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Associations between prenatal alcohol exposure and early education outcomes: a matched controls study using the born in Bradford dataset

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Original Article

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Abstract

Prenatal alcohol exposure (PAE) is associated with cognitive, behavioural, and developmental impairments throughout the lifespan of affected individuals, but there is limited evidence on how early this impact can be identified through routinely collected childhood data. This paper explores the relationship between PAE and the Early Years Foundation Stage Profile (EYFSP), a statutory teacher-based summative assessment of early development in relation to learning goals. This analysis uses the Born in Bradford dataset, a UK based cohort ($n = 13{,}959$; full dataset), which collected self-reported PAE from 11,905 mothers, with 19.8% reporting drinking alcohol at some point during pregnancy. Coarsened exact matching was conducted to examine relationships between patterns of PAE and children achieving a 'Good Level of Development' on the EYFSP, a binary variable assessed at 4–5 years of age, controlling for known confounders, including deprivation, mother's education, exposure to other teratogenic substances, and child's age at assessment. Additionally, we examined EYFSP sub-scores to identify specific developmental deficits associated with PAE.

The key finding is a statistically significant association between PAE at a level of consuming 5 or more units of alcohol (equivalent to 50 ml or 40 g of pure alcohol) at least once per week from the 4th month of pregnancy onwards and lower EYFSP scores when accounting for established confounding variables. These findings highlight that the detrimental impact of alcohol during pregnancy can be identified using statutory educational assessments. This has implications internationally for prevention work, policy, and commissioning of support services for people impacted by PAE.

Introduction

Prenatal alcohol exposure (PAE) is a significant public health concern due to the harm alcohol can cause to the developing fetus. Almost one in ten pregnancies globally may be exposed to alcohol with significantly higher rates in the UK.[1] Individuals exposed to alcohol in utero are at an increased risk of experiencing a range of cognitive, behavioural, and developmental impairments throughout their lifespans.[2–4] Fetal alcohol spectrum disorders (FASD) are a group of conditions where the effects of PAE are severe enough to produce a clinically significant neurodevelopmental profile including facial dysmorphology, growth anomalies, neuro-cognitive, and neurobehavioural impairments.[3] FASD is thought to be common in the UK with a prevalence of at least 1.8%[5] though widely under-recognised, and most children with the condition will not have a diagnosis. The impact of PAE and FASD is still widely under recognised by educators.[6–8]

The UK Early Years Foundation Stage Profile (EYFSP) is a statutory measure of development and progress of all state educated children in England during the last term of the year a child turns five years of age (aged 5 years) .[9] First introduced in 2008 and updated in 2013, the EYFSP covers seven areas of development: communication and language, physical development, personal, social and emotional development, literacy, mathematics, understanding the world, and expressive arts and design. From observing each child, educators assess whether a child is performing at 'emerging, 'expected' or 'exceeded' levels in each of these areas. The scale aims to provide an assessment of children's development and progress, with a view to identifying strengths and areas for improvement for individual children, groups, and populations.[9]

EYFSP data have been used to examine trends and patterns in children's achievements and to investigate the impact of interventions, teaching strategies, and curriculum approaches on children's outcomes.[10,11] The EYFSP has also been used to study the relationship between early development and long-term educational attainment,[12] as well as to explore the influence of factors such as socio-economic status, parental involvement, and the quality of early years

provision on a child' s progress.[13,14] EYFSP assessments are carried out at the same point for all children, in their 'reception' year (the first year of formal schooling for children in England; when they are four to five years of age) and have been used to screen children for autism.[15,16] Studies have demonstrated a low EYFSP score in reception year is associated with a higher rate of developmental disorders.[16,17] There are areas of overlap in the presentation of fetal alcohol spectrum disorder and other neurodevelopmental conditions such as autism and attention deficit hyperactivity disorder (ADHD), including social communication deficits and low impulse control.[3,4] It is therefore plausible that there is an association between PAE and low EYFSP scores.

Previous research has found a link between prenatal alcohol exposure and childhood academic outcomes at the age of 11[18] and Key Stage 2 UK based academic achievement score.[19] Research using datasets like Born in Bradford (BIB) has the advantage of data collected during pregnancy;[19] however, there is still evidence that concurrent maternal report of PAE is likely to be an underestimate.[20,21]

Previous studies on PAE have faced limitations in adequately controlling for confounding factors. As PAE in some countries, including the UK, is often positively associated with higher economic status,[19,21] the harm can then be masked by the presence of other protective factors.[20] Prenatal exposure to other teratogenic substances like tobacco, cannabis, and illicit drugs often co-occurs with PAE and is independently associated with brain alterations.[21] Previous studies that have controlled for confounding factors such as age, sex, family income and maternal educational level, have found that PAE is associated with structural brain alterations,[22] and that drinking five or more units of alcohol (where a UK unit is 10 ml or 8g of pure alcohol) on at least some occasions during the second trimester of pregnancy increases the risk of children being born small for gestational age.[23]

To better understand the specific longer-term effects of PAE, it is crucial to conduct studies with well-matched controls and isolate the impact of alcohol exposure. This study attempts to do this by making use of data from the Born in Bradford (BIB) study, a longitudinal birth cohort that includes data on PAE, EYFSP data, and relevant confounding factors.

Methods

Dataset

The Born in Bradford study is a long-term research project conducted in the city of Bradford, West Yorkshire, UK (24). Initiated in 2007, with the aim of investigating the health and well-being of children born in the city and the factors that influence childhood development, BIB has produced a large dataset comprising information from over 13,000 families, including health records, socio-economic data, genetic and environmental factors. Women were recruited at the routine oral glucose tolerance test (OGTT) which takes place at around 28 weeks' gestation during pregnancy.[24] Approval for the initial data collection was given by the Bradford Research Ethics Committee (REC reference 07/H1302/112).

Data on all mother-child dyads included in the study was accessed, giving 13,959 initial mother-child datapoints. The population of Bradford is not fully representative of the rest of the UK, with higher rates of poverty and lower average socio-economic status, as well as a high proportion of mothers in the study either being born in Pakistan or with a Pakistani family heritage.[24] The study was, however, reasonably representative of the demographics of Bradford itself, with over 80% of women attending for the initial OGTT agreeing to take part in the study. The study did slightly under-recruit younger mothers, and over-recruit South Asian and first-time mothers, but these differences were relatively small.[24]

Outcome

The primary outcome used for this study was children achieving a 'Good Level of Development' on the EYFSP, when it is assessed at 4-5 years of age. This is a commonly used binary summary measure which aggregates 12 of the 17 EYFSP items (specifically those from the communication and language; personal social and emotional development; physical development; literacy; and mathematics domains).[9] In each domain children are rated as not meeting the expected standard (classed as 'emerging'), meeting the expected standard, or exceeding the expected standard. To be classified as achieving a Good Level of Development (GLD) overall, a child must be judged to be at the 'expected' or 'exceeded' level for all 12 relevant domains. This reduces the EYFSP down to a binary outcome variable of achieving or not achieving a GLD. The EYFSP was modified in 2013, and therefore only data collected after 2013 were included in the analysis, to ensure all the data were comparable.

For the primary analysis, children were excluded if they did not have complete data on the 12 EYFSP domains needed to calculate this summary measure, but missing data were allowed on the 5 other EYFSP domains not used in this summary measure. For a small number of children, they were marked as either being absent at the time of the assessment, or having only recently arrived at the school, so teachers were not able to assess them. Children with these results were again excluded from the analysis. These 2 exclusion reasons combined resulted in the exclusion of 9 individuals from the dataset.

Predictor variables

The BiB dataset contains a range of questions about maternal alcohol consumption, that mothers complete in the baseline questionnaire at approximate 26–28 weeks' gestation. From these, a variety of comparisons can be constructed, comparing children with higher versus lower levels of PAE (each comparison gives a different binary predictor variable for PAE exposure). Mothers may fall into none, one or multiple of these categories, based on the data they report. The specific drinking patterns tested were primarily defined based on the data measured and reported in the BiB study, which asked separate questions about drinking in the 3 months before pregnancy, in the first 3 months of pregnancy, and then from the 4th month of pregnancy onwards. For each of these periods of time, mothers were asked to report whether they drank alcohol at all, and how often they drank 5 or more units of alcohol on a single occasion.

From these data, four different drinking patterns were constructed, with the ordering based on how often women reported the pattern in the BiB dataset, with pattern A the least commonly reported, and pattern D the most commonly reported:

- Drinking pattern A: Mothers who report drinking 5 or more units of alcohol at least once per week from the 4th month of pregnancy onwards.

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- Drinking pattern B: Mothers who report drinking 5 or more units of alcohol at least once per week in the first 3 months of pregnancy.
- Drinking pattern C: Mothers who report drinking any alcohol at all from the 4th month of pregnancy onwards.
- Drinking pattern D: Mothers who report drinking any alcohol at all during pregnancy.

Mothers reporting each of these drinking patterns were first compared to mothers who reported not drinking at all during pregnancy, to investigate the impact of different levels of reported PAE compared to no reported PAE. Mothers were excluded from the analyses for drinking patterns A-C if they reported drinking some alcohol during pregnancy, but do not meet the full criteria for the drinking pattern (as the purpose of this analysis was to compare those fulfilling the pattern to those not drinking at all).

Additionally, a number of other comparisons were tested, comparing mothers reporting each of these drinking patterns to those reporting lower levels of PAE.

- Drinking comparison E: Mothers who report drinking 5 or more units of alcohol at least once per week from the 4th month of pregnancy onwards (versus mothers who do not report drinking 5 or more units of alcohol at least once per week from the 4th month of pregnancy onwards).
- Drinking comparison F: Mothers who report drinking 5 or more units of alcohol at least once per week in the first 3 months of pregnancy (versus mothers who do not report drinking 5 or more units of alcohol at least once per week in the first 3 months of pregnancy).
- Drinking comparison G: Mothers who report drinking any alcohol at all from the 4th month of pregnancy onwards (versus mothers who report drinking in the 3 months before pregnancy, but not during pregnancy).
- Drinking comparison H: Mothers who report drinking any alcohol at all during pregnancy (versus mothers who report drinking in the 3 months before pregnancy, but not during pregnancy).

These analyses differ from the first four listed in the way the comparators are constructed. As an example, for the first analysis of drinking pattern A, mothers who report that drinking pattern are compared to those who report not drinking any alcohol at all during pregnancy. For drinking comparison E, women who report that drinking pattern are compared to all women who do not report that drinking pattern (which would include both those who report not drinking during pregnancy, but also those who report lower levels of drinking during pregnancy).

For each analysis, mothers were excluded if they did not answer at least one of the relevant questions on alcohol consumption, but they were not required to answer them all. For example, the maternal baseline questionnaire contains separate questions on beer, wine and spirit consumption, and so a woman who reported drinking wine from month 4 onwards would be included in the analysis, even if they did not answer the questions on beer and spirit consumption.

Analysis

For each analysis, the first step was to undertake a matching analysis, using the confounding factors listed in the section below. In the primary analyses, the dataset was restricted to those mother-child dyads with GLD data, the relevant PAE predictor variable, and complete information on confounding variables.

Coarsened exact matching (using the MatchIt function in R version 4.4.0) was used to produce a matched dataset of people who were positive and negative for the relevant predictor variable, but with similar values for each of the matching variables.[25] This approach does not necessarily match individuals one to one but includes all individuals from the full dataset for whom a suitable match can be found. The characteristics of this matched dataset were then checked to ensure sufficient balance in each of the matching variables. This is done by comparing the demographics of the two groups (those meeting and those not meeting the criteria for PAE defined in that analysis), to check there are no significant differences remaining in the matched dataset. Balance in the matched dataset was individually checked for each analysis, as a different matched dataset is generated for each definition of PAE. Coarsened exact matching is an extension of exact matching techniques, where if an individual does not have an exact match somewhere in the dataset, they can be matched with someone who is sufficiently similar, where what counts as sufficiently similar can be defined by the user.[25] The specific ways variables were categorised in this analysis are given in the confounding/matching variables section below.

Logistic regression was then conducted on the matched dataset (using generalised linear models in R v4.4.0), with GLD as the dependent variable, and the relevant measure of PAE the predictor variable. This estimates the independent effect of PAE on whether children achieved the binary GLD indicator, adjusted for the impact of the matching variables listed in the section below.

Confounding/matching variables

Variables to be included in the matching were chosen as ones available in the BiB dataset that were expected to have a potential impact on EYFSP scores, but not be on the causal pathway by which PAE might impact on EYFSP scores. The following variables were included in the matching:

- Mother's ethnicity (categorical variable) – In the BiB dataset, this is categorised as Asian, white, black, mixed and other. In this analysis black, mixed and other were combined into a single category, given the small numbers in each group.
- Sex of child (categorical variable).
- Mother's age when completing Maternal Baseline Questionnaire, usually at 26–28 weeks of gestation (continuous variable).
- Mother's highest level of education (categorical variable) – Split into 5 categories: < 5 GCSEs (General Certificate of Education, qualification usually taken at age 16 years) or equivalent, 5+ GCSEs or equivalent, A-level (Advanced Level, qualification usually taken at age 18 years) or equivalent, Higher than A-level, and Unknown.
- Whether the mother used drugs during pregnancy (binary yes/no variable). Specifically, mothers were asked if they have used "any drugs like marijuana or ecstasy during pregnancy or in the three months before pregnancy."
- National index of multiple deprivation (IMD) decile – a UK deprivation scale that ranks geographical areas on their level of deprivation across a range of categories, including income, employment, education, health, crime and housing. As most people in Bradford live in areas within the bottom 2 IMD

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deciles, the 8 highest deciles were combined into a single category.
- Whether the mother has ever been a regular smoker (binary yes/no variable).
- Whether the child is ever recorded as speaking English as a second/additional language (binary yes/no variable).
- Child's age when the EYFSP assessment took place (continuous variable).

Subdomain analyses

It is not expected that exposure to PAE would impact equally upon all the domains measured in the EYFSP. Although neurocognitive deficit profiled in those with PAE at a level that could be diagnosed with FASD are highly variable, there are some areas notably more likely to be negatively affected. The EYSFP sub scores were compared to clinical guidance on PAE related deficits.[4] A possible pattern of relative deficits was hypothesised and specified prior to running any analyses that the following patterns would be likely to result from PAE:

- In the mathematics domain, number skills were expected to be more impacted by PAE than shape, space and measure.[26,27]
- In the personal, social and emotional development domain, managing feelings and behaviour was expected to be more impacted by PAE than self-confidence and awareness.[3,28]
- In the communication and language domain, listening and attention was expected to be more impacted by PAE than speaking.[3]

If any analyses found an impact of PAE on GLD data, an equivalent analysis would then be run on the subdomains (that is, a logistic regression model using PAE to predict a binary variable of reaching at least the expected level on that single EYFSP subdomain, instead of the overall score, on the same matched dataset). If the expected subdomains were found to be more significantly impacted by PAE, this would increase confidence the findings were causally related to PAE, rather than simply the results of a correlated exposure negatively impacting across the child's whole development.

Sensitivity analyses

The primary analyses were all undertaken as complete case analyses, thus mother–child dyads had to have all of the following to be included in the analysis: an EYFSP GLD, a measure of PAE and all confounding variables. To test the sensitivity of the results to the presence of missing data, all the analyses were also run on a multiply imputed dataset, with outcome, predictor and confounding variables being simultaneously imputed by multiple imputation using chained equations (MICE).[29] For each analysis, 50 imputed datasets were created (using the MICE package in R v4.4.0), and then the same matching and logistic regression analysis was conducted for each dataset, before the results were combined.

Additionally, for some of the relevant confounding variables, there are multiple possible ways of adjusting for that variable from the BiB dataset. Some previous analyses of the BiB dataset have used free school meal status as a proxy for socio-economic status, rather than using IMD.[23] A sensitivity analysis was conducted, running the same matching and regressions analyses, but using free school meal status as a matching variable, instead of IMD decile.

Results

Baseline characteristics of the sample are given in Table 1. Of the 13,959 people in the full dataset, 10,698 had the necessary data to calculate a post-2013 EYFSP summary score. Of those, 59.6% of children were assessed as achieving a GLD, with 40.4% assessed as falling below that level in at least one relevant domain. The number of people for whom the PAE predictor variables could be calculated varied slightly between analyses, as they made use of different questions from the BIB maternal baseline questionnaire. For the most inclusive analyses (comparing mothers who reported consuming alcohol at any point during pregnancy to mothers who reported not consuming alcohol at any point during pregnancy) data on PAE was available from 11,905 mothers, with 19.8% of those reporting drinking alcohol at some point during pregnancy.

Pre-matching results

The importance of matching on potential confounding variables can be seen by looking at basic crosstabs of the data before the matching was conducted. Table 2 presents data on mothers who did and did not report drinking during pregnancy, compared with EYFSP outcomes. In this unadjusted analysis, 64.4% of children whose mothers reported drinking during pregnancy achieved a GLD on the EYFSP, compared to 59.8% of children whose mothers reported not drinking during pregnancy. Since it is implausible this is a benefit of PAE, it can only represent the presence of confounding variables in the analysis.

Similar patterns can also be seen by comparing included confounding variables with EYFSP outcomes. For example, Table 3 presents data on the age at which a child completes the EYFSP, compared to the outcome of the assessment. There is a clear pattern of older children being considerably more likely to achieve a GLD, and therefore this would lead to confounding in the analyses were it not to be adjusted for.

Table 4 presents a comparison of the baseline characteristics of the full BiB population, compared to the subset of the population reporting each unique drinking pattern. Some common themes emerge from these data:

- Women reporting drinking during pregnancy are much more likely to be white than the overall sample, and much less likely to be Asian. Differences can also be seen in other variables likely to be correlated with ethnicity in Bradford (for example, women reporting drinking during pregnancy are much less likely to have a child with English as a second or additional language).
- Women reporting drinking during pregnancy are also more likely to report the use of other substances, such as drugs or smoking.
- Women reporting drinking during pregnancy are likely to live in less deprived areas (be from higher IMD deciles) than women who do not report drinking during pregnancy.

The fact such clear demographic differences exist between populations reporting different levels of PAE underlines the importance of matching if the effect of PAE is to be isolated from the impact of these other variables.

Post-matching results (analyses comparing to no PAE)

In the analyses conducted on matched datasets for drinking patterns A-D, there was a significant association found between

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Table 1. Baseline characteristics of full sample

Maternal ethnicity	Asian: 51.6% (7197/13959) White: 39.3% (5486/13959) Black: 2.2% (304/13959) Mixed: 2.1% (289/13959) Other: 0.8% (108/13959) Missing: 4.1% (575/13959)
Sex of child	Male: 51.2% (7153/13959) Female: 48.0% (6704/13959) Missing (including indeterminate): 0.7% (102/13959)
Mother's age when completing Maternal Baseline Questionnaire (usually at 26–28 weeks gestation)	Mean: 27.63 years Standard deviation: 5.60 years Missing: 14.5% (2027/13959)
Mother's highest level of education	<5 GCSEs or equivalent: 18.6% (2603/13959) 5+ GCSEs or equivalent: 26.3% (3666/13959) A-level or equivalent: 12.0% (1679/13959) Higher than A-level: 21.6% (3016/13959) Unknown: 6.7% (933/13959) Missing: 14.8% (2062/13959) Unknown combines the categories of "Other", "Don't know" and "Foreign Unknown" from the original dataset
Mother used drugs during pregnancy	Yes: 0.9% (130/13959) No: 69.6% (9714/13959) Missing (including don't know): 29.5% (4115/13959)
National IMD decile (lower values mean more deprived)	1: 42.1% (5873/13959) 2: 14.9% (2085/13959) 3: 7.0% (981/13959) 4: 8.3% (1160/13959) 5: 5.5% (763/13959) 6: 3.8% (530/13959) 7: 1.4% (197/13959) 8: 1.1% (147/13959) 9: 0.8% (108/13959) 10: 0.6% (85/13959) Missing: 14.5% (2030/13959)
Maternal smoking status (has the mother ever regularly smoked)	Yes, for more than 1 year: 19.5% (2721/13959) Yes, for less than 1 year: 1.9% (268/13959) Yes, duration unspecified: 4.4% (614/13959) No: 59.5% (8308/13959) Missing: 14.7% (2048/13959)
Child reported as having English as a second/additional language in any year of schooling	Yes: 40.9% (5707/13959) No: 41.7% (5820/13959) Missing: 17.4% (2432/13959)
Child age at EYFSP assessment	Mean: 5.20 years Standard deviation: 0.29 years Missing: 24.1% (3361/13959)

GCSE = General Certificate of Education; A-level = Advanced level; IMD = Index of multiple deprivation; EYFSP = Early Years Foundation Stage Profile.

Table 2. Unadjusted comparison of PAE and EYFSP outcomes

		Child achieves a GLD on the EYFSP	
		No	Yes
Mother reports any drinking in during pregnancy	No	2950 (40.2%)	4384 (59.8%)
	Yes	603 (35.6%)	1090 (64.4%)

GLD = Good Level of development; EYFSP = Early Years Foundation Stage Profile.

Table 3. Unadjusted comparison of PAE and age at EYFSP assessment and EYFSP outcomes

	Probability of child achieving a GLD
Drinking at any stage of pregnancy	
No	59.8%
Yes	64.4%
Age of child at EYFSP assessment	
56 months	37.6%
57 months	39.0%
58 months	44.2%
59 months	45.8%
60 months	48.0%
61 months	57.3%
62 months	60.6%
63 months	61.1%
64 months	63.7%
65 months	68.2%
66 months	74.4%
67 months	74.7%
68 months and over	77.1%

GLD = Good Level of development; EYFSP = Early Years Foundation Stage Profile.

mothers who reported consuming 5 or more units of alcohol at least once per week from the 4th month of pregnancy onwards, compared to those who did not report drinking any alcohol during pregnancy (drinking comparison A), and worse outcomes on the EYFSP (Table 5). Specifically, children of mothers who report consuming 5 or more units of alcohol at least once per week from the 4th month of pregnancy onwards have an odds ratio of 0.395 to achieve a GLD on the EYFSP compared to mothers who do not report drinking any alcohol during pregnancy.

There were no statistically significant findings for any of the other definitions of PAE used (Table 6). The fact the milder definitions of PAE (any level of drinking during from the 4th month of pregnancy versus not drinking during pregnancy, and any level of drinking during pregnancy versus not drinking during pregnancy) were associated with a positive impact on EYFSP outcomes (albeit a non-significant one, unlike in the unmatched analyses) may imply there are additional relevant confounding variables that were not accounted for in the matching.

Post-matching results (analyses comparing differing levels of PAE)

In the analyses conducted on matched datasets for drinking comparisons E-H, there was a significant association found between mothers who reported consuming 5 or more units of alcohol at least once per week from the 4th month of pregnancy

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Table 4. Baseline characteristic for mothers reporting different drinking patterns during pregnancy

		Full population $N = 13,959$	Pattern D $N = 2,358$	Pattern C $N = 1,503$	Pattern B $N = 262$	Pattern A $N = 38$
Maternal ethnicity	**Asian**	51.6%	3.8%	3.7%	5.0%	15.8%
	White	39.3%	90.7%	93.1%	94.3%	84.2%
	Other	5.0%	5.5%	4.9%	0.4%	0.0%
	Missing	4.1%	0.1%	0.0%	0.4%	0.0%
Maternal age when completing Maternal Baseline Questionnaire	**Mean**	27.63 years	27.35 years	28.21 years	26.73 years	28.24 years
	SD	5.60 years	6.11 years	6.06 years	6.85 years	7.20 years
	Missing	14.5%	0.0%	0.0%	0.0%	0.0%
Maternal highest level of education	**<5 GCSEs or equivalent**	18.6%	17.7%	16.4%	24.8%	26.3%
	5+ GCSEs or equivalent	26.3%	32.4%	33.4%	37.4%	42.1%
	A-level or equivalent	12.0%	15.1%	15.4%	13.0%	13.2%
	Higher than A-level	21.6%	23.7%	25.7%	17.2%	10.5%
	Unknown	6.7%	10.9%	10.7%	9.2%	7.9%
	Missing	14.8%	0.2%	0.3%	0.0%	0.0%
Reported prenatal exposure to other non-prescribed drugs	**Yes**	0.9%	2.9%	3.0%	7.3%	7.9%
	No	69.6%	77.9%	78.0%	69.1%	63.1%
	Missing/Don't know	29.5%	19.2%	20.7%	23.7%	28.9%
National IMD decile	**1 – most deprived**	42.1%	34.4%	32.0%	34.0%	36.8%
	2	14.9%	14.9%	15.0%	18.7%	23.7%
	3–10	28.5%	50.7%	53.0%	47.3%	39.5%
	Missing	14.5%	0.0%	0.0%	0.0%	0.0%
Mother ever regularly smoked	**Yes**	25.8%	61.9%	63.6%	71.8%	71.1%
	No	59.5%	38.1%	38.3%	28.2%	28.9%
	Missing	14.7%	0.0%	0.0%	0.0%	0.0%
Child reported as having English as a second/ additional language	**Yes**	40.9%	4.2%	3.5%	1.1%	2.6%
	No	41.7%	75.1%	77.1%	80.2%	84.2%
	Missing	17.4%	20.7%	21.2%	18.7%	13.2%

Pattern D/E: Mothers who report drinking during pregnancy at all.
Pattern C: Mothers who report drinking at all from the 4th month of pregnancy onwards.
Pattern B: Mothers who report drinking 5 or more units of alcohol at least once per week in the first 3 months of pregnancy.
Pattern A: Mothers who report drinking 5 or more units of alcohol at least once per week from the 4th month of pregnancy onwards.
GCSE = General Certificate of Education; A-level = Advanced level; IMD = Index of multiple deprivation.

Table 5. Logistic regression model - the impact of drinking pattern A on GLD scores

Coefficient	Estimate (95% confidence interval)*	Odds ratio (95% confidence interval)*	P value
Intercept	0.728	–	–
Coefficient for drinking pattern A	−0.928 (−1.711, −0.145)	0.395 (0.181, 0.865)	0.020

*Estimates from the model where data have been matched on the following variables: mother's ethnicity; age of child; mother's age when completing Maternal Baseline Questionnaire; mother's highest level of education; whether the mother used drugs during pregnancy; national index of multiple deprivation (IMD) decile; whether the mother has ever been a regular smoker; whether the child is ever recorded as speaking English as a second/additional language; child's age when the EYFSP assessment took place.

onwards, compared to those who did not (drinking comparison E), and worse outcomes on the EYFSP (Table 7). Specifically, children of mothers who report consuming 5 or more units of alcohol at least once per week from the 4th month of pregnancy onwards have an odds ratio of 0.368 to achieve a GLD on the EYFSP compared to mothers who do not report reported consuming 5 or

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Table 6. Impact of PAE on EYFSP scores by definition of PAE

Definition of PAE	Coefficient for impact of PAE on GLD outcomes (95% confidence interval)*
Drinking pattern A	−0.928 (−1.711, −0.145)
Drinking pattern B	−0.361 (−0.779, 0.057)
Drinking pattern C	0.145 (−0.058, 0.349)
Drinking pattern D	0.093 (−0.079, 0.264)

*Estimates from the model where data have been matched on the following variables: mother's ethnicity; age of child; mother's age when completing Maternal Baseline Questionnaire; mother's highest level of education; whether the mother used drugs during pregnancy; national index of multiple deprivation (IMD) decile; whether the mother has ever been a regular smoker; whether the child is ever recorded as speaking English as a second/additional language; child's age when the EYFSP assessment took place.
PAE = Prenatal alcohol exposure; GLD = Good Level of development.

more units of alcohol at least once per week from the 4th month of pregnancy onwards.

There were no statistically significant findings for any of the other definitions of PAE used (Table 8). The fact the mildest definition of PAE (any level of drinking during pregnancy versus not drinking before or during pregnancy) was associated with a positive impact on EYFSP outcomes (albeit a non-significant one, unlike in the unmatched analyses) may imply there are additional relevant confounding variables that were not accounted for in the matching.

EYFSP subdomain analysis

EYFSP subdomain analysis was only conducted for drinking pattern A, as this definition of PAE (consuming 5 or more units of alcohol at least once per week from the 4th month of pregnancy onwards) was the only analysis to find a significant difference in GLD scores (results for these sub-analyses are given in Table 9). For two of the pre-specified subdomain comparisons (mathematics and personal, social and emotional development) the expected pattern was found (with number skills more impacted than shape, space and measures skills; and managing feelings and behaviour more impacted than self-confidence and awareness). For the third domain no pattern was found, with listening and attention appearing to be approximately equally as negatively impacted as speaking.

Sensitivity analyses

The results of the sensitivity analyses using multiple imputation were consistent with the primary analysis, with a statistically significant impact of drinking pattern A on EYFSP scores, but no significant findings for the other analyses.

The sensitivity analysis using free school meal status instead of IMD as a proxy for socio-economic status produced very similar results to the base-case analysis, with no changes in statistical significance or the magnitude of the estimated coefficients.

Discussion

The key finding of this study is a statistically significant association between reported levels of PAE – 5 or more units of alcohol in a day, at least once a week - from the fourth month of pregnancy onwards and Early Years Foundation Stage Profile (EYFSP) scores, indicating a quantifiable adverse impact of PAE on a child's learning abilities, and one that is large enough to be detectable on a routine educational measure. This finding is consistent for both of the different comparator groups tested in the analysis. Most of the women in this group also report drinking during the first 3 months of pregnancy. Two key caveats to this interpretation are that this group includes all women reporting drinking at least this level, and therefore may include some who are drinking considerably higher amounts, and that this analysis is based on women who report drinking at these levels, which may not capture all women in the sample who were doing so, due to the potential under-reporting of PAE discussed earlier.[30]

This association between PAE and lower EYFSP scores becomes evident only after accounting for established confounding variables and has been observed in other studies.[22] In the absence of controlling for these factors, PAE appears to be associated with enhanced EYFSP performance in our dataset, a trend observed in prior studies. This phenomenon often arises due to a higher prevalence of alcohol-exposed pregnancies among mothers with greater education, affluence, and English-speaking households.[31] This suggests that the education attainment of a significant number of children in UK schools will have been impacted by prenatal alcohol exposure. While there is no cure for the impacts of PAE once a child has been exposed increased awareness of the issue amongst educators could lead to more efficient allocation of resources and more successful outcomes for affected individuals.[28]

An examination of EYFSP sub-scores reveals a pattern of effects consistent with the specific developmental deficits seen in children with Fetal Alcohol Spectrum Disorder (FASD). Individuals with FASD have a variable amount of developmental difference relating to attention and executive function, emotion and behaviour regulation, learning and memory, adaptive functioning.[3,32] The impact of PAE on the EYFSP reflected this particularly around number skills and managing feelings and behaviours. While the specificity of this sub-score profile cannot be measured by this paper, the EYFSP sub-score analysis aligns with the developmental differences observed in children with FASD.[4] This finding contributes to the argument that the lower EYFSP score is attributable to PAE and not an as-yet-undiscovered confounding variable and increases the confidence that the relationship is causal. This information also indicates the need for further research to explore the possibility of using the EYFSP to pre-screen children, identifying those at an increased risk of PAE and therefore FASD.

These findings hold broad implications. Firstly, this adds to evidence that prenatal alcohol exposure may be the cause of or contribute to the special educational needs of a significant number of children in the UK,[5,31,33] and other countries with similarly high rates of PAE. This adds weight to calls for increased awareness of FASD and PAE amongst educators.[6,7]

The drinking pattern characterised by consuming five or more alcohol units at least once per week is not indicative of dependence or dysfunction. This pattern of consumption could be for example in UK terms 'two pints of lager or sharing a bottle of wine' once a week[34] - equivalent to 50 ml or 40 g of pure alcohol - a level which is below the UK government's guidance of 14 units per week for lower risk drinking.[35] Around 13% of women in England between 16 and 45 years of age regularly exceed this amount.[36] This underscores the need to consider the detrimental effects of lower levels of alcohol consumption during pregnancy, particularly when developing prevention messaging. The important role health education has to play in the prevention of PAE is widely recognised.[37,38]

It is important to note that the absence of a statistically significant association with other drinking patterns in this analysis

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Table 7. Logistic regression model - the impact of drinking pattern E on GLD scores

Coefficient	Estimate (95% confidence interval)*	Odds ratio (95% confidence interval)*	*P* value
Intercept	0.358 (−0.224, 0.959)	–	–
Coefficient for drinking comparison E	−1.000 (−1.798, −0.201)	0.368 (0.166, 0.818)	0.014

*Estimates from the model where data have been matched on the following variables: mother's ethnicity; age of child; mother's age when completing Maternal Baseline Questionnaire; mother's highest level of education; whether the mother used drugs during pregnancy; national index of multiple deprivation (IMD) decile; whether the mother has ever been a regular smoker; whether the child is ever recorded as speaking English as a second/additional language; child's age when the EYFSP assessment took place.

Table 8. Impact of PAE on EYFSP scores by definition of PAE

Definition of PAE	Coefficient for impact of PAE on GLD outcomes (95% confidence interval)*
Drinking comparison E	−1.000 (−1.798, −0.201)
Drinking comparison F	−0.265 (−0.630, 0.103)
Drinking comparison G	−0.117 (−0.057, 0.292)
Drinking comparison H	−0.063 (−0.270, 0.142)

*Estimates from the model where data have been matched on the following variables: mother's ethnicity; age of child; mother's age when completing Maternal Baseline Questionnaire; mother's highest level of education; whether the mother used drugs during pregnancy; national index of multiple deprivation (IMD) decile; whether the mother has ever been a regular smoker; whether the child is ever recorded as speaking English as a second/additional language; child's age when the EYFSP assessment took place.
PAE = Prenatal alcohol exposure; GLD = Good Level of development.

does not imply their safety; rather, lower levels did not demonstrate a statistically significant impact on the EYFSP. Long and Lebel found evidence of harm in brain imaging at lower levels of PAE[22] and this further supports the hypothesis that any PAE is harmful but current methods of measurement lack the sensitivity to separate lower levels of harm from other confounding variables.

The phenomenon where the effects of PAE become evident only after adjusting for maternal education, wealth, and English-speaking households may help explain why anecdotal reports of PAE being benign persist.[31] It is not that children exposed to alcohol in utero are unaffected, but rather that any harm is concealed by other advantages.

Strengths and limitations

A key strength of the study was the availability of a large and detailed dataset, representative of the area in which it was conducted, that measured self-reported alcohol consumption during pregnancy, child educational outcomes, and a wide range of potential confounding variables. The size of the dataset meant it was possible to include a large number of variables in the matching analysis, which would not be possible in a dataset with a smaller sample size.

The results of the study are also consistent with a number of previous studies conducted in the area. In particular, studies looking at the impact of drinking during pregnancy on the risk of children being born small for gestational age,[23] and the impact of drinking during pregnancy on educational outcomes at the age of 11,[18] have both used similar definitions of PAE (5 or more units of alcohol in a single day) as drinking pattern A in our analysis, that all three studies find evidence of harm at this level being corroboration of each individual finding. This also has the potential to explain the trajectory of the harms, with PAE causing an increased probability of being born small for gestational age, and this in turn being one of the causal pathways by which early and later educational outcomes are impacted.

The BIB dataset was collected in one city; whilst this gives an opportunity to explore data from a diverse population, the exact composition may not be representative of other populations in the UK. The large full cohort sample size is reduced significantly when examining alcohol consumption as the city of Bradford is characterised by around a third of the population identifying as South Asian ethnicity at the time the dataset was collected.[39] The prevalence of people of South Asian ethnicity in this study is even higher than this (at around 50%) because of the age distribution of the South Asian population in Bradford, with a higher proportion of younger people.

Reported South Asian ethnicity is associated in the UK with abstinence from alcohol.[24,40] In our dataset, for each drinking pattern, more than 80% of mothers who report that pattern of drinking self-report their ethnicity as white – much higher than the percentage of mothers who report a white ethnicity in the overall sample. It is therefore important to remember when interpreting the analyses that because a high proportion of those who report drinking during pregnancy self-report their ethnicity as white, the estimated impact of PAE on outcomes will be disproportionately based on that sub-population, as mothers are matched with those with the same self-reported ethnicity, meaning that more mothers who report their ethnicity as Asian are excluded by the matching process, due to not being able to find a suitable match who reports drinking during pregnancy. However, the remaining sample is still significantly larger than many active case ascertainment and clinical cohort studies which examine the relationship between PAE and education attainment. Of the participants who reported drinking during pregnancy half lived in the bottom two deciles for deprivation (i.e. most deprived), and only 10% had achieved A-levels or higher (Advanced Level, qualification usually taken at age 18 years).

Variables previously shown to be associated with early education achievement such as preterm birth, microcephaly and birthweight were not controlled for in this analysis as there is strong evidence that PAE can contribute to reduced head size and birthweight,[4] and it would not be appropriate to adjust for variables on the causal pathway from PAE to childhood outcomes. Nevertheless, if there are independent impacts of these variables on EYFSP scores, that are correlated with but not caused by PAE, this does leave the potential for residual confounding in the results. There also remains the possibility of other residual confounding not adjusted for in the dataset, as the analysis was restricted to adjusting for those variables measured in the BiB study.

While the EYFSP has been shown to be a good predictor of later academic and well-being outcomes, with good internal consistency and predictive validity, it is worth noting that as a tool designed to measure a multifaceted concept like child development, it has poor structural validity.[11,12]

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Table 9. Analysis of EYFSP sub-domains

EYFSP domain	EYFSP subdomain	Coefficient for impact of PAE on GLD outcomes
Mathematics	Numbers (expected to be more significantly affected)	−0.8506
	Shapes, space, and measures (expected to be less significantly affected)	−0.5124
Personal, social, and emotional development	Managing feelings and behaviour (expected to be more significantly affected)	−0.7367
	Self-confidence and awareness (expected to be less significantly affected)	−0.0492
Communication and language	Listening and attention (expected to be more significantly affected)	−0.5628
	Speaking (expected to be less significantly affected)	−0.5063

PAE = Prenatal Alcohol Exposure; GLD = Good Level of Development; EYFSP = Early Years Foundation Stage Profile.

Conclusion

This paper shows a significant association between PAE and adverse outcomes in a child's early education. This relationship becomes apparent only after accounting for confounding variables. These findings have wide-reaching implications, highlighting the need for increased awareness of the potential harm associated with low to moderate levels of alcohol consumption during pregnancy. While common drinking patterns, such as consuming five or more alcohol units weekly, may not indicate dependence or dysfunction, they nevertheless warrant preventative messaging. However, the absence of a statistically significant association with other drinking patterns does not imply their safety. In conclusion, this research contributes to our understanding of the detrimental consequences of PAE on child development, emphasising the importance of early identification and prevention. Nevertheless, additional research incorporating diverse populations and controlling for relevant variables is necessary to bolster the evidence base on this issue.

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Competing interests. None.

Ethical standards. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national guidelines on human experimentation the UK Concordat to Support Research Integrity and with the Helsinki Declaration of 1975, as revised in 2008, and has been approved by the institutional committees Approval for the initial data collection was given by the University of Bradford Research Ethics Committee (REC reference 07/H1302/112).

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