Light drinking in pregnancy, a risk for behavioural problems and cognitive deficits at 3 years of age?

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Summary

Background: The objective of this study was to determine whether there was an association between mothers' light drinking during pregnancy and risk of behavioural problems, and cognitive deficits in their children at age 3 years.

Methods: Data from the first two sweeps of the nationally representative prospective UK Millennium Cohort study were used. Drinking patterns during pregnancy and behavioural and cognitive outcomes were assessed during interviews and home visits. Behavioural problems were indicated by scores falling above defined clinically relevant cut-offs on the parent–report version of the Strengths and Difficulties Questionnaire (SDQ). Cognitive ability was assessed using the naming vocabulary sub-scale from the British Ability Scale (BAS) and the Bracken School Readiness Assessment (BSRA).

Results There was a J-shaped relationship between mothers drinking during pregnancy and the likelihood of high scores (above the cut-off) on the total difficulties scale of the SDQ and the conduct problems, hyperactivity and emotional symptom SDQ subscales. Children born to light drinkers were less likely to score above the cut-offs compared to children of abstinent mothers. Children born to heavy drinkers were more likely to score above the cut-offs compared to children of abstinent mothers. Boys born to mothers who had up to 1-2 drinks per week or per occasion were less likely to have conduct problems (OR 0.59, 95%CI 0.45 to 0.77) and hyperactivity (OR 0.71, 95%CI 0.54 to 0.94). These effects remained in fully adjusted models. Girls were less likely to have emotional symptoms (OR 0.72, 95%CI 0.51 to 1.01) and peer problems (OR 0.68, 95%CI 0.52 to 0.92) compared with those born to abstainers. These effects were attenuated in fully adjusted models.

Boys born to light drinkers had higher cognitive ability test scores (standard deviates, (95%CI)) BAS 0.15 (0.08 to 0.23) BSRA 0.24 (0.16 to 0.32) compared to boys born to abstainers. The difference for BAS was attenuated on adjustment for socioeconomic factors, whilst the difference for BSRA remained statistically significant.

Conclusions Children born to mothers who drank up to 1-2 drinks per week or per occasion during pregnancy were not at increased risk of clinically relevant behavioural difficulties or cognitive deficits compared with children of abstinent mothers. Heavy drinking during pregnancy appears to be associated with behavioural problems and cognitive deficits in offspring at age 3 years whereas light drinking does not.

Key Words: alcohol, pregnancy, behaviour, cognition, children, Millennium Cohort Study

Introduction

The link between heavy drinking during pregnancy and the risk of fetal alcohol syndrome is well established.[1] However, it is unclear whether low levels of drinking during pregnancy may convey harm for child health and development.[2,3] The UK currently does not recommend complete abstinence from alcohol for the duration of pregnancy and there are inconsistencies in policy statements from the National Alcohol Strategy[4] and the National Institute for Health and Clinical Evidence,[5] which are liable to lead to confusion for health professionals and the public. A recent systematic review carried out by the National Perinatal Epidemiology Unit (NPEU),[2] and a statement from the Royal College of Obstetricians and Gynaecologists (RCOG)[3] highlighted the need for studies focusing on the effects of light drinking, and for investigators to use prospective population based data. In light of this debate, questions arise as to whether the current push for policy to recommend complete abstinence during pregnancy[6,7] is merited.

Clinically relevant aspects of child behaviour and development that have previously been linked to mothers' drinking during pregnancy include externalising behaviours such as conduct problems and hyperactivity,[8-14] and cognitive deficits,[15-24] and imaging studies have reported associated structural changes in the brain.[25] Behavioural problems and cognitive development in childhood have been shown to predict health and well-being into adolescence and adulthood.[26-28]

Previous studies on the links between mothers drinking during pregnancy and behavioural and cognitive outcomes have been conducted on small and/or non-representative study samples and/or have only taken account of a limited number of covariates. This paper adds to existing research by examining prospectively the links

between mothers' drinking during pregnancy, behavioural problems and cognitive ability in a large nationally representative sample of 3 year old children, whilst taking account of mother and infant, socioeconomic and family psychosocial factors.

Methods

The Millennium Cohort Study (MCS)

The MCS is a nationally representative longitudinal study of infants born in the UK. The sample was drawn from births in England and Wales between September 2000 and August 2001, and in Scotland and Northern Ireland between November 2000 and January 2002. The survey design, recruitment process and fieldwork have been described in detail elsewhere.[29] Briefly, 18 553 households agreed to participate in the first sweep of the survey, an interview response rate of 85%. Households were identified through the Department of Work and Pensions Child Benefit system and were selected on the basis of where the family was resident shortly after the time of birth. All parents of children up to the age of 16 are eligible to receive Child Benefit and coverage is estimated at 98%. The sample has a probability design and is clustered at the electoral ward level such that disadvantaged residential areas are over represented.

The first sweep of the survey involved home visits by interviewers when cohort members were aged 9 months. Questions were asked about mothers' drinking during pregnancy, other health related behaviours, socio-economic circumstances and household composition. The second sweep of interviews took place when cohort members were aged approximately 3 years. During this home visit cognitive assessments were carried out by trained interviewers and questions were asked about the cohort members' behaviour, socio-economic factors and the psychosocial environment of the family.

Ethical approval for the MCS was gained from the relevant Ethics Committees and parents gave informed consent before interviews took place, and separate written consent for cognitive assessments.

Mothers' drinking

Mothers were asked about whether they drank alcohol during pregnancy (Every day, 5-6, 3-4, 1-2 days per week, 1-2 times per month, less than once per month, never). If the mother drank at least once or twice per week she was asked: in an average week, how many units of alcohol did you drink? If she drank once or twice per month or less than once per month she was asked: on the days when you did drink alcohol, on average how many units did you drink in a day? Mothers were told: "By a unit I mean, ½ pint of beer, a glass of wine, or a single measure of spirit or liqueur."

There are no widely agreed criteria on the levels of alcohol that constitute light or moderate drinking. We defined light and heavy/binge drinking on the criteria outlined by the National Alcohol Strategy.[4] Moderate drinking was defined as alcohol consumption at levels greater than light drinking, and less than heavy/binge drinking. Drinking categories were thus defined as follows:

- Never
- Light, not more than 1-2 units per week or per occasion
- Moderate, not more than 3-6 units per week or 3-5 units per occasion
- Heavy/binge, 7 or more units per week or 6 or more units per occasion

Behavioural and emotional problems

When cohort members were around the age of 3 years at the sweep 2 interview, parents were asked to complete the Strengths and Difficulties Questionnaire (SDQ) age 3-4 years version (www.sdqinfo.com) which asks questions about five domains of

behaviour, namely: conduct problems, hyperactivity, emotional symptoms, peer problems and pro-social behaviour. The SDQ is a validated tool which has been shown to compare favourably with other measures for identifying hyperactivity and attention problems.[30, 31] This paper focuses on aspects of behaviour previously linked to mothers' drinking during pregnancy.[8-13] Scores from the conduct problems, hyperactivity, emotional symptoms and peer problems sub-scales were summed to construct a total difficulties score.

Attributes for each of the behavioural domains are shown in appendix 1. The parent marked each of these attributes as "Not true", "Somewhat true" or "Certainly true", responses were coded as 0, 1 and 2 respectively (those in italics in appendix 1 were reverse scored). In each sub-scale scores for each of the 5 items were summed, giving a range of 0 to 10, and the total difficulties score had a range of 0 to 40. Clinically relevant cut-points for problem behaviours were determined as the top 10% of all MCS children with SDQ data at age 3. The cut-points used are as follows: hyperactivity >=8, conduct problems >=6, emotional symptoms >=4, peer problems >=4 and total difficulties >=17 and these corresponded to the upper 8.3, 9.9, 7.9, 11.5 and 9.5% of the distribution respectively. In this sample of 3 year old children the SDQ scales had comparable reliability (Crombach α coefficient=0.64) with those reported in studies of the older age group.[27]

Cognitive ability assessments

Cognitive ability at sweep 2 was assessed using widely validated, age appropriate tests, the naming vocabulary sub scale from the British Ability Scale (BAS)[32] and the Bracken School Readiness Assessment (BSRA).[33] The BAS Naming Vocabulary sub-

scale assesses expressive language and knowledge of names in English. The BSRA was made up of 6 sub-tests that assess the child's ability to identify colours, letters, numbers, shapes, and to describe and compare objects e.g. by size. Mean age and sex standardised percentile values for BAS and BSRA are reported. Z-scores were calculated and used in the analysis to aid model comparability.

Explanatory factors

Mother and infant, socioeconomic, and family psychosocial factors that were hypothesised to confound or mediate the relationship between mothers drinking and child behavioural and cognitive development were considered in explanatory models. Mother and infant factors were mother's age, number of children in the household, whether the pregnancy was planned, whether the mother smoked during pregnancy, the child's gender, birthweight and current age. Socioeconomic factors were mother's occupation, highest educational qualification, and household income. Family psychosocial markers hypothesised to mediate the relationship were mother's current mental health (K6 Questionnaire[34]), child-parent relationship (Pianta scale[35]), parental discipline and whether or not the mother currently drank alcohol.

Data analysis

Behavioural and cognitive outcomes and drinking in pregnancy are known to be moderated by ethnicity and multiple births[36, 37] therefore the sample for this paper includes all white singleton infants whose mothers participated in the first two sweeps of the MCS (n=12 495). Behavioural outcome data were available for 11 983, BAS data for

11 958, and BSRA data for 11 440 cohort members. Missing data for explanatory factors of interest for behavioural outcomes reduced the sample to 9460 (75.7%), for BAS to 9154 (73.3 percent) and for BSRA to 8775 (70.2 percent). Multivariate analyses are based on the cases with complete data on relevant variables using Stata version 9.2 [Stata Corporation, 2005]. The SVY command was used throughout to take account of the clustered sample design and the unequal probability of being sampled.

Logistic regression models were used to investigate the relative importance of mother and infant, socio-economic and family psychosocial factors on the likelihood of behavioural difficulties in children according to mothers drinking category. Linear regression models investigate relationships between mother and infant, socio-economic and family psychosocial factors to cognitive ability scores. There were gender differences in behavioural problems and cognitive ability scores and so models are presented for boys and girls separately. For the cognitive ability scores, the interaction between gender and alcohol was statistically significant ($p<0.05$). We hypothesised that some factors would confound the association between mother's drinking and child outcomes, whereas some factors would mediate this effect, so adjustment was done separately for different types of factors. All models adjust for birthweight. Behavioural outcome models additionally adjust for age at sweep 2, cognitive outcome models do not as individual scores are age standardised. Model B additionally adjusts for mother and infant factors; model C for socio-economic markers; model D for family psychosocial environment; and model E simultaneously adjusts for all factors.

A sensitivity analysis was performed to assess whether the relationship between mothers drinking and child behaviour and cognition was contingent on the way in which

data on the frequency and quantity of alcohol consumption were collected, ie whether mother's unit consumption was ascertained on weekly or occasional bases. The relationship between alcohol consumption and behavioural and cognitive outcomes did not depend on whether the data were analysed on weekly or less than weekly estimates, and so categories were conflated to create a single alcohol consumption variable.

Results

The mean age of cohort members in the sample was 3.13 years (95% CI 3.127 to 3.135). Mothers who participated in MCS sweep 1 but not in sweep 2 were more likely to be younger, have lower household incomes and be less well educated compared with mothers who took part in both sweeps (data available on request).

Patterns of mothers' drinking

Almost two thirds (63%) of mothers reported abstinence during pregnancy, and 29% were classified as light, 6% as moderate and 2% as heavy/binge drinkers. Mothers who took part in sweep 1 of the MCS but not in sweep 2 were more likely to be abstinent (70%) and less likely to be light drinkers (21%). Mothers who reported having planned their pregnancy were slightly less likely to be moderate (5.2%) or heavy/binge drinkers (1.8%) compared with mothers who had unplanned pregnancies (6.7% and 2.7% respectively).

Drinking was socially patterned, with light drinkers more likely to be better educated, from higher income households and less likely to have smoked during pregnancy compared with abstainers. Moderate drinkers tended to be older, have larger families, to have smoked during pregnancy and be the heaviest current drinkers compared with light drinkers and abstainers. Heavy/binge drinkers were more likely to be younger, from low income households and to have smoked during pregnancy compared with abstainers (table 1).

Table 1 here

Patterns of behavioural problems and cognitive ability

Boys were more likely compared with girls to have clinically relevant high total difficulties (8.7 *vs* 5.6%), hyperactivity (9.2 *vs* 4.8%), conduct (9.1 *vs* 7.4%) and peer (10.3 *vs* 8.5%) scores. Boys had lower mean scores on the BAS Naming Vocabulary sub-scale (49.7) and BSRA (58.1) compared with girls (58.5 and 65.8 respectively).

Behavioural problems were socially patterned with children of mothers in semi-routine or routine occupations more likely to have a high total difficulties score compared with children of mothers in professional and managerial occupations (12.5 *vs* 3.8% respectively). Children living in the lowest income households were more likely to have a high total difficulties score compared with children from the highest income households (16.3 *vs* 2.2% respectively).

Children whose mothers were in semi routine and routine occupations had lower mean cognitive ability scores compared to those born to mothers in managerial and professional occupations (BAS 47.3 *vs* 61.4 and BSRA 52.8 *vs* 72.7 respectively). Children from the lowest income households had lower mean cognitive ability scores compared to children from the highest income households (BAS 43.0 *vs* 61.8 and BSRA 49.1 *vs* 76.5 respectively).

Mothers' drinking, behavioural problems and cognitive ability in children

There was a J-shaped relationship between mothers reported drinking and high SDQ total difficulties score. Children born to mothers classified as light drinkers were less likely to have high scores, and children born to mothers classified as heavy/binge

drinkers were more likely to have high scores compared with children born to abstainers. Similar patterns were seen for conduct problems, hyperactivity and emotional symptoms (figure 1 and table 2).

Figure 1 here

Table 2 here

There were no differences in mean cognitive ability scores for girls born to light drinkers compared to those born to abstainers (BAS 60.4 *vs* 59.1 and BSRA 69.4 *vs* 66.6 respectively), whilst girls born to heavy/binge drinkers had lower mean BAS (51.9) and BSRA (59.4) scores. Boys born to light drinkers had higher mean scores compared to those born to abstainers (BAS 53.6 *vs* 49.0 and BSRA 64.9 *vs* 57.7 respectively) (table 3).

Table 3 here

Light drinking

For girls and boys there were no elevated risks of high, clinically relevant, SDQ scores associated with having a mother classified as a light drinker (table 2). The reduced likelihood of a high total difficulties score for those born to light drinkers (girls OR 0.64, boys OR 0.67) were attenuated in the fully adjusted model (girls OR 0.70, boys OR 0.77).

For boys born to light drinkers the reduced risk of high conduct problem (OR 0.59) and hyperactivity (OR 0.71) scores remained on adjustment for psychosocial factors and in the fully adjusted model (OR 0.59 and 0.69 respectively).

For girls born to light drinkers the reduced likelihood of emotional symptoms (OR 0.72) was further attenuated in the fully adjusted model. The reduced risk of a high peer problem score for girls born to light drinkers (OR 0.68) remained on adjustment for mother and infant, and socioeconomic factors, but was attenuated in the fully adjusted model (OR 0.76).

Boys born to light drinkers had significantly higher BAS (0.15) and BSRA (0.24) z-scores compared to boys born to abstainers. For BAS the association was attenuated on adjustment for socioeconomic factors, but for BSRA the association remained statistically significant (table 3).

Discussion

Main findings

In this large representative study we have shown that at 3 years of age children born to mothers who drank not more than 1-2 drinks per week or per occasion during pregnancy were not at increased risk of clinically relevant behavioural problems or cognitive deficits compared with children whose mothers did not drink. Boys born to light drinking mothers were less likely to have conduct and hyperactivity problems and these differences remained after statistical adjustment. Boys born to light drinking mothers had higher scores on cognitive ability assessments, and for the test on colours, shapes, numbers and letters these differences remained on statistical adjustment but were attenuated for the naming vocabulary test.

Strengths and limitations of the study

The data used in our study were from a large nationally representative sample of young children that were collected prospectively. However, the MCS sample is not representative of all pregnancies or births and so data on miscarriages, stillbirths and neonatal deaths were not included.

Another strength of the study is the statistical adjustment for the potential mediating effects of psychosocial markers such as mother's mental health, child-parent relationship, parental discipline and current drinking, as well as socioeconomic factors. There is social stigma associated with drinking, perhaps especially during pregnancy and under-reporting of alcohol consumption is widespread.[38] Some studies report that prospective data collection yields the most accurate estimates of alcohol consumption[39]

whereas other studies conclude that retrospective reporting is valid and reliable[40, 41] and that retrospective reports of alcohol consumption might give a more accurate picture of true consumption compared with contemporaneous reports.[41] In this study drinking categories were heterogeneous, for example: light drinking could range from a very occasional drink during pregnancy to up to two drinks per week throughout pregnancy; a moderate drinker could be a mother who drank three to five units on a single occasion but was otherwise an occasional drinker. In the MCS a lower proportion of mothers reported having drank alcohol during pregnancy compared with the 2001 Infant Feeding Survey (IFS)[42] and ALSPAC.[8, 12] However, there were important differences in the timing of collection of data about drinking during pregnancy, in ALSPAC this was during the second trimester of pregnancy, in the IFS this was at 6 weeks post partum and in MCS data were collected when infants were aged 9 months and so, perhaps, prone to recall bias. Another important difference compared with ALSPAC is that data were collected a decade earlier and there may have been significantly different social norms around both the consumption of and the reporting of alcohol during pregnancy. However the prevalence of heavy/binge drinking (approximately 2%) was comparable across MCS, ALSPAC and the IFS. Thus if there is misclassification of drinking categories in the MCS then this is most likely for the never drank and light drinking categories. Moreover, the net result of such misclassification would be to give conservative rather than inflated estimates of differences in behavioural and cognitive outcomes across groups. On the other hand, some mothers may have reported not drinking during pregnancy, when in fact they continued to drink until pregnancy was confirmed. This potential misclassification

may have resulted in inflating the estimates of behavioural and cognitive disadvantage observed in the never compared with the light drinking category.

It is unclear whether the effects of alcohol exposure during pregnancy depend on the timing of drinking during pregnancy and whether threshold effects exist.[43] A strength of this study was that we were able to assess drinking based on frequency and quantity of alcohol, but we did not know whether mothers reports related to specific trimesters or to the entire pregnancy. However, there was little difference in reported drinking depending on whether the pregnancy was planned or not, and this observation is consistent with data collected by the IFS.[42] The J shaped association is considered to be due to unadjusted confounding by social factors or to the fact that some women do not drink because of health problems.

A strength of this study was that we examined data on objective measures of cognitive ability for cohort members, conversely a limitation was that data on child behaviour were only available from a parent report and it has been shown elsewhere that multi-informant measures are more reliable for clinical identification of problem behaviours.[44] There is replicated evidence that behavioural and social problems can be reliably and validly diagnosed in preschoolers.[45] The core construct is the same as for school children, however, the issue of "age appropriateness" is important. For example, temper tantrums are more frequent in preschoolers while arguing with adults is less frequent. Thus, it is important to determine age-appropriate norms and in the current study we have done this using the large MCS cohort data rather than norms from a different age group. The cut-points use the same >90th percentile cut-off criterion for clinical relevance as used in the original norms.[30] Problem behaviours and cognitive

deficits at 3 years of age have previously been shown to predict later behavioural and educational outcomes.[27, 28]

Our results are consistent with other studies that did not show increased risks of behavioural and developmental problems in children born to mothers who drank low levels of alcohol.[11, 15, 16, 18, 19, 23]

Despite the scarcity of evidence linking light drinking during pregnancy with harmful effects for the developing fetus,[2,3,11,23] some commentators suggest that abstinence is the only safe message[6,7] as it is not clear whether certain mother-infant pairs are somehow more susceptible to the effects of alcohol because of genetic or metabolic characteristics.[43] A small study suggested fetal and newborn reflexes were affected by alcohol exposure in pregnancy,[46] but the significance of these findings for consequent behaviour and development are not clear. Sood and colleagues reported increased risk of aggressive behaviour in children born to light drinking mothers, however differences were small and the paper was based on a study sample who were exposed to high levels of substance use and violence.[9] A small study showed cognitive deficits at 2 and 3 years of age[18] in children born to light drinking mothers, but these effects were not apparent in the same sample at 4 to 6 years of age.[18, 19] Sayal and colleagues[8] found an increased risk of behavioural problems in girls whose mothers drank less than 1 drink per week during pregnancy, however the authors noted that their results may be spurious given the apparent lack of a dose-response effect between mothers drinking and behavioural outcomes. D'Onofrio and colleagues[13] reported an increased likelihood of conduct problems in children whose mothers drank during pregnancy, but possible threshold

effects were not clear as data on quantity of alcohol consumed on any given occasion were not presented.

In this study there were differences in the likelihood of behavioural difficulties and in cognitive ability test scores for boys and girls, and a suggestion of some gender differences in the relationship between mothers drinking and behaviour and cognitive development. Previous studies have shown gender specific effects of mothers' smoking on behavioural outcomes.[47, 48] With the exception of the ALSPAC study[8,12] no previous studies have reported gender effects on mothers drinking and childhood behaviour or cognitive ability.

Another strength of the current study was that we were able to consider a range of factors that might confound or mediate the relationship between mothers' drinking during pregnancy and later markers of behaviour and cognitive development. It was hypothesised that socioeconomic factors would confound the relationship between mothers drinking and childhood behaviour and that psychosocial environment assessed by measures of mother's mental health, parent-child relationship, parenting discipline and mother's current drinking would partly mediate the effect of mothers drinking during pregnancy. Statistical adjustment for socioeconomic confounders appears to explain more of the relationship between mothers drinking in boys, and psychosocial mediating factors in girls. It has been shown elsewhere that there may be gender differences in how environmental factors mediate behavioural problems.[49] Children's social and emotional behaviours and cognitive abilities are heavily influenced by the social environment, and in this study population light alcohol consumption is a marker of relative socio-economic advantage. Therefore it might be that these social circumstances,[50] rather than the direct

physico-chemical impact of ethanol, may be responsible for the relatively low rates of subsequent behavioural difficulties and cognitive advantage in children whose mothers were light drinkers.

Conclusion

The results of this analysis suggest that there is no increased risk of behavioural problems or cognitive deficits at age 3 for children whose mother drank not more than 1 or 2 units of alcohol per week or on any given occasion. It is important to acknowledge that problem behaviours or cognitive deficits may become apparent in these children at older ages, and the evidence presented should be used to guide future research and inform policy.

Future work on the effects of low levels of drinking during pregnancy should consider longer term effects on behavioural problems and cognitive development. Research is needed on the timing and quantity of drinking during pregnancy, and on the possible contribution of unique and shared environments to the likelihood of clinically relevant behavioural problems and cognitive deficits.

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Appendix 1

Strengths and difficulties questions – parent completion for age 3-4 years

Hyperactivity; "Restless, overactive, cannot stay still for long", "Constantly fidgeting or squirming", Easily distracted, concentration wanders", "*Can stop and think things out before acting*", "*Sees tasks through to the end, good attention span*".

Conduct problems; "Often has temper tantrums or hot tempers", "*Generally obedient, does what adults request*", "Often fights with other children or bullies them", "Often argumentative with adults", "Can be spiteful to others".

Emotional symptoms; "Often complains of headache, stomach-ache or sickness", "Many worries, often seems worried", "Often unhappy, down- hearted or tearful", "Nervous or clingy in new situations, easily loses confidence", "Many fears, easily scared".

Peer relationships; "Rather solitary, tends to play alone", "*Has at least one good friend*", "*Generally liked by other children*", "Picked on or bullied by other children", "Gets on better with adults than with other children".

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Table 1 Pattern of mothers' drinking during pregnancy

	Category of drinking			
	Never n=6162	Light n=2549	Moderate n=536	Heavy/binge n=213
Infant's gender				
Male	50.5	51.9	50.2	54.6
Mother's age at the time of birth				
13 to 19	6.5	3.7	5.6	13.6
20 to 24	15.6	8.8	10.5	21.1
25 to 29	29.1	26.5	21.8	17.7
30 to 34	31.9	38.8	36.1	23.5
35 to 39	15.1	19.3	21.5	20.8
40 plus	1.9	2.9	4.5	2.3
Number of children in the household				
one child	44.2	43.7	32.8	50.1
two children	36.2	38.9	41.2	31.5
three plus children	19.6	17.4	26.0	18.4
Mother smoked during pregnancy				
Yes	20.2	14.2	26.1	38.5
Pregnancy planned				
Yes	61.7	68.6	57.1	53.1
Household income				
£55,000 or more	6.5	14.0	15.4	8.6
£33000 - £54999	19.1	26.1	22.3	12.9
£22000 - £32999	24.6	21.8	21.0	20.9
£11000 - £21999	25.2	18.7	17.5	22.5
Less than £11000	15.5	10.1	14.7	25.5
Don't Know	9.0	9.3	9.0	9.7
Mother's highest educational qualification				
Higher degree	3.2	6.1	4.6	4.4
First degree/diploma	30.9	43.0	40.0	32.7
A/AS levels	16.9	15.2	12.1	11.4
GCSE grades A-C	32.2	25.5	27.1	30.5
GCSE grades D-G	7.7	5.8	5.8	5.7
Other/overseas	1.4	1.0	0.8	3.3
None	7.7	3.5	9.7	12.0
Mother's occupation				
Managerial & professional	32.5	47.5	39.4	35.1

Intermediate	20.8	19.0	17.3	13.0
Small employer & self employed	4.2	5.4	5.6	6.1
Low supervisory & technical	5.9	4.4	3.0	5.8
Semi-routine & routine	32.8	21.7	29.6	34.0
Never worked, long-term unemployed and other unclassified	3.8	2.1	5.2	6.1
Mother's current drinking				
Never	16.0	2.9	4.8	6.6
< once per week	44.5	26.3	21.7	23.9
1-2 times per week	26.0	37.0	28.8	32.7
3 plus times per week	13.6	33.8	44.7	36.8

Mean (SE)				
Mother's K6 score	3.03 (0.05)	2.87 (0.07)	3.08 (0.15)	3.28 (0.29)
Warmth of relationship between mother and child	49.8 (0.1)	49.4 (0.2)	48.6 (0.3)	48.5 (0.6)
Parental discipline	15.2 (0.1)	14.3 (0.1)	14.2 (0.2)	14.2 (0.4)
Birthweight (kg)	3.420 (0.008)	3.454 (0.012)	3.450 (0.027)	3.294 (0.047)

Table 2 Odds ratios (95%CI) for high behavioural difficulties scores

Boys	Prevalence of high score	Model A		Model B		Model C		Model D		Model E	
Total difficulties n=4753											
None	9.5										
Light	6.5	0.67	(0.50 to 0.90)	0.81	(0.60 to 1.08)	0.87	(0.65 to 1.18)	0.68	(0.49 to 0.95)	0.77	(0.56 to 1.07)
Moderate	7.5	0.80	(0.47 to 1.37)	0.82	(0.48 to 1.39)	0.92	(0.53 to 1.59)	0.70	(0.37 to 1.29)	0.65	(0.35 to 1.23)
Heavy/binge	17.1	1.88	(1.11 to 3.18)	1.59	(0.93 to 2.72)	1.70	(0.98 to 3.00)	2.04	(1.02 to 4.12)	1.76	(0.83 to 3.73)
Conduct problems, n=4813											
None	10.4										
Light	6.3	0.59	(0.45 to 0.77)	0.71	(0.54 to 0.94)	0.74	(0.56 to 0.98)	0.52	(0.38 to 0.70)	0.59	(0.44 to 0.81)
Moderate	10.3	1.01	(0.63 to 1.61)	1.00	(0.63 to 1.61)	1.12	(0.70 to 1.79)	0.81	(0.46 to 1.40)	0.68	(0.39 to 1.21)
Heavy/binge	10.8	1.01	(0.58 to 1.77)	0.80	(0.46 to 1.40)	0.86	(0.48 to 1.53)	0.76	(0.34 to 1.67)	0.53	(0.22 to 1.27)
.											
Hyperactivity, n=4799											
None	10.1										
Light	7.3	0.71	(0.54 to 0.94)	0.78	(0.58 to 1.04)	0.81	(0.61 to 1.08)	0.65	(0.48 to 0.89)	0.69	(0.50 to 0.95)
Moderate	8.7	0.88	(0.54 to 1.42)	0.91	(0.56 to 1.48)	0.99	(0.61 to 1.60)	0.67	(0.38 to 1.18)	0.71	(0.41 to 1.23)
Heavy/binge	12.8	1.26	(0.71 to 2.22)	1.16	(0.66 to 2.06)	1.27	(0.71 to 2.27)	1.02	(0.52 to 1.98)	1.02	(0.52 to 1.99)
Emotional symptoms, n=4811											
None	6.7										
Light	5.2	0.78	(0.57 to 1.06)	0.85	(0.62 to 1.17)	0.91	(0.66 to 1.26)	0.81	(0.58 to 1.13)	0.85	(0.60 to 1.21)
Moderate	5.5	0.84	(0.45 to 1.56)	0.89	(0.47 to 1.66)	0.90	(0.46 to 1.74)	0.80	(0.41 to 1.56)	0.81	(0.40 to 1.64)
Heavy/binge	14.9	2.34	(1.33 to 4.12)	2.17	(1.21 to 3.88)	2.14	(1.17 to 3.92)	2.25	(1.18 to 4.29)	2.15	(1.09 to 4.25)
Peer problems, n=4780											
None	10.8										
Light	9.1	0.83	(0.65 to 1.05)	0.91	(0.71 to 1.17)	1.00	(0.77 to 1.29)	0.90	(0.69 to 1.16)	0.97	(0.74 to 1.26)
Moderate	9.2	0.83	(0.51 to 1.36)	0.82	(0.51 to 1.34)	0.91	(0.55 to 1.50)	0.83	(0.49 to 1.40)	0.81	(0.47 to 1.37)
Heavy/binge	12.1	1.09	(0.59 to 2.04)	0.93	(0.50 to 1.75)	0.93	(0.49 to 1.77)	1.03	(0.55 to 1.93)	0.86	(0.45 to 1.64)

Girls	Prevalence of high score	Model A	Model B	Model C	Model D	Model E
Total difficulties, n=4593						
None	6.2					

Light	3.9	0.64	(0.43 to 0.95)	0.79	(0.53 to 1.18)	0.80	(0.53 to 1.21)	0.63	(0.40 to 0.98)	0.70	(0.43 to 1.14)
Moderate	8.2	1.36	(0.80 to 2.32)	1.33	(0.77 to 2.29)	1.32	(0.76 to 2.28)	1.46	(0.82 to 2.61)	1.18	(0.63 to 2.19)
Heavy/binge	7.2	1.15	(0.48 to 2.73)	0.85	(0.35 to 2.06)	1.07	(0.43 to 2.66)	1.00	(0.35 to 2.90)	0.83	(0.30 to 2.28)
Conduct problems, n=4637											
None	7.3										
Light	6.1	0.82	(0.62 to 1.09)	0.95	(0.72 to 1.27)	0.97	(0.73 to 1.30)	0.70	(0.51 to 0.95)	0.72	(0.52 to 1.00)
Moderate	14.6	2.17	(1.41 to 3.34)	2.05	(1.30 to 3.21)	2.17	(1.38 to 3.42)	2.02	(1.20 to 3.41)	1.60	(0.92 to 2.78)
Heavy/binge	11.4	1.60	(0.76 to 3.35)	1.25	(0.59 to 2.64)	1.56	(0.71 to 3.45)	1.31	(0.53 to 3.20)	1.18	(0.49 to 2.83)
Hyperactivity, n=4614											
None	4.9										
Light	4.8	1.02	(0.72 to 1.44)	1.14	(0.81 to 1.61)	1.29	(0.91 to 1.81)	1.01	(0.67 to 1.50)	1.18	(0.78 to 1.77)
Moderate	5.3	1.08	(0.58 to 2.04)	1.11	(0.58 to 2.11)	1.13	(0.58 to 2.17)	1.04	(0.54 to 2.01)	1.03	(0.52 to 2.06)
Heavy/binge	2.1	0.39	(0.11 to 1.36)	0.33	(0.09 to 1.16)	0.39	(0.11 to 1.39)	0.34	(0.09 to 1.24)	0.32	(0.08 to 1.19)
Emotional symptoms, n=4635											
None	6.3										
Light	4.5	0.72	(0.51 to 1.01)	0.83	(0.59 to 1.16)	0.84	(0.59 to 1.18)	0.89	(0.62 to 1.28)	0.95	(0.65 to 1.38)
Moderate	5.3	0.83	(0.45 to 1.55)	0.76	(0.40 to 1.44)	0.83	(0.45 to 1.53)	1.00	(0.50 to 2.00)	0.90	(0.45 to 1.79)
Heavy/binge	10.1	1.66	(0.79 to 3.46)	1.29	(0.63 to 2.65)	1.58	(0.72 to 3.48)	1.93	(0.85 to 4.38)	1.62	(0.72 to 3.68)
Peer problems, n=4619											
None	9.5										
Light	6.6	0.68	(0.52 to 0.92)	0.72	(0.54 to 0.96)	0.74	(0.56 to 0.98)	0.74	(0.54 to 1.00)	0.76	(0.55 to 1.03)
Moderate	8.9	0.94	(0.58 to 1.52)	0.93	(0.57 to 1.52)	0.94	(0.58 to 1.53)	0.97	(0.60 to 1.59)	0.98	(0.59 to 1.61)
Heavy/binge	6.7	0.65	(0.25 to 1.68)	0.58	(0.22 to 1.52)	0.67	(0.27 to 1.71)	0.64	(0.25 to 1.67)	0.66	(0.26 to 1.70)

Model A adjusts for: child's age, birthweight

Model B adjusts for: child's age, birthweight, mother's age at the time of birth, number of children in the household, mother smoked during pregnancy, pregnancy planned

Model C adjusts for: child's age, birthweight, household income, mother's highest educational qualification mother's occupational class

Model D adjusts for: child's age, birthweight, mother's K6 score, warmth of relationship between mother and child, parental discipline, mother's current drinking

Model E adjusts for: child's age, birthweight, mother's age at the time of birth, number of children in the household, mother smoked during pregnancy, pregnancy planned, household income, mother's highest educational qualification, mother's occupational class, mother's K6 score, warmth of relationship between mother and child, parental discipline, mother's current drinking

Table 3 Z score regression coefficients (95% CI) for BAS and BSRA cognitive ability tests

Boys	Mean test score	Model A		Model B		Model C		Model D		Model E	
BAS n=4639											
None	49.0										
Light	53.6	0.15	(0.08 to 0.23)	0.09	(0.02 to 0.17)	0.05	(-0.02 to 0.12)	0.13	(0.05 to 0.21)	0.07	(-0.01 to 0.15)
Moderate	53.6	0.15	(0.02 to 0.27)	0.15	(0.03 to 0.27)	0.08	(-0.03 to 0.20)	0.13	(0.00 to 0.26)	0.14	(0.02 to 0.25)
Heavy/binge	46.8	-0.06	(-0.29 to 0.17)	-0.02	(-0.24 to 0.21)	0.00	(-0.22 to 0.22)	-0.04	(-0.27 to 0.18)	0.02	(-0.19 to 0.24)
BSRA n=4404											
None	57.7										
Light	64.9	0.24	(0.16 to 0.32)	0.16	(0.08 to 0.23)	0.11	(0.03 to 0.18)	0.19	(0.11 to 0.28)	0.11	(0.03 to 0.19)
Moderate	61.3	0.12	(-0.04 to 0.27)	0.12	(-0.02 to 0.26)	0.03	(-0.10 to 0.16)	0.06	(-0.09 to 0.22)	0.08	(-0.05 to 0.22)
Heavy/binge	58.4	0.04	(-0.20 to 0.27)	0.08	(-0.16 to 0.32)	0.12	(-0.10 to 0.34)	0.03	(-0.21 to 0.26)	0.11	(-0.12 to 0.34)

Girls	Mean test score	Model A		Model B		Model C		Model D		Model E	
BAS n=4515											
None	59.1										
Light	60.4	0.04	(-0.03 to 0.11)	-0.02	(-0.09 to 0.05)	-0.05	(-0.12 to 0.02)	0.01	(-0.06 to 0.08)	-0.40	(-0.11 to 0.03)
Moderate	58.6	-0.02	(-0.17 to 0.14)	0.01	(-0.14 to 0.17)	-0.04	(-0.19 to 0.11)	-0.04	(-0.19 to 0.10)	0.01	(-0.14 to 0.16)
Heavy/binge	51.9	-0.24	(-0.47 to -0.02)	-0.17	(-0.37 to 0.03)	-0.24	(-0.46 to -0.03)	-0.27	(-0.49 to -0.04)	-0.20	(-0.41 to 0.01)
BSRA n=4371											
None	66.6										
Light	69.4	0.10	(0.02 to 0.18)	0.02	(-0.05 to 0.09)	-0.03	(-0.11 to 0.05)	0.02	(-0.06 to 0.09)	-0.04	(-0.11 to 0.03)
Moderate	65.8	-0.03	(-0.21 to 0.15)	0.04	(-0.12 to 0.21)	-0.05	(-0.20 to 0.10)	-0.11	(-0.28 to 0.06)	0.00	(-0.15 to 0.15)
Heavy/binge	59.4	-0.26	(-0.52 to 0.00)	-0.16	(-0.41 to 0.09)	-0.28	(-0.52 to -0.05)	-0.34	(-0.61 to -0.07)	-0.25	(-0.49 to -0.01)

Model A adjusts for: birthweight
Model B adjusts for: birthweight, mother's age at the time of birth, number of children in the household, mother smoked during pregnancy, pregnancy planned
Model C adjusts for: birthweight, household income, mother's highest educational qualification mother's occupational class
Model D adjusts for: birthweight, mother's K6 score, warmth of relationship between mother and child, parental discipline, mother's current drinking
Model E adjusts for: birthweight, mother's age at the time of birth, number of children in the household, mother smoked during pregnancy, pregnancy planned, household income, mother's highest educational qualification, mother's occupational class, mother's K6 score, warmth of relationship between mother and child, parental discipline, mother's current drinking

Figure 1: Prevalence of behavioural difficulties by mother's drinking during pregnancy