Journal of Consulting and Clinical Psychology
2004, Vol. 72, No. 5, 839–854

0022-006X/04/$12.00 DOI: 10.1037/0022-006X.72.5.839

A Randomized Trial of Long-Term Reinforcement of Cocaine Abstinence in Methadone-Maintained Patients Who Inject Drugs

Kenneth Silverman, Elias Robles, Timothy Mudric, George E. Bigelow, and Maxine L. Stitzer
Johns Hopkins University School of Medicine

This study determined whether long-term abstinence reinforcement could maintain cocaine abstinence throughout a yearlong period. Patients who injected drugs and used cocaine during methadone treatment ($n = 78$) were randomly assigned to 1 of 2 abstinence-reinforcement groups or to a usual care control group. Participants in the 2 abstinence-reinforcement groups could earn take-home methadone doses for providing opiate- and cocaine-free urine samples; participants in 1 of those groups also could earn $5,800 in vouchers for providing cocaine-free urine samples over 52 weeks. Both abstinence-reinforcement interventions increased cocaine abstinence, but the addition of the voucher intervention resulted in the largest and most sustained abstinence. Therefore, voucher-based reinforcement of cocaine abstinence in methadone patients can be a highly effective maintenance intervention.

Methadone maintenance is an effective treatment for opiate dependence (Johnson et al., 2000; McLellan, Arndt, Metzger, Woody, & O'Brien, 1993; National Consensus Development Panel on Effective Medical Treatment of Opiate Addiction, 1998; Sees et al., 2000; Strain, Bigelow, Liebson, & Stitzer, 1999; Strain, Stitzer, Liebson, & Bigelow, 1993). However, persistent cocaine use has been a serious problem in methadone patients. Although rates of cocaine use in methadone programs vary widely, the large-scale national Drug Abuse Treatment Outcome Study of treatment programs around the United States found that about 40% of methadone maintenance patients met criteria for cocaine dependence (Hser, Anglin, & Fletcher, 1998). Furthermore, on the basis of treatment outcome data from that study, the authors concluded that standard methadone treatment appears "relatively ineffective in reducing cocaine use" (Hser et al., 1998, p. 513). No pharmacotherapies and few psychosocial treatments have been shown effective in reducing cocaine use (Rawson, McCann, Hasson, & Ling, 1994; Silverman, Bigelow, & Stitzer, 1998).

Injection cocaine use by methadone patients has been particularly troubling because of its association with HIV infection (Centers for Disease Control and Prevention, 2000; Chaisson et al., 1989; Schoenbaum et al., 1989). Methadone patients who continue to inject cocaine despite the best efforts of the treatment programs pose risks of spreading or contracting HIV infection. In addition to the personal suffering associated with HIV infection and AIDS, the costs to society of HIV infection are considerable. Lifetime costs of HIV-related illnesses have been estimated at over $150,000 per person (Holtgrave & Pinkerton, 1997). Treatments that are effective in promoting cocaine abstinence in methadone patients who inject drugs should reduce transmissions of HIV infection and thereby reduce the costs associated with HIV infection.

Voucher-based abstinence reinforcement, originally developed for the treatment of primary cocaine-dependent patients (Higgins et al., 1991, 1994; Higgins, Wong, Badger, Ogden, & Dantona, 2000), has been highly effective in promoting abstinence from cocaine (Rawson et al., 2002; Silverman, Chutuape, Bigelow, & Stitzer, 1999; Silverman, Higgins, et al., 1996; Silverman, Wong, et al., 1998) and from opiates (Silverman, Wong, et al., 1996) in methadone patients who inject drugs. However, as with most other drug-abuse treatments (Hser, Hoffman, Grella, & Anglin, 2001; McLellan, Lewis, O'Brien, & Kleber, 2000; Vaillant, 1973), many methadone patients relapse to drug use soon after the abstinence-reinforcement contingencies are discontinued. In two studies of methadone patients who consistently provided cocaine-positive urine samples during the initial 5 weeks of methadone treatment (Silverman, Higgins, et al., 1996; Silverman, Wong, et al., 1998), voucher reinforcement of cocaine abstinence increased the percentage of patients who provided cocaine-negative urine samples from about 15% or fewer during baseline to about 45%–60% of patients during the 12-week voucher intervention; when the voucher intervention was discontinued, the percentage of patients who provided cocaine-negative urine samples decreased to 29% or less. One study in treatment-resistant methadone patients showed both the robust short-term effectiveness of voucher-based reinforcement of cocaine abstinence and the high rates of relapse that occur when the voucher intervention is discontinued (Silverman et al., 1999). That study included 22 methadone patients who continued to use cocaine even when exposed to a 12-week voucher intervention in which they could earn up to $1,155 in vouchers for providing cocaine-free urine samples. All of those patients were exposed in counterbalanced order to three 9-week voucher inter-

Kenneth Silverman, Elias Robles, Timothy Mudric, George E. Bigelow, and Maxine L. Stitzer, Department of Psychiatry and Behavioral Sciences, Johns Hopkins University School of Medicine.

Elias Robles is now at the Department of Pharmacology, University of Arkansas for Medical Sciences.

This research was supported by National Institute on Drug Abuse, National Institutes of Health Grants P50 DA09258, K05 DA00050, T32 DA07209, and DA R01 DA13107.

We thank Liam Harmon for administering the voucher program and coordinating the overall study. We also thank the pharmacy, physician, nursing, and counseling staff of the methadone clinic at the Behavioral Pharmacology Research Unit for providing excellent participant care and assistance in implementing this protocol.

Correspondence concerning this article should be addressed to Kenneth Silverman, Center for Learning and Health, Johns Hopkins University School of Medicine, 5200 Eastern Avenue, Suite 142 West, Baltimore, MD 21224. E-mail: ksilverm@jhmi.edu

ventions that varied in magnitude of voucher reinforcement for cocaine abstinence. All patients were exposed to a zero-, low-, and high-magnitude condition in which they could earn up to $0, $382, or $3,480 in vouchers for providing cocaine-free urine samples. The 9-week voucher intervention periods were separated by 4-week washout periods. In the high-magnitude condition, 45% of patients (10 of 22 patients) achieved 4 or more weeks of sustained abstinence. In contrast, only 4.5% (1 of 22 patients) achieved 4 or more weeks of sustained abstinence in the low-magnitude condition, and no patients achieved more than 2 weeks of abstinence in the zero-magnitude condition. Relapse was abrupt and dramatic in this study: All of the patients who achieved sustained cocaine abstinence during the high-magnitude condition returned to using cocaine by the end of the 4-week washout period that followed the high-magnitude condition. The within-subjects, crossover design used in this study was possible only because patients relapsed to cocaine use soon after an effective voucher-based, abstinence-reinforcement intervention was discontinued.

In the current randomized clinical trial, we examined the effects of arranging long-term exposure to voucher-based reinforcement of cocaine abstinence as a means of maintaining cocaine abstinence and preventing relapse. Whereas prior studies have examined relatively short-term exposure to voucher-based, abstinence-reinforcement contingencies, which have ranged from several weeks to a few months, in the current study we examine the effects of a yearlong exposure.

This intervention was examined in the context of a sound methadone maintenance treatment program in which participants could receive high doses of methadone and could earn take-home methadone doses contingent on opiate- and cocaine-free urine samples. The voucher intervention was evaluated in this context because both high-dose methadone (Strain et al., 1993, 1999) and contingent take-home methadone doses (Stitzer, Iguchi, & Felch, 1992) can be effective in promoting abstinence and can be provided at relatively little expense as a part of routine clinical care.

Finally, a usual care control condition was included in which participants received high-dose methadone but no abstinence reinforcement. Inclusion of this usual care control condition allowed for the examination of the effects of long-term exposure to the take-home methadone dose abstinence-reinforcement contingency with and without a voucher-reinforcement procedure. The most cocaine abstinence and the longest periods of sustained cocaine abstinence were expected during the long-term voucher intervention. The take-home abstinence-reinforcement intervention alone was expected to produce intermediate levels of abstinence.

Method

Participants

Study participants ($N = 78$) were selected from newly admitted patients to a methadone treatment program in Baltimore, Maryland, who enrolled between June 1996 and January 1998. The methadone program accepted applicants who (a) were 18–50 years old, (b) provided an opioid-positive urine sample at intake, (c) reported regular opioid use (70% of days) in the 30 days before intake and for half of the year preceding intake, (d) had prior methadone treatment at least 1 year before intake, (e) had not been in a study that evaluated voucher reinforcement, and (f) showed objective evidence of injection drug use (e.g., needle tracks and fresh injection sites). Applicants were excluded if they were pregnant, had a medical condition for which methadone treatment was contraindicated, or had a serious psychiatric illness (e.g., schizophrenia).

Overview of Study Phases

All volunteers who enrolled in the study could participate in four sequential phases: a 10-week baseline period, a 52-week intervention period, a 9-week postintervention period, and a 90-day poststudy disposition period. Participants first received a 10-week baseline period during which they were inducted on methadone and screened for study eligibility. After the 10-week baseline, eligible participants were given 52 weeks of methadone maintenance treatment during which they were randomly assigned and exposed to one of three different study interventions. Following the 52-week intervention period, participants were given an additional 9 weeks of methadone maintenance treatment during which the postintervention effects of the study procedures were evaluated. The final phase was a 90-day poststudy disposition period during which participants were either transferred to another methadone maintenance program or their methadone dose was gradually reduced to 0 mg.

Baseline Methadone Treatment and Participant Screening

The daily methadone dose was 20 mg at the start of treatment and increased to 60 mg per day in the 1st week of the baseline period. Patients transferring from other methadone programs began treatment at the same methadone dose at which they ended treatment in their prior program or at 20 mg, whichever was higher. If a patient provided an opiate-positive urine sample during Weeks 3, 4 or 5, the patient's daily methadone dose was increased to 100 mg. Throughout treatment, patients received weekly individual and group counseling and Monday, Wednesday, and Friday urine collections. At Week 8, all patients participated in a brief abstinence-reinforcement test (Robles et al., 2000).

During the initial 10 weeks, patients were offered participation in other ongoing research studies in the clinic. At Week 10, a total of 119 patients had not been enrolled in another study and were still in methadone treatment. Those patients were considered eligible for the present study if they provided cocaine-positive urine samples on 2 of the last 6 and 3 of the last 12 testing occasions during the final 4 weeks of the 10-week baseline period. Of the 119 patients, 80 met this requirement. A total of 78 patients enrolled in the study and 2 refused. The Johns Hopkins Bayview Medical Center institutional review board approved the protocol, and all participants signed informed consent. Figure 1 summarizes the pattern of participant recruitment, assignment, and attrition in the study.

Randomization and Sample Size

At the end of Week 10 of the baseline period, participants were stratified and randomly assigned to a usual care control, a take-home only, or a take-home plus voucher condition. For stratification, each participant was given a binary score (0 or 1) for each of the five stratification variables (100% of baseline urine samples positive for cocaine, yes–no; 100% of baseline urine samples positive for opiates, yes–no; meets *Diagnostic and Statistical Manual of Mental Disorders* [4th ed.; American Psychiatric Association, 1994] criteria for antisocial personality disorder, yes–no; employed full time for most of 3 years preceding intake, yes–no; race, White–non-White). By combining the five binary scores, we assigned each participant a five-digit binary code. Participants with the same binary code were randomly assigned to one of the three study groups unless there was an imbalance in the number of participants with that five-digit code across the groups. If a group had more participants with that five-digit code than the other two groups, the next participant with that code was randomly assigned to one of the two groups with fewer participants. If two groups had more participants with a particular five-digit code than the third group, then the next participant with that code was assigned into the third group. When 26 participants were assigned to a given group, no more participants were assigned to that group. The stratification procedure was implemented manually. A computerized, random-number generator accomplished random assignment. The same staff person identified potential participants as

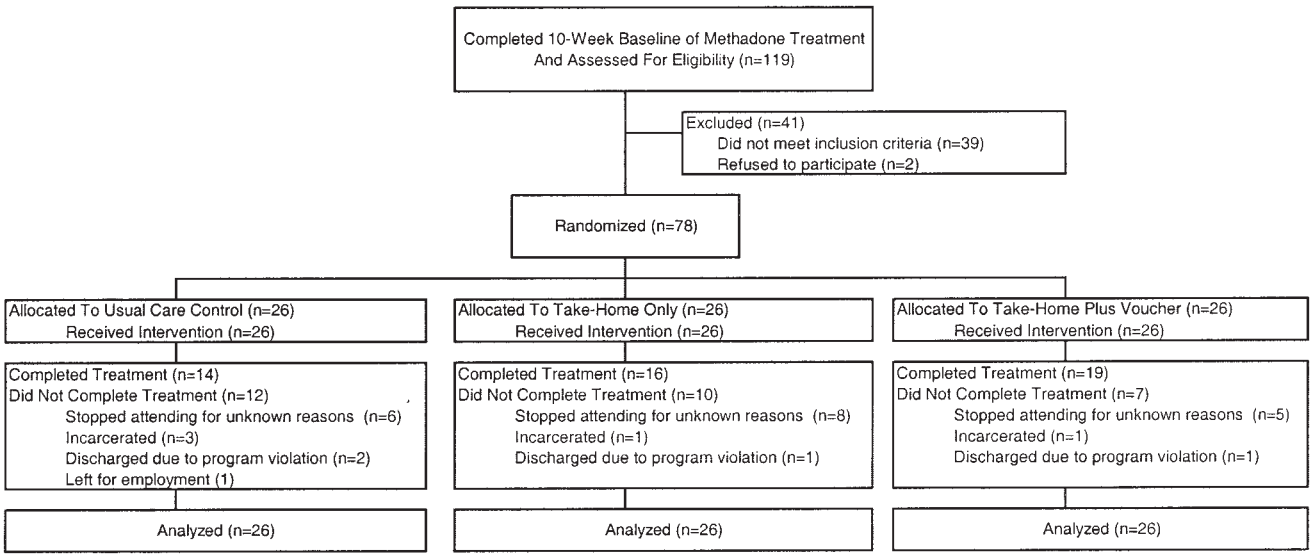

Figure 1. History of recruitment, assignment, and attrition of participants in the study.

eligible, stratified and randomly assigned them, and introduced them to their study conditions.

Treatment Conditions

On the last day of Week 10, participants were introduced to their treatment conditions. Participants were read and given written instructions that explained the details of their conditions. Participants in the take-home only and take-home plus voucher groups were given written quizzes on the details of the take-home and voucher procedures when first introduced to their conditions and during the 1st (3 quizzes), 2nd (1 quiz), 12th (1 quiz), and 24th (1 quiz) weeks of treatment. Quizzes were graded, and errors were reviewed with each participant. All participants were exposed to their respective treatment conditions for 52 weeks.

Usual care control condition. Participants assigned to the usual care control condition continued to receive the standard services they had been receiving during the baseline period, including daily methadone at the dose established during the baseline treatment and weekly individual and group counseling.

Take-home, methadone-reinforcement contingency. After the 10-week baseline period, in addition to the standard services, participants in the take-home only and take-home plus voucher groups could earn up to three take-home methadone doses per week for providing urine samples on Monday, Wednesday, and Friday that were negative for cocaine and opiates. When a participant provided three consecutive urine samples that were negative for cocaine and opiates, the participant received a take-home methadone dose for the following day. Thereafter, the participant received a take-home methadone dose for every consecutive urine sample that was negative for cocaine and opiates (maximum of three take-home doses per week on Tuesday, Thursday, and Saturday or Sunday). If a participant ever provided an opiate- or cocaine-positive urine sample or failed to provide a scheduled urine sample, the participant did not receive a take-home dose and had to provide three consecutive urine samples that were negative for cocaine and opiates to resume earning take-home doses.

To discourage diversion of take-home methadone, we instructed participants to call the clinic before drinking their take-home methadone doses each day. When they called, a prerecorded message read a list of participant identification numbers. If a participant's identification number was read, he or she was required to bring his or her unopened, shrink-wrapped, take-home bottle to the clinic that day and drink the methadone in front of the dispensing nurse. If a participant failed to bring back a recalled take-home dose or brought back a tampered bottle, the participant lost the opportunity to earn take-home doses for 2 weeks. Take-home dose recalls occurred at random times at an average of once every 2 months. Participants in the take-home only and take-home plus voucher groups successfully returned 62% and 81% of recalled take-home doses, respectively.

Voucher-reinforcement contingency. On Monday, Wednesday, and Friday of each week for 52 weeks, participants in the take-home plus voucher group could earn a monetary voucher for each cocaine-free urine sample that they provided. Vouchers were administered according to a schedule of escalating reinforcement for sustained abstinence (Higgins et al., 1991) in which the monetary value of the vouchers began at $2.50 and then increased by $1.50 to a maximum of $40.00 for every consecutive cocaine-free urine sample provided thereafter. If the participant provided a cocaine-positive urine sample or failed to provide a scheduled sample, the participant did not receive a voucher, and the value of the next earned voucher was reset to $2.50. Vouchers then increased in value for each consecutive cocaine-free urine sample. If the participant provided nine consecutive cocaine-free urine samples, the value of the voucher for the ninth urine sample increased to the highest value that the participant had previously achieved. Participants received a $10.00 bonus voucher for every three consecutive cocaine-free urine samples provided until the value of the vouchers under the escalating reinforcement schedule reached the maximum of $40.00.

Vouchers showed the amount of dollars earned. The paper itself was not negotiable but represented the amount added to the participant's account. When a participant wanted to make a purchase, the participant submitted a purchase order. If there were sufficient voucher dollars in the participant's account, the staff went into the community to make the requested purchase and deducted the amount of the purchase from the participant's voucher account. Purchases were made only if the item requested was for the participant or for a person in the participant's immediate family and if a verifiable receipt could be obtained; earnings could not be used to purchase weapons, cigarettes or alcohol, or to pay for recently obtained tickets or legal fines. Store gift certificates were allowed from stores that did not provide cash back. Purchase orders submitted by 5:00 p.m. on Monday or Wednesday would be filled by Wednesday or Friday, respectively, at 11:00 a.m.. During the study, 1,368 purchases were made with an average delay from the time the purchase order was submitted to when the participant received the requested purchase of 1.07 days, with a minimum of 0.00 days (same day) and a maximum of 8.00 days. Only 1.7% of the purchase orders took more than 4 days to fill.

Postintervention Evaluation Period

After 52 weeks of exposure to the voucher intervention (the postintervention evaluation period), the voucher intervention was discontinued, but other aspects of the treatment conditions were maintained for 9 weeks. During this period, no changes were made in participants' methadone doses, and participants in the take-home only and take-home plus voucher groups could continue to earn take-home methadone doses as they did before the voucher intervention was discontinued.

Poststudy Disposition Period

After the 9-week postintervention period, there was a 90-day poststudy disposition period during which participants were assisted in arranging longer term care in a nonresearch setting or during which they could elect to have their doses gradually reduced to zero.

Hospitalization and Incarceration

If a participant was hospitalized or incarcerated during treatment for up to 30 days, his or her protocol was interrupted during the period of hospitalization or incarceration and resumed when the participant returned to the clinic. Participants were hospitalized on 22 separate occasions and incarcerated on five separate occasions during the study.

Hospitalizations, which represented potential adverse events, occurred in 5 participants in the usual care control group, 3 participants in the take-home only group, and 6 participants in the take-home plus voucher group, on a total of 7, 3 and 12 occasions, respectively. Of the 22 hospitalizations, 2 were related to substance abuse treatment, 1 was psychiatric in nature (i.e., depression), and 19 were related to other medical conditions (e.g., gastritis, pneumonia, endocarditis). None appeared to be study related.

Urine Collection, Questionnaires, and Interviews

Routine urine collection and testing. Urine samples were collected Monday, Wednesday, and Friday of each week of the study. Specimen collections were directly observed and temperature tested to ensure that sample temperatures were near body temperatures. Samples were tested (enzyme multiplication immunoassay technique; Dade Behring Diagnostics Inc., St. Jose, California) for cocaine (benzoylecgonine) and opiates (morphine). Samples were positive for cocaine and opiates if concentrations were at or above 300 ng/ml.

Weekly assessments. One day per week throughout the baseline, treatment evaluation, and postintervention period, and then again 26 and 52 weeks after the scheduled end of the intervention evaluation period, each participant completed six self-report computerized questionnaires: (a) the Intravenous Drug Use Questionnaire (Silverman et al., 1999), (b) the Nonintravenous Drug Use Questionnaire (Silverman et al., 1999), (c) the Lifestyle Changes Questionnaire (Silverman et al., 1999), (d) the Visual Analog Questionnaire, which asked questions about their methadone dose and about cocaine and heroin craving (Silverman et al., 1999), (e) the Beck Depression Inventory (Beck & Steer, 1987), and (f) a brief questionnaire that assessed each participant's interest in initiating or sustaining cocaine abstinence. In addition, two questionnaires, the Drug Availability Questionnaire and the Staff Appearance Ratings Form, were administered that had not been used previously. The Drug Availability Questionnaire included the following 6 questions: (a) Can you get cocaine or heroin from someone living in your home? (b) How many blocks do you have to travel from your home to get cocaine or heroin? (c) How many times have you seen someone in your neighborhood selling drugs or preparing to sell drugs in the past seven days? (d) How many times did someone offer to sell you cocaine or heroin in the past seven days? (e) How many times did someone offer to give you cocaine or heroin for free in the past seven days? (f) How many times did someone offer to give you cocaine or heroin for doing something for them in the past seven days? The Staff Appearance Ratings Form was completed weekly by the staff person who administered weekly questionnaires. The staff member was asked to rate each participant along an appropriately anchored 100-mm line on the following dimensions: "Odor?" (anchored from *extremely offensive* on the left to *extremely pleasant* on the right), "Healthy Appearance?" (anchored from *extremely unhealthy* to *extremely healthy*), "Clothing?" (anchored from *extremely sloppy* to *extremely neat*), "Personal Grooming?" (anchored from *extremely unkempt* to *extremely well groomed*) and "Overall Appearance?" (anchored from *extremely poor* to *extremely good*).

Major assessments. A major battery of assessments was administered at six time points: intake to methadone treatment, Week 8 of the baseline methadone treatment period, Weeks 26 and 52 of the treatment evaluation period, and Weeks 26 and 52 after the scheduled end-of-treatment evaluation period, a time when methadone treatment had ended for some participants. The final follow-up assessments were completed for all participants between August 1998 and April 2000. The battery included urine collection, the Addiction Severity Index (McLellan et al., 1985), the Pleasant Events Scale (MacPhillamy & Lewinsohn, 1982), the Situational Confidence Questionnaire (Annis & Graham, 1988), an HIV risk assessment (King, Kidorf, Stoller, & Brooner, 2000), and a structured videotaped interview. During the 3rd week of the baseline period, the Structured Clinical Interview for *DSM–III–R* (Spitzer, Williams, Gibbon, & First, 1992) was conducted with each participant.

Outcome Measures

The primary and secondary outcome measures were based on the urine samples collected three times per week throughout treatment. Primary measures were based on measures used in prior studies of voucher reinforcement (Silverman et al., 1999) and included the percentage of urine samples negative for cocaine, for opiates, and for cocaine and opiates. The primary measures also included the longest duration of abstinence from cocaine, from opiates, and from cocaine and opiates, during the 52-week intervention period. Secondary measures, which were determined after collection and visual inspection of the urinalysis data, included the percentage of participants abstinent from cocaine, from opiates, and from cocaine and opiates on 100%, greater than or equal to 75%, and greater than or equal to 50% of the scheduled sample collections in the baseline period and each of the 13-week blocks of the intervention period. For all of these measures, analyses were conducted for the intent-to-treat sample ($n = 26$ participants per group) and separately for completers ($n = 14$ participants in the usual care control group, $n = 16$ participants in the take-home only group, $n = 19$ participants in the take-home plus voucher group). For the completers' analyses, data from the 9-week postintervention period were also included.

Statistical Analyses

Participant characteristics. Participant characteristics of the three groups as well as treatment process measures (i.e., average methadone dose, minutes of counseling) were compared with chi-square tests (for dichotomous variables) and analyses of variance (ANOVAs; for continuous measures).

Retention. Participant retention was calculated on the basis of the number of days in treatment after random assignment to the last urine collection day of the intervention evaluation period. Wilcoxon–Gehan tests were used to compare retention rates for the three groups.

Urinalysis results. The primary analyses were based on an intent-to-treat sample of all participants that was randomly assigned to an experimental condition ($n = 26$ per group). In the primary analyses, missing urine samples were considered drug positive ("missing positive analysis"). The number and pattern of all missing urine samples for each participant in the study are shown in Figures 3 and 4. Overall, 24.7%, 21.8%, and 18.4% of the urine samples were missing for the usual care control, take-home only, and take-home plus voucher groups, respectively. For each participant, the percentage of urine samples negative for each drug during the 10-week baseline period and during each of the four consecutive 13-week

blocks of the intervention period was calculated. These data were analyzed with a repeated measures ANOVA with group (usual care control, take-home only, and take-home plus voucher groups) and time (baseline, consecutive 13-week blocks of the intervention period) as factors. Tukey's honestly significant different post hoc tests were used to compare the mean for each group with the mean of each of the other groups at each of the five time points (i.e., the 10-week baseline and each of the four 13-week blocks of the intervention period). The longest durations of abstinence from each drug during the 52-week intervention period were determined for participants in each of the three groups. These data were analyzed with an ANOVA and with Tukey's honestly significant different post hoc tests to compare the mean longest durations of abstinence for each group with means for each of the other two groups.

Because the primary missing-positive analysis may overestimate drug use, a secondary analysis was conducted that used a different method of estimating missing data. In this analysis, the percentage of urine samples negative for each drug during the 10-week baseline period and during each of the four consecutive 13-week blocks of the intervention period was calculated for each participant without replacing values for the missing samples. Those values then were analyzed with multilevel analyses, with group and time as factors, with SAS Proc Mixed software (SAS Institute, Cary, North Carolina; Latour, Latour, & Wolfinger, 1994). Tukey–Kramer post hoc tests were used to compare the mean for each group with the mean for each of the other groups at each of the five time points. The results of the secondary multilevel analyses were generally consistent with the primary analyses, so those results are not presented.

Additional secondary analyses were conducted on the basis of review of individual urinalysis results (see Figures 3 and 4) to examine the percentage of participants that were completely abstinent from each drug (cocaine and opiates) and from both drugs during the baseline period and during each of the consecutive 13-week blocks of the intervention period. For this analysis, each participant was categorized as completely abstinent during a given period if all scheduled urine samples for that period were negative; missing samples were considered positive. A Cochran–Mantel–Haenszel test (Cochran, 1954; Mantel & Haenszel, 1959) was conducted to examine the effects of group on the percentage of participants that were completely abstinent. Chi-square tests were then conducted to determine whether there was a group effect at each time point. Finally, for each time point, chi-square pairwise comparisons were conducted to compare each group with every other group. Similar analyses were conducted for the percentage of participants that were abstinent on greater than or equal to 75% and greater than or equal to 50% of all the scheduled samples collected.

The same analyses were conducted for the completers except that data from the 9-week postintervention period were also included in the analyses. For the completers, pairwise comparisons were conducted to compare each group with every other group during the postintervention period, as well as during the baseline period and the four 13-week blocks of the intervention period.

Weekly and major assessments. Data from selected weekly and major assessments were analyzed with multilevel analyses, with group and time as factors, with SAS Proc Mixed software. Tukey–Kramer post hoc tests were used to compare the mean for each group with the mean of each of the other groups at each of the five time points. The same analyses were conducted for the intent-to-treat sample and for the completers.

For weekly assessments, the following selected measures were analyzed: (a) all items on the Intravenous Drug Use Questionnaire (Silverman et al., 1999), (b) cocaine-related items on the Nonintravenous Drug Use Questionnaire (sniff and smoke cocaine; Silverman et al., 1999), (c) all items on the Lifestyle Changes Questionnaire (Silverman et al., 1999), (d) questions regarding medication holding and craving for heroin and cocaine on the Visual Analog Questionnaire (Silverman et al., 1999), (e) Questions 2–6 on the Drug Availability Questionnaire, and (f) two measures (overall appearance, average of all appearance ratings) from the Staff Appearance Ratings Form. From major assessments, the following selected measures were analyzed: (a) past 30 days legal and illegal income (Addiction Severity Index [ASI]), (b) self-reported number of days in the past 30 in which the participant used heroin, cocaine, alcohol, sedatives, or cannabis (ASI), and (c) all ASI composite scores.

All tests were two-tailed and considered significant at $p \leq .05$. Effect sizes (Cohen, 1988) were calculated with Cohen's f (for the ANOVA and multilevel modeling analyses) and Cohen's w (for the chi-square tests). Statistical methods and significance criteria used to compare groups on primary outcomes are conservative and results should be considered reliable. In contrast, results from secondary outcomes should be considered more tentative and exploratory, with replication required in subsequent research.

Results

Participant Characteristics

Table 1 shows characteristics of study participants assessed at intake to methadone treatment. There are no significant differences between groups on these measures.

Treatment Exposure

There are no significant differences between the usual care control, take-home only, and take-home plus voucher groups in the mean methadone maintenance dose (94 mg, 98 mg, 98 mg, respectively), in the mean number of hours of counseling received during study participation (23.9 hr, 23.4 hr, 29.5 hr, respectively), or in treatment retention (54%, 62%, and 73% of participants, respectively, were retained in treatment until the end of the 52-week intervention period). The mean ($\pm$ standard error of the mean) number of take-home methadone doses earned by participants in the take-home plus voucher group (75.8 ± 11.0) is significantly greater than participants in the take-home only group (37.1 ± 8.2), $t(50) = 2.82$, $p = .007$. Participants in the take-home plus voucher group earned an average of $2,774 in vouchers.

Urinalysis Results

Intent-to-treat sample. The percentage of urine samples that were negative for cocaine during baseline and successive 13-week blocks of the intervention period shows significant group, time, and Group $\times$ Time interaction effects in repeated measures ANOVAs (see Table 2). The three study groups are not significantly different on the percentage of cocaine-negative samples during the 10-week baseline period (see Figure 2). Participants in the take-home plus voucher group achieved significantly higher rates of cocaine abstinence compared with participants in the usual care control group throughout the 52-week intervention and compared with participants in the take-home only group during the final three 13-week blocks of the intervention (see Figure 2). Cocaine abstinence by participants in the take-home only group increased significantly relative to participants in the usual care control group during the first three blocks but not during the final 13-week block of the intervention (see Figure 2).

Opiate urinalysis results collected during the baseline and intervention periods show significant group, time, and Group $\times$ Time interaction effects in repeated measures ANOVAs (see Table 2). For the take-home plus voucher group, the pattern of statistical significance on percentage of opiate-negative urine samples is similar to that observed for the percentage of cocaine-negative urine samples (see Figure 2). Opiate abstinence in the take-home

Table 1
Demographic Characteristics of Study Participants

Variable	Usual care control (n = 26)	Take-home only (n = 26)	Take-home plus voucher (n = 26)
M age in years (*SD*)	37.1 (6.8)	39.3 (5.6)	40.9 (5.6)
Men (%)	65	54	46
Women (%)	35	46	54
Race (%)			
Black	65	73	69
White	31	27	31
Other	4	0	0
HIV status (%)			
HIV infected	12	4	4
Not HIV infected	73	61	65
Unknown (refused testing)	15	35	31
Addiction Severity Index Interview			
Married (%)	15	19	12
12 years education (%)	58	42	50
Past 30 days curved income (*SD*)			
Illegal	$827 ($1,648)	$838 ($1,097)	$685 ($1,126)
Legal	$812 ($852)	$714 ($791)	$862 ($957)
Employment			
At least 20 days of past 30 (%)	23	15	15
Usual pattern during 3 years prior to intake	35	23	12
Days used in past 30 days (*SD*)			
Heroin	28 (5.7)	29 (2.3)	29 (3.5)
Cocaine	15 (11.6)	14 (12.3)	11 (11.3)
Alcohol (any use)	3 (6.8)	5 (7.5)	2 (2.0)
Other sedatives–tranquilizers	0.5 (1.1)	0.2 (0.4)	0.3 (1.0)
Marijuana	1 (2.9)	0.2 (0.6)	1 (4.9)
Composite score (*SD*)			
Drug	0.38 (0.06)	0.39 (0.06)	0.37 (0.06)
Employment	0.73 (0.27)	0.84 (0.23)	0.8 (0.23)
Legal	0.13 (0.17)	0.16 (0.17)	0.22 (0.31)
Medical	0.16 (0.32)	0.09 (0.23)	0.12 (0.27)
Psychiatric	0.03 (0.12)	0.07 (0.18)	0.03 (0.09)
Family–social	0.10 (0.19)	0.06 (0.12)	0.06 (0.15)
Urinalysis at intake (% negative)			
Opiates	0	0	0
Cocaine	4	4	15
Benzodiazepines	92	92	92
Methadone	100	92	96
SCID diagnoses (% with current diagnosis)[a]			
Opioid dependence	100	100	100
Cocaine dependence	81	81	81
Sedative dependence	0	4	4
Alcohol dependence	8	12	0
Cannabis dependence	12	4	0
Antisocial personality disorder	35	31	19
Borderline personality disorder	4	8	4
HIV Risk Interview (% patients)[b]			
Ever shared any gallery equipment	58	72	75
Ever given sex for money	19	20	17
Ever had sex with IV user	54	40	25
Ever had venereal disease	81	80	88

Note. SCID = Structured Clinical Interview for *DSM–III–R.*
[a] Reported if present in 5% or more of the sample; all diagnoses assessed are not listed. [b] Take-home only group (n = 25), take-home plus voucher group (n = 24).

only group is not significantly different from that observed in the usual care control group.

Urinalysis results were also examined for combined abstinence from both cocaine and opiates. There are significant group, time, and Group × Time interaction effects in repeated measure ANOVAs (see Table 2). The pattern of post hoc test results is identical to that observed for cocaine alone (see Figure 2).

Completers. Urinalysis results for study completers during the 52-week intervention are very similar to those observed with the intent-to-treat sample, except that overall rates of abstinence are higher in completers (see Figure 2). Percentage of urine samples negative for cocaine, for opiates, and for both drugs show significant group, time, and Group × Time interaction effects in repeated measures ANOVAs (see Table 2). During the postinterven-

Table 2
Results of Repeated Measures ANOVAs for Percentage of Drug-Negative Urine Samples

	Group				Time				Group × Time			
Group	*F*	*df*s	*p*	*f*	*F*	*df*s	*p* <	*f*	*F*	*df*s	*p*	*f*
Intent-to-treat												
Cocaine	10.29	2, 75	<.001	0.52	19.52	4, 300	.001	0.51	5.84	8, 300	<.001	0.40
Opiates	5.76	2, 75	.005	0.39	16.93	4, 300	.001	0.48	2.58	8, 300	.03	0.26
Cocaine and opiates	11.51	2, 75	<.001	0.55	25.60	4, 300	.001	0.59	5.81	8, 300	<.001	0.39
Completers												
Cocaine	10.32	2, 46	<.001	0.67	17.52	5, 230	.001	0.62	3.87	10, 230	.001	0.41
Opiates	9.76	2, 46	<.001	0.65	41.05	5, 230	.001	0.95	2.08	10, 230	.039	0.30
Cocaine and opiates	11.33	2, 46	<.001	0.70	22.93	5, 230	.001	0.71	3.84	10, 230	.001	0.41

Note. ANOVAs = analyses of variance; *f* = effect size.

tion period (i.e., after the voucher intervention was discontinued), rates of cocaine, opiate, and combined cocaine and opiate abstinence are significantly higher in participants in the take-home plus voucher group than participants in either the take-home only or usual care control groups (see Figure 2).

Individual Patterns of Drug Abstinence

Patterns of cocaine use and abstinence were examined for individual participants. Figure 3 shows that 11 of the 26 participants in the take-home plus voucher group (Participants 66, 68, 70, and 71–78; 42% of participants) achieved over 6 months of sustained cocaine abstinence. Several of the participants (Participants 66, 68, 70, 71) initiated these long periods of sustained abstinence after many weeks of intermittent or persistent cocaine use. After a participant in this group initiated a long period of abstinence, it was rarely interrupted by cocaine use before the end of the 52-week intervention period. Only 2 participants in the take-home only group (Participants 50 and 52; 8% of participants) and no participants in the usual care control group achieved 6 months of sustained abstinence. Participants in these groups rarely sustained cocaine abstinence beyond a few weeks. Examination of abstinence patterns for individual participants in the take-home plus voucher group show that many who achieved long periods of sustained abstinence from cocaine during the intervention continued their patterns of sustained abstinence through the 9-week postintervention period (see Figure 3). Although there are generally higher rates of opiate than cocaine abstinence in all groups, the patterns of opiate abstinence in individual participants generally parallel the patterns of cocaine abstinence (see Figure 4).

Longest Duration of Sustained Abstinence

Table 3 shows results for the longest duration of sustained abstinence measure. The take-home plus voucher group had significantly longer durations of sustained abstinence from cocaine, from opiates, and from both drugs in combination during the intervention period than did either of the other two groups. This was the case when data were analyzed for the intent-to-treat and for the completers samples, although completers tended to have longer absolute durations of sustained abstinence. For example, in the intent-to-treat analysis, participants in the take-home plus voucher group sustained about 19 weeks of continuous abstinence from cocaine and opiates. In contrast, the longest duration of sustained abstinence was 6.3 weeks for participants in the take-home only group and 2.3 weeks for participants in the usual care control group.

Percentage of Participants Achieving Complete and Intermediate Abstinence

Figure 5 and Table 4 show percentage of study participants in the intent-to-treat sample who submitted 100%, greater than 75%, and greater than 50% drug-free urine samples during each time segment of the study. This analysis provides a perspective on partial successes, which is relevant in this group of participants selected for high rates of cocaine use at baseline. Complete abstinence from cocaine and opiates was rare for participants in both the usual care control and take-home only groups during any portion of the intervention. In contrast, participants in the take-home plus voucher group were significantly more likely than those in either of the other two groups to be completely free of cocaine and opiates, especially during the second half of the 52-week intervention.

When the criteria for comparison were reduced to greater than or equal to 75% or greater than or equal to 50% drug-free urine samples, the participants in the take-home plus voucher group still performed significantly better than either of the other two groups. However, the take-home only group had, at selected time points, a significantly higher percentage of participants meeting drug-free criteria compared with participants in the usual care control group.

Figure 6 and Table 4 show the same analysis for the completers sample. During-treatment outcome patterns are identical to those seen with the intent-to-treat sample. At the postintervention time point, the groups are no longer significantly different when total abstinence is the criteria. However, the percentage of participants in the take-home plus voucher group meeting greater than or equal to 75% and greater than or equal to 50% negative urinalysis criteria is still significantly greater than that observed in the other two groups.

Major Assessments During and After Treatment

Analysis of the urine samples collected at the major assessment time points (intake, baseline, Weeks 26 and 52 of the intervention period, Weeks 26 and 52 after the end of the intervention period) shows that participants in the Take-Home Plus Voucher group had

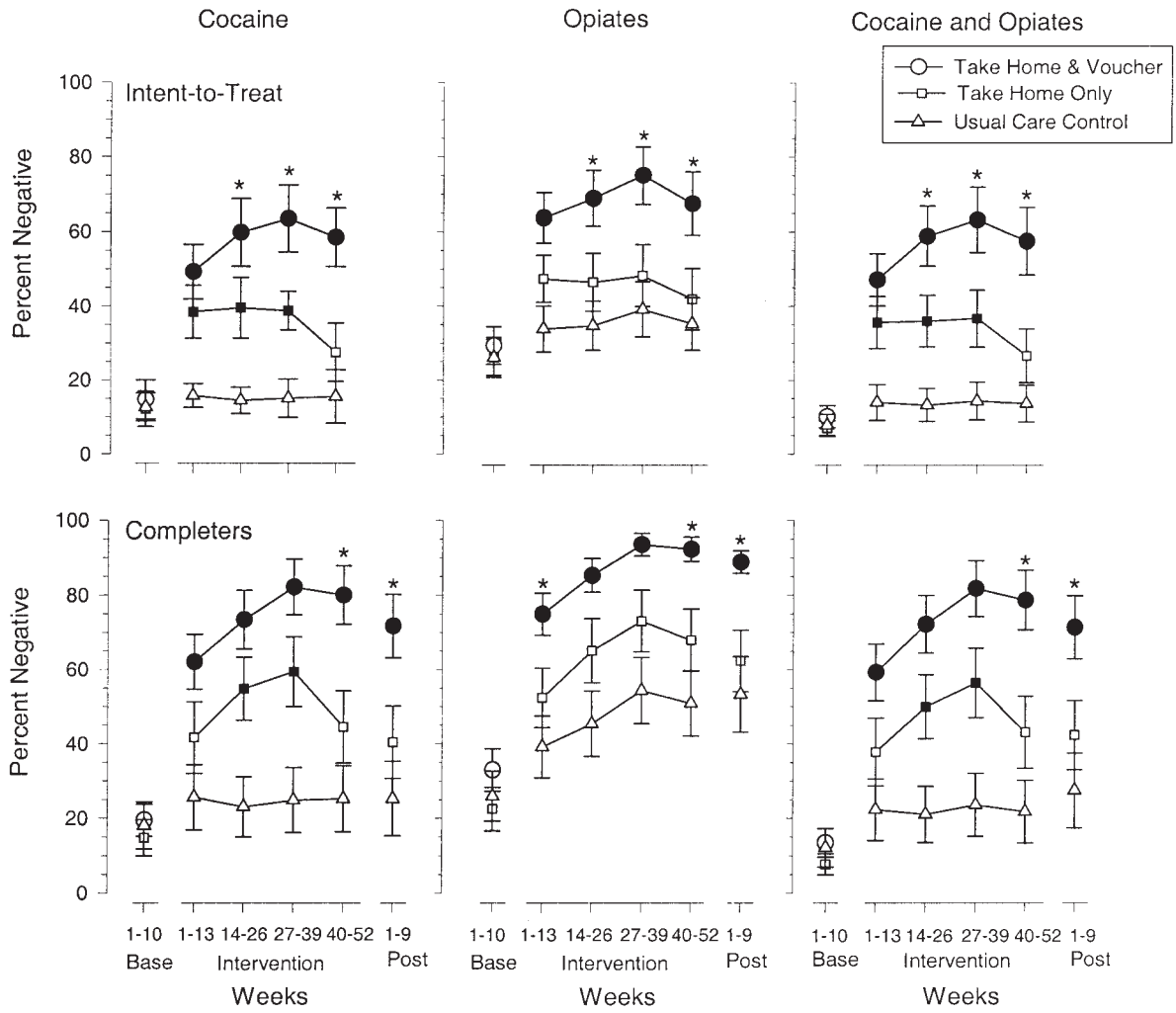

Figure 2. Mean percentage (±1 standard error of the mean) of urine samples that were negative for cocaine (left), opiates (middle), and both (right) for the intent-to-treat sample (top) and for the completers (bottom) throughout the baseline period, each of the consecutive 13-week blocks of the intervention period, and the 9-week postintervention period (completers only). The week numbers on the horizontal axes represent the first and last week of the baseline (Base), each of the 13-week blocks in the intervention period (Intervention), and the postintervention period (Post). Solid symbols and asterisks indicate significant differences from the usual care control and take-home only groups, respectively, at that time point on the basis of Tukey's honestly significant difference post hoc tests (*$p \leq .05$).

significantly (Fisher's exact $p \leq .05$) more cocaine-negative urine samples than either the usual care control or take-home only groups and had significantly more opiate-negative urine samples than the usual care control group at the 52-week end-of-intervention time point. However, there are no significant differences between the three groups at the follow-up time points, 26 or 52 weeks after the voucher intervention was discontinued. Results for completers are virtually identical, except that completers in the take-home plus voucher group also had significantly more cocaine-negative urine samples at the 26-week time point within the intervention period.

Self-Report Data

Analyses of self-reported data collected at the weekly and major assessment time points provide suggestive but inconclusive evidence of intervention effects. For the intent-to-treat sample, the analyses show significant ($p \leq .05$) group effects on (a) self-reports of the total number of cocaine injections per week; (b) the number of times that participants reported using injection equipment after someone else (from the Intravenous Drug Use Questionnaire); (c) the number of times they smoked crack cocaine (from the Nonintravenous Drug Use Questionnaire); (d) how often they avoided drug-using friends or relatives, found new things to do, spent time with people who did not use drugs, or looked for a job (from the Lifestyle Changes Questionnaire); and (e) how many times someone offered to sell them cocaine or heroin or give them cocaine or heroin for free (from the Drug Availability Questionnaire). Significant ($p \leq .05$) Group × Time interaction effects were obtained for staff ratings of the overall appearance of participants and for the average of all appearance ratings (from the Staff

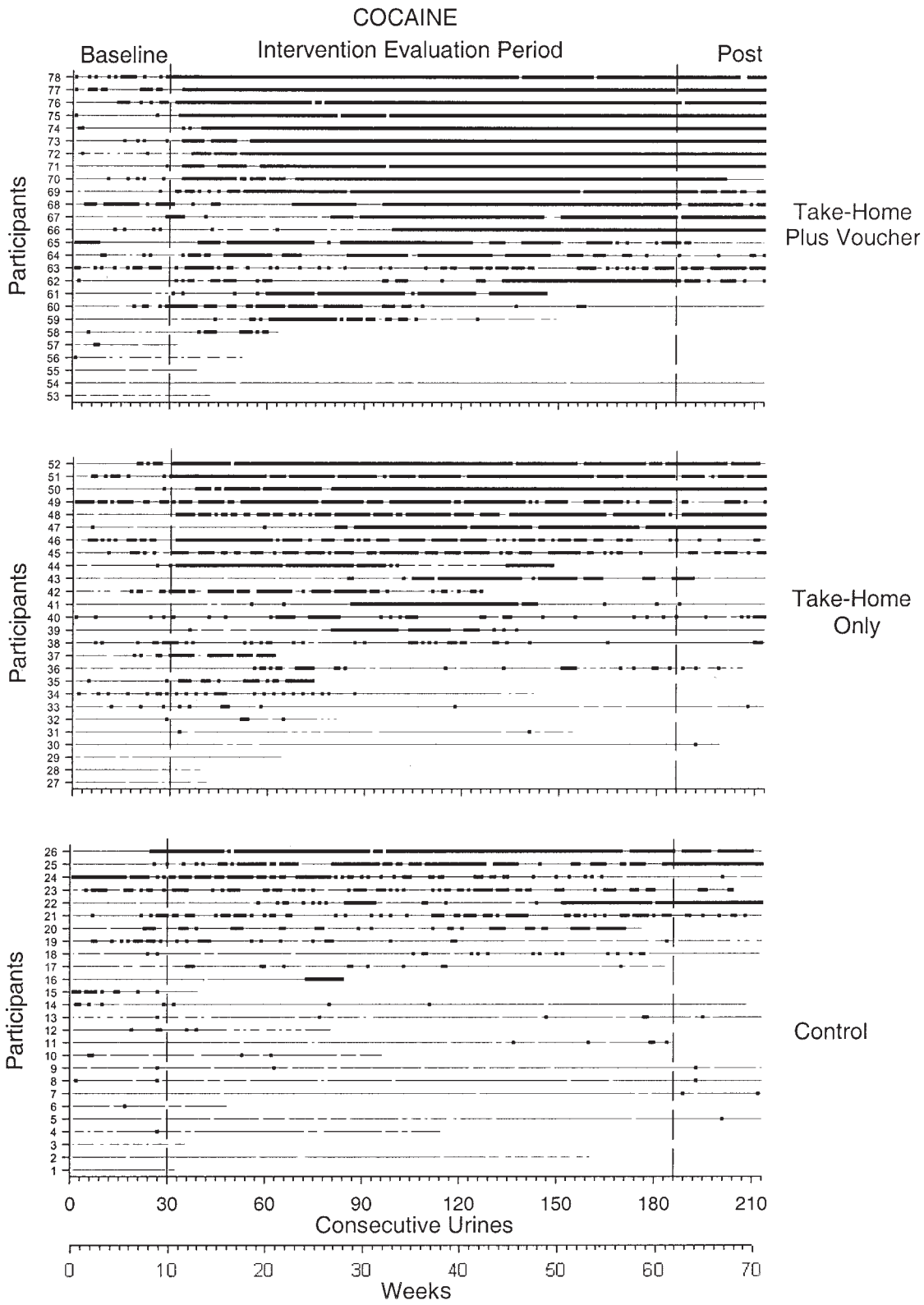

Figure 3. Cocaine urinalysis results across consecutive urine samples for individual participants in each of the three experimental conditions during baseline (left), intervention (center), and postintervention (right) periods. Horizontal lines represent the cocaine urinalysis results for individual participants across the consecutive scheduled urine collections of the study, ranked from most abstinence (top) to least abstinence (bottom). The heavy portions of each line represent cocaine-negative urinalysis results, the thin portions of each line represent cocaine-positive urinalysis results, and the blank portions represent missing urine samples. The numerals on the ordinates represent participant identification numbers. Post = postintervention.

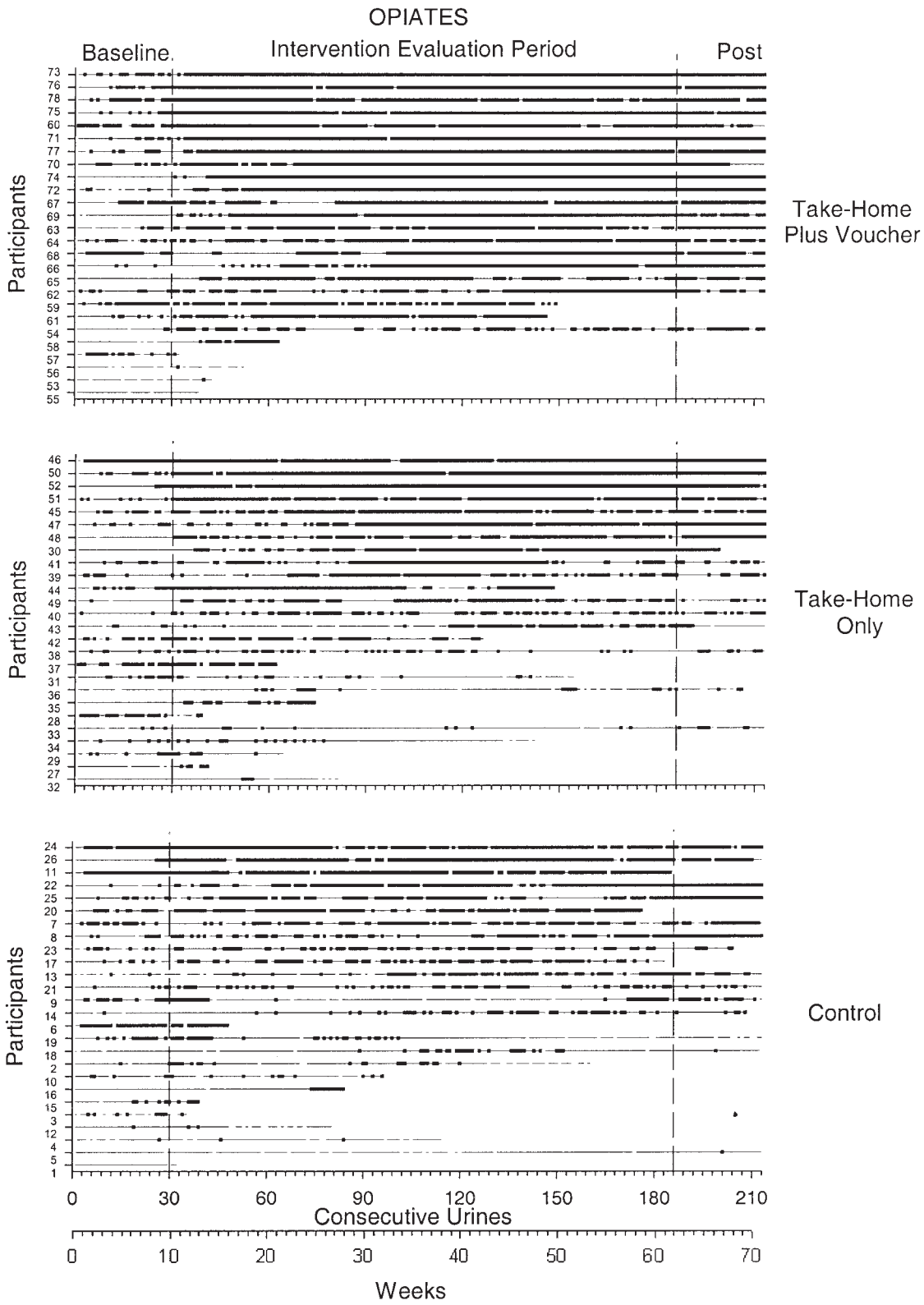

Figure 4. Opiate urinalysis results across consecutive urine samples for individual participants in each of the three experimental conditions during baseline (left), intervention (center), and postintervention (right) periods. Horizontal lines represent opiate urinalysis results for individual participants across the consecutive scheduled urine collections of the study, ranked from most abstinence (top) to least abstinence (bottom). The heavy portions of each line represent opiate-negative urinalysis results, the thin portions of each line represent opiate-positive urinalysis results, and the blank portions represent missing urine samples. The numerals on the ordinates represent participant identification numbers. Post = postintervention.

Table 3
Longest Duration of Sustained Abstinence During the 52-Week Intervention Period

Group	Usual care control	Take-home only	Take-home plus voucher	*F*	*df*s	*f*
Intent-to-Treat						
Cocaine						
M (weeks)	2.3	7.1	20.2[a,b]	16.3*	2, 75	0.66
95% CI	0.4–4.3	3.7–10.5	13.5–26.9			
Opiates						
M (weeks)	4.8	9.2	21.0[a,b]	13.0*	2, 75	0.59
95% CI	2.6–7.0	5.2–13.2	14.5–27.3			
Cocaine and opiates						
M (weeks)	2.3	6.3	18.8[a,b]	16.2*	2, 75	0.66
95% CI	0.4–4.1	3.5–9.1	12.4–25.3			
Completers						
Cocaine						
M (weeks)	3.7	10.1	26.7[a,b]	16.7*	2, 46	0.85
95% CI	0.2–3.8	5.2–12.6	19.6–35.6			
Opiates						
M (weeks)	6.3	12.5	27.4[a,b]	15.0*	2, 46	0.81
95% CI	2.9–9.8	7.1–17.9	21.0–33.9			
Cocaine and opiates						
M (weeks)	3.6	8.8	24.8[a,b]	16.3*	2, 46	0.84
95% CI	0.3–3.7	4.9–11.2	17.8–32.9			

Note. f = effect size; CI = confidence interval.
[a] Significantly different from usual care control, $p < .001$. [b] Significantly different from take-home only, $p < .001$.
* $p < .001$.

Appearance Ratings Form). Although the means for the take-home only and take-home plus voucher groups changed in the expected directions for these questionnaires relative to the usual care control group, the only significant post hoc comparisons between groups were found on two items from the Lifestyle Changes Questionnaire. In those cases, during the second 13-week block of the intervention period, participants in the take-home plus voucher group reported that they "avoided drug-using friends or relatives" and "found new things to do" significantly ($p \leq .05$) more often than participants in the usual care control group.

Analyses of self-report data for Completers yield results generally consistent with results from the intent-to-treat sample. However, post hoc comparisons show that both the take-home and take-home plus voucher groups reported significantly ($p \leq .05$) fewer cocaine injections than the usual care control group during the third (take-home only group) and fourth (both groups) 13-week block of the intervention period. ASI data (composite scores and selected items described in the Methods section) collected at the major assessment time points fails to show any significant group or Group × Time effects, and the Tukey's post hoc comparisons fail to show any significant differences between groups at any of the time points on those measures.

Discussion

In this study, we evaluated the effectiveness of long-term exposure to abstinence-reinforcement contingencies in a population of patients who injected heroin and cocaine and showed evidence of on-going drug use during treatment. Results for participants in the usual care control group suggest that individuals who show cocaine and opiate use early in treatment are likely to persist in using cocaine and heroin over extended periods of time without additional intervention even if they receive 100 mg of methadone daily and routine individual and group counseling. Because of their persistent injection drug use, these individuals are at continued risk of contracting HIV infection or of spreading HIV infection to others.

The opportunity to earn take-home methadone doses for providing urine samples negative for cocaine and opiates was shown to improve the outcome prognosis for methadone participants. In particular, although this intervention did not promote complete abstinence, it did appear to increase the proportion of participants who achieved intermediate amounts of abstinence from cocaine and from opiates (see Figures 5 and 6). These results are consistent with a report that documented the benefits of usual care counseling procedures that included abstinence-contingent take-home privileges (McLellan et al., 1993). The results are also consistent with controlled research from this laboratory (Stitzer et al., 1992) in which about 30% of new methadone intakes were shown to meet clinical criteria of improvement when offered abstinence-contingent, take-home privileges after a baseline evaluation period. Between study comparisons are difficult because the present study used a sample selected for cocaine use and because patterns of drug use have shifted over time among methadone patients. Nevertheless, both studies show benefits of contingent take-home privileges, with about 35% of urine samples collected from participants in the take-home only group in the present study being negative for cocaine and opiates during most of the intervention period; these rates are significantly higher than those observed in the usual care control group without take-home privileges (see Figure 2).

It should be noted that take-home rules were more flexible and responsive to changes in drug use than those used in most treat-

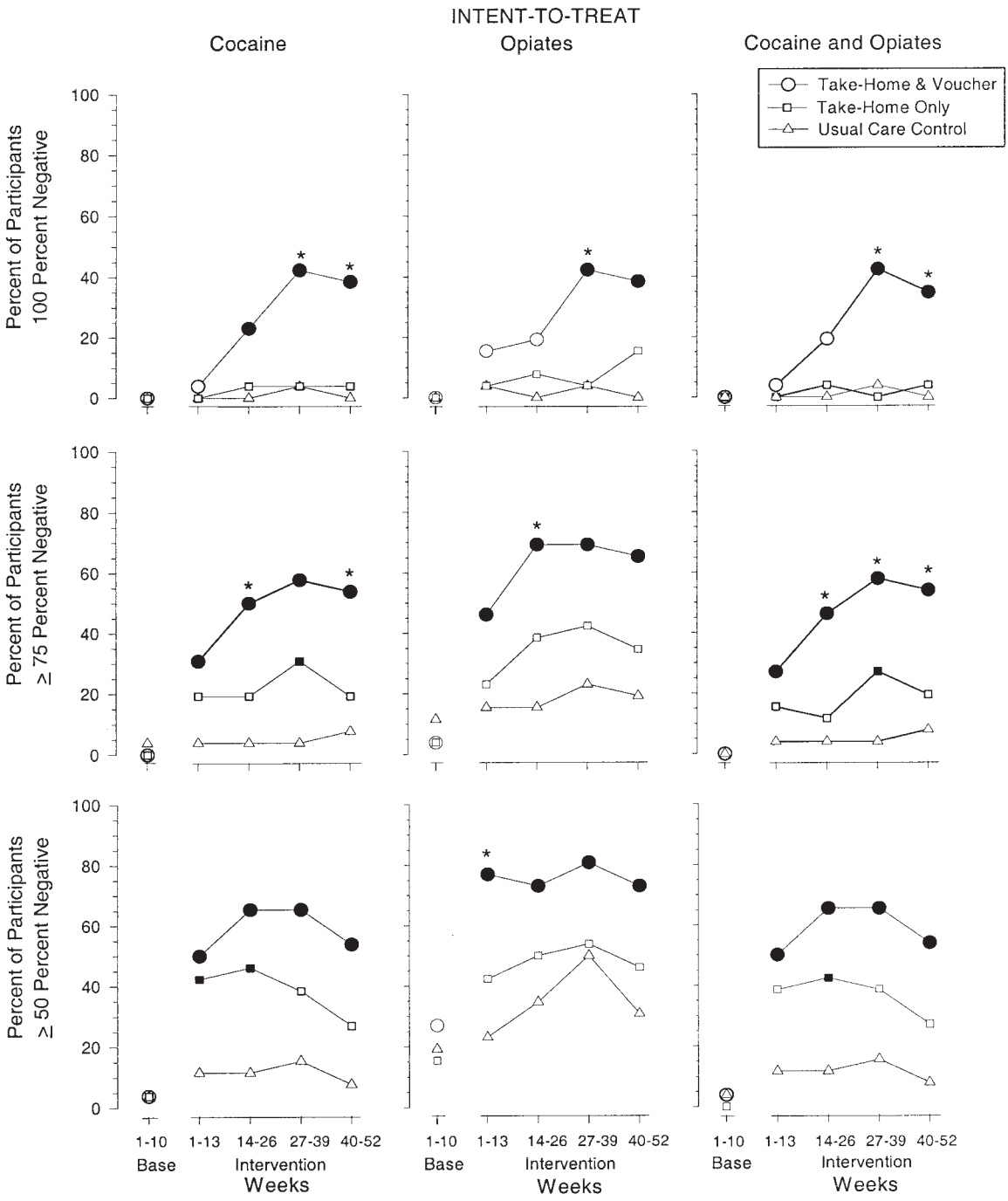

Figure 5. The percentage of all participants (intent-to-treat sample) that were 100% (top), greater than or equal to 75% (middle), and greater than or equal to 50% (bottom) abstinent from cocaine (left), opiates (middle), and both (right) throughout the baseline period and each of the consecutive 13-week blocks of the intervention period. The week numbers on the horizontal axes represent the first and last week of the baseline (Base) and each of the 13-week blocks in the intervention period (Intervention). Solid symbols and asterisks indicate significant differences from the usual care control and take-home only groups, respectively, at that time point on the basis of chi-square pairwise comparisons (*$p \leq .05$).

ment programs. Specifically, take-home privileges could be earned after only a single week of drug-free urine samples and could be reinstated following a lapse with a similarly brief period of documented abstinence. However, the rules for take-home recall were more stringent than is usually the case, and we find it noteworthy that take-home recall was only successful on 62% of occasions for participants in the take-home only group. Because study participants would lose their take-home privileges after a failed recall,

Table 4
Group Effects for Percentage of Participants Who Provided 100%, ≥75%, and ≥50% of Urine Samples Negative for the Drugs Under Study Across the Study Periods

Group	Cochran–Mantel–Haenszel ($df = 2$)	p	Chi-square tests of group at each time period ($df = 2$)											
			Baseline		Intervention								Postintervention	
			Weeks 1–10		Weeks 1–13		Weeks 14–26		Weeks 27–39		Weeks 40–52		Weeks 1–9	
			p	w	p	w	p	w	p	w	p	w	p	w
Intent-to-treat														
100% negative														
Cocaine	48.50	.001	—	—	*ns*	.161	.008	.353	.001	.486	.001	.497		
Opiates	37.61	.001	—	—	*ns*	.204	*ns*	.277	.001	.486	.001	.412		
Cocaine and opiates	46.72	.001	—	—	*ns*	.161	.023	.312	.001	.530	.001	.463		
≥75% negative														
Cocaine	49.59	.001	*ns*	.161	.040	.287	.001	.447	.001	.476	.001	.442		
Opiates	38.33	.001	*ns*	.148	.037	.291	.001	.448	.004	.381	.002	.392		
Cocaine and opiates	52.34	.001	—	—	*ns*	.262	.001	.456	.001	.483	.001	.442		
≥50% negative														
Cocaine	48.17	.001	*ns*	.000	.009	.350	.001	.453	.001	.417	.001	.415		
Opiates	35.46	.001	*ns*	.119	.001	.446	.020	.317	.046	.282	.008	.350		
Cocaine and opiates	48.80	.001	*ns*	.115	.010	.341	.001	.451	.001	.417	.001	.415		
Completers only														
100% negative														
Cocaine	41.36	.001	—	—	*ns*	.180	.020	.397	.001	.561	.001	.576	*ns*	.327
Opiates	30.19	.001	—	—	*ns*	.296	*ns*	.306	.001	.561	.001	.476	*ns*	.233
Cocaine and opiates	37.66	.001	—	—	*ns*	.180	.050	.347	.001	.618	.001	.532	*ns*	.277
≥75% negative														
Cocaine	47.95	.001	*ns*	.228	*ns*	.323	.004	.478	.001	.547	.002	.534	.005	.487
Opiates	43.25	.001	*ns*	.034	.049	.347	.002	.519	.004	.475	.002	.519	.036	.380
Cocaine and opiates	51.71	.001	—	—	*ns*	.293	.003	.478	.001	.552	.002	.534	.003	.519
≥50% negative														
Cocaine	46.89	.001	*ns*	.034	.027	.386	.004	.478	.005	.467	.003	.496	.001	.540
Opiates	48.85	.001	*ns*	.256	.001	.570	.013	.422	*ns*	.347	.001	.541	.004	.494
Cocaine and opiates	45.54	.001	*ns*	.146	.027	.386	.004	.478	.005	.467	.003	.496	.004	.503

Note. Actual percentages and group comparisions within each of the time periods are shown in Figures 5 and 6. A dash indicates that no participant in any group achieved the abstinence criterion during the time period. w = effect size.

these stringent recall procedures could possibly be a factor in the reduced efficacy of the take-home procedure seen at the end of the intervention period.

Voucher-based reinforcement of cocaine abstinence, used in combination with a standard take-home, methadone-reinforcement contingency for opiate and cocaine abstinence, produced high rates of sustained cocaine abstinence that were maintained throughout the yearlong intervention period of this study (see Figures 2–6). Long-term exposure to the voucher intervention appears to produce progressive increases in the rates of sustained cocaine abstinence. This progressive increase is particularly evident in the percentage of participants who were completely abstinent from cocaine throughout each of the successive 13-week blocks of the 52-week intervention period (see Figures 5 and 6). This progressive increase in sustained abstinence appears to result from the fact that individual participants initiated sustained cocaine abstinence after varying periods of exposure to the voucher intervention (see Figure 3). Some participants in the take-home plus voucher group did not initiate sustained abstinence during the initial weeks of exposure to the intervention. Yet after prolonged exposure to the contingencies, these individuals initiated periods of abstinence that lasted many months, abstinence durations that were not common in participants in the other two groups. Some participants initiated their longest periods of sustained cocaine abstinence after as many as 20 (Participants 66 and 68) or 40 (Participant 62) weeks of exposure to the voucher intervention.

Voucher-based reinforcement of cocaine abstinence significantly and dramatically increased abstinence from opiates (see Figures 3 and 4) even though participants were not required to provide opiate-free urine samples to earn vouchers. The magnitude of this effect on opiate use may have resulted from an interaction with the take-home reinforcement contingency, which did require abstinence from both cocaine and opiates. However, it is also consistent with observations that opiate use is often reduced concurrently with abstinence from cocaine during voucher interventions that target only cocaine (Silverman, Higgins, et al., 1996; Silverman, Wong, et al., 1998).

Although effects were not observed on most self-report measures, both the take-home and combined take-home plus voucher interventions appear to decrease rates of cocaine injections, an effect that is particularly evident among study completers. These results, along with the observation that approximately 30%–40% of the participants in the take-home plus voucher group completely stopped using cocaine throughout much of the last 6 months of the intervention period (see Figure 5), suggest that the take-home plus voucher intervention

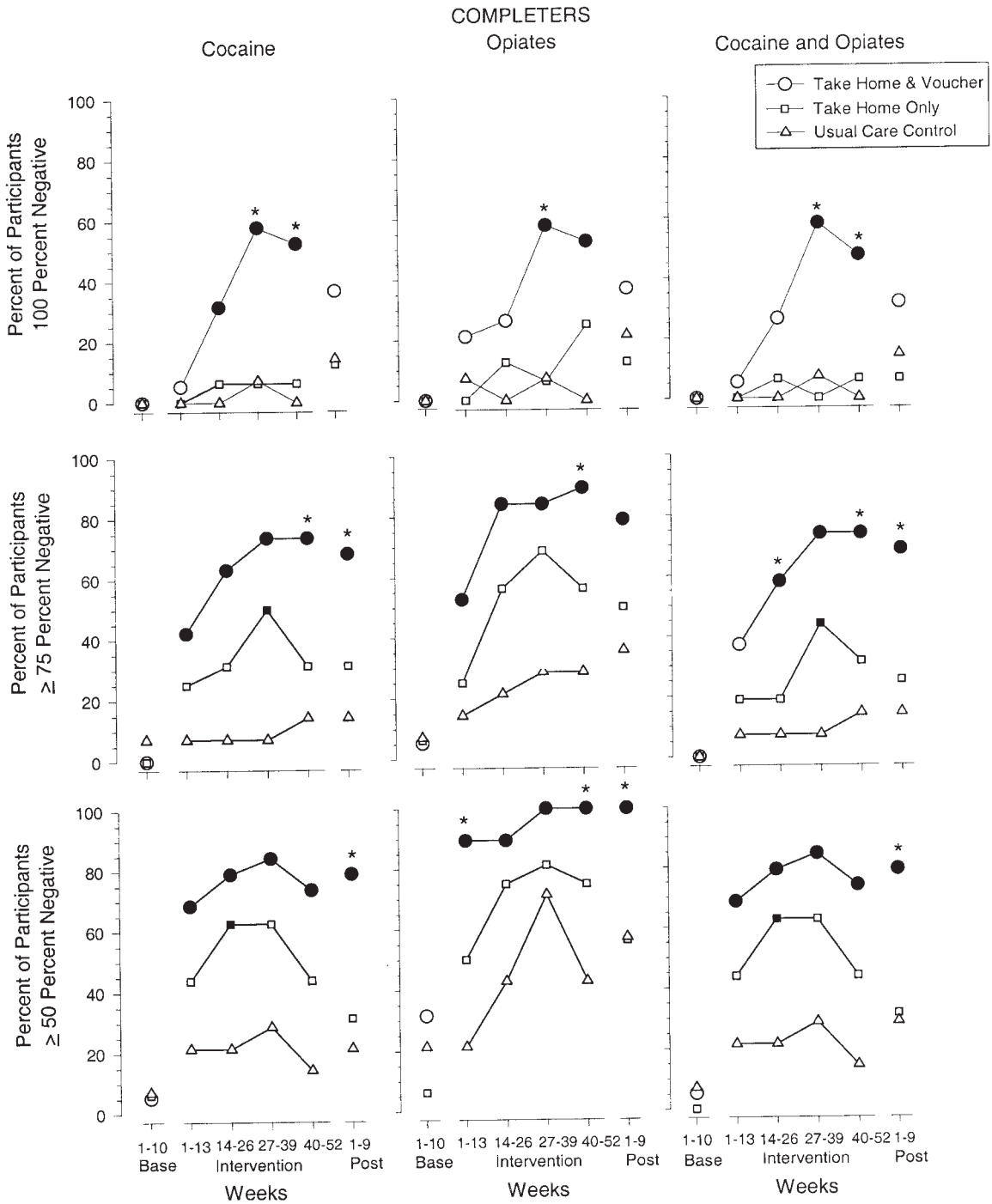

Figure 6. The percentage of completers that were 100% (top), greater than or equal to 75% (middle), and greater than or equal to 50% (bottom) abstinent from cocaine (left), opiates (middle), and both (right) throughout the baseline period and each of the consecutive 13-week blocks of the intervention period. The week numbers on the horizontal axes represent the first and last week of the baseline (Base), each of the 13-week blocks in the intervention period (Intervention), and the postintervention period (Post). Solid symbols and asterisks indicate significant differences from the usual care control and take-home only groups, respectively, at that time point on the basis of chi-square pairwise comparisons (*$p \leq .05$).

should have reduced the risk that these individuals would spread or contract HIV infection because of their cocaine use.

Analysis of data from the completers provided the opportunity to examine durability of intervention effects beyond the active voucher-reinforcement procedure. These data show that the voucher-based, abstinence-reinforcement intervention did have effects that lasted after the voucher intervention was discontinued, at least during the 9-week postintervention period. Although the data

from this study cannot be formally compared with previous studies, the postintervention effects appear greater than the effects from previous studies (Silverman, Higgins, et al., 1996; Silverman, Wong, et al., 1998). Either or both of two features of the take-home plus voucher intervention may account for the substantial postintervention effects. First, the long-term (52 weeks) exposure to the voucher-based, abstinence-reinforcement intervention may have made the abstinence effects more durable than prior studies in which participants were exposed to the voucher intervention only for 12 or fewer weeks. Second, in this study, the take-home, abstinence-reinforcement intervention was continued throughout the postintervention period. In prior studies, when the voucher-based, abstinence-reinforcement intervention was discontinued, no abstinence-reinforcement contingency was in effect. Despite the substantial 9-week postintervention effects, the effects on complete abstinence were not maintained throughout the entire 1-year postintervention period. This may in part reflect the fact that some participants were no longer in methadone treatment. Nevertheless, this observation suggests that continuation of an abstinence-reinforcement intervention may be needed to maintain complete, sustained cocaine abstinence over prolonged periods of time.

Few interventions have been demonstrated effective in the treatment of cocaine abuse in general or in the treatment of methadone patients who abused cocaine in particular (Rawson et al., 1994; Silverman, Bigelow, & Stitzer, 1998). In this context, the beneficial effects of the take-home and voucher-based abstinence-reinforcement contingencies are important. The results of the take-home contingency confirm that this intervention could be very useful in the routine treatment of cocaine use in methadone patients. However, cocaine use persisted, at least intermittently, in most participants when the take-home reinforcement contingency was used alone. Participants completely stopped using cocaine only when the voucher intervention was added.

Voucher-based reinforcement of cocaine abstinence is clearly effective, robust, and durable when in place. However, this intervention is not likely to be incorporated into standard treatment settings in its current form, primarily because of cost considerations. Practical vehicles to deliver abstinence-reinforcement interventions are required and are under development. The key to such interventions is to identify practical means of arranging and maintaining abstinence-reinforcement interventions over extended periods of time. Although this is clearly a difficult task, recent research suggests that such interventions may well be possible. One of the most direct and promising applications of the voucher-based, abstinence-reinforcement technology has been the integration of abstinence-reinforcement contingencies into an employment setting in an intervention referred to as the therapeutic workplace. Under this intervention, patients who abuse drugs are hired and paid to work in an income-producing business. Patients lacking job skills are first given intensive training. To arrange explicit reinforcement for drug abstinence, patients are required to provide drug-free urine samples on a routine basis to gain and maintain access to the workplace. In this way, patients can work and earn salary but only as long as they remain drug abstinent. If a patient ever provides a drug-positive urine sample, the patient is not allowed to work that day. We find it important that the patient is never terminated for drug use; he or she is always invited to return the next day or any day thereafter to try again.

The therapeutic workplace intervention was first developed and tested to treat a population of pregnant and recently postpartum women who had continued to use heroin and cocaine during and after pregnancy despite exposure to an intensive and state-of-the-art treatment for pregnant and postpartum women (Silverman et al., 2002; Silverman, Svikis, Robles, Stitzer, & Bigelow, 2001a, 2001b). In that study, 40 women were randomly assigned to a usual care control or a therapeutic workplace group. Both groups were monitored over time. Participants in the therapeutic workplace group were first trained to serve as data-entry operators and then hired as data-entry operators in an income-producing therapeutic workplace data-entry business. That study shows that participants can be trained to become skilled data-entry operators. The study also provides preliminary indication that the therapeutic workplace data-entry business can become a competitive and financially successful business (Silverman et al., in press). Most important, the study shows that the therapeutic workplace intervention can increase abstinence from heroin and cocaine in this population relative to the usual care control group. The study provides important evidence that salary that patients who abuse drugs earn for work may be used effectively to reinforce drug abstinence.

Much work remains to be done to further develop and evaluate the therapeutic workplace intervention (Silverman, Higgins, & Bickel, 2003), but if that research shows that therapeutic workplace businesses can become financially successful, then those businesses can serve as practical vehicles for arranging high-magnitude, monetary-based reinforcement for drug abstinence and for sustaining abstinence reinforcement over extended periods of time. The therapeutic workplace intervention is only one example of a possible practical application of the abstinence-reinforcement technology. Other applications need to be developed as well. In the current study, we provide strong evidence for the need to develop practical applications of the voucher-based, abstinence-reinforcement intervention like the therapeutic workplace intervention. Development of such applications could lead to the effective long-term treatment of persistent intravenous cocaine use in methadone patients that has proven refractory to conventional treatment approaches.

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Received February 10, 2003
Revision received December 29, 2003
Accepted January 5, 2004 ■