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Effects on birthweight of alcohol and caffeine consumption in smoking women

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Abstract

***Study objective*—Previous work found no effect on birthweight of alcohol and caffeine consumption in non-smokers but such an effect was found in smokers. This report investigates further the effects on birthweight of alcohol and caffeine at three stages of pregnancy in smoking women.**

***Design*—This was a prospective population study.**

***Setting*—District general hospital in inner London.**

***Participants*—Out of 1309 women who completed all pregnancy interviews, 895 were excluded because they did not smoke, leaving a sample of 414 smokers.**

***Measurements and main results*—Number and brand of cigarettes smoked, and quantity of alcohol and caffeine consumed were obtained by interview at booking, 28, and 36 weeks gestation. Birthweight was corrected for gestation and adjusted for maternal height, sex of infant and parity. The effect on birthweight of alcohol consumption was not explained by the amount smoked in terms of quantity and yield. Similarly the effect of caffeine was independent of smoking. When alcohol, caffeine, and smoking were analysed together, alcohol and caffeine were both associated with reductions in birthweight. Alcohol was associated with a reduction of up to 8% after adjusting for tobacco and caffeine intake, and caffeine was associated with a reduction of up to 6·5% after adjusting for tobacco and alcohol intake. Women who at booking were heavy smokers (≥13 cigarettes/day or ≥15 mg carbon monoxide/cigarette), heavy drinkers (≥100 g/week alcohol), and had high caffeine intake (≥2801 mg/week) had a predicted reduction in mean birthweight of 18% (95% CI 11% to 24%).**

***Conclusions*—It is well known that women who smoke in pregnancy have smaller babies than non-smokers. Our study suggests that if these women also drink alcohol and high quantities of caffeine then the risk of poor fetal growth is increased even further.**

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Tobacco, alcohol, and caffeine are the three most widely used psychoactive substances in Western Society.[1] Tobacco smoke contains many compounds and some of these (nicotine, carbon monoxide, and the polycyclic aromatic hydrocarbons) are known to cross the placenta.[2] Both alcohol and caffeine also enter the fetal bloodstream. It is well established that smokers have lower mean birthweight than non-smokers.[3–6] However the picture is less clear for alcohol and caffeine. One problem is that smoking and the consumption of alcohol and caffeine are highly correlated and few studies have investigated their concurrent use. Where this has been done results have been conflicting.

A relationship between alcohol consumption and lowered birthweight has been variously reported as absent[7 8] or slight[9] after controlling for smoking, independent of smoking,[10–12] or present in smokers only.[13] Similarly caffeine has been reported to have no effect on birthweight[11 14] and to reduce birthweight[7 15–17] after controlling for smoking. Reasons for the conflicting results include variation in patterns of consumption, the difficulty of obtaining accurate consumption data, particularly for alcohol and caffeine, and the method of controlling for smoking.

In previous analyses we have found no effect on birthweight of a wide range of socioeconomic and psychosocial stress factors.[6] We also found that alcohol and caffeine were associated with reduced birthweight only in smokers and not in non-smokers.[6] In this paper we describe the effect on birthweight corrected for gestational age of alcohol and caffeine consumption within smokers only. We use both quantity and yield smoked to control for smoking within smokers and hence investigate the effects on birthweight of alcohol and caffeine consumption.

Methods

The study has been described in detail elsewhere.[6] At St George's Hospital, a teaching hospital serving the Wandsworth Health District in inner London, 1860 white women booking for antenatal care were interviewed at four points in their pregnancies. Extensive social, behavioural, and psychological data were obtained from the questionnaires and a detailed obstetric history was taken from the hospital notes.

Of the 1860 eligible women, 551 were excluded because of refusal, spontaneous abortion, change of residence, macerated stillbirth, major congenital malformation, or incomplete data. The remaining 1309 women with complete data comprised 895 non-smokers (did not smoke during pregnancy) and 414 smokers (reported current smoking in at least one interview). These smokers are the subject of this report.

Women were asked about the quantity of cigarettes smoked daily and the brand smoked in the week prior to the booking, 28 week, and 36 week interviews. From the brand given, the tar, nicotine, and carbon monoxide yield was recorded from the Government Chemist's analysis.[18] Women were asked about their alcohol consumption for the previous week at the same three points in pregnancy. The interviewers probed for consumption in the following categories: liqueur, spirit, fortified wine, table wine, beer, lager, cider. The responses were recorded in terms of "pub measures" and were converted to grams of alcohol using tabulated values[19] or where these were not available, the information on the brand bottle was used with a standard formula.[19] Caffeine intake was also recorded at three points in pregnancy in terms of the number of cups of tea, coffee, cocoa, and cola drunk in the previous week. These were converted to mg caffeine using estimates of tea and coffee of 70 mg/cup and 92 mg/cup respectively from a UK study[20] and estimates of cocoa and cola of 5 mg/cup and 40 mg/serving.[21] UK estimates of tea and coffee content were used here in preference to USA values used in previous reports[6] because of national variation in mean cup size and strength of brew. However, when we compared analyses using USA estimates with those using UK estimates the broad conclusions were the same.

The outcome measure for this analysis was birthweight adjusted for gestational age, which indicates fetal growth. The adjustment was achieved by taking the ratio of the observed birthweight to the expected birthweight for that week of gestational age at birth from an external standard.[22] The statistical rationale and details are described elsewhere.[23] The resultant birthweight ratio was subsequently adjusted for maternal height, sex of infant, and parity using multiple regression. Age of the mother was not included because it had no independent effect. This gave an adjusted birthweight ratio which was suitable for use as the outcome variable in a least squares linear model. Since all the mean adjusted birthweight ratios are close to 1·0, differences between these ratios are equivalent to percentage differences: for example, the difference between the birthweight ratios 1·04 and 1·01 is 0·03, which implies that the difference between the two mean birthweights is 3%.

Previous analyses of birthweight and smoking[24] found that the yield smoked was at least as important as the quantity. We also found that the effect on birthweight of quantity and yield of cigarette was well modelled using an empirical approach. Smokers were categorised as a combination of low or high quantity and low or high yield. Using this approach an apparent threshold emerged whereby women smoking low quantity and low yield had no reduction in mean birthweight, whereas all other smokers had a reduction of 6% or more. A final categorisation of smokers into two groups (low quantity and low yield = "light smokers" *v* high quantity or high yield = "heavy smokers") was developed which explained more of the variation (4·4%) than other modelling techniques tried. Hence this method has been used here to control for smoking within smokers and to produce estimates of the sizes of effects. Light smokers were those smoking less than 13 cigarettes daily and a brand with less than 15 mg carbon monoxide per cigarette. All other smokers were classified as heavy smokers. Because of the empirical nature of this categorisation some analyses were repeated using the number of cigarettes smoked to control for smoking and the results have been compared. Alcohol consumption was categorised into five groups and caffeine consumption in three groups for the analyses.

Hence the relationships between birthweight ratio and alcohol and birthweight ratio and caffeine were tested by regression analysis where smoking was controlled for by categorising smokers as below or above the threshold. The simultaneous effect of alcohol and caffeine in smokers was examined by computing model estimates for each variable equivalent to the adjusted mean differences in birthweight ratio. Analyses were performed for the booking, 28 week, and 36 week data separately to compare the effects on birthweight of consumption at different points in pregnancy. All analyses were performed using SAS.[25]

Table I Mean adjusted birthweight ratio by smoking and alcohol consumption at booking

Factor	*No*	*Mean*	*95% CI*	*Tests of significance*
		Light smokers[a]		
Alcohol (g/week)				
0	34	1·071	(1·029, 1·113)	Alcohol adjusted
1–19	23	1·054	(1·003, 1·105)	for smoking
20–49	19	1·041	(0·985, 1·098)	in smokers: $p=0·006$
50–99	9	1·007	(0·926, 1·089)	Smoking adjusted
100+	2	0·853	(0·680, 1·027)	for alcohol: $p<0·001$
		Heavy smokers[b]		
Alcohol (g/week)				
0	174	1·011	(0·992, 1·029)	Trends:
1–19	93	0·994	(0·968, 1·019)	Light smokers: $p=0·01$
20–49	78	0·974	(0·946, 1·001)	Heavy smokers: $p=0·009$
50–99	20	0·957	(0·902, 1·012)	$R^2=0·058$
100+	20	0·942	(0·887, 0·997)	
		Non-smoker		
Alcohol (g/week)				
0	548	1·050	(1·039, 1·060)	
1–19	258	1·052	(1·037, 1·067)	
20–49	148	1·061	(1·041, 1·081)	
50–99	50	1·056	(1·022, 1·091)	
100+	16	1·082	(1·020, 1·143)	

[a] Light smokers are below apparent threshold of 13 cigarettes/day and 15 mg/cigarette carbon monoxide
[b] Heavy smokers are above threshold, ie, either 13+ cigarettes/day or 15+ mg/cigarette carbon monoxide
CI = confidence interval

Results

SMOKING AND ALCOHOL

Table I shows mean adjusted birthweight ratio by alcohol consumption for the light and heavy smokers. Means for non-smokers have been included for comparison but they have not been included in the analysis. The effects of both smoking and alcohol at booking remained significantly associated with birthweight after adjusting for each other. In addition there was a significant trend towards reduced birthweight with increased alcohol intake in both smoking groups. Among both light and heavy smokers heavy alcohol drinkers had a reduction in mean birthweight of 7% or more. At most levels of alcohol intake mean birthweight ratio was lower for heavy smokers than for light.

At 28 and 36 weeks the adjusted effect on birthweight of smoking was again very strong but the effect of alcohol consumption was less clear. There was some evidence for an effect of alcohol after adjusting for smoking at 28 weeks (p = 0·068) but there was no clear dose-response trend. There was little evidence for an effect of alcohol at 36 weeks (p = 0·28).

When the analysis of birthweight on alcohol was controlled for smoking using the quantity of cigarettes smoked at booking the results were similar. The effect of alcohol controlled for smoking was significant (p = 0·02) but the amount of variation explained by the model was reduced (R^2 = 0·038 compared with 0·058) reflecting the poorer fit of this method of measuring the effects of smoking.

Table II Mean adjusted birthweight ratio by smoking and caffeine consumption at booking

Factor	*No*	*Mean*	*95% CI*	*Tests of significance*
			Light smokers[a]	
Caffeine (mg/week)				
0–1400	16	1·087	(1·026, 1·148)	Caffeine adjusted for smoking
1401–2800	37	1·058	(1·018, 1·098)	in smokers: p = 0·005
2801 +	34	1·020	(0·978, 1·062)	Smoking adjusted for caffeine: p < 0·009
			Heavy smokers[b]	
Caffeine (mg/week)				
0–1400	51	1·024	(0·990, 1·058)	Trends:
1401–2800	128	1·006	(0·984, 1·027)	Light smokers: p = 0·07
2801 +	206	0·979	(0·962, 0·996)	Heavy smokers: p = 0·02 R^2 = 0·050
			Non-smoker	
Caffeine (mg/week)				
0–1400	335	1·052	(1·042, 1·065)	
1401–2800	420	1·051	(1·039, 1·063)	
2801 +	261	1·058	(1·042, 1·073)	

[a] Light smokers are below apparent threshold of 13 cigarettes/day and 15 mg/cigarette carbon monoxide
[b] Heavy smokers are above threshold ie either 13 + cigarettes/day or 15 + mg/cigarette carbon monoxide
CI = confidence interval

Table III Effects of smoking, alcohol, and caffeine consumption on mean adjusted birthweight (ABW) ratio according to multiple regression analysis in smokers only at booking; n = 471

Parameter	*Adjusted mean difference in ABW*	*95% CI*	*Equivalent difference in g for term baby*	*Tests of significance*
Smoking[a]				
Heavy smoker	− 0·051	(− 0·080, − 0·022)	− 178	p < 0·001
Alcohol[b] (g/week)				
1–19	− 0·016	(− 0·044, 0·012)	− 56	p < 0·01
20–49	− 0·035	(− 0·065, − 0·005)	− 122	
50–99	− 0·047	(− 0·096, 0·002)	− 164	
100 +	− 0·081	(− 0·136, − 0·026)	− 283	
Caffeine[c] (mg/week)				
1401–2800	− 0·016	(− 0·051, 0·019)	− 56	p = 0·01
2801 +	− 0·044	(− 0·077, − 0·011)	− 154	

[a] Compared with light smoker (< 13 cigarettes/day and < 13 mg/cigarette carbon monoxide)
[b] Compared with non-drinkers
[c] Compared with intake ⩽ 1400 mg/week

Table IV Effects of smoking, alcohol, and caffeine consumption on mean adjusted birthweight (ABW) ratio according to multiple regression analysis in smokers only at 28 weeks; n = 431

Parameter	*Adjusted mean difference in ABW*	*95% CI*	*Equivalent difference in g for term baby*	*Tests of significance*
Smoking[a]				
Heavy smoker	− 0·050	(− 0·077, − 0·023)	− 174	p < 0·001
Alcohol[b] (g/week)				
1–19	− 0·045	(− 0·080, − 0·010)	− 157	p = 0·07
20–49	− 0·030	(− 0·061, 0·001)	− 105	
50–99	− 0·005	(− 0·048, 0·038)	− 17	
100 +	− 0·028	(− 0·079, 0·023)	− 98	
Caffeine[c] (mg/week)				
1401–2800	− 0·060	(− 0·100, 0·021)	− 209	p < 0·01
2801 +	− 0·065	(− 0·104, − 0·026)	− 227	

[a] Compared with light smokers (< 13 cigarettes/day and < 15 mg/cigarette carbon monoxide)
[b] Compared with non-drinkers
[c] Compared with intake ⩽ 1400 mg/week

Nausea in early pregnancy is associated with both reduced alcohol consumption and higher birthweight. The effect on birthweight of alcohol consumption at booking was therefore controlled for both smoking and nausea. This analysis showed that the effect of early alcohol consumption on birthweight among smokers could not be explained by the absence of nausea.

SMOKING AND CAFFEINE

The effects on birthweight of smoking and caffeine at booking were both significant after adjusting for each other (table II). Non-smokers have again been included for comparison. In both smoking groups there was a trend towards reduced birthweight with increased caffeine intake and there was a 4% or greater difference in birthweight between women drinking low and high quantities. The pattern was similar for consumption at 28 weeks with strong effects of both smoking and caffeine (p < 0·001, p = 0·003 respectively). At 36 weeks there was a clear effect of smoking (p = 0·04) but less evidence for one of caffeine (p = 0·12). When the analysis of birthweight on caffeine was controlled for smoking using the number of cigarettes smoked at booking the results were again similar. The effect of caffeine controlled for smoking was significant (p = 0·008) and R^2 was again reduced (0·035 *v* 0·050).

SMOKING, ALCOHOL, AND CAFFEINE

When the effects on birthweight of smoking, alcohol, and caffeine at booking were examined simultaneously, all three were significant after controlling for the others. The parameter estimates are shown in table III. The model predicts a 5% reduction in birthweight for heavy smokers compared with light after adjusting for alcohol and caffeine intake. The parameter estimates for alcohol controlled for smoking and caffeine show the trend towards reduced birthweight with increased alcohol intake as previously described. The heaviest drinkers at booking (100 g + /week) had an adjusted reduction of about 8% compared with non-drinkers. Women consuming more than 280 mg/week caffeine at booking had an adjusted reduction in birthweight of 4% compared with the lightest consumers.

At 28 weeks the adjusted effects of smoking and caffeine were significant and there was some evidence for an effect of alcohol (table IV). Light smokers had an adjusted reduction of 5%. Alcohol drinkers had a predicted reduction in birthweight of about 3% compared with non-drinkers. A reduction of 6% or more was predicted for women consuming more than 1400 mg/week caffeine compared with light consumers.

In the model for 36 weeks there were consistent negative effects of alcohol and caffeine although these were not significant (table V). The effect of smoking remained significant. Women smoking above the threshold had a 3% reduction in birthweight compared with those below. There was some evidence that drinkers had a 2% reduction in birthweight compared with non-drinkers and that the heaviest caffeine consumers had a 4% reduction compared with the lightest consumers.

Discussion

Previous analyses of this study[6] had shown a strong effect of smoking on birthweight but an effect of alcohol and caffeine was only apparent in those women who also smoked. Here we have examined the relationships between alcohol and caffeine and birthweight within smokers. We have found that alcohol consumption combined with smoking was associated with reduced birthweight and that the effect of alcohol was not explained by the amount smoked. Similarly the reduction in birthweight associated with caffeine consumption was not explained by smoking. Overall, if a woman smoked, drank alcohol, and consumed caffeine at the highest levels in our study then mean birthweight was reduced by between 10% and 18%. These effects were strongest when consumption early in pregnancy was considered and weakest for consumption just before delivery. These results were obtained when smoking was controlled for by dichotomising according to an apparent threshold. However there were similar findings when the number of cigarettes smoked was used although the fit was less good.

When we investigated factors associated with alcohol consumption in pregnancy,[26] we found that in our study, higher proportions of alcohol drinkers than non-drinkers were married, better educated, or of higher social class and financial status. Since these factors were not associated with reduced birthweight,[6] it seems unlikely that the observed reduction in birthweight associated with alcohol consumption in smokers is due to mode of life characteristics.

In our previous paper[24] we have described the finding of an apparent threshold for tobacco smoke intake below which no effect on fetal growth was seen. In this paper we have looked at the effects of alcohol and caffeine intake within smokers and have found that for women smoking below and above the threshold there is an adverse effect of alcohol and caffeine which is not observed in non-smokers. Hence although "light smoking" may not reduce birthweight, when it is combined with alcohol and/or caffeine a reduction in mean birthweight is observed.

Previous studies have shown conflicting results for alcohol and caffeine for several reasons. Firstly there are methodological difficulties such as retrospective data[7 16 27] and sample sizes too small to detect these effects.[28] The second problem is that of controlling for smoking. Many studies control for smoking using two categories: smokers and non-smokers.[13–15 17] We have found in our study that this can give misleading results. When caffeine intake at booking was controlled for smoking in this way, the adjusted effect of caffeine was not significant[6] (table V). This was because the absence of an effect on birthweight in the larger non-smoking group (68%) swamped the apparent effect in the smaller smoking group, as can be seen by looking at the group means. Studies which simply use p values and do not look at means and confidence intervals within smokers and non-smokers can miss important effects.

Finally there are variations in amounts of alcohol and caffeine consumed in different studies. Hence some reports of no effect of alcohol and/or caffeine on birthweight may be due to insufficient numbers of women at higher consumption levels.[7 9 11 27] Although in our study we only found an effect of alcohol and caffeine in smokers, it may be that where consumption levels are higher than in our study an effect can be seen in non-smokers too. In a large prospective study of alcohol consumption and birthweight[12] Mills found a significant effect of alcohol overall after adjusting for smoking and other confounders. However his table of mean birthweight by alcohol and smoking shows that in non-smokers a reduction in birthweight is only apparent at the highest level of alcohol consumption (3+ drinks/day), a level of consumption for which the St George's study had very few women (0·6%). In smokers mean birthweight was reduced for lower levels of alcohol intake than in non-smokers.

In this study we have controlled for smoking by using both the quantity and yield smoked. However it is possible that the observed effects of alcohol and caffeine on birthweight among smokers are due to imprecision in measuring tobacco smoke intake. We are currently planning further research to address this issue using better estimates of consumption.

It is known that for women who smoke in pregnancy there is a risk of low birthweight. We suggest that there is an additional risk of poor fetal growth if these women also drink alcohol and high amounts of caffeine.

Table V Effects of smoking, alcohol, and caffeine consumption on mean adjusted birthweight (ABW) ratio according to multiple regression analysis in smokers only at 36 weeks; n=413

Parameter	*Adjusted mean difference in ABW*	*95% CI*	*Equivalent difference in g for term baby*	*Tests of significance*
Smoking[a]				
Heavy smoker	−0·034	(−0·063, −0·005)	−119	p=0·02
Alcohol[b] (g/week)				
1–19	−0·021	(−0·058, 0·016)	−73	p=0·24
20–49	−0·034	(−0·067, −0·001)	−119	
50–99	−0·030	(−0·073, 0·013)	−105	
100+	−0·024	(−0·079, 0·031)	−84	
Caffeine[c] (mg/week)				
1401–2800	−0·023	(−0·062, 0·016)	−80	p=0·10
2801+	−0·039	(−0·076, −0·002)	−136	

[a] Compared with light smokers (<13 cigarettes/day and <15 mg/cigarette carbon monoxide)
[b] Compared with non-drinkers
[c] Compared with intake ⩽1400 mg/week

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