Dietary patterns and alcohol consumption during pregnancy: secondary analysis of Avon Longitudinal Study of Parents and Children

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Abstract

Background

Large general population surveys show that heavy regular and episodic alcohol consumption are associated with lower intakes of fruits and vegetables, and higher intakes of processed and fried meat. This is of particular concern regarding pregnant women, as both alcohol intake and inadequate maternal nutrition are independently associated with adverse fetal outcomes. The current study aimed to determine associations between maternal dietary patterns and alcohol consumption during pregnancy.

Methods

Secondary analysis of data from the Avon Longitudinal Study of Parents and Children (ALSPAC). Women provided details of alcohol consumption at 18 weeks' gestation and diet at 32 weeks' gestation (n=9,839. Dietary patterns were derived from the food frequency questionnaire data using principal components analysis. Associations between alcohol consumption and dietary patterns were determined using multiple linear regression, adjusted for various socio-demographic and lifestyle factors.

Results

After adjustment, drinking ≥1 unit/day during the first trimester; $\beta=0.23$ (95% CI: 0.08, 0.38); $p=0.002$ and binge drinking (≥4 units in one day) during the first half of pregnancy; $\beta=0.14$ (95% CI: 0.07, 0.21); $p<0.0001$ were associated with greater adherence to the 'Processed' dietary pattern (high intakes of processed meat and low intakes of fruit and vegetables). Light to moderate alcohol consumption (≤1 drink/day) during the first trimester was associated with greater adherence to the 'Health conscious' dietary pattern (high intakes of fruit, vegetables, wholegrains and fish); $\beta=0.09$ (95% CI: 0.04, 0.14); $p<0.0001$.

Conclusions

Two important components of health behaviour during pregnancy appear to be related; greater consumption of processed foods associated with heavier alcohol consumption, and healthier dietary choices associated with light to moderate alcohol intake. Potential synergistic effects of these behaviours may have implications for

maternal and fetal health and warrant further investigation. A more holistic approach to addressing health behaviours in women of reproductive age is required.

Keywords: gestation; maternal health; heavy episodic drinking; nutrition; ALSPAC

Introduction

Alcohol consumption and unhealthy dietary choices, characterised by lower intakes of fresh fruit and vegetables and higher consumption of salt, saturated fat and free sugars, are both major health risk behaviours that contribute to the global burden of disease (Murray *et al.*, 2013). Evidence suggests that approximately two thirds of individuals in the UK engage with two or more health risk behaviours, such as poor diet, physical inactivity, alcohol consumption and smoking. However, they are commonly investigated in isolation. Based on 2008 data from the Health Survey for England, approximately 12% of women reported lack of adherence to the recommended level of fruit and vegetable consumption and excessive drinking (Buck and Frosini, 2012).

Previous observational studies involving the general adult population have investigated relationships between diet and alcohol consumption patterns. These suggest that both frequency and quantity of alcohol consumption is associated with particular dietary patterns. Three studies have shown that as mean daily alcohol consumption increased, intakes of fruits, vegetables and dairy products decreased, while red and processed meat and egg intakes increased (Ruf et al. 2005; Touvier et al. 2014). Another study, which compared dietary habits of current and never drinkers, found never drinkers to have a higher overall Healthy Eating Index (HEI) score (HEI scores represent an individual's adherence to various recommended dietary guidelines in the US), indicative of 'better quality' diet (Breslow *et al.*, 2010). Furthermore, as quantity of alcohol per occasion increased, overall diet quality decreased (Breslow, Guenther and Smothers, 2006). 'Binge' or heavy episodic drinking has also been associated with lower intakes of fruit and vegetables, higher intakes of red and processed meats, and an increased likelihood of skipping meals (Valencia-Martin, Galan and Rodriguez-Artalejo, 2011). Such diets are characterised by lower intakes and plasma concentrations of important micronutrients, in particular folate (Brevik et al. 2005).

Concomitant health risk behaviours such as consuming an unhealthy diet and exceeding recommended limits for alcohol consumption might have important implications for maternal and infant health if they persist into pregnancy. Both are independent risk factors for adverse infant and childhood outcomes, including low birth weight (LBW) (Patra et al. 2011) and poor cognitive function (Zuccolo et al. 2013).

Animal models of Fetal Alcohol Spectrum Disorder (FASD) have indicated that alcohol-induced harm to the fetus is exacerbated by inadequate intake of folate, choline, vitamins E and C and carotenoids (Cohen-kerem and Koren, 2003; Thomas *et al.*, 2010; Ballard, Sun and Ko, 2012; May *et al.*, 2014). Similar findings have been reported in recent studies with human subjects (Avalos *et al.*, 2011; Hutson *et al.*, 2012; Coles *et al.*, 2015). While these results indicate the effects of ethanol are exacerbated in the presence of poor maternal nutrition, they do not explore the relationships between dietary choices and alcohol consumption.

There is evidence to suggest that mothers of children with FASD have significantly lower intakes of key onmicronutrients compared with mothers of healthy children (May *et al.*, 2014, 2016). However, the dietary data collected as part of that study was collected seven years after birth, and since health-related behaviour may change once a woman becomes pregnant (Crozier *et al.*, 2009), it remains unclear whether the associations between dietary intake and alcohol consumption remain exist during pregnancy, a time of rapid growth and greater maternal demand for micronutrients. If this is indeed the case, then those mothers engaging in multiple health risk behaviours may be particularly at risk of adverse pregnancy outcomes.

To date, the majority of research exploring the role of diet in FASD has focused on the mediating effect of single nutrients. Whilst this method can provide valuable insight into the relationships between diet and health, nutrients are consumed as part of a diet, and in various combinations that may be interactive. Dietary patterns provide a broader representation of dietary intake and help to overcome the intercorrelations between foods and nutrients (Hu, 2002). Furthermore, studies have derived dietary patterns that include alcohol as a dietary component, however, less is known about how these two behavioural determinants are associated when alcohol is not included in the dietary pattern analysis and considered separately.

The aim of this study was to determine the association between frequency and quantity of alcohol consumption, binge consumption and dietary patterns during pregnancy using prospectively collected data from the Avon Longitudinal Study of Parents and Children (ALSPAC).

Materials and Methods

Study design and participants

We conducted a secondary analysis of data from the ALSPAC cohort, a population-based study of pregnant women from the West of England and their subsequent children. Participants were followed from eight weeks' gestation to the present day (Golding *et al.*, 2001). ALSPAC recruitment methods have previously been described in detail (Boyd et al. 2012). Briefly, women were invited to participate if they resided in a pre-defined area within the county of Avon and their estimated delivery date was between 1st April 1991 and 31st December 1992. Initially, 14,541 pregnant women were recruited into the study; a total of 647 women were excluded, due to unknown outcomes or non-live births, leaving 13,761 unique women enrolled; a total of 14,062 live births. Women were eligible for inclusion in the current analysis if they had a live, singleton birth, provided details of alcohol consumption at 18 weeks' gestation and dietary intake at 32 weeks' gestation.

Ethical approval for the study was obtained from the ALSPAC Ethics and Law Committee and the Local Research Ethics Committee. Please note that the study website contains details of all the data that is available through a fully searchable data dictionary http://www.bris.ac.uk/alspac/researchers/data-access/data-dictionary/.

Alcohol consumption

Women completed a questionnaire at 18 weeks' gestation gathering self-reported frequency and quantity of alcohol consumption during the first trimester and episodes of binge drinking during the past month. We explored frequency and quantity of alcohol consumption during the first trimester hereafter referred to as 'regular' consumption as it describes average consumption across a three-month period (approximately). Responses included 'Never', 'Less than 1 glass per week', 'More than 1 glass per week', '1-2 glasses everyday', '3-9 glasses per day', and '10+ glass per day'. Due to low numbers in the higher frequency categories, the three highest categories were grouped together as '1+ glasses per day'. One glass was defined as one pub measure of spirits, one half pint of lager or cider, or one small glass of wine, which equates to approximately one unit (10ml ethanol).

Binge drinking was assessed by participants reporting the number of days during the past month (14-18 weeks' gestation) when they had drunk the equivalent of two 568ml pints of beer, four 125ml glasses of wine, or four 25ml pub measures of spirit, each equating to approximately four standard units (40ml ethanol). The available responses were: 'None', '1-2 days', '3-4 days', '5-10 days', 'More than 10 days' and 'Everyday'. Due to low numbers of women who reported more than 2 occasions of binge drinking during mid-pregnancy, this variable was dichotomized into 'non-binge drinkers' and 'binge drinkers', defined as a woman who reported drinking four or more units on at least one day during the past month. Although binge drinking in the UK is generally defined as the consumption of six or more units during any one occasion (HSCIC, 2014), it was defined within ALSPAC as four or more units and is consistent with other secondary analyses using data from the ALSPAC study (Alati et al. 2013). We have included this variable in the current analysis as it represents a pattern of drinking that is associated with higher blood alcohol concentrations (BAC) – an important factor in FASD - (Pierce and West, 1986) compared to average frequency and quantity of alcohol consumed that is also reported in ALSPAC.

Dietary assessment

At 32 weeks' gestation women completed a food frequency questionnaire (FFQ), reporting how often they were currently consuming 44 common food and drink items. The FFQ was adapted from a previous questionnaire (Yarnell et al. 1983).

Details of how the FFQ data were prepared have been reported in detail elsewhere (Rogers et al. 1998). Briefly, standard portion sizes were allocated to food and drink items in the FFQ using a UK reference guide (Food Standards Agency, 1988) and weekly intake frequencies were recoded as 0 (Never/Rarely), 0.5 (Once in 2 weeks), 2 (1-3 per week), 5.5 (4-7 per week) and 10 (More than 1 per day). For non-alcoholic beverages and bread women recorded the number of servings/slices consumed per day. Cooking methods and types of bread consumed were also reported. Milk quantity was calculated by summing standard amounts from all tea, coffee, cereal, puddings and drinks consumed weekly. Maternal dietary patterns did not include alcohol consumption variables because the sample population comprised of pregnant women, who report lower alcohol consumption levels compared with the general population; therefore, it is unlikely that heavy or binge drinking would have been a defining characteristic of a dietary pattern.

Potential confounding factors

A wide variety of socio-demographic and lifestyle data were collected at both 8 and 18 weeks' gestation and were explored as potential confounding variables in relation to alcohol consumption and dietary intake during pregnancy. These were: maternal age (<20, 20-24, 25-29 or ≥30 years); parity (none or ≥1); ethnicity (white, non-white); smoking (current smoker/non-smoker); highest level of maternal education (vocational, O-level, A-level, degree level); housing tenure (owner occupied, council/Housing Association (HA) rented, private rented/other); house crowding index (HCI), defined as the total number of people per household, divided by the total number of rooms (excluding the kitchen and bathrooms) (Melki *et al.*, 2004); living in a single parent household; and depression symptoms measured using the Edinburgh Postnatal Depression Scale (EPDS) score (Cox, Holden and Sagovsky, 1987). Women with EPDS scores of ≥13 are more likely to be suffering from depression than those with lower scores (Murray and Cox, 1990). **Table 1** presents details of how each variable is categorised.

Statistical analysis

The dietary patterns previously described by Northstone et al. (2008) were replicated in the present analysis. Briefly, PCA with a varimax rotation was performed on the 44 standardised food and drink items. Factor loadings represent the correlation between the original dietary variable and the factor (dietary pattern) and food items with factor loadings of ≥0.3 or ≤-0.3 suggested a strong positive or negative association, respectively, and were considered to clearly contribute to that dietary pattern. The five component (dietary pattern) scores represent a participant's adherence to each dietary pattern. Scores have a mean of zero; a value above or below zero indicates stronger or weaker adherence to that dietary pattern, respectively.

Participants with missing data on >10 food and drink items were excluded from the analysis. Those with ≤10 missing items were included and the missing data recoded as 0 (Never/Rarely). Unadjusted logistic regression models were used to assess differences (socio-demographic and lifestyle characteristics) between populations of women with and without dietary data (See supplementary data).

Participant characteristics and alcohol consumption variables are presented as frequencies and percentages. Dietary pattern component scores are presented as means and standard deviations. Unadjusted linear regression models were used to explore associations between alcohol consumption and dietary pattern scores. We fitted separate regression models for each dietary pattern to minimise the risk of multicollinearity. Linear regression models were then adjusted for maternal age, parity, ethnicity, smoking, education, HCI, housing tenure, living in a single parent household and EPDS score. Results are presented as effect sizes with 95% confidence intervals and p-values. All analyses were conducted using STATA 13.1.

Results

A total of 9,839 women were included in the current analysis. Women with missing dietary data were more likely to be younger, smoke and of lower socio-economic status (SES) (see supplementary data). The socio-demographic and lifestyle characteristics of women are presented in **Table 1**. Women of lower socio-economic status (SES) and those of non-white ethnic origin were underrepresented compared to women in the UK during the same time period (Fraser *et al.*, 2013); 13% lived in council or Housing Association rented accommodation; 5% scored >1 on the HCI and 2% were of non-white ethnicity. Approximately 2% of women reported drinking ≥1 unit per day during the first trimester and 7% of women reported binge drinking on at least one day during the previous month when assessed at 18 weeks' gestation.

A full description of the five dietary patterns are provided elsewhere (Northstone *et al.*, 2008). Briefly, the 'Health conscious' component was characterised by greater consumption of wholegrains, cereals, fruits, salad, fish, and lower intake of white bread. 'Traditional' was characterised by greater consumption of vegetables and potatoes. 'Processed' was characterised by greater consumption of white bread, fried foods, processed meats, and lower intakes of wholegrains. 'Confectionery' was characterised by greater consumption of chocolate, crisps, sweets and biscuits. 'Vegetarian' was characterised by low intakes of meat and high intakes of meat substitutes, nuts and pulses. The components accounted for a total of 31.3% of the variation.

'Regular' alcohol consumption

Light-to-moderate alcohol consumption (defined as <1 drink/day) during the first trimester was associated with higher 'Health conscious' dietary pattern scores compared with no drinking during the same period (β=0.12, 95%CI=0.06, 0.17; p<0.0001) (**Table 2**). It was also associated with higher 'Confectionery' scores (β=0.10, 95%CI=0.04, 0.16; p<0.0001). Heavy alcohol consumption (defined as 1+drinks/day) during the first trimester was associated with higher 'Processed' scores (β=0.17, 95%CI=0.03, 0.31; p=0.015) and higher 'Vegetarian' scores (β=0.23, 95%CI=0.09, 0.37; p=0.001), compared with women who reported never drinking alcohol during the first trimester.

After adjustment for confounding (**Table 2**), the association between light-to-moderate alcohol consumption with the 'Health conscious' dietary pattern remained significant (β=0.08, 95%CI=0.03, 0.13; p=0.002); the association with 'Confectionery' was strengthened (β=0.11, 95%CI=0.05, 0.17; p=001). Relationships between alcohol consumption during the first trimester and adherence to the 'Processed' dietary pattern remained (β=0.24, 95%CI=0.09, 0.39; p=0.002); as alcohol consumption during the first trimester increased 'Processed' dietary pattern scores increased (**Figure 1**).

Binge drinking

Before adjustment for confounding, at least one episode of binge drinking during 14-18 weeks of pregnancy was associated with higher scores of 'Processed' (β=0.23, 95%CI=0.17, 0.30; p<0.0001) and 'Vegetarian' (β=0.09, 95%CI=0.03, 0.16; p=0.007) dietary patterns, and lower scores of the 'Health conscious' (β=-0.28, 95%CI=-0.35, -0.21; p<0.0001) and 'Confectionery' (β=-0.07, 95%CI=-0.14, -0.01; p=0.034) dietary patterns (**Table 3**). Once adjusted for confounding, however, only the association with the 'Processed' dietary pattern remained (β=0.15, 95%CI=0.07, 0.22; p<0.0001) (**Figure 1**).

Discussion

The aim of this study was to determine the associations between maternal alcohol consumption and dietary patterns during pregnancy. Whilst a number of studies have explored aspects of maternal diet in relation to alcohol consumption, before, during and post pregnancy (Keen *et al.*, 2010; Weiss and Chambers, 2013; May *et al.*, 2014), this is the first study to explore maternal dietary patterns in relation to alcohol consumption during the antenatal period. The findings from this secondary analysis have highlighted the associations between two important health risk behaviours during pregnancy – alcohol consumption and dietary intake – and suggest that women who report drinking heavily during pregnancy may also have poorer quality diets, characterised by low intakes of fruit and vegetables and high intakes of processed and fried foods.

After adjusting for potential confounders, associations were evident between drinking one or more alcoholic drinks per day and adherence to the 'Processed' dietary pattern. Previous studies have explored associations between individual food groups or nutrients and alcohol consumption in the general population. A large cohort study conducted in France explored the dietary intake of approximately 73,000 adult women and found that fruit and vegetable intakes were lower in those who consumed approximately one or more alcoholic drinks per day (Kesse *et al.*, 2001). Another study conducted in France reported that women consuming alcohol were less likely to eat ≥400g of fruit and vegetables per week and more likely to eat ≥500g of red meat per week, compared with non-drinkers (Touvier et al. 2014).

Clear associations were also observed between binge drinking and adherence to the 'Processed' dietary pattern. A study conducted in the USA explored the drinking habits and Healthy Eating Index (HEI) scores of 772 women. The mean HEI score decreased by 5.6 points in women who consumed 3 or more drinks per occasion, compared with women who reported one per occasion, after adjusting for socio-demographic characteristics (Breslow et al. 2006). A study conducted in Madrid, Spain, explored binge drinking in a randomly selected sample of approximately 12,000 adults of the general population and found that people who reported heavy episodic drinking were more likely to consume fewer than three portions of fruit and vegetables per day, and more than one serving of meat per day, compared to never drinkers, after adjusting for all socio-demographic characteristics (Valencia-Martin, Galan and Rodriguez-Artalejo, 2011).

Light to moderate alcohol consumption was associated with adherence to the ‘Confectionery’ and ‘Health conscious’ dietary patterns. The ‘Confectionery’ dietary pattern was characterised by high intakes of sweets, cake and biscuits. While two studies have reported a decrease in sweet and sugary foods as alcohol consumption increased (Smith and Smith, 1994; Herbeth *et al.*, 2012), few studies in the general population explored the intakes of confectionery in relation to alcohol consumption. The ‘Health conscious’ dietary pattern was characterised by high intakes of fruit, salad, wholegrains and fish, and similar patterns during pregnancy have been described in other studies (Crozier et al. 2006; Knudsen et al. 2007). Evidence from studies in the general population have also reported that patterns of light to moderate alcohol consumption are associated with higher intakes of fruit, vegetables and fish, compared to abstaining or drinking more heavily (Kesse *et al.*, 2001; Barefoot *et al.*, 2002; Valencia-Martin, Galan and Rodriguez-Artalejo, 2011). Breslow et al. (2006) found that light and frequent patterns of alcohol consumption were associated with the highest HEI scores compared to abstainers and heavier drinkers.

This study has indicated that women who continue to drink in potentially harmful patterns (binge and daily drinking) are also more likely to have poorer quality diets, characterised by higher intakes of red meat, processed foods and lower intakes of fresh fruits and vegetables comapred to women who do not drink. These relationships are particularly important during pregnancy; a time of rapid growth, with greater nutrient demands to the fetus. A study exploring relationships between mean daily micronutrient intakes and the same dietary patterns within the ALSPAC cohort reported that as adherence to the ‘Processed’ and ‘Confectionery’ dietary patterns increased, micronutrient intakes decreased, including folate, vitamin B6, vitamin C, vitamin E and carotene (Northstone et al. 2008). This may have implications for fetal development, as inadequate intakes of these micronutrients during pregnancy are associated with an increased risk of ethanol-induced fetal harm in experimental models (Gutierrez et al. 2007; Naseer et al. 2011) and fetal growth restriction and poor cognitive outcomes at six months in studies within human populations (Avalos *et al.*, 2011; Coles *et al.*, 2015). Two suggested mechanisms for these relationships are the interference of ethanol in one carbon metabolism (OCM) and the redox state of cells (Cohen-kerem and Koren, 2003; Ballard, Sun and Ko, 2012). If women are drinking heavily and also adhere to dietary patterns characterised by low intakes of fresh fruit and vegetables, this may increase the risk of adverse birth and childhood outcomes.

Whilst this is one of the first studies to explore maternal dietary pattern scores in relation to alcohol consumption during pregnancy, other research teams have explored relationships between maternal alcohol consumption and other aspects of diet. Preliminary findings from a trial conducted in the Ukraine found that women who reported alcohol consumption during pregnancy were more likely to have lower plasma zinc and copper concentrations compared to women in the control group (Keen *et al.*, 2010). Whilst this is an interesting finding, the sample was small (n=49) and plasma concentrations do not accurately reflect dietary intake, due to potential biological interactions influencing bioavailabilty (Moran *et al.*, 2012). Multivitamin supplements were also explored in relation to alcohol consumption during the periconceptional period in a large cross-sectional study conducted in the US and found that as alcohol consumption increased, women were less likely to take multivitamin supplements (Weiss and Chambers, 2013). This finding is particularly interesting in light of the current analysis; if women who binge drink are less likely to consume diets characterised by high intakes of fresh fruit and vegetables, are they also less likely to take folic acid and multivitamin supplements during pregnancy?

The clustering of risky health behaviours increases the risk of adverse fetal development (Lanting *et al.*, 2009), and may also provide an explanation for why some studies have published findings that suggest women who drink low to moderate amounts during pregnancy have children with better cognitive outcomes: diet may be an overlooked confounder. Negative health behaviours often cluster in populations (French et al. 2008; Shankar et al. 2010) and a previous study explored relationships between the five dietary patterns described in the ALSPAC cohort study and socio-demographic and lifestyle characteristics. The 'Health conscious' dietary pattern was indicative of higher social affluence; adherence was associated with older age, higher educational attainment, living in an owned or mortgaged property, lower parity, being white, not smoking and having fewer financial difficulties. In contrast, adherence to the 'Processed' dietary pattern was associated with the opposite trends, indicating lower social affluence (Northstone et al. 2008). Evidence also suggests that patterns of alcohol consumption during pregnancy are related to socio-demographic characteristics. A systematic review reported that five studies found higher income or social class to be associated with alcohol consumption during pregnancy, but not with binge drinking (Skagerstróm, Chang and Nilsen, 2011). A study conducted in Sweden found similar results in a non-pregnant population; binge drinking was associated with lower social affluence (Backhans, Lundin and Hemmingsson, 2012).

Evidence from studies assessing health behaviour change interventions have indicated that when two or more health risk behaviours, such as diet, smoking, alcohol consumption or exercise, are approached in combination, individuals tend to have better outcomes (Jepson, 2000). Since dietary and alcohol intake appear to be related, a more effective way of addressing these health behaviours during pregnancy might be to take a more holistic approach and consider them together rather than in isolation (Prochaska and Prochaska, 2011). Evidence from animal models show harmful fetal effects of prenatal alcohol exposure whilst controlling for the effects of nutritional status. Therefore, a dual intervention that aims to improve dietary behaviour and reduce harm from alcohol consumption would benefit the health and wellbeing of both mother and baby.

Strengths and limitations

The main strengths of this analysis were the large sample size and the number of respondents reporting alcohol consumption at different frequencies and quantities. Because ALSPAC had collected data on episodic drinking, it was possible to assess the relationships with irregular patterns of alcohol consumption, which may often go undetected when asking questions about average consumption. However, there are also a number of limitations to this study that must be acknowledged. The estimates of alcohol consumption and dietary intake are self-reported, and therefore, vulnerable to recall and social-desirability biases (Davis et al. 2010; Thompson & Subar 2008). In addition to this, the FFQ did not capture portion size data and the validity and reproducibility of the FFQ used to estimate dietary intake are uncertain. However, the values estimated in ALSPAC compared favourably with estimates reported by women in the Dietary and Nutritional Survey (Rogers et al. 1998). Furthermore, the drinking categories were also unbalanced, with a very small proportion of women reporting to drink one or more drinks per day during the first trimester. While this is fairly typical of pregnant populations in the UK it may increase the risk of erroneous results, particularly in multivariate regression models (Button *et al.*, 2013). Moreover, despite the large sample, 98% of the sample population was white, and only 13% lived in property rented by the housing association or council. Low recruitment and retention rates of women from low socio-economic backgrounds are well documented in public health research, and further work should be conducted to evaluate these relationships within populations of women of non-white ethnic origin and lower SES. Whilst a large number of potential confounders have been adjusted for in the analyses, it is possible that these relationships are due to residual confounding from unmeasured SES and other lifestyle factors. Finally, the data included in this analysis was originally collected by ALSPAC in the early 1990s and we acknowledge that this threatens external validity due to changes in alcohol (Department of Health, 2016) and dietary guidelines (SACN, 2011) since that period. Therefore, additional research must be conducted to explore whether the relationships observed in this sample population are present in populations of pregnant women today.

Conclusions

Overall, this study has indicated that the relationships between diet and alcohol that have been previously reported in the general population persist into pregnancy. The findings also suggest the need to address health risk behaviours together, rather in isolation. Alcohol behaviour change interventions during pregnancy may be more successful if tackled as a broader goal, along with diet.

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Conflicts of interest

The authors declare they have no competing interests.

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Table 1. Socio-demographic and lifestyle characteristics of sample population (n (%))

	Total	Alcohol consumption during first trimester (n= 9,839)					Binge drinking (n= 9,781)		
		Never	*<1 drink/week*	*1-6 drinks/week*	*1+ drink/day*	*p-value**	*No binge drinking*	*≥1 episodes of binge drinking*	*p-value**
Age (years)									
<20	272 (3)	150 (4)	77 (2)	39 (3)	6 (4)		250 (3)	19 (3)	
20-24	5572 (57)	2697 (61)	2185 (56)	634 (47)	56 (37)		5149 (57)	383 (54)	
25-29	3874 (39)	1502 (34)	1619 (41)	666 (49)	87 (57)		3567 (39)	294 (42)	
30+	121 (1)	52 (1)	49 (1)	16 (1)	4 (3)	<0.0001	110 (1)	9 (1)	0.647
Parity									
Primiparous	4370 (44)	2107 (48)	1621 (41)	567 (42)	75 (49)		4089 (45)	264 (37)	
Multiparous	5469 (56)	2294 (52)	2309 (59)	788 (58)	78 (51)	<0.0001	4987 (55)	441 (63)	<0.0001
Ethnicity									
Non-white	206 (2)	121 (3)	66 (2)	18 (1)	1 (1)		186 (2)	11 (2)	
White	9633 (98)	4280 (97)	3864 (98)	1337 (99)	152 (99)	0.004	8890 (98)	694 (98)	0.373
Maternal smoking									
Smoker	1766 (18)	716 (16)	672 (17)	316 (23)	62 (41)		1520 (17)	238 (34)	
Non-smoker	8073 (82)	3685 (84)	3258 (83)	1039 (77)	91 (59)	<0.0001	7556 (83)	467 (66)	<0.0001
Education									
Vocational	2655 (27)	1276 (29)	971 (25)	359 (26)	49 (32)		2354 (26)	269 (38)	
O-level	3535 (36)	1595 (36)	1450 (37)	442 (33)	48 (31)		3281 (36)	240 (34)	
A-level	2320 (24)	1018 (23)	934 (24)	341 (25)	27 (18)		2163 (24)	148 (21)	
Degree level	1329 (14)	512 (12)	575 (15)	213 (16)	29 (19)	<0.0001	1278 (14)	48 (7)	<0.0001
Single parent household									
No	9334 (95)	4190 (95)	3760 (96)	1250 (92)	134 (88)		8627 (95)	654 (93)	
Yes	505 (5)	211 (5)	170 (4)	105 (8)	19 (12)	<0.0001	449 (5)	51 (7)	0.008
Home ownership									
Owner/occupied	7756 (79)	3433 (78)	3154 (80)	1063 (78)	106 (69)		7224 (80)	490 (70)	
Council/HA rented	1232 (13)	599 (14)	449 (11)	158 (12)	26 (17)		1092 (12)	128 (18)	
Private rent/other	851 (9)	369 (8)	327 (8)	134 (10)	21 (14)	0.001	760 (8)	87 (12)	<0.0001
House Crowding Index									
≤0.5	4379 (45)	1973 (45)	1729 (44)	615 (45)	62 (41)		4105 (45)	253 (36)	
>0.5-0.75	3159 (32)	1381 (31)	1325 (34)	416 (31)	38 (25)		2926 (32)	217 (31)	
>0.75-1	1795 (18)	817 (19)	684 (17)	263 (19)	31 (20)		1607 (18)	174 (25)	
>1	506 (5)	230 (5)	192 (5)	62 (5)	22 (14)	<0.0001	438 (5)	61 (9)	<0.0001
EPDS score									
<13	8467 (86)	3780 (86)	3423 (87)	1147 (85)	117 (76)		7863 (87)	557 (79)	
≥13	1372 (14)	621 (14)	507 (13)	208 (15)	36 (24)	<0.0001	1213 (13)	148 (21)	<0.0001
Total	**9839**	**4401**	**3930**	**1355**	**153**		**9076**	**705**	

*chi-squared test

Table 2. Unadjusted and adjusted* beta-coefficients and 95% CI of dietary patterns scores by maternal alcohol consumption during pregnancy

	Health conscious			**Traditional**			**Processed**			**Confectionery**			**Vegetarian**		
Alcohol consumption during first trimester	β	95% CI	p	β	95% CI	p	β	95% CI	p	β	95% CI	p	β	95% CI	p
Unadjusted															
Never		(ref)			(ref)			(ref)			(ref)			(ref)	
<1 drink/week	0.10	(0.06, 0.14)	<0.0001	-0.01	(-0.05, 0.03)	0.511	0.01	(-0.03, 0.05)	0.673	0.07	(0.03, 0.11)	0.001	-0.08	(-0.12, -0.04)	<0.001
1-6 drinks/week	0.12	(0.06, 0.17)	<0.0001	-0.05	(-0.11, 0.00)	0.074	0.08	(0.03, 0.14)	0.004	0.10	(0.04, 0.16)	<0.0001	0.02	(-0.03, 0.08)	0.391
1+ drink/day	-0.10	(-0.23, 0.04)	0.178	0.09	*(-0.05, 0.22)*	0.230	0.17	(0.03, 0.31)	0.015	-0.07	(-0.21, 0.07)	0.353	0.23	(0.09, 0.37)	0.001
Adjusted*															
Never		(ref)			(ref)			(ref)			(ref)			(ref)	
<1 drink/week	0.03	(-0.01, 0.06)	0.167	-0.04	(-0.08, 0.01)	0.067	0.04	(0.00, 0.08)	0.049	0.07	(0.03, 0.11)	0.002	-0.06	(-0.1, -0.02)	0.009
1-6 drinks/week	0.08	(0.03, 0.13)	0.002	-0.07	(-0.13, -0.01)	0.031	0.10	(0.04, 0.15)	<0.0001	0.11	(0.05, 0.17)	0.001	0.02	(-0.04, 0.08)	0.575
1+ drink/day	0.02	(-0.1, 0.15)	0.784	0.08	(-0.08, 0.24)	0.318	0.24	(0.09, 0.39)	0.002	0.03	(-0.13, 0.19)	0.702	0.10	(-0.06, 0.26)	0.242

**adjusted for maternal age, parity, ethnicity, education, smoking, housing tenure, HCI, single parent household and EPDS score*

CI = confidence intervals

Table 3. Unadjusted and adjusted* beta-coefficients and 95% CI of dietary patterns scores by maternal binge drinking during pregnancy

	Health conscious			Traditional			Processed			Confectionery			Vegetarian		
Binge drinking	β	95% CI	p	β	95% CI	p	β	95% CI	p	β	95% CI	p	β	95% CI	p
Unadjusted															
No binge drinking		(ref)			(ref)			(ref)			(ref)			(ref)	
≥1 episodes of binge drinking	-0.28	(-0.35, -0.21)	<0.0001	0.05	(-0.02, 0.11)	0.187	0.23	(0.17, 0.30)	<0.0001	-0.07	(-0.14, -0.01)	0.034	0.09	(0.03, 0.16)	0.007
Adjusted*															
No binge drinking		(ref)			(ref)			(ref)			(ref)			(ref)	
≥1 episodes of binge drinking	-0.05	(-0.12, 0.01)	0.103	0.06	(-0.02, 0.14)	0.119	0.15	(0.07, 0.22)	<0.0001	-0.07	(-0.15, 0.00)	0.057	0.05	(-0.03, 0.13)	0.196

**adjusted for maternal age, parity, ethnicity, education, smoking, housing tenure, HCI, single parent household and EPDS score*

CI = confidence intervals

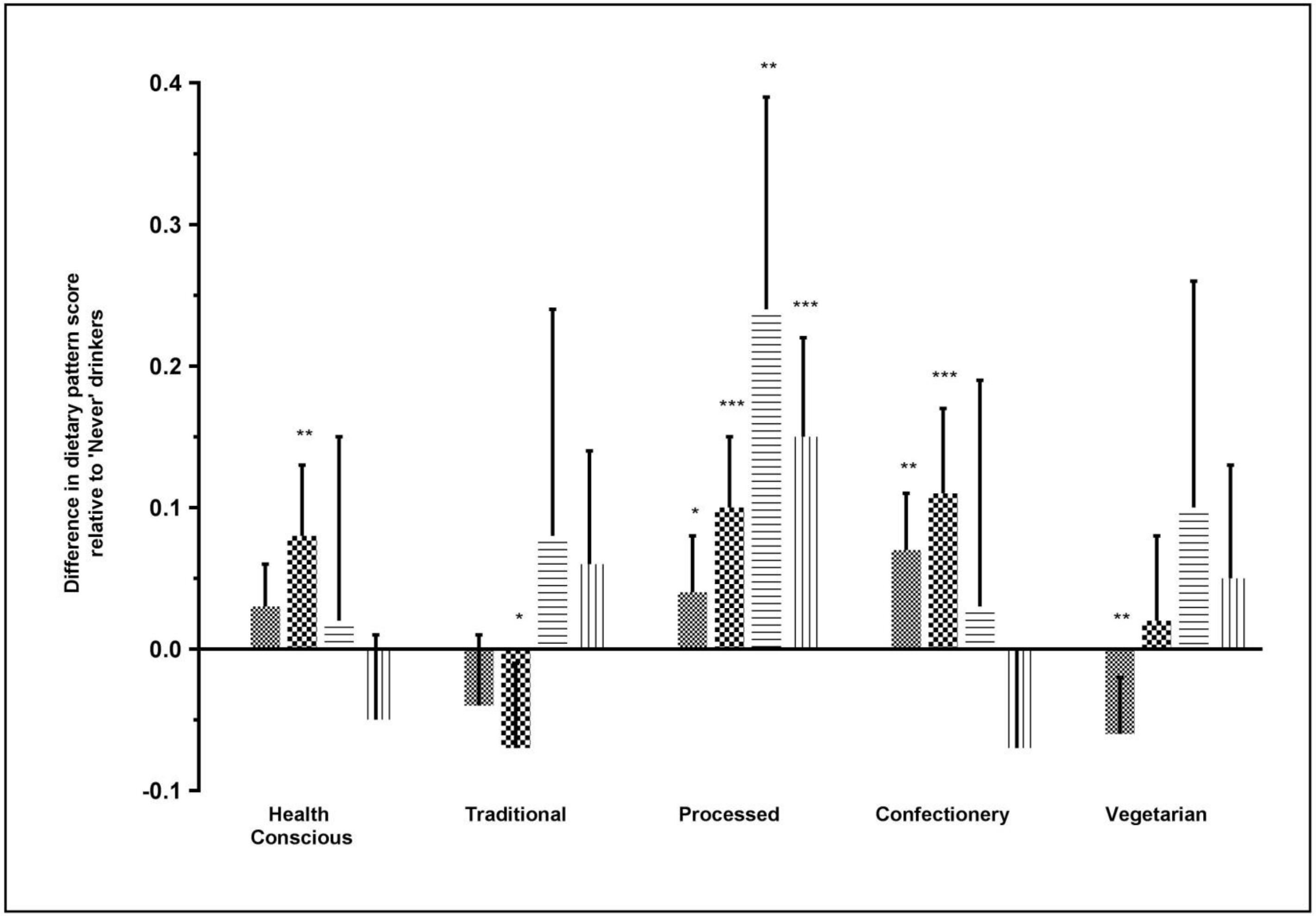

Figure 1: Differences in dietary pattern scores between categories of maternal alcohol consumption during pregnancy, relative to 'Never' drinkers (Dotted: <1 drink/week; Chequered: 1-6 drinks/week; horizontal stripes: ≥1 drinks/day). Differences in dietary pattern scores between 'binge' drinkers (≥4 drinks/day at any time during the previous month) and non-binge drinkers, are shown with vertical stripes.

All values are adjusted beta-coefficients and 95% CIs. Estimates are adjusted for: maternal age, parity, ethnicity, education, and smoking, housing tenure, HCI, single parent household and EPDS score.

*P <0.05 ** P<0.01 *** P<0.001

Table Legends

Table 1. Socio-demographic and lifestyle characteristics of sample population

Table 2. Unadjusted and adjusted* beta-coefficients and 95% CI of dietary patterns scores by maternal alcohol consumption during pregnancy

Table 3. Unadjusted and adjusted* beta-coefficients and 95% CI of dietary patterns scores by maternal binge drinking during pregnancy

Figure 1: Differences in dietary pattern scores between categories of maternal alcohol consumption during pregnancy, relative to 'Never' drinkers (Green: <1 drink/week; Orange: 1-6 drinks/week; Red: ≥1 drinks/day). Differences in dietary pattern scores between 'binge' drinkers (≥4 drinks/day at any time during the previous month) and non-binge drinkers are shown in blue.

Supplementary data

Table 1. Socio-demographic and lifestyle characteristics of included and excluded participants

Supplementary data

Table 1. Socio-demographic and lifestyle characteristics of included and excluded participants

	Included (n= 9,839)		Missing*	
	n	**%**	**n**	**%**
Age (years)				
<20	272	3	230	10
20-24	5572	57	1454	64
25-29	3874	39	554	24
30+	121	1	28	1
Parity				
Primiparous	4370	44	648	44
Multiparous	5469	56	828	56
Ethnicity				
Non-white	206	2	49	7
White	9633	98	701	93
Maternal smoking				
Smoker	1766	18	1078	68
Non-smoker	8073	82	509	32
Education				
Vocational	2655	27	376	48
O-level	3535	36	223	28
A-level	2320	24	116	15
Degree level	1329	14	68	9
Single parent household				
No	9334	95	1626	90
Yes	505	5	186	10
Home ownership				
Owner/occupied	7756	79	1089	57
Council/HA rented	1232	13	537	28
Private rent/other	851	9	290	15
House Crowding Index				
≤0.5	4379	45	533	29
>0.5-0.75	3159	32	533	29
>0.75-1	1795	18	518	28
>1	506	5	252	14
EPDS score				
<13	8467	86	339	77
≥13	1372	14	104	23
Alcohol consumption during 1st trimester				
Never	4401	45	663	11
<1 drink/week	3930	40	459	9
1-6 drinks/week	1355	14	199	11
1+ drink/day	153	2	41	17
Binge drinking				
No binge drinking	9076	93	1178	10
≥1 episodes of binge drinking	705	7	137	14

*Participants with missing dietary data at 32 weeks gestation

Unadjusted logistic regression models indicated that women with missing dietary data were more likely to be younger (OR=0.94, 95%CI=0.93, 0.95; p<0.0001), smoke (OR=1.01, 95%CI=1.01, 1.01), live in a single parent household (OR=1.78, 95%CI=1.48, 2.15; p<0.0001), live in rented accommodation (OR=1.61, 95%CI=1.51, 1.72; p<0.0001) and in more crowded conditions (OR1.54, 95%CI=1.46, 1.62; p<0.0001), drink 1+drinks/day (OR=1.72, 95%CI=1.22, 2.43; p<0.0001) and binge drink during pregnancy (OR=1.37, 95%CI=1.12, 1.66; p=0.002)