role of alcohol (drinking cultures) may further aid in normalization of the difficult process of initiating and maintaining abstinence.

Conclusions

This study demonstrates the application of big data methods to clinical outcome research and highlights the strengths and weaknesses of both theory- and data-driven methodologies. Interestingly, the theoretically-driven analysis completed in this study revealed limited benefits of application to the field of recovery. Using Elastic Net Regularized linear regression allowed the inclusion of a wide group of variables and resulted in selection of variables that independently contribute to prediction of outcome. The results will guide treatment refinement, specifically supporting increased focus on an individual's initial use profile, mental health symptoms, motivation for change, use of other substances, and treatment engagement. They also demonstrate placing an emphasis on encouraging treatment attendance (even when there are occasional missed sessions). Similarly, the results suggest de-emphasizing demographic predictors including age and gender. As such the continued implementation of data-driven methodology will aid us in re-defining unhealthy alcohol use to involve the process of balancing self-efficacy and temptation in alignment with current patterns of use, psychological distress, availability of specific treatment and social supports, as well as the potential involvement of broadly-based supports and barriers to changes in use.

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Appendix I

Description of the Day One Treatment Program by Messina, Keithcart, Brown, Dees, and Reed (In Progress):

The setting for this report is the midlevel outpatient substance abuse rehabilitation program at the *University of Vermont Medical Center*. The program is identified as the Day One program, a division of Psychiatry, *University of Vermont Medical Center*, and is the clinical component of a major research center studying cocaine, opioid, alcohol, and nicotine use. The facility is located in Burlington, Vermont on the UHC campus.

It serves the Chittenden County region (population 156,545 based on the 2010 census), but because Vermont is a rural state, it draws patients from distant counties and townships, including Addison, Washington, Lamoille, Franklin, Orleans and Grand Isle. It also receives referrals for treatment from many out of state residential treatment facilities. It interfaces externally with detoxification, residential and outpatient programs locally and throughout the state. Within the *University of Vermont Medical Center* Health Care system, it serves the needs of patients, employees and students and is linked with inpatient psychiatric services and midlevel outpatient mental health services, which provide partial hospitalization and intensive outpatient treatment to patients who do not actively use substance.

It was the Department of Psychiatry's intent, when they recruited a psychiatrist as medical director of Day One, to expand the services to include treatment of co-occurring disorders. The design was intended to enhance the treatment and educational program by integrating services.

Generally speaking, the outpatient treatment of co-occurring disorders has varied widely. While there has been a strong emphasis on integration, considerable barriers have been identified that have prevented implementation. The result has been an assortment of programs that include coordination of treatment, sequential treatment, co-location, partial integration (conforming to the parallel approach) and full integration (Mangrum, Spence & Lopez, 2006). The essential features of the fully integrated Day One program is a dually-trained staff and simultaneous treatment where one team, staffed by licensed alcoholism and drug counselors (LADCs) and the psychiatrist, coordinate the treatment plan and co-manage the treatment throughout the progression of the patient's care.

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Staff

The staff includes an administrative assistant and four licensed alcoholism and drug counselors; one clinician is also certified in mental health and leads the co-occurring disorder intensive outpatient group. One member of the staff serves in the position of clinical supervisor. The LADCs are masters level counselors and required, to complete 2000 post-graduate supervised work hours in order to be licensed in the state of Vermont. They are trained in both substance abuse and psychopathology. An onsite, half-time psychiatrist, who serves as medical director, completes the treatment team. The team jointly shares responsibility for patient care and participation in continuous staff training and medicine/psychiatry resident and graduate education in alcohol and substance treatment. The staff meets twice weekly with a clinical and administrative

agenda. The clinical team collaborates closely to assign appropriate treatment levels, to identify high-risk patients, develop risk management measures (Cornelius et al., 1995), review treatment plans and communicate and agree about probable COD patients appropriate for referral for psychiatric evaluation, consultation and perhaps treatment. Team members regularly conference on an impromptu, as-needed basis regarding patient issues.

The team jointly decides level of care and pace, timing and disposition, as patients transition through treatment and progress into remission over the course of program participation. Pharmacotherapeutic rationale and response to medication, as well as degree of psychotherapeutic engagement are regularly discussed and shared. Provisions for relapse prevention and long-term medication management are addressed.

Admission Process

Admissions begin with a phone call contacting the administrative assistance, who responds to inquiries, answers questions and explains the admission process.

Day One uses a two part procedure to adequately assess a prospective patient and determine appropriate level of care.

The first part consists of completing pre-admission paperwork, which includes insurance information, confidentiality agreement, reasons for referral, primary and social environmental supports, mental health history, educational background, occupational history, housing situation, interactions with legal system, medical history, pain assessment, dietary concerns, alcohol and drug history, AIDS risk assessment and participation agreement. In addition, the following assessments are obtained: Beck Anxiety Inventory, Beck Depression Inventory 2, Beck's Suicide Scale, and the Addiction Severity Index multimedia version connect. The patient completes the preliminary information prior to being scheduled with a counselor to improve the show rate for the screening appointment.

The second part is a screening evaluation to assess the patient's drug and alcohol history, psychiatric history, current mental status and level of risk. The evaluation will determine the appropriate level of treatment based upon American Society of Addiction Medicine (ASAM) criteria. The clinician reviews all documents and assessments before meeting with the prospective patient. The patient's motivation for treatment and current stage of change is determined. If the patient meets criteria and agrees to treatment services at Day One, additional information is obtained. Consent for treatment and release of medical information forms, are signed; emergency contact is identified and ADAP (Agency of Drug and Alcohol Program, state of Vermont) admission information is collected. Additionally, collateral contact information is obtained through the consent to release confidential information forms and self-report of current use status is confirmed by urine screen.

The patient's treatment plan is written during the evaluation. The treatment plan consists of the following informational and problem areas described and written in the patient's words: Alcohol/drug, psychiatric/medical, family/social, legal, housing, vocational, recreational, and other. Goals and quantifiable measures are established for each problem area with time-limited objectives; connection is made with responsible person for assistance in meeting goals. The patients assist in prioritizing the problem areas. Related strengths and

assets are described in the patient's words. Estimated length of stay, treatment contacts, date of treatment plan and review/update are determined before the patient signs and is given a copy of the treatment plan.

Treatment Process

Substance abuse treatment occurs in the context of a group psychotherapy process. The program is divided into three group levels.

a. The Intensive Outpatient Program (IOP). The intensive outpatient program, with a focus on co-occurring mental health disorders, meets 3 times weekly for 3 hours. The group capacity is 10 members and the typical length of stay is 9 to 12 sessions. The length of stay may be extended based on the individual's needs. If an individual is unable to achieve stabilization in the IOP, a higher level of care, such as residential, is typically recommended. The IOP program offers an environment of safety and structure addressing stabilization of co-occurring challenges. The program's goal is that group members develop the necessary coping skills to manage co-occurring psychiatric conditions and addiction. Emphasis is placed on how these two conditions impact each other and what goals need to be accomplished to promote a successful remission. Every session begins with a meditation/mindfulness practice, where members are introduced to the benefits of diaphragmatic breathing and the concept of mindfulness in an effort to learn "quiet body/quiet mind." This also affords the opportunity for group members to experience grounding prior to beginning the process time during the group session. Group therapy emphasizes safety, validation and consistency which leads to better group cohesion. Group members are often referred to the medical director for psychiatric services to address co-occurring issues such as anxiety disorders, depression, PTSD, and other conditions, which become more evident with abstinence. Accommodations are made for prompt psychiatric evaluation and medication management, as indicated, for those with acute psychiatric needs.

The group therapeutic techniques include emotion regulation, mindfulness practice, group psychotherapy, motivational enhancement, cognitive behavioral therapy, relapse prevention, coping and life skills training. Skill building is offered with an array of psychoeducational tools including worksheet, experiential exercises and substance use disorder videos. Random urinalysis is always provided to verify self-report. Once an individual has successfully stabilized, as indicated by the ability to maintain abstinence, acquisition and use of coping skills, development of relapse prevention plan and compliance with psychiatric care as indicated. They transition to lower level groups within the Day One program. Some may be referred for expanded psychiatric treatment in the outpatient mental health program, which is located in the same building, while maintaining coordination of treatment and continuity of care with the Day One psychiatrist.

A second Day One IOP is led by a single facilitator and is composed primarily of patients with substance used disorders only.

b. Level II. Day One's step-down level II group is part of a continuum of services provided within the framework of client-centered therapy. Level II groups meet 2 times per week for 2 hours each group. Level II groups have a rolling admission and each member will attend at least 9 sessions and upward of 16 sessions, depending on the stabilization of the individual patient.

A level II patient has been deemed sufficiently stable, within their substance use and/or mental health process, to manage attending therapy at a reduced level of time and intensity. This is determined by the primary therapist and the clinical team. Level II patients can anticipate a shift in treatment approach from level III where a more structured, skill-driven process exists, to one of the patient's being encouraged to "ask for what they need." The group therapy sessions offer a more psychodynamic approach with emphasis on group interaction, feedback and honest communication of emotions. This is not to say that the group psychotherapy model does not occur at higher levels of care, but rather that patients are now more stable in their remission and can explore more stressful events without resorting to former modes of coping.

The patients are expected to participate during all activities, including: Mindfulness meditation, which begin each session, check-ins, which include any use of mood altering substances, level of urge to use (LOUU) from 0 to 10, subjective unit of disturbance scale (SUDS) from 0 to 10, active listening, claiming personal use of time in group, participating in all educational sessions and discussions and providing random urine screenings on request for verification. The patients may continue seeing the program psychiatrist for medication management and/or therapy. Often, when patients first become aware of their co-occurring disorder and learn that they must simultaneously manage their substance use disorder, and their mental health issues, having a group to turn to can be very reassuring that they do not have to do this alone.

c. Level I. When the patients have achieved goals at level II, they are offered the option of continued care in level I groups, which meet weekly for 90 minutes. Level I goals include providing a continuum of care to assist patients in expanding their skill set, enhancing their understanding and management of relapse triggers and gaining insight into their substance use disorders. This group level tries to engage patients at their level of ability and psychosocial competence.

Day One level I groups include 2 weekly cognitive behavioral therapy (CBT), a group for expectant mothers addicted to opioids, a weekly women's group and two long-term relapse prevention groups, which meet weekly and biweekly. The 12-session protocol outlines a spectrum of skill enhancement objectives to foster mindfulness as the patients learn to manage urges and cravings, add structure to their lives, exercise boundary setting, embrace accountability and improve judgment. Mindfulness training is a natural segue to psychosocial and mental health issues commonly associated with substance use and underscores the application of the biopsychosocial model of disease.

The long-term relapse prevention groups strive to establish stability and maintenance of remission while more effectively managing the naturally occurring uncertainties and unpredictable setbacks of daily living that frequently undermine remission from alcohol use.

A prime example of the level I process is the women's group. A weekly women's remission group is offered to address the unique needs of women in remission. Some typical goals of the group are sustained abstinence, stress management, empowerment, breaking the cycle of co-dependency and relationship issues. Most of the women entering the group have a trauma history and often are engaged in individual therapy addressing trauma-related issues. The group can provide additional support, specifically with development and practice

of safety skills, resource installation and coping skills to effectively manage PTSD symptoms.

Women entering the group will be exposed to meditation/mindfulness practice and grounding techniques. Skill building around interpersonal skills, assertiveness, self-soothing and stress reduction are primary goals. Offering a safe, consistent, validating, therapeutic environment is key for the growth of group members. The group is intended for long-term support and women tend to build strong alliances in the group as they explore their journey into remission together.

d. Psychiatric Care in Day One. While patients engage in group-psychotherapy at Day One, stepping down from level III to level I, compliance with ongoing psychiatric care, which some patients may elect to receive from the Day One medical director or outside the Day One program, is encouraged and monitored in a collaborative manner. The Day One psychiatrist provides a combination of pharmacotherapy, medication monitoring and psychotherapy on an individual basis as indicated. The patients are seen regularly (as often as weekly), for treatment, which utilizes an eclectic approach including motivational enhancement therapy, cognitive behavioral therapy, psychoeducation, psychodynamic therapy, and supportive therapy. The degree of engagement varies. Some patients maintain sobriety, complete the first 3 levels of the Day One treatment program and remain in long-term treatment in the relapse prevention group and with the psychiatrist for medication management and relapse prevention. This extended treatment aspect of the program has enhanced continuity of care as a unique feature of the program.