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Using a randomized controlled trial to test whether modifications to contingency management improve outcomes for heavy drinkers with serious mental illness

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Abstract

Background—In contingency management (CM), individuals receive rewards for alcohol abstinence. CM is associated with reduced alcohol use in adults with co-occurring serious mental illnesses (SMI). Pre-treatment urine ethyl glucuronide (uEtG) levels equivalent to daily heavy drinking (uEtG > 349 ng/mL) are associated with poor response to CM. Modifications to CM are needed to improve outcomes for non-responders.

Aims—To determine if pre-treatment heavy drinkers, defined by uEtG, with SMI achieve higher levels of alcohol abstinence when they receive an increased magnitude of reinforcement for abstinence (High-Magnitude CM) or reinforcers for reduced drinking, prior to receiving reinforcers for abstinence (Shaping CM), relative to those who receive typical low-magnitude abstinence based CM (Usual CM). Additionally, variables in the Addictions Neuroclinical Assessment model will be examined as treatment response moderators.

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this paper.

Methods—Participants (N = 400) will be recruited from two urban mental health organizations and complete a 4-week induction period where they will be reinforced for submitting samples for uEtG testing. Participants who attain a mean uEtG > 349 mg/mL will be randomized to receive either Usual CM, High-Magnitude CM, or Shaping CM for 16 weeks. Differences in abstinence, assessed by uEtG, will be examined during treatment and during a 12-month follow-up. Measures of negative emotionality, alcohol reinforcer salience, and executive functioning will be gathered at study intake and used to predict treatment outcomes.

Discussion—This novel approach to CM will use an alcohol biomarker to identify those at risk for treatment non-response and determine if adaptations to CM might improve outcomes for this group.

Keywords

Alcohol treatment; Contingency management; Ethyl glucuronide; Serious mental illness addictions neuroclinical assessment

1. Introduction

Forty-six percent of individuals with serious mental illnesses ([SMI]; i.e., schizophrenia spectrum, bipolar, and recurrent major depressive disorders) have a co-occurring alcohol use disorder (AUD) [1–4]. Relative to people with SMI who do not use substances, those who use alcohol or drugs experience higher levels of psychotic symptoms, in-patient psychiatric care, medical expenditures, homelessness, treatment attrition, suicidal behavior, and cognitive impairment [5–14]. Few individuals receive treatment for co-occurring SMI and AUDs, and even fewer individuals receive evidenced-based treatments [15,16].

Contingency management (CM) is a behavioral intervention that provides low-cost reinforcers (i.e., total of $250–$400) for drug and alcohol abstinence [17] and is associated with decreased alcohol and drug use in individuals with SMI [18–21]. In a previous study of CM as a treatment for AUD in adults with SMI, we used the alcohol biomarker, urine ethyl glucuronide urine (uEtG) to assess abstinence. uEtG can detect use during the previous 2 days and heavy drinking up to 5 days after drinking [20,22,23]. CM participants were 3.1 times more likely to submit negative uEtG samples, relative to those receiving treatment-as-usual (TAU) and reinforcers for participation only [20]. However, participants with a pre-treatment uEtG > 499 ng/mL (i.e., daily heavy drinking) did not respond to CM [20].

This finding is consistent with other studies that have found that biologically verified drug use immediately prior to treatment is associated with poor response to low-cost, abstinence-based CM [24–27]. Increasing reinforcer magnitude (i.e., high-magnitude CM) is associated with improved outcomes, particularly for those who submitted drug-positive urine tests immediately prior to CM treatment [17,28–30]. Providing reinforcers for reductions in substance use before requiring abstinence (i.e., shaping CM) is also associated with improved outcomes for people who smoke cigarettes or use drugs, who do not respond to a typical low-cost abstinence-based CM [31–33]. However, no study has investigated the effectiveness of these CM adaptions for treating AUDs, or compared these approaches to one another.

While others have investigated predictors of treatment response, no previous study has examined predictors of outcomes using a theoretical framework. The Addictions Neuroclinical Assessment (ANA) framework, developed by the National Institute on Alcohol Abuse and Alcoholism (NIAAA), is a neuroscience-based framework for explaining the causes and maintenance of addiction [34]. This framework postulates three domains – poor executive functioning (e.g., working memory, impulsivity), negative emotionality (e.g., depression, anxiety, psychological symptoms of withdrawal), and high levels of alcohol-related incentive salience (e.g., thinking about alcohol, craving a drink) –as the primary factors that cause and maintain AUDs. This model maybe particularly applicable to heavy drinkers with SMI, because these individuals experience high levels of negative emotions, poor working memory, and high levels of impulsivity and alcohol-cravings [35,36].

Funded by NIAAA (R01AA020248), we will be conducting a randomized clinical trial to determine the following aims: 1) whether levels of alcohol abstinence during the last 3 months of treatment, and a 12-month follow-up period vary by CM condition; 2) whether groups differ on secondary alcohol outcomes, drug use, psychiatric severity, HIV risk behavior, and cigarette smoking; and 3) identify ANA-based moderators of CM treatment response across and within CM conditions.

2. Methods

2.1. Study design

Participants (N = 400) recruited from two urban mental health organizations will first take part in a 4-week induction phase during which they will receive reinforcers for submitting 2 urine samples per week, regardless of uEtG results. Participants who meet secondary eligibility criteria of attendance (estimated N = 240; see below) and uEtG-defined heavy drinking (uEtG > 349 ng/mL) will be randomized to receive either, a)4 months of standard-magnitude reinforcement CM for submitting alcohol-negative samples (uEtG < 150 ng/mL; Usual CM); b)4 months of high-magnitude CM for submitting alcohol-negative samples (High-Magnitude CM); or c)1 month of standard-magnitude CM for submitting urine samples that indicate light drinking (uEtG < 350 ng/mL), followed by 3 months of standard-magnitude CM for submitting alcohol-negative samples (Shaping CM). Our CM paradigm will use the variable magnitude of reinforcement procedure (VMRP), in which participants draw from a bowl for chances to receive items and gift cards. Groups will differ only on the number of draws they receive (Usual vs. High-Magnitude), or the contingency by which they are allowed to engage in draws (light drinking vs. abstinence).

Randomized participants will complete follow-up assessments at 1, 3, 6, and 12 months to assess long-term outcomes. The primary outcome will be alcohol abstinence, assessed as uEtG < 150 ng/mL, during the last 3 months of treatment (when all reinforcers are contingent on abstinence) and the 12-month follow-up period.

2.2. Study procedures

2.2.1. Participant eligibility—Inclusion criteria include the following: 1) 4 or more standard drinks on 5 or more occasions in the past 30 days; 2) Diagnostic and Statistical

Manual of Mental Disorders, Fifth Edition (DSM-5) diagnosis of moderate to severe AUD [37]; 3) DSM-5 diagnosis of schizophrenia or schizoaffective, bipolar I or II, or recurrent major depressive disorder (> 1 episode); 4) age 18–65 years; and 5) receipt of, or eligibility to receive TAU at study sites. Exclusion criteria include the following: 1) current DSM-5 diagnosis of a severe drug use disorder; 2) inability to demonstrate competency to provide consent on the MacAuthur Competence Assessment Tool for Clinical Research (MacCAT-CR); 3) risk of medically dangerous alcohol withdrawal (i.e., seizure within the last 12 months, concern by participant or clinician regarding a potentially dangerous withdrawal); 4) prior diagnosis of dementia; and 5) determination by the Principal Investigator (PI) and medical director that participation would be medically or psychiatrically unsafe.

2.2.2. Randomization procedures—Participants will be randomized to treatment conditions based on permuted block randomization and stratified across the following variables: 1) study site, 2) gender, and 3) baseline uEtG level > 1000 ng/mL (e.g., > 8 standard drinks), which indicates very heavy recent drinking.

2.3. Induction phase

Eligible participants will take part in a 4-week induction phase, during which they will engage in the VMRP procedure 2 times a week for providing urine samples. At each visit, they will receive 3 draws for prizes when they provide urine samples, regardless of whether the samples are positive for alcohol use. Those who provide at least 1 urine sample during each of these 4 weeks will receive a $20 bonus incentive. Consistent with previous studies [38] participants who 1) attain an average uEtG level of > 349 ng/mL (indicating recent heavy drinking) and 2) attend at least 1 study visit during the final week of the induction phase will be randomized. Participants who do not meet criteria for randomization will be referred to other available AUD treatments (See Fig. 1). Although our published research demonstrates that uEtG > 499 ng/mL is associated with poor treatment response [20], unpublished analyses suggested that a lower cut-off of uEtG > 349 ng/mL predicts poor treatment response similar to a uEtG cut-off > 499 ng/ mL. The use of a lower cut-off of uEtG > 349 ng/mL cut-off will allow increase the number of potential participants randomized into the 3 CM conditions during the treatment phase.

2.4. Study intervention

2.4.1. Treatment-as-usual—All participants will receive psychiatric services and addiction TAU. The two urban mental health organizations provide a variety of services at multiple locations in their respective cities (Spokane and Seattle, Washington). Case management, medication management, group and individual counseling, vocational services and housing services will be available to participants based on their individual needs. These organizations also offer outpatient addiction treatment and referrals to local addiction agencies.

2.4.2. Prize draws—Participants in the 3 CM conditions will engage in VMRP each time they meet criteria for obtaining reinforcers over the 16-week treatment phase. Table 1 illustrates how groups will differ only by the number of times they engage in prize draws (Usual CM vs. High-Magnitude CM) or the criterion required to receive reinforcement (light

drinking vs. abstinence). VMRP will involve drawing from a bowl of 500 chips, some of which represent prizes with different dollar amounts. Twenty-five percent will say "good job" (no prize), 62.6% will result in a small prize ($1 to $5 value), 12% will result in a large prize ($20 to $30 value), and 0.4% will result in a jumbo prize ($80 to $100 value). For each urine sample that meets reinforcement criteria, participants will complete the corresponding number of draws. The number of drawings will escalate with each full week (2 consecutive samples) that meets criteria for reinforcement. Missing samples or samples that do not meet reinforcement criteria will result in a reset to the original number of draws (5 draws for Usual and Shaping CM, 15 draws for High-Magnitude CM) on the next occasion when the participant provides a sample that meets reinforcement criteria. If a reset occurs, participants must provide 2 consecutive samples that meet reinforcement criteria before they are returned to the number of draws they previously accumulated. This procedure reduces the probability of relapse after abstinence is initiated [39].

2.4.3. Usual CM condition—Participants randomized to the Usual CM condition will earn at least 5 prize draws each time they submit an alcohol-negative urine sample (uEtG < 150 ng/mL), and an additional draw for each week (2 consecutive alcohol-negative samples) of abstinence. Continuously abstinent participants will receive 20 draws for alcohol-negative tests at each of their week 20 appointments.

2.4.4. High-magnitude CM condition—Participants randomized to this group will be required to demonstrate alcohol abstinence (uEtG < 150 ng/mL) to receive reinforcers. However, they will receive twice as many prize draws overall relative to the Usual CM group for submitting alcohol-negative samples during the 16-week treatment phase, since they will earn at least 15 draws for each negative sample. Note that, although the initial number of draws in the High-Magnitude group is 3 times higher than in the Usual CM group, the difference in the number of draws will become less pronounced over the 16-week treatment phase, and will ultimately approximate twice as many chances to engage in prize draws. One additional draw will be accumulated for each 2 continuous alcohol-negative samples of abstinence. Continuously abstinent participants will be able to earn 30 draws for alcohol-negative samples at each appointment in week 20.

2.4.5. Shaping CM condition—Participants randomized to the Shaping condition will receive the same number of prize draws as those in the Usual CM condition. However, during the first 4 weeks of treatment (weeks 5–8), participants will engage in prize draws for light drinking (uEtG < 500 ng/mL) rather than abstinence. Although the uEtG cutoff of 500 ng/mL is higher than the 350 ng/mL required for randomization, the possibility of individuals increasing their level of drinking and receiving reinforcements in the Shaping treatment condition is offset by results from our previous study that heavy drinkers who had EtG levels that were above 500 ng/mL during the induction period. Additionally our work suggests that the cutoff of 500 ng/mL is most consistently associated with recent heavy drinking a clinically significant treatment target [22]. During the final 3 months of treatment (weeks 9–20) participants will receive prize draws for alcohol abstinence (uEtG < 150 ng/mL). Participants will earn at least 3 draws for each urine sample indicating no heavy drinking during weeks 5–8 and no alcohol use at all during weeks 9–20. An additional draw

will be accumulated for each consecutive week (2 consecutive samples) in which participants meet all criteria for receiving reinforcers. Those who continuously meet criteria for reinforcers will be able to earn 20 draws at each of their week 20 appointments.

2.5. Data collection

Data collection will occur during the study (weeks 1–20, including baseline assessment, induction, and treatment) and the follow-up periods (weeks 21–71). Baseline data collection will take ~120 min and include urine tests, self-reported data, and cognitive tests. Participants will provide urine samples twice a week during the study period. At each visit, they will complete brief self-report questionnaires assessing alcohol use. Weeks 4, 8, 12, 16, and 20 will include 45-minute data collection visits to assess other outcomes. During follow-up, participants will be scheduled for 45-minute visits at weeks 25, 33, 47, and 71. Participants will receive a $30 gift card for completing the baseline interview and a $20 gift card for completing each interview in weeks 4, 8, 12, 16, 20, 25, 33, 47, and 71 (see Fig. 1).

2.6. Measures

2.6.1. Alcohol and drug biomarkers—At each study visit, urine samples will be collected and analyzed onsite for uEtG by using the uEtG immunoassay on an Indiko Bench Top Analyzer (ThermoFischer Scientific, Freemont, CA). An assay will be created for a binary indicator of alcohol use defined by uEtG < 150 ng/ mL. Recent heavy drinking will also be assessed by uEtG tests with a cut-off of uEtG > 349 ng/mL during the indication phase and a cut-off of uEtG > 499 ng/mL for participants randomized to the Shaping CM condition [22]. Although the use of alcohol-containing products has not been associated with false positives [22,40], participants will be asked to abstain from using all alcohol-containing products (i.e., hand sanitizer). Urine samples will be tested for opioids (morphine > 2000 ng/ mL), amphetamine (D-amphetamine > 1000 ng/mL), methamphetamine (D-methamphetamine > 1000 ng/mL), cocaine benzoylecgonine > 300 ng/mL, and cannabis (tetrahydrocannabinol > 50 ng/mL) with EZ-split point-of-care immunoassays at each study visit.

2.6.2. Self-report alcohol use—Days of self-reported abstinence and heavy drinking will be assessed at each visit using the Alcohol Timeline FollowBack [41], which measures the frequency and amount of daily drinking. The Addiction Severity Index Lite will assess the impact of alcohol use on psychiatric, legal, medical, and family functioning, as well as self-reported drug use and its severity [42]. We will assess alcohol cravings by using a 10 cm visual analog scale anchored at 0 (no craving) and 100 (most intense craving possible). The Stages of Change Readiness and Treatment Eagerness Scale will be administered to measure of motivation to change alcohol use [43].

2.6.3. Psychiatric symptoms—The Positive and Negative Syndrome Scale (PANSS) [44] will be used to monitor the clinician-rated severity of positive (e.g., hallucinations) and negative (e.g., avolition) symptoms of schizophrenia-type illness, as well as mood and anxiety symptoms.

2.6.4. ANA framework—At baseline and weekly during the induction phase, the NIH Toolbox Emotion battery will be administered using computerized adaptive testing to measure negative emotionality (anger, fear, sadness), psychological well-being, stress and self-efficacy, and social relationships. At baseline, the NIH Toolbox Cognition battery will be completed and includes measures of executive functioning, episodic memory, processing speed, working memory, and attention. These comprise the Fluid Cognition Composite Score, our primary measure of executive functioning from the ANA framework. The Monetary Choice Questionnaire (MCQ), a delayed discounting measure from the PhenX Toolkit will also be used to supplement the Cognitive battery [45]. Alcohol-related incentive salience will be measured with the Obsessive-Compulsive Drinking Scale, a self-report measure of frequency and consequences of alcohol-related thoughts and behaviors [46], and the Stimulus-Response Compatibility Task, a performance-based measure of approach-avoidance of alcohol-related cues [47].

2.6.5. Other outcome measures—The Timeline FollowBack method will assess the number of cigarettes smoked daily [41]. The Fagerstrom Test of Nicotine Dependence will assess the presence and severity of nicotine dependence [48]. HIV risk behavior will be assessed with the brief HIV Risk Behavior Scale [49].

2.7. Adverse events

A determination of the association of any adverse event with the study intervention will be made, and appropriate modification of the protocol will be executed if an association is suspected. If protocol modifications to ensure the safety of future study participants cannot be executed, the study will be terminated. In the case of a potential serious adverse event, all study procedures and enrollment will be stopped until an investigation conducted by the PI and Co-Investigators has occurred. The PI will determine whether the event should be classified as “serious” or not by using standard US Food and Drug Administration guidelines for a serious adverse event. All adverse events will be reported to the Institutional Review Board (IRB), Data Safety Monitoring Board, Partnering Agency Leadership, and National Institute of Health. Non-serious events will be reported to the Data Safety Monitoring Board quarterly and to the program official and IRB annually.

3. Analytic plan

3.1. Preliminary analyses

Groups will be compared for differences in demographics, and pre-treatment drug and alcohol use, including data collected during the baseline interview and the 4-week induction phase. Baseline comparisons will use analysis of variance (ANOVA) for continuous variables and chi-square tests for categorical variables. We do not anticipate differences between the two groups that will need to be accounted. However, variables that differ between groups at baseline and during the induction phase will be used as covariates in subsequent analyses, as will baseline measures that co-vary with the outcome measures. This is a strategy of preliminary analysis that we and several other teams in the area of CM and addiction treatment have utilized for several decades [20,21,23,50–53].

3.2. Primary analyses

Analyses will be conducted on the intent-to-treat sample (N = 240). Recent alcohol use will be documented by using urine test results (binary outcome: uEtG < 150 ng/mL or uEtG > 149 ng/mL) and analyzed using generalized estimating equations (GEE) with the autocorrelated working matrix, generalized regression, and Cox proportional hazard regression techniques. GEE models will be used to evaluate the differential change in primary (i.e., uEtG) and secondary outcomes (i.e., drug biomarkers, self-report alcohol and tobacco use, psychiatric symptoms, HIV risk behavior) by study condition over the 18-month study period (1 month before the baseline interview plus the 1-month induction, 4-month treatment, and 12-month follow-up periods), and whether condition interacts with change over time. This approach also allows us to characterize between-group differences in longitudinal outcomes. For GEE, we will utilize the autoregressive working correlation matrix. This has been used effectively in our previous work wherein we have many assessments (> 20) on a biochemical outcome, and the assessments are equally spaced. This matrix accounts for the fact that urine assessments made closer in time are more highly correlated, and those that are farther apart are less highly correlated. For the Cox proportional hazards regression, we will examine the outcome of time to relapse in a manner consistent with our analysis of uEtG. That is, we will examine the impact of CM condition assignment on time to relapse and as necessary, included other covariates that are not balanced across the two groups. This will answer the question of which of the three groups are at greatest versus least risk of relapse during the treatment period.

Other outcome measures will be derived from recent alcohol use, such as 1) alcohol use (yes/no) over time; 2) longest duration of abstinence; 3) total number of periods of alcohol abstinence; 4) time to first alcohol abstinence; 5) time to relapse after a specified period of alcohol abstinence; and 6) frequency of heavy drinking. GEE will be used to examine these outcomes across time, CM condition, and the CM condition-by-time interaction to determine whether one condition is superior to the others in promoting discontinuation of alcohol use. We will also use descriptive analyses (i.e., mean, SD) across CM condition to determine the mean number of heavy drinking days, mean number of longest duration of drug abstinence, and mean HIV risk score.

ANA moderators (executive functioning, negative emotionality, alcohol-related incentive salience) will be examined to determine whether they interact with CM regardless of condition.

This will help us determine whether a given moderator significantly modifies the impact of CM on alcohol abstinence. First, we will create an interaction term of CM condition by the moderator in question and examine whether the interaction is significant. Second, if the interaction is significant, we will examine whether the outcome varies within each CM condition across 3 categories of the moderator in question: 1) Mean ± 1 standard deviation, 2) > 1 standard deviation, and 3) < 1 standard deviation. This will be accomplished by conducting a planned linear trend analysis for each CM condition, since we hypothesize that, for example, more executive dysfunction will produce worse treatment outcomes [54,55]. We would expect this to be true in each of the three CM conditions, but would necessarily be more steep in the conditions that showed a stronger effect of CM and hence, a strong and

statistically significant linear trend. If a clearer clinical interpretation is needed, we will use centering (i.e., subtracting the mean from all participant values on the measure) on the ANA moderator being examined, which is consistent with current expert recommendations [54]. We will also evaluate sex as a biological variable by investigating whether sex moderates treatment outcomes.

3.3. Power

Our choice of sample size for randomization ($N = 240$) is based on statistical power calculations for the primary aim of reducing alcohol use and the secondary aim of improving other outcomes during the final 3 months of the intervention and the 12-month follow-up period. We estimated power by using clinically significant cut-off estimates in conjunction with previously reported effect sizes of adapted CM interventions [56,57], based on a sample size of 180, (60 per group), to adjust for an estimated attrition of 25% of the randomized sample ($N = 240$). All power analyses used an alpha threshold for statistical significance of $p < 0.05$ and utilized two-tailed tests to remain conservative, despite our one-tailed hypotheses. Power analyses for specific aims 1 and 2 are based on outcome measures (i.e., binary and continuous). Binary measures will have at least 85% power to detect an odds ratio of 1.36 (or a 7%, relative difference) between the three treatment groups. This analysis assumes 36 assessments across the 12 weeks of treatment and an average correlation between the assessments of $r = 0.3$. Continuous measures will have at least 99% power to detect a 50% mean reduction in measures of continuous alcohol use (e.g., heavy drinking days) between treatment groups with the same assumptions at work. We will also maintain at least 99% power to detect a 50% mean decrease in continuous alcohol use measures (e.g., heavy drinking days) when conducting our planned comparisons after our initial, omnibus test with the same assumptions at work.

3.4. Missing data

We have developed extensive tracking procedures to reduce missing data, which will be handled in a manner consistent with current expert recommendations, some of which our team has contributed to [21,25,58–60]. Maximum likelihood or multiple imputation “missing not at random” approaches, We will utilize missing at random approaches in combination with GEE in order to overcome the problematic default of GEE’s procedure for handling missing data. These approaches are preferable to other data imputation approaches, such as mean imputation or positive value (i.e., assuming the individual in question drank alcohol because they were missing) imputation [61]. Importantly, treatment assignment along with several other relevant covariates will help during the imputation process, or the altered estimation process if maximum likelihood is used, to optimize the accounting for missing data, regardless of differential dropout between the groups.

Lastly, extensive sensitivity analyses will be utilized which include examination of the robustness of treatment effects under varying assumptions, e.g., assumption of “missing completely at random”. As we have done previously [21], if necessary, we will explore the 1) Wu-Carroll selection model, 2) Diggle-Kenard selection model, and the 3) pattern-mixture model. A detailed methodological description of these models and how to conduct them can be found in Enders et al., 2011 and McPherson et al., 2014 [60,62].

4. Discussion

CM is associated with reduced alcohol use in adults with co-occurring SMI. However, heavy drinkers, as identified by uEtG, do not respond to typical low-cost abstinence-based CM. Increasing the magnitude of reinforcement, and reinforcing reduced drinking prior to requiring abstinence, are two promising strategies for non-responders. To our knowledge, this is the first study to compare these two strategies to a typical CM intervention in a sample of likely non-responders.

NIAAA proposed the ANA model as a method for conceptualizing the causes of and factors that maintain addiction, as well as a strategy to develop new treatments. Therefore, we will utilize this framework to identify potential predictors of CM treatment response across and within CM interventions. Investigating the ANA model in a sample of heavy drinkers diagnosed with co-occurring SMI, is particularly relevant as these individuals are likely to have high levels of mood dysregulation, impaired executive functioning disorders, and alcohol-related incentive salience. Therefore, this study offers a unique opportunity to determine if certain subgroups, as defined by ANA variables, respond differentially to the study interventions.

The overall goal of this program of research is to develop a personalized medicine approach to the treatment of AUDs in adults with SMI. Given the heterogeneity of this population in terms of AUD and SMI severity, it is likely that effectiveness will vary by intervention and participant subgroup. If reliable methods, such as uEtG tests or assessments of the ANA model, can be used to identify these subgroups, then clinicians could use these tools to personalize interventions for specific populations, which could have important clinical and policy implications.

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References

1. Regier DA, Farmer ME, Rae DS, et al. Comorbidity of mental disorders with alcohol and other drug abuse: results from the epidemiologic catchment area (ECA) study. JAMA. 1990; 264(19):2511–2518. [PubMed: 2232018]
2. Bauer MS, Altshuler L, Evans DR, Beresford T, Williford WO, Hauger R. Prevalence and distinct correlates of anxiety, substance, and combined comorbidity in a multi-site public sector sample with bipolar disorder. J Affect Disord. 2005; 85(3):301–315. [PubMed: 15780700]
3. Davis L, Uezato A, Newell JM, Frazier E. Major depression and comorbid substance use disorders. Curr Opin Psychiatry. 2008; 21(1):14–18. http://dx.doi.org/10.1097/YCO.0b013e3282f32408. [PubMed: 18281835]
4. Koskinen J, Löhönen J, Koponen H, Isohanni M, Miettunen J. Prevalence of alcohol use disorders in schizophrenia–a systematic review and meta-analysis. Acta Psychiatr Scand. 2009; 120(2):85–96. [PubMed: 19374633]
5. Dixon L. Dual diagnosis of substance abuse in schizophrenia: prevalence and impact on outcomes. Schizophr Res. 1999; 35:S93–S100. [PubMed: 10190230]

6. Kreyenbuhl J, Nossel IR, Dixon LB. Disengagement from mental health treatment among individuals with schizophrenia and strategies for facilitating connections to care: a review of the literature. Schizophr Bull. 2009; 35(4):696–703. http://dx.doi.org/10.1093/schbul/sbp046. [PubMed: 19491314]
7. Gonzalez VM, Bradizza CM, Vincent PC, Stasiewicz PR, Paas ND. Do individuals with a severe mental illness experience greater alcohol and drug-related problems? A test of the supersensitivity hypothesis. Addict Behav. 2007; 32(3):477–490. [PubMed: 16828977]
8. Sacks, S., Ries, RK. Substance Abuse Treatment for Persons with Co-Occurring Disorders, Treatment Improvement Protocol (TIP) Series 42. Substance Abuse and Mental Health Services Administration; 2005.
9. Smelson DA, Tunis SL, Nyhuis AW, Faries DE, Kinon BJ, Ascher-Svanum H. Antipsychotic treatment discontinuation among individuals with schizophrenia and co-occurring substance use. J Clin Psychopharmacol. 2006; 26(6):666–667. http://dx.doi.org/10.1097/01.jcp.0000245562.99036.92. [PubMed: 17110828]
10. Jackson CT, Fein D, Essock SM, Mueser KT. The effects of cognitive impairment and substance abuse on psychiatric hospitalizations. Community Ment Health J. 2001; 37(4):303–312. [PubMed: 11482748]
11. Buckley PF, Brown ES. Prevalence and consequences of dual diagnosis. J Clin Psychiatry. 2006; 67(7):1–1.
12. Galanter M, Dermatis H, Egelko S, De Leon G. Homelessness and mental illness in a professional- and peer-led cocaine treatment clinic. Psychiatr Serv. 1998; 49(4):533–535. [PubMed: 9550249]
13. Clark RE, Samnaliev M, McGovern MP. Impact of substance disorders on medical expenditures for medicaid benefficiaries with behavioral health disorders. Psychiatr Serv. 2015; 60(1):35–42.
14. Bennett ME, Bellack AS, Gearon JS. Treating substance abuse in schizophrenia: an initial report. J Subst Abus Treat. 2001; 20(2):163–175.
15. Watkins KE, Burnam A, Kung F, Paddock S. A national survey of care for persons with co-occurring mental and substance use disorders. Psychiatr Serv. 2001; 52(8):1062–1068. [PubMed: 11474052]
16. Epstein JF, Hourani LL, Heller DC. Predictors of treatment receipt among adults with a drug use disorder. Am J Drug Alcohol Abuse. 2004; 30(4):841–869. [PubMed: 15624552]
17. Petry NM, Barry D, Alessi SM, Rounsaville BJ, Carroll KM. A randomized trial adapting contingency management targets based on initial abstinence status of cocaine-dependent patients. J Consult Clin Psychol. 2012; 80(2):276. [PubMed: 22229758]
18. Ries RK, Dyck DG, Short R, Srebnik D, Fisher A, Comtois KA. Outcomes of managing disability benefits among patients with substance dependence and severe mental illness. Psychiatr Serv. 2004; 55(4):445–447. [PubMed: 15067161]
19. Bellack AS, Bennett ME, Gearon JS, Brown CH, Yang Y. A randomized clinical trial of a new behavioral treatment for drug abuse in people with severe and persistent mental illness. Arch Gen Psychiatry. 2006; 63(4):426–432. [PubMed: 16585472]
20. McDonell MG, Leickly E, McPherson S, et al. A randomized controlled trial of ethyl glucuronide-based contingency management for outpatients with co-occurring alcohol use disorders and serious mental illness. Am J Psychiatry. 2017; 174(4):370–377. appi. ajp.2016.16050627. [PubMed: 28135843]
21. McDonell MG, Srebnik D, Angelo F, et al. Randomized controlled trial of contingency management for stimulant use in community mental health patients with serious mental illness. Am J Psychiatry. 2013; 170(1):94–101. [PubMed: 23138961]
22. McDonell MG, Skalisky J, Leickly E, et al. Using ethyl glucuronide in urine to detect light and heavy drinking in alcohol dependent outpatients. Drug Alcohol Depend. 2015; 157:184–187. [PubMed: 26475403]
23. McDonell MG, Leickly E, McPherson S, et al. Pretreatment ethyl glucuronide levels predict response to a contingency management intervention for alcohol use disorders among adults with serious mental illness. Am J Addict. 2017; 26(7):673–675. [PubMed: 28833832]

24. Angelo FN, McDonell MG, Lewin MR, et al. Predictors of stimulant abuse treatment outcomes in severely mentally ill outpatients. Drug Alcohol Depend. 2013; 131(1):162–165. [PubMed: 23273776]
25. McPherson S, Packer RR, Cameron JM, Howell DN, Roll JM. Biochemical marker of use is a better predictor of outcomes than self-report metrics in a contingency management smoking cessation analog study. Am J Addict. 2014; 23(1):15–20. [PubMed: 24313236]
26. Cunningham C, Stitzer M, Campbell AN, Pavlicova M, Hu M, Nunes EV. Contingency management abstinence incentives: cost and implications for treatment tailoring. J Subst Abus Treat. 2017; 72:134–139.
27. Stitzer ML, Peirce J, Petry NM, et al. Abstinence-based incentives in methadone maintenance: interaction with intake stimulant test results. Exp Clin Psychopharmacol. 2007; 15(4):344. [PubMed: 17696681]
28. Dallery J, Silverman K, Chutuape MA, Bigelow GE, Stitzer ML. Voucher-based reinforcement of opiate plus cocaine abstinence in treatment-resistant methadone patients: effects of reinforcer magnitude. Exp Clin Psychopharmacol. 2001; 9(3):317. [PubMed: 11534542]
29. Silverman K, Chutuape MA, Bigelow GE, Stitzer ML. Voucher-based reinforcement of cocaine abstinence in treatment-resistant methadone patients: effects of reinforcement magnitude. Psychopharmacology. 1999; 146(2):128–138. [PubMed: 10525747]
30. Packer RR, Howell DN, McPherson S, Roll JM. Investigating reinforcer magnitude and reinforcer delay: a contingency management analog study. Exp Clin Psychopharmacol. 2012; 20(4):287. [PubMed: 22686494]
31. Lamb RJ, Morral AR, Galbicka G, Kirby KC, Iguchi MY. Shaping reduced smoking in smokers without cessation plans. Exp Clin Psychopharmacol. 2005; 13(2):83. [PubMed: 15943541]
32. Preston KL, Umbricht A, Wong CJ, Epstein DH. Shaping cocaine abstinence by successive approximation. J Consult Clin Psychol. 2001; 69(4):643. [PubMed: 11550730]
33. Lamb RJ, Morral AR, Kirby KC, Iguchi MY, Galbicka G. Shaping smoking cessation using percentile schedules. Drug Alcohol Depend. 2004; 76(3):247–259. [PubMed: 15561476]
34. Kwako LE, Momenan R, Litten RZ, Koob GF, Goldman D. Addictions neuroclinical assessment: a neuroscience-based framework for addictive disorders. Biol Psychiatry. 2016; 80(3):179–189. [PubMed: 26772405]
35. Manning V, Betteridge S, Wanigaratne S, Best D, Strang J, Gossop M. Cognitive impairment in dual diagnosis inpatients with schizophrenia and alcohol use disorder. Schizophr Res. 2009; 114(1):98–104. [PubMed: 19540724]
36. Ames SL, Wong SW, Bechara A, et al. Neural correlates of a go/NoGo task with alcohol stimuli in light and heavy young drinkers. Behav Brain Res. 2014; 274:382–389. [PubMed: 25172182]
37. DSM-5American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders. American Psychiatric Publishing; Arlington: 2013.
38. Silverman K, Wong CJ, Needham M, et al. A randomized trial of employment-based reinforcement of cocaine abstinence in injection drug users. J Appl Behav Anal. 2007; 40(3):387–410. [PubMed: 17970256]
39. Roll JM, Petry NM, Stitzer ML, et al. Contingency management for the treatment of methamphetamine use disorders. Am J Psychiatry. 2006; 163(11):1993–1999. [PubMed: 17074952]
40. Lowe JM, McDonell MG, Leickly E, et al. Determining ethyl glucuronide cutoffs when detecting self-reported alcohol use in addiction treatment patients. Alcohol Clin Exp Res. 2015; 39(5):905–910. [PubMed: 25866234]
41. Sobell, L., Sobell, M. Handbook of Psychiatric Measures. American Psychiatric Association; Washington, DC: 2000. p. 477-479.
42. McLellan AT, Kushner H, Metzger D, et al. The fifth edition of the addiction severity index. J Subst Abus Treat. 1992; 9(3):199–213.
43. Miller WR, Tonigan JS. Assessing drinkers' motivation for change: the stages of change readiness and treatment eagerness scale (SOCRATES). Psychol Addict Behav. 1996; 10(2):81.
44. Kay SR, Flszbein A, Opfer LA. The positive and negative syndrome scale (PANSS) for schizophrenia. Schizophr Bull. 1987; 13(2):261. [PubMed: 3616518]

45. Kirby KN, Petry NM, Bickel WK. Heroin addicts have higher discount rates for delayed rewards than non-drug-using controls. J Exp Psychol Gen. 1999; 128(1):78. [PubMed: 10100392]
46. Nakovics H, Diehl A, Croissant B, Mann K. Modifications of the obsessive compulsive drinking scale (OCDS-G) for use in longitudinal studies. Addict Behav. 2008; 33(10):1276–1281. [PubMed: 18602219]
47. Barkby H, Dickson JM, Roper L, Field M. To approach or avoid alcohol? Automatic and self-reported motivational tendencies in alcohol dependence. Alcohol Clin Exp Res. 2012; 36(2):361–368. [PubMed: 21895719]
48. Heatherton TF, Kozlowski LT, Frecker RC, Fagerstorm K. The fagerström test for nicotine dependence: a revision of the fagerstrom tolerance questionnaire. Br J Addict. 1991; 86(9):1119–1127. [PubMed: 1932883]
49. Darke S, Hall W, Heather N, Ward J, Wodak A. The reliability and validity of a scale to measure HIV risk-taking behaviour among intravenous drug users. AIDS. 1991; 5(2):181–186. [PubMed: 2031690]
50. Orr, MF., Lederhos Smith, C., Finlay, M., et al. Pilot investigation: randomized-controlled analog trial for alcohol and tobacco smoking co-addiction using contingency management. Behav Pharmacol. 2018. http://dx.doi.org/10.1097/FBP.0000000000000379
51. Roll JM, Chudzynski J, Cameron JM, Howell DN, McPherson S. Duration effects in contingency management treatment of methamphetamine disorders. Addict Behav. 2013; 38(9):2455–2462. [PubMed: 23708468]
52. Chudzynski J, Roll JM, McPherson S, Cameron JM, Howell DN. Reinforcement schedule effects on long-term behavior change. Psychol Rec. 2015; 65(2):347–353. [PubMed: 26139942]
53. McPherson, S., Orr, M., Lederhos, C., et al. Decreases in smoking during treatment for methamphetamine-use disorders: preliminary evidence. Behav Pharmacol. 2017. http://dx.doi.org/10.1097/FBP.0000000000000349
54. Aiken, LS., West, SG., Reno, RR. Multiple Regression: Testing and Interpreting Interactions. Sage; 1991.
55. MacKinnon DP, Luecken LJ. How and for whom? Mediation and moderation in health psychology. Health Psychol. 2008; 27(2S):S99. [PubMed: 18377161]
56. Hermes ED, Sokoloff D, Stroup TS, Rosenheck RA. Minimum clinically important difference in the positive and negative syndrome scale with data from the clinical antipsychotic trials of intervention effectiveness (CATIE). J Clin Psychiatry. 2012; 73(4):526–532. http://dx.doi.org/10.4088/JCP.11m07162. [PubMed: 22579152]
57. Miller WR, Miller WR, Manuel JK, Miller WR, Manuel JK. How large must a treatment effect be before it matters to practitioners? An estimation method and demonstration. Drug Alcohol Rev. 2008; 27(5):524–528. [PubMed: 18608445]
58. McPherson S, Barbosa-Leiker C, McDonell M, Howell D, Roll J. Longitudinal missing data strategies for substance use clinical trials using generalized estimating equations: an example with a buprenorphine trial. Hum Psychopharmacol Clin Exp. 2013; 28(5):506–515.
59. Graham JW. Missing data analysis: making it work in the real world. Annu Rev Psychol. 2009; 60:549–576. [PubMed: 18652544]
60. Enders CK. Missing not at random models for latent growth curve analyses. Psychol Methods. 2011; 16(1):1. [PubMed: 21381816]
61. Enders, CK. Applied Missing Data Analysis. Guilford Press; 2010.
62. McPherson S, Barbosa-Leiker C, Mamey MR, McDonell M, Enders CK, Roll J. A ‘missing not at random’(MNAR) and ‘missing at random’(MAR) growth model comparison with a buprenorphine/naloxone clinical trial. Addiction. 2015; 110(1):51–58.

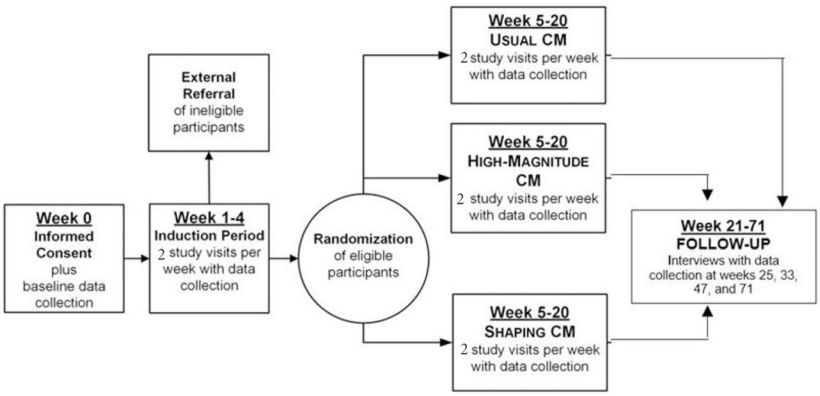

Fig. 1.
Overview of study procedures.

Table 1

Summary of Contingency Management (CM) schedules and maximum earnings for randomized groups.

Contingency Management group	Criteria for reinforcement	Maximum # of prize draws	Maximum/expected payout
Usual	uEtG < 150 ng/mL (abstinence) in weeks 5–20	400	$1370/$500
High-magnitude	uEtG < 150 ng/mL (abstinence) in weeks 5–20	720	$2411/$1000
Shaping	uEtG < 500 ng/mL (light drinking) in weeks 5–8	400	$1370/$500
	uEtG < 150 ng/mL (abstinence) in weeks 9–20		