

# Maternal Smoking During Pregnancy and Adult Male Criminal Outcomes

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**Background:** Perinatal risk factors are related to persistent and violent criminal outcomes. Prenatal maternal smoking may represent an additional perinatal risk factor for adult criminal outcomes. Our study examines maternal smoking during pregnancy as a predictor of offspring crime in the context of a prospective, longitudinal design.

**Methods:** Subjects were a birth cohort of 4169 males born between September 1959 and December 1961 in Copenhagen, Denmark. During the third trimester of pregnancy, mothers self-reported the number of cigarettes smoked daily. When the male offspring were 34 years of age, their arrest histories were checked in the Danish National Criminal Register. Additional data were collected concerning maternal rejection, socioeconomic status, maternal age, pregnancy and delivery complications, use of drugs during pregnancy, paternal criminal history, and parental psychiatric hospitalization.

**Results:** Results indicate a dose-response relationship between amount of maternal prenatal smoking and arrests for nonviolent and violent crimes. Maternal prenatal smoking was particularly related to persistent criminal behavior rather than to arrests confined to adolescence. These relationships remained significant after potential demographic, parental, and perinatal risk confounds were controlled for.

**Conclusions:** Maternal prenatal smoking predicts persistent criminal outcome in male offspring. This relationship has not been accounted for by related parental characteristics or perinatal problems. Potential physiologic or central nervous system mediators between maternal smoking during pregnancy and offspring criminal outcomes need further study.

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**R**ESULTS OF several studies suggest a relationship between perinatal complications and antisocial behavior. Pasamanick et al<sup>1</sup> found a higher rate of pregnancy complications among behavior-disordered children than among age-matched control subjects. Lewis et al<sup>2</sup> found a positive correlation between perinatal complications and rates of recidivism among delinquent children. The significant role of prenatal factors in the development of aggression is also supported by studies of minor physical anomalies, which are small, external deformities that often indicate a history of prenatal trauma. Minor physical anomalies have been correlated with aggression, hyperactivity, impulsivity, and criminal violence.<sup>3-5</sup>

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The specific prenatal risk factors associated with acting-out behaviors are numerous and diverse, ranging from toxemia<sup>1</sup> to intrauterine insult.<sup>6</sup> One such risk factor is maternal cigarette smoking during pregnancy. Maternal prenatal smoking has been associated with several externalizing behaviors, including impulsivity, truancy, conduct disorder, and attentional difficulties.<sup>7-9</sup> Maternal prenatal smoking also

has been linked to crime in offspring. Rantakallio et al<sup>10</sup> found that individuals whose mothers smoked during pregnancy were twice as likely to have a criminal record at age 22 years as were age-matched controls.

The relationship between maternal prenatal smoking and deviance persists, even when investigators control for potential confounding factors.<sup>10</sup> Weitzman et al<sup>11</sup> found that maternal prenatal smoking predicted behavior problems despite controlling for race, age, sex, birth weight, maternal education, maternal use of alcohol during pregnancy, family income, parental divorce, and quality of the home environment. Other researchers<sup>9,12</sup> found that maternal prenatal smoking predicts behavior problems after controlling for parental psychopathologic factors, pregnancy risks, number of schools attended, and parenting practices.

Studies have linked maternal smoking behavior to several adverse medical outcomes. Prenatal maternal smoking has been associated with chronic ischemia, hypoxia, hypertonicity, increased tremors, and increased startle response in infants,

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## SUBJECTS AND METHODS

### SUBJECTS

Subjects were 4169 males from a total cohort of 9125 individuals born between September 1959 and December 1961 at Rigshospitalet, Copenhagen, Denmark.<sup>19</sup> Excluded from the cohort were females (because of low rates of violent arrests, which precluded reliable statistical analyses) and males whose mothers did not provide a self-report of smoking behavior during the third trimester of pregnancy ( $n = 93$ ).

### PERINATAL FACTORS

#### Maternal Prenatal Smoking

In prenatal and postnatal interviews, mothers reported the number of cigarettes smoked daily during the third trimester of pregnancy. These self-reports resulted in the placement of mothers into the following cigarette smoking categories for data analyses: 0 ( $n = 2042$ ), 1 to 2 ( $n = 289$ ), 3 to 10 ( $n = 1206$ ), 11 to 20 ( $n = 565$ ), or more than 20 ( $n = 67$ ) smoked daily.

#### Maternal Prenatal Prescription Drug Use

Self-reports of drug use during pregnancy (scored as yes or no) were also obtained from the mothers in the cohort during prenatal and postnatal interviews at the hospital. The following types of drugs were included in this self-report: antihistamines, diuretics, antiepileptics, psychopharmaceuticals (including barbiturates), antibiotics, analgesics, and hormone treatments. Mothers were not asked about alcohol or illicit drug use during pregnancy.

#### Pregnancy and Delivery Complications

Obstetricians and their assistants recorded pregnancy and delivery complications during prenatal visits and at delivery at Rigshospitalet. Weighted pregnancy and delivery complications scales were constructed by a team of American and Danish obstetricians and pediatric neurologists. The pregnancy complications scale included items such as bleeding or illness during pregnancy, use of radiation during pregnancy, and preeclampsia. The delivery complications scale included breech delivery, transverse position, forceps extraction, umbilical cord prolapse, and long birth duration (see Baker and Mednick<sup>19</sup> for further details on scale construction).

### DEMOGRAPHIC FACTORS

Maternal age (in years) at time of birth of the child was obtained from medical records. The SES (high, middle, or low, determined by parent occupation) was obtained from the Danish Central Person's Register when the child was 1 year old; SES was available for only 3647 of the 4169 study participants. Per the recommendation of Cohen and Cohen,<sup>20</sup> these missing data were recoded to the mean, and a dummy coded variable (1, SES data missing; 0, SES data present)

was included as a statistical control in logistic regression analyses.

### PARENTAL PSYCHIATRIC HOSPITALIZATION AND CRIMINAL HISTORY

Paternal criminal history (present or absent) was assessed by a check of arrests for index crimes recorded by the Danish National Criminal Register in 1972. Parents' psychiatric hospitalization history (present or absent) was assessed by a check of the Danish Psychiatric Register of the Institute for Psychiatric Demography in 1992. All hospitalizations for psychiatric illness, including substance abuse and dependence, are included in this register.

### MATERNAL REJECTION

Mother's rejection of her infant (high or low) was measured prenatally and when the child was 1 year of age through data collected during mother interviews. This variable has been found to interact with delivery complications in the prediction of violent offending in this sample.<sup>18</sup>

### CRIMINAL OUTCOMES

Arrest histories of male offspring in the cohort were obtained from the Danish National Criminal Register, one of the most accurate in the Western world, in 1994. All arrests are recorded in a central location in Denmark.<sup>21</sup> The following criminal offenses were defined as violent: murder, attempted murder, robbery, rape, assault (including domestic assault), and illegal possession of a weapon. Nonviolent offenses were defined as theft, breaking and entering, fraud, forgery, blackmail, embezzlement, vandalism, prostitution, pimping, and narcotics offenses. Persistent and adolescent-limited crimes were defined on the basis of age at arrest. Males in the cohort who were arrested only before age 18 years were categorized as adolescent-limited offenders. Males in the cohort who were arrested before and after age 18 years were categorized as life-course persistent offenders. More than 75% of the life-course persistent offenders were last arrested for an offense at age 25 years or older.

### STATISTICAL ANALYSIS

Mantel-Haenszel  $\chi^2$  analyses were used to examine the relationship between amount of maternal smoking during pregnancy and outcomes of nonviolent crime, violent crime, persistent crime, and adolescent-limited arrests. The comparison group in all analyses consisted of males in the sample who were never arrested for a criminal index offense. Logistic regression analyses were used to control for the potential confounds of maternal rejection, SES, maternal age, pregnancy and delivery complications, use of drugs during pregnancy, paternal criminal history, and parental psychiatric hospitalization in the relationship between maternal smoking during pregnancy and offspring criminal outcomes. Logistic regression analyses were also used to test for potential interactions of maternal prenatal smoking and other potential risk factors on adult criminal outcomes;  $\alpha = .05$  for all analyses.

suggesting a relationship between maternal smoking and central nervous system deficits.<sup>13,14</sup> These central nervous system deficits may be the mediating factor between maternal smoking and offspring deviant behavior.

If maternal smoking during pregnancy represents (at least in part) a biological risk for aggression, then it may be predictive of only certain patterns of criminal offending. According to the theory of antisocial behavior

by Moffitt,<sup>15</sup> life-course persistent offending is more likely to have a biological basis than adolescent-limited offending (ie, arrests limited to adolescence). The 1 study<sup>10</sup> that examined the relationship between maternal prenatal smoking and crime did not examine this potentially important distinction in patterns of offending.

Results of existing research also suggest that perinatal factors may be especially related to aggressive and criminal outcomes for individuals exposed to multiple risk factors. In a prospective, longitudinal study in Kauai, Hawaii, Werner<sup>16</sup> found that the effects of perinatal stress on delinquent outcomes were strongest for children exposed to a disruptive family environment. Results of research<sup>17,18</sup> in Denmark showed similar biosocial interactions predicting the outcomes of violent and persistent criminal behavior. No studies to date have examined potential interactive effects of maternal prenatal smoking and other risk factors in the prediction of offspring outcomes.

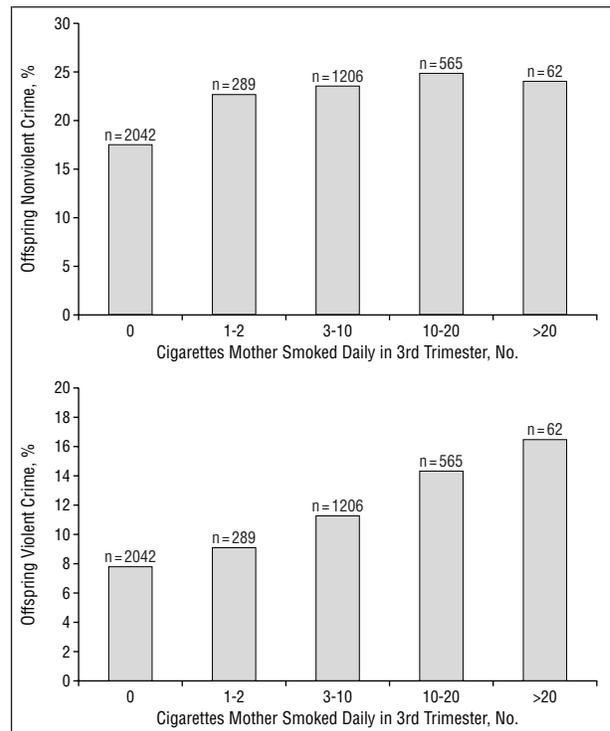
Previous studies have measured the relationship between maternal prenatal smoking and aggression in children and adolescents, but no study has examined this relationship in individuals older than 22 years. This study extended the current literature by examining the relationship between maternal smoking and offspring deviance in adults up to age 34 years. As such, we differentiated the effects of maternal smoking on adolescent-limited vs life-course persistent criminal offending. Our large sample size also enabled us to examine violent offending as a specific outcome variable.

Our data set also provided several methodological advantages over previous research. First, our sample is population based. Second, mothers' reports of smoking were collected during pregnancy rather than through retrospective reports. Third, related perinatal risk factors were recorded in a detailed, reliable manner by obstetricians and pediatric neurologists in the context of a large-scale birth cohort study. Finally, our data set allowed us to control for a variety of potential confounds and to assess potential interactions of maternal smoking and other risk factors in the prediction of criminal outcomes.

We used a perinatal birth cohort of 4129 males to assess the relationship between maternal prenatal smoking and offspring criminal arrests. We hypothesized that (1) a significant relationship existed between maternal prenatal smoking and offspring criminal behavior, (2) this relationship would be true for violent behavior and persistent criminal behavior rather than for adolescent-limited crime, and (3) the above relationships would remain significant despite controlling for socioeconomic status (SES), maternal rejection, maternal age, pregnancy and delivery complications, use of drugs during pregnancy, paternal criminal history, and parental psychiatric hospitalization. Finally, these data allowed us to explore potential interactions between maternal smoking and other risk factors in the prediction of criminal outcomes.

## RESULTS

$\chi^2$  Analyses showed a significant positive relationship between amount of maternal smoking during the third trimester of pregnancy and offspring nonviolent arrests



**Figure 1.** The relationship between maternal prenatal smoking and offspring nonviolent (top) and violent (bottom) criminal arrest.

(Mantel-Haenszel  $\chi^2_{1,N=3759} = 34.58$ ;  $P < .001$ ) (Figure 1, top). A linear relationship exists between percentage of violent offenders and number of cigarettes the mother smoked daily during her third trimester of pregnancy (Mantel-Haenszel  $\chi^2_{1,N=3307} = 39.77$ ;  $P < .001$ ) (Figure 1, bottom).

$\chi^2$  Analyses were also performed to test for a relationship between maternal prenatal smoking and adolescent-limited vs life-course persistent offending. Maternal smoking during the third trimester was related to higher rates of life-course persistent offending (Mantel-Haenszel  $\chi^2_{1,N=3289} = 31.48$ ;  $P < .001$ ) and adolescent-limited offending (Mantel-Haenszel  $\chi^2_{1,N=3176} = 6.85$ ;  $P < .001$ ).

Logistic regression analyses were performed to test whether the relationship between maternal smoking and offspring criminal outcomes would remain when potential confounds were controlled for. The potential confounds first entered as a block into the model included parental psychiatric hospitalization, pregnancy and delivery complications, mother's use of drugs during pregnancy, father's criminal arrest, maternal rejection, mother's age, and SES. Next, the maternal smoking variable was tested as to whether it would significantly enter the model. Maternal smoking significantly predicted nonviolent arrests ( $\chi^2_{1,N=3728} = 13.28$ ;  $P < .001$ ) and violent arrests ( $\chi^2_{1,N=3284} = 15.74$ ;  $P < .001$ ) when these confounds were controlled for. Maternal smoking was not significantly related to adolescent-limited offending ( $\chi^2_{1,N=3151} = 2.70$ ;  $P = .10$ ) but was significant in the prediction of life-course persistent offending ( $\chi^2_{1,N=3266} = 9.42$ ;  $P < .01$ ) after controlling for potential confounds.

The **Table** presents significance levels and odds ratios of the variables included in logistic regression models predicting nonviolent, violent, and life-course per-

**Logistic Regression Models of the Relationship Between Maternal Smoking in the Third Trimester and Offspring Criminal Outcomes, Including Controls for Potential Confounds**

	Exp( $\beta$ ) (95% CI)*		
	Nonviolent Crime (n = 3728)	Violent Crime (n = 3284)	Persistent Crime (n = 3266)
Maternal smoking	1.13† (1.06-1.21)	1.19† (1.09-1.30)	1.15‡ (1.05-1.26)
Delivery complications	0.97‡ (0.95-0.99)	0.98 (0.95-1.01)	0.97§ (0.94-0.99)
Pregnancy complications	1.00 (1.00-1.00)	1.00 (0.99-1.00)	1.00 (1.00-1.00)
Drug use during pregnancy	0.77‡ (0.64-0.93)	0.84 (0.65-1.09)	0.83 (0.63-1.08)
Father's crime	1.84† (1.44-2.35)	2.03† (1.49-2.77)	2.16† (1.58-2.94)
Father's hospitalization	1.32§ (1.06-1.64)	1.51‡ (1.14-2.00)	1.47‡ (1.11-1.96)
Mother's hospitalization	1.64† (1.35-2.00)	1.91† (1.48-2.48)	2.44† (1.90-3.13)
Maternal rejection	0.92 (0.71-1.19)	0.90 (0.64-1.26)	0.81 (0.57-1.16)
Mother's age	0.98‡ (0.97-0.99)	0.97‡ (0.95-0.99)	0.98§ (0.96-0.99)
Socioeconomic status	1.58† (1.38-1.82)	1.82† (1.50-2.22)	1.98† (1.62-2.42)

\*Exp( $\beta$ ) indicates the factor by which the odds for criminal outcome change when the independent variable increases by 1 unit; CI, confidence interval.

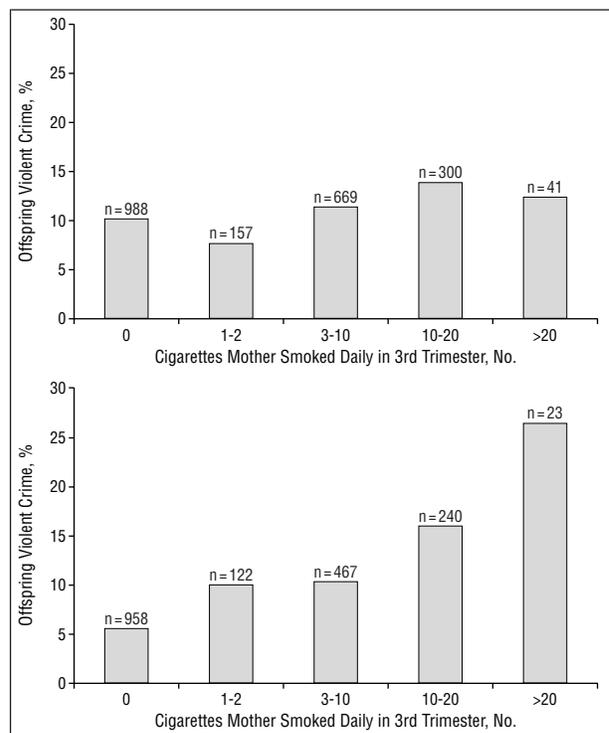
†P < .001.

‡P < .01.

§P < .05.

sistent offending. Odds ratios for the maternal smoking variable reflect a multiplicative increase in risk at each increasing level of amount smoked. Compared with males whose mothers did not smoke during the third trimester, males whose mothers smoked more than 20 cigarettes daily during the third trimester were  $1.13 \times 1.13 \times 1.13 \times 1.13$  or 1.6 times as likely to be arrested for a non-violent crime,  $1.19 \times 1.19 \times 1.19 \times 1.19$  or 2.0 times as likely to be arrested for a violent crime, and  $1.15 \times 1.15 \times 1.15 \times 1.15$  or 1.8 times as likely to be life-course persistent offenders.

Logistic regression analyses were then performed to test for possible interactions between maternal smoking and other potential risk factors in the outcomes of criminal offending. In the first block of these analyses, we entered the following variables: maternal smoking, parental psychiatric hospitalization, pregnancy and delivery complications, mother's use of drugs during pregnancy, father's criminal arrest, maternal rejection, mother's age, and SES. Next, we tested whether interaction terms produced by combining maternal smoking with the other risk factors produced a significant change in  $\chi^2$  in predicting the criminal outcome variable (nonviolent crime, violent crime, adolescent-limited crime, and persistent crime). All interaction terms in these analyses were not significant, with 1 exception. Delivery complications significantly interacted with maternal smoking in the prediction of violent crime ( $\chi^2_{1,N=3284}=4.62$ ;  $P<.05$ ). Results of post hoc logistic regression analyses controlling for potential confounds and splitting the sample into high and low delivery complications groups showed that the maternal smoking-child violence relationship was only significant in individuals with high levels of delivery complications ( $\chi^2_{1,N=1469}=19.73$ ,  $P<.001$ ) and not in those with low levels of delivery complications ( $\chi^2_{1,1815}=2.21$ ;  $P=.14$ ). **Figure 2** shows the percentage of violent offenders in each of these delivery complications and maternal smoking groups. More than 25% of the males with the highest levels of both delivery complications and maternal smoking were arrested for a violent criminal offense.



**Figure 2.** The relationship between low (top) and high (bottom) delivery complications, maternal prenatal smoking, and offspring criminal violence.

**COMMENT**

Our results support our hypothesis that maternal smoking during pregnancy is related to increased rates of crime in adult offspring. This general finding is consistent with the literature linking behavior problems, conduct disorder, and adolescent offending to prenatal maternal smoking.<sup>9-11</sup> Our study extended these findings by showing that maternal smoking is related to persistent offending rather than to adolescent-limited offending.

We did not find strong support for a potential interaction of maternal prenatal smoking and other risk fac-

tors in the prediction of adult criminal offending. Only 1 interaction was significant in our analyses. Delivery complications and maternal smoking interacted to predict criminal violence, which is consistent with results of previous works<sup>18,22</sup> noting the interactive effect of delivery complications on violent offending in particular. Delivery complications and maternal smoking were slightly negatively correlated in this sample ( $r = -0.04$ ;  $P < .05$ ), so this finding does not simply reflect more deleterious or serious effects of smoking. Instead, it indicates a particular vulnerability that results when these risk factors occur together.

Factors indicating potential social risks such as low SES and parental psychopathologic factors did not interact with maternal prenatal smoking to predict criminal outcomes. The Danish systems of national health care and low rates of severe poverty may reduce the potential effects of these social risk factors for this sample. It is also possible that biosocial interactions may be specific and that only particular social and biological risk factors interact in the prediction of criminal outcomes. Results of previous research<sup>18</sup> show that maternal rejection, but not low SES, interacted with delivery complications in the prediction of criminal violence.

Maternal smoking during the third trimester predicted nonviolent, violent, and persistent crime even when controlling for parental psychiatric hospitalization, pregnancy and delivery complications, mother's use of prescription drugs during pregnancy, father's criminal arrest, maternal rejection, mother's age, and SES. One important confound that we were not able to assess or control was the mother's psychological history outside of hospitalization, including her use of alcohol or illicit drugs during pregnancy. In studies<sup>9,11</sup> in which these variables were controlled for, the maternal smoking and child behavior problem relationship remained. In addition, we statistically controlled for serious depression, personality disorders, and drug and alcohol abuse that led to psychiatric hospitalization of the mothers. Nevertheless, our study leaves the potential moderating effect of maternal alcohol and other drug use during pregnancy and maternal psychopathologic factors largely unexplored.

Our data set did not include information on specific nicotine doses, smoking during first and second trimesters, paternal smoking, or parental smoking after the birth of the child. Therefore, we were unable to complete more fine-grained analyses on the specific effects of nicotine, specific trimester effects, or the relative impact of prenatal vs postnatal exposure to maternal smoking.

Our data were prospective in nature and did not rely on mothers' retrospective reports later in the life of the child. In addition, our criminal outcome data were available from a reliable and accurate source, and attrition was a minor concern in our study. Our results are in strong agreement with those of Rantakallio et al,<sup>10</sup> who examined 5966 members of a Finnish birth cohort. The fact that similar results were obtained from independent birth cohorts from 2 differing ethnic national populations suggests that these findings may be generalizable to other populations. We theorized that central nervous system damage may mediate the relationship between maternal smoking and offspring criminal outcomes. The next steps in this research may be to attempt to determine specific effects of smok-

ing on the fetal brain and to determine the agent in tobacco smoke that is responsible for these effects.

In this study, maternal smoking during pregnancy predicted persistent criminal offending and violent criminal offending rather than adolescent-limited delinquency. Persistent and violent criminal offending have serious deleterious effects on society. Our results therefore suggest an additional critical reason to support public health efforts aimed at improving maternal health behaviors during pregnancy.

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