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Using machine learning to examine predictors of treatment goal change among individuals seeking treatment for alcohol use disorder



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ABSTRACT

Introduction: The goals of individuals seeking treatment for alcohol use disorder (AUD) are typically quantified as abstinent or nonabstinent (e.g., moderate drinking) goals. However, treatment goals can vary over time and be influenced by life circumstances. This study aims to identify predictors of treatment goal change and direction of change from baseline to six-month follow-up among individuals seeking treatment for AUD.

Methods: This study is a secondary analysis of data from the Relapse Replication and Extension Project. The study included participants who completed assessments at baseline and six-month follow-up in the analysis (n = 441). We used decision trees to examine 111 potential predictors of treatment goal change. The study cross-validated results using random forests. The team examined changes in goal between baseline and follow-up (Decision Tree 1) and quantified them as being toward or away from a complete abstinence goal (Decision Tree 2).

Results: Nearly 50 % of the sample changed their treatment goal from baseline to 6 months, and 68.7 % changed from a nonabstinence goal toward a complete abstinence goal. The study identified seven unique predictors of goal change. The most common predictors of changing a treatment goal were number of recent treatment sessions prior to enrolling in the study, other substance use, negative affect, anxiety, social support, and baseline drinks per drinking day. Participants with a greater number of recent treatment sessions and who sought social support were most likely to change their goal. Additionally, individuals with more substance use tended to change away from complete abstinence goals. Cross-validation supported baseline drinks per drinking day, social support, baseline maximum blood alcohol concentration (BAC), lifetime tobacco use, baseline average BAC, lifetime cocaine use, Inventory of Drinking Situations total score, and Situational Confidence Questionnaire average score as important predictors.

Conclusions: This study identified seven unique predictors of treatment goal change while in AUD treatment. Prior treatment, drinking to cope, and social support were most associated with goal changes. This information can inform providers who seek to understand factors associated with treatment goal selection and changes in goals during treatment.

1. Introduction

Alcohol-related behavior change is a dynamic process and numerous factors have potential to influence an individual's goals for change and how long that goal continues to make sense for their life. Not surprisingly, goals also vary with respect to time, with potentially different goals in the short- and long-term. Commitment to these goals can also vary from no decided goal to a firm goal commitment. The goals of individuals seeking alcohol use disorder (AUD) treatment are often categorized into nonabstinence goals (i.e., controlled/moderate drinking) and abstinence goals (Haug et al., 2018; Heather et al., 2010). However, the prevailing treatment target of most AUD treatment programs is abstinence (Davis & Rosenberg, 2013; Rosenberg & Davis, 1994), possibly deterring many individuals with different goals from initiating treatment or spurring them to discontinue treatment prematurely.

A growing body of research has examined the relation between AUD treatment goal selection and treatment outcome. Multiple studies have

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Received 1 June 2021; Received in revised form 15 April 2022; Accepted 8 June 2022 Available online 16 June 2022 0740-5472/© 2022 Elsevier Inc. All rights reserved. converged on the finding that individuals with abstinence goals generally have more favorable outcomes, particularly when outcomes are defined by abstinence, at post-treatment and up to 5 years following AUD treatment entry than individuals with nonabstinence goals (Adamson et al., 2010; Berger et al., 2016; Berglund et al., 2019; Haug et al., 2018). Yet many individuals do not wish to select an abstinence goal and would prefer to select their own AUD treatment goal (Sobell et al., 1992). Regardless of treatment goal, individuals who self-select their treatment goal significantly reduce the frequency of drinking (Bujarski et al., 2013; Dunn & Strain, 2013) and most individuals achieve substantial reductions in drinking following AUD treatment (Mann et al., 2017; Witkiewitz et al., 2017).

The selection of AUD treatment goals varies based on multiple variables. In a study of outpatient AUD treatment, Heather et al. (2010) found that selecting abstinence goals was related to a variety of demographic, drinking, treatment, and psychosocial functioning variables. More specifically, individuals selecting an abstinence goal were more likely to identify as female, to be unemployed, report drinking more heavily but less frequently, have been detoxified in the two weeks prior to assessment, report more alcohol problems, be in the action stage of change, report greater negative expectancies of drinking, report worse mental and physical health, report less social support for drinking, and be more confident of their ability to resist heavy drinking in tempting situations than individuals selecting nonabstinence goals. Conversely, in the COMBINE study, lower levels of alcohol problems, less readiness to change, more social support for drinking, and lack of prior treatment were significant predictors of nonabstinence goals (DeMartini et al., 2014).

A limitation of this prior work was that it viewed individuals' selection of goals as fixed rather than a dynamic process. More recent studies have now examined how AUD treatment goals evolve over a course of AUD treatment and have found that individuals switch between both abstinence and nonabstinence goals over time (e.g., Enggasser et al., 2015). Importantly, those who set more ambitious drinking goals at baseline (i.e., greater reductions in drinking) are more likely to continue to set ambitious goals as treatment progresses, and more ambitious goals at mid-treatment are associated with better long-term treatment outcomes (DeMartini et al., 2018). DeMartini et al. (2018) also examined the individual variables associated with changes in AUD treatment goals from baseline to mid-treatment. Results indicated greater body weight and heavier peak baseline drinking were associated with changing to a less ambitious goal at mid-treatment (i.e., setting a higher level of drinking as the goal), and older age was associated with changing to a more ambitious goal at mid-treatment compared to baseline (i.e., setting a lower level of drinking as the goal). This study has important implications for clinical practice and for advancing knowledge about AUD clinical course. Specifically, understanding what variables are linked to differences in goal selection throughout treatment would allow clinicians and clients to make empirically grounded decisions about what goals make sense for who, and to understand who is most likely to change their goal. However, this study had a few factors that limit its ability to understand these factors. First, the study only included young adult drinkers (18-25-year-olds) who agreed to participate in a clinical trial examining the efficacy and safety of naltrexone. Second, the variables used to predict changes in goals from baseline to mid-treatment were limited to only baseline demographic and alcohol use variables. To better understand what variables are associated with goal changes over the course of treatment, we need to extend DeMartini's prior study in a larger, more diverse sample that has a richer set of variables from which to predict changes.

The current secondary data analysis sought to identify baseline variables that predict changing one's treatment goal while receiving AUD treatment in the community among a diverse sample of individuals with AUD. Taking advantage of an exploratory data mining technique called decision tree learning, we sought to develop intuitive decision trees that highlight the baseline factors, from a broad selection of variables including demographic variables (e.g., sex, race/ethnicity), alcohol/substance use indicators (e.g., drinks per drinking day, percent days abstinent), and other psychosocial constructs (e.g., anxiety, depression, social support), that are most predictive of changing one's treatment goal. Among those who changed their treatment goal, we developed decision trees that highlight the baseline factors that are most predictive of moving toward or away from a total abstinence treatment goal. Although we considered other analytic approaches, we selected decision trees as the primary analytic technique due to the interpretability of results (i.e., decision trees demonstrate implicit interactions between variables and include cut-points for each variable in the final model). We used another machine learning algorithm, random forest, to cross-validate results and examine similarities and differences in variable importance across algorithms.

2. Method

2.1. Participants and procedures

The current study is a secondary analysis of data from the Relapse Replication and Extension Project (RREP: Lowman et al., 1996). A total of 563 (41.2 % women, 67.3 % White, 16 % Black/African American, 8.9 % Hispanic/Latino, 2.7 % American Indian/Alaska Native; and 5.2 % "Other"; $M_{age} = 34.3$, SD = 8.7) participants were recruited for RREP, a prospective multisite longitudinal study of risk factors for relapse among individuals with AUD recruited from treatment facilities surrounding the three clinical research sites at the University of Buffalo, Brown University, and University of New Mexico. All three sites implemented their own research questions, while including some identical assessment measures. Inclusion criteria for RREP were: at least 18 years of age (or at least 21 at the University at Buffalo site), meet diagnostic criteria for alcohol abuse or dependence within the past 6 months according to Diagnostic and Statistical Manual for Mental Disorders, third edition revised (American Psychiatric Association, 1987) criteria, have no concomitant drug diagnoses more severe than the alcohol problem, have no intravenous drug use in the past 6 months, be able to read at the 8th grade level, be without major psychiatric disorder or gross intellectual impairment, have completed detoxification, plan to live within commuting distance of the research site for the ensuing year, be willing to provide the names of two locators who could provide a new address, be willing to provide serum samples to assess liver enzyme levels, be willing to engage in seven assessments at bimonthly intervals, and be willing to sign a consent statement. The Brown University site required participants to be able to describe a prior attempt to quit drinking defined as at least 4 days of abstinence followed by a heavy drinking episode (a day on which the participant consumed enough alcohol to achieve a blood alcohol concentration [BAC] of 0.10 or higher, based on gender and body weight).

To be included in the current analyses, participants (n = 441; 78.3 % of the RREP sample) needed to complete the measures we describe next.

2.2. Measures

2.2.1. Treatment goal

The study assessed treatment goal at baseline and 6-month follow-up using a single item from the Thoughts About Abstinence (TAA) scale (Hall et al., 1991): "What is your own present goal with regard to drinking?" Six response options were provided, reordered here from the strongest to weakest commitment to abstinence: 1) *Total abstinence – I want never to drink again*, 2) *Total abstinence, but I realize that I may slip sometimes*, 3) *Temporary abstinence – I want to quit for a while, but then drink again later on*, 4) *Occasional drinking when I feel a strong urge*, 5) *Controlled or moderate drinking*, 6) *No goal – I don't want to change my drinking.* For the current study, we scored treatment goal variables to capture change from baseline to 6-month follow-up (0 = *no change*, 1 = *change*) and direction of treatment goal change from baseline to 6-month

follow-up (0 = toward complete abstinence goal, 1 = away from completeabstinence goal). The study team calculated direction of treatment goal change by subtracting the baseline treatment goal score from 6-month follow-up treatment goal score. Negative scores indicated moving toward a complete abstinence goal and positive scores indicated moving away from a complete abstinence goal. For example, if "1) Total abstinence – I want never to drink again" was selected at baseline and "2) Total abstinence, but I realize that I may slip sometimes", was selected at 6-month follow-up, treatment goal change would be classified as moving away from a complete abstinence goal. If "2) Total abstinence, but I realize that I may slip sometimes", was selected at baseline and "1) Total abstinence – I want never to drink again" was selected at 6-month follow-up, we would classify the treatment goal change as moving toward a complete abstinence goal.

2.2.2. Treatment history

We assessed recent alcohol treatment sessions at baseline using the Form 90 (Miller & Del Boca, 1994). The team quantified treatment sessions as the number of "session[s] with a counselor or therapist." The average number of treatment sessions reported at baseline were 4.27 (range: 0-69) and the modal number of treatment sessions were 0 (56.3 % of sample).

2.2.3. Predictor variables

The research team entered a total of 111 predictor variables into the decision trees. The team classified variables as demographic variables (e.g., sex, race/ethnicity), alcohol/substance use indicators (e.g., drinks per drinking day, percent days abstinent), or other psychosocial constructs (e.g., Beck Anxiety Inventory, Beck Depression Inventory; Beck et al., 1988, 1961). See Table 1 for a complete list of predictor variables.

2.3. Analysis plan

We examined two outcomes with the same baseline predictor variables using a decision tree approach using the 'rpart' package (Therneau & Atkinson, 2019) in R (R Core Team, 2019). Predictors included demographic variables, alcohol/substance use indicators, and other psychosocial constructs. Decision tree 1 identified salient predictors of a binary measure of change in drinking goal from baseline to 6 months among all participants (n = 441; 0 = no change, 1 = change). This decision tree reflected any change of drinking goal but did not capture the direction of the change. Decision tree 2 identified salient predictors of a directional measure of drinking goal change among participants (n =198) who reported a change in goal from baseline to 6 months (0 =toward complete abstinence goal, 1 = away from complete abstinence goal). To decrease risk of overfitting decision trees, the team removed or "pruned" branches that did not improve prediction accuracy in crossvalidation (k = 10). We followed the "one-standard-error" rule to select a complexity parameter. The one-standard-error rule selects the most parsimonious model that is no more than one standard error greater than the error of the best fitting model (e.g., smallest standard error) (Hastie et al., 2009). The team selected a complexity parameter of 0.028 and 0.050 for models 1 and 2, respectively. We retained default settings for the minimum N to make a split (minsplit = 20), maximum depth (30), and minimum N in a terminal node (minsplit / 3). We calculated an overall measure of variable importance by summing the goodness of split for each split for which the variable was the primary variable, plus the goodness of split for all splits in which it was a surrogate variable. These values are then scaled to sum to 100.

We also created two random forests using the same baseline predictor variables as the decision tree models to cross-validate results using the "randomForest" package in R (Liaw & Wiener, 2002). Random forest 1 was a binary measure of change in drinking goal from baseline to 6 months among all participants (same outcome as Decision tree 1). Random forest 2 was a directional measure of drinking goal change among participants who reported a change in goal from baseline to 6

Table 1

	Decision trees		
	1	2	
Demographic variables			Race/ethnic group:
0 1			American Indian/Alaska
			Native
			Asian
			Black
			Hispanic
			Biracial
			Other race
			Marital status:
			Single
			Married
			Separated
			Divorced
			Widowed
			Employment:
			Full-time
			Part-time
			Retired
			Unemployed
			Homemaker
			Income:
			<\$15,000
			\$15,000-\$29,999
			\$60,000-\$89,999
			>\$90.000
			Family history of alcohol
			problems (at least one parent)
			Family history of alcohol
			problems (at least one parent o
			one sibling)
Alcohol Dependence Scale (Skinner			Total Score
& Horn, 1984)			AA Attendence Coore
Questionnaire (AAI: Tonigan			AA Attendance Score
et al. 1996) ^a			MY myorvement score
Alcohol Beliefs Ouestionnaire (ABO:			Global positive expectancies
Collins et al., 1990) ^a			Social/physical pleasures
			Sexual pleasures
			Power/aggression
			Positive personality
			Tension reduction
			Cognitive/motor impairment
Post Doprocion Inventory (PDI)			Unconcerned Total score
Beck et al 1961)			Total score
Beck Anxiety Inventory (BAI: Beck		x	Total score
et al., 1988)			
Coping Behavior Inventory (CBI;			Positive thinking
Litman et al., 1983) ^b			Negative thinking
			Avoidance/distraction
			Seeking social supports
Orinker Inventory of Consequences			Total score
(DILL); MILLET ET AL., 1995)"			Positive thinking
Inventory (ECBI: Litman 1986)			Negative thinking
inventory (ECDI, Etunan, 1980)			Avoidance/distraction
	Х		Seeking social supports
mpaired Control Scale (ICS;			Part 1: restraint past
Heather et al., 1993)			Part 2: impaired restraint
			Part 3: restraint prediction
			Total score
nventory of Drinking Situations			Negative
nventory of Drinking Situations (IDS; Annis et al., 1987)			Negative events
nventory of Drinking Situations (IDS; Annis et al., 1987) .ife Events Survey (LES; Sarason			Desitive events
nventory of Drinking Situations (IDS; Annis et al., 1987) ife Events Survey (LES; Sarason et al., 1978)			Positive events
nventory of Drinking Situations (IDS; Annis et al., 1987) .ife Events Survey (LES; Sarason et al., 1978)			Positive events Total events Total score
nventory of Drinking Situations (IDS; Annis et al., 1987) ife Events Survey (LES; Sarason et al., 1978) 'urpose in Life (PIL; Crumbaugh, 1968) ⁿ			Positive events Total events Total score
nventory of Drinking Situations (IDS; Annis et al., 1987) ife Events Survey (LES; Sarason et al., 1978) 'urpose in Life (PIL; Crumbaugh, 1968) ^a Religious Beliefs and Behaviors (Positive events Total events Total score Total SCORE

Table 1 (continued)

	trees			
	1			
	1	2		
Reasons for Drinking Questionnaire		Х	Negative emotions	
(RFDQ; Zywiak et al., 1996) ^a			Social pressure	
Situational Confidence			Total score	
Questionnaire (SCQ; Annis, 1982)				
Seeking of Noetic Goals (SONG; Crumbaugh, 1977) ^a			Total score	
Social Support Questionnaire (SSQ;		Х	Friends	
Sarason et al., 1983)			Family	
State-Trait Anxiety Inventory for Adults-Trait Subscale (Form Y-2; Spielberger et al., 1983)			Total score	
State-Trait Anger Expression			State anger	
Inventory (STAXI; Spielberger			Trait anger	Xc
et al., 1995)			Trait anger-temperament	а
			Anger expression-In ^a	b
			Anger expression-Out ^a	
			Anger control ^a	ma
			Anger expression ^a	1110
Form-90 Drinking Variables (Miller,			Percent days abstinent	vve
1995)	v		Continuous abstinence	111
	л		Drinks per day	sei
			Percent heavy drinking days	an
			Max drinkers per day	stu
			Max BAC per day	on
			Average BAC	in
			First drinking	im
Form-90 Other Variables (Miller,			Living in house	ba
1995)			Living in halfway house	for
			Living homeless	
			Living under medical care	the
	Х		Alcohol sessions	up
			Drug sessions	on
			Emotional sessions	ba
			12-step sessions Work days	Du
			School days	2
			Worship days	э.
			Meds used to treat medically	
			Meds used to prevent drinking	(0
			Meds used to detox	68
			Meds used to stabilize drugs	2.9
			blockers	av
			Meds used for psychological	sai
			problems	wa
			Tobacco ever used	ma
		х	Tobacco lifetime weeks	en
			l'obacco days current period	(1.
			period	sti
			Marijuana ever used	dri
			Marijuana lifetime weeks	oc
			Marijuana days current period	en
			Tranquilizers ever used	(5
			Tranquilizers lifetime weeks	(
			neriod	ica
			Sedatives ever used	00
			Sedatives lifetime weeks	80
			Sedatives days current period	pro
			Steroids ever used	n18
			Steroids lifetime weeks	(1:
			Steroids days current period	sco
			Stimulants lifetime weeks	-2
			Stimulants days current period	.00
			Cocaine ever used	ing
			Cocaine lifetime weeks	=.
			Cocaine days current period	Eff

Desision

Table 1 (continued)

Deettee	cisio es	n
1	2	
		Hallucinogens ever used Hallucinogens lifetime weeks Hallucinogens days current period Inhalants ever used Inhalants lifetime weeks Inhalants days current period Opiates lifetime weeks Opiates lays current period Other drugs ever used Other drug lifetime weeks Other drug days current period

lenotes the variable was a significant predictor.

Scale not administered at Brown University site.

Scale not administered at University of New Mexico site.

onths (same outcome as Decision tree 2). To create the random forests, used the "caret" package in R (Kuhn, 2021) to tune a meta-parameter ntry" to determine the optimal number of random variables to be ected for reach run of the random forest analyses. The team selected mtry value of 8 and 11 for random forest 1 and 2, respectively. The dy grew an ensemble of 1000 trees for each model following recumendations by Probst and Boulesteix (2018). We used mean decrease Gini impurity to assess variable importance for each model. Gini purity is the probability of misclassification if labelled at random sed on the composition of the group. Complete results of the random rests are reported in the supplementary materials.

Given that we could examine only change in treatment goal among ose who provided treatment goal data at baseline and 6-month follow-, we compared those with (n = 441) and without (n = 122) these data baseline covariates using independent samples t-tests for continuous seline variables and χ^2 for categorical baseline variables.

Results

Participants in the analyzed sample (n = 441) were 41.7 % female, .5 % White, 15 % Black/African American, 7.9 % Hispanic/Latinx, 9 % American Indian/Alaska Native, and 5.7 % "Other", with an erage age of 34.5 (SD = 8.8). At the start of treatment, most of the mple (90.3 %) endorsed abstinence goals (total abstinence and never anting to drink again: 59.6 %; total abstinence and recognizing slips ay occur: 29.4 %; or temporary abstinence: 1.3 %), and the other 9.7 % dorsed controlled/moderate drinking (7.6 %), occasional drinking .6 %), or no goal (0.5 %). At the six-month follow-up, most (82.0 %) ll endorsed abstinence goals, including total abstinence and never ink again (49.1 %), total abstinence with recognition that slips would cur (31.3 %), or temporary abstinence (1.6 %). The other 18.0 % dorsed controlled/moderate drinking (11.7 %), occasional drinking .4 %), or no goal (0.9 %).

Attrition analyses indicated that six baseline covariates were signifantly different between individuals who provided complete treatment al data at baseline and 6-month follow-up versus those who did not ovide treatment goal data. Participants with drinking goal data had gher positive personality effects from drinking alcohol scores (t (38.69) = -3.38, p = .001), tension reduction from drinking alcohol pres (t(251) = -2.23, p = .027), impaired restraint scores (t(549) =2.01, p = .044), and total days living rent free (t(148.39) = -3.49, p = -3.4901). Participants missing either baseline or 6-month follow-up drinkg goal data had higher purpose in life total score (t(115.07) = 2.01, p.047) and total days living in own house (t(167.04) = 4.04, p < .001). Effect sizes were in the small to medium range (Cohen's d: 0.25–0.45).

3.1. Decision tree 1: nondirectional goal change in the total sample decision tree

In the analyzed sample (n = 441), 44.9 % of individuals changed their treatment goal from baseline to 6 months. Fig. 1 presents decision tree learning results as trees and we report fit indices in Table 2. The decision trees are visually intuitive and list cut-points for continuing down each branch as well as the percent likelihood of an individual meeting the cut-point criteria to endorse the outcome. Three variables contributed to the final tree predicting AUD treatment goal change: number of recent alcohol treatment sessions attended prior to initiating the RREP study, drinks per drinking day, and the seeking social supports subscale of the Effectiveness of Coping Behavior Inventory. Among individuals who attended 3 treatment sessions or fewer prior to the RREP baseline (n = 316), 39.9 % changed their treatment goal. This group was then split based on drinks per drinking day. Among individuals with at least 31.31 drinks per drinking day (n = 46), 15.2 % changed their treatment goal. Individuals with fewer than 31.31 drinks per drinking day (n = 270) were more likely to change their treatment goal (44.1 %).

Among individuals who reported 4 sessions or more prior to the RREP baseline (n = 125), 57.6 % changed their treatment goal. The study then split this group based on seeking social supports score. Individuals who reported higher levels of seeking social supports (\geq 5.5) were less likely to change their treatment goal (46.5 %) relative to those with lower levels (<5.5) of seeking social supports (82.1 %).

The 10 most important predictor variables in model 1 were: drinks per drinking day, average BAC at baseline, seeking social supports subscale of the Effectiveness of Coping Behavior Inventory, drinks per day, positive thinking subscale of the Effectiveness of Coping Behavior Inventory, Inventory of Drinking Situations total score, percent days abstinent at baseline, percent heavy drinking days at baseline, maximum BAC at baseline, and negative thinking subscale of the Effectiveness of Coping Behavior Inventory.

3.2. Decision tree 2: directional goal change among those who changed treatment goals decision tree

In the overall sample of individuals who changed goals (n = 198),



Sensitivity

79.0 %

93.4 %

Table 2

Decision tree fit metrics.

Decision tree 1

Decision tree 2

level of social support from friends. The root of the tree was split on the negative emotion subscale of the Reasons for Drinking Questionnaire. The subscale is a summed score (min: 0, max: 70) of seven items on a response scale ranging from 0 (*Not at all important*) to 10 (*Very important*). Among individuals with higher levels of negative emotions as a reason for drinking (n = 149), 25.5 % moved away from a complete abstinence goal. This group was then split based on lifetime weeks of tobacco use, with fewer weeks of tobacco use being associated with higher probability of moving away from a complete abstinence goal (n = 14; 64.3 %). Individuals with more weeks of lifetime tobacco use (n = 135) were less likely to move away from a complete abstinence goal (21.5 %).

change (see Fig. 2): negative emotions as a reason for drinking, lifetime

weeks of tobacco use, Beck Anxiety Inventory total score, and perceived

Specificity

61.1 %

46.8 %

Note. PPV = positive predictive value. NPV = negative predictive value.

Among individuals (n = 49) with lower levels of negative emotions as a reason for drinking, 49 % moved away from a complete abstinence goal. The team then split this group based on level of anxiety based on the Beck Anxiety Inventory. Individual responses on a scale ranging from 1 = Not at all [bothered] to 4 = Severely [bothered] were summed to create an anxiety score. Among individuals who reported low anxiety levels (n = 18), 16.7 % moved away from a complete abstinence goal. Among individuals who reported higher anxiety levels (n = 31), 67.7 % moved away from a complete abstinence goal. This group was then split based on perceived level of social support from friends. Individual reported if they felt supported or not by their friends in a variety of ways and we summed scores to create a response range of 0 (*no support*) to 14



Likelihood of Changing Treatment Goal ←Lower Probability Higher Probability→

Fig. 1. Decision tree predicting binary treatment goal change (yes/no) from baseline to 6-month follow-up.

NPV

70.4 %

76.3 %

Accuracy

71.0 %

78.8 %

PPV

71.4 %

79.4 %



Likelihood of Changing Treatment Goal Away from Complete Abstinence Goal ←Lower Probability Higher Probability→

Fig. 2. Decision tree predicting directional treatment goal change from baseline to 6-month follow-up.

(*total support*). Individuals (n = 7) with high social support from friends had a lower probability of moving away from a complete abstinence goal (n = 7; 14.3 %), whereas individuals with less social support from friends had a higher probability of moving away from a complete abstinence goal (n = 24; 83.3 %).

The 10 most important predictor variables in model 2 were: lifetime tobacco use, Beck Anxiety Inventory total score, negative emotions subscale of the Reasons for Drinking scale, drinks per drinking day, perceived level of social support from friends, Situational Confidence Questionnaire average score, average BAC at baseline, lifetime cocaine use, recent alcohol treatment session, and the positive thinking subscale of the Effectiveness of Coping Behavior Inventory.

3.3. Cross-validation and variable importance

We created two random forests to cross-validate results and examine similarities and differences in variable importance across machine learning models (for complete random forest results see random forest 1 and 2 in the supplementary materials). The 10 most important predictor variables in random forest 1 (nondirectional goal change, random forest model) were: the avoidance/distraction subscale of the Effectiveness of Coping Behavior Inventory, Beck Depression Inventory total score, the avoidance/distraction subscale of the Combine Behavioral Intervention, the trait anxiety subscale of the State-Trait Anxiety Inventory, Inventory of Drinking Situations total score, maximum BAC at baseline, drinks per drinking day at baseline, lifetime tobacco use, Beck Anxiety Inventory total score, and the seeking social supports subscale of the Effectiveness of Coping Behavior Inventory. In terms of similarities in variable importance for decision tree 1 and random forest 1, we found that four of the top 10 most important variables in decision tree 1 were also in the top 10 of random forest 1. These variables were drinks per drinking day at baseline, the seeking social supports subscale of the Effectiveness of Coping Behavior Inventory, Inventory of Drinking Situations total score, and maximum BAC at baseline.

The 10 most important predictor variables in random forest 2 (directional goal change, random forest model) were: the positive thinking subscale of the Effectiveness of Coping Behavior Inventory, the positive thinking subscale of the Combine Behavioral Intervention, lifetime tobacco use, Situational Confidence Questionnaire average score, lifetime cocaine use, Inventory of Drinking Situations total score, average BAC at baseline, Religious Background and Beliefs total score, the sexual pleasures subscale of the Alcohol Beliefs Questionnaire, and drinks per day at baseline. In terms of similarities in variable importance for decision tree 2 and random forest 2, we found that four of the top 10 most important variables in decision tree 2 were also in the top 10 of random forest 2. These variables were lifetime tobacco use, Situational Confidence Questionnaire average score, average BAC at baseline, and lifetime cocaine use.

4. Discussion

The current study attempted to identify variables that predict changing one's treatment goal while receiving AUD treatment using an exploratory data analytic approach. In a sample of individuals with AUD who received treatment in diverse community treatment settings, nearly half of the sample (44.9 %) changed their treatment goal from baseline to 6 months and most of these individuals (68.7 %) changed from a nonabstinence goal toward a complete abstinence goal. The diversity of goal type and dynamic nature of the goals over time highlights the need to better understand characteristics associated with each goal and

change in goals during treatment. Across decision trees of AUD treatment goal change, the study identified seven unique predictors of goal change: number of recent alcohol treatment sessions at baseline, drinks per drinking day, seeking social supports, negative emotions as a reason for drinking, lifetime weeks of tobacco use, anxiety, and perceived level of social support from friends. Each of the factors had different levels of relevance depending on the model and where in the tree it fell. We also used random forests to cross-validate results and compare variable importance across methods. The paper discusses the main findings of each model below.

In our first decision tree, we examined predictors of change in treatment goal during the first 6 months of treatment, regardless of direction of goal change. The study identified three variables as being linked to goal change in this tree, number of recent treatment sessions, drinks per drinking day, and seeking social supports. Those with fewer recent treatment sessions prior to enrolling in the study and those with more drinks per drinking day were substantially less likely to change their goal. The structure of our analysis does not permit us to articulate the directionality of change (i.e., toward or away from abstinence). Though speculative, this result may reflect a tendency for those who are less familiar with treatment to follow guidance of a therapist (defer to the "expert"), consistent with findings by Cooper et al. (2019). Similarly, the finding may reflect a tendency to stick with their initially selected goal, successful or not. Alternatively, those with greater treatment histories may be quicker to change, given their experience with what works or does not work for them. This finding is in line with previous research highlighting the effects of previous treatment on the selection of treatment goals (DeMartini et al., 2014). Despite finding similar predictors as DeMartini et al. (2014), the current study has meaningful differences worth noting. Their study focused on predicting initial treatment goals, not change in goals during treatment. They found those with less previous treatment were more likely to choose nonabstinence goals at the beginning of treatment. Based on these findings, a therapist might want to consider a client's past treatment history and initial drinks per drinking day as it pertains to their goal selection. For example, if a client is entering treatment for the fifth time having unsuccessfully attempted moderate drinking in the past and is drinking >30 drinks per drinking day when starting treatment, a therapist might consider suggesting a new goal of abstinence, given the client is unlikely to change their goal independently. Conversely, if the same client has been unsuccessful with abstinence and initially selects an abstinence goal, then the therapist might recommend the client consider changing to a moderate drinking goal.

In our second decision tree, we examined predictors of goal change direction (i.e., toward or away from complete abstinence) among those who changed their goals between baseline and 6-month follow-up. Roughly 69 % of those who altered their goals moved their new goal closer to complete abstinence than they had originally planned. This finding is particularly noteworthy, as it might seem counter to anecdotal descriptions of this population and could reflect a realization on the client's part that they would increase their chances of success with a more ambitious goal closer to complete abstinence. These findings are consistent with previous research demonstrating that those with more ambitious treatment goals at mid-treatment exhibit better outcomes. Interestingly, only ~ 26 % of those who endorsed higher levels of drinking to cope with negative emotions moved away from a total abstinence goal. Those who endorse drinking to cope often also cite experiencing more negative affect (Armeli et al., 2014) and negative affect is cited as a key setting in which relapse occurs (Miller et al., 1996; Rubin et al., 1996; Zywiak et al., 2006). Meanwhile, individuals with low levels of drinking to cope with negative emotions, moderate to severe anxiety, and moderate or lower levels of social support were more likely to move away from an abstinence-only goal. This finding, in part, stands in contrast to prior work on social support (DeMartini et al., 2014; Heather et al., 2010). Unlike previous work, lower levels of social support from family and friends increased likelihood of moving away from

an abstinence goal. Clinically, a therapist might consider helping individuals to develop skills for managing anxiety and/or engaging social supports if an individual has an abstinence goal and would prefer not to change their goal since higher anxiety scores and lower social supports are predictive of changing goals away from an abstinence goal. Alternatively, a therapist might want to remain aware of the potential for a mid-treatment goal change among individuals with an abstinence goal who report higher anxiety and less social support at baseline.

Limited guidance exists regarding interpretability of similarities and differences in variable importance between machine learning models. We have more confidence in the predictive ability of the four variables in the top 10 most important variables in decision tree 1 that the study also found in random forest 1 (drinks per drinking day at baseline, seeking social supports subscale of the Effectiveness of Coping Behavior Inventory, Inventory of Drinking Situations total score, and maximum BAC at baseline) relative to the six variables that were not also in the top 10 most important variables in random forest 1. Interestingly, multiple measures of avoidance/distraction and of anxiety were important predictors in the random forest model. This suggests anxiety and a coping method for anxiety (i.e., avoidance/distraction) might influence treatment goal change.

Similarly, we have more confidence in the predictive ability of the four variables in the top 10 most important variables in decision tree 2 that were also found in random forest 2 (lifetime tobacco use, Situational Confidence Questionnaire average score, average BAC at baseline, and lifetime cocaine use) relative to the six variables that were not also in the top 10 most important variables in random forest 2. Commonly identified predictors across both models included metrics of alcohol and other drug use, which suggests that levels of lifetime substance use might influence directionality of treatment goal change.

4.1. Limitations

The current study has limitations that are important to note. The sample that we used was recruited between 1992 and 1994; thus, some of our findings may be different among individuals seeking treatment for an AUD today. Importantly, although AUD treatments remain primarily abstinence-based, more harm reduction/moderation-based treatments are available at present and the majority of individuals who seek treatment in more contemporary studies are interested in nonabstinent goals (Falk et al., 2019; Witkiewitz et al., 2019). Thus, our findings should be interpreted cautiously regarding base rates of these specific drinking goals among those seeking AUD treatment. Given the structure of the study, we are unable to account for the different types of treatment or changes in the type of treatment that individuals received. This feature of the design likely enhances the real-world generalizability of our findings but undermines our ability to localize how treatment modalities could contribute to our findings. Given the specific exclusion criteria, we may have excluded individuals on characteristics that may be important in predicting (change in) treatment goals. For example, all subjects had to have completed detoxification, which could limit the range and severity of withdrawal symptoms in the sample, lowering the likelihood that addiction severity and withdrawal symptoms would be predictive of treatment goal change in our analyses. In addition, some of the decision tree nodes had rather small sample sizes, which may limit generalizability. Further, the small node size makes exploratory analyses examining the relationship between goal change and treatment progress infeasible. Given the exploratory nature of our analytic approach, these findings should be replicated in independent samples.

5. Conclusion

Although the cut-points for substance use–related predictors identified by the decision trees might not generalize, the results support prior research on predictors of treatment goal selection and extend the findings by identifying predictors of treatment goal change over time. Although further work should continue to identify predictors of treatment goal change, this work identified variables that can be applied by researchers and treatment providers who are interested in predicting and understanding factors that contribute to treatment goal selection and treatment goal change.

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Appendix A. Supplementary data

Supplementary results to this article can be found online at htt ps://doi.org/10.1016/j.jsat.2022.108825.

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