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### Randomized clinical trial examining duration of voucher-based reinforcement therapy for cocaine abstinence.

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## Randomized Clinical Trial Examining Duration of Voucher-Based Reinforcement Therapy for Cocaine Abstinence

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### Abstract

**Background**—This is the first study to systematically manipulate duration of Voucher-Based Reinforcement Therapy (VBRT) to see if extending the duration increases abstinence during and following VBRT.

**Methods**—We randomized cocaine-dependent methadone-maintained adults to Standard (12 weeks; n=62) or Extended (36 weeks; n=68) VBRT and provided escalating voucher amounts contingent upon urinalysis verification of cocaine abstinence. Urinalysis was scheduled at least every two weeks during the 48-week study and more frequently during VBRT (3/week) and 12 weeks of Aftercare (2/week).

**Results**—Extended VBRT produced longer durations of continuous cocaine abstinence during weeks 1–24 (5.7 vs 2.7 weeks;  $p=0.003$ ) and proportionally more abstinence during weeks 24–36 ( $X^2=4.57$ ,  $p=.03$ , OR=2.18) compared to Standard VBRT. Duration of VBRT did not directly predict after-VBRT abstinence; but longer continuous abstinence during VBRT predicted abstinence during Aftercare ( $p=0.001$ ) and during the last 12 weeks of the study ( $p < 0.001$ ). Extended VBRT averaged higher monthly voucher costs compared to Standard VBRT (\$96 vs \$43,  $p < .001$ ); however, the average cost per week of abstinence attained was higher in the Standard group (\$8.06 vs \$5.88,  $p < .001$ ). Participants in the Extended group with voucher costs exceeding \$25 monthly averaged 20 weeks of continuous abstinence.

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### Contributors

KK conceptualized the study idea and study design and wrote sections of the manuscript; CC supervised data entry and cleaning, was responsible for data preparation for analysis, and wrote the results section; KD assisted with research design, completed data analysis and interpretation, and wrote the analysis and results sections; BR provided oversight on participant recruitment and day-to-day study operations and wrote sections of the grant; LB assisted with study design and wrote sections of the grant; EB, AJ, and RK were responsible for participant recruitment; data collection, organization, and cleaning; KS assisted with conceptualizing the study design. All authors contributed to and have approved the final version of the manuscript.

### Conflict of Interest

All authors declare that they have no conflict of interest with regard to this research.

**Conclusions**—Greater abstinence occurred during Extended VBRT, but providing a longer duration was not by itself sufficient to maintain abstinence after VBRT. However, if abstinence can be captured and sustained during VBRT, then providing longer durations may help increase the continuous abstinence that predicts better long-term outcomes.

## Keywords

VBRT; vouchers; reinforcement; cocaine abstinence; treatment duration

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## 1. Introduction

Contingency management (CM) interventions, including Voucher-Based Reinforcement Therapy (VBRT), are among the most efficacious methods for improving drug abstinence during drug abuse treatment and have been identified as an empirically-based treatment approach for both opiate and cocaine drug use disorders (Chambless et al., 1998; Chambless and Ollendick, 2001). Meta-analyses of CM yield small to medium overall effect sizes for reducing opiate use during methadone treatment ( $r=.25$ ; Griffith et al., 2000) and VBRT yields moderate effect sizes for outpatient treatment of cocaine use ( $r=.35$ ; Lussier et al., 2006).

In VBRT, each time patients provide a urine sample testing negative for specified drugs, they are given a voucher that can be exchanged for a range of goods and services. Typically, the value of the voucher increases gradually with each consecutive drug-free urine sample provided. A drug positive sample or failure to provide a scheduled sample results in the voucher value being reset to the initial value from which it can again escalate according to the same rules. The majority of VBRT studies addressing illicit drug use have implemented a 12-week escalating schedule of voucher delivery.

In surveys of community-based treatment providers, 15–22% of respondents indicate they believe that the effects of CM disappear after the intervention ends (Kirby et al., 2012). This belief is not unfounded; animal research has repeatedly demonstrated that behavior reverses toward baseline after reinforcement is terminated (Skinner, 1938, pp. 74–81). However, these studies are conducted in operant chambers that minimize extraneous variables, producing an environmental vacuum. In applied research, reinforcement may occur in a social context where individuals are exposed to many factors that can function as naturally-occurring reinforcers (see Baer, 1982) for both drug use and abstinence. In drug abuse treatment research, drug use often returns towards pretreatment levels when CM is abruptly terminated, suggesting that naturally-occurring reinforcers for abstinence are not present (e.g., Silverman et al., 1996; 1999). However, 12 weeks may be too short for changes in the surrounding environment to occur that will reinforce and maintain abstinent behavior.

Silverman et al. (2004) provided support for the view that delivering a longer CM intervention may result in better maintenance of abstinence. Relative to usual care with or without contingent take-home doses, patients receiving contingent methadone take-home doses and VBRT for a full year did not show precipitous decreases in abstinence during the 8 weeks after VBRT was terminated. Also, Higgins and colleagues (2000) reported that maximum duration of continuous cocaine abstinence during treatment predicted longer-term cocaine abstinence at 6, 9, and 12 months after treatment entry, suggesting that there is no fixed amount of abstinence needed to increase the odds of longer-term abstinence: the odds continue to increase as a function of the amount of during-treatment abstinence achieved.

Although previous studies have provided VBRT for longer than a 12-week duration (e.g., Preston et al., 2001; Silverman et al., 2004), this is the first study to systematically

manipulate duration of VBRT in a 48-week randomized controlled trial conducted in a community-based methadone treatment program (also see Carpenedo et al., 2010). The purposes of the study were to compare a standard duration (12 weeks) of VBRT to an extended duration (36 weeks) to test the following hypotheses: 1) Compared to Standard VBRT, Extended VBRT will result in (a) longer durations of continuous cocaine abstinence and (b) increased proportions of cocaine-negative urine samples; 2) Extended VBRT participants will show less cocaine use than Standard VBRT participants during (a) a 12-week Aftercare period following VBRT and (b) during the last 12 weeks of the study (i.e., weeks 37–48); and 3) The longest duration of continuous abstinence achieved during VBRT will predict (a) the percent of cocaine-negative samples provided during Aftercare and (b) during the last 12 study weeks.

## 2. Method

### 2.1. Participants

Participants were recruited from patients enrolled in a large urban methadone treatment program. Eligibility criteria included: receiving a minimum stable 40 mg methadone maintenance dose at intake, meeting DSM-IV criteria for current cocaine abuse or dependence, providing biologically-verified evidence of cocaine use during the past 30 days, ability to participate in study protocol (e.g., provide urine specimens; remain in geographical area for study duration), no history of gambling problems, no spouse or significant other enrolled in study, and ability to provide valid contact information and informed consent.

Potential participants were referred to study staff by treatment program counselors. We assessed 233 referred patients for eligibility; 58 (25%) did not meet the basic inclusion criteria (e.g., no current cocaine use; undergoing methadone detoxification). Four of the 175 remaining potential participants declined participation, three were discharged from the treatment program or entered inpatient treatment before enrollment, and 37 were excluded because they did not complete the intake assessment. The resulting 131 patients were urn randomized (controlling for cocaine and opiate intake urinalysis result) to either Standard VBRT (n=63) or Extended VBRT (n=68). One participant assigned to Standard VBRT reported having a kidney problem and was deemed ineligible because he was not able to reliably deliver urine specimens. As such, data from 130 participants were included in the final analyses (Figure 1). The study was approved and overseen by the Institutional Review Boards for the Treatment Research Institute and the Philadelphia Department of Health.

### 2.2. Procedures

Figure 2 provides a schematic summarizing the research design and the procedures described below.

**2.2.1. Treatment-as-Usual (TAU)**—The outpatient methadone treatment program scheduled all participants to receive daily methadone doses ( $M=171$  mg; range=40–340 mg), thrice weekly 3-hour group treatment sessions, and urinalysis once monthly. As is the case in most community methadone clinics where it is recommended that clinicians do not respond immediately to a single urinalysis result (Batki et al., 2005), there were no systematic consequences for positive tests (also see Benishek et al., 2010; McGovern et al., 2004).

**2.2.2. Weekly Urinalysis**—All participants were scheduled to provide urine samples three times weekly (Monday, Wednesday, Friday) during VBRT phases of the study and twice weekly (Monday/Thursday or Tuesday/Friday) during the Aftercare phase. If a participant failed to provide a sample, research staff attempted to collect one on the

following clinic day. To ensure veracity, all samples were collected under direct observation, temperature tested, and checked for adulteration via Teco Diagnostics Drug Adulteration test strips. Samples that did not pass the veracity check were not tested, but participants could provide another sample. Valid samples were tested for the cocaine metabolite benzoylecgonine using *ACON* One Step Test Strips, which return a negative result when concentrations are below 300 ng/mL. Urinalysis results were entered into a database that calculated the value of the voucher that was delivered.

**2.2.3. Biweekly Urinalysis**—In addition to weekly tests, participants provided a urine sample that was tested for benzoylecgonine every other week during the 48-week study. If a participant completed a bimonthly assessment on the same day that a weekly test was scheduled, one sample was used for both purposes. Participants received \$10 for each biweekly assessment and a \$25 bonus for every three consecutive biweekly assessments.

**2.2.4. Standard VBRT**—Upon delivery of the first cocaine-negative urine sample, participants received a \$2.50 voucher. The value of the voucher escalated by \$1.25 with each consecutive cocaine-negative sample (e.g., \$3.75, \$5.00, \$6.25, etc.) up to a maximum value of \$40. A bonus voucher value of \$10.00 was provided after each delivery of 3 consecutive cocaine-negative samples. If a cocaine-positive sample was provided, participants did not receive a voucher on that day, and escalating voucher values were reset back to the original value of \$2.50 for the next cocaine-negative sample provided. Voucher values were also reset if a participant failed to provide a scheduled urine sample. Samples collected on the following day did not prevent resets or earn vouchers. When 5 consecutive cocaine-negative samples were provided following a reset, voucher values were restored to the highest amount earned prior to the reset. VBRT remained in effect for 12 weeks. This voucher schedule is consistent with Higgins et al.'s (1994) original schedule.

**2.2.5. Extended VBRT**—The Extended VBRT schedule was identical to the Standard schedule except that it remained in effect for 36 weeks. As with the Standard schedule, the escalating voucher value was capped at \$40, consistent with Silverman et al.'s (2004) schedule modifications for use during one year of VBRT. In both the Standard and Extended conditions, vouchers were exchanged for items in the prize cabinet (including gift certificates) or requested, research staff-approved items. Gift certificates (from local retailers that did not sell alcohol, drug-related products, or firearms) were frequently selected.

**2.2.6. Aftercare**—Consistent with Higgins et al. (1994), immediately following VBRT participants entered a 12-week aftercare period where they received a \$1.00 state lottery ticket for submitting cocaine-negative samples provided twice weekly. The number of lottery tickets did not escalate with successive cocaine-negative samples.

### 2.3. Data Analysis

Demographic and drug use characteristics of the two groups were compared using chi-square tests for dichotomous variables and t-tests for continuous variables. For descriptive and/or analytic purposes, each of four 12-week periods during the 48-week study was considered a separate study phase that involved a different comparison of conditions between the Extended and Standard groups (i.e., Phase 1=VBRT vs VBRT; Phase 2=VBRT vs Aftercare; Phase 3=VBRT vs TAU; Phase 4=Aftercare vs TAU; see Figure 4). We recorded the value of the vouchers delivered to each participant and calculated the average cost of the incentives per participant per month (i.e., 4-week period) of VBRT.

**2.3.1. Longest Duration of Cocaine Abstinence (LDA) Outcomes**—Analyses of group differences in cocaine abstinence during the intervention were based on LDA, which

was calculated using the thrice weekly or twice weekly urinalysis results collected during Phases 1 and 2 (weeks 1–24). Later phases were not examined as urine testing was not frequent enough in both groups to verify continuous abstinence. LDA was also calculated separately for Phase 1 and Phase 2 to determine if group differences were present in each treatment phase. ANCOVA was used to compare each of the three measures of LDA. The analyses included intake cocaine result as a covariate since it has been shown to be significantly related to abstinence outcomes (e.g., Stitzer et al., 2007).

**2.3.2. Biweekly Cocaine Abstinence Outcomes**—A generalized estimating equation (GEE; Diggle et al., 2002) analysis was used to examine differences between the two conditions on biweekly urinalysis results collected for the 48 weeks of the study. GEE analysis can accommodate a dichotomous dependent variable that is assessed longitudinally. The repeated dependent variable was the biweekly urinalysis result ( $n=24$ ), and the model included terms for study condition, phase (1–4), follow-up week (1–24), and a condition by phase interaction. Finally, the model included the intake cocaine urinalysis result as a covariate. The model used a compound symmetry working correlation structure and empirical standard errors.

**2.3.3. After-VBRT Cocaine Abstinence**—GEE models examined the extent to which condition and LDA predicted cocaine abstinence in a) the final 12 weeks of the study (Phase 4) and b) during Aftercare (Standard Phase 2; Extended Phase 4).

In the first model, LDA during Phases 1 and 2 predicted biweekly urine results for the final 12 weeks of the study (Phase 4) when neither group was receiving the escalating voucher schedule. The repeated dependent variable was the six biweekly urine results from weeks 37 through 48. The model included terms for LDA during Phases 1 and 2, condition, and biweekly urine number (1–6 from weeks 37 through 48). In the second model, the repeated dependent variable was the six biweekly urine results from the Aftercare phase, and the predictor variables were LDA during the last 12 weeks prior to Aftercare and biweekly urine number (1–6 from Aftercare). The models included the intake cocaine urinalysis result as a covariate and used a compound symmetry working correlation structure and empirical standard errors.

**2.3.4. Missing Data**—LDA analyses were conducted first by imputing missing urines as positive and again by interpolating the missing urines as negative (up to 3 consecutive samples) if preceded and followed by a negative sample. Both series of GEE analyses were conducted first by imputing missing urines as positive (i.e., cocaine-negative samples as a proportion of scheduled tests) and again by treating missing urines as missing data (i.e., proportion of actual samples collected). As the results did not differ in significance or direction for any of the analyses, only analyses treating missing urines as positive are presented.

## 3. Results

### 3.1. Participant Characteristics

There were no significant differences between VBRT groups on any demographic characteristic, baseline drug use, or ASI composite scores, except for the ASI medical composite score ( $t_{(128)}=2.35$ ,  $p=0.02$ ; see Table 1). Extended VBRT participants had greater severity of medical problems at baseline compared to Standard VBRT participants ( $M=.44$ ,  $SD=.37$  vs  $M=.29$ ,  $SD=.36$ ). As medical problems were not associated with cocaine use outcomes, this variable was not included as a covariate in analyses.

### 3.2 Attendance at VBRT Sessions

On average, participants provided 49.8% ( $SD=26.61$ ) of VBRT weekly urine samples. There were no significant differences in VBRT session attendance between the participants in the Standard condition ( $M=57.4\%$ ,  $SD=29.06$ ) and participants in the Extended condition ( $M=61.4\%$ ,  $SD=28.85$  in Phase 1 ( $t_{(1,128)}=.80$ ,  $p=.428$ ), or in Phase 2 (Standard  $M=42.8\%$ ,  $SD=31.62$ ; Extended  $M=50.0\%$ ,  $SD=36.89$ ;  $t_{(1,128)}=1.18$ ,  $p=.240$ ).

### 3.3. VBRT Duration and During-VBRT Abstinence

#### 3.3.1. Longest Duration of Continuous Cocaine Abstinence (LDA) Outcomes—

During Phase 1 and 2 (weeks 1–24), participants in Extended VBRT averaged 5.67 weeks ( $SD=8.08$ ) of continuous cocaine abstinence; slightly more than twice that of participants in Standard VBRT ( $M=2.68$  weeks,  $SD=3.61$ ;  $F_{(1,127)}=9.19$ ,  $p=0.003$ ,  $d=.48$ ); see Figure 3. As expected, there was no significant difference between groups during Phase 1 when both were receiving VBRT, but a difference emerged during Phase 2 when participants in the Extended condition were still receiving VBRT ( $M=3.34$  weeks,  $SD=4.70$ ) and those in Standard VBRT were receiving Aftercare ( $M=1.22$  weeks,  $SD=2.07$ ;  $F_{(1,127)}=13.34$ ,  $p<0.001$ ,  $d=.58$ ). The average LDA for Extended VBRT participants over the entire 36 weeks of VBRT was 8.31 weeks ( $SD=11.19$ ).

#### 3.3.2. Biweekly Cocaine Abstinence Outcomes—

Figure 4 shows the percent of participants that provided cocaine-negative samples across each biweekly assessment during the 48-week study. Results from GEE analyses indicated no significant differences by condition, follow-up week, or phase. There was a significant phase by condition interaction effect ( $\chi^2=12.28$ ,  $p=0.007$ ). In Phase 3, participants in the Extended group (which was still receiving VBRT) provided significantly more cocaine-negative samples than did participants in the Standard group, which was receiving only TAU ( $\chi^2=4.57$ ,  $p=0.03$ ,  $OR=2.18$ ; 95%  $CI=1.07–10.22$ ). There were no differences between conditions in any other phase.

### 3.4. VBRT Duration and After-VBRT Abstinence

The proportion of cocaine-negative samples for Extended VBRT participants during the 12-week Aftercare period was not significantly different from the proportion in Standard VBRT (Phase 4 vs Phase 2, respectively). Also, there were no between-group differences in the proportion of cocaine-negative samples during the last 12 study weeks (Phase 4 vs Phase 4, see Figure 4).

### 3.5 Relationship of During Treatment Abstinence to After-VBRT Abstinence

GEE analysis indicated that participants with longer durations of continuous abstinence during Phases 1 and 2 had an increased likelihood of providing cocaine-negative urine samples during Phase 4 ( $\chi^2=12.23$ ,  $p<0.001$ ,  $OR=1.12$ , 95%  $CI=1.06–1.19$ ) independent of VBRT duration assignment. For each additional week of continuous abstinence during the first two phases, the log odds of providing cocaine-negative samples during the last phase increased by 12%. No other variables (i.e., intake urine, phase, condition, biweekly urine number) were significant predictors of abstinence during Phase 4. Likewise, participants with longer durations of continuous abstinence in the 12-week period preceding Aftercare had an increased likelihood of providing cocaine-negative samples during Aftercare ( $\chi^2_{(1)}=14.8$ ,  $p=0.001$ ,  $OR=1.23$ , 95%  $CI=1.13–1.34$ ). For each additional week of abstinence in the preceding period, the log odds of providing a cocaine-negative sample in Aftercare increased by 23%. No other variables were significant predictors of abstinence in Aftercare.



### 3.6 VBRT Incentive Costs

Although the Standard and Extended groups allowed maximum possible earnings of \$978.75 over 12-weeks in the Standard group and \$4,098.75 over 36 weeks in the Extended group, the actual average cost of incentives was \$43/month for participants in the Standard group and \$96/month for the Extended group. Figure 5 shows the average monthly voucher costs for each participant as a function of the maximum duration of cocaine abstinence achieved. Of course, the cost of the incentive program was related to the abstinence participants achieved during treatment. For participants achieving less than one week of continuous abstinence the mean incentive cost was \$0.46/month. Average costs only exceeded \$6.50/month for participants who achieved more than four weeks of continuous abstinence. Participants in the Extended group with mean monthly voucher costs exceeding \$25 averaged 20 weeks of continuous abstinence.

## 4. Discussion

This research demonstrated that providing a longer duration of VBRT produced longer durations of continuous cocaine abstinence during treatment. This is a unique contribution to our knowledge of VBRT, as previous studies have not directly compared different durations of VBRT in a randomized, controlled clinical trial. The mean LDA during the first 24 weeks of treatment was more than doubled in the Extended group relative to the Standard group (5.67 vs 2.68 weeks) and during the entire 36-week exposure to VBRT, the Extended group averaged approximately two months (8.31 weeks) of continuous abstinence.

While there was no direct relationship between VBRT duration and Aftercare abstinence, VBRT did increase LDA while it was in effect and LDA achieved during VBRT predicted abstinence after VBRT ended. Anecdotally, examination of individual results revealed that the seven individuals who maintained continuous abstinence during Aftercare displayed at least 12 weeks of continuous cocaine abstinence immediately prior to entering Aftercare. Unfortunately, only half of the participants who demonstrated 12 weeks of abstinence at the end of VBRT (Standard=1 [2%], Extended=13 [19%]) remained abstinent during Aftercare, suggesting that a lottery ticket provided contingent upon abstinence during this phase was not sufficient to sustain abstinence in our sample. A longer Aftercare period that more gradually thinned reinforcement may have been more successful. One possible reason that our finding differs from that of Higgins and his colleagues (e.g., Higgins et al., 1994) is that they implemented VBRT in conjunction with the Community Reinforcement Approach, which may have provided a better context for sustaining abstinence during an Aftercare phase than did TAU in a community-based program.

Compared to our results, Silverman et al. (2004) found a greater proportion of participants achieving more than 12 weeks of sustained cocaine abstinence during VBRT and more sustained abstinence after VBRT ended (see Silverman et al., 2004, Figure 4). The fact that Silverman et al. also provided abstinent-contingent methadone take-homes, which have been shown to function as powerful reinforcers in their own right (Stitzer et al., 1992) may have contributed to these differences. This would be consistent with research showing that providing greater amounts of reinforcement during VBRT increases the number participants who are able to achieve abstinence (Dallery et al., 2001). Also, since methadone take-homes were also delivered contingently after VBRT ended, it is not surprising that Silverman et al.'s participants were more likely to sustain abstinence.

Unfortunately, it has been our experience that most community providers are reluctant to deliver take-homes contingent upon drug abstinence during treatment. Strict federal and state regulations specifying prerequisites for delivering methadone take-homes (e.g., stable housing, treatment duration, drug abstinence) probably have discouraged their contingent

use, especially early in treatment. This is unfortunate because the cost of VBRT is one of the most common objections to its use (Kirby et al., 2006, 2012) and take-homes are a low-cost reinforcer that could reduce its costs. In fact, several of our participants earned take-home privileges during the study; however, the clinic, like most others, granted take-homes based on multiple behavior requirements, monitored the relevant behaviors infrequently (e.g., drug testing occurred once monthly), and granted and removed take-homes with significant delays. All three of these factors have been shown to reduce reinforcement efficacy (Griffith et al., 2000), making it very unlikely that take-homes had any influence on abstinence, even when participants received them.

In this study as in others, actual VBRT costs were much less than the maximum possible earnings that are typically reported. The Standard and Extended groups averaged only 13% and 21% of the maximum possible earnings, respectively, and the average monthly cost of the Standard VBRT program was under \$50; an amount that most providers who have experience with CM report as affordable (59%) and worthwhile (72%; Kirby et al., 2012). Furthermore, although Extended VBRT had average incentive costs that were about twice that of Standard VBRT, incentive costs in both conditions were proportional to the treatment's success. Unlike many behavioral treatments where costs are constant regardless of treatment success, the incentive costs in VBRT are minimal when the treatment is not producing extended periods of continuous abstinence. We showed that incentive costs were less than 50¢ per month for individuals who were not responding to the treatment, that they only exceeded \$6.50/month when participants achieved more than one month of urinalysis-verified continuous abstinence, and that Extended VBRT participants who earned more than \$25 per month achieved an average of 20 weeks, or about 5 months of continuous cocaine abstinence. Payers may object less if they better appreciate the direct relationship between cost and outcomes. However, it will probably be necessary to demonstrate reliable and cost-effective methods for maintaining long-term abstinence after reducing or eventually removing VBRT before these costs are considered worthwhile. Development of sustaining contingencies through methadone take-home incentives or community reinforcement and family-based approaches are possible longer-term maintenance strategies that also could reduce the costs, making VBRT more acceptable to community programs.

#### 4.1. Limitations

One study limitation was that we did not collect weekly urines for both groups during the entire 48-week study and therefore had urinalysis-verified continuous abstinence outcomes for only the first 6 months. Restricting weekly urinalysis testing to 24 weeks in Standard VBRT may have limited our ability to detect the full effect of the Extended VBRT condition. About one third ( $n=22$ ; 32%) of the participants in Extended VBRT either remained abstinent past study week 24 or attained at least two months (8 weeks) of abstinence and 15% ( $n=10$ ) newly initiated a period of at least 4 weeks of abstinence after that time. While it is possible that a similar proportion of participants in Standard VBRT remained or attained abstinence after week 24, it seems unlikely since the biweekly percentage of cocaine-negative samples decreased gradually during this time (see Figure 4 weeks 25–36).

Another limitation is the absence of a treatment-as-usual (TAU) comparison group. We considered including such a group, but decided that the efficacy of VBRT was well-established and did not warrant the added expense. As such, it is not possible to determine whether the VBRT implemented during Phase 1 of the study produced increases in abstinence relative to TAU alone. However, the differences in biweekly urinalysis results seen in Phase 3 of the study when the Standard group was returned to TAU and the Extended group was still receiving VBRT provides some control indicating that VBRT did produce improvements in cocaine abstinence relative to TAU.

Finally, it is difficult to know whether our results would generalize to other methadone patients, drug-free or other treatment modalities, other schedules of VBRT, or other CM programs. Additional research examining VBRT duration and after-VBRT abstinence could establish generality.

#### 4.2. Implications and Future Research

The results of this study make it clear that simply making reinforcement available for an extended period is not sufficient to sustain abstinence during a minimal aftercare period or to produce long-term maintenance of abstinence after all reinforcement is withdrawn. If abstinence can be captured and sustained during treatment using VBRT, then providing longer periods of VBRT may help patients achieve longer durations of continuous abstinence that predict better long-term outcomes. The idea of on-going care for extended periods of time is consistent with a continuing recovery model. Additional research is needed to determine the optimal duration of VBRT, or if there are specific changes in patient behavior that indicate that VBRT can be stopped or reduced without increasing the risk of relapse. For many patients, more than continued monitoring and minimal aftercare may be needed to sustain long-term abstinence after treatment has ended. Both basic and clinical behavioral research has shown that behaviors that receive immediate reinforcement tend to be maintained, while those that are not reinforced or receive delayed reinforcement relative to other behavioral alternatives tend to decrease (e.g., Madden et al., 1999; Rachlin and Green, 1972; see Reynolds, 2006; MacKillop et al., 2011 for a review). Ultimately, it is likely that substantial, relatively immediate, and sustained naturally-occurring reinforcement for abstinence is necessary to counter the reinforcing effects of drug use if an individual is to maintain long-term abstinence (cf., Ayllon and Azrin, 1968; Higgins, 1996).

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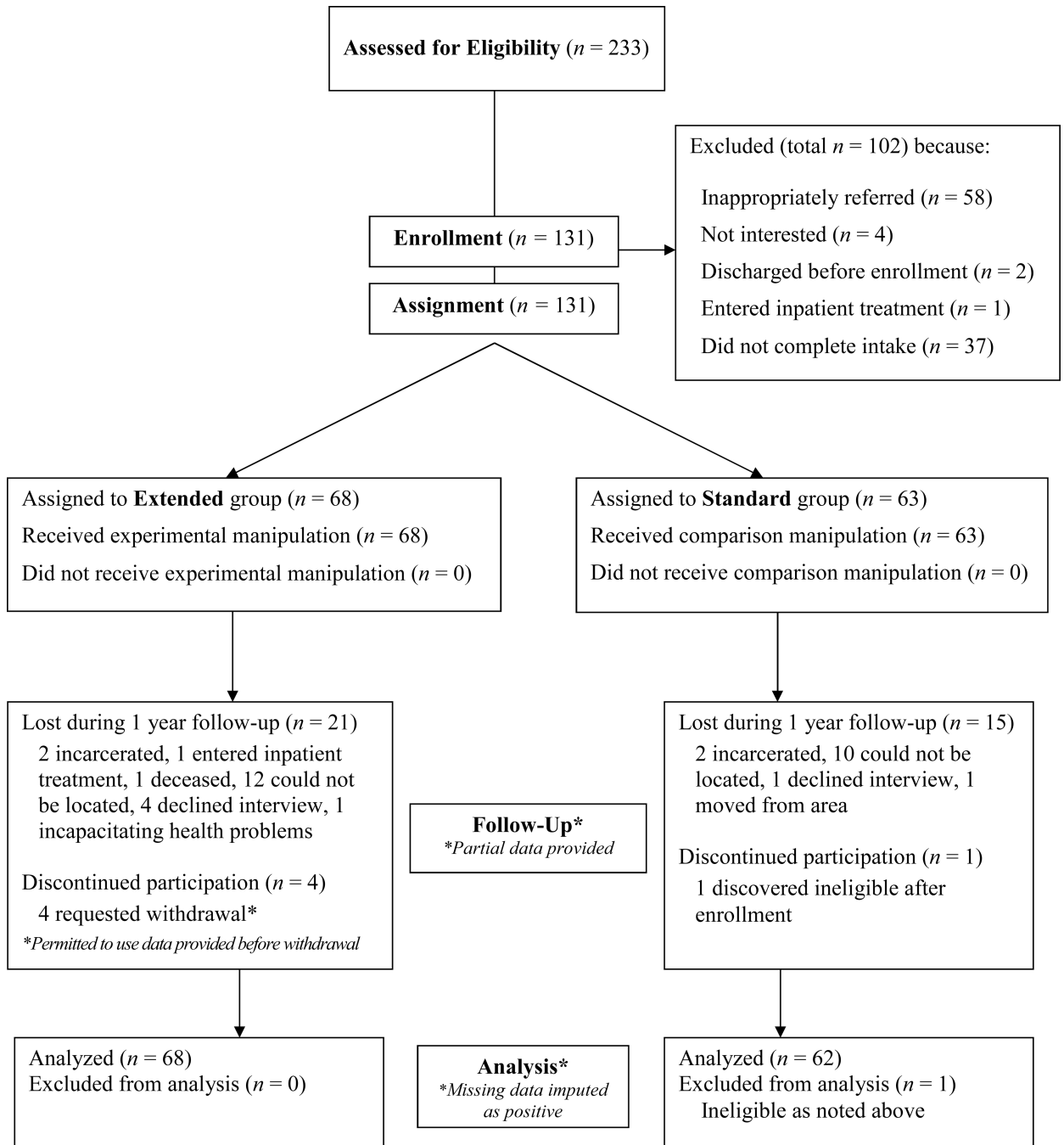
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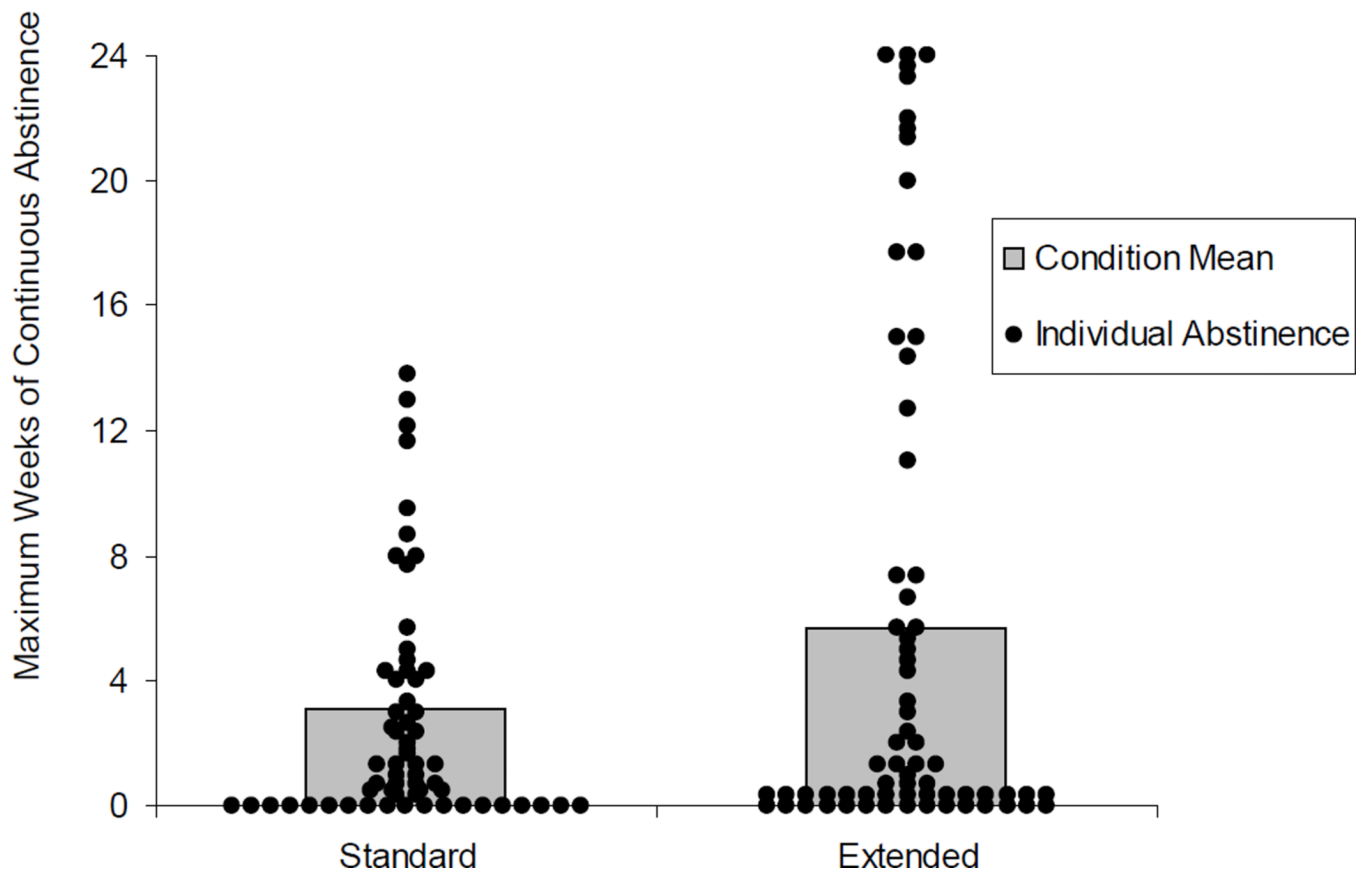


**Figure 1.**  
Participant Flow Diagram

		Weeks																																																Primary Analysis
		Phase 1												Phase 2												Phase 3												Phase 4												
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	
Treatment & Urinalysis/Wk	Standard	VBRT (3 urines/wk)												Aftercare (2 urines/wk)												TAU Only (no weekly urines)																								LDA
	Extended	VBRT (3 urines/wk)																																				Aftercare (2 urines/wk)												
Bi-Weekly Assessments	Both Groups	[Shaded bars indicating interventions and assessments]																																																GEE

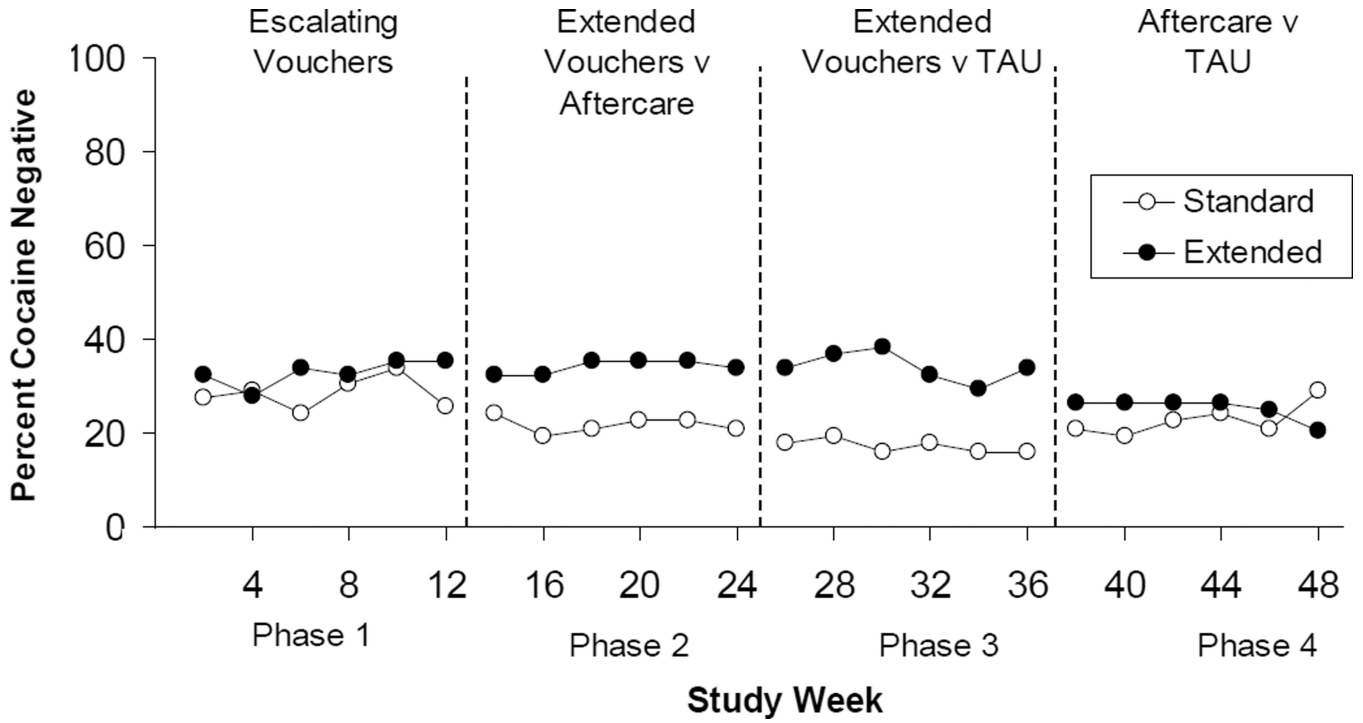
**Figure 2.**

Schematic of research procedures showing interventions and assessments implemented during each study week over all four study phases. Shaded bars indicate weeks when treatment (VBRT or Aftercare) and weekly urinalysis assessments were in effect. The final column indicates the type of analysis conducted with the data collected; LDA = Longest Duration of Abstinence, GEE = General Estimating Equation.

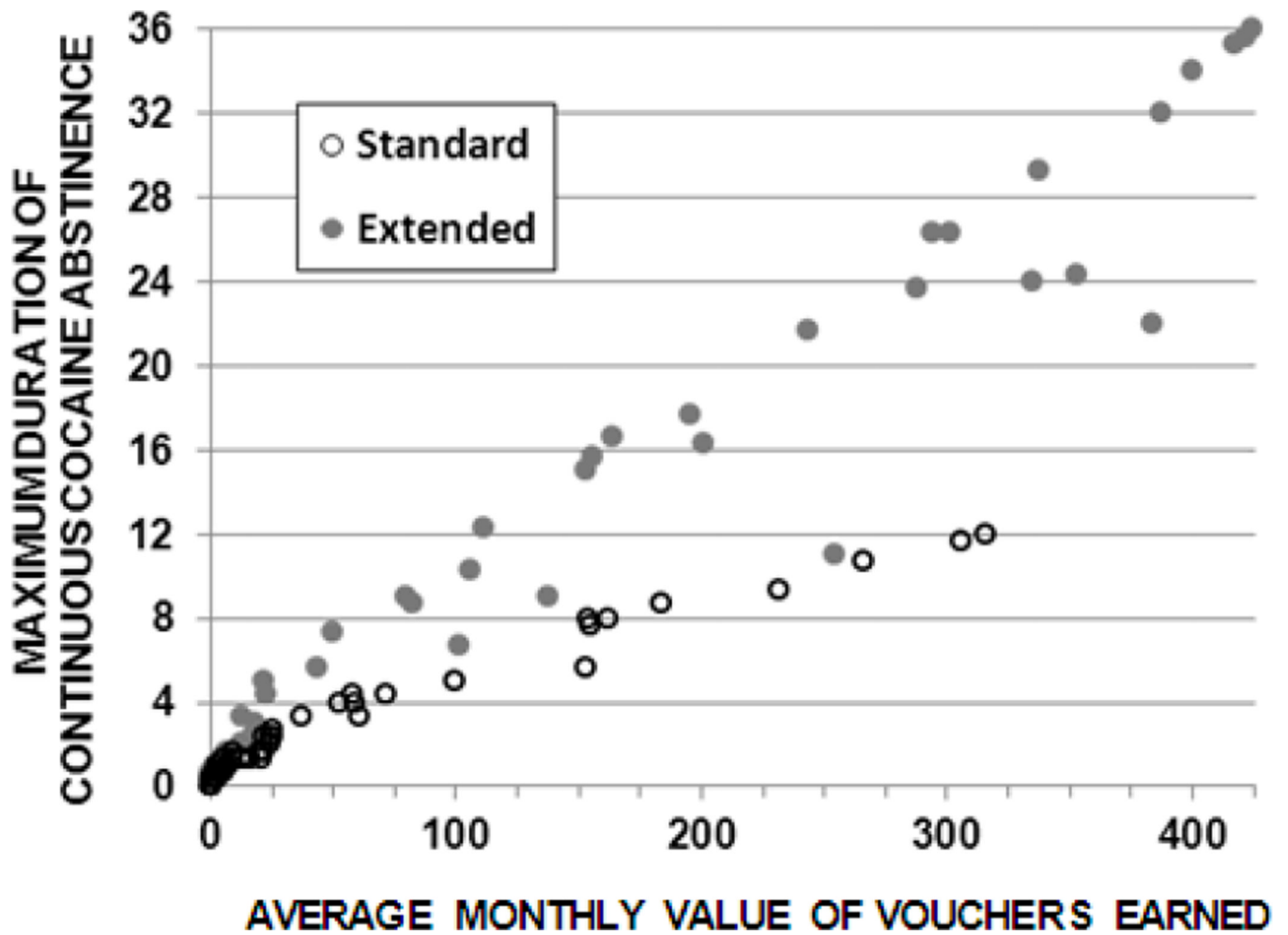


**Figure 3.** Condition and individual means for weeks of continuous cocaine-abstinence during study Phases 1 and 2 (months 1 through 6). Each data point represents an individual study participant's maximum weeks of continuous abstinence. The bars represent the condition mean across participants for maximum weeks of continuous abstinence.





**Figure 4.** Mean percent of cocaine negative urine samples provided at each biweekly assessment during the 48-week study by condition and phase. Missing urine samples are treated as positive for cocaine. TAU signifies the Treatment as Usual phase (Methadone treatment only). Between group differences were significant in Phase 3.



**Figure 5.** Scatter plot showing incentive cost as a function of longest duration of abstinence attained during treatment. Each data point represents the results for one participant.

**Table 1**

## Participant Characteristics.

	Standard (n=62)	Extended (n=68)	p-value
Mean Age (SD)	41 (11)	44 (10)	0.13
Male (%)	61.3	67.7	0.45
Years of Education Completed (SD)	12 (2)	11.85 (2)	0.61
Married (%)	19.5	10.3	0.14
Hispanic Ethnicity (%)	1.6	5.9	0.19
Race (%)			0.26
White	33.9	32.4	
Black	64.5	60.3	
Other	1.6	7.4	
Employment Status			
Employed Past 30 Days (%)			0.98
Full-time (>20 days)	11.5	10.5	
Part-time (1–20 days)	18.0	17.9	
Usually Employed, Past 3 Years (%)			
Full-time	18.7	16.2	0.85
Part-time	16.1	14.7	
Mean Methadone Dose (SD)	102 (41)	113 (51)	0.17
Days of Use, Past 30 Days (SD)			
Cocaine	18 (10)	17 (9)	0.49
Alcohol	2 (5)	4 (9)	0.09
Heroin	2.5 (6)	3 (6.5)	0.65
Other Opiates	1 (4)	1 (3)	0.56
Years of Use, Lifetime (SD)			
Cocaine	10 (8)	10.5 (8)	0.72
Alcohol	6 (9)	9 (12)	0.15
Heroin	11.5 (9.5)	14 (11)	0.19
Other Opiates	1.5 (4)	2 (3)	0.90
Route of Cocaine Administration (%)			0.42
Nasal	21.0	16.2	
Smoking	62.9	58.8	
Injection	16.1	25.0	
ASI composite scores (SD)			
medical	0.29 (0.36)	0.44 (0.37)	<b>0.02</b>
employment	0.82 (0.21)	0.82 (0.24)	0.94
alcohol	0.03 (0.09)	0.07 (0.14)	0.12
drug	0.37 (0.11)	0.37 (0.08)	0.72
egal	0.18 (0.24)	0.15 (0.22)	0.35
family	0.14 (0.20)	0.2 (0.25)	0.15
psychological	0.25 (0.23)	0.25 (0.24)	0.88