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Pre-pregnancy Body Mass Index and breastfeeding initiation, early cessation, and longevity:

Evidence from the first wave of the UK Millennium Cohort Study

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Abstract

Background: International evidence indicates relationships between pre-pregnancy Body Mass Index (BMI) and breastfeeding behaviours. This study aims to assess associations between key points in the breastfeeding trajectory (initiation, early cessation, longevity) and pre-pregnancy BMI, in a recent, nationally representative British cohort. It also aims to explore in the British context potential moderation by mothers' ethnic group.

Methods: The sample comprises 17 113 mothers from the UK Millennium Cohort Study, who have information on pre-pregnancy BMI. Associations between pre-pregnancy BMI categories and breastfeeding initiation, early cessation and longevity are tested using logistic regression. Directed Acyclic Graphics (DAG) identify appropriate minimal adjustment to block biasing pathways and classify total and direct effects.

Results: After adjusting for confounders, there are large differences in breastfeeding early cessation and longevity by pre-pregnancy BMI group. Differences in propensity to initiation are negligible. Having begun breastfeeding, overweight and obese mothers are more likely to cease in the first week, and less likely to continue past four months. Observed potential mediators within pregnancy and delivery provide little explanation for relationships. Evidence for moderation by ethnicity is scant.

Conclusions: The causal mechanisms underlying relationships between pre-pregnancy overweight, obesity, and breastfeeding behaviours require further research. However, this study suggests pre-pregnancy BMI as one predictive measure for targeting support to women less likely to establish breastfeeding in the early days, and to continue beyond four months. The nature of support should carefully be considered and developed, with mind to both intended and potential unintended consequences of intervention given the need for additional investigation into the causes of associations.

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What is already known on this subject?

Breastfeeding is beneficial to child health and development, with current recommendations of exclusive breastfeeding for the first six months of life. However, international literature suggests that rates of breastfeeding initiation and duration vary by maternal pre-pregnancy BMI.

What this study adds:

In the UK, there are large differences in breastfeeding early cessation (stopping within first week) and longevity (breastfeeding for over 4 months) by maternal pre-pregnancy BMI group. Though they are equivalently likely to initiate, overweight and obese mothers are less likely to establish breastfeeding in the early days, and less likely to continue in the longer term.

Alongside notable differences in breastfeeding behaviours across mothers' ethnic groupings, there is some very tentative evidence that the relationship between maternal BMI groupings and early cessation of breastfeeding varies by ethnic group - although this does not appear to be a robust association within this sample.

Other candidate mediators which might suggest mechanisms in the BMI – breastfeeding relationship, including gestational diabetes, gestational age, birthweight, delivery method and whether there were self-reported labour complications, were tested. They do not attenuate or explain the relationship between pre-pregnancy overweight and obesity and breastfeeding early cessation or longevity.

This research suggests that pre-pregnancy BMI could be one predictive measure in targeting of support to women substantially less likely to breastfeed for the recommended duration. However, the nature of support should carefully be tailored according to further research on explanations and mechanisms, and trialled carefully and mindfully with regard both to intended and possible unintended consequences.

Keywords: breastfeeding, obesity, perinatal, longitudinal

INTRODUCTION

Breastfeeding is dually advantageous for infant health and for maternal health(1), but despite its heavily promoted benefits, only a very small percentage of mothers in the UK meet the current World Health Organisation (WHO) recommendation of exclusive breastfeeding for the first six months of life(2). The 2010 Infant Feeding Survey indicates that while a high percentage of mothers in the UK initiate breastfeeding (81%), fewer than one fifth of babies are breastfed exclusively to

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three months (17%) and very few (1%) are breastfed exclusively to six months(3). Moderate increases in breastfeeding rates have the potential to save the NHS £40 million per annum(4), but more research is needed to identify the modifiable factors associated with breastfeeding behaviours (2).

There is accumulating evidence for the relationship between breastfeeding and body weight for both children and mothers. Exclusive breastfeeding is a viable means of reducing the risk of childhood overweight and obesity (5). Breastfeeding can also result in a quicker return postpartum to normal Body Mass Index (BMI) in the mother (6, 7). Yet, epidemiological studies provide consistent evidence of lower breastfeeding initiation and/or duration for mothers who were overweight and obese prior to pregnancy (8-12). Moreover, some suggest that the relationship between BMI and breastfeeding may be moderated by ethnicity (8, 11), and there is emergent evidence that underweight may also be negatively correlated with breastfeeding(8).

Despite the availability of rich contemporary sources of data in the UK, there is very little research on maternal BMI and breastfeeding behaviours specific to the UK context, with its distinctive ethnic composition and social / medical environment. Though Millennium Cohort Study (MCS) data has been used to provide evidence for maternal pre-pregnancy BMI influencing both children's cognitive performance(13), and childhood BMI(14), neither it, nor any of the other UK cohorts has, to the authors' knowledge, been used to investigate pre-pregnancy maternal body composition and breastfeeding behaviours.

Given associations evidenced in the UK between breastfeeding and cognitive development(15, 16), and breastfeeding and child BMI (17-19), it is possible that breastfeeding mediates the previously

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observed relationship between maternal pre-pregnancy BMI and child development. So exploring explicitly and quantifying the associations between BMI and breastfeeding, in this UK sample, will help inform the evidence base on what may be instrumental and modifiable in influencing breastfeeding, and, potentially, in affecting children's outcomes.

A number of possible confounders and mediators may interplay with the relationship between pre-pregnancy BMI and breastfeeding behaviours. Directed Acyclic Graphics (DAGs), graphical representations of conceptual models making explicit the proposed relationships between variables (20), can help to distinguish between these factors. A growing number of articles explain the benefits and logic of using DAGs(20-22), which can aid with the problem of over-adjustment bias, and calculate the minimum amount of adjustment necessary to estimate the effect of the exposure on the outcome whilst minimising this bias(23).

Confounders may relate separately to both unhealthy BMI and breastfeeding non-initiation/curtailed duration(20), and examples in the literature include age, ethnicity, parity, maternal smoking behaviour, and maternal education (8, 9, 11). Mediators include those variables that can be caused by pre-pregnancy maternal BMI and potentially subsequently effect breastfeeding behaviour(20): delivery method, birthweight, gestational age, gestational diabetes, and gestational weight gain(8, 9, 11).

Previous studies that have considered the relationship between maternal pre-pregnancy BMI and breastfeeding behaviour have described all of these variables, including potential mediators, as confounders, and treated them as such in their discussion of adjusted results (8, 9, 11). In contrast,

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the current study improves upon previous research by separating mediators and confounders at the outset, and examining the total effect and direct effect of maternal pre-pregnancy BMI on breastfeeding behaviour.

The aim of this study is therefore to provide evidence on the relationship between maternal pre-pregnancy BMI and breastfeeding initiation, early cessation, and longevity, using a nationally representative cohort of over 17,000 families within the UK. It adds to and addresses existing literature by considering, in this specific setting, both maternal underweight and overweight, by disentangling the total effect of maternal pre-pregnancy BMI from confounding variables, by looking at the extent of mediation by observed factors, and by considering interactions by ethnicity.

METHODS

Sample

The Millennium Cohort Study (MCS) is a nationally representative longitudinal survey of 18552 families with live babies born in the UK in a period of just over a year, between 2000 and 2002 (24). In England and Wales, the period started on 1st September 2000. In Scotland and Northern Ireland, it started on 1 December 2000. Disproportionate sampling ensured adequate representation of the smaller countries and ethnic minority groups(24), stratifying by country and clustering by electoral ward; wards were stratified into 'advantaged,' 'disadvantaged' and 'ethnic' areas. Only areas in England were included in the 'ethnic' stratum. Six waves of data collection have taken place to date; this study uses the first wave only. Wave one interviews took place when babies were around nine months old.

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The analytic sample (n=17 113) includes those who had both information for breastfeeding (n=18 506, no missing data) and maternal pre-pregnancy BMI (n=17 113, 7.53% missing). 55 Cases where the main survey respondent is not the baby's biological mother are removed from the sample. Multiple births (n = 224 in the analytical sample) are included. Cases of all gestations are included, and pre-term delivery (n=1 241) is accounted for in analyses.

Measures

Exposure: Maternal pre-pregnancy BMI - Mothers were asked at first interview, "how tall are you (without shoes)," and "Thinking back to just before you became pregnant with [baby], what was your weight then (without clothes)?" Reported pre-pregnancy weight (in kilos) is divided by height (in metres) squared to produce pre-pregnancy BMI. In line with WHO recommendations, BMI is banded into "underweight" (< 18.5; 5.84%% of the sample); "healthy weight" (18.5-24.99; 65.83%%); "overweight" (25-29.99; 19.71%); "obese" (30+; 8.62%) (25). BMI is also used as a continuous variable in an alternative specification (mean=23.64; CI:23.54-23.73).

Outcomes: Breastfeeding initiation, early cessation, and longevity - Mothers were asked at first interview, "Did you ever try to breastfeed [baby]?" and "How old was [baby] when [s]he last had breast milk?" Answers to these questions are combined to produce indicators of whether a) breastfeeding was initiated (70.06% of the sample); b) ceased during the first seven days, conditional upon initiation (17.93% of the sample who initiated); c) continued for more than four months (the point until which exclusive breastfeeding was recommended by the UK's National Health Service in 2000-2002 (26)), conditional upon initiation (39.63% of the sample who initiated). These definitions of breastfeeding behaviours highlight three distinct points in the breastfeeding trajectory, within the context of the mothers' personal experience and the contemporaneous advice and recommendations to which she was subject. Potentially, different intervention may be feasible at each distinct point, so disambiguating in this way is of interest. Help with intentionally planning and

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beginning breastfeeding, help with establishing breastfeeding in the early days, and help with continuing to breastfeed in the longer term, once it is well-established and the infant is introduced to additional nutritional sources, may require separate strategies.

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Table 1. Characteristics of the analytic sample categorised by potential confounder and mediator variable status.

CONFOUNDERS		**MEDIATORS**	
Ethnicity	%	***Birthweight***	%
		Heavy	11.13
White	89.65	Normal	82.02
Mixed	0.95	Low birth weight	6.86
Indian	1.85	Missing	<0.01
Pakistani	2.74	***Gestational age***	
Bangladeshi	0.72	37 weeks or over	91.86
Black Caribbean	1.08	Pre-37 weeks	7.39
Black African	1.19	Missing	0.75
Other (including Chinese)	1.83	***Gestational diabetes***	
Maternal Education		No	98.85
NVQ level 1	8.09	Yes	1.15
NVQ level 2	29.83	***Delivery***	
NVQ level 3	14.42	Vaginal	68.28
NVQ level 4	29.9	Forceps	3.93
NVQ level 5	3.65	Vacuum	5.86
Overseas qualifications	2.22	Other	0.72
None of these	11.79	Planned caesarean	9.26
Missing	<0.01	Emergency caesarean	11.96
Mother's age band		***Labour complications***	
14-24	23.65	Yes	33.53
25-34	59.07	No	66.47
35-51	17.28		
Missing	<0.01		
Siblings in house	%		
None	42.63		
One	36.21		
Two	14.61		
Three or more	6.55		
Step-siblings in house			
None	90.83		
At least one	9.17		
Smoked during pregnancy			
Didn't smoke	71.62		
Gave up in first month	7.00		
Smoked after first month	21.38		
Alcohol during pregnancy			
Never	67.03		
Less than once per month	15.03		
1-2 times per month	7.86		
1-2 times per week	8.05		
3-7 times per week	2.01		
Missing	<0.01		

Percentages relate to weighted number of cases(n=17 113). All estimates obtained using svy commands in Stata

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Confounders – Variables indicated as potentially confounding by previous research, as available in the dataset, are treated as such unless otherwise indicated: Mother's ethnicity, mother's education, mother's age, siblings in home, presence of step-siblings, smoking during pregnancy, drinking alcohol during pregnancy (see Table 1 for detail).

Mediators – Variables suggested by previous research as potentially mediating the relationship between BMI and breastfeeding are accounted for: birthweight (low: <2.5 kg; normal: 2.5-<4kg; heavy: >=4kg)), gestational age (pre- or post-37 weeks), mother's gestational diabetes, method of delivery, labour complications as reported by the mother (as opposed to her reporting she experienced no complications) (see Table 1 for detail). Gestational weight gain is not available in the MCS.

Conceptual model

Directional Acyclic Graphs (DAGs) are used in order explicitly to state model assumptions, and reduce bias in estimated outcomes(20, 21). Existing evidence, described in the previous section, is used to design the conceptual model, and open source software DAGitty to draw the conceptual model and establish appropriate minimal adjustment to block biasing pathways(27). A simplified version of this conceptual model, which does not show interrelationships between confounder or mediator variables, is presented in Figure 1. The full conceptual model is shown in web appendix 1.

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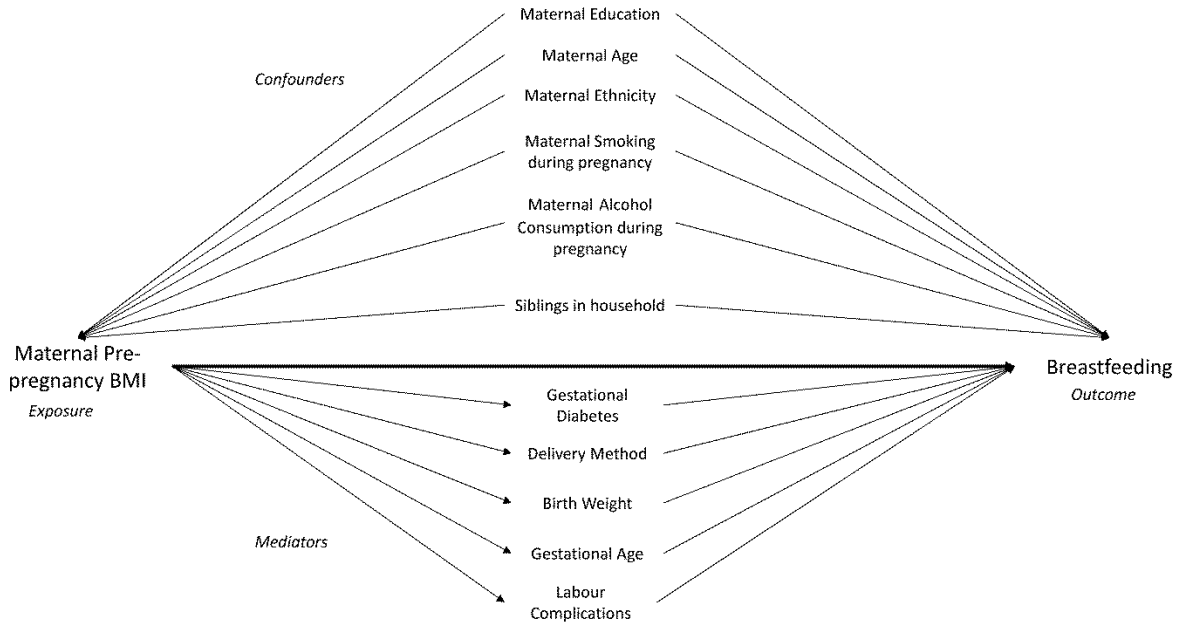

Figure 1 Simplified Directed Acyclic Graphic (DAG) of the relationship between maternal pre-pregnancy BMI and breastfeeding initiation

Statistical Analysis

Analyses were conducted using Stata version 14 (28). The complex sampling design of the MCS was accounted for using the 'svy' commands in Stata, declaring the strata, clusters, probability weight and finite population correction factor. For the results presented here, the MCS is weighted using the 'aovwt2' weight, which adjusts observations to be nationally representative for the whole of the UK based on the probability of selection into the survey, and non-response based on observable characteristics(24). Descriptive statistics calculated unadjusted odds ratios and 95% confidence intervals for the relationship between pre-pregnancy BMI category and breastfeeding initiation, early cessation, and longevity. These unadjusted relationships were estimated separately for each ethnicity.

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The total effect of pre-pregnancy BMI category on breastfeeding initiation, early cessation, and longevity, respectively, was estimated by adjusting for confounding variables in logistic regression models. The direct effect of pre-pregnancy BMI category was estimated by further adjusting for mediator variables. Results are presented as odds ratios, and as predicted marginal probabilities, to assist with the assessment of the relative and absolute size of the effects of pre-pregnancy BMI.

To test whether the effect of pre-pregnancy BMI is moderated by ethnicity, interactions between ethnicity and pre-pregnancy BMI category were added. Sensitivity analyses were conducted using BMI as a continuous variable in initiation, early cessation, and longevity models. Where confounders or mediators had missing information, missing categories were included in the analysis such that a common sample was analysed to obtain total and direct effects.

As a further sensitivity analysis, longevity was measured using breastfeeding duration in months with analysis conducted using ordered logistic regression. This analysis is available in web appendix 2.

RESULTS

Descriptive

The total analytic sample was 17 113 (92.5% of) mothers. The confounders and mediators either had no missing data (ethnicity, siblings in household, step-siblings in household, smoking during pregnancy, gestational diabetes, delivery method, labour complications), or very low percentages of missing data <1% (maternal education, maternal age, alcohol consumption during pregnancy, birthweight and gestational age).

Of this sample, 70% of mothers initiated breastfeeding. Initiation rates varied considerably by ethnicity (White (68.19%), Mixed (87.97%), Indian (84.65%), Pakistani (76.81%), Bangladeshi (87.67%), Black Caribbean (92.03%), Black African (95.31%), 'Other' ethnicity (91.37%)). Of those

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who initiated, 17.93% ceased breastfeeding at one week or earlier, and 39.63% breastfed for more than 4 months.

Table 2 shows the unadjusted relationship between pre-pregnancy BMI category and breastfeeding initiation, cessation and longevity for the whole analytic sample, and stratified by ethnicity. For the whole sample, being underweight, overweight or obese is associated with decreased odds of initiating breastfeeding (underweight OR=0.63(0.54-0.74), overweight OR=0.86(0.77-0.96), obese OR=0.83(0.72-0.96)), increased odds of ceasing breastfeeding within the first week (underweight OR=1.32(1.05-1.66), overweight OR=1.59(1.38-1.83), obese OR=1.63(1.35-1.97)), and decreased odds of breastfeeding for 4 months or more (underweight OR=0.79(0.65-0.96), overweight OR=0.75(0.67-0.84), obese OR=0.58(0.48-0.69)), compared to those who had a healthy weight prior to pregnancy. The results were very similar for the White ethnic group, who comprise almost 90% of the sample.

Despite the wide confidence intervals, the patterning of the prevalence and the odds ratios by BMI category suggests potentially varying relationships between pre-pregnancy BMI and breastfeeding behaviours for some ethnic groups. However, formal tests revealed no evidence for multiplicative interaction effects for initiation ($F(18,372)=1.07$, $p=0.39$). Small numbers of those classified as underweight in some ethnic groups with very high rates of initiation (mixed (n=11), Black African (n=13) and Black Caribbean (n=11)) limit the ability of analyses to estimate the impact of underweight on breastfeeding initiation in these groups. There was however evidence for multiplicative interaction effects for early cessation ($F(20, 370)=2.30$, $p=0.001$) and longevity ($F(21, 369)=1.91$, $p=0.01$) in unadjusted models.

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Table 2. Unadjusted relationship between pre-pregnancy BMI and breastfeeding behaviours for the whole sample and by ethnicity.

	Initiation (n=17 113)		Early cessation (n=11 989)		Longevity (n=11 989)	
Whole sample	Prevalence	OR(95%CI)	Prevalence	OR(95%CI)	prevalence	OR(95%CI)
underweight	61.48	0.63(0.54-0.74)	19.78	1.32(1.05-1.66)	36.79	0.79(0.65-0.96)
healthy weight	71.61	1.00	15.71	1.00	42.24	1.00
overweight	68.43	0.86(0.77-0.96)	22.89	1.59(1.38-1.83)	35.49	0.75(0.67-0. .84)
obese	67.77	0.83(0.72-0.96)	23.30	1.63(1.35-1.97)	29.83	0.58(0.48-0. .69)
White		(n=15 341)		(n=10 461)		
underweight	56.57	0.56(0.46-0.67)	23.05	1.51(1.17-1.97)	33.71	0.72(0.57-0.92)
healthy weight	70.10	1.00	16.48	1.00	41.23	1.00
overweight	66.22	0.84(0.74-0.94)	24.06	1.61(1.38-1.86)	33.70	0.72(0.63-0.82)
obese	65.24	0.80(0.69-0.93)	25.50	1.73(1.40-2.14)	27.06	0.52(0.43-0.64)
Mixed		(n=151)		(n=143)		
underweight	100.00	1.00 (empty)	09.25	1.45(0.14-14.90)	33.43	0.52(0.15-1.80)
healthy weight	86.47	1.00	06.58	1.00	48.79	1.00
overweight	84.87	0.88(0.23-3.35)	12.16	1.96(0.38-10.26)	48.48	0.98(0.35-2.72)
obese	95.04	3.00(0.64-13.98)	02.62	0.38(0.04-3.30)	50.79	1.08(0 .33- 3.50)
Indian		(n=316)		(n=267)		
underweight	83.21	0.88(0.31-2.51)	08.77	0.89(.26-3.11)	54.37	1.27(0.59-2.71)
healthy weight	84.98	1.00	09.69	1.00	48.28	1.00
overweight	86.42	1.12(0.45-2.81)	25.52	3.19(1.25-8.17)	42.63	0.79(0.38-1.64)
obese	74.03	0.50(0.12-2.07)	21.42	2.54(0.84-7.68)	57.16	1.42(0.36-5.61)
Pakistani		(n=467)		(n=360)		
underweight	71.71	0.71(0.46-1.10)	7.50	0.38(0.16-0.91)	40.13	1.28(0.64-2.56)
healthy weight	78.03	1.00	17.39	1.00	34.32	1.00
overweight	75.87	0.89(0.65-1.20)	23.25	1.44(0.90-2.30)	33.41	0.96(0.62-1.48)
obese	77.26	0.96(0.45-2.01)	8.69	0.45(0.22-0.95)	48.61	1.81(0.90-3.61)
Bangladeshi		(n=122)		(n=107)		
underweight	91.06	1.35(0.52-3.47)	23.9	3.49(0.88-13.96)	30.20	0.64(0.26-1.55)
healthy weight	88.33	1.00	8.24	1.00	40.33	1.00
overweight	82.96	0.64(0.22-1.89)	11.10	1.40(0.71-2.74)	39.07	0.94(0.40-2.22)
obese	95.06	2.54(0.32-20.37)	26.11	3.93(0.74-20-81)	30.30	0.64(0.23-1.76)
Black Caribbean		(n=170)		(n=169)		
underweight	100.00	1.00(empty)	16.80	3.18(0.77-13.02)	62.09	1.45(0.40-5.19)
healthy weight	89.02	1.00	5.98	1.00	52.93	1.00
overweight	93.69	1.83(0.55-6.14)	3.18	0.52(0.12-2.28)	59.96	1.33(0.53-3.29)
obese	94.10	1.97(0.39-9.87)	14.35	2.64(0.60-11.56)	23.63	0.27(0.10-0.70)
Black African		(n=193)		(n=194)		
underweight	100.00	1.00(empty)	100.00	1.00(empty)	61.62	0.92(0.23-3.69)
healthy weight	95.86	1.00	8.43	1.00	63.40	1.00
overweight	92.93	0.57(0.10-3.20)	6.49	0.75(0.24-2.41)	57.65	0.78(0.42-1.44)
obese	95.75	0.97(0.16-5.88)	5.17	0.59(0.16-2.12)	55.83	0.72(0.34-1.52)
other inc Chinese		(n=313)		(n=286)		
underweight	91.61	1.08(0.37-3.12)	4.28	0.79(0.19-3.21)	47.39	0.48(0.19-1.17)
healthy weight	91.01	1.00	5.36	1.00	65.08	1.00
overweight	91.32	1.04(0.42-2.59)	23.43	5.41(1.95-15.00)	47.13	0.47(0.22-1.02)
obese	94.84	1.81(0.23-14.52)	9.60	1.88(0.22-16.20)	56.12	0.68(0.15-3.02)

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Note: n for breastfeeding early cessation (in the first week) and longevity (past four months) are conditional upon breastfeeding initiation (ever breastfeeding, at least once). Percentages relate to weighted number of cases. All estimates obtained using svy commands in Stata.

Total and direct effects

The total effect and direct of pre-pregnancy BMI groups and continuous BMI on breastfeeding initiation, early cessation and longevity is estimated in Table 3. After adjusting for confounding variables, there was no difference in the odds of breastfeeding initiation (OR=0.95(0.79-1.15)), early cessation (OR=0.96(0.74-1.23)), or breastfeeding for at least 4 months (OR=1.14(0.91-1.42)) for underweight mothers compared to healthy weight mothers. Overweight mothers had lower odds (OR=0.88(0.78-1.00)) of initiating breastfeeding compared to healthy weight mothers. The estimated odds ratio suggests that obese mothers also had lower odds of initiating breastfeeding (OR=0.91(0.77-1.07)), but confidence intervals suggest it is a reasonable possibility that there was no difference on average between obese and healthy weight mothers.

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Table 3. Estimated total and direct effect of pre-pregnancy BMI groups, and pre-pregnancy BMI on breastfeeding initiation, early cessation, and longevity

	Initiation		Early cessation		Longevity	
pre-pregnancy BMI groups	total effect	direct effect	total effect	direct effect	total effect	direct effect
OR (95%CI)						
underweight	0.95 (0.79-1.15)	0.97 (0.80-1.17)	0.96 (0.74-1.23)	0.98 (0.75-1.27)	1.14 (0.91-1.42)	1.16 (0.92-1.46)
healthy weight	1	1	1	1	1	1
overweight	0.88 (0.78-1.00)	0.88 (0.78-0.99)	1.62 (1.41-1.88)	1.61 (1.39-1.86)	0.74 (0.66-0.83)	0.74 (0.66-0.84)
obese	0.91 (0.77-1.07)	0.90 (0.76-1.06)	1.62 (1.33-1.97)	1.57 (1.29-1.92)	0.57 (0.48-0.69)	0.59 (0.49-0.72)
Marginal probabilities						
underweight	69.88	70.03	17.70	18.07	34.49	41.17
healthy weight	70.72	70.82	18.22	18.35	38.22	38.04
overweight	68.53	68.58	25.89	25.86	32.20	32.11
obese	68.96	69.02	25.87	25.45	27.43	28.00
pre-pregnancy BMI						
OR (95%CI)	0.99 (0.98-1.00)	0.99 (0.98-1.00)	1.04 (1.03-1.06)	1.04 (1.03-1.06)	0.95 (0.94-0.96)	0.95 (0.94-0.96)
n	17 113	17 113	11 989	11 989	11 989	11 989

Note: total effect models are adjusted for potential confounding variables (age, ethnicity, maternal education, smoking during pregnancy, alcohol consumption during pregnancy, siblings). Direct effect models are further adjusted for potential mediating variables (gestational diabetes, delivery method, labour complications, gestational age and birthweight)

Overweight (OR=1.62(1.41-1.88)) and obese (OR=1.62(1.33-1.97)) mothers had higher odds of ceasing breastfeeding within the first week compared to healthy weight mothers. Further, overweight (OR=0.74(0.66-0.83)) and obese (OR=0.57(0.48-0.69)) mothers had lower odds of breastfeeding for over 4 months compared to healthy weight mothers. The estimated odds ratios were largely unchanged after adjustment for mediating variables. This suggests only a very small proportion of the total effect is mediated by the available selected variables.

Interactions between ethnicity and BMI group were tested for all three outcomes in total and direct effect models. The results were consistent – here we present the values from direct effect models. The interaction between ethnicity and BMI group was not significant for initiation: ($F(18,372)=1.11$, $p=0.34$) or longevity: ($F(21,369)=1.37$, $p=0.13$). However a significant interaction between BMI group and ethnicity for early cessation ($F(20,370)=2.10$, $P=0.004$)) suggests the effect of pre-pregnancy BMI

on early cessation differs across ethnic groups. For White and Indian mothers being overweight or obese was associated with an increased probability of ceasing breastfeeding in the first week. For Pakistani mothers being obese pre-pregnancy was associated with a lower probability of ceasing breastfeeding in the first week. However, the number of mothers who cease breastfeeding in the first week, who are underweight or obese and belong to any ethnic group except White are very small. Therefore this interaction needs to be interpreted cautiously and is likely very sensitive to small changes in the sample. Furthermore when overweight and obese groups are combined, the interaction is no longer significant ($F(13,377)=1.46$, $p=0.13$)

The marginal probabilities shown in Table 3 put the odds ratios into perspective: holding both cofounder and mediator variables constant across BMI groups, there is only a small (2 percentage points) difference in predicted initiation rates for overweight (68.58%) and healthy weight (70.82%) mothers. There is, however, a larger difference in breastfeeding for 4 months or more for healthy weight (38.04%), overweight (32.11%) and obese (28.00%) mothers and also in early cessation rates for healthy weight (18.53%), overweight (25.86%) and obese (25.45%) mothers.

Sensitivity analysis – BMI as a continuous predictor

As shown in the lower part of Table 3, after accounting for confounders and mediators, a one unit increase in pre-pregnancy BMI was associated with 0.99 (0.98-1.00) times the odds of initiating breastfeeding, 0.95(0.94-0.96) times the odds of breastfeeding for at least 4 months and 1.04 (1.03-1.06) times the odds of ceasing breastfeeding in the first week. There was no evidence for an interaction between ethnicity and BMI in initiation ($F(7,383)=0.73$, $p=0.64$), early cessation ($F(7,383)=1.64$, $p=0.12$), or breastfeeding for at least 4 months ($F(7,383)=0.77$, $p=0.62$).

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DISCUSSION

Congruent with previous research from non-UK countries (8-12), this analysis finds unadjusted associations between pre-pregnancy BMI and breastfeeding initiation, early cessation and longevity.. However, in contrast to emerging international evidence, after adjustment for confounders, there was no relationship between pre-pregnancy underweight and breastfeeding behaviours. The relationships between overweight and obesity and breastfeeding early cessation and longevity hold as both statistically and substantively important after accounting for a variety of potential confounders and mediators. Pre-pregnancy BMI appears, therefore, to be a descriptively useful predictor of breastfeeding duration. At best it potentially holds some explanatory power in elucidating the tendency of some mothers in the UK to cease breastfeeding well before the duration recommended by the World Health Organisation(29).

The reasons for differences in first-week cessation and longevity beyond the recommended (at the time) duration for exclusive breastfeeding, according to pre-pregnancy overweight, require further exploration. The combined influence of the five mediator variables tested did not explain a substantive proportion of the total effect. Previous studies indicate, tentatively, that psychological factors such as body image may play a part in breastfeeding behaviours (30). Physiological explanations have also been proposed, such as dysregulation of the hypothalamic-pituitary-gonadal axis and in fat metabolism affecting milk production and composition (31). Low prolactin levels in response to infant suckling after initiating breastfeeding reducing the ability of overweight/obese women to produce milk is another possible explanation(32), along with delayed onset of lactation perhaps resulting in early cessation(33, 34).

Whatever the explanation for the associations, pre-pregnancy overweight and obesity may provide a useful means through which to target early postnatal support services, which have been indicated as effective in promoting initiation and continuation of breastfeeding (35-38). BMI at first antenatal

appointment is easily and reliably measured. By prioritising overweight and obese mothers for breastfeeding support, both in the initial period of establishment and in later months, services may reach those less likely to continue breastfeeding. This may prove an efficient use of resources: both because of the estimated health benefits to breastfed babies and their mothers, and because research suggests relationships between maternal prenatal BMI and child BMI and cognitive development – associations within which breastfeeding may be a malleable mediating factor.

Strengths and limitations

This study provides evidence on the relationship between pre-pregnancy BMI and breastfeeding behaviours using rich data from a recent, nationally representative sample of UK families. It contributes to the literature by providing evidence on the relationships between pre-pregnancy underweight, as well as overweight, and breastfeeding behaviours, as well as testing whether relationships are moderated by ethnicity. It also accounts for confounding of associations by pre-pregnancy factors, as well as testing channelling of possible effects through mediators occurring during gestation and birth. Unfortunately, however, the data in the MCS does not allow control for gestational weight gain, which may be related to pre-pregnancy BMI, and therefore is a potential untested mediator.

A further limitation to this study is the reliance on self-reported height and weight, and the recording of pre-pregnancy weight retrospectively. Evidence suggests self-reported anthropometric measures are valid despite a tendency for height to be over-reported and weight to be underreported.(39) Moreover, there is a relatively short time period of recall in the MCS, which suggests reasonably accurate estimates of weight.(40) However, comparisons of reported and measured height and weight demonstrate an overreporting of underweight status and a underreporting of obese status.(41) Evidence also suggests that for overweight and obese mothers, pre-pregnancy weight is underreported to a greater extent than for healthy weight mothers (42, 43).

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Estimates of the relationship between pre-pregnancy overweight and obesity may therefore be biased downwards, as some women who are in reality obese/overweight may be classified as overweight/healthy weight in our analysis, which means the effects are underestimated. These underestimates should not affect the overall conclusions drawn from these analyses.

The advantage of choosing BMI as a measure here is that it is widely used, making results easily applicable and interpretable. The sensitivity check where BMI is used as a continuous predictor rather than a grouped variable alleviates the possibility that results may be an artefact of imposed cut-points.

Binary logistic regressions are used for all analyses in this paper, as our outcomes are dichotomous. The resulting odds ratios can at times be misleadingly interpreted – to mitigate this, and for clarity, model-estimated marginal means are presented in each table of results. These estimates represent the percentage probability for each group, for each outcome – thus conveying meaningful effect sizes.

Conclusion

Further research is needed into the causal mechanisms underlying the relationship between maternal pre-pregnancy overweight and obesity and breastfeeding behaviours, particularly given tentative indications in analyses here that there may be variations by ethnic group in the UK context. Scant explanation of the tendency to lower breastfeeding rates among overweight and obese mothers is offered by the pregnancy and delivery factors explored here. Nevertheless, this lack of attenuation may be pragmatically useful. This research suggests that pre-pregnancy BMI could be one predictive measure in targeting of support to some of the women who are substantially less likely to establish breastfeeding or to continue in the longer term. The nature of this support should carefully be considered and tailored according to further theory and research, in order to maximise

benefits for babies and mothers, and minimise the risk of unintended negative effects of

intervention.

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