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Associations between maternal diet, family eating habits and preschool children's dietary patterns: insights from the UPBEAT trial

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Abstract

Background Dietary behaviours in early life often track across the life course, influencing the development of adverse health outcomes such as obesity and cardiovascular disease. This study aimed to explore the between dietary patterns (DP) in preschool children and maternal DP and family eating habits.

Methods We conducted a secondary analysis of 488 mother-child pairs from the UK pregnancy Better Eating and Activity Trial (UPBEAT) at 3-year follow-up. Previously published DP from mothers and children (derived from food-frequency questionnaires and exploratory factor analysis) were used. Mothers' DP were "Fruits-Vegetables", "African-Caribbean", "Processed and Snacks", and children's DP were "Prudent", "Processed-Snacking", and "African-Caribbean". Family meal environments were evaluated using a 5-point Likert scale.

Results Linear regression models revealed that child's prudent pattern was positively associated with maternal Fruits-Vegetables (B = 0.18 (0.08, 0.27)), Snacks patterns (B = 0.10 (0.01, 0.18)), and eating the same foods during meals (B = 0.25 (0.07, 0.43)). Child's Processed-Snacking pattern was directly associated with maternal Processed (B = 0.22 (0.13, 0.30)) and Snacks (B = 0.27 (0.18, 0.36)) patterns, receiving food as reward (B = 0.22 (0.04, 0.39)) and watching TV during meals (B = 0.27 (0.09, 0.45)). Finally, the child African-Caribbean pattern was directly associated with that from the mother (B = 0.41 (0.33, 0.50)) and watching TV during meals (B = 0.15 (0.09, 0.30)), and inversely associated with maternal processed (B=-0.09 (-0.17, -0.02)) and snacking (B=-0.08 (-0.15, -0.04)) patterns.

Conclusions Unhealthy dietary patterns in childhood are directly linked to similar maternal patterns and family meal behaviours, such as television viewing and food rewards. These findings highlight targetable behaviours for public health interventions.

Keywords Dietary patterns, Childhood obesity, Preschool children, Dietary habits, Feeding behaviour

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Background

Childhood obesity is a worldwide public health challenge as it adversely affects health and well-being across the life course [1]. According to the latest report from the National Child Measurement Programme in England, over 20% of reception aged children and a 1/3 of children aged 10 to 11 had overweight or obesity in 2023 [2]. Several studies have reported that a higher body mass index (BMI) in childhood has been shown to predict obesity, and cardiovascular disease and mortality risk in adulthood [3]. Furthermore, obesity disproportionately affects those from ethnic minorities and more disadvantaged areas [4].

Early-life nutrition is pivotal in obesity development, and can be influenced by genetics, social and environmental factors [5], parental obesity, socio-economic status, household food insecurity [6–9], and the home food environment [10]. Evidence suggests that dietary habits are often established before the age of 3 [11]; the period from infancy to early-childhood has been described as a 'window of change' in the life course for shaping food preferences, eating habits and behaviours [12]. The development of dietary patterns during this window are likely to be influenced by the parental diet, and the process by which young children are introduced to the family diet is fundamental because diet in early life has been shown to continue into late childhood [13] and young adulthood [14]. Furthermore, development of adverse dietary patterns has been linked with poor cardiometabolic health outcomes [15]. Therefore, the early years presents an opportune moment to investigate the interplay between parental and child dietary intake.

Family meal environments, such as shared meals or TV viewing during meals, may also impact children's dietary habits [10, 12, 16]. Several studies indicated that having family meals together and eating the same foods are linked to healthier eating habits in children. It has been suggested that family meals are more nutritious, compared to 'child friendly' alternatives and the meal atmosphere has been linked with enjoyment of food [17]. Whereas, watching TV during meals has been associated with unhealthier dietary choices [18], a lower satiety responsiveness and consuming more calories during meals in paediatric cohorts [19].

Whether the combination of all these family meal behaviours together and maternal overall diet, rather than individual components, is associated with children's dietary patterns, have not comprehensively been analysed. Such an analysis would help in understanding the development of children's dietary patterns in early life, enabling the creation of targeted interventions to improve nutrition in childhood and prevent childhood obesity.

Methods

Aim

To explore the associations between maternal dietary patterns and the family meal behaviours with their offspring's dietary patterns at age three years of age.

Study design and setting

This is a cross-sectional observational analysis secondary to the UK Pregnancies Better Eating and Activity Trial (UPBEAT). The UPBEAT trial was a randomized controlled trial conducted between March 2009 and May 2014, involving 1,555 ethnically diverse pregnant women with obesity from eight UK inner-city settings. Women aged ≥ 16 years with a BMI ≥ 30 kg/m² were eligible. The trial aimed to assess an antenatal (between 15 and 28 gestational week) dietary and physical activity intervention's effects on preventing gestational diabetes and large-for-gestational-age infants. The intervention was delivered once a week through eight health trainer-led group sessions, of 1-hour duration. The dietary intervention aimed to promote healthy eating but not necessarily to restrict energy intake. Recommendations were tailored to the woman's habits and culture, suggested replacing foods with high glycaemic index for others with lower glycaemic index, and restricting saturated fats. Physical activity recommendations were tailored to pre-existing activities and focused on increasing in walking at a moderate intensity. Details of the intervention and results have been published previously [20, 21].

Participants

This secondary analysis included 488 mother-child pairs who attended the 3-year follow-up visit (August 2014 - October 2017). Children born before 34 weeks of gestation or with severe illness were excluded. The criteria for being included in the present analysis was to have the mother and the child food frequency questionnaires completed at 3 years postpartum. No other mother-pairs were excluded from the analyses. Further details of the cohort 3 years follow-up were published elsewhere [22].

Exposures

Family eating behaviours

Data on family habits around meals was collected at 3 years postpartum. Families were asked to report about their recent (no specific timeframe) family feeding habits on: watching TV during meals, sitting together for meals, children eating same food as parents, and the use of food as reward to encourage good behaviour (never, rarely, sometimes, often/ most of the time, always). These variables were re-categorized to 2 categories: never-sometimes vs. most of the time-always.

Mother's dietary patterns

At baseline (mother's recruitment), maternal dietary intake was assessed in all participants using a semi-quantitative, 50 item food frequency questionnaire (FFQ) adapted from the UK arm of the European Prospective Investigation Cancer Study [23]. One thousand twenty-three mothers completed the FFQ at baseline (15^{+0}-18^{+6} weeks of gestation). Exploratory factor analysis was used, with an orthogonal varimax rotation, and factors with an eigen value ≥ 1 and above the scree plot's elbow were retained [24]. This analysis identified four independent dietary patterns extracted from the baseline data. At the 3-year visit, the mothers completed the same 50-item FFQ used at baseline. The scoring system from the baseline dietary patterns (e.g. the patterns coefficients) was applied to the 3-year postpartum FFQ [24] rather than extracting new dietary patterns, to maintain consistency between publications and support the longitudinal analysis of the UPBEAT cohort. All mothers received a z-score for adherence to each of the four dietary patterns. The dietary pattern z-score was calculated with the use of a linear combination of the weighted, standardized food intakes (based on scoring weights for each food group estimated by the exploratory factor analysis) [24].

The food groups considered for identification of the dietary patterns as well as the factor loadings of the food items for each factor were previously described [24] and are summarized as Online supporting information (Table S1 and Figure S1, respectively).

The first dietary pattern was labelled 'Fruit & Vegetables', and was characterized by high intakes of bananas, citrus fruit, dried fruit, fresh fruit, green vegetables, pulses, root vegetables, salad vegetables, tropical fruit, and yoghurt. The second dietary pattern was termed 'African-Caribbean' due to its high loadings on red meat, cassava, white meat, rice including pilau, fried or jollof rice and fish. The third pattern, 'Processed', was characterized by intakes of chocolate, crisps, green vegetables, potatoes, processed meat and meat products, root vegetables, squash and fizzy drinks, sugar free squash and fizzy drinks and chips. The last dietary pattern was labelled as 'Snacks' due to high loadings on biscuits, cookies, cakes, pastries, chocolate, full fat cheese and sweets [24].

Outcomes

Children's dietary patterns

Child's dietary intake was assessed using an 88-item FFQ, adapted from the Southampton Women's Survey [25], from which 39 food groups were derived and used for dietary patterns extraction [22]. Three dietary patterns were identified using factor analysis and the same methods than in case of the mothers (orthogonal varimax rotation was applied, and factors with an eigen value ≥ 1 and above the scree plot's elbow were retained), explaining 62.9% of the variance [22]. The first pattern was labelled as 'Prudent' due to high loadings on brown bread, boiled and baked potatoes, rice and pasta, fish, vegetables, beans and pulses, fruit, and nuts. The second dietary pattern, named 'Processed-Snacking', was characterized as a diet high in white bread, crisps and savory snacks, roast potatoes, processed food, quiche and pizza, confectionary, desserts, cakes, biscuits, and low and high sugary drinks. The last pattern was labelled as 'African-Caribbean', as it was characterized by yam/cassava/plantain, red meat, chicken and turkey, soups and rice/pasta, and offal and was low in cheese, yoghurts, and spreads. The list of food groups and the factor loadings have been previously published [22] and are summarized in online supporting information (Figure S2). All children received a z-score for adherence to each of the three dietary patterns.

Confounders

Maternal age at trial entry (years), ethnicity (Black, White, Asian and Other ethnicities), educational attainment (none or low, medium (A level or equivalent), high University degree and post-degree). English Indices of Multiple Deprivation and adjusted Scottish quintiles (deprived for the two top quintiles, versus non-deprived) were obtained by questionnaire completion to estimate the socio-economic level at baseline/ randomisation visit; parity (no previous delivery vs. previous deliveries, from which it is assumed that participants born to mothers with previous deliveries have at least one sibling in most of the cases) was collected as well at randomisation visit; intervention group (standard antenatal care versus behavioural intervention including diet and exercise recommendations); maternal gestational diabetes (yes vs. no) at 28th week of gestation; infant born large for gestational age, which was considered when birth weight was ≥ de 90th customised birthweight centile for gestational age, adjusting for maternal height and weight, ethnic origin, parity, and sex of the infant and maternal BMI at 3 years postpartum, using the GROW v5.16 software for UK [26].

Statistical analysis

Demographic results were expressed as mean ± standard deviation (SD), frequency (n and percentage) as appropriate. Differences in mothers' and children's dietary patterns z-scores according to the antenatal intervention or behaviours around meals were analysed with Mann Whitney's U Test.

Linear regression models were used to analyse the association between maternal and children's dietary patterns. As z-scores for adherence to maternal dietary patterns were independent of each other, all maternal patterns were incorporated as independent variables into the same

linear regression model, to explain each of the child's dietary pattern as dependent variables. Linear regression models were used to analyse the association between children's dietary patterns and (a) maternal diet, (b) family habits around meals (the use of TV during meals, sitting together for meals, eating same food as parents and, the use of food as reward to encourage children's appropriate behaviours), and (c) both maternal diet and family habits around meals adjusted by potential confounders. Linear regression models were run introducing the behavioural modifiable factors (maternal diet and family habits around meals) as enter method. All other covariates with potential association with children's diet were introduced as forward method to the model in two steps: the first step including the sociodemographic and family structure characteristics (maternal age, ethnicity, educational attainment, Indices of Multiple Deprivation, parity (no previous delivery vs. previous deliveries, from which it is assumed that participants born to mothers with previous deliveries have at least one sibling in most of the cases), and the second step including the biological variables potentially associated: intervention group, maternal gestational diabetes, large for gestational age birth, maternal BMI at 3 years postpartum.

To further explore the potential association between family behaviours, a Chi^2 analysis was conducted.

No imputation of missing data was performed. Statistical significance was accepted at the $p<0.05$ level. All statistical analyses were performed with SPSS 29.0 (IBM Corp., Armonk, NY, USA).

Table 1 Maternal and children characteristics of the UPBEAT participants at 3 years follow – up visit

Mother's characteristics (n = 485)			
			Mean (SD[a])
Age at baseline, years			31.2 (5.2)
BMI[b], kg/m^2 3 years			36.5 (6.0)
Years in full-time education			15.1 (2.8)
			n (%)
Intervention Group			236 (49)
Ethnicity	White		329 (68)
	Black		112 (23)
	Asian		21 (4)
Other			23 (5)
BMI, category at 3 y postpartum			**n (%)**
	Normal weight (18.5 < BMI < 24.9 kg/m^2)		3 (1)
	Overweight (25.0 < BMI < 29.9 kg/m^2)		51 (10)
	Type I obesity (30.0 < BMI < 34.9 kg/m^2)		169 (35)
	Type II obesity (35.0 < BMI < 39.9 kg/m^2)		136 (28)
	Type III obesity (BMI ≥ 40 kg/m^2)		126 (26)
Parity: child born to mother as result of first delivery			243 (50)
Gestational diabetes			117 (26)
Education attainment [c]	Low		129 (27)
Medium			134 (28)
High			222 (46)
Indices of multiple deprivation [d]		(Least) 1	30 (6)
	2		31 (7)
	3		57 (12)
	4		174 (37)
	(Most) 5		181 (38)
Children's characteristics ($n = 488$)			
			Mean (SD[a])
Age, months			41.8 (3.4)
			n (%)
Sex, Female			241 (50)
Born large for gestational age			60 (12.4)
Gender-specific cut-off BMI[b] categories at 3 years			
	Underweight (< 18.5 Kg/m^2)		15 (3)
	Healthy (18.5–24.9 Kg/m^2)		298 (63)
	Overweight (25.0–29.9 Kg/m^2)		122 (26)
	Obesity (30.0–34.9 Kg/m^2)		14 (3)
	Morbid obesity (≥ 35.0 Kg/m^2)		26 (5)

[a]SD standard deviation; [b]Body Mass Index; [c]BMI categories according to the International Obesity Task Force; [d]English Indices of Multiple Deprivation and adjusted Scottish quintiles (deprived for the two top quintiles, versus non-deprived)

Results

Participant characteristics

Four hundred and eighty-five mother-child pairs provided complete dietary data and were finally analysed. Table 1 illustrates the demographic characteristics of the mothers and children. Maternal age at study entry was 31.2 (SD 5.2) years; mothers' BMI at the 3-year visit was 36.5 (SD 6.0) kg/m^2. Less than half of women (46.1%) were educated to University degree level, 75% were from a deprived region and 68% and 23% of White or Black ethnicity, respectively. The average age of the children was 41.8 (SD 3.4) months. Of the children with anthropometric measures, one hundred and sixty-two (34%) were categorized as having overweight or obesity according to the IOTF classification. There was no difference between the mean scores for any of the dietary patterns in either the mothers or the children according to the maternal antenatal intervention (data not shown).

Description of children's dietary patterns according to family habits around meals

Children frequently having meals with parents as a family and having the same meals as parents (often to always) had significantly higher scores for the Prudent dietary pattern (Fig. 1). Children often receiving food as reward to promote adequate behaviour had higher scores for the Processed-Snacking pattern and lower scores for the African-Caribbean pattern (Fig. 1). Children watching TV (often to always) during meals had lower scores

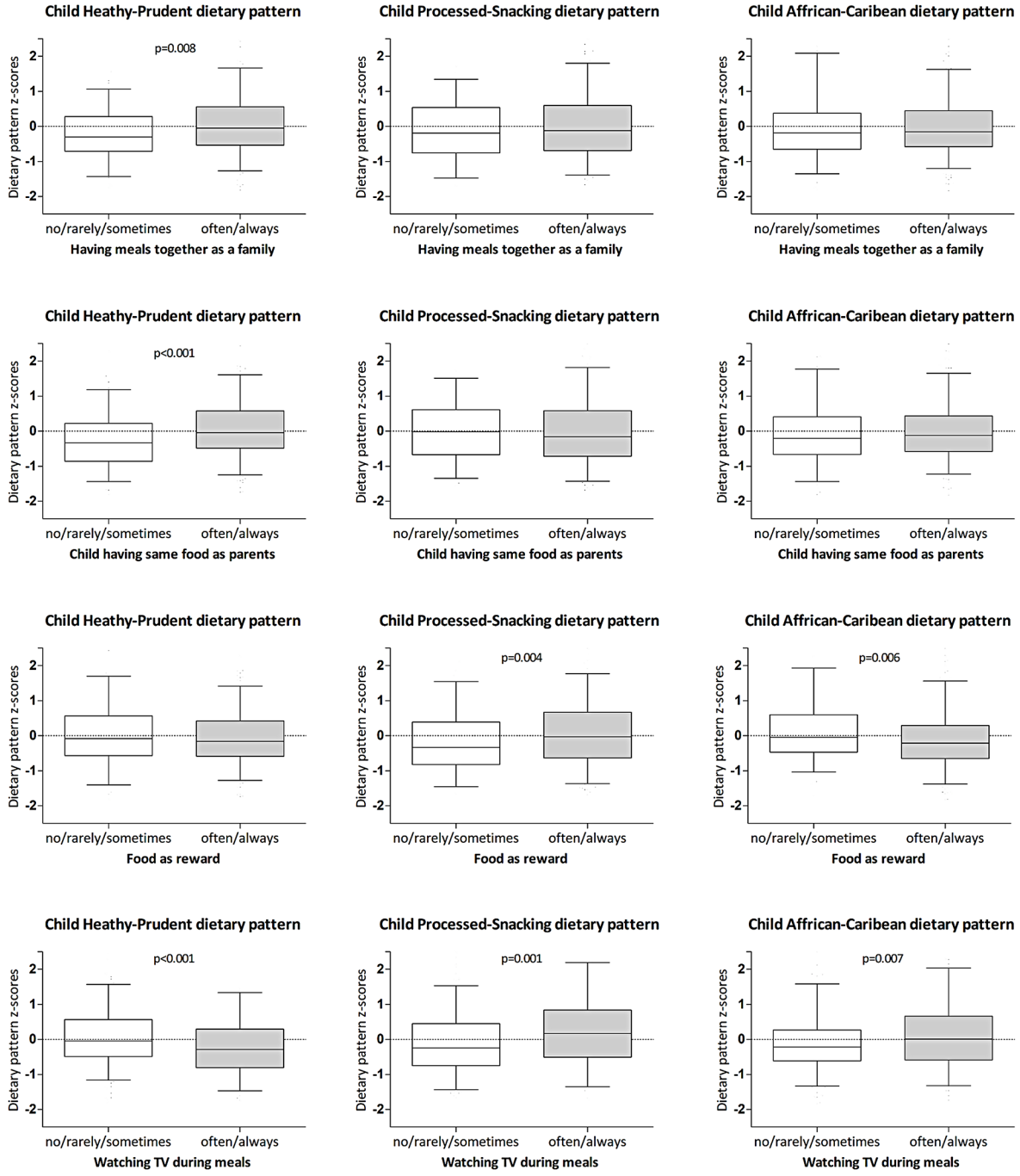

Fig. 1 Child dietary pattern scores according to family behaviors around meals

for the Prudent dietary pattern and higher scores for the Processed-Snacking pattern (Fig. 1).

Association of child's dietary patterns with maternal dietary patterns at 3 years postpartum

Unadjusted linear regression models showed that a child "Prudent" dietary pattern was significantly associated with maternal adherence to a Fruits & Vegetables pattern and to a Snacks pattern (Table 2). Overall, the maternal dietary pattern explained up to 5.2% of the child's diet. The child Processed-Snacking dietary pattern was associated with maternal dietary patterns labelled as either "Processed" foods or "Snacks". The child's African-Caribbean pattern scores were positively associated with the "African-Caribbean" maternal diet and an inverse association the maternal "Processed" and "Snacks" patterns (Table 2).

Table 2 Associations between offspring and maternal dietary paterns at 3 years follow-up (n = 488)

	Child Prudent DP[a]				Child Processed-Snacking DP[a]				Child African-Caribbean DP[a]			
	B	95% CI	*p*-value	r^2	B	95% CI	*p*-value	r^2	B	95% CI	*p*-value	r^2
Unadjusted models of maternal DP[a] on children DP[a]												
Fruit & Vegetables DP	0.198	(0.114, 0.283)	***< 0.001***	5.2%	0.055	(-0.027, 0.136)	0.190	14.1%	-0.060	(-0.133, 0.013)	0.106	22.9%
African-Caribbean DP	0.012	(-0.067, 0.091)	0.763		-0.077	(-0.159, 0.005)	0.065		0.468	(0.389, 0.547)	***< 0.001***	
Processed DP	-0.042	(-0.118, 0.035)	0.285		0.266	(0.184, 0.347)	***< 0.001***		-0.100	(-0.170, -0.029)	***0.006***	
Snacks DP	0.103	(0.028, 0.178)	***0.007***		0.261	(0.181, 0.340)	***< 0.001***		-0.085	(-0.155, -0.016)	***0.016***	
Unadjusted models of family behaviours on children DP[a]												
Together during meals	0.129	(-0.056, 0.314)	0.171	4.6%	0.146	(-0.058, 0.349)	0.116	3.5%	-0.023	(-0.213, 0.168)	0.907	2.7%
Eating same food	0.272	(0.097, 0.447)	***0.002***		-0.037	(-0.229, 0.156)	0.706		0.092	(0.088, 0.273)	0.318	
Food as reward	-0.074	(-0.234, 0.086)	0.364		0.249	(0.073, 0.425)	***= 0.006***		-0.225	(-0.390, -0.060)	***0.008***	
Watching television on during meals	-0.219	(-0.384, -0.053)	***0.010***		0.339	(0.156, 0.521)	***< 0.001***		0.244	(0.074, 0.414)	***0.005***	
Adjusted models of maternal DP[a] and family behaviours on children DP[a]												
Fruit & Vegetables DP	0.175	(0.084, 0.266)	***< 0.001***		0.077	(-0.018, 0.172)	0.111	21.6%	-0.091	(-0.174, -0.009)	0.030	
African-Caribbean DP	0.009	(-0.073, 0.090)	0.833	12.2%	-0.026	(-0.115, 0.063)	0.568		0.414	(0.330, 0.499)	**< 0.001**	31.9%
Processed DP	0.004	(-0.077, 0.086)	0.914		0.217	(0.131, 0.304)	***< 0.001***		-0.093	(-0.165, -0.021)	***0.011***	
Snacks DP	0.096	(0.012, 0.180)	***0.025***		0.271	(0.184, 0.359)	***< 0.001***		-0.077	(-0.150, -0.004)	***0.040***	
Together during meals	0.148	(-0.044, 0.341)	0.131		0.116	(-0.084, 0.315)	0.255		-0.065	(-0.236, 0.107)	0.460	
Eating same food	0.251	(0.071, 0.432)	***0.006***		-0.082	(-0.268, 0.104)	0.385		0.146	(-0.014, 0.307)	0.074	
Food as reward	-0.047	(-0.214, 0.121)	0.585		0.215	(0.042, 0.388)	***0.015***		-0.042	(-0.191, 0.107)	0.581	
Watching television on during meals	-0.098	(-0.270, 0.075)	0.267		0.269	(0.091, 0.448)	***0.003***		0.145	(0.09, 0.299)	**0.065**	
Maternal age (years) [b]	0.021	(0.006, 0.037)	***0.006***									
Ethnicity [c]					-0.174	(-0.280, -0.067)	***0.002***		0.243	(0.151, 0.335)	***< 0.001***	
Maternal education, medium	0.433	(0.222, 0.644)	***< 0.001***									
Maternal education, high	0.348	(0.152, 0.545)	***< 0.001***		-0.218	(-0.389, -0.067)	***0.013***					
Parity[d]					0.224	(0.055, 0.393)	***0.010***					
Intervention group	0.177	(0.018, 0.335)	***0.030***									

[a] DP dietary pattern; [b] 3 years postpartum; [c] Other ethnic groups (mainly black) versus Caucasian; [d]Parity: child born to mother as result of first delivery. Each model separated by a line. Family habits classified in two categories: never-sometimes vs. most of the time-always. Unadjusted models: all variables included with the enter method. Adjusted models: maternal dietary patterns and family behaviours included as enter method, potential confounders included as step-forward method. The following variables were excluded from all adjusted linear regression models: English Indices of Multiple Deprivation and adjusted Scottish quintiles (deprived for the two top quintiles, versus non-deprived), maternal body mass index 3 years postpartum, offspring sex, maternal gestational diabetes and infant born large for gestational age. Bold values indicate statistically significant associations (p<0.05).

Inter-relation between family meal behaviors and its association with child's dietary patterns

Families having often-always meals together had more frequently (often-always) the same foods (78.2%) than those having family meals never-sometimes (43.4%) ($p<0.001$). In addition, children from families having often-always meals together watched TV lesser frequently during meals (22.1% never-sometimes) than those with few family meals (32.4%) ($p=0.017$). Children from families having often-always meals together received often-always food as reward less frequently (62.2%) compared to those with lesser family meals (72.1%). Receiving food as reward was not different in children who watched TV during meals than in children who did not used to do it (65.5% vs. 62.5%, $p=0.471$).

Having family meals itself was not associated with children's dietary patterns, while eating the same food was directly associated with having a child's prudent pattern (Table 2, unadjusted models).

Watching TV during meals was inversely associated with a child prudent diet and directly associated with the processed-snacking and African-Caribbean patterns (Table 2, unadjusted analyses).

Association of child's dietary patterns with family meal habits and maternal dietary patterns at 3 years postpartum

The adjusted models in Table 2 show how maternal dietary patterns and family habits around meals contribute together to explain child's dietary patterns. The child's Prudent pattern score exhibited a direct association with maternal "Fruits and Vegetables" pattern, maternal age, educational attainment, as well as children consuming the same meals as their parents. These factors, in addition to the contribution of the mother's dietary patterns, were found to be associated with the child's Prudent pattern score. The child's Processed-Snacking pattern score was directly associated with maternal dietary patterns "Processed" and "Snacks". Other factors associated with greater scores for the child's Processed-Snacking pattern were being Caucasian, low versus high maternal education attainment, having older siblings, watching TV while having meals and receiving food as reward for good behaviour. The child's African-Caribbean pattern score displayed a negative association with the mother's scores for Snacks and Processed patterns and, coherently, exhibited a positive association with the maternal African-Caribbean pattern and having a mother from an ethnic group different than Caucasian. Adherence to an African-Caribbean pattern was associated with watching TV while having meals.

Discussion

This is the first study showing the overall association of comprehensive maternal dietary patterns and the family habits around meals on children's dietary patterns at age three years.

The results indicate that both maternal dietary patterns and specific family meal habits are associated with the dietary patterns observed in children at this age. The dietary patterns of the children were significantly associated with maternal dietary patterns that exhibited certain consistency. A child "Prudent" diet was associated with a maternal diet characterized by "Fruits and Vegetables", while a pattern dominated by "processed foods and snacks" in children was associated with maternal "Processed" and "Snacks" patterns. Similarly, the dietary patterns of children's and mothers labelled as "African-Caribbean" pattern were associated in a coherent manner. Interestingly, whereas maternal "Processed" and "Snacks" patterns were inversely associated with a child's "African-Caribbean" diet, a mother's "Snacks" pattern was directly associated with a child "Prudent" diet. While it seems to be sensible that African-Caribbean families consume less snacks and processed foods (more characteristic of a western diet), there is no explanation for a positive association between a maternal snacking pattern and a child's prudent diet.

Our analyses about the association between family behaviours with the child's dietary pattern, having family meals itself did not display any association. However, when looking at the potential interrelation between the different family behaviours, having family meals together seemed to be a main indicator of other potentially protective behaviours. In our study, we observed that children who consumed the same foods during meals as their parents displayed higher scores for the Prudent diet. Thus, a possible explanation for these results is that having meals together could promote a healthier diet only if parents eat healthy and all the family members eat the same foods. These findings underscore the significant role of parents as a positive model for children in acquiring and adopting healthy dietary patterns.

Watching TV was associated with a Processed-Snacking dietary pattern, consistently with previous studies [18, 19]. It has been reported that children from families who watch TV while eating meals had a lower-quality diet (more energy-dense foods, soft drinks, and fewer vegetables) compared to children in families where this behaviour is not observed [27, 31]. Interestingly, our results reveal an association between African-Caribbean dietary patterns and watching TV. These results might not indicate an association with a higher consumption of energy-dense foods. In this case, we may speculate that watching TV while having meals might be the result of different parenting practices already observed in

foreign-born parents living in UK, possibly as part of an acculturation process [32].

Finally, another family behavioural factor related to children's dietary intake was the use of food as a reward to reinforce good behaviour in children. This practice was associated with higher scores for the processed-snacking pattern, possibly explained by the fact that foods used as rewards often tend to be unhealthy, including sweets, sugar-sweetened beverages, or high-density processed foods [33, 34].

The important of using food as reward goes beyond the "reward event" but could also contribute to the child's perception that these types of food products are associated with happiness, potentially influencing their food decisions in the long-term and promoting emotional eating patterns [35].

Children learn to make their own food decisions, from early life, establishing their dietary behaviour patterns by observing and modelling their parents' practices and behaviours, which could permanently influence the development of reward and satiety pathways [36, 37]. Family environment is of particular importance in childhood, since young children are highly influenced by early emotional experiences and by reward-activation promoted by tasty energy dense foods [36]. All these early experiences could modulate the later self-control to perform healthy food-choices, which could start from adolescence, when the maturation of the prefrontal cortex takes place [36].

Several family characteristics were found to be significantly associated with children's dietary patterns [27, 28]. In line with prior research [16], our findings reinforce the association between increasing maternal age and healthier children's diets. This observation suggests that older mothers may demonstrate greater health consciousness and awareness regarding their child's diets. Moreover, the presence of older siblings was significantly linked to higher adherence to a Snacking-Processed pattern and lower scores for a Prudent pattern, which is consistent with previous studies [16]. This observation may reflect that looking after more children limits time to prepare meals for the entire family. Similarly, previous studies reported that children with older siblings had higher intakes of sugar-rich foods [29], were more likely to have daily consumption of energy-dense foods daily [30], or exhibited higher scores for a dietary pattern characterized by saturated/processed fats and added sugars [15]. One possible explanation for these findings could be that the presence of older siblings increases the exposure of younger siblings to unhealthy food choices.

We consider the age of three years of age as a crucial period for analysing the factors influencing the development of children's dietary patterns. During the first two years of life, infants are actively acquiring feeding skills and mothers often prepare texture-adapted meals. By the age of three, children are likely to have already acquired all their feeding-motor skills, resulting in a more mature dietary pattern primarily based on family foods, which should be fully established by this stage. Whilst current knowledge about how early eating behaviour influences lifelong food preferences is limited, it is of concern that young children with acquired low-quality dietary patterns have increased risk of having poor quality diet later in childhood [13], affecting their cardiometabolic health [15].

Children learn to take their own food choices at a stage when they are unable to purchase and prepare their own meals. Consequently, their exposure to different food options may be constrained by the variety offered within their families, as they depend on caregivers, mothers or others, to provide them with food. The association between mother's diet and that of their child, as discussed in this article, may appear self-evident and predictable, potentially perceived as a limitation in the current analysis. However, the very fact that children rely on their caregivers' food choices for their learning process underscores the significant relevance of the association between maternal and child diets for future health.

Strengths and limitations

A possible limitation of the present study is the loss to follow-up of some participants that may result in selection bias. Although there were no differences in the women who completed the 3-year follow-up compared with those who did not (except for a higher proportion of white women returning for the 3-year visit [22]), mothers included in this analysis, who completed the FFQ, might be itself a selected population. Ideally, to compare maternal and child's diet, the same questionnaire and food items should have been used. This would have allowed a more straight-forward analysis. However, given the young age of the children, the questionnaire and its food items differed from that of the mothers, and therefore the obtained dietary patterns (using an exploratory method, not driven by investigator's hypothesis) could not be the same. Besides this, FFQs are a parent-reported measure and are subject to recall bias and the caregiver's interpretation of eating habits; however, both FFQs had been previously validated. Notwithstanding, mothers with obesity could tend to underestimate their dietary intakes of unhealthy foods.

The questionnaire employed to examine exposures within the family environment, as outlined above (e.g., sharing meals, using food as a reward, or watching TV during meals), has not undergone prior validation. Nevertheless, we believe that these questions contribute to the robustness of our analyses. They are commonly investigated in research [38–42] and encompass several

aspects previously identified as influencing children's dietary habits.

Strengths of the present study are the rich UPBEAT dataset, which provides comprehensive information on the family factors that may be related to the child's dietary habits development, from a very early age in an ethnically and socioeconomic status diverse population.

It is essential to emphasize that this study was carried out in a high-risk population, characterized by maternal obesity, high deprivation indexes and ethnic minorities in the UK, population groups who are at a higher risk of developing obesity.

While the dietary patterns may be specific to this population, the practices related to mealtime and the importance of setting a positive example for children should be universal recommendations, with particular attention given to families where mothers are leaving with obesity.

Relevance and practical applications

Dietary habits formed during early childhood may persist lifelong and can significantly impact long-term health. Therefore, understanding the family practices that shape the development of these habits is crucial to enhance educational approaches.

Educational interventions beginning in early life should encompass not only dietary recommendations, but also practical guidance aimed at enhancing the feeding environment for children. As observed in this study, mothers with obesity receiving educational interventions during pregnancy, may later implement some of these recommendations with their children. Additionally, mothers from other cultures should receive tailored recommendations adapted to their cultural background.

Promoting awareness of the role of family behaviours is essential across multiple levels, including community outreach (via targeted public campaigns, school initiatives, etc.), family-oriented support groups for expectant and breastfeeding mothers, and individual-level guidance (e.g., brief counselling at paediatric primary care facilities) [43].

Figure 2 presents a concise overview of recommendations derived from the present study, in alignment with prior research, and they can be integrated into routine preventive early life care.

A potential next step in advancing our understanding could involve implementing a program centred on minimal intervention that specifically target the identified unhealthy habits, within the framework of a clinical trial. However, these habits, which are learned within the family and influenced by a socio-cultural context, require interventions at multiple levels of the socioecological framework for childhood obesity, including actions at the social media and community level.

Conclusions

We have demonstrated that the quality of young children's dietary patterns is directly associated with maternal dietary patterns, and these are influenced by family feeding practices, such as sharing meals with similar foods. Unhealthy dietary patterns are exacerbated by family feeding practices, such as using food as a reward, watching TV during meals, or exposure to unhealthy

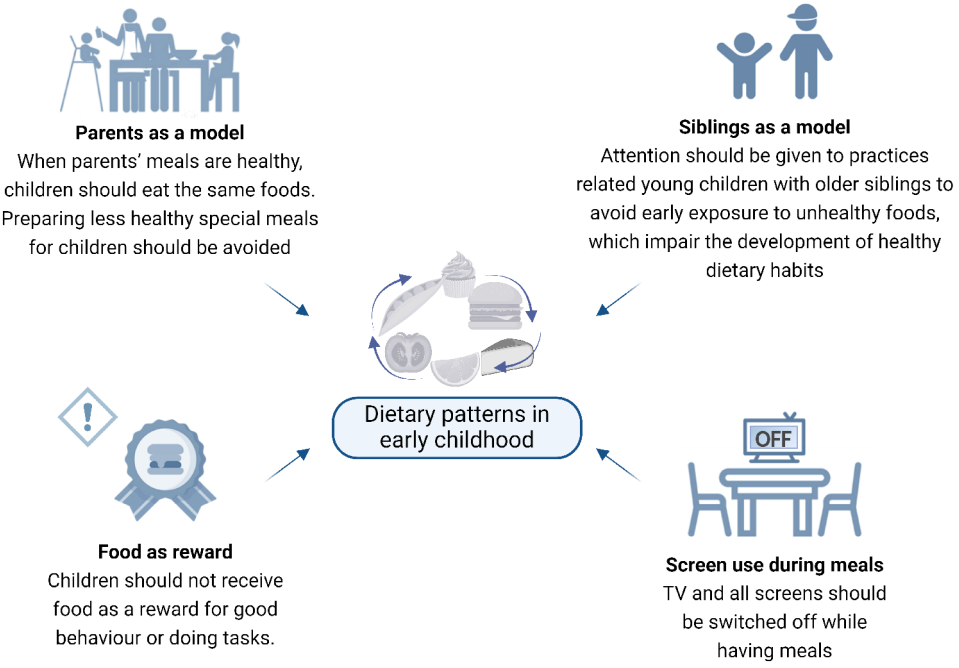

Fig. 2 Dietary habits recommendations to support appropriate development of dietary habits in early childhood

foods due to the presence of older siblings. Interventions aimed at fostering optimal parental modelling should be strategically implemented across various levels of the family's socioecological framework. These initiatives should encompass interventions on social media, community actions and educational interventions starting from early infancy, with the goal to prevent the development of unhealthy habits that may be linked to obesity and non-communicable diseases.

Abbreviations

BMI	Body mass index
TV	Television
UPBEAT	UK Pregnancies Better Eating and Activity Trial
UK	United Kingdom
FFQ	Food frequency questionnaire
SD	Standard deviation

Supplementary Information

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Supplementary Material 1

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Author contributions
VL, FM, AH performed analyses and drafted the article, VL generated the figures, ACF and KVD analysed and interpreted dietary patterns, PTS performed data management, LP conceived the experiment, coordinated and led the project, and provided essential tools to conduct the research. All authors contributed to the interpretation of the findings. All authors read and approved the final manuscript.

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Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Research Ethics Committee approval was obtained in all participating centres, UK Integrated Research Application System; reference 09/H0802/5 (South-East London Research Ethics Committee). All participants provided written informed consent.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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