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# Binge Pattern of Alcohol Consumption During Pregnancy and Childhood Mental Health Outcomes: Longitudinal Population-Based Study

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**What's Known on This Subject**

Alcohol consumption during pregnancy is a risk factor for childhood mental health and learning problems. A recent systematic review recommended research that distinguishes between risks related to intermittent binge drinking and those related to regular background levels of drinking.

**What This Study Adds**

The occasional consumption of ≥4 drinks per day during pregnancy is associated with child mental health problems in the absence of moderate daily levels of drinking. The main risks relate to hyperactivity and inattention problems.

## ABSTRACT

OBJECTIVE. Patterns of alcohol consumption during pregnancy such as episodes of binge drinking may be as important as average levels of consumption in conferring risk for later childhood mental health and learning problems. However, it can be difficult to distinguish risk resulting from episodic or regular background levels of drinking. This large study investigates whether patterns of alcohol consumption are independently associated with child mental health and cognitive outcomes, whether there are gender differences in risk, and whether occasional episodes of higher levels of drinking carry any risk in the absence of regular daily drinking during pregnancy.

METHODS. This prospective, population-based study used data from the Avon Longitudinal Study of Parents and Children. We investigated the relationships between a binge pattern of alcohol use (consumption of ≥4 drinks in a day) in the second and third trimesters of pregnancy and childhood mental health problems at 47 and 81 months of age ($n$ = 6355 and 5599, respectively). In a subgroup, we also investigated these relationships with child IQ at 49 months of age ($n$ = 924).

RESULTS. After controlling for a range of prenatal and postnatal factors, any episodes of consuming ≥4 drinks in a day were independently associated with higher risks for mental health problems (especially hyperactivity/inattention) in girls at the age of 47 months and in both genders at 81 months. There was no association with IQ scores at 49 months after adjustment for confounders. The consumption of ≥4 drinks in a day continued to carry risk for mental health problems (especially hyperactivity/inattention) in the absence of regular daily drinking.

CONCLUSIONS. The consumption of ≥4 drinks in a day on an occasional basis during pregnancy may increase risk for child mental health problems in the absence of moderate daily levels of drinking. The main risks seem to relate to hyperactivity and inattention problems. *Pediatrics* 2009;123:e289–e296

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**Key Words**
pregnancy, prenatal alcohol exposure, alcohol drinking, fetal alcohol spectrum disorder, mental health problems, hyperactivity, IQ, ALSPAC

**Abbreviations**
ALSPAC—Avon Longitudinal Study of Parents and Children
CI—confidence interval
SDQ—Strengths and Difficulties Questionnaire

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HEAVY LEVELS OF alcohol consumption during pregnancy are associated with adverse effects such as fetal alcohol syndrome. In contrast, there are mixed findings as to whether moderate (1–2 drinks per day) average levels of alcohol consumption during pregnancy are associated with childhood learning and mental health problems.[1–10] These discrepancies may reflect that intermittent episodes of heavier drinking such as binge episodes are obscured when investigating average levels. Drinking patterns may be as important as total amounts consumed in conferring risk for childhood behavioral and learning problems.[11–16] However, these findings are also inconsistent, which may reflect the choice and size of the sample, the timing and measurement of the exposure and outcomes, and limited measures of the range of potential confounders of the association between maternal drinking behavior and children's mental health.[10,17–19]

A recent systematic review has highlighted the need for research that distinguishes between adverse neurodevelopmental effects from intermittent binge drinking during pregnancy from those relating to regular background

**TABLE 1** Relationships Between Prenatal and Child Factors and Availability of Alcohol Consumption Data at 32 Weeks

| | Data Available ($n = 8240$) | Not Asked ($n = 3460$) | Missing Data ($n = 930$) | $\chi^2$ (2 *df*) | *P* |
|---|---|---|---|---|---|
| Prenatal factors | | | | | |
| Maternal age ≥ 35 y, % | 11 | 11 | 6 | 19.64 | <.001 |
| Any smoking, % | 19[a] | 19 | 35 | 150.85 | <.001 |
| Cannabis use, % | 2 | 2 | 5 | 28.70 | <.001 |
| Illicit drug use, % | 0.4 | 0.5 | 0.9 | 3.60 | .166 |
| Parity ≥ 1, % | 56 | 54 | 59 | 5.92 | .052 |
| Highest maternal education, O level or above, % | 71 | 71 | 36 | 27.57 | <.001 |
| Own home, % | 76 | 75 | 47 | 298.55 | <.001 |
| Currently married, % | 77 | 78 | 56 | 169.06 | <.001 |
| Maternal depression, % | 13 | 15 | 21 | 49.18 | <.001 |
| ≥4 drinks at 14–18 wk gestation, % | 16 | 18 | 23 | 24.54 | <.001 |
| Child factors | | | | | |
| Gestational age ≤ 36 wk, % | 4 | 5 | 10 | 48.28 | <.001 |
| Nonwhite ethnicity, % | 4 | 5 | 5 | 3.28 | .194 |
| Male gender, % | 51 | 52 | 53 | 0.77 | .679 |
| Birth weight, mean (SD), kg | 3.44 (0.52) | 3.42 (0.54) | 3.28 (0.62) | [b] | <.001 |

[a] Daily frequency of smoking during pregnancy by mothers who provided alcohol consumption data at 32 weeks' gestation: 81.4% none, 3.6% 1–4, 4.7% 5–9, 4.4% 10–14, 2.7% 15–19, 2.1% 20–24, 0.5% 25–29, and 0.2% ≥30 times (data missing in 0.3%).
[b] F statistic, F = 35.81.

levels of drinking.[20] For women, 4 drinks per occasion (equivalent to 5–6 UK units) is defined by the National Institute on Alcohol Abuse and Alcoholism as a "binge" drinking pattern.[21] Studies that have separated out women who binge drink and/or drink daily or heavily have been hindered by small sample sizes and possible selection bias.[17,20] In a large representative population sample, we examined whether patterns of alcohol consumption during pregnancy are associated with child mental health and cognitive outcomes. Given our recent findings suggesting a possible greater vulnerability in girls from occasional drinking during pregnancy,[22] we also investigated gender differences in risk and whether episodes of heavy drinking carry risk in the absence of regular daily drinking.

## METHODS

### Sample

The Avon Longitudinal Study of Parents and Children (ALSPAC) is a prospective, population-based study in England.[23] All pregnant women in the Avon area with an expected delivery date between April 1991 and December 1992 were invited to take part. Approximately 85% ($n = 14\,541$) of eligible women participated. Participants were broadly representative of the local population of mothers with infants and comparable against national census data, although were slightly more likely to be white, married or cohabiting, and home owners/occupiers (additional details available at www.alspac.bris.ac.uk).[22] Detailed information was obtained at regular intervals during the pregnancy and since the birth. In addition, a 10% subsample of children ("children in focus") born within the last 6 months of the survey have been seen in a research clinic for more detailed assessments. Ethical approval was obtained from the Local Research Ethics and ALSPAC Ethics and Law Advisory Committees.

This study is based on children from singleton births (to minimize clustering effects) alive at 1 year of age ($n = 13\,617$). Through postal questionnaires, information on alcohol use at 18 weeks' gestation was provided by 93% ($n = 12\,630$) of mothers. Of these respondents, 65% ($n = 8240$) provided additional information at 32 weeks' gestation. This discrepancy reflects 3460 (27%) mothers who were not asked these questions in the initial version of the 32-week questionnaire and missing data from 930 (7%) mothers. There seemed to be no sampling bias involving mothers not asked these questions (Table 1), but nonresponse was associated with earlier alcohol use and measured confounder variables (outlined below).

### Measures

*Exposure Variables*

Alcohol consumption during pregnancy was measured in 2 ways:

1. Pattern of drinking (primary exposure variable): at both 18 and 32 weeks' gestation, the mother was asked the number of days in the previous 4 weeks that she had consumed at least 4 U of alcohol. Examples specified that 1 drink was equivalent to 1 U (8 g) of alcohol. Response categories were 0, 1 to 2, 3 to 4, 5 to 10, or >10 days. For the analyses, we compared any days versus none.
2. Frequency and quantity of drinking (termed "frequency" in the article): at 18 weeks, the mother was asked her frequency and amount of drinking during the previous 2 weeks or around the time she first felt the infant move. Response categories were never, <1 glass per week, ≥1 glass per week, 1 to 2 glasses a

**TABLE 2 Correlates of Consuming ≥4 Drinks in a Day During Pregnancy**

| | <4 Drinks per Day ($n = 6259$) | ≥4 Drinks per Day ($n = 1981$) | $\chi^2$ (1 *df*) | *P* |
|---|---|---|---|---|
| Prenatal factors | | | | |
| Maternal age ≥ 35 y, % | 10 | 11 | 1.39 | .238 |
| Any smoking, % | 15 | 30 | 218.72 | <.001 |
| Cannabis use, % | 1 | 4 | 70.65 | <.001 |
| Illicit drug use, % | 0.3 | 0.8 | 7.99 | .005 |
| Parity ≥ 1, % | 54 | 61 | 28.31 | <.001 |
| Highest maternal education, O level or above, % | 74 | 63 | 82.89 | <.001 |
| Own home, % | 78 | 70 | 62.66 | <.001 |
| Currently married, % | 79 | 68 | 101.51 | <.001 |
| Maternal depression, % | 11 | 18 | 62.83 | <.001 |
| Child factors | | | | |
| Gestational age ≤ 36 wk, % | 5 | 4 | 0.00 | .951 |
| Nonwhite ethnicity, % | 5 | 4 | 0.02 | .881 |
| Male gender, % | 51 | 52 | 0.42 | .519 |
| Birth weight, mean (SD), kg | 3.44 (0.52) | 3.44 (0.54) | [a] | .804 |

[a] *t* test, $t = 0.25$.

day, 3 to 9 glasses a day, or ≥10 glasses a day. At 32 weeks, she was asked the amount she usually drinks per day at present. We defined daily drinking as an average of ≥1 drink a day at either time point.

Information on alcohol consumption at other times was also obtained:

1. Prepregnancy: at 18 weeks' gestation, the mother was asked about her usual drinking habits before the pregnancy. Response categories were the same as the frequency options described above.
2. First trimester: this information was also collected at 18 weeks by using the same frequency options. On the basis of our previous work, the groups consuming ≥1 glass per week were combined.[22]
3. Postnatal: when the child was aged 47 months (the primary outcome point), the mother was asked about her drinking during the previous week. Her maximum daily consumption was used to indicate postnatal episodic heavy drinking.

### Outcome Variables

Child mental health was measured by using the parent-completed Strengths and Difficulties Questionnaire (SDQ) at 47 and 81 months of age.[24] This widely used measure has been validated in a large community sample.[25] It is a dimensional measure with subscales (0–10) for hyperactivity/inattention, conduct problems, emotional symptoms, and peer relationships. Our analyses focused on the total score (0–40), conduct problems, and hyperactivity/inattention.

Among the children in focus group, cognitive outcomes were measured at 49 months of age by using IQ data from the Wechsler Preschool and Primary Scale of Intelligence.[26] The assessments were administered individually by trained psychology assistants who were blind to the exposure. Age-standardized scores were used to calculate performance and verbal and total IQ scores.

### Confounder Variables

Potential confounding factors associated with alcohol consumption and childhood mental health and learning outcomes that were measured in ALSPAC were included in the analyses. Maternal and sociodemographic variables obtained during pregnancy were categorized for analysis: maternal age (≤20, 21–34, or ≥35 years); parity (none or ≥1); highest level of maternal education ("O" levels or not); daily frequency of smoking at 18 weeks' gestation (response categories were 0, 1–4, 5–9, 10–14, 15–19, 20–24, 25–29, and ≥30 times); and use of cannabis and other illicit drugs in pregnancy, home ownership, and whether currently married (all yes/no). Maternal mental health was measured at 18 weeks' gestation and when the child was 33 months of age by using the Edinburgh Postnatal Depression Scale.[27] High scores (>12) are highly associated with a diagnosis of a depressive disorder.[28] Child factors included gestational age (≤36 or ≥37 weeks), birth weight, gender, and ethnicity.

### Analysis

The main focus was the associations between the consumption of ≥4 drinks in a day (exposure) at either 14 to 18 or 28 to 32 weeks' gestation and child SDQ scores at 47 months of age. The sample consisted of 8240 children whose mothers provided information on alcohol use at both 18 and 32 weeks' gestation. The analyses involved the following steps:

1. We identified the relationships between the exposure and confounder variables (Table 2). To check for possible selection bias at 47 months of age, we also examined whether SDQ response status was associated with the exposure and confounder variables.
2. We explored the relationships between prepregnancy daily alcohol use and SDQ scores by using multivariable linear regression analyses, adjusting for the confounder variables, to provide adjusted regression co-

**TABLE 3 Relationships Between Drinking Patterns and Mean Differences in 47-Month SDQ Scores**

| | Unadjusted (95% CI) | *P* | Adjusted (95% CI)[a] | *P* | *P* for Gender Interaction[b] |
|---|---|---|---|---|---|
| Whole sample | | | | | |
| Conduct problems (0–10) | 0.21 (0.13 to 0.29) | <.001 | 0.06 (−0.03 to 0.15) | .161 | .184 |
| Hyperactivity/inattention (0–10) | 0.40 (0.27 to 0.53) | <.001 | 0.25 (0.11 to 0.40) | .001 | .321 |
| Total problems (0–40) | 0.87 (0.61 to 1.14) | <.001 | 0.46 (0.17 to 0.74) | .002 | .037 |
| Boys | | | | | |
| Conduct problems (0–10) | 0.16 (0.04 to 0.27) | .007 | 0.00 (−0.12 to 0.13) | .894 | |
| Hyperactivity/inattention (0–10) | 0.33 (0.14 to 0.51) | .001 | 0.18 (−0.02 to 0.39) | .079 | |
| Total problems (0–40) | 0.59 (0.22 to 0.97) | .002 | 0.16 (−0.24 to 0.57) | .430 | |
| Girls | | | | | |
| Conduct problems (0–10) | 0.27 (0.15 to 0.38) | <.001 | 0.13 (0.00 to 0.25) | .047 | |
| Hyperactivity/inattention (0–10) | 0.46 (0.27 to 0.65) | <.001 | 0.33 (0.13 to 0.54) | .002 | |
| Total problems (0–40) | 1.15 (0.79 to 1.52) | <.001 | 0.80 (0.40 to 1.21) | <.001 | |

[a] Adjusted for maternal age, parity, highest level of maternal education, daily frequency of smoking during the second trimester, use of cannabis and/or other illicit drugs in pregnancy, home ownership, whether currently married, high scores (>12) on the Edinburgh Postnatal Depression Scale, and child gestational age, birth weight, gender, and ethnicity.
[b] In unadjusted model.

efficients (as per previous investigations by using the SDQ).[29] These quantified the level of possible risk associated with background alcohol consumption as opposed to the risk from intrauterine exposure.

3. The univariable relationships between the main exposure (≥4 drinks in a day during pregnancy) and SDQ scores were examined before adjusting for the confounder variables to provide adjusted regression coefficients. Assessment was made for gender interaction within the unadjusted models before univariable and multivariable linear regression analyses were repeated separately for each gender (Table 3).
4. Three sets of sensitivity analyses were performed. First, given our previous findings, the analyses were repeated after adjusting for first trimester alcohol consumption.[22] Second, as the child's birth weight might be on the causal pathway between prenatal alcohol exposure and neurodevelopmental problems, the analyses were repeated after omitting birth weight from the model. Third, the analyses were repeated after adjusting for risk factors in the postnatal environment (Edinburgh Postnatal Depression Scale at 33 months and maximum alcohol consumption at 47 months).
5. To examine whether episodes of heavier drinking carry risk in mothers who do not drink daily during pregnancy, the analyses in step 3 were repeated by using a 4-level variable based on pattern (≥4 drinks in a day) and frequency (daily drinking) of drinking. We compared, in turn, 3 subgroups of mothers (daily but not ≥4, ≥4 but not daily, ≥4 and daily) against the baseline group (not daily nor ≥4).
6. Steps 2, 3, and 5 were repeated by using the 81-month SDQ data to explore longer-term outcomes. Finally, linear regression analyses were repeated with the IQ data to examine neurodevelopmental outcomes independent of parental report.

## RESULTS

Overall, 24% (1981 of 8240) of mothers reported at least 1 occasion during pregnancy of consuming ≥4 drinks in a day. Over half (56% and 57% at each time point) of these mothers consumed ≥4 drinks on only 1 to 2 days in the previous month. SDQ results were available on 6355 children at 47 months and on 5599 at 81 months. Mothers who consumed ≥4 drinks were less likely than other mothers to provide SDQ results at 47 months (74% vs 78%; $\chi^2 = 16.57$; $P < .001$) or 81 months (64% vs 69%; $\chi^2 = 23.94$; $P < .001$). Other maternal correlates of nonresponse at 47 months included younger age, higher parity, smoking, use of cannabis and other illicit drugs, depression, being unmarried, rented tenure, and lower level of education. However, among responders, SDQ score distributions were in keeping with expected population distributions (www.sdqinfo.com).

### Relationships Between Alcohol Consumption and Outcomes

There was an interaction between child gender and alcohol exposure in relation to total problems at 47 months of age (Table 3). In the univariable analyses, the consumption of ≥4 drinks was associated with behavioral and total problems in both genders (with effect sizes of up to 0.25 of a SD). After adjustment for confounders, the associations between alcohol exposure and later problems were stronger in girls than in boys. The associations in girls remained in all 3 sensitivity analyses (omitting birth weight from the model and after adjustment for first trimester alcohol consumption and postnatal variables).

At 81 months of age, there were similar associations in the univariable analyses and no evidence of gender interactions (Table 4). The associations persisted after adjustment for confounders. As prepregnancy daily alcohol consumption was associated with higher hyperactivity/inattention scores at 81 months (adjusted regression coefficients = 0.22; 95% confidence interval [CI]:

**TABLE 4 Relationships Between Drinking Patterns and Mean Differences in 81-Month SDQ Scores**

| | Unadjusted (95% CI) | *P* | Adjusted (95% CI)[a] | *P* | *P* for Gender Interaction[b] |
|---|---|---|---|---|---|
| Conduct problems (0–10) | 0.25 (0.16 to 0.34) | <.001 | 0.12 (0.02 to 0.22) | .020 | .390 |
| Hyperactivity/inattention (0–10) | 0.37 (0.22 to 0.51) | <.001 | 0.19 (0.04 to 0.35) | .017 | .671 |
| Total problems (0–40) | 0.78 (0.48 to 1.07) | <.001 | 0.36 (0.04 to 0.68) | .026 | .594 |

[a] Adjusted for maternal age, parity, highest level of maternal education, daily frequency of smoking during the second trimester, use of cannabis and/or other illicit drugs in pregnancy, home ownership, whether currently married, high scores (>12) on the Edinburgh Postnatal Depression Scale, and child gestational age, birth weight, gender, and ethnicity.
[b] In unadjusted model.

0.02–0.41; $P = .033$), the multivariable analysis was repeated after adjusting for this. The consumption of ≥4 drinks in a day during pregnancy continued to show an association with hyperactivity/inattention scores (adjusted regression coefficients = 0.17; 95% CI: 0.00–0.33; $P = .044$), and there was no longer an association with prepregnancy alcohol consumption, suggesting that intrauterine exposure carried a risk for hyperactivity/inattention problems.

IQ data were available on 924 children. Compared with the wider sample, maternal correlates of nonavailability of IQ data included smoking (but not alcohol consumption), depression, being unmarried, rented tenure, and lower level of education. In the univariable analyses, the consumption of ≥4 drinks was associated with lower IQ scores (Table 5). The effect sizes were similar to those involving the SDQ, although the associations did not remain in the multivariable analyses.

### Relationships Between Patterns and Frequency of Drinking and Outcomes

At either the 18- or 32-week time point, 9% (589 of 6563) of mothers reported drinking daily in the preceding month. When comparing the "≥4 but not daily" subgroup with the baseline group (not daily nor ≥4), there was an association with higher hyperactivity/inattention scores at both time points after adjustment for confounders (Table 6). There was also an association with greater total problems in girls at 47 months of age. These findings suggest that the risk from ≥4 drinks on 1 or more days during pregnancy was not contingent on daily drinking. The "≥4 and daily" subgroup was small, which may have precluded the demonstration of associations, although there was a consistent pattern at 81 months of age involving the largest regression coefficients when compared against the baseline group.

**TABLE 5 Relationships Between Drinking Patterns and Mean Differences in IQ**

| | Unadjusted (95% CI) | *P* | Adjusted (95% CI)[a] | *P* |
|---|---|---|---|---|
| Performance IQ | −3.05 (−0.80 to −5.30) | .008 | −1.92 (0.38 to −4.22) | .101 |
| Verbal IQ | −2.57 (−0.50 to −4.64) | .015 | −1.54 (0.57 to −3.64) | .153 |
| Total IQ | −3.18 (−1.02 to −5.35) | .004 | −1.96 (0.22 to −4.14) | .077 |

[a] Adjusted for maternal age, parity, highest level of maternal education, daily frequency of smoking during the second trimester, use of cannabis and/or other illicit drugs in pregnancy, home ownership, whether currently married, high scores (>12) on the Edinburgh Postnatal Depression Scale, and child gestational age, birth weight, gender, and ethnicity.

## DISCUSSION

After controlling for a range of prenatal and postnatal confounding factors, we found that the consumption of ≥4 drinks in a day during pregnancy was independently associated with greater risk of mental health problems in girls at the age of 47 months and in both genders at 81 months of age. The main risks involved hyperactivity and inattention problems. This episodic pattern of drinking carried risk for these outcomes in the absence of moderate levels of daily drinking.

The multivariable analyses adjusted for a wide range of factors that were potentially associated with the exposure and outcome. Sensitivity analyses suggested that the 47-month outcomes were not explained by factors in the postnatal environment (maternal depression and high levels of drinking). The combination of adverse outcomes demonstrated here reflects a mixed pattern that has been described as alcohol-related neurodevelopmental disorder. Structural brain changes after prenatal alcohol exposure are consistent with possible difficulties with attention, learning, and executive function.[30] Our findings are in keeping with animal studies involving fetal exposure to peak levels of maternal blood alcohol with effects on neurodevelopment and hyperactivity.[30–32]

Findings are mixed about the association between prenatal alcohol exposure and attention-deficit/hyperactivity disorder.[33,34] Although some research suggests a possible association, even after controlling for prenatal smoking and parental alcohol abuse or dependence, findings based on children-of-twins or differentially exposed sibling-pair designs contradict this.[2,35–36] Conflicting findings might also reflect a gene-environment interaction.[37] Relatively few studies have examined the relationship between binge drinking and childhood hyperactivity/inattention; some have not found an association and others have not separated out binge episodes from daily drinking.[11,14,16]

Findings involving binge drinking and cognitive outcomes are inconsistent, with some studies finding no effects or effects on nonverbal IQ.[10,16–18] Other studies have reported persistent learning problems with particular risk from exposure to frequent binge episodes involving 5 to 6 drinks per occasion (40–60 g of alcohol).[8,11,13,15] After adjustment for confounders, we found no adverse effects on IQ related to 4 drinks per day (32 g of alcohol). However, we found a persistent effect for hyperactivity/inattention that was not contingent on

**TABLE 6** Relationships Between Drinking Patterns and Mean Differences in SDQ Scores in the Presence or Absence of Daily Drinking

| | Unadjusted (95% CI) | *P* | Adjusted (95% CI) | *P* |
|---|---|---|---|---|
| 47 mo (boys) | | | | |
| Conduct problems | | | | |
| Daily but not ≥4 | −0.06 (−0.37 to 0.25) | .708 | −0.06 (−0.38 to 0.27) | .724 |
| ≥4 but not daily | 0.20 (0.05 to 0.36) | .010 | 0.03 (−0.14 to 0.19) | .748 |
| ≥4 and daily | 0.17 (−0.06 to 0.41) | .145 | −0.01 (−0.27 to 0.24) | .931 |
| Hyperactivity/inattention | | | | |
| Daily but not ≥4 | −0.10 (−0.62 to 0.42) | .711 | 0.00 (−0.54 to 0.54) | .998 |
| ≥4 but not daily | 0.48 (0.23 to 0.73) | <.001 | 0.34 (0.07 to 0.61) | .015 |
| ≥4 and daily | 0.27 (−0.12 to 0.65) | .176 | 0.01 (−0.42 to 0.43) | .983 |
| Total problems | | | | |
| Daily but not ≥4 | −0.85 (−1.39 to 0.68) | .502 | −0.22 (−1.27 to 0.84) | .689 |
| ≥4 but not daily | 0.77 (0.27 to 1.28) | .003 | 0.28 (−0.25 to 0.81) | .304 |
| ≥4 and daily | 0.88 (0.12 to 1.65) | .024 | 0.24 (−0.59 to 1.06) | .577 |
| 47 mo (girls) | | | | |
| Conduct problems | | | | |
| Daily but not ≥4 | 0.00 (−0.27 to 0.28) | .988 | 0.03 (−0.26 to 0.33) | .820 |
| ≥4 but not daily | 0.26 (0.11 to 0.41) | .001 | 0.12 (−0.05 to 0.28) | .158 |
| ≥4 and daily | 0.15 (−0.08 to 0.39) | .204 | 0.05 (−0.21 to 0.30) | .710 |
| Hyperactivity/inattention | | | | |
| Daily but not ≥4 | −0.05 (−0.51 to 0.40) | .826 | 0.09 (−0.40 to 0.57) | .717 |
| ≥4 but not daily | 0.70 (0.46 to 0.95) | <.001 | 0.53 (0.27 to 0.80) | <.001 |
| ≥4 and daily | −0.01 (−0.40 to 0.38) | .967 | −0.14 (−0.57 to 0.28) | .505 |
| Total problems | | | | |
| Daily but not ≥4 | −0.28 (−1.17 to 0.60) | .533 | 0.03 (−0.92 to 0.97) | .953 |
| ≥4 but not daily | 1.52 (1.04 to 1.99) | <.001 | 1.10 (0.58 to 1.61) | <.001 |
| ≥4 and daily | 0.23 (−0.53 to 0.98) | .557 | −0.17 (−0.99 to 0.65) | .686 |
| 81 mo | | | | |
| Conduct problems | | | | |
| Daily but not ≥4 | 0.09 (−0.13 to 0.32) | .421 | 0.03 (−0.21 to 0.26) | .837 |
| ≥4 but not daily | 0.26 (0.14 to 0.38) | <.001 | 0.12 (−0.01 to 0.26) | .064 |
| ≥4 and daily | 0.27 (0.08 to 0.45) | .005 | 0.17 (−0.04 to 0.37) | .107 |
| Hyperactivity/inattention | | | | |
| Daily but not ≥4 | −0.01 (−0.37 to 0.36) | .963 | 0.09 (−0.29 to 0.46) | .655 |
| ≥4 but not daily | 0.44 (0.25 to 0.64) | <.001 | 0.29 (0.08 to 0.50) | .007 |
| ≥4 and daily | 0.54 (0.24 to 0.84) | <.001 | 0.35 (0.03 to 0.67) | .032 |
| Total problems | | | | |
| Daily but not ≥4 | 0.08 (−0.65 to 0.81) | .832 | 0.20 (−0.56 to 0.96) | .602 |
| ≥4 but not daily | 0.80 (0.40 to 1.19) | <.001 | 0.37 (−0.05 to 0.79) | .082 |
| ≥4 and daily | 0.99 (0.39 to 1.60) | .001 | 0.56 (−0.07 to 1.20) | .083 |

Range is 0 to 10 except "total problems" (0–40).

lower IQ. Follow-up studies into adulthood have also found that episodic binge drinking during pregnancy is associated with later substance use and other psychiatric disorders.[38,39]

### Gender Differences

As in our previous investigation of the effects of occasional drinking in the first trimester, we found a greater adverse effect from episodic drinking for girls at 47 months of age.[22] These associations remained after additionally adjusting for first trimester exposure. At 81 months of age, there was a similar pattern across both genders. It is not clear whether the possible mental health consequences of prenatal alcohol exposure occur earlier in girls or whether the effects are more readily demonstrable as there is less variation in SDQ scores. Animal studies also report gender differences in vulnerability to alcohol exposure,[40] and there is a need to better understand the pathways contributing to possible earlier vulnerability in girls.

### Methodologic Issues

A key strength of ALSPAC is the large data set on a representative population with prospectively collected measures of alcohol consumption. A quarter of pregnant women reported a pattern of consuming ≥4 drinks in a day, an amount which might have been consistent with social drinking. Our prevalence figure probably underestimates this pattern of drinking as it reflects 2 self-reported snapshots covering 8 weeks of pregnancy.[41] We were unable to pinpoint any specific risk period, and our findings may not generalize to binge drinking episodes at other times during pregnancy. It has been suggested that binge drinking before pregnancy recognition is associated with the greatest risk.[8,11] This might also reflect greater prevalence of drinking at this time and increased

power to demonstrate an effect. As sample attrition was greater among women who consumed ≥4 drinks per day, this may have led to an underestimate of the actual effect. In terms of measures, participants were asked the number of days rather than occasions on which they had consumed ≥4 drinks. This could have been interpreted as meaning ≥4 drinks over the course of a day rather than over a shorter time period, the latter exposing the fetus to higher peak alcohol levels. Despite adjustment for a large number of confounders relating to maternal, child, and socioeconomic factors, there remains a possibility of residual confounding especially involving paternal risk factors and postnatal factors such as parental episodic binge drinking, family dysfunction, and parental mental health problems (including hyperactivity/inattention).

### Clinical Implications

Although the adjusted regression coefficients and effects sizes were small, these were of a similar magnitude to other environmental risk factors for child mental health such as relative age within the academic school year and have implications at a population level.[29] Health professionals monitoring pregnant women should ask about and be aware of patterns of alcohol consumption during pregnancy because these may differ from regular drinking levels. Taken together with our earlier findings on the effects of occasional drinking in the first trimester,[22] there seem to be consistent effects on child mental health from both background low level alcohol consumption and occasional episodes of heavier drinking. By investigating the effects of episodic alcohol consumption beyond a particular threshold (in this case, ≥4 drinks), we highlight possible risks for women who might drink only occasionally but heavily. This has implications for health education and public health advice. For example, United Kingdom policy recommendations allow up to 4 drinks per week during pregnancy,[42] a message that could be misinterpreted in line with the drinking patterns studied here. Our findings might reflect the possible adverse effects from a perceived "safe" level of alcohol consumption and highlight the lack of a safe threshold.

## CONCLUSIONS

Our findings suggest that occasional episodes of consuming ≥4 drinks per day during pregnancy can carry a risk for children's mental health, particularly hyperactivity and inattention problems. There is a possible earlier vulnerability in girls, and the difficulties seem to persist over time. These findings require replication, especially in relation to binge drinking episodes at other periods during pregnancy.

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