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The cost effectiveness of prize-based and voucher-based contingency management in a population of cocaine- or opioid-dependent outpatients

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Abstract

Objective—To evaluate the cost-effectiveness of using prize-based and voucher-based contingency management (CM) as additions to standard treatment for cocaine- or heroin-dependent outpatients in community treatment centers.

Methods—This cost-effectiveness analysis is based on a randomized clinical trial conducted at three community-based outpatient psychosocial substance abuse treatment clinics. A total of 142 cocaine- or heroin-dependent outpatients were randomly assigned to one of three treatment conditions: standard treatment (ST), ST with prizes (prize CM), or ST with vouchers (voucher CM) for 12 weeks. The primary patient outcome was the longest duration of confirmed abstinence (LDA) from cocaine, opioids and alcohol during treatment. Unit costs were collected from the three participating clinics. Resource utilizations and patient outcomes were obtained from the clinical trial. Incremental cost-effectiveness ratios (ICERs) and acceptability curves were used to evaluate the relative cost-effectiveness of the interventions.

Results—Based on the ICERs and acceptability curves, ST is likely to be the most cost-effective intervention when the threshold value to decision makers of lengthening the LDA during treatment by 1 week is less than approximately \$166, and prize CM is likely to be the most cost-effective intervention when the threshold value is greater than approximately \$166.

Conclusions—Prize CM was found likely to be the most cost-effective intervention over a comparatively wide range of threshold values for lengthening the LDA during treatment by 1 week. However, additional studies with alternative incentive parameters are required to determine the generalizability of our results.

Keywords

acceptability curves; contingency management; cost-effectiveness; prizes; vouchers

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1. Introduction

This study analyzes the cost effectiveness of two types of contingency management (CM) interventions, voucher CM and prize CM, implemented within a randomized clinical trial. The clinical trial was conducted at three outpatient psychosocial substance abuse treatment clinics and included 142 cocaine- or heroin-dependent subjects randomly assigned within each clinic to one of three treatment conditions: standard treatment (ST), ST with vouchers (voucher CM), or ST with prizes (prize CM). Subjects earned reinforcement for (1) testing abstinent from cocaine, opioids, and alcohol, and (2) completing goal-related activities. Although none of the clinics in the trial had methadone treatment available, approximately one out of five subjects were methadone maintained, receiving that treatment at another clinic. Petry et al. (2005) analyzed patient outcomes from the trial but did not report on the cost-effectiveness of treatments.

In voucher CM, participants receive vouchers, typically exchangeable for goods and services, contingent on the desired behaviors. In contrast, participants in prize CM earn chances to win prizes, typically ranging in value from \$0.80 to \$80, contingent on the desired behaviors. Both voucher and prize CM have been shown to be highly effective with a wide range of substance use disorders (Lussier et al., 2006; Prendergast et al., 2006).

Despite the strong evidence base for both types of CM interventions, these interventions have not been adopted widely in the United States or elsewhere (Ritter and Cameron, 2007). One major hindrance to wider adoption of CM interventions is that not much is known about their cost-effectiveness (Carroll and Rounsaville, 2003; Petry, 2000). At issue is whether the additional expense associated with CM is cost-effective in terms of the additional value gained. Said differently, because both types of CM can increase costs to a financially constrained treatment system, either directly through voucher/prize incentives or indirectly by increasing length of stay, a key issue is whether the additional costs of the interventions are justifiable. Without knowing the cost effectiveness of using CM in general, or prize CM vs. voucher CM in particular, policymakers have little guidance in determining whether the additional expenditures on either of these interventions are worthwhile investments. Unfortunately, few studies have examined the cost-effectiveness of CM in general, and no studies have examined the relative cost-effectiveness of prize CM vs. voucher CM.

In this study, incremental cost-effectiveness ratios (ICERs) and acceptability curves are used to define ranges of values over which each intervention would be considered likely to be the most cost effective for improving outcomes during treatment of cocaine- or heroin-dependent patients in outpatient psychosocial substance abuse treatment clinics. The emphasis on cost-effectiveness is important for policy decisions related to the future expansion of CM interventions. In addition to increasing the evidence base for the cost-effectiveness of CM in general, to our knowledge this is the first study to shed light on the relative cost-effectiveness of prize CM vs. voucher CM. This study also adds to the growing literature on the cost-effectiveness of well-defined empirically validated treatments and interventions for substance use disorder (Barnett et al., 2001; Cartwright, 1998, 2000; French et al., 1996; Olmstead et al., 2007a, 2007b; Sindelar et al., 2007a, 2007b; Zarkin et al., 2005).

2. Methods

Cost-effectiveness analyses of prize CM and voucher CM were conducted using patient outcomes and resource utilization data collected by the original effectiveness trial (Petry et al., 2005). To these we added cost data obtained from the clinics where the trial took place. Methods and results of the effectiveness study are described in the main report of study design and

outcomes (Petry et al., 2005) and are thus summarized only briefly below, followed by a description of the analytical methods used for the cost-effectiveness analyses.

The randomized clinical trial evaluated the efficacy of prize and voucher CM coupled with standard treatment as compared to standard treatment only in each of three community-based outpatient psychosocial substance abuse treatment (SAT) clinics located in Hartford and Waterbury, Connecticut, USA. Individuals entering into treatment at the clinics were enrolled in the study between April 2001 and July 2002. The study intervention lasted 12 weeks. Patients were eligible for the study if they met past-year Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; American Psychiatric Association, 1994) criteria for cocaine or opioid dependence. Study participation was voluntary and participants provided written informed consent as approved by the University's Institutional Review Board. Study procedures were an adjunct to standard services and did not affect these services. In both CM conditions, reinforcement escalated with increasing durations of abstinence, and reinforcement was provided for abstinence and completion of goal-related activities. The final study sample comprised 142 cocaine- or heroin-dependent patients who were randomly assigned to either standard treatment, standard treatment plus prize CM, or standard treatment plus voucher CM. Random assignment was conducted at each site independently using an urn randomization procedure (Stout et al., 1994). Although methadone treatment was unavailable at the clinics in the trial, approximately one out of five subjects were methadone maintained, receiving that treatment at another clinic and requiring supplemental psychosocial treatment for substance use that was not being adequately addressed in the methadone clinics.

The sample size (about 40 per group) was estimated from effect sizes of studies that used lower-cost CM procedures (Petry et al., 2004). No significant differences between treatment conditions were found on any of the patient demographic, substance use or psychosocial functioning variables measured at baseline, with one exception—patients in the ST condition were slightly older than the other groups (by about four years). Not surprisingly, the average number of weeks that patients were retained in treatment differed across the conditions, with patients in both CM conditions retained in treatment significantly longer than their ST counterparts. Within each treatment condition, no significant differences across clinics were found on the average number of weeks patients were retained in treatment.

2.1. Treatments

2.1.1. Standard treatment (ST)—Standard treatment was similar at all three sites and consisted of intensive outpatient (IOP) care comprising primarily group therapy (up to 5 hours/day, 4 days/week) for 2–4 weeks, depending on need, followed by gradual reductions in care. However, the average duration and timing of ST care varied across the clinics. Specifically, one clinic offered ST care from 10am to 1pm (3 hours) with one 15-minute and one 30-minute break; another clinic offered ST care from 11:30am to 3:30pm (4 hours) with two 30-minute breaks; and the final clinic offered ST care from 9am to 12pm (3 hours) with two 10-minute breaks. All patients submitted breath samples for alcohol and urine specimens that were screened for opioids and cocaine. These samples were submitted 3 days/week during Weeks 1–3, 2 days/week during Weeks 4–6 and 1 day/week during Weeks 7–12, for a total of up to 21 samples submitted over the 12-week treatment period. Samples were collected on days that patients were scheduled to attend the clinic.

Patients in the ST group also met one-on-one with a research assistant for 15 minutes each week to discuss educational topics, including health and drugs, depression, AIDS, and stress management. These individualized meetings were designed to control for the personalized attention associated with activity selection in the CM conditions (see below).

2.1.2. Voucher CM—Participants assigned to the voucher CM condition received the same treatment as described above (with the exception of the weekly 15-minute educational sessions). They also received vouchers according to a two-track incentive system that provided reinforcement for both abstinence and completion of goal-related activities. Voucher amounts started at \$1.00 with submission of the first negative specimen (specimens had to be negative for all three substances—cocaine, opioids and alcohol) and increased by \$1.50 for submission of each consecutive negative specimen. A \$10 bonus was available each week for submission of all negative specimens during that week. Voucher amounts were reset to \$1.00 with submission of a positive specimen, refusal to submit a specimen, or an unexcused absence. Patients also received vouchers for completing activities related to their treatment goals. Each week patients selected 3 specific activities related to their long-term goals (e.g., completing a GED course application, making or attending a physician's appointment) to complete in the upcoming week. Accepted verifications (e.g., receipts, brochures) of agreed upon activities were also listed on weekly activity contracts. A \$3 voucher was earned for each activity completed and verified. Completing all activities in a week resulted in a \$10 bonus and a \$1 increase in the voucher amount available for each activity completed in the subsequent week. Failure to complete all activities within a week reset the voucher amount to \$3.

In total, patients could earn up to \$882 in vouchers if they submitted all 21 negative specimens (\$456) and completed all 36 activities (\$426). Participants could spend vouchers on virtually any item and were usually used for clothing, transportation, electronic equipment, movie theater passes, and gift certificates for food. Requested voucher items were purchased and provided to patients at their next scheduled visit; patients in this condition were also able to select items stocked in the prize cabinet (see below) for immediate exchange of vouchers for tangible items.

2.1.3. Prize CM—Participants assigned to the prize CM condition received the same treatment as their voucher CM counterparts. However, instead of earning vouchers, prize CM patients earned the opportunity to draw a card out of an urn each time they submitted negative specimens. Each card was marked with one of four different prize categories (“good job,” “small,” “large,” and “jumbo”). The first submitted negative specimen resulted in 1 draw from the urn, and number of draws increased by 1 for each consecutive negative specimen. A bonus of 5 draws was earned each week if all specimens were negative. Submission of a positive specimen, refusal to submit a specimen, or an unexcused absence reset the number of draws to 1. Patients in this condition also earned prize drawings for completing and verifying activities related to treatment goals. The first activity completed resulted in 1 draw, and the number of draws earned per activity increased by 1 for each consecutive week all three activities were completed. Completion of all three activities during a week resulted in a bonus of 5 draws as well. The number of draws reset to 1 if all three activities were not completed in a given week.

In total, patients could earn up to 585 draws if they submitted all 21 negative specimens (291 draws) and completed all 36 activities (294 draws). The urn contained 500 cards: 314 (62.8%) were marked “Good Job” and had no monetary value; 150 (30%) were marked “Small” and worth, on average, approximately \$0.80 (e.g., toiletries, snacks); 35 (7%) were marked “Large” and worth, on average, approximately \$16 (e.g., telephone, portable CD player); and 1 (0.2%) was marked “Jumbo” and worth, on average, approximately \$80 (e.g., television, stereo). Cards were replaced after each draw so that chances of winning remained constant. A variety of prizes in each category (i.e., small, large, jumbo) were kept onsite in locked cabinets for immediate exchange with cards. The expected value of each card drawn from the urn was \$1.52 ($\$1.52 = \$0 \times 0.628 + \$0.80 \times .300 + \$16 \times 0.070 + \$80 \times .002$). The maximum expected earnings of a patient in the prize CM group was \$889.20 ($\$889.20 = 585 \text{ draws} \times \$1.52 \text{ per draw}$), which is very close to the maximum earnings of a patient in the voucher CM group (\$882).

2.2. Cost-effectiveness analysis

Incremental cost-effectiveness analysis is the appropriate approach to use in this study as we are comparing standard treatment to two CM conditions, both of which incrementally add costs (Drummond et al., 2005; Gold et al., 1996). To calculate incremental cost-effectiveness ratios (ICERs), we first calculated the unit costs using cost data (e.g., average counselor salaries during the study period, typical amount of time to conduct a urinalysis test, cost of a urine testcup, etc.) obtained from the clinics where the effectiveness study took place. Then, for each study participant, we multiplied the resources used by the unit costs. Data on resources used (e.g., number of sessions attended, number of urine tests) came from the original effectiveness study (Petry et al., 2005). The average variable cost per participant in each condition was then calculated, followed by the incremental cost of each CM condition compared to ST. All cost-effectiveness analyses were based on a sample of 141 participants; one of the 142 participants in the effectiveness study (from the voucher CM condition) was excluded from the cost analyses due to missing data on resource utilization.

2.2.1. Incremental Costs—Costs were calculated from the perspective of the clinic and included only those costs that varied by treatment condition. Such costs included those related to counseling sessions, urine and breath sample testing, educational sessions, and the two CM systems (prize and voucher). All labor costs included fringe benefits. Because implementing CM interventions may require additional staff in the long run, and these additional staff may, in turn, increase overhead (e.g., utilities, insurance, rent, maintenance and repair, administrative salaries plus fringe, etc.), all labor costs were multiplied by the overhead rate reported at each clinic. Inasmuch as the trial took place over a relatively short 16-month period, no adjustments were made for differential timing of costs (e.g., a \$1 voucher earned at the start of the study in April 2001 was assumed to have the same value as a \$1 voucher earned at the end of the study in July 2002). All costs are therefore reported in 2001–2002 dollars.

2.2.1.1. Unit counseling cost: The unit counseling cost measures the average per participant cost of a group counseling session. This unit cost includes the time spent by the counselor both in treatment and in administration (e.g., taking notes before or after the session) and is prorated by the average number of patients in a session.

2.2.1.2. Unit testing cost: The unit testing cost measures the average cost per urine and breath test and includes material costs (urine test cup and breathalyzer tube) and time spent by staff conducting the test valued at two-thirds of counselor salary plus fringe benefits and overhead (in the clinical trial, RAs conducted all of the tests; in practice, we assume that clinics would use less expensive personnel to do these tasks).

2.2.1.3. Unit educational session cost: The unit educational session cost measures the average cost of a 15-minute educational session and applies to participants in the ST condition only.

2.2.1.4. Voucher CM costs: Voucher system costs comprise four components: activity selection and verification costs, voucher item selection costs, costs of the vouchers, and costs associated with purchasing and processing voucher items. Unit activity selection and verification costs measure the average cost of an activity session; this is the time spent by staff with each client each week verifying completed activities from the previous week and brainstorming new activities for the subsequent week, valued at counselor salary plus fringe benefits and overhead. Unit voucher item selection costs measure the average cost of a voucher selection session; this is the time spent by staff with clients deciding how to spend earned vouchers, valued at counselor salary plus fringe benefits and overhead. The unit costs of the vouchers are straightforward. Costs associated with purchasing and processing voucher items are calculated by measuring the amount of time spent by staff purchasing (e.g., traveling and

shopping) and processing (e.g., logging into inventory) requested items; this time is then valued at two-thirds of counselor salary plus fringe benefits and overhead (in the clinical trial, RAs did all of the purchasing and processing of voucher items; in practice, we assume that clinics would use less expensive personnel to do these tasks). Since staff typically perform these duties on a bi-weekly or weekly basis for voucher items, there are several ways to apportion these costs on a per participant basis. In this study, the total cost of purchasing and processing voucher items at each clinic was assigned to clinic participants in proportion to the total value of vouchers earned by each participant.

2.2.1.5. Prize CM costs: Prize system costs are similar to those for the voucher system and comprise four components: activity selection and verification costs, prize drawing and selection costs, costs of the prizes, and costs associated with purchasing and processing prizes. Unit activity selection and verification costs are as described above for voucher CM. Unit prize drawing and selection costs measure the average cost of a prize drawing and selection session; this is the time spent by staff facilitating each drawing and subsequent client selection of prizes from the prize cabinet, valued at counselor salary plus fringe benefits and overhead. The prize costs are the value of the prizes won during the drawing sessions. Costs associated with purchasing and processing prizes are calculated by measuring the amount of time spent by staff purchasing (e.g., traveling, shopping) and processing (e.g., logging into inventory) prizes; this time is then valued at two-thirds of counselor salary plus fringe benefits and overhead. Since staff typically perform these duties on a monthly or quarterly basis for prizes, there are several ways to apportion these costs on a per participant basis. In this study, the total cost of purchasing and processing prizes at each clinic was assigned to clinic participants in proportion to the total value of prizes won by each participant.

2.2.1.6. Resources used: In order to calculate the total variable costs, we multiplied the above calculated unit costs by the number of units of each resource used. Resource utilizations for each participant were obtained from the effectiveness study (Petry et al., 2005). Data on the number of each of the following were collected: counseling sessions, urinalysis and breathalyzer tests, education sessions, activity selection and verification sessions, voucher item selection sessions, and prize drawing and selection sessions. Data were also collected on the value of vouchers and prizes received by study participants. Variable costs per participant were then estimated straightforwardly by multiplying unit costs by corresponding resource utilizations.

2.2.2. Incremental Cost-Effectiveness Analysis—We conducted incremental cost-effectiveness analyses (ICEAs) to evaluate the relative cost-effectiveness of the three interventions. The primary patient outcome used in the ICEAs was the longest duration of abstinence (LDA) from cocaine, opioids and alcohol during the 12-week study period. LDA is defined as the longest span of consecutive weeks in which all urine and breath samples collected read negative for cocaine, opioids and alcohol. The LDA during treatment was chosen as the primary patient outcome for the ICEAs both because (1) the escalating nature of the incentives in both CM interventions was designed specifically to reinforce long durations of abstinence during treatment, and (2) the longest duration of abstinence achieved during treatment is among the best predictors of improved outcomes at follow-up periods (Petry et al., 2007; Higgins et al., 2003, 2000; Carroll et al., 1994). As a check on the robustness of our results, we also considered a secondary objective patient outcome measure: the number of negative specimens submitted during the 12-week study period (i.e., negative for cocaine, opioids and alcohol).

For each of the patient outcome measures, we calculated incremental cost-effectiveness ratios (ICERs). The ICER is defined as the incremental cost divided by the incremental effect. We used incremental costs estimated as described above and incremental effects obtained from the

effectiveness study (Petry et al., 2005). The ICERs measure the incremental cost of using the two CM interventions, compared to ST, to produce an extra unit of effect for each of the patient outcomes.

We also developed acceptability curves, for each of the patient outcomes, to show the probability that each intervention is the most cost-effective, given the observed data, under different assumptions about the value of an extra unit of effect. Costs and effects for each intervention were bootstrapped with 1,000 replicates to produce the acceptability curves for each of the patient outcome measures (see Fenwick et al., 2001, for a detailed explanation of how to create acceptability curves for trials with more than two interventions).

3. Results

As shown in Table 1, the effectiveness study found that participants assigned to the two CM conditions had significantly better outcomes during treatment ($p < .05$) than participants assigned to ST alone (Petry et al., 2005). Given that sample characteristics were similar across the three groups, observed differences in patient outcomes were likely due to the interventions provided.

Unit costs were estimated following the methods described above using the cost data obtained from the three treatment sites where the effectiveness trial took place. Table 2 presents the weighted average of the unit costs, where the average is taken across all clinics and weighted by the sample size at each clinic. For example, the average per participant cost of a group counseling session was \$10.40. Each test comprising a urinalysis and breathalyzer cost an average of \$12.23. The average cost of an individualized 15-minute education session or an activity selection and verification session was \$6.58. The average per participant cost of purchasing and processing incentive items was \$26.37 and \$18.01 for subjects in the voucher CM and prize CM groups, respectively. The difference in “purchasing and processing” costs between the two CM conditions was due to the need to make many small shopping trips for voucher CM participants (who were allowed to request specialty items outside the prize cabinet) compared to the need to make only a few large “stockpiling” shopping trips for prize CM participants (who were required to select all items from the prize cabinet).

Average resource utilizations per participant were obtained from the original effectiveness study and are summarized in Table 3. Table 4 presents the average variable cost per participant in each treatment group. As shown in Table 4, as would be expected, participants in the two CM conditions had the highest average variable cost, due primarily to the cost of the incentives system.

The incremental cost-effectiveness ratios (ICERs) are shown in Table 5. The ICERs were calculated using incremental costs derived from Table 4 and incremental effects derived from Table 1. Specifically, compared to standard treatment (ST), the incremental cost of using voucher CM to lengthen the LDA during treatment by one week was \$212 ($\$212 = (\$792 - \$289)/(7.00 - 4.63)$), while the incremental cost of using prize CM to lengthen the LDA during treatment by one week was \$166 ($\$166 = (\$823 - \$289)/(7.84 - 4.63)$). The corresponding ICERs for an additional negative specimen during treatment were \$156 ($\$156 = (\$792 - \$289)/(12.40 - 9.18)$) and \$121 ($\$121 = (\$823 - \$289)/(13.58 - 9.18)$) for voucher CM and prize CM, respectively.

Although it may be tempting to conclude that prize CM is more cost effective than voucher CM on the basis of the ICERs alone, it is important to recognize that there is considerable uncertainty in the ICERs, as evidenced by the fairly wide confidence intervals in Table 5. To rigorously address the uncertainty inherent in the ICER point estimates, acceptability curves are presented in Figure 1a and Figure 1b for the patient outcomes LDA and number of negative

specimens, respectively. Acceptability curves are a relatively new approach that is used to illustrate the statistical uncertainty inherent in the ICERs due to the use of a single sample (Briggs, 2001; Fenwick et al., 2001; Lothgren and Zethraeus, 2000). Each acceptability curve shows the probability that a given intervention is the most cost-effective given the observed data (Fenwick et al., 2001). Note that acceptability curves are a function of the threshold willingness-to-pay of the decision maker for an additional unit of outcome. Intuitively, as seen in Figure 1, as the threshold value of an additional unit of a given patient outcome *increases*, the intervention that produces the *largest effect* (i.e., prize CM) becomes increasingly more likely to be the most cost effective, even though it adds incremental costs. Similarly, as the threshold value of an additional unit of a given patient outcome *decreases*, the intervention that has the *lowest cost* (i.e., ST) becomes increasingly more likely to be the most cost-effective.

For example, as the threshold value (perhaps determined by society's willingness to pay) of extending the LDA during treatment by one week increases from \$0 to approximately \$166, then Figure 1a shows that the likelihood that ST is the most cost-effective intervention decreases from 100% to 49.2%, the likelihood that prize CM is the most cost-effective intervention increases from 0% to 49.6%, and the likelihood that voucher CM is the most cost-effective intervention increases from 0% to 1.2%. Note that when the threshold value of extending the LDA during treatment by one week is approximately \$166, ST and prize CM are equally likely to be the most cost-effective intervention. As the threshold value increases from approximately \$166 to approximately \$250, the likelihood that prize CM is the most cost-effective intervention increases from 49.6% to 88.0%, while the likelihood that ST is the most cost-effective intervention decreases from 49.2% to 3.4% and the likelihood that voucher CM is the most cost-effective intervention increases from 1.2% to 8.6%. For threshold values greater than \$250, the likelihood that prize CM is the most cost-effective remains close to 88%, while the likelihood that ST is the most cost-effective decreases to 0% and the likelihood that voucher CM is the most cost-effective increases to 12%.

Although the prize CM condition had better patient outcomes during treatment than the voucher CM condition, these differences were non-significant. Given that effect differences between the two CM conditions were non-significant and the incremental cost of voucher CM was slightly lower than the incremental cost of prize CM, it may seem surprising that prize CM is more likely to be cost-effective than voucher CM over a comparatively wide range of threshold values for each patient outcome. The reason for this potentially unintuitive result is that cost-effectiveness depends on the *joint* density of cost and effect differences, as opposed to *individual* differences in either cost or effect. Moreover, "absence of evidence is not evidence of absence." That is, a focus on hypothesis testing leads to an overemphasis on type I errors at the expense of type II errors (Briggs and O'Brien, 2001; Drummond et al., 2005; Glick et al., 2007).

4. Discussion

In a population of cocaine- or heroin-dependent individuals treated in community-based outpatient psychosocial SAT clinics, both prize CM and voucher CM produced significant improvements in patient outcomes during treatment, as well as significant increases in treatment costs. Said differently, both CM conditions provided better LDAs and more negative specimens than standard treatment but required additional costs.

Which intervention (i.e., ST alone, ST with prize CM, or ST with voucher CM) is likely to be the most cost-effective for improving patient outcomes during treatment depends on the value that decision makers place on an additional unit of effect. At this time, however, no consensus threshold values exist for any patient outcomes in substance abuse treatment. In the absence of consensus threshold values for substance use outcomes, we present ranges of values, defined

by the ICERs and acceptability curves for each patient outcome, over which each intervention is likely to be the most cost-effective compared to the others. Specifically, if the threshold value for extending the LDA during treatment by one week is less than approximately \$166, then ST is most likely to be the most cost-effective intervention (see Table 5 and Figure 1a). However, if the value of extending the LDA during treatment by one week is greater than approximately \$166, then prize CM is most likely to be the most cost-effective intervention. Similarly, if the threshold value of an additional negative specimen during treatment is less than approximately \$121, then ST is most likely to be the most cost-effective intervention (see Table 5 and Figure 1b), while prize CM is most likely to be the most cost-effective intervention if the value of an additional negative specimen during treatment is greater than approximately \$121.

Decision makers can use the results of this study in combination with their own evaluation of the value of patient outcomes during treatment to make policy decisions. For example, the link between illicit drug use and crime is well established (Basu et al., 2008; Sindelar and Olmstead, 2006; Jofre-Bonet and Sindelar, 2001), and Cohen et al. (2004) estimate the per-offense cost (in 2000 dollars) of a burglary and an armed robbery at \$25,000 and \$232,000, respectively. Based on the ICERs in Table 5, if decision makers believe that extending the longest duration of abstinence during treatment by one week would reduce the probability during that week of a single burglary by at least 0.66% (i.e., $\$166/\$25,000$) or of a single armed robbery by at least 0.072% (i.e., $\$166/\$232,000$), then the additional costs of prize CM would be justified by avoided crime costs alone. Moreover, based on the acceptability curves in Figure 1a, if decision makers believe that extending the LDA during treatment by one week would reduce the probability during that week of a single burglary or a single armed robbery by at least 1% (i.e., $\$250/\$25,000$) or 0.11% (i.e., $\$250/\$232,000$), respectively, then prize CM is very likely (88%) to be the most cost-effective intervention. These findings are conservative for two reasons. First, they do not include the benefits associated with reductions in other types of crime (e.g., property damage, assault), nor do they include the benefits of improvements in other negative externalities associated with drug abuse such as disease and welfare. Second, because the LDA during treatment is among the best predictors of improved patient outcomes during longer-term follow-up periods (Petry et al., 2007; Higgins et al., 2003, 2000; Carroll et al., 1994), improvements in the LDA during treatment are likely to result in additional benefits that accrue during the post-treatment period. In light of the above, it seems reasonable to conclude that the benefits of both CM interventions outweigh their additional costs.

A practical finding of this study is that the cost of implementing the two CM conditions (comprising costs associated with activity selection and verification sessions, voucher/prize selection sessions, and purchasing and processing voucher/prize items) accounted for a substantial portion of the total incentive system costs. Specifically, as seen in Table 4, implementation costs for both CM conditions accounted for 32% of their respective incentive system costs (i.e., $\$144/\$451$ for prize CM and $\$148/\$462$ for voucher CM). Moreover, if voucher CM had been implemented in this study as traditionally described (i.e., without a cabinet of items for immediate exchange with vouchers), the cost of purchasing and processing voucher items likely would have been higher due to more frequent shopping trips necessitated by accommodating individualized requests with a rapid turnaround. Clinic administrators, therefore, must budget for implementation costs accordingly when adopting CM interventions. These findings underscore the need for research on ways to reduce the cost of implementing CM interventions, with the goal of improving the cost-effectiveness of CM overall. For example, some programs have considered providing only gift certificates or items that can be purchased online, but the efficacy of such approaches is not yet established.

The present study has several strengths. First, it is based on a randomized clinical trial that used a relatively large sample size and relied on objective indicators of patient outcomes (Petry et al., 2005). Thus, the observed patient outcomes are likely to be related to the interventions

delivered. Second, to increase the external validity of the results, the trial included patients with either cocaine or opioid use diagnoses and was conducted at three clinics with a diverse set of standard treatment practices and patient populations. Third, the present study relied on cost data collected from the clinics where the trial took place. Fourth, in the absence of consensus threshold values for an additional unit of effect, we use ICERs and acceptability curves to present ranges of values, for each patient outcome, over which each intervention is most likely to be the most cost-effective compared to the others. Decision makers can use this information in combination with their own evaluation of the value of patient outcomes to make policy decisions. Finally, the ICERs estimated in the present study can be used as thresholds for future studies.

There are also several limitations. First, given that the trial examined two CM conditions, each with a single reinforcement schedule, additional studies are needed to determine the generalizability of our results. Said differently, although the prize CM and voucher CM protocols were designed to be very similar in terms of their respective reinforcement schedules, other protocols with different incentive parameters may give different cost-effectiveness results. Nevertheless, the relative cost-effectiveness of prize CM over a comparatively wide range of threshold values in this study underscores the promise of this approach. Second, inasmuch as the effectiveness trial targeted cocaine- or heroin-dependent individuals, and 20.4% of the overall sample included patients receiving methadone maintenance services from another clinic, the ICERs and acceptability curves may not generalize to populations using other types of drugs. Third, the cost-effectiveness analysis in this study is based on patient outcomes measured during treatment, as opposed to outcomes measured at longer-term follow-up periods. However, the primary patient outcome in this study (i.e., the longest duration of abstinence achieved during treatment) is among the best predictors of improved outcomes measured at longer-term follow-up periods (Petry et al., 2007; Higgins et al., 2003, 2000; Carroll et al., 1994). Fourth, because breath samples and urine specimens were collected on days that patients were scheduled to attend treatment, these samples were not collected randomly throughout each week. Finally, our cost estimates include only those costs that vary by treatment condition. Hence, they do not measure the total cost of the interventions and are thus not directly comparable to “total cost” estimates in the literature.

In conclusion, this study adds to the growing literature on cost-effectiveness in substance abuse treatment by providing (1) ICERs for both prize and voucher CM compared to ST in a population of cocaine- or opioid-dependent outpatients, and (2) acceptability curves that compare the relative likelihood that each of the three interventions is the most cost effective across a wide range of threshold values for two different patient outcomes measured during treatment. Cost-effectiveness analyses of CM interventions are critical because CM adds clear and certain costs to standard treatment. Future research is necessary to determine methods of improving the cost-effectiveness of CM overall, including examination of alternative reinforcement schedules and implementation procedures.

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Figure 1.

Acceptability curves for longest duration abstinent (LDA) during treatment (a), and number of negative specimens submitted during treatment (b). For a given threshold value, the probability of being cost effective is equivalent to the proportion of the 1,000 bootstrapped replicates for which each intervention (ST, Prize CM, Voucher CM) had the highest net benefit (Fenwick et al., 2001).

Table 1 Average Patient Outcomes During Treatment in each Treatment Arm^a

	Standard Treatment (N = 38)	Voucher CM (N = 53)	Prize CM (N = 50)
LDA during treatment	4.63 (3.4)	7.00 (4.2) *	7.84 (4.3) *
# of negative specimens during treatment	9.18 (5.9)	12.40 (6.3) *	13.58 (5.8) *

LDA = longest duration abstinent

^aValues represent means and standard deviations (in parentheses).

* p-value < .05 (compared to standard treatment).

Table 2 Average Unit Costs of Resources ^a (N = 141)

	Unit Cost (\$/unit)
Counseling (group) ^b	10.40 (1.42)
Testing ^c	
Materials	8.72 (0.00)
Labor	3.51 (0.56)
Extra education (ST only) ^d	6.58 (1.05)
Incentives	
Activity selection/verification ^e	6.58 (1.05)
Voucher selection ^f	5.49 (0.88)
Prize drawing/selection ^g	4.94 (0.79)
Shop/process vouchers ^h	26.37 (24.54)
Shop/process prizes ⁱ	18.01 (15.20)

^aValues represent means and standard deviations (parentheses). Unit costs are averaged across all sites and weighted by sample size at each site. All labor includes fringe benefits and overhead.

^b\$ per participant per session. Includes session time plus administrative time (e.g., taking notes). Prorated by average number of session participants.

^c\$ per test. Includes both alcohol and drug testing.

^d\$ per 15-minute education session given only to participants in the ST group to control for the individualized attention associated with activity selection in the CM conditions.

^e\$ per 15-minute activity selection session (applicable only to participants in the CM conditions). Includes time to verify activities completed during previous week and brainstorm activities for subsequent week.

^f\$ per voucher item selection session. Includes time to select voucher items.

^g\$ per prize drawing session. Includes time to facilitate drawing and selection of prizes.

^h\$ per participant in Voucher CM group. Includes time to shop and process voucher items (prorated by value of vouchers awarded).

ⁱ\$ per participant in Prize CM group. Includes time to shop and process prizes (prorated by value of prizes awarded).

Table 3 Average Resources Consumed per Participant in Each Treatment Arm^a

	Standard Treatment (N = 38)	Voucher CM (N = 53)	Prize CM (N = 50)
Counseling sessions (#)	13.4 (11.8)	16.5 (10.8)	19.6 (11.1)
Tests (#)	9.7 (5.7)	13.4 (5.7)	14.2 (5.4)
Extra education sessions (#)	5.6 (3.6)	0 (0)	0 (0)
Incentives			
Activity selection sessions (#)	0 (0)	8.2 (3.8)	9.3 (3.7)
Voucher/prize selection sessions (#)	0 (0)	12.6 (6.2)	13.7 (5.9)
Vouchers/prizes awarded (\$)	0 (0)	314 (287)	307 (264)

^aValues represent means and standard deviations (parentheses).

Table 4 Average Variable Cost per Participant in each Treatment Arm^a

	Standard Treatment (N = 38) (\$)	Voucher CM (N = 53) (\$)	Prize CM (N = 50) (\$)
Counseling	137 (108)	166 (102)	200 (114)
Testing	117 (66)	163 (68)	172 (64)
Extra education (ST only)	35 (21)	0 (0)	0 (0)
Incentives			
Activity selection/verification	0 (0)	54 (26)	60 (25)
Voucher/prize selection	0 (0)	68 (35)	66 (29)
Shop/process vouchers/prizes	0 (0)	26 (25)	18 (15)
Vouchers/prizes awarded	0 (0)	314 (287)	307 (264)
Subtotal	0 (0)	462 (359)	451 (312)
Total	289 (187)	792 (500)	823 (455)

^aValues represent means and standard deviations (in parentheses).

Table 5 Incremental Cost Effectiveness Ratios (ICERs) for Voucher CM vs. ST and Prize CM vs. ST^a

	Voucher CM vs. ST (\$)	Prize CM vs. ST (\$)
LDA during treatment	212 (154, 470)	166 (128, 278)
# of negative specimens during treatment	156 (108, 665)	121 (93, 230)

ST = standard treatment; LDA = longest duration abstinent

^aValues represent ICERs with 95% confidence intervals (parentheses)