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EFFECTS OF AN INTERNET-BASED VOUCHER REINFORCEMENT PROGRAM FOR SMOKING ABSTINENCE: A FEASIBILITY STUDY

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The present study tested the feasibility of an Internet-based method to obtain objective evidence of smoking abstinence and to deliver vouchers for evidence of abstinence. Four heavy smokers participated in this 4-week study. Twice daily, participants made video recordings of themselves providing a breath carbon monoxide (CO) sample with a Web camera. The video was sent electronically to the smoking clinic. Participants could earn vouchers for gradual reductions in breath CO during an initial shaping condition, and then for achieving abstinence (CO $\leq$ 4 ppm). Vouchers could be exchanged for merchandise at select Internet vendors. Relative to baseline conditions, participants substantially reduced their smoke intake, and 3 achieved sustained periods of abstinence. The study suggests that an Internet-based voucher reinforcement program is a feasible method to promote abstinence from cigarette smoking.

DESCRIPTORS: cigarette smoking, drug abstinence, reinforcement, nicotine, vouchers

Voucher reinforcement therapy is an effective method to promote abstinence from cigarette smoking (Corby, Roll, Ledgerwood, & Schuster, 2000; Lamb, Kirby, Morral, Galbicka, & Iguchi, 2004; Rand, Stitzer, Bigelow, & Mead, 1989; Roll & Higgins, 2000; Roll, Higgins, & Badger, 1996; Shoptaw, Jarvik, Ling, & Rawson, 1996; Stitzer & Bigelow, 1984, 1985; Tidey, O'Neill, & Higgins, 2002). Vouchers have monetary value, and they are delivered for objective evidence of abstinence. Usually, abstinence is measured by breath carbon monoxide (CO) output. Because the authenticity of CO results must be verified, participants must travel to a clinic (Corby et al.; Lamb et al.; Rand et al.), or clinic staff must make home visits to observe the sampling procedure (Crowley, MacDonald, Zerbe, & Petty, 1991). In addition, CO samples are often obtained several times per day to provide a reliable index of abstinence. Thus, although breath CO is an immediate, noninvasive method to assess smoking status, in practice CO sampling entails response effort that may limit the accessibility and success of voucher reinforcement for smoking cessation. The purpose of the present study was to test the feasibility of an Internet-based method to obtain COs on a frequent and sustained basis.

Frequent sampling is required because CO is expelled rapidly from the body; breath CO has a half-life of 6 to 8 hr (Jarvis, Tunstall-Pedoe, Feyerabend, Vesey, & Saloojee, 1987). Schuh and Stitzer (1995) described the time course of changes in CO with abstinence. Ten participants smoked ad lib for 15 min before the experimental session. After smoking, their average CO output was 30 parts per million (ppm). After 6 hr of abstinence, their average CO fell to 13.8 ppm. Other studies have attempted to distinguish smokers from nonsmokers based on CO output, and have suggested cutoff CO values ranging from 6 to 8 ppm (Jarvis et al.; Middleton & Morice, 2000). Middleton and Morice's cutoff value of 6 ppm detected 94% of smokers and 96% of nonsmokers. In voucher reinforcement programs, the most common criteria for abstinence were 11 ppm (Corby et al., 2000; Rand et al., 1989; Roll et al., 1996; Stitzer, Rand, Bigelow,

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& Mead, 1986; Tidey et al., 2002) and 8 ppm (Gilbert, Crauthers, Mooney, McClernon, & Jensen, 1999; Roll & Higgins, 2000; Stitzer & Bigelow, 1984). More recently, Lamb et al. (2004) and Alessi, Badger, and Higgins (2004) used a cutoff of 4 ppm, which is the most rigorous criterion used to date.

Based on these cutoff values, and the time course of CO with abstinence, it would be prudent to collect samples twice per day to generate an accurate profile of smoking status. If samples were collected only once per day, for example, a smoker could probably smoke throughout most of the day, submit a CO of 30 ppm at 5:00 p.m., expect the CO to fall to about 13 ppm by 11:00 p.m., and then wake up in the morning and expect to provide a sample below 6 to 8 ppm (Schuh & Stitzer, 1995). This and similar patterns of use may represent reductions in overall smoking, but the measurement procedure would not provide a valid index of longer term abstinence. A more valid method would be to collect two CO samples on a daily basis, and require some minimum duration between the samples. At the very least, providing vouchers for two samples per day rather than one should produce larger reductions in smoking.

However, as noted above, frequent sampling for a sustained duration presents significant challenges (Corby et al., 2000; Crowley et al., 1991; Lamb et al., 2004; Rand et al., 1996; Roll & Higgins, 2000; Roll et al., 1996; Shoptaw et al., 1996; Stitzer & Bigelow, 1984, 1985). First, there is a significant response effort associated with participants making daily visits to a clinic or staff traveling to participants' homes. It is likely that such costs would compete with the benefits of the voucher intervention. Second, traveling to a clinic to deliver samples may restrict access to the treatment, particularly if the clinic is far away or if the individual is disabled. Third, most clinics are open only during workdays, and thus visits could occur only for 5 of 7 days.

To circumvent the obstacles associated with CO sampling, we have developed an Internet-based method to obtain CO samples from participants' homes. Also, our study Web site provided participants with access to cessation techniques, an individualized home page for each participant (which included a graph of each participant's progress), and other tobacco-related resources. The goals of the current study were to establish that the method was feasible, to identify potential problems with the method, and to assess the effectiveness of the program in reducing smoking in a small sample of smokers.

METHOD

Participants

Participants were 4 healthy smokers recruited through newspaper advertisements and flyers posted in the community. Demographic characteristics are presented in Table 1. To qualify for the study, participants were required to be between the ages of 18 and 60, to be a heavy smoker ($\geq$20 cigarettes per day by self-report, CO at intake $\geq$20 ppm), to report a minimum 2-year smoking history, and to express some desire to quit smoking. Applicants were excluded if they lived with another smoker who smoked inside the home, showed evidence of current alcohol dependence or drug use (verified by urinalysis for cocaine, benzodiazepines, and opiates), or reported a history of medical or psychiatric illness that, in our judgment, would interfere with the study. Qualifying participants signed an informed consent that described the study procedures in detail (including the phases of the study, total earnings possible, etc.), and comprehension was tested by requiring a score of at least 80% on a quiz about the consent. The local institutional review board approved all study procedures.

Materials

The home-based monitoring system consisted of a laptop (Gateway, M305), a Web

Table 1
Demographic Characteristics of Study Participants

Participant	Age	Gender	Ethnicity	Weekly income	Cigarettes per day	Years smoking
C0037	47	M	W	$501–600	40	30
P0038	47	F	W	$401–500	20	27
H0040	20	M	W	$100–200	20	8
B0042	42	F	B	$601–700	20	25

camera (Logitech, QuickCam 8.0), a CO monitor (Bedfont piCO Smokerlyzer), and an Internet provider (America On-Line 8.0); for security purposes, a computer-tracking device (Stealth Signal) was installed in each laptop. All equipment was loaned to participants. The CO reading was displayed in parts per million by illumination of a series of light-emitting diodes (LEDs) on the front panel of the monitor. Each LED corresponded to 1 ppm, and the monitor could read up to 80 ppm. Thus, if 10 LEDs were illuminated, the CO level was 10 ppm. Also, the numbers corresponding to the CO level were backlit by the LEDs, such that one had to simply read the number associated with the highest LED illuminated.

CO Monitoring

Research technicians set up the equipment, and they explained the monitoring procedure before the study commenced. There were four essential elements of the sampling procedure. First, participants were required to e-mail two video clips per day, and they had to be separated by at least 8 hr. Second, each video clip had to show that the CO monitor was set at zero before the participant provided a sample. Third, the video clip had to show the participant exhaling fully into the monitor, and a hiss from the monitor during the exhalation had to be audible for at least 4 s. Fourth, the final CO reading had to be visible.

Once the participant was ready to leave a sample, he or she started the software associated with the camera. The participant pressed a button labeled ''record,'' and then pressed a start button on the CO monitor. Fifteen LEDs were illuminated on the monitor, and then each was extinguished over the course of 15 s. This was the initial countdown during which participants were instructed to inhale deeply, and then hold their breath for the duration of the countdown. At the end of the 15 s, a single LED started to flash. The flashing LED signaled that the monitor was ready for operation. The front panel of the monitor, and the participant, faced the camera. Thus, it was easy to detect that the monitor was set at zero and ready for operation. After the participant exhaled into the monitor, the appropriate number of LEDs were illuminated. For example, if the participant had just smoked, then perhaps 25 LEDs in the left column of LEDs would be illuminated. Also, the LEDs below the final reading turned off to signal the final reading (i.e., the lights below the 25th LED were extinguished). Once the appropriate LED flashed, the sampling procedure was complete and the participant pressed a button to stop the video recording. The sample was sent immediately to research technicians by pressing a button labeled ''e-mail'' in the camera software. The sampling procedure required about 35 to 45 s from start to finish.

All video clips, and attempts to alter them, were automatically date and time stamped by Microsoft Windows®. Participants were informed that any attempt to falsify a sample would be easily detected, and that they could be dismissed from the study if attempts were detected. Participants were also blocked from altering the date and time on the laptop by restricting them from administrative options. (However, as will be discussed below, participants with sophisticated computer abilities could circumvent these restrictions.)

The study Web site contained a Web page for each participant. Each page showed a graph of the participant's CO results, a statement of cumulative voucher earnings, and a link to a page that listed the vendors at which the vouchers could be redeemed. The site also provided a list of smoking-cessation Web sites and health-related information.

Vouchers could only be used at specified Internet vendors (e.g., amazon.com). Once a participant found an item he or she wished to purchase, the participant e-mailed the description of the item to research staff. If the participant's cumulative earnings were sufficient, then the item was purchased. Research staff delivered items to participants. Purchases were limited in that participants could not buy firearms, weapons, drugs, or alcohol. Participants typically received their items within 1 to 2 weeks of placing an order.

Interobserver agreement was obtained by having an independent observer watch 50% of the videos at the completion of the study to obtain a CO reading. These readings were then compared to the readings obtained during the study by the primary observer. Interobserver agreement was calculated by dividing the number of agreements by the number of agreements and disagreements and multiplying this number by 100%. Agreement was 98%. In no case did the discrepancy between the primary observer and the secondary observer result in participants being considered abstinent or nonabstinent when they had been judged nonabstinent or abstinent during the study.

Experimental Design and Conditions

Baseline. A concurrent multiple baseline reversal design was employed. During the first several days of the procedure, participants earned $5 per day if they sent two samples per day. There were no contingencies with regard to the CO value. This was the baseline condition. The duration of the baseline condition varied across participants. The duration for the first participant was six samples and then increased by four samples for each subsequent participant.

Shaping. Then, participants earned $3 for specified reductions in CO for 4 days. The reductions were determined as follows: First, the average CO during baseline was determined. Then, we calculated progressively lower CO values such that in over eight samples the CO would be ≤4 ppm. For example, if the average baseline CO was 32 ppm, then each successive sample would have to be 4 ppm lower than the previous sample. That way, at the end of this 4-day condition, the CO was required to be below our criterion for abstinence, which was defined as ≤4 ppm. This phase was included to increase the likelihood that participants would contact the programmed reinforcers.

Abstinence induction. During the next 10 days, participants could earn vouchers for evidence of abstinence. The first CO sample ≤4 ppm resulted in a $3 voucher. The value increased by $0.25 for each successive negative sample. Bonus vouchers ($5) were delivered for each third consecutive negative sample. If a participant failed to submit a sample without notifying research staff or submitted a positive sample, the value of the next voucher was reset to $3 (Higgins et al., 1991). After three consecutive negative samples following a reset, the value of the vouchers returned to the highest value previously obtained. According to this schedule, participants had progressively more to gain by continued abstinence and more to lose if they lapsed. This schedule of voucher earnings was modeled after other studies that have been effective in promoting abstinence (Roll & Higgins, 2000; Roll et al., 1996).

Thinning. Subsequently, for 4 days participants could earn $5 for their fourth and eighth samples if they were negative. The other COs were simply collected; no contingency was imposed on these samples. This phase was included so that participants would not experience an immediate cessation of earning contingent vouchers.

Return to baseline. Finally, the last 5 days were identical to the baseline condition, with the exception that the duration of the condition was held constant across participants.

Each participant could earn a maximum of $171.50 in voucher earnings if he or she was abstinent for the duration of the study. In addition, each participant received $100 for completing the study.

RESULTS

The CO values across all conditions are displayed in Figure 1. Three of the 4 participants produced CO values during abstinence induction, thinning, and return to baseline that met the CO criterion, and they achieved some sustained period of abstinence. Relative to baseline, abstinence induction produced average reductions of 82% (P0038), 67% (B0042), 65% (H0040), and 32% (C0037) in breath CO output. C0037's experienced significant family-related stress, the beginning of which is indicated by the asterisk in Figure 1.

In terms of missing samples, P0038 missed one, B0042 missed one, H0040 missed three, and C0037 missed seven. The total amount each participant earned in vouchers was $14 (C0037), $156 (P0038), $163.50 (H0040), and $55 (B0042).

DISCUSSION

The present study suggests that an Internet-based voucher program is a feasible method to obtain objective evidence of abstinence and to deliver voucher reinforcement. The system allowed us to obtain CO samples twice per day 7 days per week for approximately 4 weeks. After the system was in place, it was easy to collect two samples per day via e-mail. It was also simple to visually detect that the monitor was set at zero and that the participant was exhaling into the mouthpiece. The procedure was clearly visible, and the CO monitor generated an audible hiss when air passed through the mouthpiece. Thus, the sampling procedure provided objective evidence that the participant was exhaling through the monitor and that the reading was valid.

The home-based system obviated many of the logistical problems entailed by frequent CO monitoring, and voucher reinforcement produced substantial reductions in smoking in this small sample of heavy smokers. Although it is possible that the monitoring procedure alone or some other factor contributed to the reductions in smoking (e.g., see the reduction during baseline for P0038), 3 of 4 participants reduced smoking only during the 18-day voucher period, and they sustained long periods of abstinence. In previous studies that used a 1-week reinforcement phase, the percentages of negative COs during the intervention were 54% (Roll, Higgins, Steingard, & McGinley, 1998) and 69% (Roll & Higgins, 2000). Corby et al. (2000) achieved 96% negative samples in adolescent smokers over a 5-day period. In the current study, 7% of COs were negative during baseline, and 60% were negative during abstinence induction. Thus, despite the longer treatment duration in the current study, the present results are comparable to other voucher-based studies of smoking cessation.

Participants could have attempted to falsify the results in two ways: (a) by modulating the way they blew into the mouthpiece or (b) by manipulating the electronic data before it was e-mailed to the clinic. As just described, however, it was not possible for participants to modulate the way they blew into the monitor without obvious visual and auditory evidence that they were doing so. The CO monitor made an audible hiss as the participant blew through it, which lasted for a minimum of 4 s. Nevertheless, it would be desirable to collect salivary cotinine (a metabolite of nicotine) samples to verify the validity of the CO samples.

In terms of the electronic data, participants could have tried to modify the date and time associated with the video clip. In the present

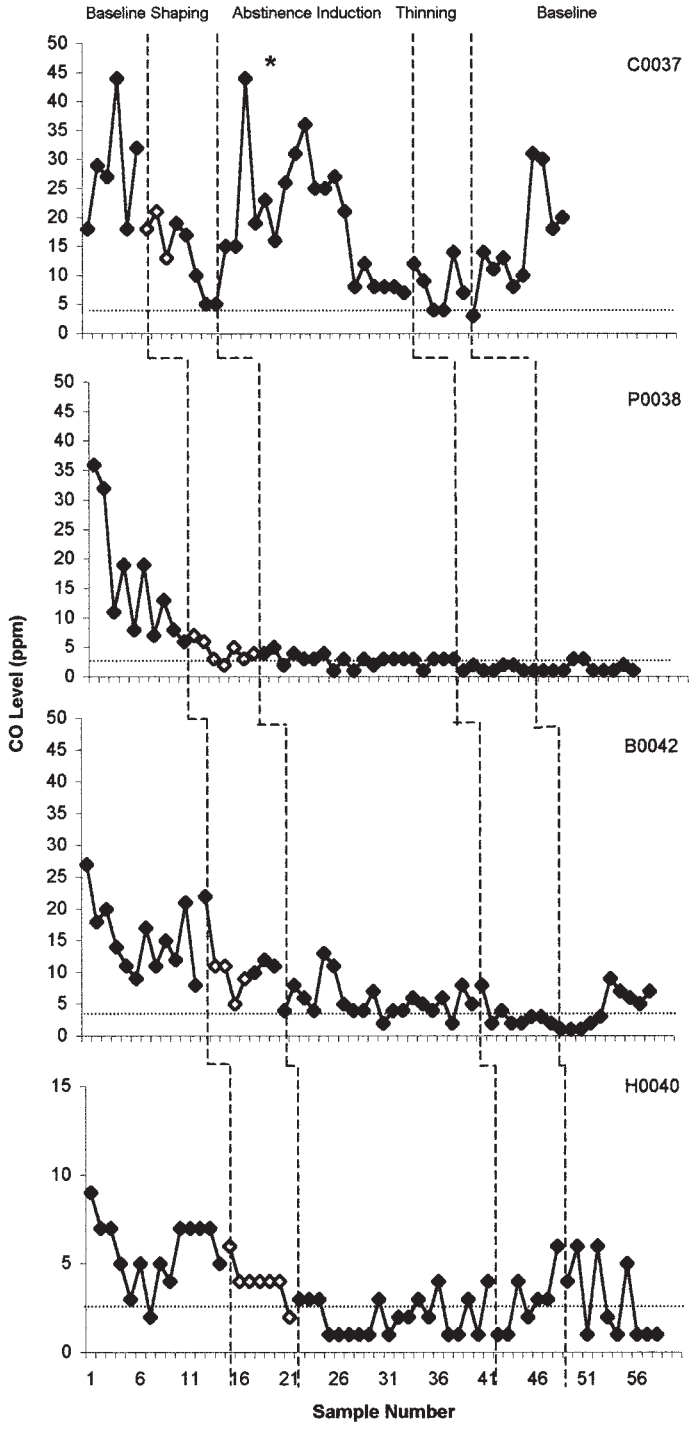

Figure 1. CO (ppm) values for all participants across baseline, shaping, abstinence induction, thinning, and return to baseline. The dashed horizontal line marks a reading of 4 ppm (4 ppm or below is considered abstinent). The open circles in the shaping condition indicate when the shaping criteria were met. The asterisk indicates the day when C0037 started to experience significant family-related stress. Note that Participant H0040 has a different *y* axis.

study, a laptop was loaned to each participant. Participants were blocked from modifying the date and time once they were logged into the computer. However, there are commands that could circumvent this difficulty. Yet even if a participant could change the date and time stamp, he or she would still need to stop smoking in order to provide breath COs of 4 ppm or below. Then he or she would have to record multiple videos at once and change clothes after every two readings (so it would not be obvious to the observer that all videos were taken on the same day). Our close scrutiny of the video clips and of the properties of the video file yielded no evidence that any of the participants modified the electronic data.

Nonetheless, future studies should test more foolproof methods to collect CO samples. For example, we are developing a method to collect samples through an online database. In this method, participants will log in to a Web site to upload their videos. After log-in, the server will generate a random string of letters and numbers and record the date and time the string was generated. The string will be displayed clearly on the site and thus on the participants' computer screens. Participants will be required to show this random string in their video clip. Then, the experimenter can check the database to verify the time a particular string was generated. The date and time associated with the string can be compared easily to the date and time at which the sample was sent to the clinic. A significant advantage of this method is that participants can use their own computers, which would minimize the expense of the monitoring system.

Furthermore, the Internet-based treatment could be tailored in a variety of ways to promote abstinence. For example, the magnitude of voucher reinforcers could be increased, or the treatment could be used in conjunction with other pharmacological interventions such as nicotine replacement devices (e.g., Tidey et al., 2002). Behavioral plus pharmacological treatments may produce additive treatment gains (Stitzer, 1999). In addition, computer-based and Web-assisted tobacco interventions for smoking are receiving increased attention by researchers and clinicians (e.g., Feil, Noell, Lichtenstein, Boles, & McKay, 2003; Meis et al., 2002; Riley, Jerome, Behar, & Weil, 2002; Woodruff, Edwards, Conway, & Elliot, 2001). It should be possible to export the voucher-based treatment into other web-based cessation programs, thereby reaching a large number of smokers (Feil et al.). Indeed, the portability of the home-based system entails significant benefits in terms of accessibility and dissemination. Future studies may also examine the possibility of using handheld computers with built-in cameras as one means of reducing the cost of the current program. Along these lines, a system similar to the present one could also be applied to alcohol abstinence or weight loss.

The development of the Internet-based voucher program will follow the same development as other voucher-based treatments for drug dependence. The efficacy of the treatment was firmly established under rigorous conditions, first with primary cocaine-dependent patients (Higgins et al., 1994) and then with other drug classes (e.g., Budney, Higgins, Radonovich, & Novy, 2000; Dallery, Silverman, Chutuape, Bigelow, & Stitzer, 2001; Petry, Martin, Cooney, & Kranzler, 2000; Silverman et al., 1996). Similarly, we intend to test the efficacy of the Internet-based intervention and then refine the treatment.

Researchers are also exploring more cost-effective methods of treatment delivery (e.g., Amass & Kamien, 2004; Petry et al., 2000; Silverman, Svikis, Robles, Stitzer, & Bigelow, 2001). For example, Amass and Kamien assessed the effects of soliciting donations for use in a voucher program for drug users in two cities. In Toronto, $8,000 was collected in 2 months, and in Los Angeles, $161,000 was donated over the course of 34 months. There may be a number of funding sources for

voucher programs for smoking abstinence, such as employers and insurance companies. Patients could even contribute their own money and then earn it back for evidence of abstinence. Before we can fully explore these options and extend the treatment to clinical settings, it will be necessary to determine more thoroughly which parameters of the program will maximize treatment gains and minimize financial costs.

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