Original Investigation

A Randomized Trial of Computer-Delivered Brief Intervention and Low-Intensity Contingency Management for Smoking During Pregnancy

Steven J. Ondersma, Ph.D.,^{1,2} Dace S. Svikis, Ph.D.,^{3,4,5} Phebe K. Lam, Ph.D.,⁶ Veronica S. Connors-Burge, M.Ed.,⁶ David M. Ledgerwood, Ph.D.,² & John A. Hopper, MD⁶

¹ Merrill Palmer Skillman Institute, Wayne State University, Detroit, MI

² Department of Psychiatry and Behavioral Neurosciences, Wayne State University, Detroit, MI

³ Department of Psychology, Virginia Commonwealth University, Richmond, VA

⁴ Department of Psychiatry, Virginia Commonwealth University, Richmond, VA

⁵ Department of Obstetrics/Gynecology, Virginia Commonwealth University, Richmond, VA

⁶ Department of Pediatrics, Wayne State University, Detroit, MI

Corresponding Author: Steven J. Ondersma, Wayne State University, 71 East Ferry Avenue, Detroit, MI 48202, USA.
Telephone: 313-577-6680; Fax: 313-993-1372; E-mail: s.ondersma@wayne.edu

Received February 22, 2011; accepted August 23, 2011

Abstract

Introduction: Implementation of evidence-based interventions for smoking during pregnancy is challenging. We developed 2 highly replicable interventions for smoking during pregnancy: (a) a computer-delivered 5As-based brief intervention (CD-5As) and (b) a computer-assisted, simplified, and low-intensity contingency management (CM-Lite).

Methods: A sample of 110 primarily Black pregnant women reporting smoking in the past week were recruited from prenatal care clinics and randomly assigned to CD-5As ($n = 26$), CM-Lite ($n = 28$), CD-5As plus CM-Lite ($n = 30$), or treatment as usual ($n = 26$). Self-report of smoking, urine cotinine, and breath CO were measured 10 weeks following randomization.

Results: Participants rated both interventions highly (e.g., 87.5% of CD-5As participants reported increases in likelihood of quitting), but most CM-Lite participants did not initiate reinforcement sessions and did not show increased abstinence. CD-5As led to increased abstinence as measured by cotinine (43.5% cotinine negative vs. 17.4%; odds ratio [OR] = 10.1, $p = .02$) but not for CO-confirmed 7-day point prevalence (30.4% abstinent vs. 8.7%; OR = 5.7, $p = .06$). Collapsing across CM-Lite status, participants receiving the CD-5As intervention were more likely to talk to a doctor or nurse about their smoking (60.5% vs. 30.8%; OR = 3.0, $p = .02$).

Conclusions: Low-intensity participant-initiated CM did not affect smoking in this sample, but the CD-5As intervention was successful in increasing abstinence during pregnancy. Further research should seek to replicate these results in larger and more diverse samples. Should CD-5As continue to prove efficacious,

it could greatly increase the proportion of pregnant smokers who receive an evidence-based brief intervention.

Introduction

Smoking during pregnancy has long been associated with adverse fetal outcomes. For example, smoking during pregnancy has been linked to fetal growth retardation, with estimates suggesting that 20%–30% of all cases of low birth weight can be attributed to prenatal tobacco exposure (Andres & Day, 2000). Increasing evidence also suggests that prenatal exposure to tobacco is associated with a range of additional risks from sudden infant death syndrome to long-term cognitive and behavioral deficits (e.g., Ness et al., 1999; Shea & Steiner, 2008; Stroud et al., 2009).

A range of intervention approaches has been found to be efficacious in promoting smoking cessation. Among these are brief intervention approaches, which were supported in the most recent Clinical Practice Guidelines on smoking cessation (Fiore et al., 2008). Brief interventions are associated with small but clear increases in smoking cessation (Heckman, Egleston, & Hofmann, 2010; Hettema & Hendricks, 2010; Lai, Cahill, Qin, & Tang, 2010), including among pregnant women (Ferreira-Borges, 2005; Melvin, Dolan-Mullen, Windsor, Whiteside, & Goldenberg, 2000; Mullen, 1999; Pbert et al., 2004). Despite its small effects, the brief nature and primary care application of brief approaches means that they can theoretically be presented to a relatively large proportion of women who smoke during pregnancy, giving it the potential for high population impact.

Contingency management (CM), in contrast, consistently yields strong effects but requires more effort and resources than

doi: 10.1093/ntr/ntr221

Advance Access published on December 9, 2011

© The Author 2011. Published by Oxford University Press on behalf of the Society for Research on Nicotine and Tobacco.
All rights reserved. For permissions, please e-mail: journals.permissions@oup.com

brief interventions. CM has demonstrated efficacy in reducing use of several substances of abuse, including cocaine, opiates, methamphetamine, benzodiazepines, and others (for meta-analyses, see Lussier, Heil, Mongeon, Badger, & Higgins, 2006; Prendergast, Podus, Finney, Greenwell, & Roll, 2006). CM is also efficacious in reducing smoking (e.g., Alessi, Badger, & Higgins, 2004; Corby, Roll, Ledgerwood, & Schuster, 2000), including among pregnant women (Donatelle, Prows, Champeau, & Hudson, 2000; Heil et al., 2008; Higgins et al., 2010).

Despite good evidence of efficacy, implementation challenges are substantial for both approaches. With respect to brief interventions, training in these approaches can be expensive and time consuming and typically has modest or transient effects on trainee behavior (Baer et al., 2004; DePue et al., 2002; Miller & Mount, 2001) that, even when present, do not subsequently lead to reductions in smoking among patients of trainees (Lancaster, Silagy, & Fowler, 2000). Few physicians providing care for pregnant women fully implement recommended brief intervention strategies (Chapin & Root, 2004; Goldenberg, Klerman, Windsor, & Whiteside, 2000; Grimley, Bellis, Raczynski, & Henning, 2001), in large part because of insufficient time (Yarnall, Pollak, Ostbye, Krause, & Michener, 2003). Implementation challenges are likely to be even greater for CM, which requires regular contact, tracking of reinforcement history, and the resources to purchase incentives (e.g., voucher values averaged \$461 per participant in Heil et al., 2008). Even among substance abuse treatment specialists and despite CM's clear evidence of efficacy, readiness to adopt CM in community agencies is relatively low (McGovern, Fox, Xie, & Drake, 2004). Furthermore, even following training, substance abuse therapists often fail to meet CM performance criteria (Andrzejewski, Kirby, Morral, & Iguchi, 2001).

Such evidence suggests the need to make both approaches easier to implement in community settings. Given its inherent replicability, low cost, and reach, technology may provide a way to do so. Computer- and/or Internet-delivered interventions for health-related behaviors are becoming increasingly common in primary care settings and have shown promising efficacy for a range of health-related behaviors (Rooke, Thorsteinsson, Karpin, Copeland, & Allsop, 2010). Furthermore, using technology to assist in tracking, testing, and reinforcement of participants in a CM program—along with other modifications—may increase its penetration into community settings.

This four-arm clinical trial therefore had three goals. First, it sought to evaluate whether computer delivery of a brief intervention (CD-5As; see below) for smoking during pregnancy is feasible and acceptable in a prenatal clinic setting and whether it can facilitate short-term reductions in smoking during pregnancy. We hypothesized that the computer-delivered brief intervention would result in decreased smoking when compared with treatment as usual (TAU). Secondary analyses also examined the extent to which the brief intervention could facilitate help-seeking in the form of either speaking to a physician or nurse about smoking or calling a local smoking quitline. Second, this study sought to evaluate a highly modified low-intensity version of CM (hereafter referred to as CM-Lite) designed to be maximally replicable in the community—in part through the use of technology to facilitate implementation. We hypothesized that the CM-Lite intervention would result in decreased smoking when compared with time control plus TAU but did not predict greater efficacy than the brief intervention because

of the substantial differences (e.g., participant initiated, less frequent sessions, lower incentive value) between CM-Lite and traditional CM. Third, we wished to examine the extent to which the combination of CD-5As and CM-Lite might lead to enhanced effects relative to each intervention alone.

To meet these goals, we recruited 110 women reporting smoking during pregnancy from one of four prenatal care clinics and randomly assigned them to either a single-session computer-delivered brief intervention (CD-5As), an invitation to participate in CM-Lite, a combined condition (CD-5As plus an invitation to participate in CM-Lite), or a brief nonsmoking-related computer session (to control for time using the computer) plus TAU. Data were collected at baseline and 10-week follow-up.

Methods

Participants

Participants were 110 pregnant women recruited from one of four prenatal care clinics in Detroit, MI. Inclusion criteria included being age 18 years or older, being no further than 27 weeks into gestation, and reporting smoking in the past week (while pregnant); women were excluded if they were unable to understand spoken English. The sample size of 110 was determined primarily by funding and time constraints in this preliminary trial, which was not intended to be fully powered. The Wayne State University's Institutional Review Board approved all procedures used in this study.

Design and Procedures

The present study was a factorial randomized clinical trial (registered with Clinicaltrials.gov, number NCT01028131, protocol available from first author) in which research staff were blind to each participant's brief intervention status but were aware of CM-Lite status (research staff conducted all CM-Lite testing and reinforcement procedures for this study). Participants were reevaluated approximately 10 weeks after the initial baseline/randomization/intervention session by research assistants who were blind to that participant's brief intervention status.

Women were approached while in the clinic waiting area and completed eligibility screening either by computer or paper-and-pencil self-report. Those who met criteria and provided informed consent were brought to a private room or a secluded section of the waiting area and were given a convertible touch screen tablet PC, with which they completed all self-report measures and received either the computer-delivered intervention or the control content (see below for details). The computer randomized all participants into either CD-5As or time control conditions (with odds of 0.50 for either group), each of which involved the same level of interaction with the computer and took the same approximate amount of time, thus keeping research assistants blind to computer-delivered intervention condition. As a second step in randomization—after participants completed all computer-delivered content—research assistants used a predetermined list of random numbers generated from www.randomization.com (Dallal, 2010) to further randomize half of all participants into the CM condition. This two-step randomization process resulted

in random assignment of all participants into one of four unique conditions: CD-5As, CM-Lite, combined, and time control/TAU.

Computer-Delivered Brief Intervention

The software platform utilized for this study (described in detail in Ondersma, Chase, Svikis, & Schuster, 2005) features an interactive three-dimensional narrator, clear and relevant graphics, and aural presentation of all content and has received high ratings for ease of use from similar samples of low-income women (Ondersma et al., 2005). Participants used headphones for privacy while working with the computer.

The CD-5As condition was designed to be consistent with guidelines outlined by Fiore et al. (2000, 2008), who describe a process involving the 5As (Ask, Advise, Assess, Assist, Arrange) and—for those who are unwilling to set a quit goal—the 5Rs (with steps involving the highlighting of Relevance, Risks, Rewards, Roadblocks, and Repetition). For the “Advise” element, participants viewed a 4- to 6-min professionally produced video featuring a male Black Obstetrician and up to three testimonials from women of varying race (all were professional actors). These videos were tailored to participants on (a) reactivity, rated dichotomously (Karno & Longabaugh, 2005; Resnicow et al., 2008); (b) defensiveness with respect to the possible negative effects of smoking during pregnancy; and (c) quit status (not changing her smoking during pregnancy, trying to quit but failing, or cutting down). All participants received advice to quit from the Obstetrician, whose advice to quit was direct but who provided an almost exclusively gain-framed message regarding smoking during pregnancy (e.g., describing the potential benefits of quitting rather than the risks of not quitting; Fucito, Latimer, Salovey, & Toll, 2010; McKee et al., 2004; Toll et al., 2007).

Following the tailored video “Advise” element, the software completed the remaining 5As elements using a combination of narrated graphics, feedback (e.g., regarding money spent on cigarettes), education, and interactive questioning using branching logic and reflective responses (e.g., “So you think it’s important to cut down on your smoking . . .”). For those choosing a change goal, the software provided assistance in developing a specific plan and provided a menu of options involving the three most readily available approaches: self-help, calling the local quitline (1-800-QUITNOW), and talking with the doctor or nurse. Those unwilling to set a change goal received a motivational intervention consistent with the 5Rs.

Lower Intensity CM: CM-Lite

CM-Lite involved a number of modifications designed to maximize its potential for transfer into ongoing clinical practice. First and perhaps most significantly, CM-Lite was designed for use with nontreatment-seeking persons in a health care setting with the presumption of (a) at least occasional repeat office visits and (b) limited ability of medical staff to monitor participants or participate in training. Thus, no proactive tracking was provided in CM-Lite: It was designed to be patient initiated, with staff checking eligibility if and when a patient asks to have their smoking status verified rather than relying on staff to check the eligibility of every incoming patient. This process thus reduces staff burden while also reducing the cost of unnecessary testing (participants who continue to use a substance may be less likely to ask for testing, see Downey, Helmus, & Schuster, 2000, for more on this approach).

Second, CM-Lite calls for testing at prenatal care visits only rather than multiple times per day. In this respect, CM-Lite is substantially different from many other forms of CM for cigarette smoking that include very frequent (sometimes two to three times daily) visits and constant monitoring by a health care professional (Ledgerwood, 2008). Finally, CM-Lite calls for unlimited incentivization attempts, but only up to a maximum of five episodes of reinforcement (in the form of retail gift cards worth \$50), only at prenatal clinic visits, each at least a week apart. This level and schedule of reinforcement was chosen for its feasibility relative to programs with higher incentive levels, for its similarity to values used in a previously successful trial (Donatelle et al., 2000), who found a \$50 per month reinforcement to be effective at reducing smoking, and for its relative simplicity.

Finally, CM-Lite was delivered with the help of a website. This website facilitated the process of verifying eligibility of participants, provided step-by-step guidance in how to conduct a valid test for urinary cotinine, recorded the results of testing, and provided a record of all incentive attempts and their outcome. For the purposes of this study, this website intentionally avoided guidance regarding how to encourage or motivate patients who participate in CM-Lite. Research assistants restricted their activities for participants in the CM condition to testing urine and providing gift cards.

TAU/Time Control Condition

Participants randomly assigned to this condition received TAU from their prenatal care providers without influence from the investigators. To promote research assistant blindness to condition and control for possible effects of time working with the computer, participants in this condition completed a brief series of questions regarding musical preferences, watched a series of videos tailored to their preferences, and answered questions regarding those video clips.

Measures

To evaluate acceptability of the CD-5As intervention, participants were asked at baseline to respond to 11 self-report items designed to evaluate ease of use, enjoyment, helpfulness, and other satisfaction-related constructs. These items, which were rated by participants on a 1 (*not at all*) to 5 (*very much*) Likert scale, were based on those used successfully in previous research (Ondersma et al., 2005). In addition, participants assigned to the CD-5As condition responded to five items (on a 1–10 scale, where “1” = *not at all*, and “10” = *very much*) evaluating their likelihood of quitting while pregnant, intentions to quit while pregnant, confidence in ability to quit, readiness to quit, and desire to quit. These items (taken from Ondersma et al., 2005) were completed before and after completing the brief computer-delivered motivational intervention in order to evaluate any immediate changes in state motivation; Cronbach’s alpha for these items in this study was .89.

This study utilized two co-primary outcomes, both measured at the 10-week follow-up. The first 7-day point prevalence carbon monoxide (CO)-confirmed abstinence was measured via a timeline followback calendar (Sobell & Sobell, 1996) along with a test of expired CO levels using an EC50-MP Micro CO monitor (Bedfont). CO levels less than 4 ppm are generally considered negative for smoking (e.g., Lamb, Morral, Kirby, Iguchi,

& Galbicka, 2004). This timeframe was chosen to maximize the relevance of breath CO as confirmation of reports of abstinence. The second co-primary outcome was urinary cotinine, a metabolite of nicotine that is indicative of cigarette smoking (and use of other products containing nicotine). Cotinine levels were analyzed using the Nymox NicAlert[™] test strip system (Nymox Pharmaceutical Corporation, Hasbrouck Heights, NJ). Following manufacturer's recommendations, the NicAlert test strip was scored positive for strip results of 3 or higher (which corresponds to a cotinine level of 100 or higher).

Also at the 10-week follow-up, secondary help-seeking outcomes were evaluated in terms of whether participants reported use of 1-800-QUITNOW for smoking cessation assistance or had spoken with their physician or nurse about their smoking. Secondary outcomes regarding sustained abstinence were also evaluated using the timeline followback calendar to evaluate smoking in the past thirty days (without confirmation). Participants also completed the Fagerström Test for Nicotine Dependence (FTND) to evaluate dependence at baseline (Fagerstrom & Schneider, 1989; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991) as well as the K6 brief measure of overall emotional distress (Kessler et al., 2003).

Data Analysis

We first evaluated participant-rated acceptability of the CD-5As program using descriptive analysis. Second, we evaluated changes in self-reported motivation, self-efficacy, and intention to change among participants receiving the CD-5As program using paired samples *t* tests. Third, we examined the proportion of participants assigned to CM-Lite who actively participated in the incentive program, as well as the frequency of success and subjective responses to CM-Lite among those who did participate. Fourth, following evaluation of the success of randomization, we examined differences in abstinence between experimental conditions (CD-5As, CM-Lite, and combined) and the control condition using logistic regression with the categorical covariates procedure. All analyses were on an intent -to-treat basis that analyzed participants as allocated to condition without respect to completion of treatment elements. These analyses controlled for level of smoking at baseline as well as any variables found to differ between groups at $p \leq .10$ (with unadjusted analyses also presented). Secondary analyses of intervention effects on help-seeking and sustained abstinence were also conducted. Finally, we collapsed across conditions in order to compare participants receiving CD-5As (with or without CM-Lite) with those who did not. These collapsed groups are hereafter referred to as "intervention groups" in order to distinguish them from conditions defined above.

Results

A total of 1,317 participants were screened between July of 2008 and November of 2009; 1,207 were excluded, primarily due to being beyond 27-week gestation or denying smoking in the past week (Figure 1). The trial ended after 110 participants were randomized. These 110 randomized participants (26 in CD-5As, 28 in CM-Lite, 30 in the combined condition, and 26 in TAU) averaged 27.9 ($SD = 6.4$) years of age, with a range of 18–44; a total of 90 (81.8%) were Black, with one participant reporting Hispanic ethnicity. Cigarettes per day in the week prior to

recruitment averaged 8.0 ($SD = 8.2$, range = 1–50). A total of 57 participants (52.8%) scored above the FTND cutoff for nicotine dependence. See Table 1 for details on baseline participant characteristics and differences between conditions on those variables. There were no significant differences between conditions on any of the baseline characteristics examined, although one variable (minority vs. nonminority race) was below $p = .10$ and so was controlled for in subsequent analyses. There were no site differences on any baseline or demographic variables, so subsequent analyses collapsed across site.

Follow-up evaluation took place between January of 2009 and January of 2010 at a mean of 10.1 ($SD = 3.9$) weeks post-randomization/intervention; a total of 94 (85.4%) of the 110 participants completed follow-up evaluation (Figure 1). There were no significant differences between conditions on loss to follow-up. Two participants who completed follow-up data collection (one from the TAU condition and one from the Combined condition) experienced a miscarriage before follow-up evaluation took place. The analyses presented below represent all 94 participants for whom follow-up data were available; sensitivity analyses showed that the results did not differ when focused on just the 92 participants who were still pregnant at follow-up or when considering all participants lost to follow-up as positive for smoking (data not shown). One additional participant (in the combined condition) delivered a stillborn infant at 25-week gestation. No other adverse events were reported.

Acceptability of CD-5As

As noted above, all 56 participants assigned to the CD-5As condition completed a series of 11 items evaluating satisfaction, perceived helpfulness, acceptability, and ease of use. Ten of these items were phrased positively (e.g., "How much did you like working with the computer?"); between 82.1% and 98.2% of participants provided the highest possible rating ("very much") on these items. Ratings for ease of use, respectfulness, and interest in using the computer again were particularly high (given the highest possible rating by between 92.9% and 98.2% of participants). Furthermore, 49 participants (87.5%) completing the CD-5As intervention indicated that it had made them rethink their smoking and that it had made them more likely to change. The single negatively worded item ("I was bothered by some parts of this software") received the best possible rating ("not at all") from 35 participants (62.5%).

During-Session Change: CD-5As

As noted above, all 56 participants randomly assigned to the CD-5As conditions completed a series of five items (measured on a 1–10 scale) evaluating change intention, motivation, and self-efficacy at two separate timepoints: once during the study assessment process (before discovering that they had been randomly assigned to the CD-5As condition) and once at the conclusion of CD-5As. Paired samples *t* tests evaluating during-session change indicated significant increases on all five variables; effect size of increases (Cohen's *d*) ranged from $d = .25$ to $d = .59$ (see Table 2).

Use of CM-Lite

Of 58 participants assigned to the CM-Lite conditions (with or without concomitant CD-5As), 22 (37.9%) initiated testing of at least one urine sample; of those initiating testing of at least

Note. All participants randomized received the allocated intervention (the single-session CD-5As was administered at the recruitment visit, and the CM-Lite intervention was conceptualized as optional; 11 participants in the CM-Lite condition and 11 in the Combined condition chose to seek reinforcement).

Figure 1. Participant flow.

one sample, the mean number of samples submitted was 3.7 ($SD = 1.9$). Also among those who chose to submit at least one sample, the modal number of negative samples was 5 (the maximum allowable). Of the 82 urine samples tested, 66 (80.5%) were negative for cotinine. The average gift card value earned by participants assigned to the CM-Lite condition was \$56.90; among those initiating at least one testing, this value was \$150.00.

Primary Outcomes: Cotinine and 7-day Point Prevalence CO-Confirmed Abstinence

As seen in Table 3, comparisons between each of the three intervention conditions and control showed a significant effect for the CD-5As condition over the control group for cotinine

Table 1. Sample Characteristics at Baseline by Condition (N = 110)

Participant characteristic	Total	Control	CD-5As	CM-Lite	Combined	p Value
Black (%)	90 (81.8)	18 (69.2)	24 (92.3)	21 (75.0)	27 (90.0)	.08
Baseline carbon monoxide ≥ 4 ppm (%)	64 (58.2)	17 (65.4)	15 (57.7)	17 (60.7)	15 (50.0)	.69
Weeks gestation >20 (%)	36 (32.7)	7 (26.9)	7 (26.9)	14 (50.0)	8 (26.7)	.17
Lives with a smoker (%)	70 (63.6)	19 (73.1)	15 (57.7)	15 (53.6)	21 (70.0)	.37
FTND ≥ 4 (%)	58 (52.7)	13 (50.0)	11 (42.3)	14 (50.0)	20 (66.7)	.30
Age in years (SD)	27.9 (6.4)	28.5 (7.5)	25.8 (4.8)	29.3 (6.7)	27.7 (6.1)	.23
Average cigarettes per day in past week (SD)	8.0 (8.2)	7.6 (9.6)	7.6 (7.4)	8.3 (5.8)	8.3 (9.6)	.98
K6 emotional distress (SD)	14.9 (5.3)	14.3 (4.6)	14.8 (5.3)	15.3 (4.1)	15.3 (7.0)	.91

Note. Significance values for dichotomous data are based on chi-square analyses; analysis of variance was used for age, cigarettes per day, and K6. FTND = Fagerström Test for Nicotine Dependence; ppm = parts per million.

Table 2. During-Session Increase in State Motivation, Intention, and Self-efficacy

	Presession rating	Postsession rating	Cohen's <i>d</i>	<i>t</i>	<i>df</i>	<i>p</i> Value
1. Likelihood of quitting while pregnant	6.6	8.1	.55	4.2	55	<.001
2. Intention to quit while pregnant	7.9	9.0	.42	3.4	55	.001
3. Confidence in a successful quit attempt	7.1	8.5	.61	5.4	55	<.001
4. Readiness to quit throughout pregnancy	7.9	8.8	.42	3.8	55	<.001
5. Desire to quit for duration of pregnancy	8.7	9.3	.27	2.6	55	.013

Note. These data are from all participants randomly assigned to one of the two conditions receiving the CD-5As intervention (alone or in combination with CM-Lite, $N = 56$). Ratings range from 1 to 10, where 1 = *not at all*, and 10 = *very much*. Participants responded to these items before and after completing the CD-5As computer-delivered brief intervention.

outcomes (43.5% cotinine negative vs. 17.4%; odds ratio [OR] = 10.1, $p = .02$) but not for 7-day point prevalence (30.4% abstinent vs. 8.7%; OR = 5.7, $p = .06$). Given the lack of clear effects for the CM-Lite condition, we also considered the effects of CD-5As with or without CM-Lite versus conditions that did not receive CD-5As (that is, collapsing across CM-Lite status). As seen in Table 4, this analysis did not show an advantage for the CD-5As intervention group on the cotinine outcome (28.6% cotinine negative for participants receiving CD-5As, with or without concomitant CM-Lite, vs. 15.6%; OR = 2.7, nonsignificant [ns]) but did show a relative advantage for this group on confirmed 7-day point prevalence abstinence (24.5% vs. 8.9%; OR = 5.0, $p = .03$). Effects were in the expected direction for the CD-5As and combined conditions in all comparisons.

Secondary Outcomes: Continuous Abstinence Over 30 Days

Logistic regression analyses considering all four treatment groups separately, again controlling for baseline level of smoking and race, showed a significant advantage for the CD-5As condition for past thirty-day abstinence (26.1% abstinent vs. 4.3%; OR = 14.2, $p = .04$; see Table 3). Similar analyses for the CD-5As intervention group (collapsing across CM-Lite and non CM-Lite conditions) also showed a significant advantage in 30-day abstinence for participants receiving the CD-5As (22.4% abstinent vs. 6.7%; OR = 5.3, $p = .03$; Table 4).

Secondary Outcomes: Help-Seeking

Help-seeking was examined with respect to self-report of calling the 1-800-QUITNOW tobacco quitline, and self-report of talking to a doctor or nurse about smoking. As seen in Table 3, only one comparison between any of the three intervention conditions and control was significant. Specifically, participants assigned to the combined condition were more than twice as likely to report speaking to their doctor or nurse about smoking (68.2% vs. 30%, OR = 4.5, $p = .03$). Again because of a lack of apparent effects for CM-Lite, comparisons collapsing across CM-Lite (e.g., any CD-5As vs. no CD-5As) were also conducted. These analyses showed a significant increase in talking with a physician or nurse about one's smoking for participants receiving a CD-5As intervention (60.5% vs. 30.8%; OR = 3.0, $p = .02$) but no difference on calling 1-800-QUITNOW (18.6% for CD-5As vs. 5%; ns). As with smoking abstinence, all effects were in the expected direction (Table 4).

Discussion

The results of this pilot trial suggest that a single-session computer-delivered motivational intervention following the 5As/5Rs approach was acceptable to patients in an urban prenatal care setting and that it was associated with small to moderate during-session increases in motivation, efficacy, and intention to change. Our hypothesis that this intervention would also result in significant increases in abstinence was partially supported, in that significant results were found for one of two primary analyses and with differences in the expected direction for all analyses. Effect sizes were higher for this condition than for most other brief intervention studies, but this was less true for the unadjusted ORs and may in part be a result of the short follow-up period. Further evaluation of the efficacy of this approach is needed. If confirmed as efficacious, computer-delivered interventions of this type could be an important part of overall efforts to bring some level of intervention to a high proportion of pregnant smokers, many of whom do not currently receive such assistance. Evidence that this intervention may facilitate help-seeking suggests that this brief approach could help motivate pregnant smokers to utilize available smoking cessation assistance.

Contrary to our expectations, CM-Lite did not result in reductions in smoking in this sample. In an effort to facilitate implementation into the community, CM-Lite differed in substantial ways from traditional CM. For example, this condition only involved the availability of contingent reinforcement rather than its direct administration to a group that agreed to participate in a condition involving regular provision of urine samples as part of a CM program. Furthermore, we intentionally provided only modest promotion of this option with participants to test an intervention approach that was maximally replicable; only 37.9% of participants availed themselves of the opportunity to ask that their urine sample be tested. Second, frequency of assessment and size of reinforcement in CM-Lite were substantially reduced from typical levels. Notably, our study is consistent with findings from another recent trial (Menza et al., 2010) that found no effects for a CM intervention with a mean received total incentive level of \$112 (compared with the mean of \$461 in Heil et al., 2008). Third, we intentionally did not pair CM-Lite testing sessions with encouragement or advice and did not utilize shaping by ensuring that participants could obtain an initial success. Significant interpersonal contact, encouragement to participate or try again, and assurance of relatively easy success at the outset are all part of model delivery of CM (Petty, Alessi, Ledgerwood, & Sierra, 2010). Further research should

Table 3. Smoking and Help-Seeking Outcomes by All Four Conditions

	Treatment as usual (<i>n</i> = 23)			CD-5As (<i>n</i> = 23)			CM-Lite (<i>n</i> = 22)			CD-5As + CM-Lite (<i>n</i> = 26)		
	<i>N</i> (%)	<i>OR</i> (95% <i>CI</i>)		<i>N</i> (%)	<i>ORa</i> (95% <i>CI</i>)	<i>OR</i> (95% <i>CI</i>)	<i>N</i> (%)	<i>ORa</i> (95% <i>CI</i>)	<i>OR</i> (95% <i>CI</i>)	<i>N</i> (%)	<i>ORa</i> (95% <i>CI</i>)	<i>OR</i> (95% <i>CI</i>)
Primary outcomes												
Cotinine	4 (17.4)	–		10 (43.5)	10.1 (1.4–75.0)	3.7 (.94–14.2)	3 (13.6)	0.6 (0.1–4.2)	0.8 (0.2–3.8)	4 (15.4)	0.7 (0.1–4.0)	0.9 (0.2–3.9)
7-day point prevalence + carbon monoxide	2 (8.7)	–		7 (30.4)	5.7 (0.9–34.3)	4.6 (.84–25.2)	2 (9.1)	0.5 (0.1–6.7)	1.1 (0.1–8.2)	5 (19.2)	2.8 (0.5–16.9)	2.5 (0.4–14.4)
30-day abstinence	1 (4.3)	–		6 (26.1)	14.2 (1.2–172.3)	7.8 (0.9–70.8)	2 (9.1)	2.7 (0.2–36.6)	2.2 (0.2–26.2)	5 (19.2)	7.0 (0.6–81.2)	5.3 (0.6–48.7)
Help-seeking												
Talking to doctor	6 (30.0)	–		11 (52.4)	2.1 (0.5–8.1)	2.6 (0.7–9.3)	6 (30.0)	1.0 (0.2–3.9)	1.0 (0.3–3.9)	15 (68.2)	4.7 (1.2–18.6)	5.0 (1.4–18.6)
Calling quitline	1 (5.0)	–		3 (14.3)	2.7 (0.2–33.7)	3.2 (0.3–33.3)	1 (5.0)	1.1 (0.1–22.2)	1.0 (0.1–17.2)	5 (22.7)	5.4 (0.5–63.2)	5.6 (0.6–52.7)

Note. Treatment as usual was the referent for calculation of all *ORs*. *ORa* values are adjusted for minority status and baseline smoking. All *CI*s are 95%. *ORs* in bold are significant at $p < .05$. *OR* = odds ratio

Table 4. Smoking and Help-Seeking Outcomes for CD-5As Versus No CD-5As (collapsing across CM-Lite status)

	No CD-5As (<i>n</i> = 45)		CD-5As (<i>n</i> = 49)		
	<i>N</i> (%)	<i>OR</i> (95% <i>CI</i>)	<i>N</i> (%)	<i>ORa</i> (95% <i>CI</i>)	<i>OR</i> (95% <i>CI</i>)
Primary outcomes					
Cotinine	7 (15.6)	–	14 (28.6)	2.7 (0.8–8.8)	2.2 (0.8–6.0)
7-day point prevalence + carbon monoxide	4 (8.9)	–	12 (24.5)	5.0 (1.2–20.2)	3.3 (.99–11.2)
30-day abstinence	3 (6.7)	–	11 (22.4)	5.3 (1.2–23.4)	4.1 (1.1–15.6)
Help-seeking					
Talking to doctor	12 (30.0)	–	26 (60.5)	3.2 (1.2–8.4)	3.6 (1.4–8.9)
Calling quitline	2 (5.0)	–	8 (18.6)	3.7 (0.7–19.7)	4.3 (0.9–21.9)

Note. Participants not receiving the CD-5As intervention (treatment as usual plus CM-Lite only) were the referent for calculation of all *ORs* for the active group in this comparison (participants receiving either CD-5As only or CD-5As plus CM-Lite). *ORa* values are adjusted for minority status and baseline smoking. All *CI*s are 95%. *ORs* in bold are significant at $p < .05$. *OR* = odds ratio.

investigate whether other approaches can ease implementation of CM while retaining efficacy.

Low-level contingent reinforcement and a brief motivational intervention did not have a synergistic effect; the combined condition in fact fared less well than the CD-5As condition. Although the reasons for this finding are unclear, it is consistent with Self-determination Theory, which suggests that the provision of external reinforcement will inhibit internal motivation (e.g., Deci, Koestner, & Ryan, 1999). Self-determination Theory, however, initially appears inconsistent with the results from traditional CM interventions, which show substantial effects that—although fading after the cessation of incentives—do not result in greater use than in control conditions. It is possible that CM in the context of (a) sufficient external reinforcement, (b) sufficiently frequent testing, (c) sustained reinforcement of the target behavior, and (d) appropriate encouragement can provide sufficient external motivation to induce sustained behavior change in many people. This sustained behavior change may then allow the development of new habitual behavior patterns that have reinforcement value in their own right. In contrast, contingent reinforcement that is insufficient in magnitude or frequency to induce sustained change (as with CM-Lite) may be more likely to actually suppress the target behavior as predicted by self-determination theory. Regardless, it does appear that future efforts focused on maximizing reach should consider the use of brief interventions alone and that efforts to maximize effectiveness (rather than reach) should utilize a CM approach with more traditional levels of reinforcement and oversight. Implementation of a motivational intervention following active CM (as opposed to concurrently) should also be considered.

Limitations

The findings reported here should be considered in light of several limitations. First, although all effects favored participants receiving CD-5As, the relatively small sample size limited our ability to detect small effects. The small sample size also limited the precision of effect size estimates as seen in the wide *CI*s for many estimates of intervention effect. Second, the sample was almost exclusively low-income Black women in an urban setting, thus limiting generalizability to other populations. Additionally, the tendency for many participants to delay seeking prenatal care until the second trimester restricted us to a

relatively short follow-up duration of 10 weeks. It will be important for future studies to examine longer term effects by studying women who seek prenatal care early in the first trimester and following participants until just before giving birth.

Implications

This study evaluated the feasibility, acceptability, and preliminary efficacy of two potentially high-reach interventions for smoking during pregnancy. One of those, CM-Lite, did not appear to facilitate abstinence in this sample. However, our findings suggest that the brief computer-delivered motivational intervention (CD-5As) was well accepted by participants, was associated with increases in state motivation, and showed promising results in terms of abstinence and help-seeking. These results are consistent with a number of recent meta-analyses showing small but significant effects of brief motivational interventions on smoking (Heckman et al., 2010; Hettema & Hendricks, 2010; Lai et al., 2010). Thus, the clearest implication of these findings is that further fully powered trials investigating the CD-5As approach are merited. Confirmation of the acceptability and efficacy of this approach could allow a substantial increase in the proportion of pregnant smokers who receive an evidence-based brief intervention.

Funding

This research was supported by grant # DA021668 from the National Institute on Drug Abuse and the Eunice Kennedy Shriver National Institute of Child Health & Human Development to SJO.

Declaration of Interests

SJO is part owner of a company marketing authorable intervention software. No other authors have competing interests to declare.

References

- Alessi, S. M., Badger, G. J., & Higgins, S. T. (2004). An experimental examination of the initial weeks of abstinence in cigarette smokers. *Experimental & Clinical Psychopharmacology*, 12, 276–287. doi:10.1037/1064-1297.12.4.276

- Andres, R. L., & Day, M. C. (2000). Perinatal complications associated with maternal tobacco use. *Seminars in Neonatology*, 5, 231–241. doi:10.1053/siny.2000.0025
- Andrzejewski, M. E., Kirby, K. C., Morral, A. R., & Iguchi, M. Y. (2001). Technology transfer through performance management: The effects of graphical feedback and positive reinforcement on drug treatment counselors' behavior. *Drug and Alcohol Dependence*, 63, 179–186. doi:10.1016/S0376-8716(00)00207-6
- Baer, J. S., Rosengren, D. B., Dunn, C. W., Wells, E. A., Ogle, R. L., & Hartzler, B. (2004). An evaluation of workshop training in motivational interviewing for addiction and mental health clinicians. *Drug and Alcohol Dependence*, 73, 99–106. doi:10.1016/j.drugalcdep.2003.10.001
- Chapin, J., & Root, W. (2004). Improving obstetrician-gynecologist implementation of smoking cessation guidelines for pregnant women: An interim report of the American College of Obstetricians and Gynecologists. *Nicotine & Tobacco Research*, 6(Suppl. 2), S253–S257. doi:10.1080/14622200410001669123
- Corby, E. A., Roll, J. M., Ledgerwood, D. M., & Schuster, C. R. (2000). Contingency management interventions for treating the substance abuse of adolescents: A feasibility study. *Experimental & Clinical Psychopharmacology*, 8, 371–376. doi:10.1037/1064-1297.8.3.371
- Dallal, G. E. (2010). Randomization scheme. Retrieved from <http://www.randomization.com>
- Deci, E. L., Koestner, R., & Ryan, R. M. (1999). A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychological Bulletin*, 125, 627–668. Discussion 692–700. doi:10.1037/0033-2909.125.6.627
- DePue, J. D., Goldstein, M. G., Schilling, A., Reiss, P., Papandonatos, G., Sciamanna, C., et al. (2002). Dissemination of the AHCPR clinical practice guideline in community health centres. *Tobacco Control*, 11, 329–335. doi:10.1136/tc.11.4.329
- Donatelle, R. J., Prows, S. L., Champeau, D., & Hudson, D. (2000). Randomised controlled trial using social support and financial incentives for high risk pregnant smokers: Significant other supporter (SOS) program. *Tobacco Control*, 9(Suppl 3), III67–III69. doi:10.1136/tc.9.suppl_3.iii67
- Downey, K. K., Helmus, T. C., & Schuster, C. R. (2000). Contingency management for accurate predictions of urinalysis test results and lack of correspondence with self-reported drug use among polydrug abusers. *Psychology of Addictive Behaviors*, 14, 69–72. doi:10.1037/0893-164X.14.1.69
- Fagerstrom, K. O., & Schneider, N. G. (1989). Measuring nicotine dependence: A review of the Fagerstrom Tolerance Questionnaire. *Journal of Behavioral Medicine*, 12, 159–182. doi:10.1016/j.jpmed.2004.11.013
- Ferreira-Borges, C. (2005). Effectiveness of a brief counseling and behavioral intervention for smoking cessation in pregnant women. *Preventive Medicine*, 41, 295–302. doi:10.1016/j.jpmed.2004.11.013
- Fiore, M. C., Bailey, W. C., Cohen, S. J., Dorfman, S. F., Gritz, E. R., Heyman, R. B., et al. (2000). *Treating tobacco use and dependence: Clinical practice guidelines*. Rockville, MD: U.S. Department of Health and Human Services, Public Health Service.
- Fiore, M. C., Jaen, C. R., Baker, T. B., Bailey, W. C., Benowitz, N. L., Curry, S. J., et al. (2008). *Treating tobacco use and dependence: 2008 update*. Clinical practice guideline. Rockville, MD: U.S. Department of Health and Human Services, Public Health Service.
- Fucito, L. M., Latimer, A. E., Salovey, P., & Toll, B. A. (2010). Nicotine dependence as a moderator of message framing effects on smoking cessation outcomes. *Annals of Behavioral Medicine*, 39, 311–317. doi:10.1007/s12160-010-9187-3
- Goldenberg, R. L., Klerman, L. V., Windsor, R. A., & Whiteside, H. P., Jr. (2000). Smoking in pregnancy: Final thoughts. *Tobacco Control*, 9 (Suppl. 3), III85–III86. doi:10.1136/tc.9.suppl_3.iii85
- Grimley, D. M., Bellis, J. M., Raczynski, J. M., & Henning, K. (2001). Smoking cessation counseling practices: A survey of Alabama obstetrician-gynecologists. *Southern Medical Journal*, 94, 297–303. doi:10.1097/00007611-200103000-00006
- Heatherton, T. F., Kozlowski, L. T., Frecker, R. C., & Fagerstrom, K. O. (1991). The Fagerstrom Test for Nicotine Dependence: A revision of the Fagerstrom Tolerance Questionnaire. *British Journal of Addiction*, 86, 1119–1127. doi:10.1111/j.1360-0443.1991.tb01879.x
- Heckman, C. J., Egleston, B. L., & Hofmann, M. T. (2010). Efficacy of motivational interviewing for smoking cessation: A systematic review and meta-analysis. *Tobacco Control*, 19, 410–416. doi:10.1136/tc.2009.033175
- Heil, S. H., Higgins, S. T., Bernstein, I. M., Solomon, L. J., Rogers, R. E., Thomas, C. S., et al. (2008). Effects of voucher-based incentives on abstinence from cigarette smoking and fetal growth among pregnant women. *Addiction*, 103, 1009–1018. doi:10.1111/j.1360-0443.2008.02237.x
- Hettema, J. E., & Hendricks, P. S. (2010). Motivational interviewing for smoking cessation: A meta-analytic review. *Journal of Consulting and Clinical Psychology*, 78, 868–884. doi:10.1037/a0021498
- Higgins, S. T., Bernstein, I. M., Washio, Y., Heil, S. H., Badger, G. J., Skelly, J. M., et al. (2010). Effects of smoking cessation with voucher-based contingency management on birth outcomes. *Addiction*, 105, 2023–2030. doi:10.1111/j.1360-0443.2010.03073.x
- Karno, M., & Longabaugh, R. (2005). Less directiveness by therapists improves drinking outcomes of reactant clients in alcoholism treatment. *Journal of Consulting & Clinical Psychology*, 73, 262–267. doi:10.1037/0022-006X.73.2.262
- Kessler, R. C., Barker, P. R., Colpe, L. J., Epstein, J. F., Gfroerer, J. C., Hiripi, E., et al. (2003). Screening for serious mental illness in the general population. *Archives of General Psychiatry*, 60, 184–189. doi:10.1001/archpsyc.60.2.184
- Lai, D. T., Cahill, K., Qin, Y., & Tang, J. L. (2010). Motivational interviewing for smoking cessation. *Cochrane Database of Systematic Reviews*, (1), CD006936.
- Lamb, R. J., Morral, A. R., Kirby, K. C., Iguchi, M. Y., & Galbicka, G. (2004). Shaping smoking cessation using percentile schedules.

- Drug and Alcohol Dependence*, 76, 247–259. doi:10.1016/j.drugalcdep.2004.05.008
- Lancaster, T., Silagy, C., & Fowler, G. (2000). Training health professionals in smoking cessation. *Cochrane Database of Systematic Reviews*, (3), CD000214.
- Ledgerwood, D. M. (2008). Contingency management for smoking cessation: Where do we go from here? *Current Drug Abuse Reviews*, 1, 340–349. doi:10.2174/1874473710801030340
- Lussier, J. P., Heil, S. H., Mongeon, J. A., Badger, G. J., & Higgins, S. T. (2006). A meta-analysis of voucher-based reinforcement therapy for substance use disorders. *Addiction*, 101, 192–203. doi:10.1111/j.1360-0443.2006.01311.x
- McGovern, M. P., Fox, T. S., Xie, H., & Drake, R. E. (2004). A survey of clinical practices and readiness to adopt evidence-based practices: Dissemination research in an addiction treatment system. *Journal of Substance Abuse Treatment*, 26, 305–312. doi:10.1016/j.jsat.2004.03.003
- McKee, S. A., O'Malley, S., Steward, W. T., Neveu, S., Land, M., & Salovey, P. (2004). How to word effective messages about smoking and oral health: Emphasize the benefits of quitting. *Journal of Dental Education*, 68, 569–573.
- Melvin, C. L., Dolan-Mullen, P., Windsor, R. A., Whiteside, H. P., Jr., & Goldenberg, R. L. (2000). Recommended cessation counselling for pregnant women who smoke: A review of the evidence. *Tobacco Control*, 9 (Suppl. 3), III80–III84. doi:10.1136/tc.9.suppl_3.iii80
- Menza, T. W., Jameson, D. R., Hughes, J. P., Colfax, G. N., Shoptaw, S., & Golden, M. R. (2010). Contingency management to reduce methamphetamine use and sexual risk among men who have sex with men: A randomized controlled trial. *BMC Public Health*, 10, 774. doi:10.1186/1471-2458-10-774
- Miller, W. R., & Mount, K. A. (2001). A small study of training in motivational interviewing: Does one workshop change clinician and client behavior? *Behavioural & Cognitive Psychotherapy*, 29, 457–471. doi:10.1017/S1352465801004064
- Mullen, P. D. (1999). Maternal smoking during pregnancy and evidence-based intervention to promote cessation. *Primary Care*, 26, 577–589. doi:10.1015/S0095-4543(05)70118-4
- Ness, R. B., Grisso, J. A., Hirschinger, N., Markovic, N., Shaw, L. M., Day, N. L., et al. (1999). Cocaine and tobacco use and the risk of spontaneous abortion. *New England Journal of Medicine*, 340, 333–339. doi:10.1056/NEJM199902043400501
- Ondersma, S. J., Chase, S. K., Svikis, D. S., & Schuster, C. R. (2005). Computer-based brief motivational intervention for perinatal drug use. *Journal of Substance Abuse Treatment*, 28, 305–312. doi:10.1016/j.jsat.2005.02.004
- Pbert, L., Ockene, J. K., Zapka, J., Ma, Y., Goins, K. V., Oncken, C., et al. (2004). A community health center smoking-cessation intervention for pregnant and postpartum women. *American Journal of Preventive Medicine*, 26, 377–385. doi:10.1016/j.amepre.2004.02.010
- Petry, N. M., Alessi, S. M., Ledgerwood, D. M., & Sierra, S. (2010). Psychometric properties of the contingency management competence scale. *Drug and Alcohol Dependence*, 109, 167–174. doi:10.1016/j.drugalcdep.2009.12.027
- Prendergast, M., Podus, D., Finney, J., Greenwell, L., & Roll, J. (2006). Contingency management for treatment of substance use disorders: A meta-analysis. *Addiction*, 101, 1546–1560. doi:10.1111/j.1360-0443.2006.01581.x
- Resnicow, K., Davis, R. E., Zhang, G., Konkel, J., Strecher, V. J., Shaikh, A. R., et al. (2008). Tailoring a fruit and vegetable intervention on novel motivational constructs: Results of a randomized study. *Annals of Behavioral Medicine*, 35, 159–169. doi:10.1007/s12160-008-9028-9
- Rooke, S., Thorsteinsson, E., Karpin, A., Copeland, J., & Allsop, D. (2010). Computer-delivered interventions for alcohol and tobacco use: A meta-analysis. *Addiction*, 105, 1381–1390. doi:10.1111/j.1360-0443.2010.02975.x
- Shea, A. K., & Steiner, M. (2008). Cigarette smoking during pregnancy. *Nicotine & Tobacco Research*, 10, 267–278. doi:10.1080/14622200701825908
- Sobell, L. C., & Sobell, M. B. (1996). *Timeline followback: A calendar method for assessing alcohol and drug use*. Toronto, Ontario, Canada: Addiction Research Foundation.
- Stroud, L. R., Paster, R. L., Goodwin, M. S., Shenassa, E., Buka, S., Niaura, R., et al. (2009). Maternal smoking during pregnancy and neonatal behavior: A large-scale community study. *Pediatrics*, 123, e842–e848. doi:10.1542/peds.2008-2084
- Toll, B. A., O'Malley, S. S., Katulak, N. A., Wu, R., Dubin, J. A., Latimer, A., et al. (2007). Comparing gain- and loss-framed messages for smoking cessation with sustained-release bupropion: A randomized controlled trial. *Psychology of Addictive Behaviors*, 21, 534–544. doi:10.1037/0893-164X.21.4.534
- Yarnall, K. S., Pollak, K. I., Ostbye, T., Krause, K. M., & Michener, J. L. (2003). Primary care: Is there enough time for prevention? *American Journal of Public Health*, 93, 635–641. doi:10.2105/AJPH.93.4.635