

# Using a genetically informative design to examine the relationship between breastfeeding and childhood conduct problems

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**Abstract** A number of public health interventions aimed at increasing the uptake of breastfeeding are in place in the United States and other Western countries. While the physical health and nutritional benefits of breastfeeding for the mother and child are relatively well established, the evidence for psychological effects is less clear. This study aimed to examine whether there is an association between breastfeeding and later conduct problems in children. It also considered the extent to which any relationship is attributable to maternally-provided inherited characteristics that influence both likelihood of breastfeeding and child conduct problems. A prenatal cross-fostering design with a sample of 870 families with a child aged 4–11 years was used. Mothers were genetically related or unrelated to their child as a result of assisted reproductive technologies. The relationship between breastfeeding and conduct problems was assessed while controlling for theorised measured confounders by

multivariate regression (e.g. maternal smoking, education, and antisocial behaviour), and for unmeasured inherited factors by testing associations separately for related and unrelated mother-child pairs. Breastfeeding was associated with lower levels of conduct disorder symptoms in offspring in middle childhood. Breastfeeding was associated with lower levels of conduct problems even after controlling for observed confounders in the genetically related group, but not in the genetically unrelated group. In contrast, maternal antisocial behaviour showed robust associations with child conduct problems after controlling for measured and inherited confounders. These findings highlight the importance of using genetically sensitive designs in order to test causal environmental influences.

**Keywords** Breastfeeding · Conduct problems · Genetic · IVF · ART · Egg donation · Embryo donation · Sperm donation · Surrogacy · Natural experiment

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## Introduction

Breastfeeding, a prime instance of close physical contact between mother and infant, has been linked with physical and cognitive benefits for the child [1–5]. Public health interventions aimed at increasing the uptake of breastfeeding have been established in the United States [6, 7] and other Western countries [8, 9]. In addition to providing nutritional and health benefits to the child, breastfeeding has important psychological effects on the mother. It stimulates the release of oxytocin, which is linked to reduced maternal anxiety, elevated mood and blunted physiological stress response, behaviours that prepare the maternal central nervous system for child rearing [10]. Breastfeeding is theorised to foster a maternal bond with

the infant by encouraging eye-to-eye gaze and physical contact [10] and has been associated with higher levels of maternal sensitivity at 3 months [11]. More generally, the potential importance of early postnatal experiences (including mother's health related behaviour and caregiving) for children's well-being as indexed by rates of hospitalisations, abuse and neglect at 2 and 15 years old has been shown using randomised clinical trials testing the effects of nurse visitation as an early intervention programme [12–14]. Long-term associations with child behavioural outcomes at 15 years old included lower levels of involvement in crime and fewer sexual partners, but there were no programme effects on delinquency and acting out in school [14]. Taken together, therefore, research indicates the potential importance of breastfeeding as a component of sensitive and responsive maternal behaviour as well as documenting links between the early postnatal period and mothers' long-term mental health and child's physical health. Whether breastfeeding, specifically, confers psychological benefits for the child is less well established.

This study examines whether there is a relationship between breastfeeding in infancy and levels of conduct problems in childhood. One problem in drawing conclusions about the causal effects of breastfeeding from epidemiological studies is that infant exposure to breastfeeding is not random. The same social and inherited factors that reduce the likelihood of a mother breastfeeding could also increase the risk of conduct problems in offspring. Some confounds (e.g. maternal education and antisocial behaviour) can be assessed, but many others will remain unmeasured [15, 16]. Randomised controlled trials are one solution, but these are not always possible or ethical [15, 17].

An alternative is to use a natural experiment that is genetically sensitive [17]. This approach to addressing questions of causal inference can be usefully employed to consider whether aspects of parental behaviour influence indices of psychological adjustment in children and the extent to which such relationships are mediated by genetic and/or environmental risk effects [15]. One such method is to investigate the links between risk exposure and outcomes among offspring conceived using assisted reproductive technologies (ART). For instance, mothers who conceive using homologous in vitro fertilisation or sperm donation will be genetically related to their offspring and provide the rearing environment. This group can be compared to mothers who conceive using egg or embryo donation and who therefore are genetically unrelated to their offspring, but who do also provide the rearing environment. Importantly, previous research suggests that findings relating to child psychopathology can be meaningfully generalised to the general population insofar as offspring conceived using ART do not differ in levels of adjustment problems [18].

A genetically sensitive approach was used in the present study to explore whether inherited factors contributed to the link between breastfeeding and conduct problems. We used a prenatal "cross-fostering design" [19, 20] where mothers are either genetically related or genetically unrelated to their children as a result of ART. If significant effects were only found in the related group, this would suggest that the association between breastfeeding and childhood conduct problems arises because of inherited factors provided by the mother. If significant effects were also found in the unrelated group, this would suggest that the relationship was not wholly attributable to maternally-provided inherited factors indexing unmeasured confounds and, therefore, indicate the role of the rearing environment.

The aim of the study was to provide a stringent test of a possible protective effect of breastfeeding on child conduct problems. A series of observed confounders (maternal education, prenatal smoking and antisocial behaviour) were included in the analyses of associations between breastfeeding and conduct problems. Analyses were then conducted separately for related and unrelated mother-child pairs to control for unmeasured inherited factors.

## Methods

### Sample and procedures

Families who had a live birth between 1994 and 2002 (children aged 4–11 years), following successful ART treatment using the parents' gametes (homologous), sperm donation, egg donation, embryo donation and gestational surrogacy were recruited from 18 UK clinics and 1 USA clinic [18–20]. Gamete donors and surrogates were unrelated to either parent. Nineteen of the twenty-two clinics contacted about the study agreed to participate and recruited families, representing a response rate of 86%. The study received approval from the Multi Centre Research Ethics Committee for Wales, UK. Parents gave informed consent before participating in the study. Data were collected from parents using postal questionnaire (888 families provided questionnaire data: 605 fathers and 873 mothers), and by examining the ante- and post-natal medical records where consent was given (77% of women gave written consent for their records to be reviewed). Records were not requested for mothers who were treated in the US clinic ( $n = 23$ ) or from families who had a child using surrogacy.

The sample has been described in detail elsewhere and found to be representative of the general population in terms of child birth weight, child behaviour and parental characteristics (ART was provided under freely available NHS care in the UK for most of the sample) [18–21].

However, parental age is older than in the general population (maternal age at birth: mean = 35.23 years, SD = 4.86; paternal age at birth: mean = 38.18 years, SD = 6.49) [20]. Nonetheless, these figures are comparable with international figures gathered for the year 2000 on ART [18]. The figures for maternal education showed that 11% of mothers had no formal education, 57% had school leaver qualifications, and 31% had a degree. The majority of parents were of European origin (96% mothers, 95% fathers). Approximately 20% of children had spent time in the special care baby unit and 22% of the sample was a multiple birth (a rate comparable with UK rates of multiplicity in ART) [18, 22].

Mother and father questionnaires were administered when children were aged 4–11 years old (mean child age = 6.25 years, SD = 1.26). This study considers cases where the mother provided information about breastfeeding and child conduct problems ( $N = 870$ ). Information from 583 fathers (67% of the study sample) about child conduct problems and the medical records of 461 mothers (53% of the study sample) that recorded information about breastfeeding were also used. In the case of multiple births, parents were asked to report on the behaviour of the first born twin or triplet.

The mother was genetically related to the child where the method of ART was homologous IVF ( $N = 434$ , 50%), sperm donation ( $N = 208$ , 24%) and gestational surrogacy ( $N = 21$ , 2.4%; total related  $N = 663$ ) and unrelated to the child where the method of ART was egg donation ( $N = 172$ , 20%) and embryo donation ( $N = 35$ , 4%; total unrelated  $N = 207$ ).

## Measures

### *Breastfeeding*

Use of breastfeeding was assessed by maternal report to the question ‘Did you breastfeed the child’ and was scored as No ‘0’ and Yes ‘1’. A second question assessed duration of breastfeeding on a four point scale (ranging from, ‘1–2 weeks’ scored as ‘1’ through to ‘over 6 months’ scored as ‘4’). The third index of breastfeeding was obtained from the neonatal medical record. Information about breastfeeding from the record was coded as breastfed or artificially fed. Agreement between maternal report and information in the neonatal medical record was good ( $\kappa = 0.79$ ).

### *Conduct problems*

Mother- and father-reported conduct problems were assessed using the five item conduct problems subscale of the Strengths and Difficulties Questionnaire (SDQ) [23, 24]. Items included, ‘Often has temper tantrums or hot

tempers’, ‘Generally obedient, usually does what told’ (recoded), ‘Often fights with other children or bullies them’, ‘Often lies or cheats’, and ‘Steals from home, school or elsewhere’. Response options include ‘0’ Not true, ‘1’ Somewhat true, ‘2’ Certainly true. Total scores can range from 0 to 10.

### *Covariates*

Covariates were selected on the basis of known correlates of breastfeeding use and/or conduct problems. Covariates included: maternal smoking during pregnancy (‘0’ = No, ‘1’ = Yes), maternal education (‘0’ = no formal qualifications to ‘4’ = higher degree), multiple birth status (‘0’ = singleton, ‘1’ = multiple), time in a special care baby unit (‘0’ = No, ‘1’ = Yes), birth weight (g), child age and sex (‘0’ = female, ‘1’ = male) and maternal antisocial behaviour. Maternal antisocial behaviour was assessed using the SCL-90-R hostility dimension [25]. Example items include, ‘getting into frequent arguments’ and ‘having urges to break or smash things’. These items reflect hostility in general and not directed towards the child, specifically.

### *Statistical analyses*

First, relationships between the maternal reports of breastfeeding (yes or no) and the study covariates and mother-rated conduct problems were examined for the total sample. Second, the reliability of findings was assessed by examining whether an association between breastfeeding and conduct problems was evident when: (a) the neonatal medical record of breastfeeding was used and (b) father-rated conduct problems was used. Third, multiple regression was used to examine whether any identified relationship between the use of breastfeeding and conduct problems was maintained after controlling for potential confounding risk factors, including smoking during pregnancy, maternal education and maternal antisocial behaviour. Fourth, regression analyses were conducted separately for related and unrelated mother-child pairs. Significant association between breastfeeding and child conduct problems in genetically unrelated mother-child pairs after controlling for observed correlated risk factors would be consistent with a protective effect of breastfeeding on child conduct problems. We compared the magnitude of association across groups by testing the interaction between genetic relatedness and breastfeeding. A significant interaction with greater association for related mother-child pairs would provide evidence of a heritable component to the association between breastfeeding and child conduct problems. Analyses presented here used untransformed conduct scores to allow for easier interpretation and

comparison with SDQ conduct norms [24]. Ordinal logistic regression and the use of square root transformed scores in linear regression produced equivalent results (available on request).

## Results

Nearly three-quarters (74%) of mothers breastfed their child. Approximately 13% of the mothers who breastfed did so for up to 2 weeks, 13% for up to 1 month, 37% for between 1 and 6 months and 36% for longer than 6 months. Chi-square analysis showed no relationship between mothers' use of breastfeeding (yes or no) and the mothers' relationship to the child (genetically related or unrelated;  $\chi^2 = 2.73$ ,  $p = 0.10$ ; 73% of related and 79% of unrelated mothers breastfed their child).

### Breastfeeding and maternal characteristics

As expected, mothers' use of breastfeeding was associated with a number of maternal and child characteristics. Breastfeeding was associated with maternal education ( $\chi^2 = 45.54$ ,  $p < 0.001$ ). Women who breastfed their child were more likely to have a college degree (20 vs. 9%) and less likely to have no formal qualifications (8 vs. 21%). Breastfeeding was also associated with maternal smoking in pregnancy ( $\chi^2 = 21.01$ ,  $p < 0.001$ ). Women who breastfed were less likely to have smoked during pregnancy (3 vs. 11%). There was no difference between mothers who breastfed and those who didn't in levels of maternal antisocial behaviour ( $t = 0.43$ ,  $p = 0.67$ ). Offspring who were singleton births were more likely to be breastfed than multiple births ( $\chi^2 = 17.27$ ,  $p < 0.001$ ; 78 vs. 63%). Offspring who were subsequently breastfed had a higher birth weight compared to those not breastfed ( $t = 2.99$ ,  $p < 0.01$ ; mean breastfed group: 3,131.9 g; SD = 668.4; mean non-breastfed group: 2,960.7 g; SD = 757.2), but there was no association between the use of breastfeeding and the child spending time in a special care baby unit ( $\chi^2 = 2.55$ ,  $p = 0.11$ ).

### Breastfeeding and child conduct problems

Use of breastfeeding (yes or no) was negatively associated with mother-rated conduct problems ( $r = -0.13$ ,  $p < 0.01$ ; breastfed mean = 1.40, SD = 1.37, non-breastfed mean = 1.81, SD = 1.50; Cohen's  $d = -0.29$ ), as was the duration of breastfeeding ( $r = -0.16$ ,  $p < 0.01$ ; prolonged breastfeeding, over 6 months mean = 1.17, SD = 1.35, other mean = 1.62, SD = 1.44; Cohen's  $d = -0.32$ ). Similar results were found when reports of breastfeeding from the medical record were used ( $r = -0.11$ ,  $p < 0.05$ ,  $n = 461$ ;

breastfed mean = 1.37, SD = 1.40; non-breastfed mean = 1.77, SD = 1.56; Cohen's  $d = -0.29$ ) and replicated for father-rated conduct problems: any breastfeeding ( $N = 583$ ):  $r = -0.13$ ,  $p < 0.01$ ; breastfed mean = 1.42, SD = 1.39; non-breastfed mean = 1.82, SD = 1.49; Cohen's  $d = -0.28$ ; duration of breastfeeding ( $N = 583$ ):  $r = -0.14$ ,  $p < 0.01$ ; prolonged mean = 1.26, SD = 1.37; other mean = 1.62, SD = 1.42; Cohen's  $d = -0.26$ ; medical record ( $N = 328$ ):  $r = -0.14$ ,  $p < 0.01$ ; breastfed mean = 1.35, SD = 1.34; non-breastfed mean = 1.83, SD = 1.46; Cohen's  $d = -0.34$ . Thus, the association between breastfeeding and lower offspring conduct problems was robust across multiple measures of breastfeeding and conduct problems.

Table 1 shows that a variety of maternal and child factors were associated with either breastfeeding or child conduct problems or both. Regression analysis was used to examine whether the association between the use of breastfeeding and mother-rated conduct problems was maintained after controlling for these factors (smoking during pregnancy, maternal antisocial behaviour, maternal education, special care baby unit, multiple birth, child birth weight, child sex and age). The results (shown in the left hand column of Table 2) show that breastfeeding continued to be negatively related to conduct problems for the sample as whole ( $b = -0.28$ ,  $\beta = -0.09$ ,  $p = 0.008$ ). Thus, breastfeeding was associated with a modest 0.28 reduction in the mother-rated SDQ conduct problem score (score can range from 0 to 10). Time in a special care baby unit, lower maternal education, younger child age, sex of child as male, and mothers' antisocial behaviour were associated with increased conduct problems. The proportion of variance accounted for by the regression model was 15%. Analyses were repeated focusing on prolonged breastfeeding (more than 6 months). Results were equivalent (unadjusted  $\beta = -0.14$ ,  $p < 0.001$ ; adjusted  $\beta = -0.08$ ,  $p = 0.02$ ).

We reasoned that there was potential ambiguity in the surrogacy group as to who had breastfed the child (surrogate or commissioning mother) because children may have been breastfed by either mother in the early hours of life. The regression analysis was conducted excluding this group of 21 families and the results were equivalent.

### The role of genetic relatedness

Examining the pattern of multiple regression results separately for the genetically related and unrelated groups revealed a significant association between breastfeeding and conduct problems for the related group ( $b = -0.33$ , CI:  $-0.56$ ,  $-0.09$ ,  $\beta = -0.10$ ,  $p = 0.01$ ; Table 2). For the unrelated group, the multiple regression analyses found significant associations between child conduct problems and maternal antisocial behaviour, multiple birth, child sex

**Table 1** Inter-correlations between mother-rated study variables, means and standard deviations

	Breastfeeding	Maternal smoking	Maternal antisocial	Maternal education	Birth weight	Multiple birth	SCBU	Child age	Child sex	Conduct problems
1. Breastfeeding (No = 0 or Yes = 1)	–									
2. Maternal smoking in pregnancy (No = 0 or Yes = 1)	–0.16**	–								
3. Maternal antisocial behaviour	0.01	0.01	–							
4. Maternal education	0.20**	–0.12**	–0.03	–						
5. Birth weight (g)	0.11**	–0.11**	0.04	0.05	–					
6. Multiple birth (No = 0 or Yes = 1)	–0.14**	–0.02	0.01	0.01	–0.52**	–				
7. Special care baby unit (No = 0 or Yes = 1)	–0.05	0.03	–0.01	0.05	–0.51**	0.30**	–			
8. Child age	0.00	0.06	0.01	0.00	–0.03	–0.02	0.01	–		
9. Child sex (0 = female, 1 = male)	–0.03	0.03	–0.01	–0.01	0.03	0.03	0.07*	0.04	–	
10. Conduct problems (mother rated)	–0.13**	0.08*	0.31**	–0.14**	–0.07	0.10**	0.10*	–0.07*	–0.08*	–
Mean (or median in italics)	<i>1.00</i>	<i>0.00</i>	3.90	1.84	3,088.39	<i>0.00</i>	<i>0.00</i>	6.25	<i>1.00</i>	1.51
Standard deviation	0.44	0.22	3.49	1.25	695.85	0.42	0.40	1.26	0.50	1.42

N = 870

\* *p* < 0.05

\*\* *p* < 0.01

**Table 2** Results of regression analyses predicting mother-rated conduct problems in middle childhood from breastfeeding

	Total sample ( <i>n</i> = 870)		Related group ( <i>n</i> = 663)		Unrelated group ( <i>n</i> = 207)	
	<i>b</i> (95% CI)	$\beta$	<i>b</i> (95% CI)	$\beta$	<i>b</i> (95% CI)	$\beta$
Unadjusted model						
Breastfed (Yes or No)	–0.41 (–0.63, –0.20)	–0.13**	–0.45 (–0.69, –0.21)	–0.14**	–0.33 (–0.81, 0.16)	–0.09
<i>R</i> <sup>2</sup>		0.02		0.02		0.01
Adjusted model						
1. Breastfed (Yes or No)	–0.28 (–0.49, –0.08)	–0.09**	–0.33 (–0.56, –0.09)	–0.10**	–0.09 (–0.55, 0.38)	–0.02
2. Maternal smoking in pregnancy	0.33 (–0.08, 0.73)	0.05	0.48 (0.05, 0.92)	0.08*	–0.12 (–1.11, 0.86)	–0.02
3. Maternal antisocial behaviour	0.13 (0.10, 0.15)	0.31**	0.13 (0.10, 0.16)	0.32**	0.11 (0.06, 0.17)	0.28**
4. Maternal education	–0.13 (–0.21, –0.07)	–0.11**	–0.14 (–0.22, –0.06)	–0.12**	–0.09 (–0.23, 0.05)	–0.08
5. Birth weight	0.00 (0.00, 0.00)	0.01	0.00 (0.00, 0.00)	0.03	0.00 (0.00, 0.00)	–0.09
6. Multiple birth	0.22 (–0.01, 0.44)	0.07	0.07 (–0.22, 0.36)	0.02	0.64 (0.15, 1.13)	0.19*
7. Special care baby unit	0.28 (0.05, 0.52)	0.08*	0.25 (–0.04, 0.55)	0.07	0.23 (–0.29, 0.76)	0.07
8. Child age	–0.09 (–0.16, –0.02)	–0.08*	–0.07 (–0.15, 0.02)	–0.06	–0.15 (–0.29, –0.01)	–0.13*
9. Child sex (female = 0, male = 1)	0.21 (0.04, 0.39)	0.08*	0.12 (–0.08, 0.32)	0.04	0.46 (0.09, 0.83)	0.16*
<i>R</i> <sup>2</sup>		0.15		0.16		0.20

\* *p* < 0.05

\*\* *p* < 0.01



and age, but no association with breastfeeding ( $b = -0.09$ , CI:  $-0.55, 0.38$ ,  $\beta = -0.02$ ,  $p = 0.74$ ; Table 2). Results for analyses of prolonged breastfeeding were equivalent. There was no association between prolonged breastfeeding and child conduct problems in the unrelated group ( $\beta = -0.05$ ,  $p = 0.49$ ).

Further tests showed that the interaction term between breastfeeding (yes or no) and genetic relatedness was not significant either in unadjusted ( $b = -0.12$ ,  $\beta = -0.04$ ,  $p = 0.66$ ) or adjusted models ( $b = -0.14$ ,  $\beta = -0.05$ ,  $p = 0.58$ ). Post hoc power analysis undertaken using G\*Power 3.1 [26] indicated sufficient power (>80%) for detecting an effect of  $\beta = 0.10$  within the smaller unrelated sample.

## Discussion

While the physical health and nutritional benefits of breastfeeding for the mother and the child are relatively well established, the evidence for psychological effects is less clear [11, 27, 28]. This study used a research design that included multiple reporters of the main study constructs, hypothesised confounders and information about genetic relatedness to consider whether breastfeeding is related to a key index of psychological functioning in middle childhood (conduct problems). Findings showed a modest association between breastfeeding and lower levels of conduct problems in middle childhood. This effect appeared robust across different reports of breastfeeding and child behaviour, and when controlling for a number of measured confounders including maternal antisocial behaviour and maternal education. However, in this sample, the association was only apparent in related mother-child pairs and was not detected when mothers and children were genetically unrelated. This suggests additional possible influences of unmeasured heritable confounding factors.

Epidemiological and clinical studies have found links between breastfeeding and improved cognitive ability [29] and lower rates of psychopathology in children [30], although findings have been mixed [31]. Duration of breastfeeding is also associated with a lowered risk of child abuse and neglect [10] and with increased maternal sensitivity towards the infant [11]. These findings are based on observational studies, and though efforts have been made to control for measured confounders, the contribution of unmeasured factors has been difficult to rule out. Only a handful of research designs are able to address whether the association between breastfeeding and indices of child psychological adjustment is attributable to a causal influence of breastfeeding or arises because of unmeasured confounds including genetic influences shared between

mother and child [15, 16, 20, 31–34]. The use of a natural experiment enabled us to test the role of breastfeeding over and above maternally-provided inherited factors that might underlie this relationship. The absence of significant association in the unrelated group is inconsistent with a strong protective effect of breastfeeding on child behaviour problems. However, tests also showed no difference in associations across genetically related and unrelated groups. Thus, further studies are needed to test the possibility of environmentally-mediated influences of breastfeeding of small effect size, and also to clarify the role of inherited factors.

Since many pre- and post-natal risk and protective factors (e.g. smoking in pregnancy, breastfeeding) are influenced by maternal characteristics that are in part inherited (e.g. influenced by heritable behaviours or traits such as personality and cognitive ability) [16], and because mothers transmit genes to their offspring, the link between breastfeeding and offspring adjustment outcomes could be attributable to inherited factors that influence maternal use of breastfeeding and child propensity for conduct problems [31]. Randomised controlled trials, discordant sibling designs, and the offspring of twins design are additional research designs that could be usefully employed to address this important issue.

Randomised controlled trials provide an important means of testing for causal effects because exposure to breastfeeding is then non-selected. Previous research provides strong evidence for the likely health benefits for mother and child of breastfeeding, but also provides no firm evidence for a protective effect in relation to child behaviour problems. The Promotion of Breastfeeding Intervention Trial (PROBIT) was the first randomised controlled trial of the Baby-Friendly Hospital Initiative and has provided important information about the physical and mental health benefits of breastfeeding [35–38]. For instance, PROBIT has identified some health benefits in infancy (e.g. lowered risk of gastrointestinal tract infection and atopic eczema) [37] and cognitive benefits in childhood (IQ at 6.5 years) [38], but long-term benefits on child mental health and behaviour have not been found [27]. These findings and the results of the present study suggest that conclusions about the causal effects of breastfeeding on behaviour in children are premature. More research using genetically sensitive designs and randomised controlled trials is required.

In contrast, the study is consistent with previous evidence from genetically sensitive studies [39] and longitudinal designs [40] in showing parent antisocial behaviour to be an important environmentally-mediated risk factor for child conduct problems. Here, associations of equivalent effect size were observed regardless of genetic relatedness, and even when controlling for other measured covariates.

Some early preventive interventions have been shown to be effective at improving a range of different child health, behavioural and cognitive outcomes [12, 13]. A crucial issue for the development, refinement and implementation of these early preventive interventions is establishing which specific elements carry beneficial effects for which child outcomes [13]. The current results would suggest that aspects addressing maternal antisocial behaviour (e.g. by targeting parenting skills) will have more of an impact on child conduct problems than those addressing take-up of breastfeeding. The benefits associated with promoting breastfeeding may instead be greater for other health or cognitive outcomes.

### Limitations

The children in this study were conceived using ART, which may have implications for generalising the findings to children conceived naturally. However, a previous study using this sample found no evidence that levels of conduct problems differed from population norms [18]. Furthermore, three-quarters of women in the study had breastfed their child. This is consistent with rates of breastfeeding in the general population where estimates indicate that 76% of UK mothers initiate breastfeeding [28]. The pattern of associations where breastfeeding was associated with higher maternal education is also consistent with previous literature for women conceiving naturally [9]. A second limitation was the concurrent assessment of all parent-rated study variables, including the retrospective report of mothers' breastfeeding (although similar results were obtained when using reports of breastfeeding from the neonatal medical record). Reverse causation is also plausible, whereby infant temperament affects the relative success of breastfeeding [35]. It seems likely, however, that a reverse causation effect would only give rise to a reduction in the association between breastfeeding and conduct problems in the unrelated group, if this was a reciprocal process involving influences from mother and child, rather than a purely evocative effect of infant temperament. A prospective research design with assessments in infancy and childhood would give greater confidence about the strength of association and direction of effects between these behaviours. An antenatal assessment of intentions to breastfeed might also be helpful in this regard. Finally, differences in the sample size meant there was less power for detecting effects in the unrelated than in the related sample. A larger sample size of unrelated mothers and offspring might have afforded greater power to detect an association between breastfeeding and conduct problems when assessed simultaneously with the hypothesised confounds. Confidence intervals around the coefficient for

breastfeeding overlapped in the two groups, and larger sample sizes might have enabled detecting a difference in degree of association between breastfeeding and conduct problems between the two groups. This would conclusively demonstrate the role of inherited factors in the association between breastfeeding and conduct problems with this design.

### Conclusions

This study contributes to an emerging literature studying the effects of breastfeeding on psychological well-being in middle childhood [10, 11, 27]. Breastfeeding showed a small association with lower levels of conduct problems in middle childhood that is maintained across informants and several key potential measured confounders. Nevertheless, the findings, like those of a recent trial, provide no firm support that this association reflects a causal protective effect [27]. To our knowledge, no previous study has examined the relationship between breastfeeding and offspring psychosocial adjustment using a genetically informative design. While breastfeeding is associated with a host of well-documented health benefits for mother and child, additional research properly taking account of social and inherited confounders is required to demonstrate a protective effect for child conduct problems. At the same time, the study adds to the body of evidence implicating maternal antisocial behaviour as an important risk factor for child behaviour problems. This indicates avenues for prevention and intervention efforts.

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