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Review

Financial incentives for smoking cessation among pregnant and newly postpartum women

Stephen T. Higgins [a,b,*], Yukiko Washio [a], Sarah H. Heil [a,b], Laura J. Solomon [b,c], Diann E. Gaalema [a], Tara M. Higgins [a], Ira M. Bernstein [d]

[a] Department of Psychiatry, University of Vermont, USA
[b] Department of Psychology, University of Vermont, USA
[c] Department of Family Practice, University of Vermont, USA
[d] Department of Obstetrics, Gynecology and Reproductive Sciences, University of Vermont, USA

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ABSTRACT

Objective. Smoking during pregnancy is the leading preventable cause of poor pregnancy outcomes in the U.S., causing serious immediate and longer-term adverse effects for mothers and offspring. In this report we provide a narrative review of research on the use of financial incentives to promote abstinence from cigarette smoking during pregnancy, an intervention wherein women earn vouchers exchangeable for retail items contingent on biochemically-verified abstinence from recent smoking.

Methods. Published reports based on controlled trials are reviewed. All of the reviewed research was conducted by one of two research groups who have investigated this treatment approach.

Results. Results from six controlled trials with economically disadvantaged pregnant smokers support the efficacy of financial incentives for increasing smoking abstinence rates antepartum and early postpartum. Results from three trials provide evidence that the intervention improves sonographically estimated fetal growth, mean birth weight, percent of low-birth-weight deliveries, and breastfeeding duration.

Conclusions. The systematic use of financial incentives has promise as an efficacious intervention for promoting smoking cessation among economically disadvantaged pregnant and recently postpartum women and improving birth outcomes. Additional trials in larger and more diverse samples are warranted to further evaluate the merits of this treatment approach.

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Contents

Introduction

In this report we review research on the systematic use of financial incentives to promote abstinence from cigarette smoking during pregnancy and early postpartum, an approach referred to as contingency management (CM) in the addictions literature (Higgins et al., 2008).

* Corresponding author at: Department of Psychiatry, University of Vermont, UHC Campus, Rm 3100B Old Hall, 1 S. Prospect St., Burlington, VT 05401, USA. Fax: +1 802 656 9628.
E-mail address: Stephen.Higgins@uvm.edu (S.T. Higgins).

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Maternal smoking remains the leading preventable cause of poor pregnancy outcomes in the U.S. and other developed countries (Bonnie et al., 2007; Cnattingius, 2004). Smoking during pregnancy is associated with increased risk of spontaneous abortion, ectopic pregnancy, premature rupture of membranes, placental abruption, placenta previa, and early weaning (Cnattingius, 2004; Pauly and Slotkin, 2008). Infants born to mothers who smoked during pregnancy are at increased risk of fetal growth restriction, preterm birth, stillbirth, infant death, childhood externalizing disorders and becoming smokers themselves, as well as latter-in-life cardiac and metabolic diseases (Cnattingius, 2004; Cohen et al., 2010; Dietz et al., 2010; Pauly and Slotkin, 2008; Rogers, 2009).

Most research in the area of smoking cessation during pregnancy has focused on brief (5–15 min) interventions such as brief advice from health professionals, pregnancy-specific self-help materials, and feedback on levels of biochemical markers of smoking (see Lumley et al., 2009). While an important component of a comprehensive approach, cessation rates produced by these interventions are often low (<20%), especially among socioeconomically disadvantaged women where cessation rates are often below 15% (Ershoff et al., 2004; Melvin and Gaffney, 2004). A recent meta-analysis on interventions for smoking cessation for pregnant women indicated that on average such treatments result in only a 6% increase in late-pregnancy point-prevalence abstinence rates compared to control interventions (Lumley et al., 2009). There is growing recognition of the need to develop smoking-cessation interventions that are efficacious with socioeconomically disadvantaged smokers generally (Niederdeppe et al., 2008; Roddy et al., 2006) and disadvantaged pregnant smokers more specifically (Higgins et al., 2009). That is the rationale behind investigating financial incentives with this population and for reviewing in a single report the emerging evidence on the efficacy of this approach. In that same meta-analysis mentioned above, financial incentives were associated with a 24% increase over control conditions in late-pregnancy point-prevalence abstinence (Lumley et al., 2009). Below we provide a narrative review of the published literature on this approach to increasing smoking cessation among pregnant women that includes background information on the development of this treatment approach and more recent studies on birth outcomes and breastfeeding outcomes associated with the intervention that were published after the meta-analysis.

Background information on financial incentives in the treatment of substance use disorders

A common approach to using financial incentives in the treatment of substance use disorders (SUDS) is to offer them in the form of vouchers exchangeable for retail items (Higgins et al., 2008). In studies with pregnant cigarette smokers, women earn vouchers exchangeable for retail items contingent on biochemically-verified abstinence from recent smoking (Donatelle et al., 2000a; Donatelle et al., 2004; Heil et al., 2008; Higgins et al., 2004a). Voucher-based CM was initially developed as one part of a multi-component, outpatient treatment for cocaine dependence (Higgins et al., 1991). The seminal trials demonstrated the efficacy of this multi-component intervention compared to usual care (Higgins et al., 1991, 1993), but did not experimentally isolate the effects of the incentives. A series of subsequent trials isolated their treatment effects (Higgins et al., 1994, 2000), demonstrated the reliability of positive outcomes across trials (Higgins et al., 1993, 1994, 2000, 2007), showed generality to methadone maintenance patients dependent on cocaine (Silverman et al., 1996, 1998), illustrated the necessity of the contingency between incentive delivery and cocaine-negative urine-toxicology results for increasing abstinence (Higgins et al., 2000; Silverman et al., 1996), and showed that treatment effects remained discernible for almost 2 years after the incentives were discontinued (e.g., Higgins et al., 2000, 2007).

Interest and research activity on the use of voucher-based incentives as a treatment for addictions increased considerably in the 20 years since the first publication, extending use of the intervention to a wide range of different substances, populations and settings (Higgins et al., 2008). A meta-analysis of voucher-based incentives identified more than 60 reports of controlled studies published in peer-reviewed journals and offered strong evidence in support of its efficacy as a treatment for SUDs including cigarette smoking (Lussier et al., 2006). Also important to the development of this treatment approach was its extension to the treatment of special populations with SUDs, including adolescents, those with serious mental illness, and pregnant women (reviews on these topics and others are found in this supplemental issue). The application to pregnant cigarette smokers is a notable example of this extension. The efficacy of voucher-based incentives with relatively treatment refractory and socioeconomically disadvantaged populations provided the rationale for examining whether it might be efficacious with pregnant smokers.

Theoretical rationale

There are sound scientific rationales for the systematic use of financial incentives to treat addictions. Most fundamentally, the approach is based on well-established principles of operant conditioning, that is, the study of how environmental consequences alter the future probability of voluntary behavior (Bouton, 2007). Behavior that is followed by reinforcing consequences increases in future probability while behavior that is followed by punishing consequences decreases. There is overwhelming scientific evidence that drug use, including drug use by those who meet diagnostic criteria for dependence or addiction, conforms to the principles of operant conditioning (e.g., Higgins et al., 2004b). One aspect of that extensive evidence that is directly relevant to efforts to treat pregnant smokers and other disadvantaged populations is that impoverished environments where there are relatively fewer alternatives to drug use available render drug-using behavior more resistant to change (see Higgins, 1997; Higgins et al., 2004b).

Also relevant is an emerging area of behavioral economic research on delay discounting documenting that individuals with addictions discount the value of temporally delayed reinforcement more than do matched controls without SUDs (Bickel et al., 2007). That is, consequences that are delayed in time have less effect on current behavior than do more immediate consequences. The shape of the function relating delay to reinforcement value is hyperbolic, meaning that value diminishes precipitously with relatively brief delays and then levels off as delays continue to increase. This is true for humans generally as well as many other species, but individuals who have SUDs appear to be particularly sensitive to temporal delays (Bickel et al., 2007). Considering that most of the naturalistic reinforcers for discontinuing drug use (e.g., improved health of self and baby) are delayed in time while those derived from drug use are relatively immediate (e.g., euphoria, enhanced social interaction), it is perhaps not too surprising that so many individuals with SUDs struggle in trying to discontinue drug use. Knowing about greater discounting among those with SUDs also provides a rationale for why providing relatively immediate reinforcement contingent on therapeutic progress in the form of financial incentives might be especially helpful in bridging the temporal gap between discontinuing drug use and reaping naturalistic rewards for doing so.

To what extent these discounting differences among those with vs. without SUDs represent causes or consequences of chronic drug use remains unclear, but there is evidence that chronic drug use can directly diminish frontal lobe cortical functions (executive functions) that underpin effective goal directed behavior across time (e.g., Garavan and Hester, 2007; Lundqvist, 2005). Such diminished frontal lobe functioning quite plausibly leaves individuals with SUDs more likely to opt for the more immediate, mesolimbic-based reinforcement that drug use represents compared to the more delayed and probabilistic consequences of a drug-free lifestyle (e.g., Bickel et al., 2007). A considerable strength of CM is that financial incentives act

through that same mesolimbic brain reward system (Knutson et al., 2001), thereby leveraging the same brain reward system that drives repeated drug use and addiction to promote recovery. Financial incentives also increase activity in brain regions associated with top-down cortical functions underpinning attention, error monitoring and other executive functions that are important to successful long-term goal seeking (Aston-Jones and Cohen, 2005; Muller et al., 2007) and that are often diminished among those with SUDs (Garavan and Hester, 2007; Lundqvist, 2005). That is, in addition to increasing motivation for making healthier choices through the reinforcement process, financial incentives recruit other processes associated with effective goal attainment.

Controlled trials on smoking cessation during pregnancy and early postpartum

All of the published research on the use of financial incentives with pregnant smokers was conducted by investigators at Oregon State University or the University of Vermont. A summary of the procedures and results from the six trials in this area are presented in Table 1.

Trials conducted by investigators at Oregon State University

The seminal study on incentives with pregnant smokers involved 220 women recruited from Women, Infants, and Children (WIC) programs (Donatelle et al., 2000a). Participants were randomly assigned to the incentives or usual-treatment control condition and assessed at baseline, 8 months gestation, and 2 months postpartum. All participants received a smoking self-help kit that included a pregnancy/maternal specific guide to quitting smoking (Windsor, 1997). Additionally, women in the incentive condition received a monthly $50 voucher contingent on biochemically-verified (salivary thiocyanate<100 μg/ml) smoking abstinence through 2 months postpartum. Participants in the incentives condition also were asked to involve a social-support person. The support person received $50 when the

Table 1
Smoking cessation outcomes in randomized trials using financial incentives with pregnant smokers.

Reference	Sample size	Experimental intervention(s)	Comparison intervention	% Biochemically-confirmed point-prevalent abstinent end of pregnancy	Mean (±SEM) % antepartum visits biochemically-confirmed abstinent	% Biochemically-confirmed point-prevalent abstinent postpartum
Donatelle et al. (2000a)		Visit frequency: monthly				2 months
	E = 112	Voucher magnitude/visit	• Usual care	E = 32%		E = 21%
	C = 108	$50 for pregnant women	• Pregnancy-specific smoking cessation self-help kit	C = 9%	NA*	C = 6%
		$25 for social supporter		$p<.0001$		$p<.001$
		Reset contingency: no				
Donatelle et al. (2000b) reported in Donatelle et al. (2004)	E = 62	Visit frequency: monthly	• Historical control	E = 28%	NA	NA
	C = 108	Voucher magnitude/visit: $50	(Same as above)	C = 9%		
		Reset contingency: no				
Donatelle et al. (2000b) reported in Donatelle et al. (2004)		*E1: incentive only condition*			NA	NA
	E1 = 67	Visit frequency: monthly		E1 = 19%		
	E2 = 59	Voucher magnitude/visit: $25	• Best-practice 5A's (ask, advise, assess, assist, arrange)	E2 = 22%		
	C = 60	Reset contingency: no		C = 12%		
		E2: Incentive + CO feed-back condition				
		All same as above + CO feedback				
Higgins et al. (2004a)	E = 30		• Usual care	E = 37%	E = 46.8 ± 7.7%	3 months
	C = 23	Visit frequency:**	• Pregnancy-specific smoking cessation pamphlets	C = 9%	C = 19 ± 4.9%	E = 33%
		• Antepartum	• Non-contingent vouchers	$p<.05$	$p<.01$	C = 0%
		Week 1 = daily				$p<.05$
		Weeks 2–8 = 2x weekly				6 months
		Weeks 9–12 = 1× weekly				E = 27%
		Weeks 13-delivery = 2× monthly				C = 0%
		• Postpartum				$p<.05$
Higgins et al. (unpublished)	E = 21	Weeks 1–4 = 1× weekly				3 months
	C = 20	Weeks 5–12 = 2× monthly	(Same as above)	E = 10%	E = 15.6 ± 5.2%	E = 5%
		Voucher magnitude/visit:		C = 0%	C = 3.8 ± 1.0%	C = 5%
		Began at $6.25, escalated by $1.25 for each cotinine-negative specimen to $45 maximum		p = ns	$p<.05$	p = ns
		Reset contingency: yes				6 months: E = 5% C = 0% p = ns
Heil et al. (2008)	E = 37		(Same as above)	E = 41%	E = 56.3 ± 7.1%	3 months
	C = 40			C = 10%	C = 17.0 ± 3.4%	E = 24%
				$p<.01$	$p<.0001$	C = 3%
						$p<.01$
						6 months
						E = 8%
						C = 3%
						p = ns

* NA = Not assessed.
** Same experimental intervention for last three studies in this table.

participant was abstinent during the first month and then $25 monthly for continued abstinence, with the last voucher increasing to $50 if the participant was abstinent at the final 2-month postpartum assessment. Vouchers were awarded immediately after abstinence was biochemically verified. Women assigned to the incentives condition achieved significantly greater abstinence than those assigned to the control condition. Point-prevalence abstinence rates at end-of-pregnancy and 2-month-postpartum in the voucher and usual-treatment control conditions were 32% vs. 9% and 21% vs. 6%, respectively (Table 1). The outcomes achieved in the control condition were consistent with the literature on smoking-cessation with disadvantaged pregnant smokers while the results obtained in the incentives condition were several-fold better (Lumley et al., 2009).

In a subsequent trial, 170 women were recruited from WIC programs (Donatelle et al., 2000b reported in Donatelle et al., 2004). The intervention focused on the antepartum period during which participants could earn a $50 monthly voucher contingent on abstinence. The social support component was omitted. The comparison condition was a usual-treatment historical control, which has limitations but provided a comparison condition for evaluating this change in the voucher intervention. Point-prevalence abstinence rates at the end-of-pregnancy assessment again were significantly greater in the voucher than control conditions, 28% vs. 9%, respectively, suggesting that the vouchers given directly to the pregnant women was likely responsible for the majority of effects observed in the earlier trial (Table 1).

A third trial from this group was a randomized controlled trial conducted with 186 women from WIC programs designed to investigate outcomes using a lower-cost incentive program (Donatelle et al., 2000b reported in Donatelle et al., 2004). All participants received a best-practice 5A's (ask, advise, assess, assist, and arrange) intervention (Fiore et al., 2000). Women were randomly assigned to one of three treatment conditions: 5As only intervention, 5As combined with incentives where women received a monthly $25 abstinence-contingent voucher (a decrease from the $50 monthly voucher used in earlier trials), or a condition where the 5As and incentives were combined with immediate feedback about risk associated with specific breath CO levels at the monthly assessments. The goal was to examine whether a lower-value voucher was effective when combined with other interventions. There was a trend toward greater abstinence in the incentive conditions but it was not statistically significant, with point-prevalence abstinence rates at an end-of-pregnancy assessment of 12%, 19%, and 22% in the 5A's only, 5 A's plus incentives, and 5 A's plus incentives plus CO feedback conditions, respectively (Table 1). Outcomes achieved in the two incentive conditions were below those achieved with incentives in the prior trials, which are consistent with prior findings in individual experimental studies and meta-analysis showing that decreasing voucher value reduces the size of the treatment effect (Higgins et al., 2007; Lussier et al., 2006). Adding the 5A's or feedback about harmful effects of different CO values appeared to be insufficient to make up for any loss of effect size associated with the lower reinforcement magnitude.

Trials conducted by investigators at the University of Vermont

The University of Vermont group has reported results from three controlled trials (Heil et al., 2008; Higgins et al., 2004a, 2010a). In all trials, women were recruited from university and community obstetric practices and the local WIC office and assigned to an abstinence-contingent incentive condition or a non-contingent control condition wherein vouchers were delivered independent of smoking status. In addition to the vouchers, women received whatever was usual care for smoking-cessation through their obstetric provider. The first trial included 53 low-income women (Higgins et al., 2004a). The initial 37 subjects in this pilot study were assigned to treatment conditions as consecutive admissions while the remaining participants were assigned randomly. Whether women were assigned to treatment conditions as consecutive admissions or randomly had no significant effect on treatment outcomes. Abstinence monitoring was relatively intensive and structured along the lines used in studies with the cocaine-dependent population (e.g., Higgins et al., 1994).

Women began their cessation effort on a Monday and reported to the clinic daily for 5 consecutive days for abstinence monitoring. The frequency of abstinence monitoring decreased to twice weekly in week 2 where it remained for the next 7 weeks, then decreased to once weekly for 4 weeks, and then to every other week until delivery. During the postpartum period, abstinence monitoring was increased to once weekly again for 4 weeks, and then decreased to every other week through 12 weeks postpartum at which point it was terminated. Voucher value in the abstinence-contingent condition began at $6.25 and escalated by $1.25 per each consecutive negative specimen to a maximum of $45.00 where it remained through the remainder of the intervention save for positive results or a missed visit. Positive test results or failure to provide a scheduled specimen reset the value of vouchers back to their initial low level, but two consecutive negative tests restored voucher value to the pre-reset level. Abstinence verification was based on breath CO specimens $\leq$6 ppm during the initial 5 days of the intervention and switched to urine cotinine ($\leq$80 ng/ml) beginning in week 2 and remained that way through the remainder of the study. Because of cotinine's relatively long half-life, it cannot be used to verify abstinence in the initial days of the quit attempt. Women assigned to the non-contingent voucher condition received the same schedule of assessments but vouchers were delivered independent of smoking status and at values of $11.50 per visit antepartum and $20.00 per visit postpartum, which approximated anticipated average earnings in the contingent condition.

Seven-day point-prevalence abstinence was significantly greater in the contingent than non-contingent conditions at end-of-pregnancy (37% vs. 9%), 12-weeks postpartum (33% vs. 0%) and 24-weeks postpartum (27% vs. 0%) assessments with the last assessment being conducted 12 weeks after discontinuation of the incentives (Table 1). For a measure of abstinence more representative of smoking status throughout antepartum, the mean percent of all scheduled antepartum smoking-status assessments was greater in the contingent than non-contingent conditions ($46.8 \pm 7.7\%$ vs. $19.0 \pm 4.9\%$, $p<.01$, Cohen's $d = .82$). This percent abstinent measure is based exclusively on the biochemical tests and is not influenced by self-report. Mean voucher earnings per woman in the contingent- and non-contingent conditions did not differ significantly and were $\$397 \pm 414$ and $\$313 \pm 142$, respectively, across the approximately 9-month intervention (~$44/month in the intervention condition).

The second trial was conducted to replicate results from the initial study using a fully randomized research design and to investigate treatment effects on fetal growth using serial ultrasound assessments (Heil et al., 2008). Seventy-seven pregnant smokers participated. The contingent-and non-contingent-voucher conditions were largely identical to those described for the initial study. Mean voucher earnings per women in the contingent and non-contingent-voucher conditions were $\$461 \pm 456$ and $\$413 \pm 163$, respectively (~$51/month in the intervention condition). Two ultrasound examinations were performed at approximately 30 and 34 weeks gestation to estimate fetal growth.

Seven-day point-prevalence abstinence was significantly greater among women in the contingent compared to the non-contingent voucher conditions at the end-of-pregnancy (41% vs. 10%) and 12-week postpartum assessments (24% vs. 3%, Table 1). Treatment effects were not significantly different at the 24-week assessment (8% vs. 3%) in this trial whereas they had been in the Higgins et al. (2004a) trial (27% vs. 0%). The mean ($\pm$SEM) percent of all scheduled antepartum smoking-status assessments at which women were abstinent was greater in the contingent than non-contingent conditions ($56.3 \pm 7.1\%$ vs. $17.0 \pm 3.4\%$, $p<.0001$, Cohen's $d = 1.19$).

Seven-day point-prevalence abstinence levels at the end-of-pregnancy assessment among the subgroup of 57 women who completed both ultrasound assessments were quite comparable to those seen overall, with 41% vs. 11% abstinent at the end-of-pregnancy assessment in the contingent- and non-contingent-voucher conditions, respectively. There was a significant increase in estimated fetal weight in the contingent compared to the non-contingent treatment conditions (Fig. 1, top panel). In addition, estimated growth rates of two of the three individual parameters used to compute fetal weight (femur length, abdominal circumference) were greater in the contingent than the non-contingent conditions (Fig. 1, bottom panels). Birth-outcome measures, including mean birth weight,% low-birth weight deliveries, mean gestational age,% preterm births, and% Neonatal Intensive Care Unit admissions were each somewhat improved in the contingent compared to the non-contingent conditions, but none of those differences was statistically significant.

Collapsing across trials to increase power to further examine outcomes

Considering the strong association between ultrasonographic measures of intrauterine growth rate and birth weight (Reeves and Bernstein, 2008) and the relatively small number of women studied in the Heil et al. trial, it seemed plausible that the failure of the differences in birth outcome measures to achieve significance may have resulted from being insufficiently powered to detect them. Thus, a follow-up analysis was conducted using data collapsed from women across three trials (Higgins et al., 2010a). All three trials contained the same treatment and control groups. Two of those trials were described above (Heil et al., 2008; Higgins et al., 2004a); a third unpublished randomized trial (Higgins, unpublished) conducted by the same investigators and involving the same treatment conditions was included as well. The unpublished trial was conducted for staff-training purposes following unexpected staff turnover between the pilot (Higgins et al., 2004a) and fully-randomized trials (Heil et al., 2008). In the unpublished trial with 41 participants, 7-day point-prevalence abstinence at the end-of-pregnancy assessment was somewhat higher in the contingent compared to the non-contingent condition (10% vs. 0%), but that difference was not statistically significant, nor were the differences in point-prevalence abstinence levels observed at 12-weeks (5% vs. 5%) and 24-weeks (5% vs. 0%) postpartum (Table 1). However, there was a significant treatment effect favoring the contingent condition in the mean (±SEM) percent of all scheduled antepartum smoking-status assessments at which women were biochemically confirmed abstinent (15.6±5.2% vs. 3.8±1.0%, $p<.05$, Cohen's $d=.69$), which is particularly relevant to improving birth outcomes (Higgins et al., 2010a).

Treatment conditions were the same across the three trials except for assigning the initial group of 37 study participants in the pilot study to treatment conditions as consecutive admissions as was described above. All of the remaining women in that and subsequent trials were assigned randomly to treatment conditions. A total of 183 women were enrolled in these trials. Seventeen of those women were excluded from this study on birth outcomes due to abortions (12), multiple births (3), and missing birth records (2), leaving 166 women who contributed data. Of the 17 exclusions, 8 were from the intervention and 9 from the non-contingent control conditions. All birth outcome information was obtained from review of the hospital delivery summary records.

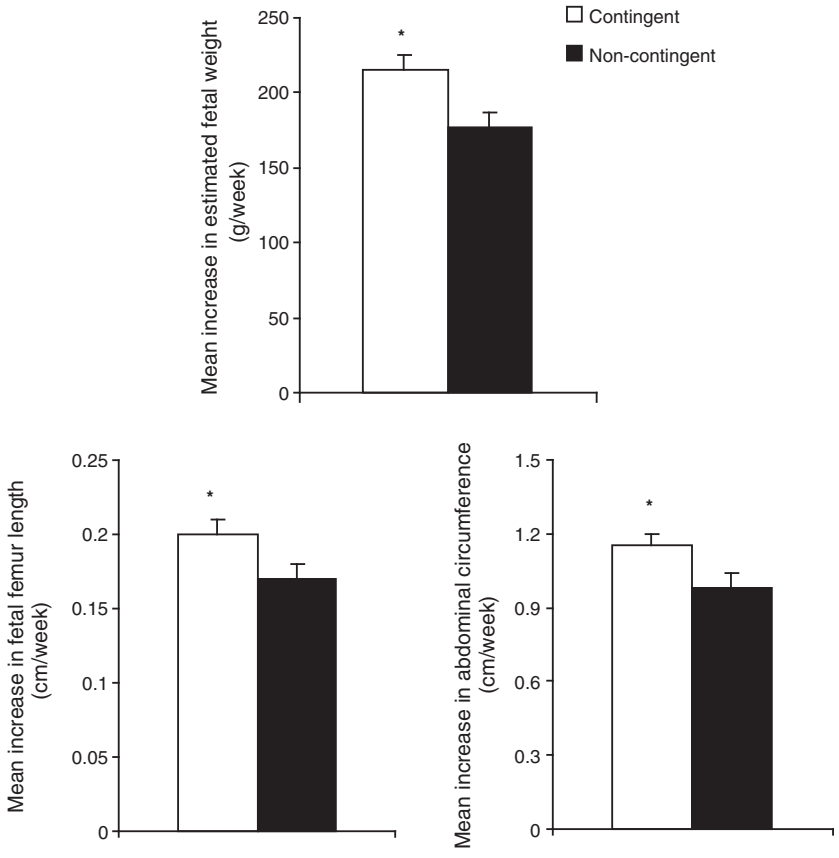

Fig. 1. Mean (±SEM) rates of growth in estimated fetal weight (top panel), fetal femur length (bottom left panel), and fetal abdominal circumference (bottom right panel) between ultrasound assessments conducted during the third trimester. Women in the contingent condition received vouchers exchangeable for retail items contingent on biochemically verified smoking abstinence while those in the non-contingent condition received vouchers of comparable value but independent of smoking status. * indicates a significant difference between conditions ($p<.05$).
From Heil et al., 2008.

Seven-day point-prevalence abstinence at the end-of-pregnancy assessment was significantly greater in the contingent compared to the non-contingent control condition (34% vs. 7%; p<.001, Fig. 2). Smoking abstinence levels remained significantly greater in the contingent compared to the non-contingent condition at 12-weeks postpartum (24% vs. 3%, p<.0001), and at the 24-weeks postpartum assessment (14% vs. 1%; p=.003) completed 12 weeks after the incentive program was discontinued (Fig. 2). The mean (±SEM) percent of all scheduled antepartum smoking-status assessments at which women were biochemically confirmed abstinent was greater in the contingent than non-contingent conditions (39.6±3.4% vs. 13.3±3.5%; p<.0001, Cohen's d=.88).

Regarding birth outcomes, mean birth weight differed significantly between treatment conditions, with infants born to mothers treated in the contingent condition weighing on average 202 g more than those born to mothers treated in the non-contingent condition (Table 2). That difference between treatment conditions reflected an upward shift in the distribution of birth weights of infants born to mothers treated in the contingent compared to the non-contingent condition (Fig. 2). The percent of low birth weight (<2500 g) deliveries was 12.6% lower in the contingent than non-contingent conditions (Table 2) and that difference was also discernible in the distribution of birth weights in the two treatment conditions (Fig. 3). Treatment effects approached but did not achieve statistical significance for the three other birth-outcome measures examined, which we are confident is attributable to still being underpowered for detecting these changes (Table 2). Regressions were conducted confirming that smoking status mediated treatment effects on mean birth weight (Kraemer et al., 2001).

The larger data set that resulted from collapsing across trials created an opportunity to investigate treatment effects on breastfeeding (Higgins et al., 2010b). Inadequate duration of breastfeeding remains a challenge in developing and developed countries (Horta et al., 2001; van Rossem et al., 2009), which has prompted efforts to identify modifiable determinants of breastfeeding duration (Horta et al., 2001; van Rossem et al., 2009). Maternal cigarette smoking is among the most consistently identified predictors of early weaning across studies, but whether smoking-cessation treatment increases breastfeeding duration had not been reported. This data set provided an opportunity to examine that question.

Study participants were 158 of the cohort in the birth outcomes study who completed a yes–no self-report item at 2-, 4-, 8-, 12-, and 24-weeks postpartum asking whether they were breastfeeding. As shown in Fig. 4, there were no significant treatment effects on the percentage of women reporting breastfeeding at 2-weeks (p=.11) or 4-weeks (p=.07), but significant differences emerged at 8-weeks, with 41% in the contingent vs. 26% in the non-contingent control conditions reporting breastfeeding (p=.01). That difference remained discernible at 12-weeks, with 35% in the contingent condition vs. 17% of women in the non-contingent condition reporting breastfeeding (p=.002). By 24 weeks, 12 weeks following termination of the smoking-cessation intervention, treatment effects on breastfeeding were no longer significant (p=.10). Smoking status (7-day point-prevalence abstinence at respective postpartum follow-up assessments) was a significant mediator of breastfeeding in a regression model of mediation effects.

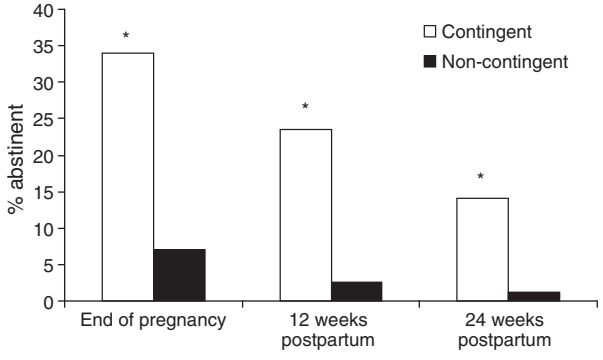

Fig. 2. Seven-day point-prevalence abstinence at the end-of-pregnancy, 12-, and 24-week postpartum assessments in the contingent (n=85) and non-contingent (n=81) treatment conditions. Treatment conditions are the same as described in Fig. 1. * indicates a significant difference between conditions (p=.003 or below across the three assessments).

Table 2
Infant outcomes at delivery.
Based on results reported in Higgins et al. (2010a).

Measure	Contingent (n=85)	Non-contingent (n=81)	P values
Birth weight (grams)	3295.6±63.8	3093.6±67.0	.03
% Low birth weight	5.9	18.5	.02
Gestational age (weeks)	39.1±0.2	38.5±0.3	.06
% Preterm births	5.9	13.6	.09
% NICU admissions	4.7	13.8	.06

Values represent mean±standard error, unless specified otherwise. Women in the contingent condition received vouchers exchangeable for retail items contingent on biochemically verified smoking abstinence while those in the non-contingent condition received vouchers of comparable value but independent of smoking status. NICU: neonatal intensive care unit.

Discussion

There is broad consensus regarding the need for more effective interventions for increasing smoking cessation among pregnant women. Financial incentives as described in the studies reviewed herein hold promise for meeting that need. The cessation rates described above are several-fold above those observed among pregnant smokers in the most comprehensive meta-analysis of this area (Lumley et al., 2009). The same appears to hold for the treatment effects observed on birth outcomes (Heil et al., 2008; Higgins et al., 2010a, 2010b). In the Lumley et al. (2009) meta-analysis, smoking-cessation treatments were estimated to increase mean birth weight by 53 g and decrease the relative risk for low birth weight deliveries by 17%. Treatment effects on mean birth weight and percent low birth weight deliveries in the studies reviewed above were more than three-fold greater. At least part of the explanation for these differences in treatment-effect size on birth outcomes is that treatment

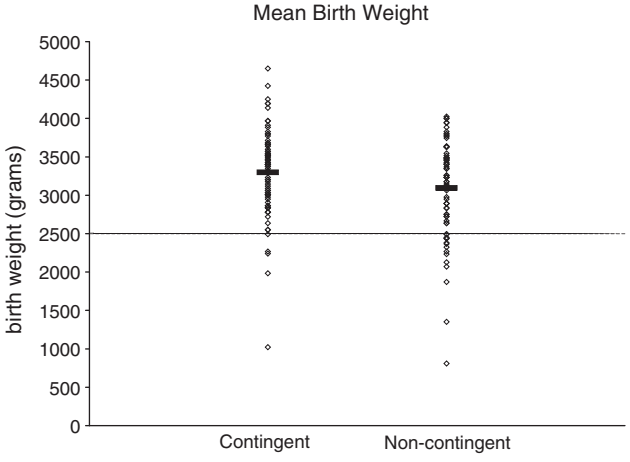

Fig. 3. Birth weights of infants born to mothers treated in the contingent (left column, n=85) and non-contingent (right column, n=81) treatment conditions. Treatment conditions are the same as described in Fig. 1. Each symbol represents an individual infant's birth weight and the solid line in each column represents the least square mean weight for that condition. The dashed line demarcates the 2500 g cutoff for low birth weight. Mean birth weight differed significantly between treatment conditions (P=.03) as did the percent of low birth weight deliveries (P=.02).
From Higgins et al., 2010b.

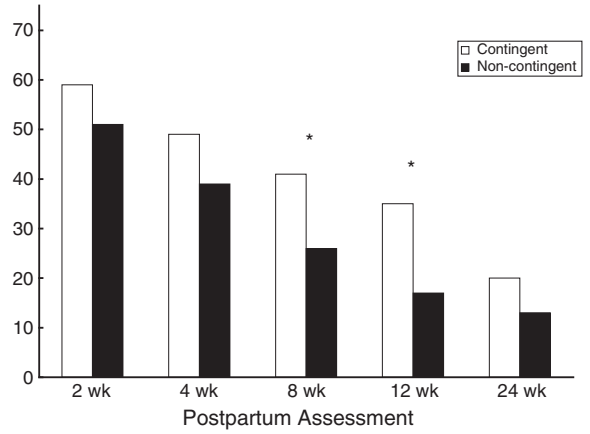

Fig. 4. Percentage of women who reported breastfeeding at the 2-, 4-, 8-, 12- and 24-week postpartum assessments in the contingent (n = 81) and non-contingent (n = 77) conditions. Treatment conditions are the same as described in Fig. 1. Asterisks denote significant differences between treatment conditions with $p \leq .05$.
From Higgins et al., 2010a.

effects on antepartum abstinence rates in the meta-analysis and the incentives studies also differed by more than three-fold, with, for example, the average difference in late-pregnancy abstinence levels between intervention and controls in the meta-analysis being 6% whereas in the Higgins et al. (2010a) collapsing across the three trials, that difference was 27%. The positive treatment effects on breastfeeding duration observed with financial incentives have not been reported previously (Lumley et al., 2009).

A potentially important overall message to be gleaned from this comparison of results from the meta-analysis and outcomes with financial incentives when considering strategies for reducing smoking during pregnancy is that the extra treatment effort and costs involved in achieving lower smoking rates appear to translate into proportionately greater improvements in important birth outcomes and related postpartum outcomes. Those improvements have the potential to readily offset the costs of the intervention. Of particular relevance to that point, the United Kingdom's National Institute for Health and Clinical Excellence (NICE) commissioned an economic analysis of the interventions reviewed in the Lumley et al. meta-analysis comparing financial incentives, cognitive behavioral strategies, stages of change, feedback, pharmacotherapies, and "other" therapies (Taylor, 2009). They estimated that financial incentives produced the highest net cost benefit per intervention, with a net benefit of £2261 lb or $3482 after accounting for the cost of the intervention.

Considering how important smoking abstinence is to the immediate and longer-term health of the offspring, more research is needed to determine how to get a larger proportion of women to successfully quit. The research conducted on reinforcement magnitude (i.e., monetary value) when using incentives to treat other SUDs suggests that it will be an important parameter (Lussier et al., 2006). Donatelle and colleagues saw a reduction in treatment effect when voucher earnings were reduced from $50 to $25 per month despite efforts to bolster the intervention by including the 5A's and feedback about potential harmful effects of smoking, which provides an initial hint at where the lower limit may be in voucher values for promoting abstinence. The trials conducted at the University of Vermont have involved voucher values that amount to approximately $50/month, but also a schedule involving more frequent monitoring of smoking status and associated opportunities for reinforcing sustained abstinence. The extent to which treatment effects with this intervention can be increased by further increasing voucher value has not yet been researched with pregnant smokers, but research with other populations of substance abusers suggests that improved outcomes are likely (e.g., Higgins et al., 2007; Silverman et al., 1999). Importantly, while the value of the voucher may be primary it is by no means the only parameter in need of further investigation in developing this treatment approach (e.g., frequency of clinic contact and duration of postpartum treatment merit investigation). Combining voucher-based CM with pharmacotherapies or other effective cessation treatments represents another viable method for further increasing cessation rates above those observed to date that warrants investigation, especially in light of the importance of initial abstinence to longer-term outcomes (Higgins et al., 2007), problems of nicotine withdrawal during those initial weeks (Heil et al., 2006), and the promising increases in birth weight reported in at least one placebo-controlled, randomized clinical trial on nicotine replacement therapy with pregnant smokers (Oncken et al., 2008).

As discussed above, the focus in treatment development for smoking during pregnancy largely has been on public-health interventions that have relatively broad reach and low cost. There is little question that such treatments should continue to represent an important aspect of the effort to eliminate smoking during pregnancy. That said, the four-fold differences in effectiveness between these more typical low-intensity interventions and financial incentives also suggest that such interventions are inadequate for treating an important subset of this population, namely socioeconomically disadvantaged women and heavier smokers (Lumley et al., 2009). In order to meet the treatment needs of the entire range of pregnant smokers, the low-cost, broad-reach approach may need to be supplemented with higher cost, more intensive interventions of the type offered to pregnant women dependent on substances other than cigarette smoking (e.g., French et al., 2002; Heil et al., 2009). We believe that voucher-based financial incentives offer an opportunity to expand in that more intensive direction.

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Conflict of interest statement

None of the authors have competing interests.

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