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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 3 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.

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). 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 (Ramsay 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., 2006) or evaluating the offspring from assisted reproductive technology (Thapar 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

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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., in press).

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 et al. (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 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).

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. 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 and 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 20 min 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 3 months before pregnancy, during pregnancy, and specifically during the third trimester.

The Child Behavioral Checklist (CBCL) is a very commonly employed instrument in the prenatal nicotine field (Supplementary Table 1). 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 (0–2 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 3 months preceding and throughout pregnancy ($N = 320$); (2) Smokers who used cigarettes in the 3 months before as well as throughout pregnancy and specifically in the third-trimester ($N = 83$), and (3) Quitters who used cigarettes in the 3 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.