Published in final edited form as:

Prev Med. 2012 November ; 55(Suppl): S46–S53. doi:10.1016/j.ypmed.2012.03.013.

Maintenance of reinforcement to address the chronic nature of drug addiction

Kenneth Silverman^a, Anthony DeFulio^a, and Sigurdur O. Sigurdsson^{a,b}

^aJohns Hopkins University School of Medicine, Department of Psychiatry and Behavioral Sciences, 5200 Eastern Avenue, Ste. W142, Baltimore MD 21224

^bUniversity of Maryland Baltimore County, Department of Psychology, 1000 Hilltop Circle, Baltimore, MD, 21250

Abstract

Background—Drug addiction can be a chronic problem. Abstinence reinforcement can initiate drug abstinence, but as with other treatments many patients relapse after the intervention ends. Abstinence reinforcement can be maintained to promote long-term drug abstinence, but practical means of implementing long-term abstinence reinforcement are needed.

Methods—We reviewed 8 clinical trials conducted in Baltimore, MD from 1996 through 2010 that evaluated the therapeutic workplace as a vehicle for maintaining reinforcement for the treatment of drug addiction. The therapeutic workplace uses employment-based reinforcement in which employees must provide objective evidence of drug abstinence or medication adherence to work and earn wages.

Results—Employment-based reinforcement can initiate (3 of 4 studies) and maintain (2 studies) cocaine abstinence in methadone patients, although relapse can occur even after long-term exposure to abstinence reinforcement (1 study). Employment-based reinforcement can also promote abstinence from alcohol in homeless alcohol dependent adults (1 study), and maintain adherence to extended-release naltrexone in opioid dependent adults (2 studies).

Conclusion—Treatments should seek to promote life-long effects in patients. Therapeutic reinforcement may need to be maintained indefinitely to prevent relapse. Workplaces could be effective vehicles for the maintenance of therapeutic reinforcement contingencies for drug abstinence and adherence to addiction medications.

Keywords

Reinforcement; Incentives; Contingency Management; Cocaine; Heroin; Drug Addiction; Treatment; Employment; Poverty; Relapse

© 2012 Elsevier Inc. All rights reserved.

Corresponding Author: Kenneth Silverman, Ph.D., Johns Hopkins University School of Medicine, Department of Psychiatry and Behavioral Sciences, 5200 Eastern Avenue, Ste. W142, Baltimore MD 21224, Telephone: 410-550-2694; Fax: 410-550-7495; ksilverm@jhmi.edu.

Conflict of Interest: The authors declare no conflict of interest.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Introduction

Drug addiction can be a chronic problem that can persist for many years (McLellan et al., 2000; Vaillant 1973; Vaillant 2003; Hser et al., 2001; Hser et al., 2007; Hser et al. 2008; Galai et al., 2003). One study (Hser et al., 2001; Hser et al., 2007) investigated the 16-year trajectories of heroin use after initiation in 471 “narcotic-dependent criminal offenders” who were enrolled in treatment between 1962 and 1964 and showed that most individuals (59%) maintained stable high levels of heroin use throughout the 16 year period; about one third (32%) maintained high levels of use for about 10 years, but then decreased their use; a few individuals (9%) stopped their heroin use within 3 years after initiation. Another study (Grella and Lovinger, 2011) of the 30-year trajectories of heroin use in 341 adults who were enrolled in methadone treatment in California between 1976 and 1978 showed that about 25% maintained stable heroin use throughout the 30-year period; 35% showed a gradual decrease; 15% showed a moderate decrease; and 25% showed a rapid decrease, virtually stopping all heroin use within the first 15 years. Similar patterns have been observed for cocaine and methamphetamine users (Hser et al., 2008).

Treatments can promote drug abstinence in some patients, but relapse is common after treatment (Sees et al., 2000; Veilleux et al., 2010; Lancaster et al., 2006; Knapp et al., 2007; Etter and Stapleton, 2006; Tonstad et al., 2006). Many individuals can achieve extended periods of drug abstinence that can last a year or more, but still relapse (Galai et al., 2003; Shah et al., 2006). A 12-year longitudinal study of 1,339 injection drug users in Baltimore, Maryland (Galai et al., 2003) showed that about 29% maintained persistent injection drug use over the 12-year period, 20% stopped injecting, 14% stopped but relapsed once, and 37% relapsed multiple times. A further analysis (Shah et al., 2006) showed that 70% reported achieving at least 6 months without injecting drugs; however, 50% of the individuals who achieved this benchmark relapsed to injection drug use within a year, and about 75% relapsed within 3 years.

Some treatments can produce small effects that are evident after treatment, suggesting that some patients derive long-term benefits from treatment (e.g., Etter and Stapleton, 2006). However, even in those cases many patients relapse to drug use after treatment. One review “failed to detect a clinically significant effect of existing relapse prevention interventions in sustaining successful attempts to stop smoking (Lancaster et al., 2006).” A review of psychosocial interventions for the treatment of cocaine and stimulant addiction concluded that no type of treatment resolves “the chronic, relapsing nature of addiction (Knapp et al., 2007).” Thus, the development of more enduring solutions to sustain abstinence over years and lifetimes is perhaps the greatest challenge facing the substance abuse treatment research community today.

Abstinence Reinforcement Interventions for the Treatment of Drug Addiction

Abstinence reinforcement in which patients receive an incentive contingent on providing objective evidence of drug abstinence is one of the most effective psychosocial approaches to initiate drug abstinence (Knapp et al., 2007; Dutra et al., 2008; Lumley et al., 2009; Pilling et al., 2007; Lussier et al., 2006). Voucher-based abstinence reinforcement, in which patients receive monetary vouchers exchangeable for goods and services contingent on providing drug-free urine samples (Higgins et al., 1991), has been particularly effective (Lussier et al., 2006). The effectiveness of abstinence reinforcement increases as the reinforcement magnitude increases (Petry et al., 2004; Silverman et al., 1999; Dallery et al., 2001; Higgins et al., 2007; Stitzer and Bigelow, 1984; Stitzer and Bigelow, 1983). Although abstinence reinforcement interventions are effective, laboratory research suggests that many patients may relapse to drug use after abstinence reinforcement is discontinued, and clinical studies have confirmed that this is indeed a problem.

Laboratory models of relapse—Laboratory research shows that drug use is operant behavior that is maintained and modifiable by its consequences (Schuster and Thompson, 1969; Silverman et al., 2011; Bigelow and Silverman, 1999). Drugs can reinforce drug seeking and drug taking, and environmental antecedent stimuli that signal the availability of drug reinforcement can come to serve as conditioned and discriminative stimuli that can control drug self-administration. Operant laboratory models of drug addiction have shown that drug use can be decreased or eliminated by strategic arrangement of non-drug reinforcers, particularly if those reinforcers are provided contingent on alternative behaviors that are incompatible with drug seeking (Higgins et al., 2004).

Operant laboratory models of relapse have also shown that discriminative stimuli for drug self-administration can precipitate relapse when they are re-introduced after the self-administration response has been extinguished (Carroll and Comer, 1996). Since drug abuse treatments typically do not alter the everyday environments that previously acquired discriminative control of drug self-administration (e.g., availability of drugs, presence of drug users), it is reasonable to expect that such environmental “triggers” could precipitate relapse to drug use, even months after treatment.

Relapse after abstinence reinforcement ends—Abstinence reinforcement interventions have produced long-term effects (e.g., Higgins et al., 2000). However, no type of treatment, including abstinence reinforcement, has reliably prevented the relapse that commonly occurs over the long term after a treatment is discontinued. The propensity of individuals to relapse after abstinence reinforcement is discontinued has been evident for some time (e.g., Miller et al., 1974; Stitzer et al., 1982; Winett, 1973) and is common in cigarette smokers (Winett, 1973; Shoptaw et al., 2002; Heil et al., 2008) and alcohol (e.g., Miller et al., 1974), benzodiazepine (e.g., Stitzer et al., 1982), heroin (e.g., Silverman et al., 1996; Stitzer et al., 1980; Preston et al., 2002), and cocaine (Silverman et al., 1999; Silverman et al., 1996; Silverman et al., 1998) users.

Employment-Based Reinforcement: A Practical Way to Maintain Therapeutic Reinforcement

Winett (1973), who conducted early research using abstinence reinforcement (contingency contracts) to promote smoking cessation, observed that relapse was common after the intervention was discontinued. Winett considered the possibility that “some smokers will require a contract that simply never terminates.” Maintaining long-term exposure to abstinence reinforcement raises an obvious practical challenge. To address this challenge, we have been investigating the potential of using the workplace as a vehicle for maintaining high magnitude reinforcement for the long-term treatment of drug addiction. Workplaces can be used to maintain therapeutic behavior change by requiring that employees provide objective evidence of selected therapeutic behaviors (e.g., drug abstinence) to access the workplace and maximize wages.

Several investigators have used employment-based reinforcement to treat drug addiction (Cohen et al., 1973; Milby et al., 1996; Crowley, 1986) and it has been used in routine clinical practice for special populations, including physicians (McLellan et al., 2008; DuPont et al., 2009a; DuPont et al., 2009b) and workers in safety-sensitive jobs (Cashman et al., 2009). However, these studies have not experimentally evaluated the specific effects of employment-based abstinence reinforcement. We have been conducting research to develop and experimentally evaluate a treatment for drug addiction called the “therapeutic workplace” that uses employment-based reinforcement as a maintenance intervention to maintain long-term drug abstinence. The scientific foundation of this intervention and early studies of its effectiveness were outlined previously (Silverman, 2004). This article provides

an overview of the overall research program conducted by our research group, but emphasizes research published since the earlier review. Table 1 provides a summary of the studies included in this review.

Initiating and Maintaining Cocaine Abstinence in Methadone Patients

The initial studies were conducted in methadone patients who used injection or crack cocaine. Cocaine use is a common in methadone patients and injection drug use and crack cocaine use are each independently associated with increased risk for transmission of HIV (Silverman et al., 1998). A series of studies showed that voucher-based reinforcement could promote cocaine abstinence in methadone patients (Silverman, 2004). One study showed that a year-long exposure to voucher-based reinforcement of cocaine abstinence in methadone patients could sustain cocaine abstinence (Silverman et al., 2004). This study suggests that long-term exposure to abstinence reinforcement can effectively maintain drug abstinence.

A prototype of the therapeutic workplace: initiating and maintaining

abstinence—A prototype of the therapeutic workplace was first evaluated in unemployed pregnant and postpartum women who were enrolled in methadone treatment and used heroin or cocaine during treatment (Silverman et al., 2001). Participants (N=40) were randomly assigned to a Therapeutic Workplace group or Usual Care Control group. Both groups were enrolled for 6 months and invited to repeatedly re-enroll in the study for several years. Therapeutic Workplace participants were invited to attend the workplace and were paid for attendance and work performance. To promote drug abstinence, participants were required to provide urine samples negative for opiates and cocaine to work.

Based on the occupational interests of this population (Silverman et al., 1995), the therapeutic workplace was initially designed to employ participants as data entry operators. Our research showed that many of these women lacked needed skills (Silverman et al., 1995). Thus, the therapeutic workplace intervention was divided into a training phase (Phase 1) and an employment phase (Phase 2). In Phase 1, each participant's "job" was to engage in an intensive skills training program. Participants could earn a base pay of \$7 per day in vouchers for arriving on time and working a complete work shift, but the base pay escalated (Higgins et al., 1991) by \$0.50 per day that the participant completed a 3-hour work shift to a maximum of \$27 per day. If a patient ever provided a drug-positive urine sample or failed to provide a scheduled sample, the participant's base pay was reset to the initial low value of \$7 per day. Participants could also earn \$2 per hour for acceptable professional demeanor and \$1 per hour for training performance.

Participants who became skilled and abstinent progressed to Phase 2 and were hired as data entry operators in our data entry business, Hopkins Data Services (Silverman et al., 2002; Silverman et al., 2005). The data entry operators could work 6 hours every weekday and earn a base pay hourly wage of \$5.25 per hour, plus a productivity bonus of about \$4 per hour based on their data entry work. Participants were required to provide urine samples that were negative for opiates and cocaine every Monday, Wednesday and Friday to work. If a participant provided a drug-positive urine sample or failed to provide a scheduled sample, the participant was not allowed to work that day and the amount of her productivity bonus was temporarily decreased so that she could earn about \$1 per hour for her data entry work.

Therapeutic Workplace participants provided significantly more urine samples negative for cocaine than Usual Care Control participants during the first 24 weeks (54% vs. 32% negative, respectively, $p=.04$; Silverman et al., 2001). Those effects were maintained from 18 through 36 months (see Fig. 1; 54% vs. 28% negative, respectively, $p=.04$; Silverman, et al, 2002), more Therapeutic Workplace participants provided urine samples negative for

cocaine at all of those time points than Usual Care Controls (30% vs. 5%, $p=.04$), and fewer Therapeutic Workplace participants reported using injection or crack cocaine than Controls during that period (55% vs. 90%, respectively, $p=0.01$). Forty percent of the Therapeutic Workplace participants (8 of 20) were hired as data entry operators in Hopkins Data Services (Silverman, et al, 2005).

Initiating cocaine abstinence—In an effort to replicate the therapeutic workplace effects (Knealing et al., 2006), unemployed crack cocaine users who were enrolled in community methadone programs and who provided a cocaine-positive urine sample at intake were randomly assigned to a Therapeutic Workplace ($n=22$) or Usual Care Control ($n=25$) group. Therapeutic Workplace participants were invited to participate in intensive computerized training in typing, keypad and data entry skills for 4 hours every weekday for 9 months. The therapeutic workplace in this and subsequent studies was implemented using a web-based application (Silverman et al., 2005). Participants were required to provide urine and breath samples negative for opiates, cocaine and alcohol every Monday, Wednesday and Friday to work and could earn a base pay for attending the workplace and productivity pay for training program performance. The base pay started at \$2 per hour and increased to \$7.50 per hour by \$0.50 for every day that the participant provided cocaine-, opiate-, and alcohol-negative samples; arrived to work on time; and completed a work shift. Participants' base pay was reset for providing a drug- or alcohol-positive sample, or for repeatedly arriving late or failing to work complete work shifts. Participants could earn up to about \$6 per hour for training program performance. Contrary to the results of prior and subsequent studies, analyses of monthly urine samples showed that the two groups did not differ in their rates of urine samples negative for cocaine or opiates (see Table 1).

A subsequent study (Silverman et al., 2007) modified several of the procedures used by Knealing et al. (2006) to improve outcomes and isolated the effects of employment-based abstinence reinforcement in promoting cocaine abstinence. In that study, we enrolled unemployed community methadone patients who used injection drugs and provided a cocaine-positive urine sample. Participants were invited to attend the workplace 4 hours per day every weekday for 8 weeks and could earn \$8 per hour for attending the workplace and about \$2 per hour for training program performance. To facilitate workplace engagement, participants were not required to provide drug-free urine samples to work during the first 4 weeks. After the 4-week induction period, participants who attended the workplace and continued to provide cocaine-positive urine samples were invited to attend the workplace for 26 weeks and randomly assigned to an Abstinence & Work group or Work Only group. Abstinence & Work participants were required to provide evidence of recent drug abstinence to work and Work Only participants could work independent of their urinalysis results. To improve the reinforcement for abstinence initiation, four changes were made to the procedures used in the Knealing et al. (2006) study. First, participants were only required to provide evidence of cocaine abstinence to work. Second, instead of requiring participants to provide urine samples that met the standard criterion for cocaine negativity (i.e., 300 ng/ml urinary concentration of the cocaine metabolite benzoylecgonine) which may not be reached until several days after initiating cocaine abstinence, participants were only required to provide urine samples that decreased in urinary benzoylecgonine concentration by 20% per day from the last sample provided or had a benzoylecgonine concentration 300 ng/ml. Adapted from procedures developed by Preston et al. (1997), this procedure allowed participants to gain access to the workplace after brief periods of abstinence. Third, each participant's base pay started at \$8 per hour. If a participant failed to provide a urine sample that met the criteria of recent cocaine abstinence, only then was the participant's base pay temporarily reset to \$1 per hour, after which the base pay increased by \$1 per hour every day that the participant attended the workplace and met the cocaine abstinence requirement. Finally, participant's base pay was not reset for being late or not working complete shifts.

During the 26-week intervention period, Abstinence & Work participants provided significantly more cocaine-negative urine samples than Work Only participants based on urine samples collected at the monthly assessments (27% vs. 14%, respectively; $p=.01$; $OR=5.02$) and based on urine samples collected every Monday, Wednesday and Friday (29% vs. 10% cocaine negative, respectively; $p=.004$; $OR=5.80$). At the 30-day assessments, Abstinence & Work participants reported not injecting drugs or using crack cocaine significantly more often than Work Only participants (on 28% vs. 16% of the 30-day assessments, respectively; $p=.04$, $OR=3.37$). This study replicated the effectiveness of the therapeutic workplace in promoting cocaine abstinence, and demonstrated that beyond employment alone, the employment-based abstinence reinforcement contingency was effective in promoting abstinence.

Another study replicated the effectiveness of employment-based reinforcement in promoting cocaine abstinence and identified factors that predict responsiveness to employment-based abstinence reinforcement (Donlin et al., 2008). Participants were unemployed cocaine-dependent welfare recipients who were in a community methadone program and provided a cocaine-positive urine sample at intake ($N=128$). All participants were invited to attend the therapeutic workplace for 26 weeks using procedures similar to Silverman et al. (2007). During an induction period, participants provided urine samples, but could work and earn wages independent of their urinalysis results. Participants who completed the induction ($n=111$) were required to provide urinalysis evidence of recent cocaine abstinence in order to work and maintain maximum pay. To assess the effects of the employment-based abstinence reinforcement, participants were divided into two cohorts. Both cohorts showed stable rates of cocaine-negative urine samples during the 4 weeks prior to onset of the contingency, and abrupt and significant increases in the percentage of cocaine-negative urine samples in the four weeks after the onset of the contingency.

Participants who achieved at least 3 weeks of sustained cocaine abstinence during the intervention (i.e., responders) had attended the workplace significantly more during the induction period than non-responders (61% vs. 43% of minutes; $p<.001$; Fig 2). These data suggest that induction period attendance may measure the reinforcing value of employment and could guide the improvement of employment-based abstinence reinforcement.

Maintaining cocaine abstinence—Another study was conducted to determine if employment-based reinforcement in a therapeutic business was necessary and effective in maintaining cocaine abstinence over a yearlong period (DeFulio et al., 2009). This study was conducted in 51 participants from the Donlin et al. (2008) study who met minimal requirements for drug (opiate and cocaine) abstinence, attendance, and skill acquisition. These participants were offered employment as data entry operators in our data entry business for one year and were randomly assigned to one of two groups: an Abstinence-Contingent Employment or Employment Only group. All participants could work 30 hours per week, earn an hourly wage at about minimum wage and productivity pay. Productivity pay was set so that participants could earn about \$4 per hour. Employment Only participants could work independent of their urinalysis results. Abstinence-Contingent Employment participants were required to provide drug-free urine samples to work and to maintain maximum pay. Urine samples were initially collected every Monday, Wednesday and Friday, but switched to a random schedule that became progressively more intermittent as each Abstinence-Contingent Employment participant sustained longer and longer periods of abstinence. If a participant provided a positive urine sample or failed to provide a required sample, the productivity pay was temporarily reset to about \$1 per hour and the frequency of urine testing increased to the original schedule. Based on urine samples collected every 30 days during the year of employment, Abstinence-Contingent Employment participants provided significantly more cocaine-negative samples than Employment Only participants

(79% and 51%, respectively, $p=.004$, $OR=3.73$; see Fig. 3). Significantly more Employment Only participants (17%) reported that they had traded sex for drugs or money than Abstinence-Contingent Employment participants (0%).

Analysis of urine samples collected every 6 months during and for one year after employment (DeFulio and Silverman, 2011) showed (see Fig. 4) that Abstinence-Contingent Employment participants provided significantly more cocaine-negative urine samples than Employment-Only participants during the year of employment (83 and 54%, respectively; $p=.01$, $OR=4.61$); however, the two groups provided similar percentages of cocaine negative urine samples during the year following employment when all contingencies for both groups had ended (44% vs. 50%; $p=.93$) This study showed that employment-based reinforcement can maintain long-term cocaine abstinence, but many patients relapse when the contingency is discontinued, even after a year of abstinence-contingent employment.

Promoting Abstinence from Alcohol in Homeless Alcohol-Dependence Adults

One study replicated the effectiveness of the therapeutic workplace in homeless alcohol-dependent individuals (Koffarnus et al., 2011). Participants ($N=124$) were randomly assigned to a Work Only, Abstinence & Work or No Voucher group. Work Only and Abstinence & Work participants earned a base pay of up to \$5 per hour in vouchers and additional voucher earnings for training program performance. Work Only participants could work and earn wages in vouchers independent of their daily or random breath results. Abstinence & Work participants could work and earn wages in vouchers only when their breath samples demonstrated alcohol abstinence; positive samples also resulted in a temporary reset of base pay to a low amount. No Voucher participants could work in the workplace independent of breath sample results, but did not receive vouchers for attendance or training program performance. The percentage of days in attendance at the workplace for the Work Only (45%) and Abstinence & Work (39%) groups were similar and each was significantly higher than the No Voucher group (19%; $p<.001$). Work Only participants had significantly ($p=.03$) higher rates of alcohol-positive samples (42%) than Abstinence & Work (24%) participants. Abstinence comparison with the No Voucher group was complicated by that group's poor attendance, but their rates of abstinence (26% positive) were intermediate between the other two groups. The results of this study suggest that employment-based abstinence reinforcement can increase alcohol abstinence in homeless alcohol-dependent individuals.

Promoting Adherence to Naltrexone in the Treatment of Heroin Addiction

Naltrexone is an opioid antagonist that could serve as an effective medication for opioid addiction (Martin et al., 1973; Walsh et al., 1996; Mello et al., 1981). Oral naltrexone that requires near daily dosing has been available since the 1980s, but its utility has been limited because most opioid-dependent individuals refuse it (Veilleux et al., 2010; Adi et al., 2007; Minozzi et al., 2006; Roozen et al., 2006). Extended-release naltrexone formulations have been developed to reduce the need for frequent dosing (Comer, et al, 2007). Extended-release naltrexone has increased retention (Comer et al., 2006; Krupitsky et al., 2011), and there is some evidence that it has increased opiate abstinence, although its effects on opiate abstinence are confounded by differential rates of retention and urine sample collection across groups (Comer et al., 2006; Krupitsky et al., 2011). Previous studies have shown that many patients discontinue extended-release naltrexone formulations prematurely (Comer et al., 2006; Krupitsky et al., 2011).

Two studies were conducted to determine if employment-based reinforcement could maintain adherence to extended-release naltrexone. In each study, after completing an opioid detoxification, participants were inducted onto oral naltrexone, invited to attend the

therapeutic workplace, and required to take scheduled doses of oral naltrexone to work. Participants were then randomly assigned either to a Naltrexone Contingency or Prescription group and invited to attend the therapeutic workplace for 26 weeks, where they could work 4 hours every weekday and earn about \$8 per hour for attendance and about \$2 per hour for training program performance. Contingency participants were required to take scheduled doses of naltrexone to maintain workplace access and maximum pay. Prescription participants were prescribed naltrexone, but were not required to take naltrexone to access the workplace. In one study (Everly et al., 2011) participants were offered Depotrex[®], an investigational medication that was given once every three weeks. In the other (Defulio et al., 2012), participants were offered Vivitrol[®], an FDA-approved formulation that was given once every 4 weeks. In both studies participants were offered at total of 6 injections.

Contingency participants accepted significantly more naltrexone injections than Prescription participants (81% versus 42%, respectively, $p=0.008$ in Depotrex[®] study; 87% versus 52%, respectively, $p=.002$ in Vivitrol[®] study), and were more likely to accept all injections (66% versus 35%, respectively, $p=.026$ in Depotrex[®] study; 74% versus 26%, $p=.004$ in Vivitrol[®] study). In both studies, Contingency and Prescription participants maintained high and similar rates of workplace attendance (see Fig. 5). Neither study showed a significant effects on the percentage of opiate-negative urine samples (74% versus 62%, respectively, $p=.41$ in Depotrex[®] study; 72% versus 65%, $p=.56$ in Vivitrol[®] study). Both studies found fairly low rates of cocaine-negative urine samples across groups (56% versus 54%, respectively, $p=.94$ in Depotrex[®] study; 58% versus 54%, $p=.75$ in Vivitrol[®] study,) and both studies showed that opiate-positive urine samples were significantly more likely when participants provided cocaine-positive urine samples, suggesting that cocaine use may have compromised the effects of extended-release naltrexone on opiate use.

Discussion

Drug addiction can be a chronic problem. Abstinence reinforcement is one of the most effective approaches for initiating drug abstinence, but as with other addiction treatments many patients relapse after the intervention is discontinued. Abstinence reinforcement can be maintained to sustain long-term abstinence; however, practical methods are needed to sustain high magnitude therapeutic reinforcement contingencies over time. The studies reviewed suggest that workplaces could be effective vehicles for maintaining long-term therapeutic reinforcement. Employment-based reinforcement can initiate (Silverman et al., 2001, 2007; Donlin et al., 2008) and maintain (Silverman et al., 2002; DeFulio et al., 2009) drug abstinence over extended periods of time. However, as with all other drug abuse treatments, many patients will relapse to drug use after the intervention is discontinued even if the employment-based abstinence reinforcement contingencies are maintained for periods as long as 18 months (DeFulio and Silverman, 2011). These data suggest that for some people abstinence reinforcement may have to be maintained for very long periods of time and possibly indefinitely to produce life-long drug abstinence. We do not know whether sustaining abstinence reinforcement contingencies for any length of time will produce irreversible effects.

The studies reviewed suggest that employment-based reinforcement can maintain adherence to extended release naltrexone (Everly et al., 2011; Defulio et al., 2012). Under usual care conditions, most participants stopped taking naltrexone, but employment-based reinforcement maintained adherence to extended release naltrexone in most participants until the end of treatment. Many patients continued opiate use under naltrexone blockade, particularly patients who used cocaine. Future studies should determine if employment-based reinforcement can simultaneously maintain adherence to extended-release naltrexone and drug abstinence. The data from these studies suggest that special interventions may be

needed to promote adherence to other addiction medications that are under development and that block the reinforcing effects of other abused drugs (e.g., Collins et al., 2011; Carroll et al., 2011). Employment-based reinforcement might be useful in maintaining adherence to these medications.

The therapeutic workplace intervention could address the interrelated problems of poverty and drug addiction. Most of the participants in this research have long histories of chronic unemployment, poverty, and drug addiction and face two major obstacles to employment, limited job skills and persistent illicit drug use. Phase 1 of the therapeutic workplace can establish needed job skills and initiate drug abstinence, which should prepare these individuals for gainful employment. Once hired, employers could maintain employment-based reinforcement contingencies during employment to ensure that these individuals remain abstinent. If employers could be confident those employees will remain abstinent during employment, this overall model could increase the chances that employers would hire these individuals and provide a sustainable way to maintain therapeutic reinforcement contingencies to maintain drug abstinence and/or medication adherence over time.

This intervention has only been applied in a model research-supported therapeutic workplace. Future research should examine the acceptability and effectiveness of these procedures in community workplaces. Future research will have to assess whether employers will hire individuals with histories of drug addiction and maintain employment-based reinforcement contingencies during employment. Fortunately, an enormous infrastructure and guidelines for workplace drug testing exist that could be coopted to apply employment-based abstinence reinforcement as a therapeutic intervention in workplaces throughout the U.S. The system, overseen by the U.S. Department of Transportation (DOT, 2011), was designed to ensure that employees in safety-sensitive jobs (e.g., trucking) stay drug-free while at work (Cashman et al., 2009). In addition, specialized companies exist that provide drug-free workplace services to companies, including overseeing random workplace drug testing for individuals. A similar system is used for physicians (McLellan et al., 2008; DuPont et al., 2009a; DuPont et al., 2009b). The Federal system has been used throughout the U.S. to protect the public from the hazards associated with drug-impaired workers. Beyond this protective function, our research suggests that the Federal drug testing system could be used therapeutically for a wide range of individuals with drug problems. If employers will hire individuals with histories of drug addiction and then implement random drug testing and employment-based reinforcement contingencies to maintain drug abstinence, future research should evaluate whether such a system can be effective in maintaining employment and drug abstinence over time. If this approach proves effective, it could become accepted as an effective treatment for drug addiction, and supported by governments for low-income individuals and/or by insurance companies. Clearly, the dissemination of employment-based reinforcement contingencies into community workplaces will not be simple. However, in the absence of effective interventions that successfully address the problem of relapse in the years following treatment, research to investigate and facilitate the dissemination of employment-based reinforcement contingencies into community workplaces is warranted, especially considering its success when deployed as a long-term intervention. Importantly, employment-based abstinence reinforcement holds considerable promise as a sustainable intervention as well. Since wages are a standard operating cost for any business, the cost of the intervention during maintenance can be reduced to the cost of the drug testing program.

Conclusions

Relapse is common after all types of treatment, including abstinence reinforcement. We cannot be satisfied when our treatments only produce short-term remission of drug use. Our

treatments should be designed to promote life-long effects. The research reviewed here suggests that reinforcement can maintain long-term abstinence and adherence to addiction medications, and workplaces could be effective vehicles for maintaining those contingencies. Integration of employment-based reinforcement contingencies for drug abstinence and adherence to addiction medications into community workplaces could provide an effective approach to treat chronic drug addiction and prevent relapse over extended periods of time.

Acknowledgments

Preparation of this review was supported by Award Numbers R01DA019386, R01DA019497 R01DA023864 from the National Institute on Drug Abuse. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute on Drug Abuse or the National Institutes of Health.

References

- Adi Y, Juarez-Garcia A, Wang D, Jowett S, Frew E, Day E, et al. Oral naltrexone as a treatment for relapse prevention in formerly opioid-dependent drug users: a systematic review and economic evaluation. *Health Technol Assess.* 2007; 11:iii-iv. 1–85.
- Bigelow, GE.; Silverman, K. Theoretical and empirical foundations of contingency management treatments for drug abuse. In: Higgins, ST.; Silverman, K., editors. *Motivating Behavior Change Among Illicit-Drug Abusers: Research On Contingency Management Interventions.* American Psychological Association; Washington, DC: 1999.
- Carroll ME, Gao Y, Brimijoin S, Anker JJ. Effects of cocaine hydrolase on cocaine self-administration under a PR schedule and during extended access (escalation) in rats. *Psychopharmacology (Berl).* 2011; 213:817–829. [PubMed: 20972552]
- Carroll ME, Comer SD. Animal models of relapse. *Exp Clin Psychopharmacol.* 1996; 4:11–18.
- Cashman CM, Ruotsalainen JH, Greiner BA, Beirne PV, Verbeek JH. Alcohol and drug screening of occupational drivers for preventing injury. *Cochrane Database Syst Rev.* 2009; (2):CD006566. [PubMed: 19370641]
- Cohen M, Bigelow G, Hargett A, Allen R, Halsted C. The Use of Contingency Management Procedures for the Treatment of Alcoholism in a Work Setting. *Alcoholism.* 1973; 9:97–104.
- Collins GT, Narasimhan D, Cunningham AR, Zaks ME, Nichols J, Ko MC, et al. Long-Lasting Effects of a PEGylated Mutant Cocaine Esterase (CocE) on the Reinforcing and Discriminative Stimulus Effects of Cocaine in Rats. *Neuropsychopharmacology.* 2011
- Comer SD, Sullivan MA, Hulse GK. Sustained-release naltrexone: novel treatment for opioid dependence. *Expert Opin Investig Drugs.* 2007; 16:1285–1294.
- Comer SD, Sullivan MA, Yu E, Rothenberg JL, Kleber HD, Kampman K, et al. Injectable, sustained-release naltrexone for the treatment of opioid dependence: a randomized, placebo-controlled trial. *Arch Gen Psychiatry.* 2006; 63:210–218. [PubMed: 16461865]
- Crowley TJ. Doctor's Drug Abuse Reduced During Contingency-Contracting Treatment. *Alcohol and Drug Research.* 1986; 6:299–307. [PubMed: 4091896]
- Dallery J, Silverman K, Chutuape MA, Bigelow GE, Stitzer ML. Voucher-based reinforcement of opiate plus cocaine abstinence in treatment-resistant methadone patients: effects of reinforcer magnitude. *Exp Clin Psychopharmacol.* 2001; 9:317–325. [PubMed: 11534542]
- DeFulio A, Donlin WD, Wong CJ, Silverman K. Employment-based abstinence reinforcement as a maintenance intervention for the treatment of cocaine dependence: a randomized controlled trial. *Addiction.* 2009; 104:1530–1538. [PubMed: 19686522]
- DeFulio A, Everly JJ, Leoutsakos JM, Umbricht A, Fingerhood M, Bigelow GE, et al. Employment-based reinforcement of adherence to an FDA approved extended release formulation of naltrexone in opioid-dependent adults: A randomized controlled trial. *Drug Alcohol Depend.* 2012; 120:48–54. [PubMed: 21782353]

- DeFulio A, Silverman K. Employment-based abstinence reinforcement as a maintenance intervention for the treatment of cocaine dependence: post-intervention outcomes. *Addiction*. 2011; 106:960–967. [PubMed: 21226886]
- Donlin WD, Knealing TW, Needham M, Wong CJ, Silverman K. Attendance rates in a workplace predict subsequent outcome of employment-based reinforcement of cocaine abstinence in methadone patients. *J Appl Behav Anal*. 2008; 41:499–516. [PubMed: 19192855]
- DuPont RL, McLellan AT, Carr G, Gendel M, Skipper GE. How are addicted physicians treated?. A national survey of Physician Health Programs. *J Subst Abuse Treat*. 2009a; 37:1–7. [PubMed: 19482236]
- DuPont RL, McLellan AT, White WL, Merlo LJ, Gold MS. Setting the standard for recovery: Physicians' Health Programs. *J Subst Abuse Treat*. 2009b; 36:159–171. [PubMed: 19161896]
- Dutra L, Stathopoulou G, Basden SL, Leyro TM, Powers MB, Otto MW. A meta-analytic review of psychosocial interventions for substance use disorders. *Am J Psychiatry*. 2008; 165:179–187. [PubMed: 18198270]
- Etter JF, Stapleton JA. Nicotine replacement therapy for long-term smoking cessation: a meta-analysis. *Tob Control*. 2006; 15:280–285. [PubMed: 16885576]
- Everly JJ, DeFulio A, Koffarnus MN, Leoutsakos JM, Donlin WD, Aklon WM, et al. Employment-based reinforcement of adherence to depot naltrexone in unemployed opioid-dependent adults: a randomized controlled trial. *Addiction*. 2011; 106:1309–1318. [PubMed: 21320227]
- Galai N, Safaeian M, Vlahov D, Bolotin A, Celentano DD. ALIVE Study. Longitudinal patterns of drug injection behavior in the ALIVE Study cohort, 1988–2000: description and determinants. *Am J Epidemiol*. 2003; 158:695–704. [PubMed: 14507606]
- Grella CE, Lovinger K. 30-year trajectories of heroin and other drug use among men and women sampled from methadone treatment in California. *Drug Alcohol Depend*. 2011; 118:251–258. [PubMed: 21549528]
- Heil SH, Higgins ST, Bernstein IM, Solomon LJ, Rogers RE, Thomas CS, et al. Effects of voucher-based incentives on abstinence from cigarette smoking and fetal growth among pregnant women. *Addiction*. 2008; 103:1009–1018. [PubMed: 18482424]
- Higgins ST, Delaney DD, Budney AJ, Bickel WK, Hughes JR, Foerg F, et al. A behavioral approach to achieving initial cocaine abstinence. *Am J Psychiatry*. 1991; 148:1218–1224. [PubMed: 1883001]
- Higgins ST, Heil SH, Dantona R, Donham R, Matthews M, Badger GJ. Effects of varying the monetary value of voucher-based incentives on abstinence achieved during and following treatment among cocaine-dependent outpatients. *Addiction*. 2007; 102:271–281. [PubMed: 17222282]
- Higgins ST, Heil SH, Lussier JP. Clinical implications of reinforcement as a determinant of substance use disorders. *Annu Rev Psychol*. 2004; 55:431–461. [PubMed: 14744222]
- Higgins ST, Wong CJ, Badger GJ, Ogden DE, Dantona RL. Contingent reinforcement increases cocaine abstinence during outpatient treatment and 1 year of follow-up. *J Consult Clin Psychol*. 2000; 68:64–72. [PubMed: 10710841]
- Hser YI, Hoffman V, Grella CE, Anglin MD. A 33-year follow-up of narcotics addicts. *Arch Gen Psychiatry*. 2001; 58:503–508. [PubMed: 11343531]
- Hser YI, Huang D, Brecht ML, Li L, Evans E. Contrasting trajectories of heroin, cocaine, and methamphetamine use. *J Addict Dis*. 2008; 27:13–21. [PubMed: 18956525]
- Hser YI, Huang D, Chou CP, Anglin MD. Trajectories of heroin addiction: growth mixture modeling results based on a 33-year follow-up study. *Eval Rev*. 2007; 31:548–563. [PubMed: 17986707]
- Knapp WP, Soares BG, Farrel M, Lima MS. Psychosocial interventions for cocaine and psychostimulant amphetamines related disorders. *Cochrane Database Syst Rev*. 2007; (3):CD003023. [PubMed: 17636713]
- Knealing TW, Wong CJ, Diemer KN, Hampton J, Silverman K. A randomized controlled trial of the therapeutic workplace for community methadone patients: a partial failure to engage. *Exp Clin Psychopharmacol*. 2006; 14:350–360. [PubMed: 16893278]

- Koffarnus MN, Wong CJ, Diemer K, Needham M, Hampton J, Fingerhood M, et al. A randomized clinical trial of a therapeutic workplace for chronically unemployed, homeless, alcohol-dependent adults. *Alcohol Alcohol*. 2011; 46:561–569. [PubMed: 21622676]
- Krupitsky E, Nunes EV, Ling W, Illeperuma A, Gastfriend DR, Silverman BL. Injectable extended-release naltrexone for opioid dependence: a double-blind, placebo-controlled, multicentre randomised trial. *Lancet*. 2011; 377:1506–1513. [PubMed: 21529928]
- Lancaster T, Hajek P, Stead LF, West R, Jarvis MJ. Prevention of relapse after quitting smoking: a systematic review of trials. *Arch Intern Med*. 2006; 166:828–835. [PubMed: 16636207]
- Lumley J, Chamberlain C, Dowswell T, Oliver S, Oakley L, Watson L. Interventions for promoting smoking cessation during pregnancy. *Cochrane Database Syst Rev*. 2009; (3):CD001055. [PubMed: 19588322]
- Lussier JP, Heil SH, Mongeon JA, Badger GJ, Higgins ST. A meta-analysis of voucher-based reinforcement therapy for substance use disorders. *Addiction*. 2006; 101:192–203. [PubMed: 16445548]
- Martin WR, Jasinski DR, Mansky PA. Naltrexone, an antagonist for the treatment of heroin dependence. Effects in man. *Arch Gen Psychiatry*. 1973; 28:784–791. [PubMed: 4707988]
- McLellan AT, Lewis DC, O'Brien CP, Kleber HD. Drug dependence, a chronic medical illness: implications for treatment, insurance, and outcomes evaluation. *JAMA*. 2000; 284:1689–1695. [PubMed: 11015800]
- McLellan AT, Skipper GS, Campbell M, DuPont RL. Five year outcomes in a cohort study of physicians treated for substance use disorders in the United States. *BMJ*. 2008; 337:a2038. [PubMed: 18984632]
- Mello NK, Mendelson JH, Bree MP. Naltrexone effects on morphine and food self-administration in morphine-dependent rhesus monkeys. *J Pharmacol Exp Ther*. 1981; 218:550–557. [PubMed: 7195937]
- Milby JB, Schumacher JE, Raczynski JM, Caldwell E, Engle M, Michael M, et al. Sufficient conditions for effective treatment of substance abusing homeless persons. *Drug Alcohol Depend*. 1996; 43:39–47. [PubMed: 8957141]
- Miller PM, Hersen M, Eisler RM, Watts JG. Contingent reinforcement of lowered blood-alcohol levels in an outpatient chronic alcoholic. *Behav Res Ther*. 1974; 12:261–263. [PubMed: 4139949]
- Minozzi S, Amato L, Vecchi S, Davoli M, Kirchmayer U, Verster A. Oral naltrexone maintenance treatment for opioid dependence. *Cochrane Database Syst Rev*. 2006; (1):CD001333. [PubMed: 16437431]
- Petry NM, Tedford J, Austin M, Nich C, Carroll KM, Rounsaville BJ. Prize reinforcement contingency management for treating cocaine users: how low can we go, and with whom? *Addiction*. 2004; 99:349–360. [PubMed: 14982548]
- Pilling S, Strang J, Gerada C. NICE. Psychosocial interventions and opioid detoxification for drug misuse: summary of NICE guidance. *BMJ*. 2007; 335:203–205. [PubMed: 17656545]
- Preston KL, Silverman K, Schuster CR, Cone EJ. Assessment of cocaine use with quantitative urinalysis and estimation of new uses. *Addiction*. 1997; 92:717–727. [PubMed: 9246799]
- Preston KL, Umbricht A, Epstein DH. Abstinence reinforcement maintenance contingency and one-year follow-up. *Drug Alcohol Depend*. 2002; 67:125–137. [PubMed: 12095662]
- Roozen HG, de Waart R, van der Windt DA, van den Brink W, de Jong CA, Kerkhof AJ. A systematic review of the effectiveness of naltrexone in the maintenance treatment of opioid and alcohol dependence. *Eur Neuropsychopharmacol*. 2006; 16:311–323. [PubMed: 16361086]
- Schuster CR, Thompson T. Self administration of and behavioral dependence on drugs. *Annu Rev Pharmacol*. 1969; 9:483–502. [PubMed: 4978013]
- Sees KL, Delucchi KL, Masson C, Rosen A, Clark HW, Robillard H, et al. Methadone maintenance vs 180-day psychosocially enriched detoxification for treatment of opioid dependence: a randomized controlled trial. *JAMA*. 2000; 283:1303–1310. [PubMed: 10714729]
- Shah NG, Galai N, Celentano DD, Vlahov D, Strathdee SA. Longitudinal predictors of injection cessation and subsequent relapse among a cohort of injection drug users in Baltimore, MD, 1988–2000. *Drug Alcohol Depend*. 2006; 83:147–156. [PubMed: 16364568]

- Shoptaw S, Rotheram-Fuller E, Yang X, Frosch D, Nahom D, Jarvik ME, et al. Smoking cessation in methadone maintenance. *Addiction*. 2002; 97:1317–28. discussion 1325. [PubMed: 12359036]
- Silverman K. Exploring the limits and utility of operant conditioning in the treatment of drug addiction. *The Behavior Analyst*. 2004; 27:209. [PubMed: 22478430]
- Silverman K, Chutuape MA, Bigelow GE, Stitzer ML. Voucher-based reinforcement of cocaine abstinence in treatment-resistant methadone patients: effects of reinforcement magnitude. *Psychopharmacology (Berl)*. 1999; 146:128–138. [PubMed: 10525747]
- Silverman K, Chutuape MA, Svikis DS, Bigelow GE, Stitzer ML. Incongruity between occupational interests and academic skills in drug abusing women. *Drug Alcohol Depend*. 1995; 40:115–123. [PubMed: 8745133]
- Silverman, K.; DeFulio, A.; Everly, JJ. Wolters Kluwer. Ruiz, P.; Strain, EC., editors. Lipponcott Williams & Wilkins; Philadelphia, PA: 2011. p. 88
- Silverman K, Higgins ST, Brooner RK, Montoya ID, Cone EJ, Schuster CR, et al. Sustained cocaine abstinence in methadone maintenance patients through voucher-based reinforcement therapy. *Arch Gen Psychiatry*. 1996; 53:409–415. [PubMed: 8624184]
- Silverman K, Robles E, Mudric T, Bigelow GE, Stitzer ML. A randomized trial of long-term reinforcement of cocaine abstinence in methadone-maintained patients who inject drugs. *J Consult Clin Psychol*. 2004; 72:839–854. [PubMed: 15482042]
- Silverman, K.; Stitzer, ML.; Bigelow, GE. Treatment of cocaine abuse in methadone patients. In: Higgins, ST.; Katz, JL., editors. *Cocaine Abuse: Behavior, Pharmacology, and Clinical Applications*. Academic Press, Inc; San Diego, CA: 1998. p. 363-388.
- Silverman K, Svikis D, Robles E, Stitzer ML, Bigelow GE. A reinforcement-based therapeutic workplace for the treatment of drug abuse: six-month abstinence outcomes. *Exp Clin Psychopharmacol*. 2001; 9:14–23. [PubMed: 11519628]
- Silverman K, Svikis D, Wong CJ, Hampton J, Stitzer ML, Bigelow GE. A reinforcement-based therapeutic workplace for the treatment of drug abuse: three-year abstinence outcomes. *Exp Clin Psychopharmacol*. 2002; 10:228–240. [PubMed: 12233983]
- Silverman K, Wong CJ, Grabinski MJ, Hampton J, Sylvest CE, Dillon EM, et al. A web-based therapeutic workplace for the treatment of drug addiction and chronic unemployment. *Behav Modif*. 2005; 29:417–463. [PubMed: 15657415]
- Silverman K, Wong CJ, Higgins ST, Brooner RK, Montoya ID, Contoreggi C, et al. Increasing opiate abstinence through voucher-based reinforcement therapy. *Drug Alcohol Depend*. 1996; 41:157–165. [PubMed: 8809505]
- Silverman K, Wong CJ, Umbricht-Schneiter A, Montoya ID, Schuster CR, Preston KL. Broad beneficial effects of cocaine abstinence reinforcement among methadone patients. *J Consult Clin Psychol*. 1998; 66:811–824. [PubMed: 9803700]
- Stitzer ML, Bigelow GE. Contingent reinforcement for carbon monoxide reduction: within-subject effects of pay amount. *J Appl Behav Anal*. 1984; 17:477–483. [PubMed: 6526768]
- Stitzer ML, Bigelow GE. Contingent payment for carbon monoxide reduction: Effects of pay amount. *Behavior therapy*. 1983; 14:647.
- Stitzer ML, Bigelow GE, Liebson I. Reducing drug use among methadone maintenance clients: contingent reinforcement for morphine-free urines. *Addict Behav*. 1980; 5:333–340. [PubMed: 7211531]
- Stitzer ML, Bigelow GE, Liebson IA, Hawthorne JW. Contingent reinforcement for benzodiazepine-free urines: evaluation of a drug abuse treatment intervention. *J Appl Behav Anal*. 1982; 15:493–503. [PubMed: 6130059]
- Tonstad S, Tonnesen P, Hajek P, Williams KE, Billing CB, Reeves KR, et al. Effect of maintenance therapy with varenicline on smoking cessation: a randomized controlled trial. *JAMA*. 2006; 296:64–71. [PubMed: 16820548]
- Vaillant GE. A 60-year follow-up of alcoholic men. *Addiction*. 2003; 98:1043–1051. [PubMed: 12873238]
- Vaillant GE. A 20-year follow-up of New York narcotic addicts. *Arch Gen Psychiatry*. 1973; 29:237–241. [PubMed: 4741515]

- Veilleux JC, Colvin PJ, Anderson J, York C, Heinz AJ. A review of opioid dependence treatment: pharmacological and psychosocial interventions to treat opioid addiction. *Clin Psychol Rev.* 2010; 30:155–166. [PubMed: 19926374]
- Walsh SL, Sullivan JT, Preston KL, Garner JE, Bigelow GE. Effects of naltrexone on response to intravenous cocaine, hydromorphone and their combination in humans. *J Pharmacol Exp Ther.* 1996; 279:524–538. [PubMed: 8930154]
- Winett RA. Parameters of deposit contracts in the modification of smoking. *The Psychological Record.* 1973; 23:49–60.

HIGHLIGHTS

- Drug addiction can be a chronic problem and often recurs after all types of treatment.
- Abstinence reinforcement is very effective, but many patients relapse after it ends.
- Therapeutic reinforcement may need to be maintained indefinitely to prevent relapse.
- Employment-based reinforcement can maintain abstinence and medication use.
- Workplaces could be effective vehicles to maintain therapeutic reinforcement.

Fig 1. Percentage of cocaine-negative urine samples based on monthly urine samples collected from 18 to 36 months after treatment entry for the Usual Care Control (left) and Therapeutic Workplace (right) groups. Dots represent data for individual participants and the horizontal lines represent group means. Missing samples are considered-cocaine positive. The study was conducted in Baltimore, MD from October 1996 to January 2001. The figure is adapted from Fig. 1 in Silverman et al. (2002). *Experimental and Clinical Psychopharmacology*, 10, 234.

Fig 2.

Percentage of minutes worked in the induction period for individual participants grouped according to the “responder” or “non-responder” designation. Dots represent individual participant values, and bars represent group means. Participants were considered responders if they achieved 3 weeks of sustained cocaine abstinence during the intervention period. The induction period data includes data from the first 20 days of the induction period. The study was conducted in Baltimore, MD from October 2003 to August 2006. Reprinted with permission from Donlin et al. (2008). *Journal of Applied Behavior Analysis*, 41, 515.

Fig 3.

Cocaine urinalysis results at intake, end of phase 1, and across consecutive months during the intervention (phase 2). Within each panel, rows of data represent the cocaine urinalysis results for individual participants. Filled squares indicate cocaine-negative urine samples, and open squares indicate cocaine-positive urine samples. Empty sections indicate missing samples. Within each panel, participants are arranged from those showing the least abstinence (fewest cocaine-negative urine samples) on the bottom to those with the most abstinence on the top. The study was conducted in Baltimore, MD from October 2003 to August 2007. Reprinted with permission from DeFulio et al. (2009). *Addiction*, 104, 534.

Fig 4.

Percent of cocaine-negative samples collected at intake (Study Month 0), the end of the abstinence initiation and training phase (Study Month 6), during employment (Study Months 12 and 18), and at post-treatment follow-up (Study Months 24 and 30). Missing samples were counted as positive. The asterisk indicates that the groups are significantly different ($p < .05$) based on a GEE analysis. The study was conducted in Baltimore, MD from October 2003 to August 2008. Reprinted with permission from DeFulio and Silverman (2011). *Addiction*. 106, 963.

Fig. 5.

The percentage of participants retained in extended-release naltrexone treatment (continued to take scheduled injections; top panel) and the therapeutic workplace (continued attending the workplace; bottom panel) across study weeks. The study was conducted in Baltimore, MD from September 2008 to April 2010. Reprinted with permission from DeFulio et al. (2012). *Drug and Alcohol Dependence*. 120, 51.

Table 1

Studies that have experimentally evaluated the therapeutic workplace intervention and employment-based reinforcement to promote drug abstinence or adherence to addiction medication.^a

Citation	Population of Unemployed Drug Users	Study N	Control Condition	Primary Outcome Assessed				
				Outcome Measure	Study Months Included	Control Result (%)	Intervention Result (%)	p value
Promoting Drug Abstinence								
Silverman et al., (2001, 2002)	Pregnant and Postpartum Women Who Used Cocaine and/or Heroin during Methadone Treatment	40	Usual Care Control	Cocaine-Negative Urinalysis Every M, W, F	1 – 6	32	54	0.042
				Cocaine-Negative Urinalysis Every 30-days	18 – 36	28	54	0.040
Knealing et al., (2006)	Cocaine-Dependent Welfare Eligible Adults Who Used Crack Cocaine During Methadone Treatment	47	Usual Care Control	Cocaine-Negative Urinalysis Every 30-days	1 – 9	22	27	0.560
Silverman et al., (2007)	Injection Drug Users in Who Used Cocaine During Methadone Treatment	56	Work Only	Cocaine-Negative Urinalysis Every M, W, F	2 – 7	10	29	0.004
Donlin et al., (2008)	Cocaine-Dependent Welfare Recipients Who Used Cocaine During Methadone Treatment-Cohort 1	67	Work Only	Cocaine-Negative Urinalysis Every M, W, F	1 – 6	23	49	<0.001
	Cocaine-Dependent Welfare Recipients Who Used Cocaine During Methadone Treatment-Cohort 2	44	Work Only	Cocaine-Negative Urinalysis Every M, W, F	1 – 6	9	31	<0.001
DeFulio et al., (2009, 2011)	Cocaine-Dependent Welfare Recipients Who Used Cocaine During Methadone Treatment and then Became Abstinent & Skilled in the Therapeutic Workplace (from Donlin et al study)	51	Employment Only	Cocaine-Negative Urinalysis Every 30-days	7–18	51	79	0.004
				Cocaine-Negative Urinalysis Every 6 Months After Intervention	24–30	50	44	0.930
Kofamus et al., (2011)	Alcohol-Dependent Homeless Adults	124	Work Only	Alcohol-Negative Breath Samples at Random Twice Weekly Assessments	2 – 7	58	76	0.030
			No Voucher	Alcohol-Negative Breath Samples at Random Twice	2 – 7	74	76	0.620

Citation	Population of Unemployed Drug Users	Study N	Control Condition	Primary Outcome Assessed				p value
				Outcome Measure	Study Months Included	Control Result (%)	Intervention Result (%)	
Weekly Assessments								
Promoting Medication Adherence								
Everly et al., (2011)	Opioid-Dependent Heroin Users not Interested in Methadone Treatment	35	Prescription	Naltrexone Adherence (6 injections)	1 – 6	42	81	0.008
DeFulio et al., (2012)	Opioid-Dependent Heroin Users not Interested in Methadone Treatment	38	Prescription	Naltrexone Adherence (6 injections)	1 – 6	52	87	0.002

^a All studies were conducted in Baltimore, MD from 1996 through 2010.