Mobile Contingency Management as an Adjunctive Treatment for Co-Morbid Cannabis Use Disorder and Cigarette Smoking

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Abstract

Introduction—Cannabis is the most widely used illicit drug in the U.S. with 19.8 million current users. Population-based data indicate that almost all cannabis users (90%) have a lifetime history of tobacco smoking and the majority (74%) currently smoke tobacco. Among cannabis users, smoking tobacco is associated with increased frequency of cannabis use, increased morbidity, and poorer cannabis cessation outcomes. There is a lack of research, however, focused on addressing cessation of both substances simultaneously. The purpose of the current pilot study was to evaluate the feasibility and acceptability of a multi-component tobacco/cannabis abstinence treatment.

Methods—Five participants completed Abstinence Reinforcement Therapy, an intervention that included five sessions of cognitive-behavioral telephone counseling for tobacco/cannabis, pharmacotherapy for smoking cessation, and five weeks of mobile contingency management to remain abstinent from tobacco and cannabis.

Results—Feasibility of recruitment, retention and treatment completion was high. Satisfaction with the treatment was also high.

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Conclusion—Results support the feasibility and acceptability of this approach with dual cannabis and tobacco users and suggest that further research examining the efficacy of this approach is warranted.

Keywords

Cannabis treatment; tobacco control; comorbidity; smoking cessation

1.1. Introduction

Cannabis is the most widely used illicit drug in the U.S. with 19.8 million current users (Substance Abuse Mental Health Services Administration, 2014). Population-based data indicate that almost all cannabis users (90%) have a lifetime history of tobacco smoking (Agrawal, Budney, & Lynskey, 2012) and the majority (68–79%) currently smoke tobacco (Richter, Ahluwalia, Mosier, Nazir, & Ahluwalia, 2002; Richter et al., 2004; Schauer, Berg, Kegler, Donovan, & Windle, 2016). Among adult smokers, as many as 22% use marijuana While cannabis use alone is associated with significant adverse health effects (Hall & Degenhardt, 2009; Hall, Degenhardt, & Lynskey, 2001), tobacco smoking is the number one preventable cause of illness and death in the U.S. (Centers for Disease Control and Prevention, 2010; Lejuez et al., 2002). This is especially true for illicit drug users, for whom the tobacco-related mortality rate is twice that of the general population (Hurt et al., 1996). Among cannabis users, smoking tobacco is associated with increased frequency of cannabis use (Richter et al., 2004), increased morbidity (Peters, Budney, & Carroll, 2012; Taylor et al., 2002), and poorer cannabis cessation outcomes (de Dios, Vaughan, Stanton, & Niaura, 2009; Gray et al., 2011; Moore & Budney, 2001), Treatment among dual users is complicated as the cessation of one substance is often associated with increased utilization of the other (Akre, Michaud, Berchtold, & Suris, 2010; Allsop et al., 2014; Copersino et al., 2006). There is limited research, however, focused on addressing cessation of both substances simultaneously (Agrawal et al., 2012; Becker, Haug, Sullivan, & Schaub, 2014; Hill et al., 2013; Lee et al., 2014; Lee et al., 2015; Peters et al., 2012). Preliminary studies suggest that interventions focused on dual cessation are feasible and desirable by co-smokers (Becker et al., 2014; Becker et al., 2013; Hill et al., 2013; Lee et al., 2014; Lee et al., 2015).

Intensive behavioral therapies, including contingency management (CM) approaches, have demonstrated short-term efficacy for the treatment of cannabis use disorder (CUD; (Carroll et al., 2006; Kadden, Litt, Kabela-Cormier, & Petry, 2007) and tobacco smoking (Carpenter et al., 2015; Davis et al., 2015; Hertzberg et al., 2013). Implementation of CM approaches for tobacco smoking and illicit drug use has been limited by the need to verify abstinence *via* repeated clinic visits (often multiple times daily in the case of tobacco smoking and more than once weekly for cannabis).

The standard in the field for detection of cannabis use has been urinalysis examining excretion of the cannabis metabolite 11-nor- 9-tetrahydrocannabinolic acid (THC-COOH) *via* immunoassay completed in a clinic setting (Budney et al., 2015). There are several drawbacks to this approach for CM. While multiple factors affect detection times for cannabis use *via* urine screening (e.g., frequency of use, dosage, individual metabolism),

THC-COOH levels are typically elevated in regular cannabis users (e.g., background levels 1,000 ng/ml). As a result, a washout period (1–2 weeks or longer) is needed between cessation of use and submission of negative urine samples to verify daily abstinence. Thus, this washout period requires at least 1–2 weeks of sustained abstinence before CM procedures can typically be started. As a result, implementation of CM for CUD has been discouraged in health care settings because this lag-time between cessation of use and submission of negative samples makes CM for CUD more complicated to administer (Petry, DePhilippis, Rash, Drapkin, & McKay, 2014). Following a washout period, the detection window for single use of cannabis is typically 3–4 days (based on a 50 ng/mL cutoff level) or up to 7 days (based on a 20 ng/mL cutoff for cannabinoids) using urinalysis (Huestis, Mitchell, & Cone, 1996). As a result, most previous CM approaches for CUD have required clinic-based monitoring at least twice a week to verify abstinence. Consequently, detection of cannabis use *via* traditional urinalysis methods makes it impossible to contingently reinforce reductions in *daily* cannabis use.

In contrast to traditional urine- or blood-based drug testing approaches) saliva (i.e., oral fluid) is a relatively new biological matrix for forensic and clinical drug testing. Saliva testing is non-invasive and has the benefits of directly observable sample collection methods (reducing potential for sample adulteration), lower biohazard risk during collection, ease of multiple sample collections, and stronger correlation with blood-based drug-testing results than urine concentrations (Lee & Huestis, 2014). In contrast to urinalysis, which detects cannabis metabolites, the majority of current OF devices directly measure 9-tetrahydrocannabinol (THC). The reliability/validity of OF drug testing has improved significantly over the past decade (Lee & Huestis, 2014; Lee et al., 2012; Niedbala et al., 2001) and there is currently one FDA-approved saliva testing method (Oratect® Oral Fluid Drug Screen Device) that can be used to detect all forms of THC use (e.g., inhaled and ingested; 40 ng/mL) in the past 12–14 hours. The accuracy of Oratect has been evaluated in comparison to GC/MS methods with 100% agreement for positive samples and 95% agreement for negative samples (Confirm Biosciences, 2012), but has not been compared to urinalysis. Importantly, cigarette smoke and multiple food/beverage and hygiene products (mouthwash) have been demonstrated to not interfere with the test (Branan Medical Corporation, 2015). To date, no studies have examined the feasibility of using OF testing methods for CM to treat CUD.

Dallery and colleagues developed web-based and internet based contingency management approaches to overcome the need for clinic monitoring for smoking cessation (Dallery, Meredith, & Glenn, 2008; Dallery & Raiff, 2011; Dallery et al., 2017). Building upon their work, we utilized a mobile health (mHealth) application to increase the feasibility and reach of contingency management for tobacco smoking (Carpenter et al., 2015; Hertzberg et al., 2013). Our group has now developed Abstinence Reinforcement Therapy (ART), a multi-component cannabis and tobacco smoking cessation tele-health intervention that combines 1) intensive behavioral therapy through a mobile contingency management (mCM) app and the use of oral fluid (OF) strips to assess recent cannabis use; 2) a cognitive behavioral treatment (CBT) intervention for both substances (informed with expert consultation from two cannabis CBT treatment experts – AJB and RSS), and 3) nicotine replacement therapy. The purpose of the current pilot study was to evaluate the acceptability and feasibility of the

study procedures and whether the procedures led to short or long term abstinence from cannabis or tobacco.

1.2. Materials and methods

1.2.1. Recruitment and enrollment

Participants were recruited from substance use disorder (SUD), mental health, and primary care clinics in the Duke University Health System. Craigslist ads and flyers were also posted in community settings. This study was approved by the Duke University IRB and no procedures were administered prior to consent. An NIH certificate of confidentiality was obtained so that information obtained from the saliva strips could not be accessed outside the study protocol.

1.2.2. Screening procedures

Prior to study entry, potential participants completed screening procedures as part of the baseline assessment, including informed consent, the psychosis and substance misuse modules of the structured clinical diagnostic interview for DSM-5 (SCID-5; (First, Williams, Karg, & Spitzer, 2015), self-report measures, demographic data, and tobacco and cannabis history. Urine and saliva samples were collected to assess for cannabis use and other illicit drugs. A breath sample was used to assess CO level. Urine pregnancy tests were completed for women of childbearing potential. Sexually active women consented to use appropriate contraception during the study and to notify study staff if they become pregnant due to harmful effects of cannabis and nicotine on fetuses. If no contact from the primary health care physician could be obtained, the participants' health information was evaluated by the study physician, who provided medical clearance for pharmacotherapy use and participation.

1.2.3. Inclusion/exclusion criteria

Inclusion criteria included: (a) currently met criteria for cannabis use disorder (American Psychiatric Association, 2013) (b) 40 or more days of cannabis use in the past 90 days, (b) currently smoked 7 cigarettes in the past 7 days, and smoking for at least the past year; (c) 18–70 years of age; (d) could speak and write fluent conversational English and (e) were willing to make an attempt to quit both cannabis and tobacco smoking. Participants were excluded if they: (a) expected to have a significant change in their psychiatric medication regimen during the study; (b) were currently receiving non-study CUD or smoking treatment; (c) met criteria for serious mental illness (e.g., current manic episode or psychotic disorder); (d) used of other forms of nicotine such as cigars, pipes, or chewing tobacco (e) became imprisoned; (f) became hospitalized for psychiatric reasons; (g) were pregnant; (h) reported imminent risk for suicide or homicide, (i) met criteria for a substance use disorder other than CUD or tobacco, or alcohol use disorder, or (j) history of myocardial infarction in the past 6 months and contraindication to NRT with no medical clearance. Two individuals were screened out (one for alcohol use disorder and the other for sedative use disorder).

1.2.4. ART treatment components and procedures

ART combines mCM, telephone CBT, and a telehealth clinic for NRT. Participants attended an initial baseline session and were given smartphones with the mCM app. Participants also

received a CO monitor and numbered OF cannabis test kits. Participants received training on mCM procedures by study staff. They then completed one week of baseline OF assessments and CO monitoring to ensure that they were expert at using the mHealth technology and any problems could be addressed with the assistance of study staff. During the baseline week, participants were reinforced for completing readings, regardless of abstinence. The baseline monitoring was followed by four weeks of active mCM. Following the active CM treatment phase, two weeks of monitoring (without contingent reinforcement) was completed to test the durability of treatment effects. The entire six-session CBT phone counseling component took place over six weeks. Three sessions occurred before the active mCM phase once a week, with the fourth session occurring on or near the set quit date. Target quit dates were set for week 3 of the intervention. Participants received two more counseling sessions after their quit date for maintenance of coping skills, identifying potential challenges, and motivation interviewing as needed. Session content included learning skills to prepare for the quit date, identifying and coping with triggers for using both substances, monitoring behaviors associated with cravings, identifying social support, urge surfing, refusal skills, and education on smoking cessation medication. Each session lasted approximately 30–40 minutes.

1.2.5. mCM for cannabis and tobacco smoking

The structure of CM interventions has varied considerably across studies, and previous study results have provided valuable information in designing the proposed intervention. CM has varied in duration, frequency, and magnitude of reinforcement. An *escalating reinforcement schedule* was set so that each subsequent sample indicating abstinence is reinforced with a greater amount of money (Davis et al., 2016). *Reset contingencies* are designed to promote abstinence following a lapse by providing a reading indicating substance use will result in reinforcement levels being reset to their initial amount. Escalating reinforcement schedules and reset contingencies have each been shown to improve smoking outcomes (Heil et al., 2008; Stoops et al., 2009), and both were used in the intervention.

Participants videotaped themselves twice daily (at least 8-hours apart) while providing CO readings and taking the OF cannabis test. The reinforcment schedule included both an escalating reinforcement schedule for abstinence from smoking and cannabis independently and together in the form of an escalating bonus payment for dual abstinence. Participants could earn a maximum of $1351 for complete abstinence during the four weeks of active CM treatment phase. Given interest in the relationship between self-report and bioverification, participants also received compensation for uploading CO and saliva videos (regardless of abstinence). The reinforcement schedule is shown in Table 1.

1.2.6. Bioverification of abstinence via CO monitoring and saliva test kit

As in previous studies, a portable CO monitor was given to participants to measure CO outside the laboratory (Carpenter et al., 2015; Dallery et al., 2008; Dallery & Raiff, 2011; Dallery et al., 2017; Hertzberg et al., 2013). Oratect® Oral Fluid Drug Screen Devices were used to assess recent cannabis use. The accuracy of Oratect has been evaluated in comparison to GC/MS methods with 100% agreement for positive samples and 95% agreement for negative samples (Confirm Biosciences, 2012). Importantly, cigarette smoke

and multiple food/beverage and hygiene products (mouthwash) have been demonstrated to not interfere with the test (Branan Medical Corporation, 2015).

Participants were trained to self-administer the test. They were then asked to videotape themselves twice daily (at least 8-hours apart) while taking the test during a 1-week *ad lib* period followed by 4-weeks of mobile CM. During each video recording, participants: 1) started a video recording session using the smartphone; 2) showed the unused test strip to the camera; 3) swabbed his/her cheek while on camera; 4) placed the strip on a flat surface for 5 minutes; and 5) recorded the final result with the camera. Saliva sticks were numbered to ensure they were not reused or substituted. For CO readings, participants followed a similar procedure but for steps 2–4 showed the zeroed CO monitor, blew into the monitor, and then recorded the final result with the camera. Videos were uploaded and transmitted to a secure server using the mobile app. Abstinence was operationally defined as THC readings that are <40 ng/mL (i.e., negative test strip in the presence of clearly visible control band) and CO readings that are < 6 ppm.

1.2.7. Cognitive behavior therapy for CUD and smoking cessation

Cognitive behavior therapy (CBT) has been used to concurrently treat cannabis use and smoking and was feasibly implemented and well-tolerated (Davis et al., 2015; Hill et al., 2013; Lee et al., 2014; Lee et al., 2015). We worked extensively with one of the co-authors (AJB) to ensure that CBT for cannabis use was adequately incorporated in the dual abstinence CBT therapist manual and participant workbook. The CBT consisted of six sessions already adapted from the CBT portions of the CUD treatment manuals one of the co-authors (AJB) used in his clinical trials (Lee et al., 2015; Litt, Kadden, Stephens, & Marijuana Treatment Project Research Group, 2005; Steinberg et al., 2002; The Marijuana Treatment Project Research Group, 2004; Walker et al., 2011; Walker, Stephens, Towe, Banes, & Roffman, 2015) as well as content from the CBT for smoking cessation protocol used in our previous studies (Carpenter et al., 2015; Hertzberg et al., 2013; McFall et al., 2010).

1.2.8. Pharmacotherapy for smoking cessation

Standard nicotine replacement therapy for smoking cessation was provided. This consisted of a standard 8-week course of NRT and up to two rescue methods (e.g., nicotine lozenge). Participants were screened for suitability for NRT. Participants who reported being contraindicated to NRT (e.g., high blood pressure not controlled by medication) were required to obtain physician authorization prior to receiving the corresponding medication. Participants received a tailored amount and delivery type of NRT based on number of cigarettes smoked per day using an established protocol (Bars et al., 2006). The study physician wrote the prescriptions.

1.2.9. Measures

Baseline measures—Demographic information was collected. The substance misuse SCID modules were administered; cannabis use years and age of first cannabis use were collected. Participants completed the Fagerström Test of Nicotine Dependence (FTND; (Heatherton, Kozlowski, Frecker, & Fagerström, 1991), and a general smoking history

questionnaire (e.g., number of cigarettes smoked/day, age of first smoking, number of previous quit attempts, living with a smoker). To measure therapeutic alliance, the 16-item Individual Treatment Alliance Scale Revised Short Form (ITASr-SF) was used. The ITASr-SF has been shown to be related to treatment dropout and treatment response in behavioral interventions and the highest possible score is 112 (Pinsof, Zinbarg, & Knobloch-Fedders, 2008).

1.2.10. Outcome measurement and biochemical verification

Outcome measurement occurred in-person at 3-month, and 6-month follow-up. Self-reported 30-day abstinence from cannabis was verified by a urinalysis examining excretion of the cannabis metabolite THC-COOH < 50 ng/ml. Abstinence from tobacco was be based on saliva cotinine <10 ng/ml. Secondary cannabis use and tobacco smoking outcomes included 7- point prevalence abstinence (i.e., no use in the past 7 days) and prolonged abstinence (abstinent for the entire period) at each assessment. Prolonged abstinence was assessed using the TLFB (Lewis-Esquerre et al., 2005). Outcomes also included number of times of cannabis use per day and proportion of days abstinent. Participants reported number of cigarettes smoked each day and days of smoking abstinence. These data were used to calculate number of dual abstinence days and longest duration of dual abstinence. Participants were compensated $50 for follow-up procedures at both 3-month and 6-month visits.

1.3. Results

Enrollment and completion of procedures—Twelve individuals called and were phone screened. Ten were scheduled for a screen; 7 attended the screening session and 2 were excluded (1 for alcohol use disorder and 1 for comorbid sedative and stimulant use disorder). Five were enrolled and 5 completed procedures (including all the CBT sessions) through the post-treatment phase. Demographic variables are reported in Table 2 and reasons for quitting marijuana are listed in Table 3.

Inter-rater agreement for OF cannabis tests—Two raters independently reviewed each cannabis saliva test video and indicated whether the saliva test was positive or negative for cannabis. In 1% of videos, coordinators identified a problem (i.e., control strip was not legible) and the sample was rated as invalid (participants were given the benefit of the doubt in these rare instances). Agreement between raters for the saliva tests was excellent (100%).

Using the reinforcement schedule in Table 1 (which provided incentives for video uploads irrespective of abstinence, cannabis abstinence, tobacco abstinence and dual abstinence), the video upload rate for cannabis was 61.3% and for tobacco was 70.0%. Two of the five (40%) participants achieved early dual abstinence and 4 of the 5 participants were bioverified abstinent from cannabis at the end of the treatment phase. Three of the five (60%) achieved 7 days of abstinence from cigarettes or marijuana during treatment. For the two weeks of non-contingent CM post-treatment, 4 of the 5 participants remained abstinent from cannabis and 2 of the 5 participants remained abstinent from tobacco. The range of uploaded videos among those who were abstinent from cannabis was 7% to 97% (median 46.4%). The range

of the uploaded videos among those who were abstinent from tobacco was 7% to 97% (median 50.0%). At 6-month follow-up, 1 participant was bioverified abstinent from both tobacco smoking and cannabis and 2 of the 5 (40%) were abstinent from cannabis. Among those not abstinent at 6 months, daily cigarette consumption had decreased by a mean of 47% from baseline, and 90-day cannabis use frequency decreased by a mean of 70% from baseline. Average compensation was $427 (range $22–$1217).

1.4 Discussion

These pilot data suggest (1) home monitoring with salvia strips for cannabis is feasible, (2) the use of ART for both cannabis and tobacco appears feasible, and (3) participants will complete the intervention procedures that may lead to abstinence from cannabis and/or tobacco. Although the total possible compensation for participation was $1477, the average amount achieved was $427. In a review of contingency management compensation (Davis et al., 2016), compensation for nicotine abstinence (among pregnant women) was as high as $1180 (Higgins et al., 2014) and for marijuana (among adolescents) was $570 (Stanger, Budney, Kamon, & Thostenson, 2009). We chose a higher reinforcement rate because we were asking participants to quit two substances, and behavioral theories of choice (Dallery & Raiff, 2012; Hernstein, 1970) support high reinforcement amounts, particularly for special populations.

This pilot study is limited by the small sample size and lack of diversity of race and sex within the sample. Despite these limitations, these pilot results suggest that mCM for tobacco and marijuana was feasible and acceptable (as measured by treatment satisfaction), and was associated with initial quit rates, and reductions in both tobacco and cannabis use as part of a multi-component smoking cessation intervention. mCM may allow these smokers through frequent incentives (particularly early in the quit period), to remain abstinent when experiencing increased craving. Given the demonstrated feasibility and observed quit rates associated with this pilot study, a larger randomized clinical trial of mCM with longer, bioverified follow-ups for tobacco and cannabis abstinence smokers is warranted.

1.5 Conclusion

ART, an innovative mobile and telehealth intervention to increase abstinence of cannabis and tobacco, appears feasible and resulted in promising quit rates in this small pilot. Although these data support the feasibility of this approach, further research is required to determine the efficacy and cost-effectiveness of this approach.

Acknowledgments

References

Agrawal A, Budney AJ, Lynskey MT. The co-occurring use and misuse of cannabis and tobacco: A review. Addiction. 2012; 107(7):1221–1233. DOI: 10.1111/j.1360-0443.2012.03837.x [PubMed: 22300456]

Akre C, Michaud PA, Berchtold A, Suris JC. Cannabis and tobacco use: Where are the boundaries? A qualitative study on cannabis consumption modes among adolescents. Health Education Research. 2010; 25(1):74–82. DOI: 10.1093/her/cyp027 [PubMed: 19515745]

Allsop DJ, Dunlop AJ, Saddler C, Rivas GR, McGregor IS, Copeland J. Changes in cigarette and alcohol use during cannabis abstinence. Drug and Alcohol Dependence. 2014; 138:54–60. DOI: 10.1016/j.drugalcdep.2014.01.022 [PubMed: 24613633]

American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition. Arlington, VA: American Psychiatric Association; 2013.

Bars MP, Banauch GI, Appel D, Andreachi M, Mouren P, Kelly K, Prezant DJ. "Tobacco free with FDNY:" The New York city fire department World Trade Center tobacco cessation study. Chest. 2006; 129(4):979–987. DOI: 10.1378/chest.129.4.979 [PubMed: 16608947]

Becker J, Haug S, Sullivan R, Schaub MP. Effectiveness of different web-based interventions to prepare co-smokers of cigarettes and cannabis for double cessation: A three-arm randomized controlled trial. Journal of Medical Internet Research. 2014; 16(12):e273.doi: 10.2196/jmir.3246 [PubMed: 25486674]

Becker J, Hungerbuehler I, Berg O, Szamrovicz M, Haubensack A, Kormann A, Schaub MP. Development of an integrative cessation program for co-smokers of cigarettes and cannabis: Demand analysis, program description, and acceptability. Substance Abuse Treatment, Prevention, and Policy. 2013; 8:33.doi: 10.1186/1747-597X-8-33

Biosciences C. Oratect Oral Fluid Drug Screen Device. 2012:1–4.

Branan Medical Corporation. Oratect III Oral Fluid Drug Screen Device ME/TH/CO/AM/OP/PC or B2 Catalog HM11 or HM12. 2015

Budney AJ, Stanger C, Tilford JM, Scherer EB, Brown PC, Li Z, … Walker DD. Computer-assisted behavioral therapy and contingency management for cannabis use disorder. Psychology of Addictive Behaviors. 2015; 29(3):501–511. DOI: 10.1037/adb0000078 [PubMed: 25938629]

Carpenter VL, Hertzberg JS, Kirby AC, Calhoun PS, Moore SD, Dennis MF, … Beckham JC. Multicomponent smoking cessation treatment including mobile contingency management in homeless veterans. Journal of Clinical Psychiatry. 2015; 76:959–964. DOI: 10.4088/JCP. 14m09053 [PubMed: 25699616]

Carroll KM, Easton CJ, Nich C, Hunkele KA, Neavins TM, Sinha R, … Rounsaville BJ. The use of contingency management and motivational/skills-building therapy to treat young adults with marijuana dependence. Journal of Consulting & Clinical Psychology. 2006; 74(5):955–966. DOI: 10.1037/0022-006X.74.5.955 [PubMed: 17032099]

Centers for Disease Control and Prevention. Tobacco use: Targeting the nation's leading killer. Atlanta, GA: Centers for Disease Control and Prevention; 2010.

Copersino ML, Boyd SJ, Tashkin DP, Huestis MA, Heishman SJ, Dermand JC, … Gorelick DA. Quitting among non-treatment-seeking marijuana users: Reasons and changes in other substance use. American Journal of Addiction. 2006; 15(4):297–302. DOI: 10.1080/10550490600754341

Dallery J, Meredith S, Glenn IM. A deposit contract method to deliver abstinence reinforcement for cigarette smoking. Journal of Applied Behavior Analysis. 2008; 41(4):609–615. DOI: 10.1901/jaba.2008.41-609 [PubMed: 19192864]

Dallery J, Raiff B. Monetary-based consequences for drug abstinence: Methods of implementation and some considerations about the allocation of finances in substance abusers. The American Journal of Drug and Alcohol Abuse. 2012; 38(1):20–29. DOI: 10.3109/00952990.2011.598592 [PubMed: 22149758]

Dallery J, Raiff BR. Contingency management in the 21st century: Technological innovations to promote smoking cessation. Substance Use and Misuse. 2011; 46:10–22. DOI: 10.3109/10826084.2011.521067 [PubMed: 21190402]

Dallery J, Raiff BR, Kim SJ, Marsch LA, Stitzer M, Grabinski MJ. Nationwide access to an internet-based contingency management intervention to promote smoking cessation: A randomized controlled trial. Addiction (Abingdon, England). 2017; 112(5):875–883. DOI: 10.1111/add.13715

Davis DR, Kurti AN, Skelly JM, Redner R, White TJ, Higgins ST. A review of the literature on contingency management in the treatment of substance use disorders, 2009–2014. Preventive Medicine. 2016; 92:36–46. [PubMed: 27514250]

Davis ML, Powers MB, Handelsman P, Medina JL, Zvolensky M, Smits JA. Behavioral therapies for treatment-seeking cannabis users: A meta-analysis of randomized controlled trials. Evaluation & The Health Professions. 2015; 38(1):94–114. DOI: 10.1177/0163278714529970 [PubMed: 24695072]

de Dios MA, Vaughan EL, Stanton CA, Niaura R. Adolescent tobacco use and substance abuse treatment outcomes. Journal of Substance Abuse Treatment. 2009; 37(1):17–24. DOI: 10.1016/j.jsat.2008.09.006 [PubMed: 19004603]

First, MB., Williams, JBW., Karg, RS., Spitzer, RL. Structured Clinical Interview for DSM-5 (SCID-5 for DSM-5). Arlington, VA: American Psychiatric Association; 2015.

Gray KM, Riggs PD, Min SJ, Mikulich-Gilbertson SK, Bandyopadhyay D, Winhusen T. Cigarette and cannabis use trajectories among adolescents in treatment for attention-deficit/hyperactivity disorder and substance use disorders. Drug and Alcohol Dependence. 2011; 117(2–3):242–247. DOI: 10.1016/j.drugalcdep.2011.02.005 [PubMed: 21411243]

Hall W, Degenhardt L. Adverse health effects of non-medical cannabis use. Lancet. 2009; 374(9698):1383–1391. DOI: 10.1016/S0140-6736(09)61037-0 [PubMed: 19837255]

Hall, W., Degenhardt, L., Lynskey, J. The health and psychological effects of cannabis use. National Drug Strategy Monograph No. 25. Australia: University of New South Wales, National Drug and Alcohol Research; 2001.

Heatherton TF, Kozlowski LT, Frecker RC, Fagerström KO. The Fagerström Test for Nicotine Dependence: A revision of the Fagerström Tolerance Questionnaire. British Journal of Addiction. 1991; 86:1119–1127. DOI: 10.1111/j.1360-0443.1991.tb01879.x [PubMed: 1932883]

Heil SH, Higgins ST, Berstein IM, Solomon LJ, Rogers RE, Thomas CS, … Lynch ME. Effects of voucher-based incentives on abstinence from cigarette smoking and fetal growth among pregnant women. Addiction. 2008; 103:1009–1018. DOI: 10.1111/j.1360-0443.2008.02237.x [PubMed: 18482424]

Hernstein RJ. On the law of effect. Journal of the Experimental Analysis of Behavior. 1970; 13:243–266. [PubMed: 16811440]

Hertzberg JS, Carpenter VL, Kirby AC, Calhoun PS, Moore SD, Dennis MF, … Beckham JC. Mobile contingency management as an adjunctive smoking cessation treatment for smokers with posttraumatic stress disorder. Nicotine & Tobacco Research. 2013; 15(11):1934–1938. DOI: 10.1093/ntr/ntt060 [PubMed: 23645606]

Higgins ST, Washio Y, Lopez AA, Heil SH, Solomon LJ, Lynch ME, … Bernstein IM. Examining two different schedules of financial incentives for smoking cessation among pregnant women. Preventative Medicine. 2014; 68:51–57. DOI: 10.1016/j.ypmed.2014.03.024

Hill KP, Toto LH, Lukas SE, Weiss RD, Trksak GH, Rodolico JM, Greenfield SF. Cognitive behavioral therapy and the nicotine transdermal patch for dual nicotine and cannabis dependence: A pilot study. American Journal on Addictions. 2013; 22(3):233–238. DOI: 10.1111/j.1521-0391.2012.12007.x [PubMed: 23617864]

Huestis MA, Mitchell JM, Cone EJ. Urinary excretion profiles of 11-nor-9-carboxy-delta 9-tetrahydrocannabinol in humans after single smoked doses of marijuana. Journal of Analytical Toxicology. 1996; 20(6):441–452. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8889681. [PubMed: 8889681]

Hurt RD, Offord KP, Croghan IT, Gomez-Dahl L, Kottke TE, Morse RM, Melton LJ 3rd. Mortality following inpatient addictions treatment. Role of tobacco use in a community-based cohort. Journal of American Medical Association. 1996; 275(14):1097–1103. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8601929.

Kadden RM, Litt MD, Kabela-Cormier E, Petry NM. Abstinence rates following behavioral treatments for marijuana dependence. Addictive Behaviors. 2007; 32(6):1220–1236. DOI: 10.1016/j.addbeh. 2006.08.009 [PubMed: 16996224]

Lee D, Huestis MA. Current knowledge on cannabinoids in oral fluid. Drug Testing and Analysis. 2014; 6(1–2):88–111. DOI: 10.1002/dta.1514 [PubMed: 23983217]

Lee DC, Budney AJ, Brunette MF, Hughes JR, Etter JF, Stanger C. Treatment models for targeting tobacco use during treatment for cannabis use disorder: Case series. Addictive Behaviors. 2014; 39(8):1224–1230. DOI: 10.1016/j.addbeh.2014.04.010 [PubMed: 24813547]

Lee DC, Budney AJ, Brunette MF, Hughes JR, Etter JF, Stanger C. Outcomes from a computer-assisted intervention simultaneously targeting cannabis and tobacco use. Drug and Alcohol Dependence. 2015; 155:134–140. DOI: 10.1016/j.drugalcdep.2015.08.001 [PubMed: 26307942]

Lee DC, Schwope DM, Milman G, Barnes AJ, Gorelick DA, Huestis MA. Cannabinoid disposition in oral fluid after controlled smoked cannabis. Clinical Chemistry. 2012; 58(4):748–756. DOI: 10.1373/clinchem.2011.177881 [PubMed: 22273566]

Lejuez CW, Read JP, Kahler CW, Richards JB, Ramsey SE, Stuart GL, … Brown RA. Evaluation of a behavioral measure of risk taking: The Balloon Analogue Risk Task (BART). Journal of Experimental Psychology: Applied. 2002; 8(2):75–84. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12075692. [PubMed: 12075692]

Lewis-Esquerre JM, Colby SM, Tevyaw TO, Eaton CA, Kahler CW, Monti PM. Validation of the timeline follow-back in the assessment of adolescent smoking. Drug and Alcohol Dependence. 2005; 79(1):33–43. [PubMed: 15943942]

Litt MD, Kadden RM, Stephens RS. Marijuana Treatment Project Research Group. Coping and self-efficacy in marijuana treatment: Results from the marijuana treatment project. Journal of Consulting & Clinical Psychology. 2005; 73(6):1015–1025. DOI: 10.1037/0022-006X.73.6.1015 [PubMed: 16392975]

McFall M, Saxon A, Malte C, Chow B, Bailey S, Baker D, … Lavori PW. Integrating tobacco cessation into mental health care for posttraumatic stress disorder: A randomized controlled trial. Journal of the American Medical Association. 2010; 304(22):2485–2493. DOI: 10.1177/1740774507076923 [PubMed: 21139110]

Moore BA, Budney AJ. Tobacco smoking in marijuana-dependent outpatients. Journal of Substance Abuse. 2001; 13(4):583–596. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11775084. [PubMed: 11775084]

Niedbala RS, Kardos KW, Fritch DF, Kardos S, Fries T, Waga J, … Cone EJ. Detection of marijuana use by oral fluid and urine analysis following single-dose administration of smoked and oral marijuana. Journal of Analytical Toxicology. 2001; 25:289–303. [PubMed: 11499881]

Peters EN, Budney AJ, Carroll KM. Clinical correlates of co-occurring cannabis and tobacco use: A systematic review. Addiction. 2012; 107(8):1404–1417. DOI: 10.1111/j.1360-0443.2012.03843.x [PubMed: 22340422]

Petry NM, DePhilippis D, Rash CJ, Drapkin M, McKay JR. Nationwide dissemination of contingency management: The Veterans Administration initiative. The American Journal of Addictions. 2014; 23(3):205–210. DOI: 10.1111/j.1521-0391.2014.12092.x

Pinsof WM, Zinbarg R, Knobloch-Fedders LM. Factorial and construct validity of the revised short form integrative psychotherapy alliance scales for family, couple, and individual therapy. Family Process. 2008; 47:281–301. [PubMed: 18831308]

Richter KP, Ahluwalia HK, Mosier MC, Nazir N, Ahluwalia JS. A population-based study of cigarette smoking among illicit drug users in the United States. Addiction. 2002; 97(7):861–869. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12133125. [PubMed: 12133125]

Richter KP, Kaur H, Resnicow K, Nazir N, Mosier MC, Ahluwalia JS. Cigarette smoking among marijuana users in the United States. Substance Abuse. 2004; 25(2):35–43. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/15982966.

Schauer GL, Berg CJ, Kegler MC, Donovan DM, Windle M. Differences in tobacco product use among past month adult marijuana users and nonusers: Findings from the 2003–2012 national survey on drug use and health. Nicotine & Tobacco Research. 2016; 18(3):281–288. DOI: 10.1093/ntr/ntv093 [PubMed: 26009578]

Stanger C, Budney AJ, Kamon JL, Thostenson J. A randomized trial of contingency management for adolescent marijuana abuse and dependence. Drug and Alcohol Dependence. 2009; 105(3):240–247. DOI: 10.1016/j.drugalcdep.2009.07.009 [PubMed: 19717250]

Steinberg KL, Roffman RA, Carroll KM, Kabela E, Kadden R, Miller M. … Marijuana Treatment Project Research Group. Tailoring cannabis dependence treatment for a diverse population. Addiction. 2002; 97(Suppl 1):135–142. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12460135. [PubMed: 12460135]

Stoops WW, Dallery J, Fields NM, Nuzzo PA, Schoenberg NE, Martin CA, … Wong CJ. An internet-based abstinence reinforcement smoking cessation intervention in rural smokers. Drug and Alcohol Dependence. 2009; 105(1–2):56–62. DOI: 10.1016/j.drugalcdep.2009.06.010 [PubMed: 19615830]

Substance Abuse Mental Health Services Administration. National Survey of Substance Abuse Treatment Services (N-SSATS): 2013. Data on Substance Abuse Treatment Facilities. Rockville, MD: 2014.

Taylor DR, Fergusson DM, Milne BJ, Horwood LJ, Moffitt TE, Sears MR, Poulton R. A longitudinal study of the effects of tobacco and cannabis exposure on lung function in young adults. Addiction. 2002; 97(8):1055–1061. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12144608. [PubMed: 12144608]

The Marijuana Treatment Project Research Group. Brief treatments for cannabis dependence: Findings from a randomized multisite trial. Consulting and Clinical Psychology. 2004; 72:455–466. [PubMed: 15279529]

Walker DD, Stephens R, Roffman R, Demarce J, Lozano B, Towe S, Berg B. Randomized controlled trial of motivational enhancement therapy with nontreatment-seeking adolescent cannabis users: A further test of the teen marijuana check-up. Psychology of Addictive Behaviors. 2011; 25(3):474–484. DOI: 10.1037/a0024076 [PubMed: 21688877]

Walker DD, Stephens RS, Towe S, Banes K, Roffman R. Maintenance check-ups following treatment for cannabis dependence. Journal of Substance Abuse Treatment. 2015; 56:11–15. DOI: 10.1016/j.jsat.2015.03.006 [PubMed: 25922136]

Table 1

Final Reinforcement Schedule

	Days pre-quit	1st CO	2nd CO	1st Saliva	2nd Saliva	CO Upload	Saliva Upload	Bonus	Total
	1	$.50	$.50	2.50	2.50	N/A	N/A	N/A	$6.00
	2	$.50	$.50	2.50	2.50	N/A	N/A	N/A	$6.00
	3	$.50	$.50	2.50	2.50	N/A	N/A	N/A	$6.00
Practice	4	$.50	$.50	2.50	2.50	N/A	N/A	N/A	$6.00
	5	$.50	$.50	2.50	2.50	N/A	N/A	N/A	$6.00
	6	$.50	$.50	2.50	2.50	N/A	N/A	N/A	$6.00
	7	$.50	$.50	2.50	2.50	N/A	N/A	N/A	$6.00
	Days post-quit	**1st CO**	**2nd CO**	**1st Saliva**	**2nd Saliva**	**CO Upload**	**Saliva Upload**	**Bonus**	**Total**
	1	$1.00	$1.25	$2.50	$2.75	$1.00	$5.00	$1.00	$14.50
	2	$1.50	$1.75	$3.00	$3.25	$1.00	$5.00	$1.50	$17.00
	3	$2.00	$2.25	$3.50	$3.75	$1.00	$5.00	$2.00	$19.50
Week1	4	$2.50	$2.75	$4.00	$4.25	$1.00	$5.00	$2.50	$22.00
	5	$3.00	$3.25	$4.50	$4.75	$1.00	$5.00	$3.00	$24.50
	6	$3.50	$3.75	$5.00	$5.25	$1.00	$5.00	$3.50	$27.00
	7	$4.00	$4.25	$5.50	$5.75	$1.00	$5.00	$4.00	$29.50
	8	$4.50	$4.75	$6.00	$6.25	$1.00	$5.00	$4.50	$32.00
	9	$5.00	$5.25	$6.50	$6.75	$1.00	$5.00	$5.00	$34.50
	10	$5.50	$5.75	$7.00	$7.25	$1.00	$5.00	$5.50	$37.00
	11	$6.00	$6.25	$7.50	$7.75	$1.00	$5.00	$6.00	$39.50
Week2	12	$6.50	$6.75	$8.00	$8.25	$1.00	$5.00	$6.50	$42.00
	13	$7.00	$7.25	$8.50	$8.75	$1.00	$5.00	$7.00	$44.50
	14	$7.50	$7.75	$9.00	$9.25	$1.00	$5.00	$7.50	$47.00
	15	$8.00	$8.25	$9.50	$9.75	$1.00	$5.00	$8.00	$49.50
	16	$8.50	$8.75	$10.00	$10.25	$1.00	$5.00	$8.50	$52.00
Week3	17	$9.00	$9.25	$10.50	$10.75	$1.00	$5.00	$9.00	$54.50
	18	$9.50	$9.75	$11.00	$11.25	$1.00	$5.00	$9.50	$57.00

Week	Days pre-quit	1st CO	2nd CO	1st Saliva	2nd Saliva	CO Upload	Saliva Upload	Bonus	Total
	19	$10.00	$10.25	$11.50	$11.75	$1.00	$5.00	$10.00	$59.50
	20	$10.50	$10.75	$12.00	$12.25	$1.00	$5.00	$10.50	$62.00
	21	$11.00	$11.25	$12.50	$12.75	$1.00	$5.00	$11.00	$64.50
	22	$11.50	$11.75	$13.00	$13.25	$1.00	$5.00	$11.50	$67.00
	23	$12.00	$12.25	$13.50	$13.75	$1.00	$5.00	$12.00	$69.50
Week4	24	$12.50	$12.75	$14.00	$14.25	$1.00	$5.00	$12.50	$72.00
	25	$13.00	$13.25	$14.50	$14.75	$1.00	$5.00	$13.00	$74.50
	26	$13.50	$13.75	$15.00	$15.25	$1.00	$5.00	$13.50	$77.00
	27	$14.00	$14.25	$15.50	$15.75	$1.00	$5.00	$14.00	$79.50
	28	$14.50	$14.75	$16.00	$16.25	$1.00	$5.00	$14.50	$82.00
	1	$.50	$.50	2.50	2.50	N/A	N/A	N/A	$6.00
	2	$.50	$.50	2.50	2.50	N/A	N/A	N/A	$6.00
	3	$.50	$.50	2.50	2.50	N/A	N/A	N/A	$6.00
Week5	4	$.50	$.50	2.50	2.50	N/A	N/A	N/A	$6.00
	5	$.50	$.50	2.50	2.50	N/A	N/A	N/A	$6.00
	6	$.50	$.50	2.50	2.50	N/A	N/A	N/A	$6.00
	7	$.50	$.50	2.50	2.50	N/A	N/A	N/A	$6.00
	1	$.50	$.50	2.50	2.50	N/A	N/A	N/A	$6.00
	2	$.50	$.50	2.50	2.50	N/A	N/A	N/A	$6.00
	3	$.50	$.50	2.50	2.50	N/A	N/A	N/A	$6.00
Week6	4	$.50	$.50	2.50	2.50	N/A	N/A	N/A	$6.00
	5	$.50	$.50	2.50	2.50	N/A	N/A	N/A	$6.00
	6	$.50	$.50	2.50	2.50	N/A	N/A	N/A	$6.00
	7	$.50	$.50	2.50	2.50	N/A	N/A	N/A	$6.00
							TOTAL POSSIBLE COMPENSATION		$1,477.00

Table 2

Demographic and Cannabis/Tobacco Use Variables among Pilot Participants (N=5)

	n (%)	*M* (SD)	Range
Age		43.6 (8.87)	35–57
Years of Education		15.2 (3.27)	12–20
Total Years Cigarettes Smoked		15.8 (13.1)	3–33
Number of Cigarettes Smoked Daily		10.6 (11.2)	2–30
Number of Cigarette Quit Attempts		1.8 (1.1)	1–3
FTND Score		4.8 (2.49)	1–8
PHQ-9 Score		2.6 (2.30)	0–5
PCL-5 Score		13 (13.44)	6–37
B Symptoms		3.6 (3.90)	0–10
C Symptoms		2.0 (1.87)	0–5
D Symptoms		4.6 (3.13)	2–10
E Symptoms		2.8 (5.17)	0–12
Cannabis Use Start Age		22.2 (9.18)	14–34
Cannabis Use Years		21.4 (12.44)	10–40
Treatment Satisfaction			
*How helpful was CM in helping you quit marijuana?		8.0 (1.41)	6–9
*How helpful was CM in helping you quit smoking?		5.8 (3.03)	3–9
*How helpful was behavioral counseling in helping you quit marijuana?		7.0 (2.45)	3–9
*How helpful was behavioral counseling in helping you quit smoking?		5.8 (3.35)	1–9
**How easy to understand was the CM app?		7.0 (1.87)	4–9
**How easy to understand was the behavioral counseling participant manual?		8.2 (0.84)	7–9
×What did you think about the information provided in the participant manual?		4.4 (1.34)	2–5
**How easy to use was the CM app?		7.2 (1.10)	6–9
**How easy to use was the participant manual?		8.0 (1.00)	7–9
Therapeutic Alliance		102 (7.39)	93–111
Gender - male	1 (20%)		
Married	0 (0%)		
Race – African American	5 (100%)		
Hispanic	1 (20%)		
Employed	4 (80%)		

*
Question was rated on a scale of 1–9 (1=Not at all helpful, 9=Extremely helpful)

**
Question was rated on a scale of 1–9 (1=extremely difficult, 9=extremely easy)

×
Question was rated on a scale of 1–9 (1=too little information, 4=the right amount of information, 9=too much information)

Table 3

Reasons for Quitting Smoking Marijuana among Pilot Participants

Participant	Reason to Quit Marijuana	Marijuana use in Past 90 Days	Cigarettes Per Day
39 year old, AA Hispanic woman	*"I want to set a better example for my kids, save money, and get a better job."*	90	30
36 year old, AA woman	*"I want to be healthier, look and smell better and save money."*	47	6
39 year old, AA woman	*"I want to be present. I need to decrease my dependency, and I want to save money."*	43	5
57 year old, AA man	*"I don't want to be controlled by substances. I need clean urine tests as part of parole."*	45	10
48 year old, AA woman	*"I want more energy. I want to live a healthier life and spend time with my son."*	45	2

Table 4

Change in Cigarette and Cannabis Use

	Pre-treatment	Post-treatment (end of mCM & CBT)	6-month follow-up	Change from pre-treatment to 6-month follow-up
	M (SD)	M (SD)	M (SD)	
Number of Cigarettes Smoked Each Day	15.8 (13.1)	1.6 (1.5)	4.8 (4.0)	−11.0
Percent of Days Abstinent from Cigarettes	0%	36.15% (36.9)	27.6% (43.7)	27.6%
Number of Days Smoked Marijuana in the Past 90	54 (20.2)	N/A	13.2 (10.7)	−40.8
Percent of Days Abstinent from Marijuana	40.0%	54.2% (24.4)	85.3% (11.9)	45.3%