Prenatal maternal smoking, maternal offending, and offspring behavioural and cognitive outcomes in early childhood

Running title: Prenatal smoking and maternal offending

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Abstract

**Background:** Maternal smoking during pregnancy and parental offending are both linked to adverse offspring outcomes. Few studies have examined how these exposures together influence diverse offspring outcomes in early childhood.

**Aims:** To examine associations between quantity of prenatal maternal smoking and frequency of maternal offending and offspring behavioural and cognitive outcomes at age 5 years.

**Methods:** Over 66,000 Australian children (mean age 5.6 years) were drawn from an intergenerational data linkage study. Unadjusted and adjusted logistic regressions were conducted for the two key exposures (maternal prenatal smoking and mother having at least two criminal convictions) and offspring behavioural and cognitive vulnerabilities. Population attributable fractions (PAFs) were also estimated for each outcome for the two exposures.

**Results:** Prenatal smoking and maternal offending were, separately and together, associated with most of the developmental vulnerabilities examined, even after adjusting for other familial and prenatal risk factors. PAFs for prenatal smoking ranged from 5.3% to 15.8% and PAFs for maternal offending ranged from 3.4% to 11.8% across the offspring outcomes.

**Conclusions:** Maternal smoking during pregnancy and maternal offending were uniquely associated with a range of offspring vulnerabilities, but mothers who smoked during pregnancy tended experience multiple problems that should also be considered as indicators of child vulnerabilities. While early behavioural difficulties were in these children, it was striking that they were also likely to have cognitive vulnerabilities. Early intervention to support cognitive development in these children may minimise their risk of academic underachievement and long-term disadvantage.
Considerable evidence suggests that maternal smoking while pregnant is associated with various adverse offspring outcomes across developmental periods, including antisocial behaviour and offending (Pratt, McGloin, & Fearn, 2006; Wakschlag, Pickett, Cook, Benowitz, & Leventhal, 2002), other externalising problems (Linnet et al., 2003), internalising problems (Ashford, Van Lier, Timmermans, Cuijpers, & Koot, 2008), and poor cognitive performance (Ramsay et al., 2016). While several studies have identified a dose-response relationship between prenatal smoking and adverse offspring outcomes (Moylan et al., 2015; Obel et al., 2009) that may be consistent with a causal relationship, other large population-based studies have failed to find a causal relationship, or observed that other family factors strongly influenced the relationship between prenatal smoking and offspring outcomes – such as severe mental illness (Quinn, Rickert, Weibull, & et al., 2017), externalising problems (Roza et al., 2009; Skoglund, Chen, Lichtenstein, & Larsson, 2014), internalising problems (Meier et al., 2017), and poor cognitive and physical development (Gilman, Gardener, & Buka, 2008). Prenatal smoking may therefore more parsimoniously signify risk associated with other factors that should be accounted for where possible (Maughan, Taylor, Caspi, & Moffitt, 2004; Monuteaux, Blacker, Biederman, Fitzmaurice, & Buka, 2006). Women who smoke during pregnancy are characterised by other risk factors known to impact on child development including: low education, young motherhood, other substance use problems, antisocial behaviour, and poor prenatal care (Mohsin & Bauman, 2005; Schneider, Huy, Schuetz, & Diehl, 2010; Willford, Day, & Cornelius, 2006).

There is also a strong body of evidence demonstrating intergenerational continuities in antisocial behaviour and offending (Bijleveld & Wijkman, 2009; Farrington, Coid, & Murray, 2009; Kendler, Ohlsson, Morris, Sundquist, & Sundquist, 2015). Although much research on parental offending has focused on later offspring outcomes (e.g., delinquency, adult offending), there is increasing evidence that intergenerational transmission begins in earlier
developmental periods. Parental antisocial behaviour, for instance, is linked to child externalising problems (Kim, Capaldi, Pears, Kerr, & Owen, 2009; Rhule, McMahon, & Spieker, 2004), and maternal antisocial behaviour is also a risk factor for early childhood physical aggression (Tremblay et al., 2004; Tzoumakis et al., 2017; Tzoumakis, Lussier, & Corrado, 2014). In addition, parental offending has also been shown to be associated with offspring cognitive and internalising problems in early childhood (Coley, Carrano, & Lewin-Bizan, 2011; Laurens et al., 2017), suggesting a more pervasive effect.

While criminological studies are increasingly investigating the role of prenatal factors, such as low birth weight and prenatal smoking, on the development of delinquency and offending (for a review, Tibbetts, 2014), few disentangle the unique effects of prenatal smoking and parental offending on child outcomes. These two risk factors are associated with many of the same poor outcomes, and therefore might be indicators of the same risk status of offspring in vulnerable families. Some studies have examined both risk factors simultaneously and their relationship with offspring aggression in infancy and early childhood (Hay et al., 2011; Huijbregts, Seguin, Zoccolillo, Boivin, & Tremblay, 2008; Tzoumakis, Lussier, & Corrado, 2012) and adolescent antisocial behaviour (D’Onofrio, Van Hulle, Goodnight, Rathouz, & Lahey, 2012; Shlafer, Poehlmann, & Donelan-McCall, 2012) but, due to sample size restrictions, it was either not possible to consider frequency of offending/smoking, and/or those displaying more frequent risk behaviours were few (resulting in small cell sizes for analysis). Accounting for frequency of these behaviours is important, with at least one previous study showing that heavy prenatal smoking (≥10 cigarettes/day) and serious maternal antisocial behaviour predict high level of early childhood physical aggression (Huijbregts et al., 2008).

Our aim was to examine two outcomes reflecting externalising behaviours (aggression, hyperactivity and inattention) and two cognitive outcomes (literacy and numeracy) with
maternal smoking or offending. In addition, we investigated an outcome reflecting self-control and rule-breaking (responsibility and respect), as prenatal smoking has been linked to low offspring self-control (Boutwell & Beaver, 2010), and an internalising outcome for the same reason (Ashford et al., 2008). Our hypothesis was that both prenatal smoking and maternal offending, and in particular more frequent smoking and offending, would be associated with offspring developmental vulnerabilities. We also hypothesised that the magnitudes of association would be attenuated by accounting for other prenatal and family risk factors.

**Method**

**Ethics**

Ethical approval was obtained from the NSW Population and Health Services Research Ethics Committee (HREC/11/CIPHS/14), with data custodian approvals granted by the relevant Government Departments.

**Sample and procedures**

Data were drawn from the New South Wales Child Development Study (NSW-CDS; [nsw-cds.com.au](http://nsw-cds.com.au)), a multi-agency, intergenerational data linkage study, which combines information from a teacher-reported cross-sectional survey of early childhood functioning with routinely collected administrative records for 87,026 children (Carr et al., 2016). The NSW-CDS cohort was defined by all children who entered their first year of full-time schooling (kindergarten) in 2009 in the state of New South Wales (NSW), Australia, for whom teachers completed the Australian Early Development Census (AEDC), representing 99.7% of eligible NSW children (Brinkman et al., 2014). An independent agency, the Centre for Health Record Linkage ([www.cherel.org.au](http://www.cherel.org.au)), used probabilistic linkage methods to link the AEDC to child and
parent records using matching variables (e.g., name, date of birth, residential address, sex); false positive linkages were low (rate ≤ 0.5%). Parental data were identified via linkage to the children’s birth records when registered in NSW.

The sample for this study is restricted to 66,523 children after excluding: children without linked parental data (birth not registered in NSW: n=14,781); children with special needs (required special assistance due to chronic medical, physical, or intellectually disabling conditions: n=3,129); and multiple births (n=2,593). The mean age of the children was 5.6 years (SD=0.4). Approximately half were male (50.6%; n=33,641).

**Measures**

*Offspring outcomes:* The AEDC is a population measure of children’s developmental readiness, for which adequate psychometric properties have been demonstrated to be consistent internationally (Brinkman et al., 2007; Janus et al., 2011). Six sub-domains within the broader ‘Social’ and ‘Emotional’, and ‘Language and Cognition’ domains of the AEDC were examined: aggression (7 items including: kicks, bites, hits; bullies or is mean); hyperactivity and inattention (6 items including: restless; distractible); responsibility and respect (8 items including: follows rules; self-control); anxiety and fearfulness (5 items including: worries; cries a lot); basic literacy (8 items including: identifies letters; writes own name); and, basic numeracy (7 items including: counts to 20; recognizes 1-10); a full list of the items can be found in Brinkman et al. (2014). The AEDC was completed by the child’s kindergarten teacher based on a minimum of 1 month’s contact with the child, although most had about 5 months’ contact. Children were considered ‘developmentally vulnerable’ on the sub-domains if they scored in the lowest 10% of the national AEDC population distribution; binary outcome variables (not vulnerable/vulnerable) were examined.
**Prenatal and perinatal indicators:** Data were obtained from the *NSW Ministry of Health Perinatal Data Collection* (2000-2006). Maternal smoking during pregnancy was reported by mothers during antenatal visits. Quantity of smoking data (none: 0 cigarettes/day; moderate: 1-10 cigarettes/day; heavy: ≥10 cigarettes/day) were only available for the second half of pregnancy; however, only 301 mothers who reported smoking at any time during pregnancy did not report smoking during the second half of pregnancy. Since heavy prenatal smoking is associated with poorer offspring outcomes, the indicator reflecting smoking quantity was used in the analyses; an indicator reflecting any smoking during pregnancy was also computed (yes/no); however, analyses repeated this indicator yielded unchanged results. Several prenatal and perinatal indicators were derived: maternal pregnancy complications (yes/no; any among: maternal diabetes, gestational diabetes, hypertension, and pre-eclampsia), child gestational age (<37 weeks/≥37 weeks), child birth weight (<2500g/≥2500g), and number of weeks pregnant at first antenatal visit.

**Parental offending:** Data were obtained from the *NSW Bureau of Crime Statistics* (1994-2009). This includes information on parents convicted of a criminal offence in NSW and their subsequent criminal court appearance data for charges before the Local, District, Supreme, or Children’s Criminal Courts. A categorical indicator reflecting maternal offending frequency was created (0/1/≥2 offences) and a binary indicator for paternal offending (0/≥ 1 offence).

**Maternal substance use:** Data from the *NSW Ministry of Health Mental Health Admitted Patients* (public and private hospitals) and *Mental Health Ambulatory* (public outpatient) records (2001-2009) were used to derive an indicator for mothers who had any contact with mental health services for substance misuse (yes/no), including ICD-10 codes (ICD=International Classification of Disease) representing substance use disorders or mental disorders due to substance intoxication (F10 to F19) (World Health Organization, 1992).
**Socio-demographic indicators:** Child sex and Socio-Economic Index for Areas (SEIFA) were obtained from the AEDC. SEIFA quintiles are based on the average income and employment status for each residential postcode in Australia (Australian Government, 2011). Considering the important associations between low socioeconomic status with maternal prenatal smoking and maternal antisocial behaviour (Huijbregts et al., 2008; Willford et al., 2006), a binary indicator of socioeconomic disadvantage was created by classifying the SEIFA quintile 1 as ‘socioeconomic disadvantage’ and quintiles 2 to 5 as ‘less disadvantaged’. Maternal age at child’s birth (<26 years/≥26 years) was derived from the NSW Birth Registrations and NSW Ministry of Health Perinatal Data Collection.

**Analyses**

Descriptive statistics were completed, stratified by maternal smoking frequency (none/moderate/heavy). Differences in the relative proportions (Z-tests) of maternal offending exposures and other covariates among the maternal prenatal exposure categories were also determined. Logistic regressions for each of the six offspring outcomes were conducted: first, separate unadjusted models for prenatal smoking quantity and maternal offending frequency were tested; secondly, a fully adjusted model including both key exposures in addition to socioeconomic status, maternal age at child’s birth, pregnancy complications, child’s birth weight, maternal substance use problems, and paternal offending was tested. This adjusted model included both prenatal smoking and offending exposures to determine their relative effects in the same model; to establish whether the strengths of their association were significantly different, post hoc tests of beta equivalence were completed for these two exposures in the adjusted models. Analyses were also completed separately for boys and girls. Results were considered statistically significant if the 95% confidence interval (CI) did not cross
1. Missing data were minimal (≤1%) across the variables and offspring were excluded from the specific analyses when data were missing.

Public health and epidemiological methods are used in forensic mental health research (Fazel, Grann, & Långström, 2009) but have rarely informed criminological research (Akers & Lanier, 2009; Vaughn, DeLisi, Beaver, Perron, & Abdon, 2012), despite the focus of epidemiology (i.e., prevalence, incidence, aetiology, prevention) being congruent with criminology. Population attributable fractions (PAFs) are commonly used in epidemiological studies to estimate the proportion of an outcome that can be attributable to an exposure (Braun, Kahn, Froehlich, Auinger, & Lanphear, 2006; Williams et al., 1998). PAFs estimate the proportion of “disease” or the “burden” in a population that is attributable to the exposure of interest (such as maternal prenatal smoking), or the incidence in the population that might be prevented by effective elimination of that exposure, assuming the relationship is not confounded (Gordis, 2013). PAFs can therefore help to guide policymaking and planning. We calculated PAFs, with confidence intervals, for prenatal maternal smoking and offending and the six offspring outcomes.

All analyses were conducted in SPSS 24 (IBM, 2016) and STATA 13 (StataCorp, 2013).

Results

Descriptive statistics stratified by quantity of prenatal smoking (Table 1) showed that offspring exposed to smoking before birth were also more likely to have had an offending mother; 23.6% of children exposed to heavy prenatal smoking had mothers involved in ≥2 offences, compared to 17.1% for moderate smoking, and 2.5% for non-smoking. Statistically significant differences in proportions of maternal offending among the prenatal smoking
quantity categories were identified across all comparisons except for maternal history of one
difference where offending prevalence was ~9% for both the moderate and heavy smoking
categories (see Supplementary Table S1). As the quantity of maternal parental smoking
increased, so did young maternal age at child’s birth, socioeconomic disadvantage, maternal
substance use problems, and paternal offending together with risk of prematurity and low
birth weight. Mothers who reported heavy smoking during pregnancy also attended their first
prenatal visit approximately two weeks later than non-smoking mothers at approximately 15
weeks (Welch statistic=193.8, p<0.001). The index of pregnancy complications was less
prevalent for mothers who smoked prenatally, which may be due to non-smoking mothers
being older and therefore at higher risk of complications regardless of smoking status (Joseph
et al., 2005). Among mothers who said they did not smoke during pregnancy, average age at
the child’s birth was 30.7 years (SD=5.3), but 27.9 years (SD=6.2) for mothers did smoke.

[Insert Table 1 about here]

Logistic regression models

Associations between prenatal smoking, maternal offending, and offspring outcomes
are presented in Table 2. Unadjusted ORs for heavy smoking were higher than those for
moderate smoking across the six offspring outcomes. A similar dose-response pattern of
association was observed for unadjusted associations between maternal offending and
offspring outcomes. The largest unadjusted associations were observed between maternal
history of ≥2 offences and offspring vulnerability for literacy (OR=3.53; 95%CI=3.19-3.90) or
numeracy (OR=3.35; 95%CI=3.07-3.66). The magnitude of the associations for prenatal
smoking and maternal offending decreased across offspring outcomes after adjusting for
covariates. Maternal involvement in one offence was no longer statistically significant for the
two externalising outcomes and for ‘responsibility and respect’. The highest adjusted OR was
observed for heavy smoking and numeracy (OR=1.91; 95%CI=1.73-2.10). Post hoc tests of beta equivalence revealed significant differences in the strength of the associations for prenatal smoking and maternal offending in approximately half of the comparisons (see Supplementary Table S2). The strength of the associations for moderate and heavy prenatal smoking tended to be significantly greater compared to maternal offending when only one offence was considered, and this was consistent across all the offspring outcomes. However, comparing prenatal smoking with maternal offending when ≥2 offences were considered revealed only three significant differences (for moderate levels of prenatal smoking on childhood numeracy, and heavy prenatal smoking on childhood hyperactivity/inattention and anxiety/fearfulness).

Separate analyses by the child’s sex confirmed that patterns of association for prenatal smoking were similar for boys and girls (see Supplementary Tables S3 and S4). Maternal history of one offence was not significantly associated with any of the outcomes for the boys, but both categories of maternal offending (1/≥2 offences) were significantly associated with anxiety and fearfulness for girls.

**Population Attributable Fractions (PAFs)**

PAFs for any prenatal smoking and any maternal offending for the six child outcomes are presented in Table 3. These suggested that prenatal smoking accounted for 5.3-15.8% of child vulnerability while maternal offending did so for 3.4%-11.8%. Overall, basic literacy and numeracy outcomes had the largest PAFs, and anxiety and fearfulness the lowest.
Discussion

We found that maternal prenatal smoking and official maternal offending are both associated with offspring behavioural and cognitive vulnerability in early childhood, even after accounting for other important pre-/peri-natal and family risk factors. The influence of both prenatal smoking and maternal offending were attenuated by these other risk factors, underlining the need to account for the effects of related factors on child developmental outcomes, rather than focusing on single exposures that may be misinterpreted. In line with other studies that found a dose-response relationship (Brennan, Grekin, & Mednick, 1999; Moylan et al., 2015), we found that frequency did matter for both exposures; the odds of childhood vulnerability in the context of heavy smoking and more frequent offending tended to be highest, and the relationship between maternal history of one offence was only associated with three of the six outcomes when accounting for other risk factors. Comparisons of the effects of prenatal smoking relative to those for more frequent maternal offending (1/≥2 offences) revealed few differences, suggesting that the effects on child developmental vulnerabilities are similar.

Estimated population attributable fractions indicated that prenatal smoking could account for approximately 15-16% of offspring cognitive vulnerability, 9% of externalising, and 5% of internalising problems, and that maternal offending could account for 10-12% of offspring cognitive vulnerability, 6-7% of externalising, and 3% of internalising problems. These are likely, however, to be overestimates, as the analyses demonstrated that the association between prenatal smoking and offending with the offspring outcomes are confounded by each other, and by other risk factors. Other studies estimating of population attributable fractions for prenatal smoking and early childhood externalising problems have reported higher
proportions of 18-25% (Stene-Larsen, Borge, & Vollrath, 2009; Williams et al., 1998), in part explained by their higher incidences of maternal smoking and externalising problems.

Strong co-occurrence of health and offending risk factors were found among the mothers in this population cohort. Mothers who smoked heavily during pregnancy tended to have premature and low birth weight infants, socio-economic disadvantage, substance use problems, offending partners and have been convicted of two or more offences themselves. They were also likely to have attended their first antenatal visit at the beginning of their second trimester, approximately two weeks later than non-smoking mothers, and to be younger at the child’s birth. This prevalence of officially recorded offending for heavy smokers is comparable to that in a Swedish study using population register data, where 24% of mothers who smoked ≥10 cigarettes per day had a history criminal convictions (Ellingson, Rickert, Lichtenstein, Långström, & D’Onofrio, 2012).

Two other studies have reported that both maternal prenatal smoking and self-reported maternal antisocial behaviour are linked to trajectories of offspring physical aggression from 17 to 42 months old (Huijbregts et al., 2008; Tremblay et al., 2004). Another study, however, found that both prenatal smoking and maternal conduct problems were linked to parent-rated infants’ aggressiveness at age 12 months, but not to observed aggressiveness (Hay et al., 2011). This suggests that parental accounts of their offspring may be coloured by their own behaviours, and the importance of using multiple sources of measurement. Our findings extend the previous literature by showing associations with behavioural as well as cognitive outcomes at age 5 years.

In this study, we used linked data for a large population-based sample which minimises sampling, attrition, and recall biases. The sample was restricted to children with NSW birth registrations but can be considered representative of the Australian population (Carr et al.,
2016). The administrative data were not originally collected for research purposes, which may lead to classification errors, although any such errors would be minimised by the sample size. The indicators of offending and substance use likely reflected parents with more serious offending and substance use problems due to the data sources (court appearances; absence of primary care health records); within these record sets, older parents were likely to have been underrepresented due to left truncation of the data for offending (from 1994) and substance use problems (from 2001). Prenatal smoking was self-reported by mothers at antenatal visits, so may be somewhat underreported (Gorber, Schofield-Hurwitz, Hardt, Levasseur, & Tremblay, 2009). An individual-level indicator of socioeconomic status would have been preferable to our geographic measure. We did not include gestational age as a covariate because of the high correlation with birth weight (66% of low birth weight infants were also premature); low birth weight was retained in analyses since it is associated with prenatal smoking (Thapar et al., 2009). The sample size enabled examination of relatively uncommon exposures but may be subject to other confounding factors. Important factors such as the degree of parental contact with the child, parenting practices, or genetic factors were not considered, despite their potential importance for developmental (especially cognitive) outcomes (D’Onofrio et al., 2010).

Poor health and social risk factors of mothers in this sample were common, so rather than focus specifically on smoking during pregnancy, public health programmes might encourage early and regular antenatal care among vulnerable women, particularly those involved in offending, perhaps just using smoking as a marker of more general difficulties. Considering that parental offending influences offspring cognitive abilities (Latvala, Kuja-Halkola, Langstrom, & Lichtenstein, 2015; Laurens et al., 2017), and cognitive ability is also a robust predictor of early onset and persistent offending (McGloin & Pratt, 2003), interventions may most helpfully focus on improving cognitive skills in these children. This could minimise
academic underachievement which, combined with externalising behaviour problems, is likely to promote educational disengagement and the perpetuation of disadvantage.
References


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StataCorp. (2013). *Stata Statistical Software: Release 13*. College Station, TX: StataCorp LP.


Table 1: Descriptive statistics stratified by maternal prenatal smoking

<table>
<thead>
<tr>
<th></th>
<th>Total sample (n=66,523)</th>
<th>Maternal prenatal smoking</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>None (86.7%; n=57,490)</td>
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<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>Weeks pregnant at first antenatal visit</td>
<td>12.7 (5.9)</td>
<td>12.5 (5.7)</td>
</tr>
<tr>
<td></td>
<td>% (n)</td>
<td>% (n)</td>
</tr>
<tr>
<td>Maternal offending history</td>
<td></td>
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</tr>
<tr>
<td>None</td>
<td>91.5 (60,871)</td>
<td>94.8 (54,486)</td>
</tr>
<tr>
<td>1 offence</td>
<td>3.6 (2,409)</td>
<td>2.8 (1,587)</td>
</tr>
<tr>
<td>≥ 2 offences</td>
<td>4.9 (3,243)</td>
<td>2.5 (1,417)</td>
</tr>
<tr>
<td>Maternal pregnancy complications</td>
<td>10.7 (7,097)</td>
<td>11.2 (6,416)</td>
</tr>
<tr>
<td>Prematurity (&lt;37 weeks)</td>
<td>4.9 (3,269)</td>
<td>4.4 (2,552)</td>
</tr>
<tr>
<td>Low birth weight (&lt;2500g)</td>
<td>4.0 (2,648)</td>
<td>3.3 (1,872)</td>
</tr>
<tr>
<td>Mother &lt;26 years at child's birth</td>
<td>22.3 (14,848)</td>
<td>19.3 (11,105)</td>
</tr>
<tr>
<td>Male child</td>
<td>50.6 (33,641)</td>
<td>50.7 (29,133)</td>
</tr>
<tr>
<td>Socioeconomic disadvantage</td>
<td>23.5 (15,659)</td>
<td>21.5 (12,367)</td>
</tr>
<tr>
<td>Maternal substance use problems</td>
<td>3.0 (1,971)</td>
<td>1.1 (654)</td>
</tr>
<tr>
<td>Paternal offending</td>
<td>25.9 (17,259)</td>
<td>21.7 (12,459)</td>
</tr>
<tr>
<td>Offspring vulnerability (lowest 10% of national population)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggression</td>
<td>8.4 (5,528)</td>
<td>7.6 (4,321)</td>
</tr>
<tr>
<td>Hyperactivity and inattention</td>
<td>10.5 (6,963)</td>
<td>9.5 (5,437)</td>
</tr>
<tr>
<td>Responsibility and respect</td>
<td>8.5 (5,634)</td>
<td>7.7 (4,401)</td>
</tr>
<tr>
<td>Anxiety and fearfulness</td>
<td>10.7 (7,039)</td>
<td>10.1 (5,760)</td>
</tr>
<tr>
<td>Basic literacy</td>
<td>5.9 (3,904)</td>
<td>4.9 (2,827)</td>
</tr>
<tr>
<td>Basic numeracy</td>
<td>8.5 (5,635)</td>
<td>7.2 (4,148)</td>
</tr>
</tbody>
</table>
Table 2: Associations between maternal prenatal smoking, maternal offending, and offspring early childhood developmental vulnerability

<table>
<thead>
<tr>
<th></th>
<th>Aggression</th>
<th>Hyperactivity and inattention</th>
<th>Responsibility and respect</th>
<th>Anxiety and fearfulness</th>
<th>Basic literacy</th>
<th>Basic numeracy</th>
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<tbody>
<tr>
<td><strong>UNADJUSTED Model for maternal prenatal smoking</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Moderate</td>
<td>1.74 (1.59-1.91)</td>
<td>1.75 (1.61-1.91)</td>
<td>1.75 (1.60-1.92)</td>
<td>1.38 (1.27-1.51)</td>
<td>2.38 (2.16-2.63)</td>
<td>2.13 (1.95-2.33)</td>
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<tr>
<td>Heavy</td>
<td>2.11 (1.93-2.32)</td>
<td>2.23 (2.05-2.42)</td>
<td>2.13 (1.94-2.34)</td>
<td>1.63 (1.49-1.79)</td>
<td>2.92 (2.64-3.23)</td>
<td>3.10 (2.84-3.37)</td>
</tr>
<tr>
<td><strong>UNADJUSTED Model for maternal offending</strong></td>
<td></td>
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<tr>
<td>1 offence</td>
<td>1.41 (1.23-1.61)</td>
<td>1.46 (1.30-1.65)</td>
<td>1.48 (1.30-1.69)</td>
<td>1.42 (1.26-1.60)</td>
<td>1.97 (1.72-2.27)</td>
<td>1.82 (1.61-2.06)</td>
</tr>
<tr>
<td>≥ 2 offences</td>
<td>2.42 (2.20-2.66)</td>
<td>2.32 (2.12-2.54)</td>
<td>2.47 (2.24-2.71)</td>
<td>1.55 (1.40-1.71)</td>
<td>3.53 (3.19-3.90)</td>
<td>3.35 (3.07-3.66)</td>
</tr>
<tr>
<td><strong>ADJUSTED Model</strong></td>
<td></td>
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<tr>
<td>Maternal prenatal smoking</td>
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<td></td>
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<tr>
<td>Moderate</td>
<td>1.29 (1.17-1.42)</td>
<td>1.33 (1.22-1.46)</td>
<td>1.30 (1.18-1.43)</td>
<td>1.21 (1.10-1.33)</td>
<td>1.59 (1.43-1.77)</td>
<td>1.41 (1.28-1.54)</td>
</tr>
<tr>
<td>Heavy</td>
<td>1.50 (1.35-1.66)</td>
<td>1.64 (1.49-1.80)</td>
<td>1.50 (1.35-1.66)</td>
<td>1.38 (1.25-1.52)</td>
<td>1.78 (1.60-1.99)</td>
<td>1.91 (1.73-2.10)</td>
</tr>
<tr>
<td>Maternal offending</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 offence</td>
<td>1.03 (0.89-1.18)</td>
<td>1.08 (0.95-1.23)</td>
<td>1.10 (0.96-1.26)</td>
<td>1.21 (1.07-1.37)</td>
<td>1.30 (1.12-1.51)</td>
<td>1.19 (1.05-1.36)</td>
</tr>
<tr>
<td>≥ 2 offences</td>
<td>1.42 (1.27-1.60)</td>
<td>1.36 (1.22-1.51)</td>
<td>1.50 (1.34-1.68)</td>
<td>1.14 (1.02-1.28)</td>
<td>1.85 (1.64-2.08)</td>
<td>1.70 (1.53-1.89)</td>
</tr>
<tr>
<td>Male child</td>
<td>3.11 (2.92-3.31)</td>
<td>3.49 (3.30-3.70)</td>
<td>2.53 (2.38-2.68)</td>
<td>1.28 (1.21-1.34)</td>
<td>1.76 (1.64-1.88)</td>
<td>1.40 (1.32-1.48)</td>
</tr>
<tr>
<td>Socioeconomic disadvantage</td>
<td>1.12 (1.05-1.19)</td>
<td>1.11 (1.04-1.17)</td>
<td>1.31 (1.23-1.39)</td>
<td>1.09 (1.03-1.16)</td>
<td>1.71 (1.60-1.84)</td>
<td>1.65 (1.56-1.75)</td>
</tr>
<tr>
<td>Mother &lt;26 years at child's birth</td>
<td>1.44 (1.35-1.53)</td>
<td>1.42 (1.34-1.51)</td>
<td>1.34 (1.25-1.43)</td>
<td>1.11 (1.04-1.18)</td>
<td>1.46 (1.36-1.58)</td>
<td>1.62 (1.52-1.73)</td>
</tr>
<tr>
<td>Pregnancy complications</td>
<td>1.04 (0.95-1.14)</td>
<td>1.11 (1.03-1.21)</td>
<td>1.09 (1.00-1.20)</td>
<td>1.13 (1.05-1.23)</td>
<td>1.19 (1.07-1.32)</td>
<td>1.22 (1.12-1.33)</td>
</tr>
<tr>
<td>Low birth weight</td>
<td>1.11 (0.97-1.27)</td>
<td>1.40 (1.24-1.57)</td>
<td>1.30 (1.14-1.47)</td>
<td>1.22 (1.09-1.37)</td>
<td>1.57 (1.38-1.80)</td>
<td>1.51 (1.34-1.70)</td>
</tr>
<tr>
<td>Maternal substance use problems</td>
<td>1.52 (1.32-1.74)</td>
<td>1.48 (1.30-1.68)</td>
<td>1.35 (1.18-1.56)</td>
<td>1.27 (1.11-1.46)</td>
<td>1.20 (1.04-1.40)</td>
<td>1.19 (1.04-1.35)</td>
</tr>
<tr>
<td>Paternal offending</td>
<td>1.40 (1.31-1.49)</td>
<td>1.35 (1.28-1.43)</td>
<td>1.32 (1.24-1.41)</td>
<td>1.13 (1.06-1.20)</td>
<td>1.34 (1.24-1.44)</td>
<td>1.42 (1.33-1.51)</td>
</tr>
</tbody>
</table>

Note: n = 65,794 to 66,061; Odd ratios and 95% confidence intervals. All confidence intervals that do not cross 1 are significant at p < .05.
Reference category for smoking during pregnancy is none. Reference category for maternal offending is no offending.
<table>
<thead>
<tr>
<th>Exposures</th>
<th>Aggression</th>
<th>Hyperactivity and inattention</th>
<th>Responsibility and respect</th>
<th>Anxiety and fearfulness</th>
<th>Basic literacy</th>
<th>Basic numeracy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PAF (95% CI)</td>
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</tr>
<tr>
<td>Any maternal prenatal smoking (n=9,318)</td>
<td>9.3 (8.2-10.6)</td>
<td>9.5 (8.5-10.6)</td>
<td>9.5 (8.3-10.6)</td>
<td>5.3 (4.3- 6.3)</td>
<td>15.8 (14.3- 17.4)</td>
<td>14.6 (13.4-15.8)</td>
</tr>
<tr>
<td>Any maternal offending (n=5,652)</td>
<td>6.6 (5.6-7.5)</td>
<td>6.1 (5.3-6.9)</td>
<td>6.8 (5.9-7.8)</td>
<td>3.4 (2.7-4.2)</td>
<td>11.8 (10.6-13.1)</td>
<td>10.1 (9.3-11.3)</td>
</tr>
</tbody>
</table>

Note: n = 65,819 to 66,333; PAF=population attributable fraction; CI=confidence interval