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Positive parenting behaviors in women who spontaneously quit smoking during pregnancy: Clues to putative targets for preventive interventions

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Abstract

Background—While the majority of pregnant smokers do not respond to intervention, little is known about how a subset of pregnant smokers known as spontaneous quitters achieve sustained biologically-confirmed abstinence through delivery in the *absence* of intervention. We explore a developmental framework to address this question by viewing spontaneous quitting as an adaptive parenting behavior, facilitated by abilities necessary for sensitive parenting, or *responsiveness*. Utilizing existing data, we examined responsiveness from parenting assessments in women who exhibited a variety of smoking patterns during pregnancy, including spontaneous quitting.

Methods—Participants were N=305 pregnant women assessed for smoking prospectively and biochemically at 16 weeks, 28 weeks, delivery, and 4 weeks postpartum, then reassessed with their children 5 years later with directly-observed home- and lab-based measures of parenting. We used

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linear regression analysis to compare spontaneous quitters with women who exhibited other prenatal smoking patterns on parenting responsiveness, controlling for potential confounders.

Results—In home-based observations, spontaneous quitters ($n=22$) exhibited greater responsiveness with their children relative to intermittent pregnancy smokers ($n=70$; $\beta=.258$, $p=.022$); persistent pregnancy smokers [$n=66$; $\beta=.228$, $p=.040$]; former smokers (quit before pregnancy) [$n=78$; $\beta=.266$, $p=.028$]; and never smokers [$n=69$; $\beta=.312$, $p=.009$]. Hypothesized differences were not observed in lab-based and self-report measures.

Conclusions—Putative protective characteristics in spontaneous quitters were captured in mother-child interactions at home, but not in lab-based and maternal report measures of responsiveness. Specification of these characteristics using prospective designs that oversample for spontaneous quitters is recommended to enable translation to preventive interventions.

Keywords

Pregnancy smoking; prenatal tobacco exposure; protective factors; maternal sensitivity

1. Introduction

Following over 40 years of intervention research, maternal smoking during pregnancy (MSDP) remains a leading modifiable risk factor for adverse neonatal, neurodevelopmental, and cardiometabolic outcomes across the lifespan (Johnson et al., 2017). Behavioral interventions recommended by the U.S. Preventive Services Task Force and financial incentive-based approaches to this problem are ineffective for the majority of pregnant smokers who have not quit on their own (Chamberlain et al., 2013). Understudied, is how a subset of smokers known as *spontaneous quitters*, constituting 40–65% of privately-insured pregnant smokers and 11–28% of publicly-insured smokers, successfully suspend smoking in early pregnancy, and remain abstinent through delivery, as confirmed with biomarkers (Solomon and Quinn, 2004). Interestingly, spontaneous quitters achieve far better 6-month abstinence rates than non-pregnant smokers who are highly-motivated to quit for reasons other than pregnancy, for example, men and women who recently suffered a heart attack (Dornelas et al., 2000). Indeed, when viewed as a natural intervention, *pregnancy is associated with a greater protective effect on women's drug use than any intervention*, independent of demographic, environmental, and heritable influences (Kendler et al., 2017) including women's intentions to raise the child (Massey et al., 2011; Massey et al., 2012; Massey et al., 2016). Yet the mechanisms that underlie pregnancy's apparent protective effect are unclear, and if elucidated, could substantially improve the effectiveness of interventions (Massey and Wisner, In Press).

Towards this end, we have shown that MSDP exists within a broader interpersonal framework that includes women's psychosocial context (Wakschlag et al., 2003), the maternal fetal relationship (Massey et al., 2015a; Massey et al., 2012), and ways that women tend to relate to others (Bradstreet et al., 2012; Maxson et al., 2012). Moreover, as genetic factors and social cognitive abilities implicated in caregiving behavior have been linked to variability in MSDP (Massey et al., 2015b), the highly evolutionarily-conserved

neurobiological processes that subserve caregiving may facilitate attempts to abstain from smoking while pregnant (Massey et al., 2017).

Indeed, the belief that ‘smoking harms [the] baby’ is associated with a 14-fold increase in the odds of quitting smoking during pregnancy—an effect that far exceeds the effect of nicotine dependence (White et al., 2014). Thus, while spontaneous quitters may have lower nicotine dependence and fewer psychosocial risks relative to persistent pregnancy smokers (Solomon and Quinn, 2004), yet-to-be identified protective characteristics (and/or their interaction with the recognition of a pregnancy) beyond a relative absence of risks, likely account for the well-documented positive changes in smoking and other drug use observed in pregnant women. For example, we have provided support, in our earlier work, for a protective developmental trajectory associated with quitting smoking during pregnancy. In a large epidemiologic sample, we found that toddlers of mothers who quit smoking during pregnancy exhibited fewer behavioral problems relative to toddlers of mothers who did *not* quit, and also toddlers of women who had *never smoked* (Hutchinson et al., 2010). Thus, parallel to the well-studied risk pathway associated with MSDP, there appears to be a *protective* pathway associated with quitting smoking during pregnancy (Pickett et al., 2008). We extend this work to elucidate positive characteristics that differentiate spontaneous quitters from other pregnancy smokers and also other pregnant women.

We have previously proposed as a candidate protective factor, the ability to accurately perceive the needs of others and respond by helping, described by the construct, empathy {Decety, 2016 #792}. Empathy is fundamental to maternal caregiving {Eisenberg, 1987 #94} and can be approximated through the degree of responsiveness observed in parents when interacting with their children (Bornstein and Tamis-LeMonda, 1997; Wakschlag and Hans, 2002). Thus, in the absence of direct assessments of empathy in pregnant smokers at the present time, in this study, we aimed to provide initial support for the hypothesized empathy-related model of spontaneous quitting (Massey et al., 2017). Using existing data from a large, well-characterized prenatal smoking cohort with follow-up assessments of observed parenting responsiveness, (used here, as a proxy measure of empathy during pregnancy), we tested the following hypotheses. First, we expected that spontaneous quitters would exhibit greater responsiveness relative to smokers who did not quit. Second, as the relevance of responsiveness to quitting smoking is likely unique to pregnancy, we expected spontaneous quitters would be more responsive than women who had quit smoking earlier in life, presumably for reasons other than the pregnancy (i.e., former smokers). Finally, to replicate our earlier findings about a protective developmental trajectory associated with quitting smoking during pregnancy, we hypothesized that spontaneous quitters would also be more responsive than women who had *never* smoked.

2. METHODS

2.1 Participants

Women were recruited in early pregnancy (65% prior to 16 weeks, 100% by 28 weeks) over a 4.5 year period from obstetric clinics in Southern Illinois and in a mid-sized city in Nebraska for the Midwest Infant Development Study (MIDS)(Wang et al., 1997). As the MIDS was designed to compare tobacco-exposed and non-exposed infants on developmental

outcomes while minimizing the influence of other exposures, cigarette smokers were oversampled, while women who reported illegal drug use or consumption of four or more alcoholic drinks in a single sitting at enrollment were excluded. At 4 weeks postpartum, women reported on infant temperament. When children were approximately 5 years of age ($M=5.06$, $SD=0.26$; range=1.37), mothers and children were reassessed in a preschool follow-up study (MIDS-P). Parent-child interactions were assessed during a one-hour home visit, during a 1.5 hour laboratory visit, and by maternal report. Figure 1 shows the derivation of the analytic sample. Since women with multiple births ($n=7$ sets of twins) were assessed with each child separately, resulting in two sets of parenting measures, we excluded these dyads from the current analysis. All procedures were approved by the Institutional Review Boards of the University of Nebraska–Lincoln (MIDS), University of Illinois—Carbondale (MIDS), and Northwestern University (MIDS-P) and conducted after informed consent procedures.

2.2 Maternal smoking

During pregnancy, smoking patterns were characterized prospectively using repeated timeline follow back interviews (Sobell and Sobell, 1996) and cotinine assays at 16 and 28 week visits and at delivery ($M = 4.3$ visits, $SD = 1.1$, range 1 – 6). At baseline, we also assessed smoking history, including any lifetime smoking (yes/no), current smoking (yes/no), partner smoking (yes/no), and, for lifetime smokers who were not currently smoking, their quit date. Concentration of cotinine, the major proximate metabolite of nicotine exposure (Benowitz, 1996), was analyzed from maternal urine specimens collected at 16 and 28 weeks of gestation, from infant meconium at delivery, and from maternal urine at 4 weeks postpartum, using gas chromatography-mass spectroscopy with a limit of detection of 4 ng/ml (United States Drug Testing Laboratories, Inc., Des Plaines, IL). At the preschool follow-up, mothers reported on average cigarettes/day smoked in the past week.

2.2.1 Categorization of prenatal smoking groups—While pregnancy-specific cut-offs are typically used to distinguish true smoking from environmental smoke exposure by pregnant women (Dempsey et al., 2002; Kim, 2016), cutoffs do not distinguish between smoking that occurred one or more days prior to specimen collection from environmental tobacco exposure (George et al., 2006). Since certainty about successful abstinence was of utmost importance for the current study, we favored under-identification rather than over-identification of spontaneous quitters, and considered *any* nonzero cotinine value, *a priori*, as a positive indication of smoking. Based on all available interview and biological data, we categorized women into the following groups (Table 1):

- A. *Never smokers* - reported never having smoked in their lifetime or during pregnancy and all cotinine values were zero;
- B. *Former smokers* - reported lifetime smoking, quit prior to month of LMP (mean time = 5.5 years prior to LMP; range = 0.3 to 16.9 years), reported no smoking during pregnancy and all cotinine values were zero;
- C. *Spontaneous quitters* - reported smoking in month of the LMP, quit before the baseline visit, reported no smoking during pregnancy and all cotinine values were zero;

- D. *Intermittent pregnancy smokers* - evidence of smoking either from self report or cotinine at some but not all visits; and
- E. *Persistent pregnancy smokers* - evidence of smoking from either self report or cotinine at every visit.

2.3 Responsiveness

2.3.1 In-home observation—Parenting was assessed by direct observation and structured interviews in participants' homes using the Early Childhood Home Observation for Measurement of the Environment (EC-HOME) (Totsika and Sylva, 2004). This descriptive profile, designed for children 3 – 6 years of age, measures the quality and quantity of support and stimulation available to a child in his/her home environment in a naturalistic context (Bradley, 1993) and has been validated in both community and high-risk samples (Totsika and Sylva, 2004). The EC-HOME was coded independently by two trained research assistants (weighted Kappa = .85 – 1 for all subscales). For hypothesis testing, we used the 7-item Responsivity Subscale (range 0 – 7) which quantifies warm and responsive interactions towards the child (Cronbach's α = .619). An example interview question from this subscale is: "As your child has gotten older, does he/she still want to be held by you or sit close to you?" Sample observations assessed are: "Parent answers child's questions or requests verbally" and "Parent caresses, kisses, or cuddles child twice during visit."

2.3.2 Direct-observation in the lab—Responsiveness was also assessed with the Responsive Involvement Domain (range 0 – 20) of the Parent Clinical Observation Schedule (PCOS) (Hill et al., 2008) based on parenting behaviors during a 20-minute interaction involving a series of standardized laboratory activities specifically designed to elicit variations in parent engagement across different interactional contexts (working on a challenging puzzle together, putting crayons back into a box together, parent asking child to work independently while he/she is busy filling out a questionnaire). Specific parenting behaviors viewed in video recordings were coded for responsiveness on a 4-point scale (0=none to 3=high) by two trained independent raters (weighted Kappa=0.77).

2.3.3 Maternal report and correlations among responsiveness measures—During the laboratory visit, mothers completed the Parenting Styles and Dimensions Questionnaire (PSDQ) (Robinson et al., 1995). In the PSDQ, parents rate the degree to which statements are true about them on a 1 to 5 scale (i.e., I give my child comfort and understanding when he/she is upset). We used the 11-item Warmth and Involvement Dimension (Cronbach's α = .72 in analyses (range 3 – 20).

2.4 Covariates

At baseline, we measured several potential covariates for inclusion in our regression models based on their previous associations with smoking during pregnancy and parenting responsiveness. These included maternal age, marital status, education, race and ethnicity, partner smoking, and hostility (Homish et al., 2012). As covariates of parenting behavior, we considered infant temperament (Clark et al., 2016), concurrent smoking, impulsivity (White et al., 2014), depressive symptoms (Lovejoy et al., 2000), antisocial behaviors (Ehrensaft et

al., 2003), and family conflict (Cooklin et al., 2015). Specific measures used are shown in the legend under Table 1.

2.5 Data analysis

We assessed between-group differences among covariates using one-way ANOVA and two-sided Pearson χ^2 tests for continuous and binary variables, respectively (Table 1). To discern the degree to which responsiveness differed as a function of successful smoking cessation versus continued smoking (hypothesis 1), we compared spontaneous quitters with intermittent and persistent smokers. To examine the association of responsiveness with smoking cessation in and outside the context of being pregnant (hypothesis 2), we compared spontaneous quitters with former smokers. Finally, to determine whether spontaneous quitters exhibited a level of responsiveness beyond the absence of risks associated with lifetime smoking (hypothesis 3), we compared spontaneous quitters with never smokers.

Covariates showing significant between-group differences ($\alpha < .05$) were selected for inclusion in subsequent regression models. No evidence of multicollinearity, defined *a priori*, as $r \geq .60$, was found among variables from bivariate correlations. Finally we conducted 3 separate linear regression models using the EC-HOME, PCOS, and PSDQ as dependent variables, respectively, using spontaneous quitters as the reference group, and the 4 other smoking groups entered as dummy variables.

3. Results

3.1 Maternal demographics

At study enrollment, mothers were primarily non-Hispanic Caucasian women (81.6%) in their mid-twenties ($M = 25.9 \pm 4.9$ years) with one year of post-high-school education ($M = 13.3 \pm 2.0$ years). Over half of women (58.0%) were unmarried, had other children at the time of the studied pregnancy (59.0%), and reported having a romantic partner who smoked (51.3%).

3.2 Maternal tobacco and other drug use

Cotinine-corrected MSDP, and cotinine concentrations from maternal and infant specimens (ranges = 1905.67 ng/ml and 81.67.0 ng/g, respectively) are shown in Table 1. One third (33.4%) of mothers ($n=102$) reported using alcohol during pregnancy and 22 (8.6%) out of the 281 infants with meconium data were positive for alcohol metabolites. Metabolites of marijuana and opioids were additionally detected from meconium in 11 (3.9%) and 7 infants (2.5%), respectively.

Among the 70 women categorized as intermittent pregnancy smokers, 36 (51.4%) had quit at enrollment but showed evidence of relapse at a later study visit. Three relapsed before 16 weeks (8.3%); 20 relapsed between 16 and 28 weeks (55.6%); and 13 relapsed close to delivery (36.1%). The remaining 34 intermittent smokers (48.6%) were smoking at enrollment. Of these, 31 (91.2%) were abstinent just before delivery (91.2%); 2 were abstinent just prior to the 16 week visit (5.9%); and 1 was abstinent before the 28 week visit (2.9%). Among the 22 spontaneous quitters, 10 had resumed smoking (45.5%) by 4 weeks

postpartum, 8 were still abstinent (36.4%), and the remaining 4 reported abstinence, but did not have cotinine data for confirmation.

3.3 Responsiveness

The PCOS showed small but significant correlations with the EC-HOME ($r = .148$, $p = .019$) and the PSDQ ($r = .215$, $p = .001$). The EC-HOME and PSDQ were not significantly correlated with one another ($r = .093$, $p = .108$). Concurrent smoking at the preschool follow-up was unrelated to scores of responsiveness from the EC-HOME ($r = .035$, $p = .535$); PCOS ($r = .030$, $p = .647$); and PSDQ ($r = .045$, $p = .461$).

In between-group comparisons of responsiveness, spontaneous quitters had higher EC-HOME scores relative to women who did not quit (i.e. intermittent and persistent pregnancy smokers) (4.5 ± 1.5 versus 3.6 ± 1.7 ; $p = .011$); former smokers (4.5 ± 1.5 versus 3.5 ± 2.0 ; $p = .016$); and never smokers (4.5 ± 1.5 versus 3.4 ± 2.0 ; $p = .009$). Responsiveness measured by the PCOS and PSDQ, maternal depressive symptoms, maternal impulsivity, and family conflict did not show hypothesized between-group differences (Table 1).

3.4 Covariates

Among covariates of prenatal smoking, maternal age ($F(4, 299) = 3.664$; $p = .006$), unmarried status ($F(4, 300) = 4.390$; $p = .002$), education ($F(4, 300) = 7.735$; $p < .001$) and partner smoking ($F(4, 299) = 11.025$; $p < .001$) showed between-group differences. At 4 weeks postpartum, spontaneous quitters were less likely to rate their infants' temperament as 'easy' compared to former smokers ($p = .025$) and never smokers ($p = .043$); spontaneous quitters were also more likely to rate their infants as 'slow to warm' relative to never smokers ($p = .028$). At the preschool follow-up, we observed between-group differences in concurrent smoking ($F(4, 270) = 54.723$; $p < .001$) and antisocial behavior ($F(4, 296) = 10.450$; $p < .001$).

3.5 Regression models of responsiveness

Table 2 shows estimated marginal means of responsiveness (EC-HOME) by prenatal smoking pattern (left), and contrast estimates (right) relative to spontaneous quitters (reference group) derived from linear regression. Spontaneous quitters were more responsive than pregnancy smokers, former smokers, and never smokers, controlling for maternal age, unmarried status, education, partner smoking, infant temperament, concurrent smoking, and maternal antisocial behavior. We did not observe differences in responsiveness measured by the PCOS or the PSDQ. Responsiveness measured by the PCOS was predicted, instead, by maternal educational attainment ($\beta = .167$, $p = .025$) while responsiveness measured by the PSDQ was predicted by easier infant temperament at 4 weeks postpartum ($\beta = .142$; $p = .009$).

4. Discussion

While pregnancy is associated with an unparalleled protective effect on women's smoking (Solomon and Quinn, 2004) and other drug use (Kendler et al., 2017), the underlying mechanisms are unclear, but potentially valuable for identifying novel intervention targets. Building on our prior work aimed at characterizing a pregnancy-specific mechanism of

smoking behavior change (Massey et al., 2017; Massey et al., 2015b; Massey and Wisner, In Press), we examined responsive parenting behavior, as a proxy measure of empathic capacity (Eisenberg and Miller, 1987), hypothesized to differentiate smokers who successfully quit in early pregnancy (spontaneous quitters) from women who did not engage in this protective action during pregnancy (either because they continued smoking, had quit earlier in life for reasons other than pregnancy, or had never smoked) (Massey, 2017 #732).

We found partial support for our hypotheses. When observed with their children at home (EC-HOME), spontaneous quitters compared favorably on responsiveness relative to other women including never smokers, which broadly echoes our previous findings about a protective developmental trajectory associated with quitting (Hutchinson et al., 2010; Pickett et al., 2008). However, exactly how quitters differ from other women may not be wholly captured by the construct of responsiveness, as operationalized here, since the PCOS and PSDQ did not show these differences. This was unexpected due to overlap among these measures. However, one aspect of parenting assessed by the PCOS and PSDQ, but not the EC-HOME, is how parents react to their child's frustration. Thus, it is plausible that while spontaneous quitters displayed greater warmth with their children at home relative to other mothers, they did not differ in their ability to respond to their children's distress, by their own reports, or elicited in the lab-setting.

Nonetheless, we carefully considered a number of alternative explanations for these results in light of the discrepancy. For example, spontaneous quitters could have represented outliers with unusually favorable characteristics. But this possibility was not supported by the data. Spontaneous quitters were hardly free from risk - they engaged in more antisocial behaviors (i.e. skipping school, legal problems, physical fights, being fired from a job for performance) relative to former smokers and never smokers. This heterogeneity in subsamples categorized based on prenatal smoking patterns was also evident in our previous work (in a different sample); pregnancy quitters were more likely to be in a stable romantic relationship compared to other groups, but were less likely to obtain adequate preventive health care (Wakschlag et al., 2003).

Another potential explanation for superior responsiveness observed in spontaneous quitters is an increase in self-efficacy resulting from quitting smoking (Mathieu et al., 1993) that was later observable as responsive parenting (Coleman and Karraker, 2003). However, if this were the case, former smokers would be expected to demonstrate comparable responsiveness to spontaneous quitters, but they did not. Summarily, responsive mother-child interactions at home differentiated mothers who had abruptly suspended smoking in early pregnancy and remained abstinent through delivery from other mothers in this sample, including mothers who never smoked. This finding, together with our earlier work regarding children of women who quit smoking during pregnancy (Hutchinson et al., 2010; Pickett et al., 2008), provide compelling support for the presence of protective factors, partially described by responsiveness, that could plausibly facilitate smoking cessation in the context of pregnancy, independent of nicotine dependence and psychosocial stressors. Confirmation of these initial findings using a prospective design, and specification of key malleable component(s) that facilitate or sustain behavior change could provide the empirical foundation for a pregnancy-

specific conceptual model from which novel prenatal intervention strategies could be developed.

4.1 Limitations

Findings should be interpreted in the context of study limitations, especially the small sample of 22 spontaneous quitters, who represented 13.9% of the 158 women who were smoking at the time of their LMP. While this cessation rate is well-within ranges previously reported in pregnant women recruited from public obstetric clinics when biochemical verification is used (i.e. 11 – 28%) (Higgins and Solomon, 2016; Kendrick et al., 1995; Secker-Walker et al., 1998; Windsor et al., 1998), replication is recommended. Relatedly, our approach to characterizing spontaneous quitters, (i.e. zero cotinine values rather than a cutoff) could raise concern about miscategorization of ‘true’ spontaneous quitters who were exposed to partner smoking as intermittent smokers. We considered the possibility, for example, that the 22 spontaneous quitters all had non-smoking partners, and avoided this common source of exposure to secondhand smoke. But the data do not support this. The prevalence of partner smoking was comparable between spontaneous quitters and pregnancy smokers ($p=.806$), and higher in spontaneous quitters compared to former smokers ($p=.055$), and never smokers ($p=.004$), as would be expected (Table 1).

Furthermore, as a *post hoc* test of validity of our categorization scheme, we recategorized the intermittent smokers who had abstinent study visits later in pregnancy ($n=34$) into the quitters group, then re-examined between group-differences in responsiveness. Recategorization had the effect of reducing the quitters’ EC-HOME score, and rendered previously-found differences between spontaneous quitters and other groups non-significant ($p=.362$). The PCOS and PSDQ still did not differentiate quitters from other groups, as seen before. This provided a measure of validity of the found relationship between quitting before 16 weeks and remaining abstinent through delivery and responsive mother-child interactions 5 years later. Finally, the use of other substances by pregnant smokers is documented in nationally-representative survey studies (Coleman-Cowger et al., 2017). Women who endorsed binge drinking or illicit drug use at enrollment were excluded from this study which could threaten generalizability. However, available meconium data showed that alcohol, cannabis, and opioid use in late pregnancy was not uncommon (Section 3.3).

5. Conclusions

Findings from this study add to the limited knowledge about mechanisms associated with pregnancy that facilitate the phenomenon of abrupt and successful suspension of smoking in the absence of treatment (Solomon and Quinn, 2004). Replication and elaboration of the proposed developmental framework via secondary analysis of pooled developmental cohorts to increase power is recommended. Ultimately, confirming exactly how pregnancy exerts a protective effect on smoking and substance use will require new prospective investigation(s) that oversample for and accurately identify spontaneous quitters, and assess putative protective mechanisms directly (Massey et al., 2017). This research could yield novel targets for interventions aimed at initiating and sustaining changes in smoking and other drug use (Massey and Wisner, In Press).

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Highlights

- Most pregnant smokers who have not quit on their own do not quit with intervention.
- Smokers who quit on their own early in pregnancy are understudied.
- Spontaneous quitters may possess unmeasured protective factors beyond lower risks.
- Quitters were more responsive to their children at home compared to other women.
- Quitters were more responsive even compared to women who never smoked.

Figure 1.

Derivation of analytic sample (N=305 mother-child dyads).

LMP = Last menstrual period preceding the studied pregnancy

Table 1

Descriptive characteristics by prenatal smoking pattern

	A - E	A	B	C	D	E	A - E	C vs. D+E	B vs. C	A vs. C
	Total (N = 305)	Never smokers (n = 69)	Former smokers (n = 78)	Spontaneous pregnancy quitters (n = 22)	Intermittent pregnancy smokers (n = 70)	Persistent pregnancy smokers (n = 66)	All groups	Spontaneous pregnancy smokers	Spontaneous quitters vs. former smokers	Spontaneous quitters vs. never smokers
<i>p</i> or χ^2										
Timing of assessments										
Prenatal (16-28 weeks)										
Age, mean (SD)	25.9 (4.9)	27.4 (5.5)	25.7 (3.8)	26.1 (6.2)	26.0 (5.0)	24.2 (4.2)	.006	.479	.722	.411
Non- Hispanic White (%)	81.6	73.9	84.6	95.5	94.3	78.8	.153	.129	.287	.035
Unmarried (%)	58.0	43.5	48.7	63.6	70.0	69.7	.002	.621	.237	.141
Education in years	13.3 (2.0)	14.0 (1.9)	13.7 (2.0)	13.2 (2.3)	13.1 (2.0)	12.3 (1.6)	<.001	.276	.331	.094
Multiparous (%)	59.0	63.8	61.5	59.1	48.6	62.1	.371	.819	.999	.801
Maternal income in USD	824 (803)	904 (8.3)	838 (785)	988 (1351)	870 (679)	623 (651)	.201	.197	.623	.784
Partner smoking (%)	51.3	27.5	39.7	63.6	61.4	75.4	<.001	.806	.055	.004
^a Nicotine dependence	--	--	--	1.6 (0.9)	1.7 (0.8)	2.9 (1.9)	--	.205	--	--
Cig/day (cotinine-corrected)	1.5 (2.9)	--	--	--	0.7 (1.6)	2.9 (4.0)	--	--	--	--
Cotinine, maternal (ng/ml)	255 (390)	--	--	--	107 (231)	495 (455)	--	--	--	--
Cotinine, meconi um (ng/g)	114 (653)	--	--	--	55.7 (202)	505 (1386)	--	--	--	--
Alcohol use (% within group)	40.0	16.7	34.9	47.4	45.2	59.6	<.001	.806	.420	.013
^b Depressive symptoms	2.8 (3.5)	2.1 (2.8)	3.3 (3.9)	3.1 (3.3)	2.7 (3.1)	3.1 (3.9)	.299	.729	.859	.210
^c Hostility	3.3 (2.9)	2.8 (2.4)	3.2 (3.1)	3.7 (2.6)	3.5 (2.9)	3.6 (3.0)	.448	.828	.522	.170
^d Infant Temperament (4 weeks postpartum)										
Easy (%)	33.7	40.9	43.8	15.8	30.8	26.3	.060	.166	.025	.043
Slow to warm (%)	37.8	30.3	34.2	57.9	38.5	43.9	.190	.334	.060	.028
Difficult (%)	28.5	28.8	21.9	26.3	30.8	29.8	.789	.722	.684	.833
Preschool Follow-Up (Age 5)										
^e Depressive symptoms	6.3 (5.2)	6.0 (5.4)	5.6 (4.8)	6.0 (4.9)	7.1 (5.5)	6.6 (5.4)	.439	.478	.733	.983
^f Impulsivity	8.5 (5.4)	8.4 (4.8)	8.5 (5.2)	8.1 (5.3)	8.5 (5.8)	8.6 (6.0)	.996	.726	.781	.800

	A - E	A	B	C	D	E	A - E	C vs. D+E	B vs. C	A vs. C
	Total (N = 305)	Never smokers (n = 69)	Former smokers (n = 78)	Spontaneous pregnancy quitters (n = 22)	Intermittent pregnancy smokers (n = 70)	Persistent pregnancy smokers (n = 66)	All groups	Spontaneous quitters vs. pregnancy smokers	Spontaneous quitters vs. former smokers	Spontaneous quitters vs. never smokers
<i>g</i> Antisocial behavior	2.6 (2.2)	1.6 (1.9)	2.2 (1.7)	3.8 (2.2)	2.9 (2.3)	3.6 (2.5)	<.001	.353	.001	<.001
<i>h</i> Family conflict	45.0 (9.9)	43.4 (8.7)	44.5 (9.6)	44.4 (9.5)	44.7 (10.3)	48.2 (10.9)	.057	.426	.990	.641
Maternal smoking (cig/day)	4.2 (6.6)	0.1 (0.9)	0.9 (3.4)	6.1 (6.2)	4.5 (6.3)	12.0 (6.6)	<.001	.277	<.001	<.001
Maternal responsiveness										
<i>i</i> EC-HOME	3.6 (1.9)	3.4 (2.0)	3.5 (2.0)	4.5 (1.5)	3.7 (1.8)	3.5 (1.6)	.178	.011	.016	.009
<i>j</i> PCOS	12.4 (3.1)	13.3 (3.1)	12.6 (2.5)	11.9 (3.0)	12.2 (33.2)	12.4 (3.1)	.079	.977	.334	.110
<i>k</i> PSDQ	4.5 (0.4)	4.5 (0.4)	4.5 (0.4)	4.5 (0.5)	4.5 (0.4)	4.5 (0.4)	.976	.975	.997	.886

^aFagerstrom Test of Nicotine Dependence;

^bBrief Symptom Inventory, Depression subscale;

^cBrief Symptom Inventory, Hostility subscale;

^dEarly Infant Temperament Questionnaire;

^eCenter for Epidemiological Studies-Depression Scale, 9-item version;

^fConnors Adult ADHD Rating Scale, Impulsivity Subscale;

^gZoccolillo Antisocial Behavior Questionnaire;

^hFamily Environment Scale, Conflict subscale;

ⁱEC-HOME = Early Childhood Home Observation for Measurement of the Environment, Responsivity Subscale;

^jPCOS = Parent-Child Observation Schedule, Responsive Involvement Domain;

^kPSDQ = Parenting Styles and Dimensions Questionnaire, Warmth and Support dimension

Table 2Estimates of maternal responsiveness ^a by prenatal smoking pattern from linear regression

	Responsiveness estimated marginal means (SE)	95% C.I.	Difference from spontaneous quitters (SE)	95% C.I. for difference
Never smokers	3.390 (.257)	2.885 – 3.895	–1.351 (.513) **	–2.362 – –.341
Former smokers	3.644 (.229)	3.193 – 4.095	–1.097 (.497) *	–2.077 – –.118
Spontaneous quitters	4.741 (.427)	3.900 – 5.583	-	-
Intermittent pregnancy smokers	3.640 (.228)	3.192 – 4.088	–1.101 (.479) *	–2.044 – –.159
Persistent pregnancy smokers	3.688 (.316)	3.066 – 4.311	–1.053 (.511) *	–2.059 – –.047

Covariates:

Prenatal- maternal age, unmarried status, maternal education, partner smoking*Postpartum*- infant temperament (difficult/slow to warm vs. easy);*Preschool*- maternal smoking and antisocial behavior^aEC-HOME = Early Childhood Home Observation for Measurement of the Environment, Responsivity Subscale (range 0 – 7)

* p < .05;

** p < .01