The effects of low to moderate alcohol consumption and binge drinking in early pregnancy on behaviour in 5-year-old children: a prospective cohort study on 1628 children*

Å Skogerbø, a US Kesmodel, b,c CH Denny, d MIS Kjaersgaard, e T Wimberley, e NI Landrø, f EL Mortensen

a Department of Public Health, University of Copenhagen, Copenhagen, Denmark b Section of Epidemiology, Department of Public Health, Aarhus University, Aarhus, Denmark c Department of Obstetrics and Gynaecology, Aarhus University Hospital, Aarhus, Denmark d Centers for Disease Control and Prevention (CDC), Atlanta, GA, USA e Section of Biostatistics, Department of Public Health, Aarhus University, Aarhus, Denmark f Department of Psychology, Center for the Study of Human Cognition, University of Oslo, Oslo, Norway g Department of Public Health and Center for Healthy Aging, University of Copenhagen, Copenhagen, Denmark

Correspondence: Dr Å Skogerbø, Department of Public Health, Medical Psychology Unit, University of Copenhagen, Øster Farimagsgade 5A, DK–1353 Copenhagen K, Denmark. Email aask@sund.ku.dk

Accepted 15 December 2012. Published Online 21 March 2013.

Objective To examine the effects of low to moderate maternal alcohol consumption and binge drinking in early pregnancy on behaviour in children at the age of 5 years.

Design Prospective cohort study.


Population A total of 1628 women and their children sampled from the Danish National Birth Cohort.

Methods Participants were sampled based on maternal alcohol drinking patterns during early pregnancy. When the children were 5 years of age the parent and teacher versions of the Strengths and Difficulties Questionnaire (SDQ) were completed by the mothers and a preschool teacher, respectively. The full statistical model included the following potential confounding factors: maternal binge drinking or low to moderate alcohol consumption, respectively; parental education; maternal IQ; prenatal maternal smoking; the child’s age at testing; the child’s gender; maternal age; parity; maternal marital status; family home environment; postnatal parental smoking; prepregnancy maternal body mass index (BMI); and the child’s health status.

Main outcome measure Behaviour among children assessed by the SDQ parent and teacher forms.

Results Adjusted for all potential confounding factors, no statistically significant associations were observed between maternal low to moderate average weekly alcohol consumption and SDQ behavioural scores (OR 1.1, 95% CI 0.5–2.3; OR 1.1, 95% CI 0.6–2.1 for the total difficulties scores) or between binge drinking and SDQ behavioural scores (OR 1.2, 95% CI 0.8–1.7; OR 0.8, 95% CI 0.6–1.2).

Conclusion This study observed no consistent effects of low to moderate alcohol consumption or binge drinking in early pregnancy on offspring behaviour at the age of 5 years.

Keywords Behaviour, binge drinking, low to moderate alcohol consumption, neurodevelopmental effects, prenatal exposures, SDQ, Strengths and Difficulties Questionnaire.

Introduction

Numerous studies have demonstrated that heavy prenatal alcohol exposure can affect fetal brain development in a number of different ways,1–3 but the effects of more moderate drinking patterns are much less clear. Both low to moderate weekly consumption of alcohol and binge drinking are examples of consumption patterns that few studies have investigated systematically,4–6 even though a substantial proportion of women drink at low to moderate levels during pregnancy. Different patterns of alcohol consumption during early pregnancy and the potential effects on children’s

*The findings and conclusions in this report are those of the author(s) and do not necessarily represent the official position of the Centers for Disease Control and Prevention.
neuropsychological development have been the focus of a recent comprehensive Danish study. Consistent non-significant effects on intelligence, executive functions, sustained and selective attention, and motor functions have been observed.\textsuperscript{7–12} Kelly et al.\textsuperscript{13} found that up to the age of 5 years there was no increased risk of poor socio-emotional or cognitive developmental outcomes in children born to mothers who drank no more than 1–2 units of alcohol per week during pregnancy. In a large cohort study including nearly 7500 children, no association between prenatal alcohol exposure (1 + units/day in the first 3 months of pregnancy) and general behavioural problems was observed.\textsuperscript{14} One of the few studies investigating behavioural difficulties in children exposed to a moderate level of alcohol described such children as being more ‘fidgety’ and less compliant.\textsuperscript{15}

Traditionally, effects of prenatal alcohol exposure have been evaluated with cognitive desk tests or computerised tests, with less emphasis on behavioural effects observable in the home or in social environments, such as preschool or school. As hyperactivity and attention deficits are common behavioural difficulties in children who have been exposed to heavy prenatal alcohol consumption,\textsuperscript{16–18} there is a need to further investigate behavioural effects of low to moderate maternal consumption during pregnancy. The present study is based on an assessment of children’s behaviour in real-life settings as observed by parents and preschool teachers, and the aim was to analyse the potential effects of low to moderate weekly alcohol consumption and binge drinking during early pregnancy on children’s behaviour at the age of 5 years.

**Methods**

**Study sample**

This study formed part of the Lifestyle During Pregnancy Study (LDPS), which has been described in detail elsewhere.\textsuperscript{7–12,19} Briefly, the study is a prospective follow-up study based on a sample from the Danish National Birth Cohort (DNBC).\textsuperscript{20} The DNBC contains information on 101 042 women and their children. Based on information on maternal alcohol consumption during pregnancy, 3189 mothers and their children were sampled from the DNBC and invited to participate in a follow-up when the children were between 60 and 64 months of age. Of the invited mother–child pairs, 1628 participated in the follow-up. Valid information on binge drinking was missing for 11 of the 1628 mothers, and consequently the binge drinking analyses were conducted on 1617 mothers and their children. Data collection for the follow-up took place from September 2003 to June 2008.

Exclusion criteria were: multiple pregnancies; inability to speak Danish; impaired hearing or vision likely to compromise the ability to perform cognitive tests; and congenital disabilities implying or likely to imply intellectual disability (e.g. trisomy 21 or infantile autism).

**Exposure assessment**

Information on alcohol intake during pregnancy was derived from the first prenatal DNBC interview.\textsuperscript{19} For women participating in the follow-up, the median week of gestation for completing the interview was 17 weeks (range 7–39 weeks).\textsuperscript{7–12} During the interview the women were asked about the average number of beers, glasses of wine, and glasses of spirits they currently consumed during a week, and based on this information, the total number of weekly drinks was calculated. Information on binge drinking during pregnancy included data on the number of binge episodes (defined as an intake of $\geq 5$ drinks on a single occasion) and the timing (gestational week) of these episodes.\textsuperscript{7–12} The definition of a drink followed the definition from the Danish National Board of Health, with one standard drink being equal to 12 grams of pure alcohol.

All mothers were sampled in strata defined by their average alcohol intake ($0, 1–4, 5–8, \geq 9$ drinks per week) and the timing of binge episodes, defined as $\geq 5$ drinks on one occasion in gestational weeks 1–2, 3–4, 5–8, and 9 or later. The higher exposure categories were oversampled in an effort to ensure that all exposure categories included enough children to attain sufficient statistical power.\textsuperscript{19} For the analyses presented in this paper, the alcohol consumption categories of 5–8 and $\geq 9$ drinks per week were collapsed into a 5 + category because of the few abnormal and borderline scores in the $\geq 9$ drinks per week group. Binge drinking was classified as yes/no, number of binge episodes was classified as 0, 1, 2, and $\geq 3$ episodes, timing of episodes was classified as gestational weeks 1–2, 3–4, 5–8, $\geq 9$, and multiple episodes.

**Outcome measures**

The Strengths and Difficulties Questionnaire (SDQ) is a brief behavioural screening questionnaire for parents and teachers/preschool teachers comprising 25 questions on psychological attributes, some positive and others negative (www.sdqinfo.com).\textsuperscript{21} The 25 attributes cover five domains of behaviour, namely emotional symptoms, conduct problems, hyperactivity/inattention, peer relationship problems, and prosocial behaviour. Scores are derived for each of these domains and the first four domain scores are summed to generate a total difficulties score. It is designed for a broad range of children, ages 3–16 years.\textsuperscript{21} The SDQ is a well-validated measure of childhood mental health.\textsuperscript{21,22}

The SDQ was originally developed in the UK, and a translated Danish version was used in this study.\textsuperscript{23} In contrast to British children, Danish children have not yet started school at the age of 5 years. Consequently, the
words of two questions referring to school were changed. The question referring to school was changed to kindergarten, and the question in the parent version concerning learning abilities was deleted.

We applied the method of score bandings reported by Goodman.22 As SDQ scores tend to be quite skewed, the total difficulties score was categorised into normal, borderline, and abnormal scores based on cut-offs at the 80th and 90th percentile (a lower score is better). The four difficulty subscores were dichotomised with cut-off for normal and abnormal scores at the 90th percentile. For the prosocial score higher scores indicate better social functioning, and cut-offs for abnormal, borderline, and normal behaviour were set at the 10th and 25th percentiles (additionally, analyses of abnormal versus normal scores were conducted using a cut-off at the 10th percentile). When the distribution of the scores did not permit a cut-off at the exact 80th and 90th percentiles for the ‘borderline’ or the ‘abnormal’ band, the cut-off for the next percentile was chosen; this made for under-inclusive rather than over-inclusive bands for the ‘borderline’ and ‘abnormal’ bands.

The large sample enabled us to conduct analyses to evaluate the psychometric characteristics of the SDQ scales in our study population. For the total LDPS sample, Cronbach’s z was 0.76 for the total difficulties score for the parent version, whereas it was 0.85 for the teacher version of the questionnaire. These figures suggest that the SDQ is a highly reliable instrument.

The follow-up assessments were conducted at four sites located in Copenhagen, Aarhus, Odense, and Aalborg. The assessment comprised a comprehensive neuropsychological test battery, described in detail elsewhere.19 The parents answered the SDQ parent version as part of a broad questionnaire on the child’s postnatal health/development as well as parental education and lifestyle. The SDQ teacher version was mailed to the kindergarten a few weeks before the planned test date. The completed SDQ was returned to the LDPS research group by mail. A maximum of two reminders were mailed to the parents and/or daycare institutions if they did not respond to the initial letter.19

Covariates

The following covariates obtained in the prenatal interview were coded as follows: parity (0, 1, 2+); prenatal smoking (yes/no); and maternal prepregnancy body mass index [BMI; weight in kg/(height in m)2]. At the time of the 5-year follow-up, the following variables were recorded: maternal marital status (single at either the prenatal interview or follow-up/with partner at both times); parental education in years (total duration of attained education averaged for both parents, or maternal education only if information on the father was missing); an index of the quality of postnatal home environments (suboptimal in the presence of two or more of the following adverse conditions: living with only one biological parent; changes in primary care givers; daycare for more than 8 hours/day before the age of 3 years; ≥ 14 days of separation from parents; breakfast irregularities; maternal depression and maternal/paternal alcohol intake above the official recommendations from the Danish National Board of Health at the time of follow-up; otherwise normal); an index of the child’s health status (suboptimal in the presence of any handicaps, illness/diseases, and/or medication with potential influence on cognitive test performance; otherwise normal).

Maternal age was obtained from the unique Danish personal identification number, as was the sex and age of the child. Birthweight in grams and gestational age in days were obtained from the Danish Medical Birth Registry. Maternal IQ was assessed at the follow-up,7–12 with two verbal subtests (Information and Vocabulary) from the Wechsler Adult Intelligence Scale (WAIS) and Raven’s Standardized Progressive Matrices.24,25

In the analyses of maternal average alcohol consumption, binge drinking was included as a potential confounding factor (based on preliminary analyses coded as yes/no in the statistical analysis), whereas the maternal average number of drinks per week during pregnancy was included as a potential confounding factor in the analyses of the effects of binge drinking.

Data analysis

The number of missing values for the covariates ranged from 1 to 33. For the SDQ parent total difficulties scale and parent prosocial scale, information for ten and eight children, respectively, were missing, whereas information was missing for 210 children on the SDQ teacher total difficulties scale and for 209 on the teacher prosocial scale. Multiple imputation was conducted with a dedicated model for imputations, where variables were modelled from other variables thought to be most predictive of each variable (the specific equations are available upon request).7–12 Essentially the same results were obtained when only subjects with full information on the variables needed in any given analysis were included. In this article we report the results of the dedicated model for imputations, i.e. the results are based on the complete sample with imputed values.

The analyses were conducted with average alcohol consumption and binge drinking as exposure variables. For each type of exposure the parent and the teacher versions of SDQ were analysed. The main analysis was a logistic regression on the dichotomous total difficulties score (abnormal + borderline) versus normal, and on the dichotomous prosocial scale (abnormal + borderline) versus normal. Supplementary analyses were conducted on the total difficulties scale analysing abnormal versus normal and
borderline versus normal, as well as analysing abnormal versus normal prosocial scores and borderline versus normal prosocial scores.

In supplementary analyses, we analysed potential interactions between average alcohol consumption and binge drinking, as well as interactions of the alcohol exposure variables with sex of child, parental education, and maternal smoking during pregnancy. These variables were dichotomized, and the corresponding strata-specific analyses were also conducted. When necessary the number of categories of binge episodes was reduced, with the ≥ 3 category combined with the ≥ 2 category, and the categories for gestational weeks 5–8 and ≥ 9 in the timing of binge episodes were collapsed into a gestational week ≥ 5 category.

All statistical analyses were conducted in STATA 11 (StataCorp LP, College Station, Texas) and weighted by sampling probabilities. All statistical tests were two-sided and determined to be significant at the 5% level. All estimates are accompanied by 95% confidence intervals.

**Results**

Sample characteristics across levels of low to moderate maternal alcohol intake and number of binge episodes in pregnancy are presented elsewhere. Notably, women reporting no alcohol consumption during a typical week were significantly younger and had less education than the women in the 1–4 and 5+ drinks per week categories. They were also significantly more likely to be primiparous, less likely to be smokers, and less likely to have suboptimal family/home conditions. Smoking and suboptimal family/home conditions were more frequent among women reporting five or more drinks per week. Women without binge drinking episodes were significantly older, less likely to be primiparous, had significantly higher BMIs, were less likely to be smokers, and had significantly lower IQs compared with binge drinkers.

**Results for low to moderate alcohol intake**

The results for the SDQ total difficulties scale and the prosocial scale are presented in Table 1. Both the parent and teacher data indicated that no statistically significant effects of low to moderate consumption were observed for either the SDQ total difficulties scale or the prosocial scale. This was also the case for supplementary analyses of abnormal versus normal scores and borderline versus normal scores (data not shown).

Analyses for the SDQ parent and teacher subscales (emotional symptoms, conduct problems, hyperactivity/inattention, and peer relationship problems) showed no statistically significant associations with average alcohol exposure when adjusting for all potential confounding factors.

Test of interaction between low to moderate alcohol consumption and binge drinking (dichotomized) was not statistically significant. Tests of interaction between low to moderate alcohol consumption and sex, parental education, and maternal smoking during pregnancy were not statistically significant either.

**Results for binge drinking**

We observed no statistically significant effects of abnormal or borderline scores on the SDQ total difficulties and pro-

| Table 1. Effects of maternal low to moderate alcohol consumption in pregnancy on offspring mean SDQ scores,* Denmark, 2003–2008 |
|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|
| **Parent-rated SDQ total scale** (abnormal + borderline)** | **Parent-rated SDQ prosocial score** (abnormal + borderline) | **Teacher-rated SDQ total scale** (abnormal + borderline) | **Teacher-rated SDQ prosocial scale** (abnormal + borderline) |
| | **OR*** | **95% CI** | **OR** | **95% CI** | **OR** | **95% CI** | **OR** | **95% CI** |
| **Average no. drinks/week in pregnancy** | | | | | | | | |
| 0 (n = 758) Reference – | 1.1 | (0.7–1.7) | 0.9 | (0.6–1.3) | 0.9 | (0.6–1.4) | 0.9 | (0.6–1.3) |
| 1–4 (n = 675) | 1.1 | (0.5–2.3) | 1.0 | (0.5–2.0) | 1.1 | (0.6–2.1) | 1.1 | (0.5–2.3) |
| 5 + (n = 195) | 0.9 | 0.85 | 0.91 | 0.68 |

*SDQ total difficulties scale and SDQ prosocial scale.

**The abnormal and borderline range: three binary scores are generated indicating abnormal versus normal, borderline versus normal, and (abnormal + borderline) versus normal for the total difficulties score and the categorised prosocial score. Only the abnormal + borderline range is reported in the table, representing the range of behavioural difficulties reported in the children.

***Adjusted for all potential confounding factors: parental education, maternal IQ, prenatal maternal smoking, child’s age at testing, child’s gender, binge drinking, maternal age, parity, maternal marital status, family home environment, postnatal parental smoking, prepregnancy maternal body mass index (BMI), and the child’s health status.

****P value for the hypothesis of no difference in SDQ scores across levels of average alcohol intake.
social scales with the dichotomized binge variable, number of binge episodes, or timing of binge episodes (Table 2). Further analyses of abnormal versus normal scores and borderline versus normal scores showed no significant associations of SDQ scores with binge drinking.

Analyses for the SDQ parent and teacher subscales (emotional symptoms, conduct problems, hyperactivity/inattention, and peer relationship problems) showed no statistically significant associations with binge drinking when adjusting for all potential confounding factors.

Tests of interactions with the dichotomised variables of sex, parental education, and maternal smoking during pregnancy were not statistically significant; however, for the parent version of the SDQ total difficulties scale the interaction between number of binge drinking episodes and average alcohol consumption was statistically significant, even after adjusting for all potential confounding factors ($P = 0.01$). Stratified analyses showed a significantly elevated risk for a high score (abnormal and borderline collapsed) in children whose mothers had two binge episodes during early pregnancy and drank five or more drinks per week ($P = 0.03$); however, three or more binge episodes were not associated with elevated risk, and thus the result did not consistently suggest stronger effects of binge episodes in women consuming five or more drinks per week.

**Intercorrelations and inter-rater agreements among SDQ scores**

Because the distributions of SDQ scores were skewed, Spearman’s correlations were calculated to evaluate associations between SDQ scores. For the SDQ parent version the correlation between the total difficulties scale and the prosocial scale was $-0.29$. For the SDQ teacher version the correlation between the total difficulties scale and the prosocial scale was $-0.52$. Additionally, the correlations across the corresponding SDQ parent and teacher scales were analysed. The correlation between the parent total difficulties scale and the teacher total difficulties scale was 0.34, and for the parent prosocial scale and the teacher prosocial scale the correlation was 0.25.

**Discussion**

The present study examined the potential effects of low to moderate prenatal alcohol exposure and binge drinking on the behaviour of children at the age of 5 years. No statistically significant effects were observed for low to moderate weekly alcohol consumption levels during early pregnancy, and no consistent associations between binge drinking during early pregnancy and child behaviour were observed. No consistent evidence of an interaction between binge drinking episodes and average alcohol consumption was found.

**Limitations and strengths**

The SDQ is a measure of children’s behavioural difficulties and strengths in daily life, and the possibility that the SDQ is not sensitive enough to detect subtle effects of low to moderate prenatal alcohol exposure should be considered. However, the SDQ and the well-known Child Behaviour Checklist (CBCL) correlate highly,26 and the two questionnaires appear to be equally able to discriminate between children drawn from high-risk and low-risk samples. Furthermore, the lack of significant effects of low to moderate prenatal exposure and binge drinking on behaviour are corroborated by the analyses based on the Behavior Rating Inventory of Executive Function (BRIEF) parent and teacher ratings of executive functions in 5-year old LDPS children.9 For both the SDQ and the BRIEF, the correlations between the parent and teacher ratings were low, but this may primarily reflect the fact that the parents observe the child in a family context, whereas the kindergarten teacher observes the child together with other children of the same age.

A possible limitation of our study is the age of the children at the time of the follow-up, as a child’s behaviour, including social and emotional functioning, continues to develop, and is unlikely to remain stable throughout childhood and adolescence. On the one hand this means that any observed effects of prenatal alcohol exposure at the age of 5 years may not reflect permanent deficits, on the other hand it also means that developmental problems associated with maternal drinking during pregnancy may emerge later in childhood.13,27

As with all active participation studies, potential differences between those who agreed to participate and those who did not must be considered. While the 51% participation rate for this study is quite good for studies of this nature, and no notable differences between LDPS participating and non-participating mothers have been observed,9,10 the possibility remains that mothers of children who were not cognitively or behaviourally functioning at age level may have been more likely to decline participation.

As with any study of teratogenic effects, limitations in exposure measurement must be acknowledged. If the damaging effects of alcohol depend on the maximal blood concentration, the number and timing of binge drinking episodes would only be indirect estimates of such exposures. The blood concentration depends not only on the volume of alcohol consumed, but also on the duration of drinking as well as on the blood volume and speed of enzymatic breakdown; consequently, the observed estimates of the relationship between binge drinking and behaviour are likely to be conservative estimates.

In this study, information on average alcohol use reflects the specific time of the DNBC prenatal interview, which varied from 7 to 39 weeks of gestation. Any interactions of
Table 2. Effects of maternal binge drinking in pregnancy on offspring mean SDQ scores,* Denmark, 2003–2008

<table>
<thead>
<tr>
<th>Binge drinking in pregnancy</th>
<th>Parent-rated SDQ total scale (abnormal + borderline)**</th>
<th>Parent-rated SDQ prosocial scale (abnormal + borderline) **</th>
<th>Teacher-rated SDQ total scale (abnormal + borderline)</th>
<th>Teacher-rated SDQ prosocial scale (abnormal + borderline)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No (n = 495)</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td>Yes (n = 1122)</td>
<td>1.2 (0.8–1.7)</td>
<td>0.9 (0.7–1.2)</td>
<td>0.8 (0.6–1.2)</td>
<td>1.1 (0.8–1.6)</td>
</tr>
<tr>
<td>P***</td>
<td>0.37</td>
<td>0.53</td>
<td>0.25</td>
<td>0.46</td>
</tr>
<tr>
<td>Number of binge drinking episodes in pregnancy</td>
<td>Parent-rated SDQ total scale (abnormal + borderline)**</td>
<td>Parent-rated SDQ prosocial scale (abnormal + borderline) **</td>
<td>Teacher-rated SDQ total scale (abnormal + borderline)</td>
<td>Teacher-rated SDQ prosocial scale (abnormal + borderline)</td>
</tr>
<tr>
<td>0 (n = 495)</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td>1 (n = 783)</td>
<td>1.3 (0.9–1.9)</td>
<td>1.0 (0.7–1.3)</td>
<td>0.8 (0.6–1.2)</td>
<td>1.1 (0.8–1.6)</td>
</tr>
<tr>
<td>2 (n = 225)</td>
<td>0.9 (0.5–1.5)</td>
<td>0.7 (0.4–1.1)</td>
<td>0.9 (0.5–1.5)</td>
<td>1.2 (0.7–2.1)</td>
</tr>
<tr>
<td>≥3 (n = 114)</td>
<td>1.1 (0.5–2.1)</td>
<td>1.1 (0.6–2.0)</td>
<td>0.6 (0.3–1.3)</td>
<td>1.3 (0.7–2.4)</td>
</tr>
<tr>
<td>P***</td>
<td>0.36</td>
<td>0.42</td>
<td>0.52</td>
<td>0.82</td>
</tr>
<tr>
<td>Timing of binge drinking episodes in pregnancy (gestational week)</td>
<td>Parent-rated SDQ total scale (abnormal + borderline)**</td>
<td>Parent-rated SDQ prosocial scale (abnormal + borderline) **</td>
<td>Teacher-rated SDQ total scale (abnormal + borderline)</td>
<td>Teacher-rated SDQ prosocial scale (abnormal + borderline)</td>
</tr>
<tr>
<td>No binge drinking (n = 495)</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td>1–2 (n = 237)</td>
<td>1.3 (0.8–2.1)</td>
<td>0.8 (0.5–1.2)</td>
<td>0.8 (0.5–1.3)</td>
<td>1.2 (0.8–1.9)</td>
</tr>
<tr>
<td>3–4 (n = 261)</td>
<td>1.4 (0.9–2.2)</td>
<td>1.0 (0.7–1.5)</td>
<td>0.8 (0.5–1.2)</td>
<td>0.9 (0.6–1.5)</td>
</tr>
<tr>
<td>5–8 (n = 216)</td>
<td>1.0 (0.6–1.7)</td>
<td>0.9 (0.6–1.5)</td>
<td>1.0 (0.6–1.6)</td>
<td>1.3 (0.8–2.1)</td>
</tr>
<tr>
<td>≥9 (n = 234)</td>
<td>1.2 (0.7–1.9)</td>
<td>1.0 (0.6–1.6)</td>
<td>1.1 (0.7–1.8)</td>
<td>1.4 (0.8–2.3)</td>
</tr>
<tr>
<td>Multiple episodes (n = 174)</td>
<td>0.8 (0.5–1.4)</td>
<td>0.8 (0.5–1.3)</td>
<td>0.7 (0.4–1.3)</td>
<td>1.3 (0.8–2.2)</td>
</tr>
<tr>
<td>P***</td>
<td>0.44</td>
<td>0.90</td>
<td>0.59</td>
<td>0.60</td>
</tr>
</tbody>
</table>

*SDQ total scale and SDQ prosocial scale.

**The abnormal and borderline range: three binary scores are generated indicating abnormal versus normal, borderline versus normal, and (abnormal + borderline) versus normal for the total difficulties score and the categorised prosocial score. Only the abnormal + borderline range is reported in the table, representing the range of behavioural difficulties reported in the children.

***Adjusted for all potential confounding factors: parental education, maternal IQ, prenatal maternal smoking, child age at testing, child gender, low to moderate alcohol consumption, maternal age, parity, maternal marital status, family home environment, postnatal parental smoking, prepregnancy maternal BMI, and the child’s health status.

****P value for the hypothesis of no difference in SDQ scores across levels of binge drinking.
timing with exposure and with the specific unfavourable behaviours may have been diluted if either were sensitive to a specific gestational time period. If the harmful effects of average maternal consumption or binge drinking occur mainly later in pregnancy (i.e. in the late second or third trimester), when the growth and development of the central nervous system is rapid, our study could not assess such risk.

In general, information bias, in particular misclassification because of under-reporting, is a possibility in all studies of alcohol intake during pregnancy, as reliable biomarkers are not currently available. Compared with other studies, under-reporting in this study may have been reduced because we used methods shown to yield valid and reliable information among Danish pregnant women, and because the consumption of small quantities of alcohol during pregnancy was generally not considered to be problematic in Denmark during the time of data collection.

Finally, in studies with null effects, a lack of sufficient statistical power must be considered, especially when potentially subtle effects are investigated. In this study and the other LDPS studies the small number of women drinking nine or more drinks per week is an obvious weakness.

Even so, the LDPS has important strengths compared with many previous studies, in particular the large sample consisting of a relatively homogenous population of middle-class women who generally are not stigmatised for consuming small quantities of alcohol during pregnancy. In addition, the LDPS includes a wide range of potential confounding factors. None of the previous studies of alcohol and behaviour adjusted for all of the confounding factors included in this study. In particular, we controlled for maternal IQ and parental education, which are important confounding factors that may have resulted in residual confounding in many previous studies.

Interpretation

There are a number of previous reports of effects of heavy alcohol exposure on behaviour and neurobehavioural outcomes, but studies evaluating the effects of low quantities of alcohol are rare. Recently, LDPS studies of low to moderate maternal alcohol consumption and binge drinking during early pregnancy have consistently observed non-significant associations with intelligence, executive functions, and sustained and selective attention, as well with as motor functions. These results are consistent with the findings of the present study, which are also consistent with a recent British study using SDQ as one of several outcomes. The study observed no increased risk of socio-emotional difficulties or cognitive deficits in children born to light drinkers compared with children born to mothers that did not consume any alcohol during pregnancy. Two Australian studies have used the CBCL to evaluate effects of prenatal alcohol exposure. One study found no evidence of increased risk of behavioural problems in children exposed to light or moderate consumption. The other study confirmed the results for light consumption, but found increased risk associated with moderate or higher exposure. The latter study controlled parental income, but not parental education or maternal intelligence, which tend to be the most important confounding factors in studies of neurobehavioural outcomes.

The lack of statistically significant findings in the present study suggests that any true effects of low to moderate alcohol consumption and maternal binge drinking on child behaviour may be subtle and difficult to detect with current measures of neurodevelopment, such as the SDQ, or that there are no effects. A null effect always raises the possibility that the study design and the chosen measures were not sensitive enough to detect a true effect; however, for low maternal consumption our results are supported by consistent negative findings in previous studies, and in LDPS studies with behavioural and cognitive outcomes. For average consumption in the LDPS, the exposure primarily represented the lower tail of the distribution for the low and moderate consumption categories, suggesting that our findings are more in line with occasional weekly drinking (one or two drinks) or, at most, levels of less than one drink per day. Thus, a conservative interpretation of the LDPS studies is that one or two drinks per week were not associated with detectable effects on offspring behavioural and cognitive development. For binge drinking the observed lack of association can obviously not be generalised to studies using other definitions of binge drinking or focusing on different timings in relation to pregnancy.

From a public health perspective it is important that neither the LDPS studies nor the general scientific literature have established a safe level of alcohol consumption during pregnancy, and that low and moderate maternal alcohol consumption and binge drinking may compromise other developmental outcomes and increase the risk for other adverse outcomes, such as fetal death. Consequently, negative findings in studies of behavioural and cognitive development should not alone lead to changes in health policies, and therefore the conservative advice is for women to abstain from alcohol, a known teratogen, during pregnancy.

Future studies of the possible effects of minimal alcohol consumption during pregnancy should be designed to overcome the potential weaknesses of the LDPS studies. They should include a more precise assessment of exposure with possible biological markers of alcohol consumption, a large sample with concomitant statistical power, and comprehensive outcome assessments of children at different ages.
Disclosure of interests
None to declare.

Contribution to authorship
USK, CHD, NIL, and ELM contributed to the design of the Lifestyle During Pregnancy Study. AS wrote the first draft of the article, and MISK and TW conducted the statistical analyses. All authors contributed to the interpretation of the results and assisted with critical comments and revisions of the article.

Details of ethics approval
The study was approved by the DNBC Board of Directors, the DNBC Steering Committee, the regional Ethics Committee, the Danish Data Protection Agency, and the Institutional Review Board at the Centers for Disease Control and Prevention. Signed informed consent was obtained for the LDPS.

Funding
This study was supported primarily by the Centers for Disease Control and Prevention (CDC), Atlanta, Georgia, USA.

Acknowledgements
The primary support for this study was provided by the Centers for Disease Control and Prevention (CDC), Atlanta, Georgia, USA. The Danish National Research Foundation established the Danish Epidemiology Science Centre that initiated and created the Danish National Birth Cohort. Furthermore, the cohort was the result of a major grant from this foundation. Additional support for the Danish National Birth Cohort was obtained from the Pharmacy Foundation, the Augustinus Foundation, the March of Dimes Birth Defects Foundation, the Augustinus Foundation, and the Health Foundation. The authors would like to thank all of the participants for their time and effort.

References


