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Educational Attainment and Smoking Among Women: Risk Factors and Consequences for Offspring

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Abstract

We examine the association between education and smoking by women in the population, including smoking during pregnancy, and identify risk factors for smoking and the consequences of smoking in pregnancy for children's smoking and behavioral problems. Secondary analyses of four national data sets were implemented: The National Survey of Drug Use and Health (2006), the National Longitudinal Survey of Youth (1979–2004); the National Longitudinal Survey of Adolescent Health (Wave III); The National Health and Nutrition Examination Survey (2005–2006). The lower the level of education, the greater the risk of being a current smoker, smoking daily, smoking heavily, being nicotine dependent, starting to smoke at an early age, having higher levels of circulating cotinine per cigarettes smoked, and continuing to smoke in pregnancy. The educational gradient is especially strong in pregnancy. Educational level and smoking in pregnancy independently increase the risk of offspring smoking and antisocial and anxious/depressed behavior problems. These effects persist with control for other covariates, except maternal age at child's birth, which accounts for the impact of education on offspring smoking and anxious/depressed behavior problems. Women with low education should be the target of public health efforts toward reducing tobacco use. These efforts need to focus as much on social conditions that affect women's lives as on individual level interventions. These interventions would have beneficial effects not only for the women themselves but also for their offspring.

Keywords

Education; Smoking by women; Smoking in pregnancy; Offspring smoking; Offspring behavior problems

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1. Introduction

The association between socioeconomic disadvantage, smoking, and morbidity and mortality in the population has been well established in the U.S. (U.S. Department of Health and Human Services, 2001; 2007; Greaves et al., 2006; House, 2002; McCaffery et al., 2007; Mirowsky et al., 2000; Robert and House, 2000; Schaap et al., 2008; Schnittker and McLeod, 2005) as well as in other Western countries (Giskes et al., 2005; Graham et al., 2008). While socioeconomic indicators other than education contribute to disparities in rates of smoking (Schaap et al., 2008), education, which is highly related to overall status (Laaksonen et al., 2005), is the most frequently used indicator of socioeconomic status (SES) in studies of smoking (Schaap et al., 2008). The disparity in smoking rates related to educational level persists even in societies with a strong welfare system (Eikemo et al., 2007; Olafsdottir, 2007).

The negative association between educational level and smoking among women is also observed in pregnancy (Matthews, 2001). Smoking during pregnancy has special public health relevance because of the impact of prenatal smoking on offspring. Children whose mothers have smoked during pregnancy are more likely to smoke in adolescence (Al Mamun et al., 2006; Cornelius et al., 2000; Kandel et al., 1994; unpublished data; O'Callagan et al., 2006) and to become dependent on nicotine (Buka et al., 2003). Furthermore, epidemiological, clinical and animal studies have also established that offspring of mothers who smoke during pregnancy are more likely to manifest behavior problems, both externalizing and internalizing (D'Onofrio et al., 2008; Griesler et al., 1998; Milberger et al., 1996; Orlebeke et al., 1997; Richardson and Tizabi, 1994; Shea and Steiner, 2008; Vaglenova et al., 2004; Wakschlag et al., 2002; 2006; Weissman et al., 1999; Winzer-Serhan, 2008). Behavioral disturbances, e.g., hyperactivity and conduct disorder, are risk factors for delinquency and substance use (Moffitt, 1993), in particular smoking (Brown et al., 1996; Kollins et al., 2005; Lynskey and Ferguson, 1995), and nicotine dependence (Breslau et al., 1993; Storr et al., 2004). Effects on child smoking may be direct due to an induced biological vulnerability to the addictive properties of nicotine and indirect through nicotine induced behavioral problems in childhood. It is not clear to what extent the impact of prenatal smoking varies according to SES.

Why is there such a strong negative relationship between educational attainment and smoking? How is educational level associated with differential exposure to risk factors that contribute to smoking? Education is related to most aspects of a person's lifestyle, social performance and psychosocial adjustment, including participation in the labor force, family roles, parenting, and psychological well being. The higher the education, the higher the labor force participation and marriage rates, and the lower the levels of psychological distress and depression (Lorant et al., 2003; Thornton et al., 1995; U.S. Census Bureau, 2007). Thus, at any particular historical point in time, the association between SES and a health-related behavior, such as smoking, could be accounted for by differential attitudes about health related behaviors, differential psychosocial characteristics, and differential participation in the social roles of adulthood.

In this article, we address four issues:

1. What is the association between education and patterns of smoking among women?
2. Do these patterns persist with control for covariates?
3. What is the association between education and patterns of smoking in pregnancy?
4. Does education account for the impact of prenatal smoking on offspring smoking and psychosocial adjustment?

We provide a broad overview of these issues and new empirical findings rather than an in-depth exploration of each question. We explore these issues in multiple data sets that each

provides unique information to illuminate a particular question. We use data from three surveys to explore the first two issues: the National Survey on Drug Use and Health (*NSDUH 2006*) (Substance Abuse and Mental Health Services Administration, 2007a), the National Longitudinal Survey of Adolescent Health (*ADD HEALTH III*) (Harris et al., 2003; Kandel et al., 2007a), and the National Health and Nutrition Examination Survey (2005-2006) *NHANES* (National Center for Health Statistics, cdc.gov/nchs/nhanes.htm accessed on 3/4/2008). We use data from The National Longitudinal Survey of Youth (*NLSY*) (1979-2004) (Center for Human Resource Research, 2006) to explore the last two issues.

We explicitly do not deal with questions related to race/ethnicity, although these are relevant to socioeconomic disadvantage, because race/ethnicity is the specific focus of the article by J. M. Wallace (in press). However, we control for race/ethnicity in our statistical models.

2. Methods

2.1. Data Sources

Greater detail about each of the four national surveys and the measurement of variables of interest is provided in the references cited for each study, although we briefly describe the design and selected variables for each study.

2.1.1. NSDUH 2006—The NSDUH 2006 is a national multistage area probability sample of the US population 12 years old and over. The target civilian non-institutionalized population represents over 98% of the total population, including persons living in non-institutionalized group quarters, such as homeless shelters, rooming houses and college dormitories. Individuals on active military duty, in jail or drug treatment programs, and the homeless not in shelters were excluded. Youths (12-25 years old) were over-sampled. The completion rate was 67.2%. Weights take into account the stratified multistage cluster sampling design and correct for over-sampling and non-response rates so that the resulting weighted sample is representative of the U.S. population.

Respondents were administered computer assisted structured personal household interviews and asked about the use of tobacco and 11 other drug classes, selected attitudes about drugs, major depressive disorder episode experienced in the last year, and sociodemographic characteristics (Substance Abuse and Mental Health Services Administration, 2007b). Nicotine dependence was assessed by the Nicotine Dependence Syndrome Scale (NDSS) (Shiffman et al., 2004). Although developed as continuous scale, a cut-off point was identified to define dependence as a categorical variable.

The analyses are based on females 18 years old and over (N=19,574).

2.1.2. ADD HEALTH Wave III—Data were derived from Wave III of ADD HEALTH, a subset of participants in a school survey conducted in 1994-1995 with a national representative sample of 90,118 adolescents in grades 7-12. In 1994-95 (Wave I), interviews were completed with 20,745 adolescents and their parents (78.9% participation rate) at mean age, 15.5 years, SD=1.7. In 1996 (Wave II), 14,738 of 16,706 Wave I adolescents in target grades 7-11 were reinterviewed, including dropouts (88.2% completion). In 2001-2002, (Wave III), interviews were completed with 15,197 youths whose mean age was 21.8 years (SD=1.9) (77.4% participation rate). A urine sample was collected from respondents at a random time.

At Wave III, 2,982 youths reported smoking on 30 of the last 30 days and were assumed to have smoked on the survey day. An analytical subsample of 1,016 cases was selected, which included all the minorities [African Americans (N=307), Hispanics (N=274), and Asians (N=125)] and a random subsample of Whites to equal the number of African Americans

(N=310); 904 respondents provided urine samples. Since cotinine has a half-life of 16-20 hours, the current smokers in the analytical sample were expected to have detectable cotinine levels. Cotinine level per cigarette smoked was calculated by dividing total values by the number of cigarettes currently smoked per day. The Clinical Pharmacology Laboratory at the University of California, San Francisco, assayed the samples for cotinine. For further details see Kandel et al. (2007a).

2.1.3. NHANES, 2005-2006—NHANES is a nationally representative sample of the civilian non-institutionalized population two months old and over. Conducted as a continuous annual survey since 1999, data are released in two-year increments. Interviews are conducted in households and blood sera are collected in mobile examination centers via venipuncture.

Data from 2005-2006 are used in this report (77.4% completion rate). The analysis is based on current smokers among women aged 20 and over (N=350). Cotinine level per cigarette smoked was calculated by dividing total cotinine values by the number of cigarettes currently smoked per day. Serum cotinine was measured by an isotope dilution-high performance liquid chromatography/atmospheric pressure chemical ionization tandem mass spectrometry (NHANES, 2008).

2.1.4. NLSY 1979-2004—The NLSY is a multistage stratified national probability sample, representative of youths 14-22 years old in 1979 born between 1957 and 1963 in the coterminous United States. As of 1979, subjects have been re-interviewed annually through 1994, biennially thereafter. Biennial assessments of children were implemented as of 1986 from mothers about all children. As of 1988, children aged 10 years and older also completed a self-administered questionnaire. The 1979 interview completion rate was 90%; retention rates have consistently been over 90%. Informed consent was obtained from mothers for their own participation and that of their children.

The analyses are based on mothers and their first born child (N=4,911) with data on maternal smoking during and after pregnancy (mothers' mean age at child's birth=23.9 years, SD=5.6; children's age range in 2004=1 to 34 years). Prenatal exposure to maternal tobacco use was first ascertained in 1983 for the youngest child, in 1986 for all births not asked about previously (62.6% of children), and as of 1988 biennially for all new births. As of 1988, children 10 and older reported biennially on their cigarette smoking. Two children's behavior problems, antisocial and anxious-depressed, were measured by the Behavior Problems Index (BPI) (Peterson and Zill, 1986), administered biennially to mothers since 1986. Mothers reported on the frequency of behavior problems experienced in the last 3 months among children aged 4 and older from 1986 to 1992, and 4-14 as of 1994. For analytical purposes, two scores were defined for each behavior: maximum score over the multiple waves; score prior to the child's first smoking report. High scores for each behavior problem were dichotomized at the top quartile.

2.2. Analysis

Regular and multinomial logistic regressions were implemented to assess the unique effects of education and other covariates on the outcomes of interest. For NSDUH, the analyses were implemented with SUDAAN V9.0.1 in order to account for design effects. This was not possible for NLSY, since variables necessary to correct for design effects are not available on the public use data file, or for *ADD HEALTH* and NHANES, since selected subsamples were used.

3. Results

3.1. Education and smoking behavior

The association between education and patterns of smoking differs for lifetime and current (last 30 days) smoking. An inverse relationship appears with respect to current but not lifetime smoking. As documented by NSDUH 2006, women with less than a high school education are less likely to have ever smoked (54.7%) than high school graduates (65.9%), those with some college (70.3%), or college graduates (66.6%). The opposite pattern characterizes current smoking, for which college graduates have the lowest rates of smoking of any group; the rate of current smoking is twice as high among women who have not graduated from high school (29.3%), among high school graduates (28.5%), and among those with some college (25.2%) than among college graduates (13.0%). Indeed, persistence of smoking decreases strikingly and linearly with level of education: more than half (53.7%) of women with the lowest education continue to smoke compared with less than a fifth (19.5%) of college graduates; the rates of persistence are 43.3% among high school graduates and 35.8% among women with some college (Table 1).

Not only is education inversely related to persistent smoking, but women with lower education are more likely to exhibit behavioral patterns reflecting greater involvement in smoking (Table 1). Educational level is inversely related to having ever smoked daily, number of cigarettes smoked per day, and being dependent on nicotine. Women who have not graduated from high school smoke on average 14.1 cigarettes per day compared with 8.6 cigarettes for college graduates. Educational level is also related to older age at smoking onset. Women with less than a high school education started to smoke on average 15 months earlier than college graduates.

Furthermore, women with lower education have higher concentrations of cotinine per cigarette smoked than those with higher education. Cotinine levels were assessed from urine samples in ADD HEALTH and blood sera in NHANES. Cotinine levels assessed in urine can be 3-8 times higher than in serum (NHANES, 2008; Jarvis et al., 1984). In both samples, the mean cotinine levels are 37%-40% higher among women with less than a high school education than those with more education, although the difference is statistically significant only in ADD HEALTH (Table 2). In ADD HEALTH, the values for high school graduates are not statistically significantly different from the other two educational groups, while in NHANES, they are not different from women with more than a high school education.

Thus, besides differences in smoking patterns associated with educational level, there are also differences with respect to levels of cotinine circulating in the body.

3.2. Do individual risk factors explain educational disparities in smoking among women?

We tested the hypothesis that individual characteristics might explain the disparities in smoking behaviors associated with educational level by controlling relevant variables available in the NSDUH. We categorized smoking behavior into four categories of increasing extensiveness of involvement: (1) never smoked; (2) former smoker, did not smoke in last month; (3) last month smoker, not nicotine dependent; (4) last month smoker, nicotine dependent. We implemented multinomial logistic regressions in which each smoking group was compared to each succeeding group. The covariates included sociodemographic variables (age, education, race/ethnicity, family income), family roles (marital status, number of own children in household), labor force participation, psychological characteristics (major depression episode last year, risk taking), religious commitment (religiosity, religious services attendance), and attitudes about harmfulness of drugs, smoking cigarettes, drinking heavily and using marijuana (Table 3).

With the exception of perceived risk of alcohol drinking, all the covariates were statistically significant and the majority, including education, remained highly statistically significant at each stage of progressive involvement in smoking with control for other covariates. The lower the level of education, the lesser the risk of quitting smoking and the greater the risk of smoking currently and being dependent on nicotine. The relationship is not linear. Compared with smokers with less than a high school education, the odds of being dependent are four times lower (.24) for college graduates, 1.5 lower (.68) for high school graduates, and 1.7 (.60) lower for those with some college. Attitudes are the least important factors.

3.3. Education and smoking in pregnancy

The association between educational level and smoking is exacerbated with respect to smoking in pregnancy. In the NLSY, the rates of smoking in pregnancy were 45.0% for those with less than high school, 34.1% for high school graduates, 17.4% for those with some college, and 5.1% for college graduates. The rate of smoking was nine times higher among those without a high school degree than among college graduates. In a sample of women 18-44 years old drawn from the NSDUH, the rate was 2.8 times higher. We compared the rates of smoking in the NSDUH among currently pregnant and non-pregnant women after standardizing the age distributions of the two groups. These ratios ranged from .85 among those without a high school degree to .68 among high school graduates, .45 among those with some college, and .20 among college graduates. While among college educated women the rate of smoking in pregnancy was one fifth of those not pregnant, the rate among those with less than a high school education was almost as high as among those not pregnant. Education is highly related to quitting smoking in pregnancy.

Not only is education inversely related to persistence of smoking, it is also highly related to extensiveness of smoking during pregnancy. When pregnant, 0.3% of college graduates in the NLSY smoked a pack or more of cigarettes a day on average compared with 13.6% of those who failed to graduate from high school (Figure 1).

3.4. Maternal education, prenatal smoking, and child outcomes

Both mother's educational level at the time of the child's birth and smoking in pregnancy have independent deleterious effects on offspring. We examined three child outcomes in the NLSY: lifetime smoking and two behavior problems, antisocial and anxious/depressed. Maternal education was still defined as of the child's birth since it clearly preceded the children's outcomes and preserved parallelism with the analysis of smoking in pregnancy. Furthermore, education at child's birth is very highly related ($r=0.86$) to maternal highest educational attainment.

There is a very strong association between maternal education at the time of the child's birth and child outcomes. Almost five times as many children of mothers without a high school degree have smoked (73.0%) as among the children of college graduates (15.8%) (Figure 2-a). Similarly, the rates of antisocial behavior and anxiety/depression decline with increasing level of maternal education at the time of the child's birth (Figure 2-b).

Parallel trends are observed in relation to maternal smoking in pregnancy. Fifty percent more children have smoked when their mothers smoked a pack or more of cigarettes a day compared with children whose mothers did not smoke (Figure 3-a). Behavior problems in offspring increase also with increasing levels of smoking in pregnancy (Figure 3-b).

In order to specify the unique impact of maternal education on children's outcomes, over and beyond the impact of prenatal and postnatal smoking, we estimated logistic regressions to predict offspring's smoking (Table 4) and problem behaviors (Table 5). Maternal education

was included in the models together with prenatal and postnatal smoking and other covariates. The predictors included sociodemographic variables, and measures of maternal depression and delinquency to control for maternal psychopathology. Child behavior problems (antisocial and anxious/depressed) prior to the onset of smoking were also included in the model for child smoking.

The patterns of significant zero-order predictors were very similar for all three outcomes, with two exceptions: race/ethnicity did not predict anxious/depressed behavior; child gender predicted neither anxious/depressed behavior nor lifetime smoking. All other covariates were highly significant. Maternal education at the time of the child's birth, maternal prenatal and postnatal smoking, maternal depression and delinquency were highly significant zero-order predictors of the three outcomes. In the multivariate models, with control for the other covariates, maternal education remained significant, albeit at a much lower level for antisocial behavior, and lost its significance for lifetime smoking and anxiety/depression (Table 5, Models 1). Further analysis, where each covariate was excluded from the models in turn, indicated that the disparity in children's outcomes observed with maternal education appeared to be explained by maternal age at time of child's birth for lifetime smoking and anxiety depression, and only partially explained for antisocial behavior (see Tables 4 and 5, Models 2). Maternal education regained its significance when maternal age at child's birth was omitted from the models. Maternal age at child's birth and educational level are very highly related ($r=0.67$). Maternal age at child's birth apparently explains the seemingly protective effect of maternal education on child lifetime smoking and anxiety depression but does not eliminate the benefit of having a mother with at least some college education for child antisocial behavior.

Prenatal smoking remained a highly significant predictor of offspring smoking irrespective of the extensiveness of maternal smoking, but was significant only when the mother smoked heavily (one or more packs of cigarettes per day) for both problem behaviors. Postnatal smoking was no longer significant for offspring smoking but remained significant for both problem behaviors, but only when smoking a pack or more a day for anxious/depressed. Maternal depression remained significant for the two problem behaviors, but not lifetime smoking, while maternal delinquency remained significant only for antisocial behavior.

4. Conclusion

Disparities in women's smoking by educational level are pervasive. This study provides further confirmation for the observation that lower education significantly increases the risk of smoking and smoking heavily (Yang et al., 2008; Marmot and Wilkinson, 1999).

The negative impact of educational disadvantage for smoking by women persists with controls for participation in adult social roles, attitudes toward drug use, religiosity, and other predictors of smoking behavior. Each of these factors, which reflect every aspect of women's lives, is related to their smoking. Women's educational disadvantage also has a pervasive negative impact on the second generation. Indeed, women of lower educational level are more likely than women of higher educational level to smoke during pregnancy and their offspring are more likely to smoke themselves and to manifest behavior problems. Thus, the increased risk of smoking associated with lower education appears not only for the women themselves but also for their offspring. Both maternal educational level and smoking in pregnancy have independent negative effects on offspring antisocial behavior, with control for each other and for other predictors of child behavior, except maternal age at time of the child's birth. Maternal education is highly positively related to maternal age at child's birth. Inclusion of this covariate eliminates the impact of maternal education on child smoking and anxiety/depression, but not an antisocial behavior. Maternal smoking in pregnancy is a more important predictor than postnatal smoking of child's smoking. An important finding is the observation that maternal

pathology has general or specific effects, depending on the pathology. Maternal depression is associated with increased problem behaviors in offspring, whether antisocial or anxious/depressed, while maternal delinquency is associated only with antisocial behavior. Maternal depression has more widespread consequences than maternal delinquency for the child's adjustment.

A developmental perspective on educational disparities in smoking behavior needs also to consider that there is a cumulative impact of socioeconomic disadvantage from childhood to adulthood that we could not measure in this study. Thus, a British survey found that heavy smoking by young women was related to cumulative exposure to childhood disadvantage, educational disadvantage, early motherhood, and financial hardship (Graham et al., 2006). Similarly, Melchior et al. (2007) found in the Dunedin New Zealand cohort that nicotine dependence at age 32 was higher for those with low SES as children.

In accounting for the impact of socioeconomic disadvantage on women's smoking, one may need to consider other individual factors as well as contextual and biological ones. Contextual factors, in particular tobacco control interventions, may be especially important for low education women (Greaves et al., 2006; Thomas et al., 2008). The smoking behavior of women with lower socioeconomic status appears to be more influenced by tobacco control policies than women with higher status (Kim and Clark, 2006; Levy et al., 2006).

From a biological perspective, we observed that lower education was related to lower levels of circulating cotinine, controlling for number of cigarettes smoked. It should be noted that in prior waves of NHANES, O'Connor et al. (2006) found smaller differences than we did in cotinine levels across educational groups (NHANES III, 1988-1994) or no differences at all (NHANES, 1999-2002). Fidler et al. (2008) report for a national English sample that nicotine intake was significantly higher among individuals with lower social class and higher levels of economic deprivation. Whether higher levels of cotinine among smokers of lower education are due to differences in the topography of smoking cannot be determined from these data. We could not locate national data sets with the appropriate measures to investigate this hypothesis further. However, data on inhalation were available on the mothers of a school-based sample of adolescents in our study of the Transition to Nicotine Dependence in Adolescence (Kandel et al., 2007b). In that sample, while there were no differences in reported frequency of inhalation by educational levels, there were sharp differences in depth of inhalation. The proportions of mothers reporting inhaling deeply or very deeply in the lungs decreased with increasing education from 27.8% of smokers without a high school degree compared with 15.4% of high school graduates, 13.5% of those with some college, and 11.1% of college graduates. Women of lower education may smoke in such a way as to increase the yield of nicotine from cigarettes by inhaling more deeply, but not necessarily more often. This novel finding needs to be replicated. Education may be related to smoking behaviors that enhance the absorption of nicotine from cigarettes, with all the negative health consequences that this entails.

The educational disparity in rates of smoking in pregnancy documented in the NLSY replicates the findings reported in the literature (Clay et al., 1988; Ebrahim et al., 2000; Gilman et al., 2008; Mathews, 2001). Similarly, the impact of prenatal smoking on offspring smoking and negative child behaviors has been reported by others (Al Mamun et al., 2006; Cnattingius, 2004; Griesler et al., 1998; Kandel et al., 1994; Obel et al., 2009; Wakschlag et al., 2002; 2006; Weissman et al., 1999). However, Maughan et al. (2004) found that the association between prenatal smoking and conduct problems disappeared with control for maternal depression and antisocial behavior, whereas the association persisted in our analysis of the NLSY. Furthermore, a recent study stresses that, because of methodological flaws, epidemiological findings regarding the negative consequences of prenatal smoking on

children's behavior problems, which did not consider familial factors, may have led to misleading conclusions (D'Onofrio et al., 2008). In multiple births with discrepant maternal smoking across pregnancies within the same family, rates of problem behaviors among offspring were the same irrespective of maternal smoking in pregnancy. The authors conclude that the observed effect of prenatal smoking is due to genetic or environmental factors and not to prenatal smoking. However, it is difficult to reconcile this conclusion with the well documented impact of prenatal smoking on offspring behavioral problems observed repeatedly in animal models (Baler et al., 2008; Slotkin, 2008). Animal studies suggest strongly that these effects are due to nicotine induced neurophysiological changes in the brain of the fetus. There may well be additional genetic or environmental determining factors acting by themselves or in interaction with prenatal smoking (Becker et al., 2008). Prenatal smoking itself appears to have a strong negative influence on offspring development.

Women of low education, especially those without a high school education, are particularly vulnerable to the consequences of smoking, not only for themselves but also for their offspring. These women are more likely to smoke than any other group, and more likely also to continue smoking while pregnant. Their children are more likely to smoke and to exhibit behavioral problems. Since tobacco control policies, such as price and media campaigns, are more effective among women with low education than those with high education (Kim and Clark, 2006; Levy et al., 2006), public health efforts specifically targeted toward low education women would have beneficial effects not only for the women themselves but also for their offspring. As emphasized by Graham et al. (2006), these efforts need to focus as much on social conditions and social policies that affect women's lives, including those in childhood, as on individual level interventions. These would include taxation, social transfer policies, and publicly funded services, such as education, health care, and housing (Graham et al., 2006: p.ii10). We believe that the data we presented make it clear that the optimum strategy for reducing smoking among low SES women, and the negative consequences of smoking for themselves and their children, is to enhance academic achievement and reduce educational disparities at their inception. Targeting the educational system and expanding efforts to enable adolescents to complete high school and strive for higher education will have greater benefits, both for reducing smoking and more broadly for enhancing the life opportunities of women, than remedial efforts targeted towards reducing smoking initiated later in the life cycle when these young women have become adults. Additional educational interventions during pregnancy and postnatally would also be beneficial.

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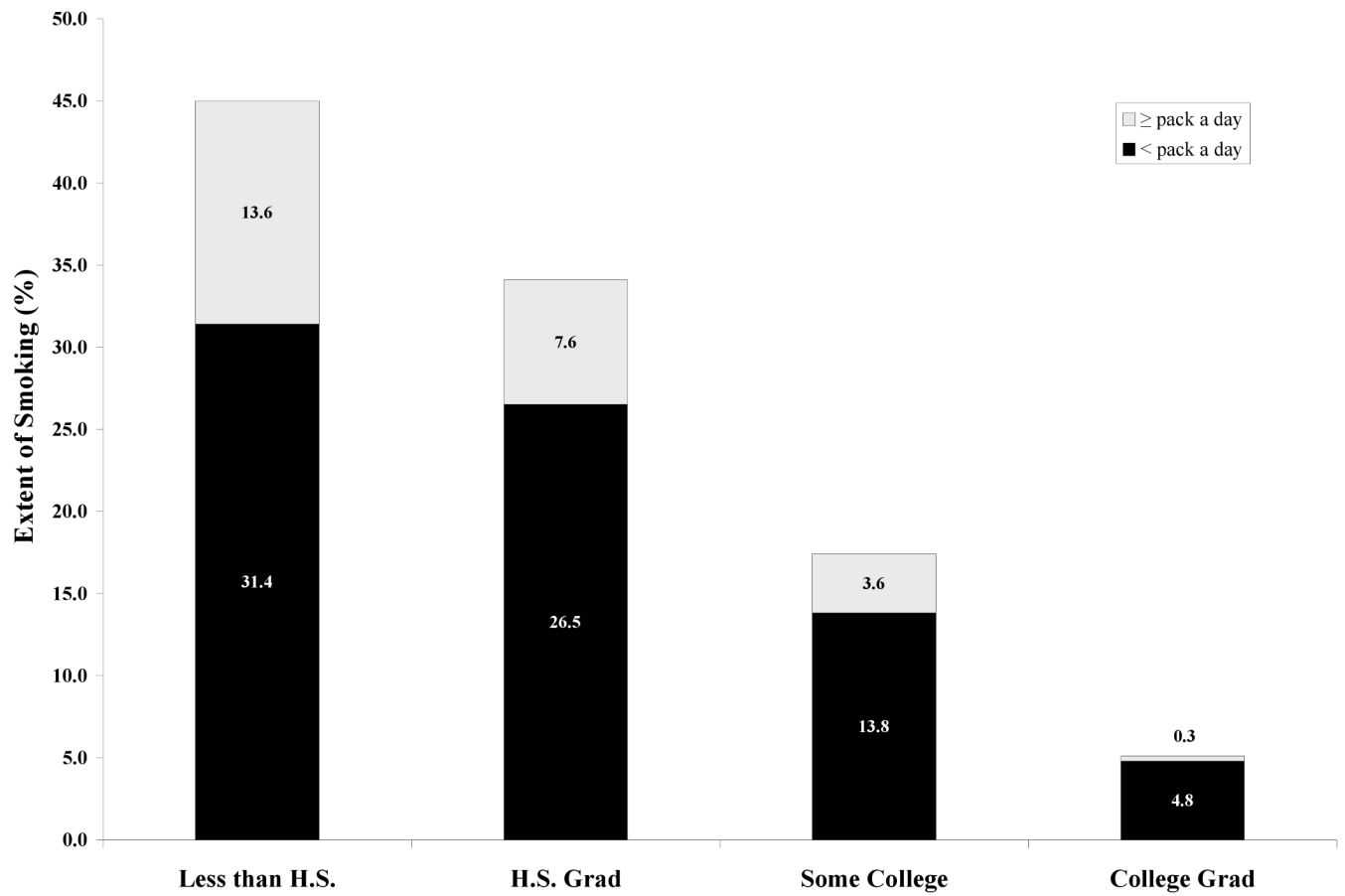


Figure 1.
Extent of smoking in first pregnancy by maternal education at child's birth (NLSY 1979-2004,
 $N=4,553$)

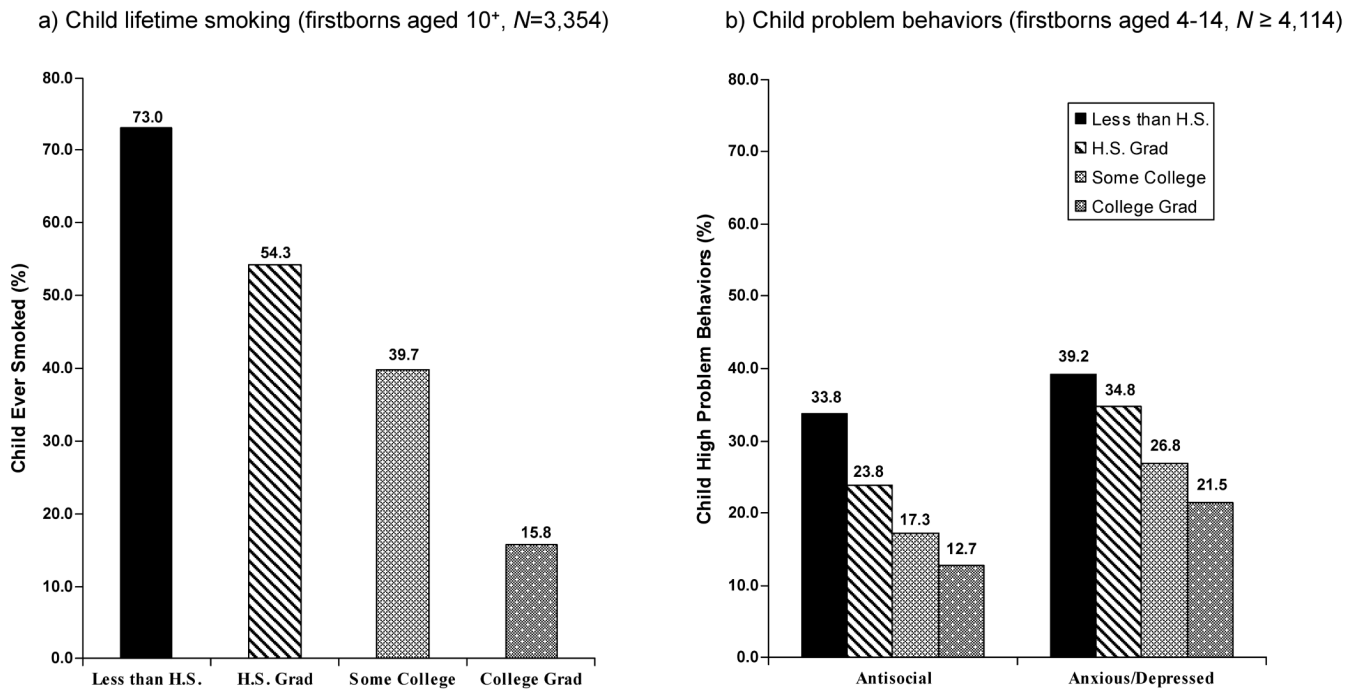


Figure 2.
Maternal education at birth of firstborn child and child outcomes (NLSY 1979-2004)

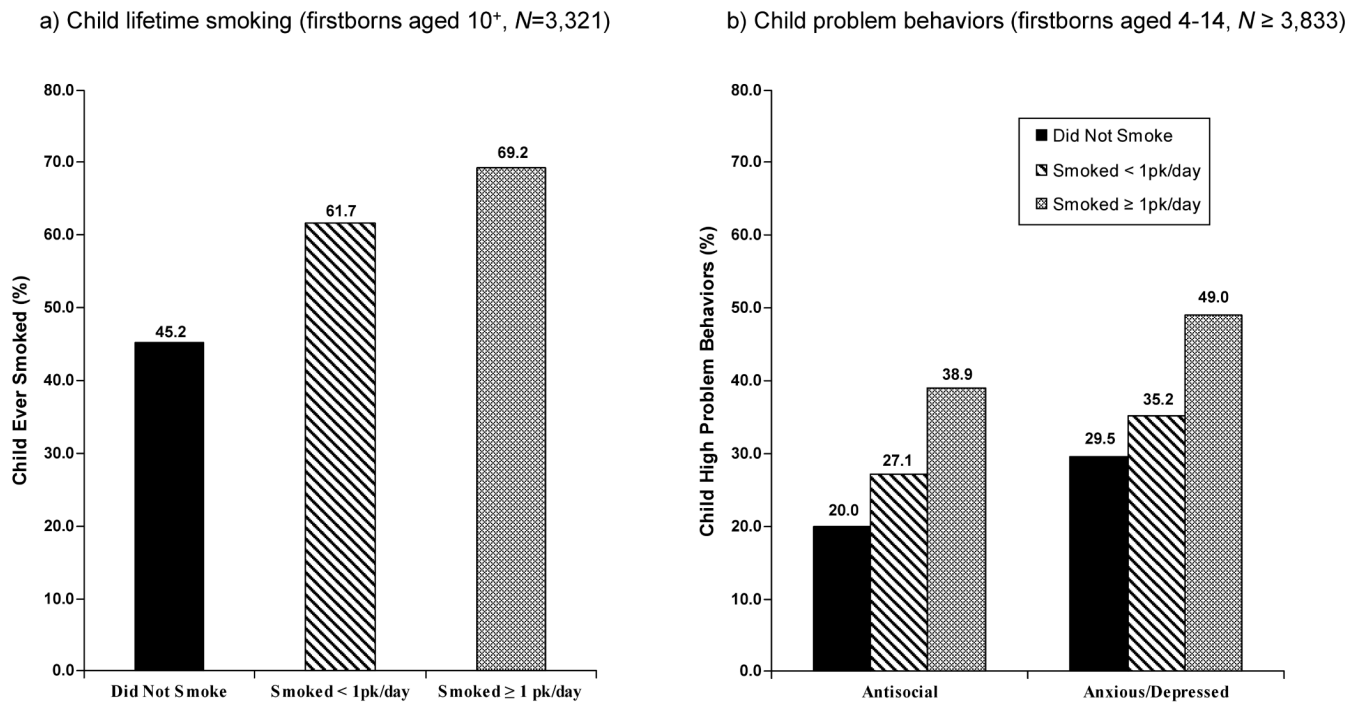


Figure 3.
Maternal smoking in pregnancy and firstborn child outcomes (NLSY 1979-2004)

Smoking history by education among women smokers aged 18 and over (NSDUH 2006, N=13,043)

Table 1

Smoking History	Less than H.S.	H.S. Graduate	Some College	College Graduate
Among lifetime smokers				
Smoked last month (%)	53.7	43.3	35.8	19.5
Ever smoked daily (%)	73.8	66.3	55.5	41.0
Age of onset (years) (M (S.D.))	14.9 (3.8)	15.6 (4.0)	15.7 (3.6)	16.2 (4.1)
Total N	(1,913)	(4,212)	(4,077)	(2,742)
Among last month smokers				
Cigarettes per day (M (S.D.))	14.1 (12.2)	12.0 (9.7)	11.6 (5.8)	8.6 (8.4)
Nicotine dependent (%)	51.3	42.3	43.3	24.1
Total N	(1,200)	(2,227)	(1,813)	(708)

Table 2
Cotinine intake per cigarette smoked by education in two national samples (ADD HEALTH III, N=386; NHANES 2005-2006, N=349)

	Less than H.S.		H.S. Graduate		More than H.S.	
	M	S.D.	M	S.D.	M	S.D.
ADD HEALTH III (18-24 years)						
Urine cotinine (ng/ml)	162.4 ^a	(174.4)	138.0 ^{ab}	(135.5)	115.6 ^b	(117.3)
Total N	(105)		(149)		(132)	
NHANES 2005-2006 (20+ years)						
Serum cotinine (ng/ml)	32.3 ^a	(61.0)	19.1 ^b	(16.6)	23.6 ^{ab}	(30.1)
Total N	(108)		(111)		(130)	

^{a, b} Cells with different letters are statistically significantly different from each other.

Table 3

Multinomial logistic regression predicting cigarette smoking and nicotine dependence among women aged 18 and over (NSDUH 2006, N≥18,973)

Covariates	Former smoker (not last month) vs. Never			Last month smoker, not dependent vs. Former			Nicotine dependent vs. Last month smoker, not dependent		
	UOR	95% CI	AOR	95% CI	UOR	95% CI	95% CI	AOR	95% CI
Age (vs. 18-25 years)									
26-34	1.41 ***	(1.23-1.61)	1.31 ***	(1.12-1.54)	0.57 ***	(0.50-0.66)	(0.71-1.05)	1.32 *	(1.06-1.64)
35-49	1.73 ***	(1.52-1.96)	1.57 ***	(1.33-1.87)	0.43 ***	(0.38-0.48)	(0.34-0.86)	1.74 ***	(1.46-2.09)
50 and older	1.66 ***	(1.47-1.88)	1.96 ***	(1.67-2.31)	0.22 ***	(0.19-0.26)	(0.34-0.52)	1.31 ***	(1.12-1.84)
Education (vs. < H.S.)									
H.S. graduate	1.70 ***	(1.43-2.01)	1.42 ***	(1.17-1.71)	0.79 **	(0.66-0.95)	(0.67-0.99)	0.71 ***	(0.59-0.86)
Some college	2.22 ***	(1.90-2.58)	1.72 ***	(1.45-2.04)	0.59 ***	(0.49-0.70)	(0.45-0.68)	0.58 ***	(0.48-0.69)
College graduate	2.65 ***	(2.24-3.14)	1.60 ***	(1.29-1.98)	0.34 ***	(0.28-0.41)	(0.32-0.51)	0.25 ***	(0.19-0.33)
Race/ethnicity (vs. white)									
African American	0.38 ***	(0.33-0.44)	0.52 ***	(0.45-0.61)	1.13	(0.97-1.33)	(0.77-1.10)	0.65 ***	(0.53-0.81)
Hispanic	0.43 ***	(0.37-0.49)	0.61 ***	(0.53-0.71)	1.00	(0.86-1.18)	(0.61-0.91)	0.37 ***	(0.27-0.51)
Other	0.29 ***	(0.23-0.36)	0.35 ***	(0.28-0.44)	1.34	(0.95-1.90)	(0.82-1.81)	0.58 *	(0.39-0.95)
Marital status (vs. married/widowed)									
Divorced/separated	1.33 ***	(1.12-1.58)	1.41 ***	(1.18-1.72)	2.12 ***	(1.79-2.51)	(1.57-2.28)	1.22 ***	(1.00-1.48)
Never married	0.67	(0.61-0.74)	0.85 *	(0.74-0.98)	2.99	(2.66-3.35)	(1.32-1.83)	0.66	(0.57-0.76)
Children in household (vs. none)									
1	1.03	(0.91-1.17)	1.23 **	(1.08-1.41)	1.03	(0.90-1.18)	(0.94-1.26)	1.38 **	(1.13-1.68)
2	1.16	(1.02-1.31)	1.37 ***	(1.17-1.80)	0.80 **	(0.69-0.92)	(0.86-1.21)	1.16	(1.16-1.73)
3 or more	1.17	(0.96-1.43)	1.52 ***	(1.19-1.94)	0.70	(0.57-0.86)	(0.66-1.16)	1.39 *	(1.07-1.81)
Work status last week (vs. worked)									
Had job, did not work	1.07 ***	(0.86-1.32)	1.08	(0.86-1.34)	0.87 ***	(0.69-1.10)	(0.66-1.06)	0.96	(0.70-1.31)
Unemployed	0.57 ***	(0.41-0.79)	0.90	(0.64-1.27)	2.33	(1.79-3.03)	(0.98-1.75)	1.24	(1.04-1.85)
Kept house	0.68 ***	(0.58-0.80)	0.81 *	(0.88-0.97)	0.88	(0.73-1.06)	(0.80-1.20)	1.25	(0.96-1.63)
School/training	0.55 ***	(0.45-0.66)	0.74 **	(0.80-0.90)	1.63 ***	(1.26-2.13)	(0.72-1.28)	0.48 **	(0.30-0.78)
Disabled/retired/no job	0.95 ***	(0.85-1.07)	1.01	(0.88-1.17)	0.55 ***	(0.47-0.63)	(0.60-0.85)	1.85 ***	(1.56-2.19)
Family income	1.00 ***	(1.00-1.00)	1.00	(1.00-1.00)	1.00 ***	(1.00-1.00)	(1.00-1.00)	1.00 ***	(1.00-1.00)
Major depressive episode last year	1.46 ***	(1.24-1.72)	1.29 ***	(1.06-1.56)	1.56 ***	(1.31-1.87)	(1.01-1.51)	1.38 ***	(1.31-1.98)
Risk taking	1.51 ***	(1.40-1.64)	1.36 ***	(1.25-1.48)	1.48	(1.37-1.59)	(1.11-1.32)	1.17 ***	(0.98-1.16)
Perceived risk of: Smoking 1+ pack cigarettes/day (vs. no/slight/moderate risk)									
Great	1.12	(0.99-1.27)	1.31 ***	(1.13-1.52)	0.35 ***	(0.31-0.40)	(0.36-0.48)	0.80	(0.70-0.91)
Having 5+ drinks 1-2 times/week (vs. no/slight risk)									
Moderate	0.95	(0.84-1.08)	1.00	(0.86-1.16)	0.68 ***	(0.59-0.79)	(0.75-1.04)	1.04	(0.88-1.22)
Great	0.62 ***	(0.55-0.69)	0.83 ***	(0.73-0.96)	0.59	(0.52-0.68)	(0.83-1.14)	1.02	(0.82-1.15)
Smoking marijuana once/month (vs. no risk)									
Slight	0.86	(0.72-1.04)	0.84 ***	(0.70-1.03)	0.60 ***	(0.52-0.71)	(0.62-0.90)	0.76 *	(0.62-0.94)
Moderate	0.59 ***	(0.49-0.71)	0.61 ***	(0.50-0.75)	0.43 ***	(0.37-0.50)	(0.52-0.76)	0.80 *	(0.66-0.96)
Great	0.37	(0.30-0.44)	0.42 ***	(0.33-0.53)	0.36	(0.30-0.43)	(0.58-0.90)	0.75	(0.60-0.93)
Frequency attended religious services last year (vs. 0 times)									
1-2	1.05	(0.89-1.24)	1.14 **	(0.95-1.37)	0.92	(0.77-1.10)	(0.77-1.17)	0.77 *	(0.62-0.94)
3-5	1.17 *	(1.01-1.36)	1.24 **	(1.08-1.46)	0.84 ***	(0.71-1.01)	(0.83-1.20)	0.67 **	(0.54-0.84)
6-24	1.11	(0.98-1.26)	1.14	(0.98-1.32)	0.72	(0.61-0.85)	(0.78-1.15)	0.71	(0.60-0.99)

Covariates	Former smoker (not last month) vs. Never		Last month smoker, not dependent vs. Former		Nicotine dependent vs. Last month smoker, not dependent	
	UOR	AOR 95% CI	UOR	AOR 95% CI	UOR	AOR 95% CI
25-52	0.93	(0.81-1.07)	0.41 ***	(0.35-0.49)	0.47 ***	(0.35-0.61)
52 or more	0.73 ***	(0.63-0.84)	0.26 ***	(0.21-0.33)	0.53 **	(0.37-0.78)
Importance of religion	0.76 ***	(0.72-0.80)	0.66 ***	(0.62-0.67)	0.95	(0.89-1.01)
Total N's ≥		(13,196)		(10,452)		(5,777)

* p<0.05;

** p<0.01;

*** p<0.001

UOR= unadjusted odds ratio; AOR= adjusted odds ratio

Table 4

Maternal education at child's birth and prenatal smoking as predictors of child lifetime $N=3,262$)

Covariates	Lifetime Smoking					
	Model 1			Model 2		
	UOR	95% CI	AOR	95% CI	AOR	95% CI
Maternal education at child's birth (vs. less than high school)						
High school	0.44 ^{***}	0.37-0.52	1.02	0.81-1.28	0.53 ^{***}	0.43-0.65
Some college	0.24 ^{***}	0.20-0.30	1.13	0.85-1.51	0.40 ^{***}	0.31-0.51
College or more	0.07 ^{***}	0.05-0.09	0.70	0.48-1.02	0.17 ^{***}	0.12-0.24
Maternal prenatal smoking (vs. no)						
Smoked < pack/day	1.95 ^{***}	1.66-2.29	1.35 ^{**}	1.09-1.69	1.30 [*]	1.06-1.61
Smoked ≥ pack/day	2.72 ^{***}	2.07-3.57	1.56 ^{**}	1.10-2.22	1.41 [*]	1.01-1.99
Maternal postnatal smoking (vs. no)						
Smoked < pack/day	1.76 ^{***}	1.49-2.07	0.95	0.77-1.19	0.93	0.76-1.15
Smoked ≥ pack/day	1.44 ^{**}	1.12-1.85	0.90	0.65-1.25	0.81	0.59-1.10
Maternal age at first birth	0.79 ^{***}	0.07-0.80	0.78 ^{***}	0.76-0.81	-	--
Income at first birth	0.97 ^{***}	0.96-0.97	0.99	0.98-0.99	0.97 ^{***}	0.97-0.98
Marital status at first birth (vs. married)						
Divorced, separated, widowed	1.41 ^{***}	1.01-1.96	0.90	0.60-1.35	0.68 [*]	0.47-0.99
Never married	2.08 ^{***}	1.75-2.45	0.86	0.68-1.08	1.10	0.89-1.37
Number of children ever born	1.14 ^{***}	1.08-1.21	0.89 ^{**}	0.83-0.96	0.89 ^{**}	0.83-0.96
Maternal depression	1.05 ^{***}	1.03-1.06	0.99	0.97-1.01	0.98	0.97-1.00
Maternal delinquency	1.69 ^{***}	1.34-2.13	1.25	0.94-1.66	1.23	0.94-1.61
Race/ethnicity (vs. white)						
Hispanic	1.54 ^{***}	1.20-1.98	0.89	0.66-1.20	0.88	0.66-1.20
African American	1.00	0.85-1.19	0.38 ^{***}	0.30-0.48	0.44 ^{***}	0.36-0.56
Child sex (vs. female)	1.10 ^{***}	0.97-1.24	0.95	0.81-1.11	1.04	0.97-1.11
Child antisocial (vs. no)	3.74 ^{***}	3.16-4.42	2.64 ^{***}	2.14-3.24	2.59 ^{***}	2.12-3.15
Child anxious/depressed (vs. no)	2.45 ^{***}	2.11-2.84	1.65 ^{***}	1.37-2.00	1.66 ^{***}	1.38-1.98
-2 log likelihood (df)				4036.11 (27)		4345.11 (26)

* $p<0.05$;** $p<0.01$;*** $p<0.001$

UOR= unadjusted odds ratio; AOR= adjusted odds ratio

Table 5

Maternal education at child's birth and prenatal smoking as predictors of child behavior problems (NLSY first born mother-child dyads 1979-2004, child 4-14 years $N \geq 3,971$)

Covariates	Anxious/Depressed ($N=3,977$)															
	Antisocial ($N=3,971$)					Model 1					Model 2					
	UOR	95% CI	AOR	95% CI	AOR	UOR	95% CI	AOR	95% CI	AOR	UOR	95% CI	AOR	95% CI	AOR	95% CI
Maternal education at child's birth (vs. less than high school)																
High school	0.61***	0.52-0.72	0.84	0.69-1.04	0.80*	0.82	0.66-0.97	1.12	0.71-0.97	1.12	0.82	0.66-0.97	1.12	0.71-0.97	1.12	0.92-1.36
Some college	0.41***	0.33-0.51	0.68**	0.51-0.90	0.62***	0.57***	0.48-0.80	1.34	0.47-0.69	1.34	0.57***	0.48-0.80	1.34	0.47-0.69	1.34	0.81-1.34
College or more	0.28	0.22-0.36	0.67	0.48-0.96	0.59	0.43	0.43-0.80	1.08	0.34-0.52	1.08	0.43	0.43-0.80	1.08	0.34-0.52	1.08	0.79-1.46
Maternal prenatal smoking (vs. no)																
Smoked < pack/day	1.48***	1.25-1.75	1.01	0.82-1.24	1.01*	1.30***	0.82-1.25	0.98	1.11-1.52	0.98	1.30***	0.82-1.25	0.98	1.11-1.52	0.98	0.81-1.18
Smoked \geq pack/day	2.54***	1.99-3.25	1.45*	1.07-1.96	1.44*	2.30	1.06-1.95	1.51**	1.82-2.91	1.51**	2.30	1.06-1.95	1.51**	1.82-2.91	1.51**	1.13-2.01
Maternal postnatal smoking (vs. no)																
Smoked < pack/day	1.63***	1.38-1.92	1.25*	1.02-1.54	1.26*	1.33***	1.02-1.54	1.00	1.14-1.56	1.00	1.33***	1.02-1.54	1.00	1.14-1.56	1.00	0.83-1.21
Smoked \geq pack/day	1.94***	1.51-2.47	1.51**	1.11-2.05	1.50**	2.04***	1.11-2.03	1.40*	1.63-2.56	1.40*	2.04***	1.11-2.03	1.40*	1.63-2.56	1.40*	1.06-1.86
Maternal age at first birth	0.93***	0.92-0.94	0.98	0.96-1.00	-	0.94***	-	0.94***	0.92-0.95	0.94***	0.94***	-	0.94***	0.92-0.95	-	0.92-0.96
Income at first birth	0.99	0.99-0.99	0.99	0.99-1.00	0.99	0.99	0.99-1.00	0.99	0.99-0.99	0.99	0.99	0.99-1.00	0.99	0.99-0.99	0.99	0.99-0.99
Marital status at first birth (vs. married)																
Divorced, separated, widowed	1.63***	1.18-2.26	1.24	0.87-1.77	1.22	0.92	0.86-1.74	0.74	0.67-1.27	0.74	0.92	0.86-1.74	0.74	0.67-1.27	0.74	0.52-1.05
Never married	2.22***	1.86-2.64	1.35**	1.09-1.67	1.39**	1.61	1.13-1.72	1.19	1.37-1.89	1.19	1.61	1.13-1.72	1.19	1.37-1.89	1.19	0.98-1.45
Number of children ever born	1.19	1.12-1.27	1.11	1.04-1.19	1.11	1.16	1.04-1.19	1.07***	1.09-1.22	1.07***	1.16	1.04-1.19	1.07***	1.09-1.22	1.07***	1.00-1.14
Maternal depression	1.10***	1.09-1.12	1.08***	1.06-1.10	1.08***	1.10	1.06-1.10	1.09***	1.09-1.12	1.09***	1.10	1.06-1.10	1.09***	1.09-1.12	1.09***	1.07-1.10
Maternal delinquency	1.93	1.56-2.40	1.46	1.15-1.84	1.45	1.56	1.15-1.84	1.45	1.27-1.93	1.22	1.56	1.15-1.84	1.45	1.27-1.93	1.22	0.98-1.53
Race/ethnicity (vs. white)																
Hispanic	1.42**	1.09-1.84	1.21	0.91-1.62	1.22	0.97	0.92-1.63	0.79	0.76-1.24	0.79	0.97	0.92-1.63	0.79	0.76-1.24	0.79	0.61-1.05
African American	2.03***	1.69-2.42	1.66***	1.30-1.98	1.62***	0.94	1.31-2.00	0.67***	0.79-1.12	0.67***	0.94	1.31-2.00	0.67***	0.79-1.12	0.67***	0.54-0.82
Child sex (vs. female)	1.97	1.72-2.27	2.12	1.83-2.46	2.13	0.91	1.83-2.47	0.91	0.81-1.03	0.91	0.91	1.83-2.47	0.91	0.81-1.03	0.92	0.80-1.04
-2 log likelihood (df)				4448.01 (23)			4450.52 (22)									5381.57 (22)

* $p < 0.05$;** $p < 0.01$;*** $p < 0.001$

UOR= unadjusted odds ratio; AOR= adjusted odds ratio