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Maternal Smoking Cessation and Reduced Academic and Behavioral Problems In Offspring*

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Abstract

Background—There is some debate whether smoking during pregnancy causes or is only a risk factor for negative academic outcomes and increased risk of psychopathology in offspring. This study evaluated whether maternal smoking cessation would reduce the risk of adverse outcomes in school-aged children.

Methods—Women completed an online survey that included items about child scholastic performance and the Child Behavior Checklist (CBCL). Mothers were divided based on pre-pregnancy and pregnancy smoking status into: 1) Nonsmokers (N=320); 2) Women that smoked in the three months preceding and throughout pregnancy (Smokers, N=83); and 3) Smoking before, but not during pregnancy (Quitters, N=72).

Results—The Smokers and Quitters groups each had lower education and incomes compared to Nonsmokers but were indistinguishable from each other on these measures. The offspring of Smokers were more likely ($p < .05$) to be behind their peers on standardized tests in math (27.8%) relative to both Nonsmokers (17.4%) and Quitters (13.0%) with similar findings for reading. Smokers reported more behavioral problems by their children in several areas including Hyperactivity and Impulsivity, Social problems, and Externalizing problems including Aggression and Rule-Breaking. Further, the children of Quitters had significantly fewer Attention and Externalizing problems than Smokers. These outcomes were observed even after accounting for the variance attributable to maternal education and several other potential confounds.

Conclusions—Together, these findings indicate that smoking cessation is associated with reduced risk of having children with academic and neuropsychological difficulties. These outcomes are discussed within the framework that nicotine may be a neurobehavioral teratogen.

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Keywords

aggression; attention; math; nicotine; psychopathology; prenatal

1. Introduction

The deleterious neurocognitive profile of preschool and school-aged children of women who smoke cigarettes during pregnancy has been well described. This profile includes dose-dependent increases in externalizing behaviors, particularly symptoms of conduct disorder, inattention and impulsivity, and reductions in IQ and academic performance (Cornelius et al., 2011; Fergusson et al., 1998; Huizink and Mulder, 2006; Kandel et al., 2009, see also Supplemental Table 1¹). These findings are congruent with rodent studies using analogous measures (Schneider et al., 2011; Thomas et al., 2000). However, ethical limitations preclude controlled human behavioral teratology investigations, and the quasi-experimental design necessarily employed by the preponderance of investigators has raised concerns about whether there is a true causal relationship between maternal smoking and subsequent neurobehavioral outcomes (Ramsey and Reynolds, 2000). An alternative view is that smokers are an atypical population that pass several traits to their offspring, either through genetic (Knopik, 2009; Uhl et al., 2009) or environmental mechanisms. Support for this non-teratological model has been provided by investigators employing ingenious research designs like comparing siblings where the mother smoked in one pregnancy but not the other (D'Onofrio et al., 2008; Lambe et al., 2008) or evaluating the offspring from assisted reproductive technology (Thepar et al., 2009).

Studying children of women who quit smoking provides a unique opportunity to examine whether an offspring's traits are related to the prenatal environment or to features of the smoking population in general. Smoking during late pregnancy in the United States, while not taboo, is at least discouraged. Pregnancy offers an important window of opportunity for women to, at least temporarily, modify their cigarette use. A recent meta-analysis identified cessation rates of 23–43% among pregnant women (Schneider et al., 2010). To date, most research that has been conducted on the potential benefits of reducing cigarette consumption has been focused on perinatal outcomes (Crawford et al., 2008; Johansson et al., 2009). Importantly, low-income women randomly assigned to the contingency management arm of a voucher based program were more likely to abstain from smoking and less likely to deliver a low-birth-weight baby (Higgins et al., 2010) which corroborates and extends upon other cross-sectional investigations (Bailey et al., 2011; Seybold et al., 2011).

The Child Behavior Checklist (CBCL) is, arguably, one of the most commonly utilized tools by investigators interested in describing the long-term neurobehavioral profile of offspring from women that used licit and illicit drugs during pregnancy (Bada et al., 2007; Marroun et al., 2011; Sood et al., 2001). The CBCL is widely employed by pediatric psychologists and child psychiatrists as a clinical tool. This instrument is available in slightly different versions for preschool and school-aged children and may be completed by parents, children, or their teachers. Sawyer and colleagues (1991) found that delivering the CBCL instructions and content on a touch-screen monitor with each item displayed individually produced results that were largely indistinguishable from traditional (i.e., paper and pencil) administration with a very high correlations for Externalizing ($r = 0.91$) and Internalizing ($r = 0.88$) problems. Similarly, two computerized administrations of the CBCL separated by several weeks resulted in very high ($r = 0.96$) test-retest reliability (Berg et al., 1992).

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Drug use during pregnancy is a particularly sensitive behavior which may be more readily disclosed with novel methodologies. Although, to our knowledge, the CBCL has never before been administered online, internet based survey research offers clear benefits over more traditional (i.e., paper and pencil or computer assisted interview) procedures in terms of data collection and processing efficiency. Participant anonymity and the decreased likelihood of interviewer judgments have made this methodology particularly appealing for investigations of various illicit drug using populations (Mullens et al., 2010; Hirshfield et al., 2004; Gamma et al., 2005). The first online investigation in the neurotoxicology and teratology field was recently completed which identified dose-dependent increases in problems in maternally rated executive functioning among the children of smokers (Piper and Corbett, in press).

The primary objective of the present report is to determine if smoking cessation prevents adverse behavioral and educational endpoints. If this outcome is observed, this would support, but certainly not prove, a teratological model and also provide additional impetus for smoking cessation among reproductive-aged women. Alternatively, if the offspring of smokers showed evidence of more problematic behaviors on the CBCL which are independent of whether the mother quits smoking during pregnancy, this data would support a non-teratological model. A secondary objective is to evaluate the psychometric properties of this instrument with web-based administration.

2.0 Methods

2.1 Procedures

Flyers posted on community boards throughout Doernbecher Children's Hospital, Oregon Health and Science University (OHSU), the Portland metro area, western Oregon, and western Washington (e.g., grocery stores, libraries, coffee shops) recruited mothers for a child behavior study. Electronic links to the investigation were also displayed on the community and volunteer sections of Craigslist (craigslist.org) in the western US. This anonymous survey was administered through Research Electronic Data Capture (REDCap), version 1.3.9, a web-based application for procuring online databases which offers maximal security for sensitive information (Harris et al., 2009). The Institutional Review Boards at OHSU and NAU approved all procedures with data collection between 6/10 – 5/11.

2.2 Measures

After providing an online consent to participate in this study, the mothers of children ($6 \leq \text{Age} < 19$) began the survey which typically took about twenty minutes to complete. The items on the first half were organized from less to more sensitive and included questions about maternal and child demographics (e.g., age, sex, ethnicity), lifestyle (e.g., "Did the biological mother engage in physical exercise during pregnancy?"), academic performance (e.g., "Please rate your child's performance in math with relation to their scores on the state's standardized test." with options of below, at, or above grade level), and child/maternal neurological or psychiatric conditions (e.g., "Has your child (or the biological mother) been diagnosed with any of the following" with options of ADHD and ADD). Items on maternal drug use (nicotine, alcohol, marijuana, cocaine, and the opiates) were organized into three periods: in the three-months before pregnancy, during pregnancy, and specifically during the third trimester².

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The Child Behavioral Checklist (CBCL) is a very commonly employed instrument in the prenatal nicotine field (Supplementary Table 1²). As has also been done by others (Sawyer et al., 1991), the first part of the CBCL/6–18 containing items on child involvement in social activities and sports was omitted. The latter part of the CBCL consists of 118 statements that are rated as not true, somewhat or sometimes true, or very true/often true (0 to 2 points, respectively). The CBCL provides an index of the child's social and behavioral functioning relative to other children of the same age and gender. Internalizing problems include Somatic Complaints, Withdrawn/Depressed, and Anxiety/Depression; and Externalizing problems include delinquent (Rule Breaking) and Aggressive Behaviors. The CBCL also includes scales for Social, Thought, and Attention Problems which are not categorized as either Externalizing or Internalizing but are incorporated in the Total Problems behavioral score. Due to a technical error, data from item 64 (Prefers being around younger kids), was unavailable therefore the mean from the remaining ten items was used for determining the Social Problems scale score. Further information including CBCL psychometric properties is available elsewhere (Achenbach and Rescorla, 2001).

2.3 Sample Characteristics

For the entire sample (N=473), the respondents were typically in their late-thirties (Mean = 37.4, Min = 21.9, Max = 59.2); Caucasian (86.1%) followed by Hispanic/Latino (4.6%) American Indian (2.3%); largely from west-coast states (OR = 35.4%, WA = 12.6%; CA = 9.6%); with an education of college (59.7%), high-school/GED (24.5%), and graduate/professional school (15.6%); and yearly family incomes of \$50K+ (45.6%), \$20–49K (36.6%), or < \$20K (36.6%). The percentage of children in each of the following age categories were 6–8 (34.7%), 9–10 (14.7%), 11–12 (14.3%), 13–14 (13.5%), 15–16 (12.0%), and 17–18 years (10.7%). The majority of children attended a public-school (84.6%) with a minority enrolled in a private institution (5.1%), an alternative education program (4.6%), or home-schooled (3.0%).

2.4 Statistics

Biological mothers who completed at least the first-half of online survey were divided into three groups: 1) Non-smokers who did not smoke in the three-months preceding and throughout pregnancy (N = 320); 2) Smokers who used cigarettes in the three-months before as well as throughout pregnancy and specifically in the third-trimester (N=83), and 3) Quitters who used cigarettes in the three-months before but not at any point during pregnancy (N=72). Respondents who were not the biological mother (N = 85 adoptive or foster parents; N = 40 biological fathers; and N=26 other family members) were excluded as their knowledge about maternal substance use patterns is likely to be incomplete. Some women did not complete all of the CBCL which resulted in further exclusion of Nonsmokers (N=23, or 7.2% of the initial sample), Smokers (N=4, 4.8%), or Quitters (N=6, 8.0%). Although REDCap has the capability to mandate completion of each question, the consent was the only non-optional item in order to keep the procedures as similar as possible to traditional (i.e., paper and pencil) administration. In keeping with the CBCL instructions, group differences were evaluated using the raw scores as dependent variables. Analysis of covariance was conducted using two separate models; unadjusted and adjusted for child age and sex, maternal education, age when pregnant and the use of other recreational drugs common in this sample (alcohol, marijuana, and methamphetamine). These covariates were selected after consulting prior research, e.g., the well known group difference between smokers and non-smokers in education (Batty et al., 2006; Kandel et al., 2009) and also empirically based on non-tobacco variables that statistically differentiated the groups ($p < .05$). Non-parametric analyses were conducted with chi-square or, if the N/cell was < 5, Likelihood Ratios using SPSS version 16.0. The validity of online administration of the CBCL was also evaluated by examining Attention Problems of children with and without

ADHD within the Nonsmoking group. The internal consistency of each CBCL scale was calculated using Cronbach's alpha (Cronbach, 1951). A $p < .05$ was considered significant although statistics that met more conservative alphas were also noted.

3. Results

The maternal and child characteristics of Nonsmokers, Smokers, and Quitters are shown in Table 1. Smokers were on average three-years younger when they became pregnant, were less educated, and had lower incomes than Nonsmokers. In the three months before pregnancy, both Smokers and future Quitters smoked the majority of the month (Smokers = 28.3 ± 0.7 days, Quitters = 25.6 ± 1.0) but this small difference was statistically significant ($t(127.4) = 2.18$, $p < .05$). Similarly, the Smokers group smoked more cigarettes per day (15.7 ± 0.9) than did future Quitters (9.5 ± 0.8 , $t(151) = 4.96$, $p < .0005$). The Smokers group reported that during pregnancy (overall) they smoked the majority of days each month (26.1 ± 1.0) and slightly over a half-pack each day (11.6 ± 1.0 cigarettes). This number of cigarettes per day was maintained in the third-trimester (11.2 ± 0.9). Quitters and Smokers were indistinguishable in terms of socioeconomic status variables but Quitters were less likely to use alcohol, marijuana, cocaine, or methamphetamine during pregnancy. Importantly, all groups were equal in terms of the frequency of maternal ADHD. Smokers and Quitters were equally likely to be diagnosed as having depression, anxiety, or bipolar disorder. The offspring of Smokers were approximately twice as likely, relative to both Nonsmokers and Quitters, to be behind classmates on state standardized tests. More specifically, the children of Smokers, but not Quitters, were behind peers in math and reading (Figure 1A).

The internal consistency of the CBCL on the primary scales of interest (Externalizing Behavior alpha = 0.87 and Attention Problems alpha = 0.84) was virtually indistinguishable from paper and pencil administration with Achenbach and Rescorla (2001) reporting reliabilities of 0.86 and 0.84, respectively (see also Supplemental Table 2³). In support of CBCL validity, unexposed ADHD+ children showed the anticipated elevation in Attention Problems (9.6 ± 0.6) compared to the ADHD- group (3.1 ± 0.2 , $t(55.3) = 10.67$, $p < .0005$).

Two sets of analyses were then completed: unadjusted and adjusted for both child and maternal variables. Table 3 shows that Smokers, but not Quitters, had elevations on Externalizing including both Rule-Breaking and Aggressive Behavior, and also the Hyperactivity-Impulsivity and Aggressive Behavior Scales which were significant after removing the variance due to both child and maternal factors. Further, both Smokers and Quitters had increased scores on the Thought Problems, Somatic Complaints and on the miscellaneous "Other Problems" area. As the internal consistency of Other Problems was relatively modest (Cronbach's alpha = 0.57), additional analyses determined that Smokers and Quitters were both elevated ($p < .05$) on the "Bragging, boasting" item. Figure 1B depicts that maternal ratings, expressed as a percentage of Nonsmokers, were more problematic among Smokers on Externalizing and Hyperactivity-Impulsivity, relative to both Nonsmokers and Quitters.

4. Discussion

The key finding of this investigation is that the offspring of women who quit smoking were less likely than smokers to have scholastic difficulties and elevations in child psychiatric symptomology. There are currently two competing views regarding the origins of

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neurobehavioral group differences between nicotine exposed and unexposed children. Proponents of the teratological (i.e., causal) model make a mechanistic argument that smoking results in decreased blood flow through the placenta to the fetus, exposure to the neuroteratogen nicotine as well as other tobacco additives, and dose-dependent increases in prematurity and low-birth weight (Berlin et al., 2009; Orlebeke et al., 1997; Winzer-Serhan, 2008). This latter outcome is of particular concern because a low-birth weight baby is at heightened risk of infant mortality, school failure, and neurodevelopmental handicaps (McCormick, 1985). Numerous cross-sectional investigations including those that statistically account for maternal psychopathology may be viewed as consistent with the teratological perspective (Piper et al., in press; Williams et al., 1998; see also Supplemental Table 2). More recently, advocates of a non-teratological (i.e., correlative) model convincingly argue that smokers and non-smokers are broadly different on socioeconomic and mental health variables (Knopik, 2009, see also Table 1). Psychopathology and academic success are complex functions that are also determined by the interplay of parental genetics and the social environment and smoking is only one of many risk-factors for adverse outcomes. Clear support for the non-teratological perspective comes from creative natural experiments such as evaluating the offspring where the mother smoked during one pregnancy but not the other (D'Onofrio et al., 2008; Obel et al., 2011). Unfortunately, although it is an ingenious notion to untangle genetic and environmental contributions with *in vitro* fertilization patients, these studies have not yet produced unambiguous outcomes because women undergoing assisted reproduction may smoke at abnormally low levels and these reports have been substantially underpowered (Rice et al., 2009; Thapar et al., 2009).

The present CBCL findings were that the offspring of smokers, but not quitters, had elevations in Externalizing behaviors, both Aggression and Rule-Breaking, Social Problems, and Hyperactivity-Impulsivity. The offspring of quitters were different from smokers in terms of Attention Problems, including both Inattention and Hyperactivity-Impulsivity, and Externalizing behaviors, particularly Aggressive Behavior. Importantly, these differences in CBCL ratings in the offspring of smokers and nonsmokers were retained when other maternal drug use variables were included as covariates. Although the sample and methodology were quite different, there are certainly some parallels between the observed profile and that recently reported in the Western Australia Pregnancy (Raine) Cohort (Robinson et al., 2010). This prospective longitudinal study of children ages two to fourteen found that women who smoked during pregnancy, but not women who quit in the second trimester (18 weeks), had elevations in Externalizing and Internalizing behaviors relative to nonsmokers. Interestingly, even though nonsmokers and smokers did not differ based on maternal self-efficacy, this research group interpreted their data as supportive of a non-teratological (in this case, psychological) model. Given the extensive preclinical literature on the consequences of nicotine exposure (Winzer-Serhan, 2008) and the key role of the acetylcholine system in brain development (Pauley and Slotkin, 2008), we believe that the present findings for Externalizing and Hyperactivity-Impulsivity may be more consistent with a teratological model but that the increase in Thought Problems and Somatic Complaints (which was independent of smoking cessation) is consistent with a non-teratological explanation. On the other hand, we do not discount that women who are sufficiently concerned about their pregnancy to quit smoking may also be more likely to engage in several other behaviors that could be advantageous for their offspring's development (e.g., regularly taking prenatal vitamins, breast feeding (Kendzor et al., 2010), maintaining a social-network with more experienced parents). Notably, the quitters group was defined to only include women who actively quit their smoking habit before becoming pregnant and this subset of women may be highly conscious of the problems their smoking habits may cause for a baby. If, in the future, a psychosocial (e.g., parenting practices) or genetic factor (Knopik, 2009; Uhl et al., 2009) were identified that clearly differentiated women who smoked from those who quit and also predicted their offspring's subsequent

behaviors, the present outcomes would then need to be reevaluated within a non-teratological framework.

Smoking, acting either directly through a toxicological mechanism or indirectly via nutrient deficiencies (Cogswell et al., 2003), could account for offspring's academic difficulties which were not observed among women who stopped smoking. In addition to nicotine, cigarettes are well known to contain lead and several volatile organic compounds including toluene, acrolein, benzene, acetaldehyde, and formaldehyde (Hammond and O'Connor, 2008) which may be deleterious to brain development. Plasma levels of the heavy metal cadmium were elevated seven-fold in women that smoked at high levels (Butler Walker et al., 2006). Further, the placentas of smokers had elevated quantities of cadmium and zinc but decreases in iron (Ronco et al., 2005). Interestingly, deficits in math have been identified in the children of drinkers (Goldschmidt et al., 1996) and in reading for the offspring of smokers (Fried et al., 1997). Performance on the McCarthy Scales of Children's Abilities was lower among the offspring of smokers relative to women who discontinued smoking in the second trimester on the verbal and quantitative scales among three-year olds (Sexton et al., 1990).

The present findings should be placed within a broad context (Knopik, 2009). There are two very large and well-designed reports which support a non-teratological model of cognitive function in the offspring of smokers. First, Batty et al. (2006) determined that dose-dependent group differences in mathematics and reading performance were only present when findings were not adjusted for maternal education. It bears emphasizing, therefore, that the smokers and quitters group were indistinguishable on this measure. Second, Lambe and colleagues (2006) noted that the children of smokers were at greater risk of poor academic achievement, even after controlling for maternal characteristics. A within family comparison where the mother's smoking habits were discordant (e.g., smoking during the first pregnancy but not the second) revealed that both offspring were at elevated risk of academic difficulties. Although we do not currently have a simplistic explanation for differences between the present findings and those of others (Batty et al., 2006; Knopik, 2009; Lambe et al., 2006), we feel that quasi-experimental designs examining neurobehavioral outcomes of the offspring of former smokers will continue to be informative for public health. Longitudinal studies in which women are randomized to treatment conditions known to reduce maternal smoking (Higgins et al., 2010) and determining the offspring's academic, cognitive, and affective profile will be integral to differentiating teratological versus non-teratological models.

The psychometric properties of the CBCL when administered electronically are noteworthy. While both the efforts of Sawyer et al. (1991) and Berg et al. (1992) provide a key methodological foundation for the present endeavor, it was certainly not a foregone conclusion that traditional and online administration would produce indistinguishable reliability and validity (Buchanan et al., 2005). Participants could be filling out these inventories at a time of their choosing on a computer where there are other distractions (e.g., late at night at home) or, due to increased anonymity, be less likely to respond in a socially desirable manner. The general guideline for internal consistency is that Cronbach's alpha values should exceed 0.7 (Nunnally, 1978) which was generally obtained. The anticipated increase on the Attention Problems scale among ADHD children was also identified. Together, these outcomes are supportive of online administration with the parental form of the CBCL.

Several important limitations should be considered in discussion of the outcomes of this research. First, the information about child ADHD should be regarded as especially tentative. As the sample consisted of a wide-age range of offspring, it is quite possible that

some younger children were undiagnosed or that older children were diagnosed incorrectly. Second, maternal substance use patterns were identified retrospectively. Although it is commonly recognized that retrospective maternal drug use information is inferior to that obtained through other means (Huizink and Mulder, 2006), empirical comparisons of retrospective, prospective, and urine analysis do not lead to simplistic conclusions (Krall et al., 1989; Pickett et al., 2009). Third, this investigation relied on maternal report but future studies should also employ teacher and self (i.e., the child) CBCL ratings as well as directly examine the academic records to verify the veracity and generalizability of the observed results.

In conclusion, this study has shown that the offspring of quitters and smokers differ on symptoms of attention problems, externalizing behaviors, and in terms of academic performance. Future investigations employing this group comparison are needed to clarify the bio/social mechanism(s) (teratological or non-teratological) mediating these differences. Until then, there is already sufficient evidence that perinatal smoking increases the risk for mortality (e.g., stillbirth, SIDS) and morbidity (e.g., asthma) to warrant optimizing interventions for permanent smoking cessation among reproductively- aged women.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

Percent of children behind their peers on state standardized tests in math and reading (A) among the 6–18 year old children of nonsmokers, smokers, and women that quit smoking before becoming pregnant. Total scores ($\pm$ SEM), expressed as a % of Nonsmokers, on the Externalizing and Hyperactivity-Impulsivity scales of the Child Behavior Checklist (B). $N_p < .05$ versus Nonsmokers, $Q_p < .05$ versus Quitters.

Characteristics of women (Percent or mean/SEM) and their children by nicotine use prior to and during pregnancy. GED: General Equivalency Diploma

Table 1

	Nonsmokers		Smokers		Quitters	
	% or Mean	N	% or Mean	N	% or Mean	N
<u>Pregnancy</u>						
Age when pregnant	27.2 (0.4)	318	24.3 (0.7) ^{NN}	83	21.5 (0.6) ^{NNN,SS}	72
Income (% < 15K) ^P	19.1%	298	52.4% ^{NNN}	82	44.3% ^{NNN}	70
Alcohol (%)	10.1%	317	30.1% ^{NNN}	83	5.6% ^{SSS}	72
Marijuana (%)	4.1	320	30.1% ^{NNN}	83	12.5% ^{NN,S}	72
Cocaine (%)	0.3%	320	9.6% ^{NNN}	83	0.0% ^{SS}	72
Methamphetamine (%)	0.3%	320	21.7% ^{NNN}	83	4.2% ^{N,SS}	72
<u>3rd Trimester</u>						
Alcohol (%)	0.3%	320	3.6%	83	0.0%	72
Marijuana (%)	2.2%	320	16.9% ^{NNN}	83	4.2% ^S	72
Cocaine (%)	0.0%	320	2.4% ^N	83	0.0%	72
Methamphetamine (%)	0.0%	320	7.2% ^{NNN}	83	0.0% ^S	72
<u>Maternal Characteristics</u>						
Age (years)	38.8 (0.5)	318	36.2 (0.9) ^N	83	32.0 (0.7) ^{NNN,SS}	72
Education (≤ high-school/GED)	17.3%	318	42.2% ^{NNN}	83	36.1% ^{NNN}	72
Ethnicity (% Non-Caucasian)	16.0%	319	12.0%	83	6.9% ^N	72
Exercise During Pregnancy (% Yes)	65.7%	312	54.9%	82	59.2%	71
Current Income (< 20K) ^P	25.5%	298	63.4% ^{NNN}	82	54.3% ^{NNN}	70
ADHD	4.4%	320	6.0%	83	9.7%	72
Anxiety (lifetime)	24.1%	320	42.2% ^{NN}	83	37.5% ^N	72
Depression (lifetime)	34.7%	320	55.4% ^{NN}	83	37.5%	72
Bipolar (%)	3.8%	320	16.9% ^{NNN}	83	8.3%	72
<u>Child Characteristics</u>						
Age	11.6 (0.2)	320	11.9 (0.4)	83	10.7 (0.4) ^{N,S}	72

	Nonsmokers		Smokers		Quitters	
	% or Mean	N	% or Mean	N	% or Mean	N
Sex (% Female)	50.8%	317	52.4	82	45.8%	72
Ethnicity (% Non-Caucasian)	24.8%	318	16.9%	83	22.2%	72
Premature	13.1%	312	14.6%	82	11.4%	70
ADHD (%)	15.3%	320	14.5%	83	16.7%	71
School (% Below)	11.3%	319	22.0% ^S	82	12.5%	72

N $p < .05$,
NN $p < .005$, or
NNN $p \leq .0005$ versus Nonsmokers;
S $p < .05$,
SS $p < .005$,
SSS $p \leq .005$ versus Smokers.
P participants that selected the “Prefer not to disclose option” were excluded from the total N.

Table 2

Child Behavior Checklist 6/18 scores (Mean, SEM, N) by smoking during pregnancy.

	<u>Nonsmokers</u>	<u>Smokers</u>	<u>Quitters</u>
Attention Problems	4.1 (0.2) 292	5.4 (0.5) 78 ^U	4.2 (0.5) 65 [#]
Inattention	2.6 (0.1) 295	3.3 (0.3) 79 ^U	2.8 (0.3) 66 [#]
Hyperactivity-Impulsivity	2.2 (0.1) 292	3.1 (0.3) 78 ^{UU,A}	2.4 (0.3) 65 [#]
Social Problems	2.3 (0.2) 293	3.4 (0.4) 79 ^{UU,A}	2.9 (0.4) 63
Thought Problems	2.0 (0.2) 291	2.7 (0.4) 78 ^{UU,A}	3.0 (0.4) 66 ^{U,A}
Externalizing	7.5 (0.5) 286	11.7 (1.2) 79 ^{UUU,A}	9.4 (1.3) 65 [#]
Rule-Breaking	2.4 (0.2) 292	3.9 (0.5) 79 ^{UU,A}	3.2 (0.6) 65
Aggressive Behavior	5.0 (0.3) 291	7.8 (0.8) 79 ^{UU,A}	6.1 (0.8) 66 [#]
Internalizing	7.4 (0.4) 295	9.2 (1.0) 79	8.6 (1.0) 66
Anxious-Depressed	3.2 (0.2) 295	4.1 (0.5) 79	3.6 (0.5) 66
Withdrawn-Depressed	1.9 (0.2) 297	2.3 (0.3) 79	2.2 (0.4) 66
Somatic Complaints	2.3 (0.1) 295	2.8 (0.4) 79	2.8 (0.3) 66 ^{U,A}
Other Problems	3.4 (0.2) 278	4.7 (0.4) 77 ^{UUU,A}	4.7 (0.4) 65 ^{UU,A}

^U p < .05,

^{UU} p < .005, or

^{UUU} p ≤ .0005 unadjusted versus Nonsmokers;

^A p < .05 adjusted for child and maternal variables versus Nonsmokers;

[#] p < .05 adjusted for child and maternal variables versus Smokers.