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Contingency Management for the Treatment of Alcohol Use Disorders

Ohio Department of Behavioral Health

CASE WESTERN RESERVE UNIVERSITY
Jack, Joseph and Morton Mandel School of Applied Social Sciences
Center for Evidence-Based Practices

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Executive Summary

Background

Alcohol use disorder (AUD) is associated with high mortality and morbidity rates in the United States. The growing rates of excessive alcohol use and AUD pose a major threat to public health. Contingency management (CM) is an evidence-based intervention, based on operant conditioning principles, that has shown promise in treating other substance use disorders. By providing incentives to clients who demonstrate substance use abstinence and/or treatment attendance, for example, CM could motivate clients and facilitate behavioral changes necessary for substance use recovery. This report outlines findings from a literature review conducted to examine the effectiveness of CM in the treatment of AUD specifically.

Methods

A comprehensive literature search was conducted using multiple databases to identify studies that investigated the effectiveness of CM for individuals with AUD. To be reviewed, studies had to meet the following criteria: use an experimental design wherein participants were randomly assigned to the treatment groups; collect primary data; include samples predominantly comprised of individuals with AUD; examine alcohol use or mortality outcomes; be conducted in North America; and be published within the last 10 years. The main outcomes of interest were alcohol use, treatment retention, and mortality/morbidity.

Findings

The search yielded 11 relevant experimental studies that met the inclusion criteria. The reviewed studies provided evidence for the effectiveness of CM in reducing alcohol use and promoting abstinence from alcohol. Five studies reported positive outcomes, five showed mixed results, and one found favorable but statistically untested results for alcohol use. Positive outcomes included increased alcohol abstinence, decreased alcohol use, and reduced AUD symptoms. Studies characterized by mixed findings also provided some support to the effectiveness of CM, but the results varied by assessment timing, measurement type, and participant characteristics. Some studies showed immediate benefits that were not maintained at follow-up, while others demonstrated delayed positive effects. Effectiveness was sometimes influenced by factors such as court-mandated status or the type of alcohol use measurement. Many studies focused on special or vulnerable populations such as individuals experiencing homelessness, American Indians and Alaska Natives (AI/AN), and/or those with co-occurring mental illness. Treatment retention was tested by five studies with mixed outcomes, and only one study examined mortality- and morbidity-related outcomes.

Conclusion

Contingency management demonstrates effectiveness for AUD treatment through reduced alcohol use and increased abstinence across diverse populations. The integration of remote monitoring technologies suggests potential for widespread implementation. Future research should expand the range of outcomes studied beyond alcohol use to include the impact of AUD treatment associated with client retention and improvements in mortality/morbidity outcomes.

Alcohol Use Trends in the U.S. and Ohio

Over the last 30 years, alcohol-related deaths have outpaced opioid-related ones by tens of thousands annually, positioning alcohol misuse at the forefront of public health discourse (Hurst, 2024). Despite widespread acceptance of alcohol use among people in the U.S. (Castro et al., 2014), recent research has demonstrated that even low levels of alcohol consumption are associated with increased risk of adverse health outcomes, while heavy alcohol use has been associated with increased risk of cancer, coronary heart disease, and/or stroke (Bergmann et al., 2013; Ronksley et al., 2011). Increases in the national prevalence of alcohol use disorder (AUD), often accompanied by another substance use disorder (SUD), a co-occurring mental health disorder, or both, present a significant threat to public health and wellbeing in the United States (Hurst, 2024).

Defining Problematic Alcohol Use

The Centers for Disease and Control and Prevention (CDC) definition of "excessive alcohol use" encompasses "four ways that people drink alcohol that can negatively impact health," including "binge-drinking" (four or more drinks for women, five or more drinks for men on any occasion), weekly "heavy drinking" (eight or more drinks for women, 15 or more drinks for men), "underage drinking" (any use by people under age 21), and "drinking while pregnant" (any use during pregnancy) (Centers for Disease Control and Prevention [CDC], 2024a). Excessive alcohol use has a wide range of adverse health outcomes that include but are not limited to alcohol poisoning, overdose, pre- and post-natal complications (e.g., unplanned pregnancies, miscarriage, stillbirth, fetal alcohol spectrum disorder) (CDC, 2024a), increased risk of various forms of cancer (e.g., throat, colon, breast, liver) (National Cancer Institute, 2015), heightened risk for heart and liver disease, as well as an array of mental health conditions (e.g., depression, anxiety), cognitive issues, and relationship problems with family, friends, and co-workers (CDC, 2024a).

The Diagnostic and Statistical Manual of Mental Disorders, 5th ed. (DSM–5TR) defines AUD as "a problematic pattern of alcohol use leading to clinically significant impairment or distress" (American Psychiatric Association [APA], 2022). An individual may be diagnosed with AUD when meeting at least two of the following criteria within a 12-month period: increased use over time, impaired ability to stop or control use, cravings, withdrawal symptoms, increased tolerance, and continued use despite negative consequences on one's health, psychological well-being, work, and social relationships (APA, 2022). Remission from AUD involves not meeting any of the DSM–5TR criteria for AUD except for cravings (APA, 2022). Recovery from AUD is a broader term characterized by remission and cessation of heavy drinking. For individuals who experienced severe impairments from AUD, recovery also involves "the fulfillment of basic needs, enhancements in social support and spirituality, and improvements in physical and mental health, quality of life, and other dimensions of well-being" (National Institute on Alcohol Abuse and Alcoholism [NIAAA], 2022). Recovery goes beyond abstinence and is influenced by a combination of biological (e.g., genes, neurobiology), psychological (e.g., cognition, behaviors, emotions), and social, environmental, or contextual (e.g., social networks, socioeconomics, systemic facilitators and barriers) factors (Witkiewitz & Maisto, 2022). Common treatments for AUD include withdrawal management, medications (e.g., disulfiram, naltrexone, and acamprosate), behavioral health treatments (e.g., cognitive-behavioral therapy, motivational enhancement therapy, contingency management, individual or group counseling, twelve-step facilitation), as well as continued recovery support groups such as Alcoholics Anonymous and Self-Management and Recovery Training (SMART) (NIAAA, 2022).

Current Trends in Alcohol Use

According to the 2023 National Survey on Drug Use and Health (Substance Abuse and Mental Health Services Administration [SAMHSA], 2024), overall alcohol use among individuals aged 12 and older increased from 132.5 million (47.4% of the population) in 2021 to 134.7 million (47.5% of the population) in 2023. In 2023, approximately 134.7 million Americans aged 12 and older reported drinking alcohol in the past month, 61.4 million reported binge use (45.6% of alcohol users), and 16.4 million reported heavy alcohol use (12.2% of alcohol users). The largest cohort of binge and heavy alcohol users among all age groups is comprised of those between the ages of 18 to 25 (SAMHSA, 2024). Underage binge alcohol use has seen no significant change. Among 48.5 million 2023 respondents age 12 or older diagnosed with an SUD, 28.9 million were

diagnosed with AUD (SAMHSA, 2024). The largest age cohort diagnosed with AUD was young adults between 18 and 25 years of age (SAMHSA, 2024).

In Ohio statewide drinking habits align with national averages. In 2023, 15.6% of adults in Ohio reported binge drinking, compared to the national median of 15.2% (CDC, 2024b). According to the 2021 Youth Risk Behavior Survey (YRBS), roughly 23% of Ohio high-school students reported consuming at least one drink of alcohol on at least 1 day during the 30 days before the survey (CDC, 2024c). Binge drinking rates (four or more drinks for women or five or more drinks for men during an occasion) on at least 1 day during the 30 days before the survey among Ohio high-school students (12.6%) are slightly higher than the national average (10.5%) (CDC, 2024c).

Alcohol Use and Mortality

It is estimated that 178,307 Americans died from excessive alcohol use in 2020-2021, representing a 29.3% increase in deaths from 137,927 in 2016-2017 (Esser et al., 2024). Deaths from excessive alcohol use among males between these periods rose 26.8% from 94,362 to 119,606, while deaths among females increased at a higher rate of 34.7% from 43,565 to 58,701 (Esser et al., 2024). Alcohol-related death rates also rose between these periods from 23.2 to 29.4 per 100,000 (Esser et al., 2024).

The CDC estimated that 6,750 people died from excessive alcohol use in Ohio between 2020 and 2021 (CDC, 2024d). Among those deaths attributed to excessive alcohol use, close to 55% have been linked to chronic causes such as AUD (CDC, 2024d). Apart from public health costs linked to alcohol consumption (e.g., alcohol users' increased risk for experiencing certain diseases and death, as well as causing injury and death to others), it is estimated that in 2022 Ohio taxpayers spent an equivalent of $11.502 billion as a result of excessive alcohol use (National Center for Drug Abuse Statistics [NCDAS], 2024).

In light of this escalating public health challenge, this report describes the use of CM for addressing AUD.

The following sections define and describe CM and summarize the results of a literature review conducted to surface evidence of the effectiveness of CM in treating AUD. The literature review focused on answering the following questions about the effectiveness of using CM to address AUD:

- What are the alcohol use outcomes associated with the use of CM to address AUD?
- What are the treatment retention outcomes associated with the use of CM to address AUD?
- What are the mortality and morbidity related outcomes associated with the use of CM to address AUD?

Contingency Management

Contingency management is grounded in operant conditioning, a learning process focused on behavioral modification through the association of stimuli with positive reinforcement or punishment (Higgins & Petry, 1999). Historically, CM has been employed to support drug use cessation although more recently it also has been used to support treatment retention, attendance, and medication compliance. Typically, CM is structured around urine drug tests (UDTs) administered multiple times each week to detect periods of abstinence and abstinence is positively reinforced each time a negative UDT is submitted. Incentives can take a variety of forms. For example, an incentive can be monetary-based and consist of vouchers that are exchangeable for goods, analogous to a clinic-managed bank account or a clinic-managed store. Some programs allow participants to earn a certain number of entries to a raffle- or lottery-style draw for each instance of meeting a behavioral goal, with prizes usually ranging from $1 to $100 in value. Other CM programs may include a negative reinforcement component, where missed or positive UDTs might result in a reset of the voucher magnitude or number of lottery draws. In effective CM interventions, the magnitude of reinforcement provided (voucher amounts or draws for prizes) increases with sustained periods of abstinence and resets upon non-compliance (Budney & Higgins, 1998; Petry, 2000; Petry & Stitzer, 2002).

Voucher-Based Contingency Management

Voucher-based CM is used commonly in trials that reinforce abstinence from stimulants and/or opioids. In the early 1990's Higgins et al. were among the first to apply the principles of operant behavioral learning to the understanding and modification of drug use behavior (Higgins et al., 1994; Higgins & Silverman, 1999). They manualized a 24-week intervention to support cocaine abstinence that included a combination of community reinforcement approach (CRA) and 12 weeks of voucher-based CM. Participants were expected to attend counseling sessions twice a week and undergo UDTs for cocaine three times a week during the first 12 weeks. Between weeks 13 and 24, the schedule was reduced to one weekly counseling session and twice a week UDTs. Higgins et al. (2019) explained in their later work that allowing participants to earn vouchers for submitting cocaine-negative urine samples during the initial 12 weeks of the intervention served as a crucial first step. This approach was intended to establish naturalistic sources of reinforcement for a healthy lifestyle. Specifically, Higgins et al. (2019) provided vouchers exchangeable for retail items "to bridge that temporal gap between entering treatment and initiating cocaine abstinence and establishing natural sources of nondrug reinforcement in one's community that would be necessary to sustain longer-term abstinence" (p. 504).

The key characteristics of a voucher system manualized by Budney & Higgins (1998) included an escalating schedule, a bonus, and a reset contingency. According to the recommended reinforcement schedule, participants could earn points for negative UDTs, each point worth approximately $0.25. During the initial 12 weeks of the intervention, the first negative UDT was worth 10 points ($2.50), with points per urine sample increasing by five points with each consecutive negative UDT (e.g., second negative UDT = 15 points (10 + 5) or $3.75 ($2.50 + $1.25). A $10 bonus was given for every three consecutive negative UDTs. Positive UDTs earned zero points and resulted in a reset. A reset implies that the subsequent negative UDT would revert to the starting value of 10 points ($2.50). However, following a reset, five consecutive negative UDTs would restore the voucher back to its value prior to the reset. Each patient could earn up to a total of $997.50 in vouchers throughout the initial 12 weeks of treatment (Budney & Higgins, 1998; Higgins et al., 1994). Although quantified as cash values, the vouchers were redeemable only for retail items, previously approved and in support of a cocaine-free lifestyle (Budney & Higgins, 1998). During weeks 13-24 of the intervention, participants were eligible to receive one state lottery ticket for each drug-negative UDT (Budney & Higgins, 1998). Several more recent adaptations of the CRA and voucher-based CM system have used the original design proposed by Higgins et al. (1994) to promote continuous abstinence, while others have explored the effectiveness of varying reinforcement schedules (Roll et al., 2006).

Prize-based Contingency Management

Another widely used technique, also known as the "fishbowl," or simply prize-based CM, was developed and later manualized by Petry and Stitzer (2002) as part of a National Institute on Drug Abuse (NIDA) funded initiative. The manual drew from earlier CM research, focused on individuals with cocaine and opioid use disorders (Petry et al., 2000, 2001, 2002), and proposed low-cost clinical management strategies for a range of treatment settings (Petry & Stitzer, 2002).

While voucher-based CM rewards abstinence with a predictable monetary value exchangeable for goods or services, the "fishbowl" technique is a probabilistic approach that reinforces abstinence with a chance of winning a prize. For example, for every twice-a-week drug-negative UDT, an individual would get one draw from the fishbowl. If they drew a winning slip, the individual would select a prize from the appropriate category. The prizes usually range from small ($1) to jumbo ($100), but approximately half of the draws result in "no win." Each consecutive negative drug test earns the participant chances to draw for prizes, including bonus rounds. Missed or positive UDTs typically result in the reset in the number of draws. Petry and Stitzer (2002) also argued for allowing participants to suggest desired future prizes to both motivate the patient to maintain their abstinence and help reduce the overall cost of running a CM program. The authors estimated that even with a $5,000 budget for prizes and 50 participants, the cost would be an average of $100 per patient. Figure 3 below is a sample fishbowl schedule that would allow the patients to earn 20 draws per week.

FIGURE 1. SAMPLE FISHBOWL SCHEDULE

	Number of Slips	Probabilities of Winning	Average Price/Prize	Cost per Draw
Non-winners	375	0.500		
Smalls	269	0.359	$0.70	$0.25
Mediums	75	0.100	3.50	0.35
Larges	30	0.040	14.00	0.56
Jumbo	1	0.001	70.00	0.09
Total	**750**			**$1.25**

Source: Petry & Stitzer (2002). Contingency Management: *Using Motivational Incentives to Improve Drug Abuse Treatment.* Yale University Psychotherapy Development Center Training Series No. 6.

The fundamental difference between voucher-based and prize-based CM lies in the reward certainty. In voucher-based CM, clients receive guaranteed monetary-based rewards (typically vouchers or gift cards) when they meet the conditions of CM. In contrast, prize-based CM uses a probability-based system where clients earn opportunities to draw for a prize, with each draw having a chance of winning prizes of varying values. Some draws may result in no prize, while others may yield small, medium, or large rewards.

Culturally tailored CM for AUD

Substance use disorders (SUDs) and related health disparities disproportionately affect indigenous communities compared to other racial/ethnic groups, and there is a need for interventions that are not only effective but also widely accessible and culturally appropriate (Campbell et al., 2023). Culturally tailored evidence-based practices (EBPs) for SUDs reflect the beliefs, values, views, history, behaviors, language, and are inclusive of traditional healing practices of AI/AN people (Campbell et al., 2023; University of California Los Angeles Integrated Substance Use & Addition Programs [UCLA ISAP], 2021).

Contingency management is one of the EBPs that has been adapted for SUDs in AI/AN communities. Such culturally tailored CM is built on principles of operant conditioning and past research findings, but also specific community values that include building relationships between clinicians, patients, and their families, the idea of honoring individuals with gifts (e.g., rewarding reductions in alcohol and drug use), and providing a range of practical and culturally tailored prizes that can

be shared with families (e.g., gift cards for local businesses, fishing equipment, prizes for family activities, and supplies for culturally centered arts and crafts) (McDonell et al., 2021a; UCLA ISAP, 2021). For instance, for some AI/AN communities, each CM visit should align with the Medicine Wheel, which embodies the four directions and symbolizes dimensions of health and the cycles of life. In practical terms, the wheel can be adapted to center the intervention around the concept of gratitude and four intervention activities (e.g., greet the client and measure, reinforce, and record the outcome) (UCLA ISAP, 2021).

Another aspect of adapting and implementing CM for specific cultural groups or special populations is the focus on addressing barriers to care (e.g., transportation, language, lack of Internet access) and ensuring that interventions are delivered or facilitated by staff members in culturally appropriate ways (UCLA ISAP, 2021). Partnerships between AI/AN community groups and outside researchers/providers can facilitate the education of both parties, fostering adaptation, integration, development, and ongoing refinement of both indigenous community and non-indigenous community best practices to promote healthier AI/AN populations (Campbell et al., 2023). For example, recent efforts have been made to expand access to culturally tailored CM for more remotely located AI/AN populations through digital therapeutics (Campbell et al., 2023).

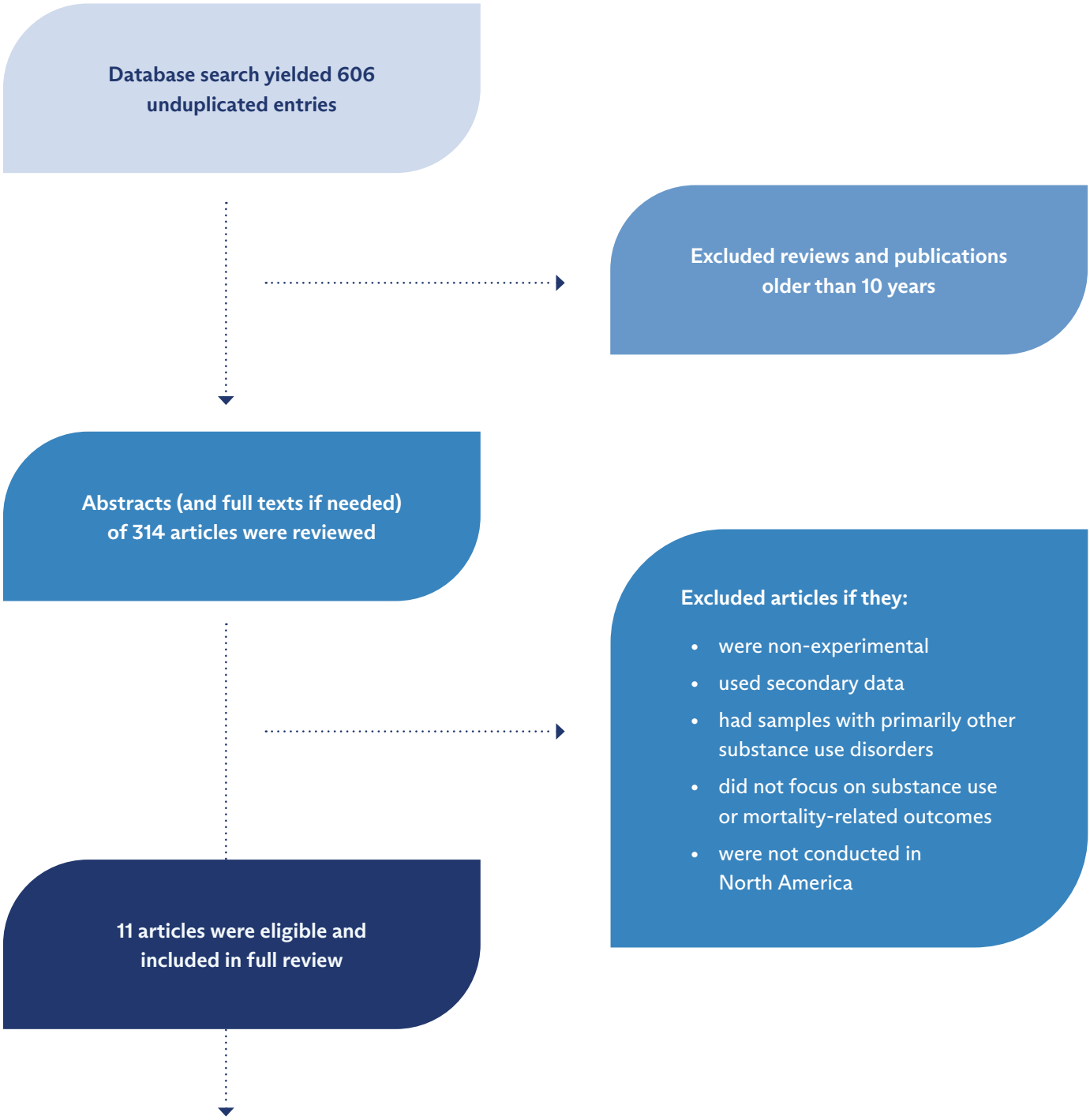
Literature Review Process

Literature reviews often are conducted to promote an in-depth understanding of a given topic. The stages of a literature review involve creating a search strategy, identifying relevant sources, summarizing and organizing them around relevant themes, and synthesizing the information that is presented by the sources. The purpose of this literature review was to identify and synthesize relevant CM studies to assess CM utility and effectiveness.

The first phase of the literature review included developing and refining relevant search terms that represent the topic of interest and identifying key social and behavioral science research databases for use in the literature search. A comprehensive search was conducted using the following databases: PsycINFO, CINAHL, MEDLINE, SocINDEX, Psychology and Behavioral Sciences Collection. The search included combinations of key terms related to CM and AUD, specifically "(Contingency management OR voucher OR prize AND alcohol use disorder OR alcoholism)." The search was carried out in September 2024 and encompassed all existing literature up to that date. The second phase included using the same search terms to conduct a related search in the Cochrane Library, a well-reputed healthcare and medical research database that includes clinical trials, systematic reviews, and meta-analyses (Cochrane, 2023).

Both searches yielded a total of 606 unduplicated results. Publications older than ten years as well as reviews were excluded, which yielded a total of 314 results. Abstracts and full texts of the articles or conference abstracts were screened. They were included in the full review if they were experimental in design, collected primary data, included samples predominantly comprised of individuals with AUD, examined alcohol use or mortality-related outcomes, and were conducted in North America. When conference abstracts lacked sufficient information for inclusion in the review, an attempt was made to locate a related article using the same dataset. If a related article was not found or the article was determined to be irrelevant, the conference abstract was excluded from full review. This process resulted in a total of 11 articles for comprehensive review in this report (see Figure 2 and Appendix A for a full list of articles).

FIGURE 2. LITERATURE SEARCH PROCESS FUNNEL FOR IDENTIFYING CONTINGENCY MANAGEMENT OUTCOME STUDIES



Summary of the Outcome Studies for Contingency Management

The review included 11 studies all of which employed experimental designs where participants were randomly assigned to a CM condition or another treatment condition for comparison purposes. Seven studies evaluated voucher-based CM intervention while four studies examined prize-based CM. Participants across the studies had an AUD diagnosis. All 11 studies focused on alcohol use outcomes, five studies reported treatment retention, and one reported mortality/morbidity-related outcomes. Five studies included participants from special or vulnerable populations such as individuals experiencing homelessness formerly (Jett et al., 2024) or currently (Novak et al., 2023), and AI/AN adults (Campbell et al., 2023; McDonell et al., 2021a, 2021b). All studies were conducted in the U.S. Fidelity was monitored in only one study (McDonell et al., 2021b).

Alcohol Use Outcomes

Outcomes related to alcohol use were frequently assessed through objective measures including UDT screenings (Campbell et al., 2023; Hammond et al., 2021; McDonell et al., 2017; McDonell et al., 2021a, 2021b; Orr et al., 2018), breathalyzer tests (Hammond et al., 2021; Koffarnus et al., 2018; Koffarnus et al., 2021), blood-based biomarker phosphatidyl ethanol (PEth) (Jett et al., 2024), and transdermal alcohol concentration (TAC) results (Dougherty et al., 2023; Novak et al., 2023). Seven studies incorporated self-report measures of alcohol use in addition to the objective measures (Campbell et al., 2023; Jett et al., 2024; Koffarnus et al., 2018; Koffarnus et al., 2021; McDonell et al., 2017; McDonell et al., 2021a, 2021b). Studies were classified into three categories based on their results: positive, mixed, or inconclusive. A study was considered to have a positive result if the majority of its analyses showed statistically significant results favoring CM. Studies were categorized as mixed if they reported both positive and neutral/negative outcomes. One study (Hammond et al., 2021) was classified as inconclusive because it did not conduct any statistical analyses.

Studies with Positive Results

In studies reporting both objective measures of abstinence and self-reported alcohol use, the results of the objective measure were given precedence. A study was classified as having a positive outcome even if self-reported data did not corroborate the objective findings. Five studies described in greater detail below yielded positive results supporting the use of CM for AUD. One study reported follow-up outcomes at one-month assessment (Koffarnus et al., 2018) and one monitored fidelity to CM (McDonell et al., 2021b).

Koffarnus et al. (2018) evaluated the effectiveness and feasibility of a remote CM intervention to promote alcohol abstinence among adults with AUD using breathalyzer results. A total sample of 40 were randomly assigned to either a contingent group, which received monetary incentives for alcohol-negative samples, or a non-contingent group, which received matched payments regardless of alcohol use. Using a breathalyzer with remote photo verification, the contingent group earned escalating incentives starting at $5 per day, increasing by $1 daily up to a maximum of $25 per day, with $5 bonuses for every three consecutive days of abstinence. Participants could earn up to $350 for 21 continuous days of abstinence, but if alcohol was detected or a test was missed, the reward reset to $5 per day, requiring three alcohol-free days to resume prior incentive levels. The study consisted of a 6-day monitoring phase followed by a 21-day intervention phase, with participants submitting three breathalyzer samples per day. The primary outcome was the percentage of abstinent days. The contingent group achieved 85% abstinent days compared to 38% in the non-contingent group, a difference that was statistically significant. Self-reported alcohol use results showed statistically significantly fewer drinks in the contingent group per day during the intervention and at one-month follow-up. Alcohol use disorder symptoms measured by the Alcohol Use Disorders Identification Test (AUDIT; Saunders et al., 1993) scores also decreased more in the contingent group, with significant differences at the 1-month follow-up.

Orr et al. (2018) examined whether targeting alcohol use or tobacco smoking with CM would increase abstinence from the non-targeted substance among a sample of 34 participants with AUD and tobacco use disorder. The study included four treatment conditions by using a 2X2 factorial design: non-contingent (NC) for alcohol and tobacco, CM for alcohol and

NC for tobacco, CM for tobacco and NC for alcohol, and CM for alcohol and tobacco. The last group (CM for alcohol and tobacco) was not included in the analysis because many participants in this group did not want to pursue the experiment when they found out that they needed to stop using both alcohol and tobacco to earn incentives. Participants in the CM conditions earned monetary rewards in an escalating schedule for negative samples with a reset to starting value in the rewards in the presence of positive samples. The intervention spanned four weeks with three visits per week. Analyses examined both binary outcomes (abstinence from alcohol and tobacco) and continuous measures including urinary ethyl glucuronide (EtG) and cotinine levels to assess alcohol and tobacco use. Participants receiving CM for alcohol submitted statistically significantly more alcohol- and tobacco-abstinent urine samples compared to those receiving NC for both substances. Similarly, the CM for tobacco group also submitted statistically significantly more substance-negative urine samples for both substances compared to the NC group. Analysis of continuous measures showed that the CM for alcohol group submitted samples with statistically significantly lower EtG and cotinine levels compared to the NC group.

The CM for tobacco group showed statistically significantly lower cotinine levels, but no significant difference in EtG levels compared with the NC group. The Orr et al. (2018) study findings suggested that CM can promote abstinence not only from the targeted substances but also from non-targeted substances.

McDonell et al. (2021a) conducted a randomized controlled trial to assess the effectiveness of a culturally tailored CM intervention on alcohol abstinence among 158 AI and AN adults with AUD. All participants received treatment as usual and were randomized to either the CM group, where they received prizes contingent on submitting alcohol-negative urine samples, or the control group, where they received prizes regardless of urine test results. Participants in both groups submitted urine samples twice a week for 12 weeks. Unlike participants in the control group who drew prizes for each submitted urine sample, individuals assigned to the CM group could increase their number of draws by showing continuous abstinence, or risk resetting the number of draws to a lesser number after missing a urine test or submitting an alcohol-positive sample. The winning draws (50%) included small ($1 value), large ($20 value), and jumbo (up to $80 value) prizes.

Winning prizes included a range of practical and culturally tailored items, including gift cards for local businesses, fishing equipment, prizes for family activities, and supplies for culturally appropriate arts and crafts. The total cost of prizes per participant was up to $194 in the control group and up to $128 in the CM group. The primary study outcome was abstinence operationalized through the alcohol-negative EtG urine test result (defined as EtG<150 ng/mL). The secondary outcome was self-reported alcohol use within the last 30 days. The results indicated that participants in the CM group were statistically significantly more likely to submit an alcohol-negative urine sample compared to the control group. It was estimated that participants in the CM group had a 65.6% probability of submitting an alcohol-negative urine sample compared to a 52.8% probability among control participants. Although participants in the CM group self-reported fewer days of alcohol use within the last 30 days (8.1) compared to the control group (5.9), the difference was not statistically significant.

McDonell et al. (2021b) examined the effectiveness of CM interventions on alcohol and drug abstinence among 114 AI adults who had AUD and used drugs. During the 12-week intervention period, participants were randomly assigned to one of the four conditions: incentives for submission of urine samples only (control condition), CM incentives for alcohol abstinence, CM incentives for drug abstinence, or CM incentives for abstinence from both alcohol and drugs. The study utilized an escalating reinforcement schedule with bonus and reset, meaning that the number of draws or bonuses increases when a participant continues the desired behavior and resets upon lack of compliance with the desired behavior. Participants in the three CM conditions (alcohol, drug, and alcohol and drug use) would increase their number of draws with each consecutive substance-negative urine sample. Missed or positive urine samples resulted in a reset to a lower number of draws. The winning draws (50%) included small ($1 value), large ($20 value), and jumbo (up to $80 value) prizes. Non-winning draws were culturally tailored to include AI concepts and teachings, while winning prizes included grocery store gift cards, baby diapers, fishing poles, and camping gear. The maximum earnings per participant who demonstrated continued abstinence was $667, while the mean value of reinforcement per participant was $155.22. Fidelity to CM was monitored weekly. Primary outcomes included urine EtG (alcohol) and drug tests conducted three times per week during the 12-week intervention period. Secondary outcomes included self-reported alcohol and drug use and attendance. The odds of having alcohol abstinence were approximately three times higher for those in the CM for alcohol and CM for drug and alcohol abstinence groups compared

to control participants. Participants in the CM for drug abstinence group had 1.6 times higher odds of being abstinent from alcohol, even though alcohol was not targeted as part of CM in this group. The CM groups did not differ from each other in alcohol abstinence. Self-reported alcohol use did not show a significant difference across the groups. CM groups, except for the CM for alcohol abstinence group, also were more likely to submit stimulant-negative urine drug samples than the control group.

Novak et al. (2023) conducted a randomized clinical trial to assess the effectiveness of abstinence-contingent wage supplements in promoting alcohol abstinence, employment, and financial stability among adults experiencing homelessness with AUD. The study involved 119 participants randomly assigned to either an intervention group receiving financial incentives contingent on alcohol abstinence or a control group receiving usual care including counseling and referrals. Alcohol use was monitored using transdermal alcohol concentration (TAC) analysis via SCRAM ankle bracelets and BACtrack Skyn wrist sensors, both of which provided continuous monitoring. Participants using the SCRAM device were eligible to receive $100 per month for continuous wear, while those using the BACtrack Skyn earned $0.25 per hour for device usage, with an additional $5 bonus for wearing the device for more than 18 hours per day. During the induction phase, participants were introduced to workplace contingencies. In the first week they could earn $5 per hour for up to four hours each day by contacting research staff, followed over the next three weeks by the opportunity to earn $8 per hour for the same duration on weekdays. Since the BACtrack Skyn device did not require participants to provide an alcohol-negative breath sample to begin usage, incentives during the induction phase focused on consistent device wear rather than abstinence. During the intervention period, participants in the experimental group could earn stipends for engaging with employment specialists and participating in job-seeking activities for up to 20 hours per week, with a wage of approximately $10 per hour. Additionally, they could receive wage supplements of up to $8 per hour for a maximum of 40 hours per week, contingent upon maintaining alcohol abstinence. If alcohol use was detected, the participant's pay rate was reduced to $1 per hour. Each subsequent day of confirmed abstinence allowed the participant to increase their pay rate by $1 per hour, up to a maximum of $8 per hour. The experimental group demonstrated statistically significantly higher rates of alcohol abstinence than the control group during the 6-month intervention, maintaining abstinence for about 83% of months compared to 60% of months in the study period. The experimental group participants had three times higher odds of achieving abstinence than those in the control group. The finding suggested that abstinence-contingent wage supplements are an effective approach to promoting both alcohol abstinence and economic stability among a vulnerable sample of adults experiencing homelessness and AUD.

Studies with Mixed Results

Five studies yielded mixed but promising results on the effectiveness of CM for the treatment of AUD with varying reasons for mixed findings. McDonell et al. (2017) and Koffarnus et al. (2021) found a statistically significant effect of CM at the end of the intervention, but this effect was not maintained at follow-up assessment. In contrast, Campbell et al. (2023) found no significant difference between CM and control groups during the intervention, but a significant difference emerged at follow-up assessment. In their analysis of participants who were mandated by court to wear a TAC monitoring device versus those who wore it voluntarily (as part of the study requirement), Dougherty et al. (2023) found favorable outcomes only for the voluntary participants, not for the court-mandated group. Jett et al. (2024) reported differential findings across different alcohol-use outcome measures within their study.

McDonell et al. (2017) examined the efficacy of a CM intervention that employed the EtG alcohol biomarker to monitor alcohol consumption among a sample of individuals with AUD and co-occurring mental illness. Seventy-nine participants from a community-based mental health and substance use treatment agency were randomized to either prize-based CM or non-contingent control groups for 12 weeks after a four-week observation period. The CM group earned prize draws contingent on EtG-negative urine samples three times a week with a reset in the case of positive samples and received gift cards for weekly treatment attendance. The winning draws (50%) included small ($1 value), large ($20 value), and jumbo (up to $80 value) prizes. The non-contingent group received incentives regardless of the test results. CM participants had statistically significantly higher odds of submitting an EtG-negative urine sample during the intervention, had lower EtG levels on average, and reported significantly fewer days of drinking and/or drinking to intoxication compared to the control group. The differences held statistically significant at the three-month follow-up assessment for the self-reported outcomes but not for the objectively measured outcomes.

Koffarnus et al. (2021) assessed the effectiveness and feasibility of remotely administered CM with participant-funded incentives to promote alcohol abstinence among adults with AUD. Thirty-six participants were randomly assigned to either a contingent group, which earned escalating incentives for alcohol-negative breathalyzer results (starting at $5 per day, increasing by $1 daily, with a $5 bonus every three consecutive alcohol-free days, and a maximum of $350 over 21 days), or a non-contingent group, which received matched payments regardless of alcohol use. The study consisted of a 7-day monitoring phase followed by a 21-day treatment phase, with alcohol use monitored remotely via breathalyzer. Adherence was high across both groups, with 95.7% of breathalyzer samples submitted. The contingent group achieved statistically significantly higher abstinence rates (86% vs. 44%) and reported fewer drinks per day during the intervention phase compared to the non-contingent group. Self-reported alcohol use assessments (e.g., AUDIT scores) indicated a statistically significant reduction in drinking during and at the end of the intervention for the contingent group compared to the non-contingent group. However, the two groups did not have any statistically significant differences during the follow-up periods, likely due to missed assessment sessions by heavier drinkers. While the study demonstrated the effectiveness of remote CM in promoting abstinence, the $75 participant-funded deposit required to access the intervention posed a barrier for individuals with lower incomes or more severe alcohol use, highlighting the need for alternative funding models to increase accessibility.

Campbell et al. (2023) conducted a pilot randomized controlled trial to assess the effectiveness of a culturally tailored digital therapeutic intervention among 53 AI and AN adults seeking outpatient treatment for SUD. Participants were randomized to 12 weeks of treatment-as-usual (TAU) or TAU plus Therapeutic Education System-Native Version (TAU+TES-NAV). TES-NAV consisted of 26 online learning modules grounded in the CRA and included prizes contingent on alcohol or drug abstinence and module completion. The study utilized an escalating reinforcement schedule with bonus and reset. Participants increased their number of draws from a prize bowl every time they presented an alcohol-and/or drug-negative sample, achieved an extended period of abstinence, were abstinent from all substances, and completed training modules. The number of draws would reset to one if a participant submitted a positive alcohol or drug sample. The winning draws (50%) included small ($1 value), large ($20 value), and jumbo (up to $100 value) prizes. The maximum amount of reward per participant was $625. The two groups did not show a significant difference in the percentage of abstinent days from heavy drinking and drug use during the last four weeks of the intervention, but there was a significant difference at the follow-up assessment. Specifically, the TAU+TES-NAV group had a statistically significantly higher percentage of days abstinent from heavy drinking and drug use (69%) compared to TAU (49%) during the three-month follow-up. The results offered no breakdown by primary substance.

Dougherty et al. (2023) examined the effectiveness of CM through the use of a TAC monitoring device to determine if this procedure reduces heavy drinking among individuals who were arrested for driving while intoxicated (DWI). The intervention took place over an 8-week period and included a total of 216 participants. Both mandated (court-ordered TAC monitoring) and non-mandated (study-provided TAC monitoring) participants were included in the study. One-hundred and nine participants were randomly assigned to the CM group (35 mandated and 74 non-mandated), and the remaining 107 participants were then randomly assigned to the control group (36 mandated and 71 non-mandated). CM participants received $50/week if they maintained a TAC of 0.02 g/dL during the previous week, a level used to identify the absence of heavy drinking. The control group received incentives that were yoked to the CM group's earnings. Because the impact of the CM varied depending on whether participants were mandated to TAC monitoring, the results were presented by the status of being mandated or not. Among non-mandated participants, those in the CM group maintained consistent contingency compliance across all eight visits, while control group participants showed a trend toward decreasing compliance over time, with no statistically significant differences in trends between the groups. However, statistically significantly more CM participants met the contingency criteria compared to controls (61% vs 37% by the final visit). For mandated participants, the pattern was different. Control group participants maintained stable contingency compliance across visits, while CM participants showed a decline over time, with this difference in trends being statistically significant. Unlike the non-mandated group, mandated participants showed no significant benefit from CM treatment, either overall or at the final visit. The percentage of heavy drinking days also was compared across the groups. Non-mandated participants in the CM group drank heavily less often than their counterparts in the control group with a statistically significant difference (10% vs. 17%). The percentage of heavy drinking days remained stable for the non-mandated CM participants, whereas it increased for the controls. This difference in trends between the two groups was statistically significant. Heavy drinking outcomes for the mandated participants did not significantly differ from those in the control group. The researchers noted that CM treatment

showed limited additional improvement among mandated participants, likely because most had already reduced their heavy drinking before the study began and maintained these lower levels throughout the study, leaving no room for improvement.

Jett et al. (2024) evaluated the efficacy and feasibility of telehealth-based CM using a blood-based biomarker PEth among a sample of 16 individuals with AUD. The participants experienced homelessness in the past and were involved with housing programs at the time of the study. They were randomly assigned into 26 weeks of CM or non-contingent control conditions. Alcohol use was measured remotely via self-collected blood samples that were mailed to the researchers. CM participants earned rewards for reducing PEth levels weekly during Phase 1. After four weeks of abstinence (PEth <20 ng/mL), they entered Phase 2 with less frequent testing (every other week and then once a month). Participants received $20 for decreases in PEth (Phase 1) or sustained abstinence (Phase 2), plus $5 per consecutive abstinent week. If the PEth levels were higher than 20 ng/mL in Phase 2, participants returned to Phase 1 without rewards.

Participants could earn a maximum of $2,045 for continuous abstinence. The non-contingent control group received rewards equivalent to past four-week earnings of the CM group regardless of the alcohol test results. Compared to the control group, CM participants had five times higher odds of submitting PEth samples indicative of alcohol abstinence, a difference that was statistically significant. Specifically, CM participants demonstrated alcohol abstinence in 72% of the study visits compared to 34% for the control group. CM group also had longer periods of abstinence (12.3 weeks) than the control group (3.4 weeks), however, the difference was not statistically significant. Secondary outcomes included heavy alcohol use, alcohol use measured via urine samples, and self-reported alcohol consumption. CM participants had lower odds of heavy drinking, higher odds of abstinence verified by urine samples, and fewer self-reported drinks per day on average compared to the control group. These differences were not statistically significant.

Inconclusive

A study by Hammond et al. (2021) found favorable outcomes for the CM group; however, it did not conduct any statistical analyses. The study evaluated the feasibility of the DynamiCare Health smartphone application as a supplement to usual care among 61 participants with AUD enrolled in a community-based SUD treatment program. Participants were randomly assigned to two groups, with both receiving TAU that varied based on individual needs, and one group additionally received CM via DynamiCare smartphone application. The application prompted random testing for alcohol and drug use remotely and rewarded participants when a test was negative for alcohol and drugs. Alcohol use was measured via breathalyzer that was uploaded to the application automatically via Bluetooth and other drug use was tested via saliva samples, which required client submission to the researchers. Testing was prompted three to 10 days per week randomly, with more frequent testing in the evenings, weekends, and holidays. Participants had to test negative for alcohol and nine nonprescribed substances comprised of cocaine, opiates, amphetamine, methamphetamine, THC, benzodiazepines, methadone, buprenorphine, and oxycodone to earn coins which had an average value of $1, ranging from $0 to $50. The first negative sample was worth two coins and each consecutive negative sample value increased by one coin to a maximum value of ten coins and a positive sample resulted in a reset to one coin for the next negative sample, whereas missed samples resulted in a decrease in one coin for the next reward. Rewards were loaded on the debit cards that were issued to the participants. The maximum earnings for a participant who tested negative continuously were about $560-$600. The average earning in this study was $248. For assessment purposes, both groups were tested once a month for alcohol and substances for three months during the treatment and one month after the intervention period ended. Alcohol and substance use were reported together and descriptively with no statistical tests. The rate of abstinence from alcohol and substances was 33% for the group that received CM and 16% for the TAU group. Forty-one percent of the CM group compared to 22% of TAU had at least two instances of abstinence across the assessment points.

Summary of Drug Use Outcomes

The reviewed studies point to the effectiveness of CM in decreasing alcohol use and promoting abstinence among individuals with AUD. Five studies found that CM helped reduce alcohol use, five studies showed mixed results, and one study was inconclusive yet found favorable results for CM.

Among the studies with positive findings, CM was associated with higher odds of abstinence from alcohol among AI and AN adults (McDonell et al., 2021a, 2021b) and those experiencing homelessness (Novak et al., 2023). Similarly, compared to non-contingent conditions, CM groups had higher abstinent days (Koffarnus et al., 2018), and submitted more alcohol-abstinent urine drug samples (Orr et al., 2018). Participants in the CM group also reported having fewer drinks and decreased AUD symptoms measured by AUDIT (Koffarnus et al., 2018). Another study classified as having a positive outcome found that CM participants reported fewer days of alcohol use compared to the control group, but the difference was not statistically significant (McDonell et al., 2021a).

Studies with mixed results showed promising results for CM, which varied by the assessment timing (McDonell et al., 2017; Koffarnus et al., 2021; Campbell et al., 2023), measure (Jett et al. 2024), or the participant characteristics (Dougherty et al., 2023). Two studies with follow-up assessment found a significant difference between the groups, favoring CM at the end of the intervention period, however these differences were not sustained at follow-up assessments (McDonell et al., 2017; Koffarnus et al., 2021). While McDonell et al. (2017) found a significant difference in self-reported alcohol use outcomes at 3-month follow-up, these self-reported outcomes were not corroborated by urinalysis results. The study by Koffarnus et al. (2021) examined multiple follow-up assessment points, up to six months, and attributed lack of sustained effect at follow-up to missed assessment sessions by participants who drank heavily. Interestingly, Campbell et al. (2023) found no significant difference between CM and control groups during the intervention, but a significant difference emerged at the one-month follow-up assessment. The researchers cited "sleeper" effect (Campbell et al., 2023, p. 7) that was seen in some other intervention studies (Carroll et al., 2009; as cited in Campbell et al., 2023), which refers to delayed positive treatment response.

One study was characterized by mixed findings because the results varied depending on the type of alcohol use outcome that was measured (Jett et al., 2024). The study found that participants in the CM group showed significantly higher odds of abstinence according to PEth blood biomarker analysis, but this effect was not detected when using urinalysis. Some of the other non-significant findings were related to periods of abstinence, heavy alcohol use, and self-reported alcohol consumption. Lastly, Dougherty et al. (2023) found a significant effect for those who were not mandated by court to wear TAC monitoring device. However, the researchers mentioned that those who were court-mandated to wear the devices had already reduced their drinking prior to the study, leaving little room for further improvement, which is statistically known as the floor effect.

Finally, one study did not conduct any statistical comparisons, yet found promising outcomes for the effectiveness of CM. This Hammond et al. (2021) study reported higher abstinence rates for the CM group compared to the TAU group.

Treatment Retention Outcomes

Retention in treatment was reported by five studies. Studies often reported treatment completion rates (Campbell et al., 2023; Jett et al., 2024; McDonell et al., 2017), number of days in SUD treatment on average and staying in treatment for 90 days (Hammond et al., 2021), and dropping out of treatment (McDonell et al., 2021a).

Hammond et al. (2021) compared treatment retention between those who received a digitally delivered CM and those who received TAU. Participants in the CM group had a higher number of days in SUD treatment on average (29.8 days) compared to the TAU group (22.2 days) with no statistically significant difference. However, 24% of CM group stayed in treatment for 90 days compared to 3% of TAU participants and the difference was statistically significant. The duration of CM smartphone application use was not significantly correlated with the duration of SUD treatment.

Jett et al. (2024) reported retention rates for the CM group in their study of feasibility of telehealth-based CM using PEth biomarker. On average, CM participants completed 18.6 weeks of the intervention. Three out of 7 participants (43%) completed the full 26-week intervention. Participants left the CM program for various reasons: one disagreed with PEth test results, two experienced unrelated health issues, and one had conflicts with the required time commitment.

Two culturally tailored CM intervention studies did not report a significant difference in retention rates across the groups among samples of AI and AN adults. Campbell et al. (2023) reported comparable end of treatment retention rates across the two study conditions (50% for TAU and 52% for TAU+TES-NAV). Despite a slightly higher retention rate among TAU+TES-

NAV participants compared to TAU, the difference was not statistically significant. Similarly, McDonell et al. (2021a) did not find a statistically significant difference in drop-out rates between the study groups (53.8% in the CM group and 46.3% in the control group) with a higher rate in the CM group.

McDonell et al. (2017) examined the efficacy of a CM intervention among a sample of individuals with AUD and co-occurring mental illness. The study found that 65% of the CM and 74% of the non-contingent participants completed the 12-week intervention phase, with no statistically significant difference.

Overall, these studies demonstrate mixed results for retention for the CM groups, with some studies reporting slightly better retention and others reporting slightly worse retention. Studies usually did not find any statistical differences between the groups.

Mortality and Morbidity-Related Outcomes

Only one study reported mortality/morbidity-related outcomes. In their culturally tailored CM intervention, Campbell et al. (2023) reported no significant change in total drug and sexual risk behavior scores across or between the two treatment groups, suggesting that adding TES-NAV to TAU had no effect on improving participant outcomes.

Limitations

This literature review provides important insight into the utility and effectiveness of CM, but it has some limitations. First, while the search process was systematic, it was limited to studies published within the last 10 years and conducted in North America. The purpose was to provide current and contextually relevant information about CM; however, it might have excluded potentially valuable research from other time periods or countries. The review also only included studies with experimental designs and may have overlooked important findings from observational or qualitative studies that could have provided additional context or nuance to the understanding of CM utility and effectiveness. Moreover, studies were included for review only if the whole sample or the majority of the participants had a diagnosis of AUD.

Second, studies had considerable variations in the treatment duration and the amount of reward value with respect to voucher-based CM. For example, some studies provided CM for three weeks (Koffarnus et al., 2018; Koffarnus et al., 2021) or four weeks (Orr et al., 2018) while others provided CM for 12 weeks (Campbell et al., 2023; Hammond et al., 2021; McDonell et al., 2017; McDonell et al., 2021a, 2021b) or 26 weeks (Jett et al., 2024). For voucher-based CM studies that reported maximum earnings from CM intervention (n=6), values ranged from $350 for a 3-week period (Koffarnus et al., 2018; Koffarnus et al., 2021) to $2,045 for a 26-week period (Jett et al., 2024). For their 12-week period of voucher-based CM, Hammond et al. (2021) reported maximum earnings of $560-$600. Prize-based CM studies did not vary as much in terms of prize value. The value of prizes won ranged from $1 to $100 (Campbell et al., 2023; McDonell et al., 2017; McDonell et al., 2021a, 2021b).

Finally, operationalization and measurement of alcohol use outcomes pose another limitation. While all of the studies employed objective measures of alcohol such as urinalysis or transdermal monitoring, the intensity of the assessment periods and other methodological conceptualization varied across studies. Many of the studies reported outcomes based on both objective and self-report measures (Campbell et al., 2023; Jett et al., 2024; Koffarnus et al., 2018; Koffarnus et al., 2021; McDonell et al., 2017; McDonell et al., 2021a, 2021b). Operationalization of alcohol use measurement also varied across studies, which made direct comparisons challenging, with two studies looking at abstinent days (Campbell et al.,2023; Koffarnus et al., 2018) and others examining the duration of abstinence (Novak et al., 2023) or rates of abstinence (Hammond et al., 2021). Some studies examined the number of participant alcohol-negative UDTs (e.g., McDonell et al., 2021a, 2021b; Orr et al., 2018) and levels of EtG (Orr et al., 2018) and two examined heavy drinking outcomes (Campbell et al., 2023; Dougherty et al., 2023). Despite these limitations this review provides valuable insights into the current state of experimental research on CM and offers a strong foundation for understanding the potential utility and effectiveness of this intervention for AUD.

Conclusion

The results of this literature review suggest that CM can be effective in reducing alcohol consumption and promoting abstinence. Five out of 11 studies reported positive outcomes (Koffarnus et al., 2018; McDonell et al., 2021a, 2021b; Novak et al., 2023; Orr et al., 2018), and another five showed mixed results (Campbell et al., 2023; Dougherty et al., 2023; Jett et al., 2024; Koffarnus et al., 2021; McDonell et al., 2017). One study that did not conduct statistical analyses also reported favorable outcomes for the CM group which demonstrated higher CM group abstinence rates compared to the TAU group (Hammond et al., 2021).

The studies included in this review explored to a lesser degree other outcomes such as treatment retention and mortality or morbidity. Five studies reported retention outcomes (Campbell et al., 2023; Hammond et al., 2021; Jett et al., 2024; McDonell et al., 2017; McDonell et al., 2021a) and showed mixed and typically non-significant differences between CM and comparison groups. Mortality or morbidity outcomes were rarely reported in the reviewed literature. Only one study reported mortality/morbidity by focusing on drug and sexual risk behaviors and did not find an effect of CM. More research is needed to assess the impact of CM on these outcomes.

Several studies focused on special or vulnerable populations including AI/ANs (Campbell et al., 2023; McDonell et al., 2021a, 2021b) and individuals experiencing homelessness formerly (Jett et al., 2024) or currently (Novak et al., 2023), and those experiencing co-occurring mental illness (McDonell et al., 2017). The review surfaced that motivational interventions were generally effective with these unique populations. Importantly CM often was tailored to specific population needs in these studies. For instance, in their prize-based CM intervention studies McDonell et al. (2021a, 2021b) included prize items that were meaningful to AI/AN individuals. Another study utilized an abstinence-contingent wage supplement program that provided employment support for individuals experiencing homelessness, promoting both alcohol abstinence and some economic stability (Novak et al., 2023).

Six studies monitored alcohol use remotely. The monitoring methods included breathalyzers (e.g., Koffarnus et al., 2018), transdermal monitoring devices (e.g., Novak et al., 2023), and blood collection devices (Jett et al., 2024). A study that tested a smartphone app that enables the delivery of CM digitally found high levels of compliance and satisfaction with the app and showed higher retention in substance use treatment among app users compared to the non-app using control group (Hammond et al., 2021). Such remote applications have the potential to reduce CM patient-tracking burdens on staff by automating and digitizing test results and reward statuses, yet they should be implemented with caution.

One study reported adverse events such as rashes and cuts related to TAC monitoring devices (Novak et al., 2023). Some participants quit the study because they did not want to wear the device anymore. While specific reasons for exiting the study were not always described in detail, one participant quit because of dress-code restrictions posed by a new job (Novak et al., 2023). While these remote monitoring technologies and digital delivery of CM can facilitate dissemination and increase accessibility to this highly effective intervention, careful consideration must be given to selecting appropriate monitoring methods to maximize client comfort.

In conclusion, this review examines the effectiveness of CM in treating AUD. The successful adaptation of CM for vulnerable populations and integration of remote monitoring presents opportunities for broader implementation. Even though the evidence supports CM's effectiveness in reducing alcohol use and promoting abstinence, to better guide implementation future research should address gaps in long-term outcomes, such as fidelity to CM, treatment retention, and mortality/morbidity.

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