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Dietary patterns in pregnancy and respiratory and atopic outcomes in childhood

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Abstract

Background: Studies of the relation between maternal diet in pregnancy and respiratory and atopic outcomes in the offspring have focused on effects of individual nutrients and foods, rather than dietary patterns.

Objective: To determine whether dietary patterns in pregnancy are related to childhood asthma and related outcomes.

Design: In a population based birth cohort, the Avon Longitudinal Study of Parents and Children (ALSPAC), we related dietary patterns in pregnancy, previously identified using principal components analysis (‘health conscious’, ‘traditional’, ‘processed’, ‘vegetarian’, and ‘confectionery’), to: early wheezing phenotypes and eczema; wheezing, hayfever, eczema, doctor-diagnosed asthma, atopy and total IgE at 7 years; lung function and bronchial responsiveness at 8-9 years. In regression models we controlled for confounders using propensity scores.

Results: Univariately, the ‘health conscious’ pattern was positively associated with eczema, total IgE, FEV_1 and FEF_{25-75}, and negatively associated with early wheezing and asthma (unadjusted odds ratios per standard deviation (SD) increase in pattern score for early persistent wheeze and asthma, respectively: 0.78 (95% CI: 0.70 to 0.87), $P=7.3x10^{-6}$, N=8886; 0.90 (95% CI: 0.84 to 0.97), P=0.007, N=7625). The ‘processed’ pattern was positively associated with early wheezing, and negatively associated with atopy and FVC. On controlling for confounders, effects were substantially attenuated and became non-significant (adjusted odds ratios for the associations of the ‘health-conscious’ pattern with early persistent wheeze and asthma, respectively: 1.00 (0.86 to 1.16), P=0.99; 0.95 (0.86 to 1.04), P=0.27).

Conclusions: In this cohort, dietary patterns in pregnancy do not predict asthma and related outcomes in the offspring after controlling for confounders.

Introduction

Epidemiological studies of diet and respiratory and atopic diseases have focused largely on relations with intakes of individual nutrients and foods or food groups[1]. A major limitation with this methodology is that intakes of dietary components are highly correlated, and chance findings may arise from the multiple statistical comparisons which need to be carried out. An alternative and less reductionist approach, commonly used to investigate associations between diet and cancer, heart disease and diabetes, is to explore associations using dietary patterns. This can be done either by using pre-defined scores, as used to describe a 'Mediterranean' diet, or by data-driven methods such as principal components analysis (PCA)[2-4]. The PCA approach has the advantage of reducing a large number of correlated dietary measurements down to a small number of overall dimensions of diet which are uncorrelated. Another advantage may be that dietary patterns analysis takes account of interactions between nutrients, thus allowing consideration of the effect of the whole diet.

Prospective studies in adults have recently reported relations of dietary patterns, identified using PCA, to respiratory disease outcomes. One found that a 'meat-dim sum' dietary pattern was associated with an increased risk of chronic bronchitis symptoms in a Singapore Chinese population[5]. Others reported that a 'prudent' dietary pattern (high intake of fruits, vegetables, fish and whole grain products) was associated with a reduced risk of chronic obstructive pulmonary disease in men and women in the USA, and a 'western' dietary pattern (high intake of refined grains, cured and red meats, desserts and French fries) was associated with an increased risk[6;7]. None of these studies found associations with adult-onset asthma.

There is increasing interest in the role of maternal diet in pregnancy in relation to respiratory and atopic outcomes in the offspring, and various associations with individual nutrients[8-12] and foods[13-15] have been reported. Whilst recent studies have suggested that a pre-defined 'Mediterranean' diet during pregnancy and childhood might have protective effects on childhood wheezing and allergic outcomes[16;17], we are not aware of any data on possible effects of maternal dietary patterns, identified using PCA, on childhood respiratory and atopic outcomes. We have therefore examined this in a population based birth cohort, the Avon Longitudinal Study of Parents and Children (ALSPAC), in which five dietary patterns in pregnancy have previously been identified[18].

Subjects and Methods

The Avon Longitudinal Study of Parents and Children (ALSPAC) is a population-based birth cohort established in the former county of Avon, UK, by recruitment of 14,541 women pregnant women who were resident in Avon and had expected dates of delivery between 1st April 1991 and 31st December 1992. There were 14,062 live born children. The study protocol has been described previously[19-22] and further information is available on the ALSPAC website: http://www.alspac.bris.ac.uk. Ethics approval for all aspects of data collection was obtained from the ALSPAC Law and Ethics Committee (IRB 00003312).

Outcomes

Twelve-month prevalence of eczema at 2.5 years was defined on the basis of a positive response to the question: "Has your child had an itchy dry skin rash in joints and creases of his/her body (eg behind the knees, under the arms) since he/she was 18 months old?"[23]. Information on wheezing in the child at 3.5 years was obtained by asking the mother at 3.5 years: "In the last 12 months has he/she had any periods when there was wheezing with whistling on his/her chest when he/she breathed?" A similar question at 6 months of age asked about wheezing since birth, and we used the information from these two periods to identify children with four mutually exclusive patterns of wheezing, that we have shown to be associated with different risk factors: non-wheezers, transient infant wheezers, later onset wheezers and persistent wheezers[24].

When the children were 7.5 years old, mothers were asked: 'Has your child had any of the following in the past 12 months?: wheezing; asthma; eczema; hayfever?'. Children were defined as having current doctor-diagnosed asthma at 7.5 years (primary outcome of interest) if mothers responded positively to the question 'Has a doctor ever actually said that your study child has asthma?' **and** positively to one or both of the questions on wheezing and asthma in the past 12 months. 44% of children fulfilling this definition of asthma demonstrated bronchial hyper-responsiveness (BHR) as defined by a drop in FEV_1 of 20% or more following methacholine challenge up to and including the maximum dose ($PD_{20} \leq 1.2$mg), and 52% were atopic. We defined sub-phenotypes of asthma with and without atopy, and with and without bronchial hyper-responsiveness.

Atopy at 7 years was defined as a positive reaction (maximum diameter of any detectable weal) to *D. pteronyssinus*, cat or grass (after subtracting positive saline reactions from histamine and allergen weals, and excluding children unreactive to 1% histamine). Serum total IgE (kU/l) was measured by fluoroimmunoassay using the Pharmacia UNICAP system (Pharmacia & Upjohn Diagnostics AB, Uppsala, Sweden).

At 8-9 years of age pulmonary function was measured using a Vitalograph 2120 electronic spirometer with a computer-based on-screen incentive (Vitalograph, Maids Moreton, England). The tests adhered to American Thoracic Society criteria for standardisation and reproducibility of flow-volume measurement[25], with the exception of ATS recommendations for duration of expiration[26]; as many children did not fulfil forced expiratory time >6 seconds end of test criteria, a minimal volume change over the final 1 second was used. Outcomes included FEV_1, FVC, FEF_{25-75}, and the FEF_{25-75}/FVC ratio (proposed as a measure of dysynaptic lung growth[27]), adjusted for gender, age and height and expressed in standard deviations (SDs)[28]. Bronchial responsiveness (BR) to methacholine was measured using the method of Yan[29].

Saline (0.9%) solution was administered and a post-saline FEV_1 measurement was used as the baseline. Subsequently, eight doubling doses of methacholine from 0.05 to 6.1 μmol were given at 1-minute intervals with repeat measurement of FEV_1 after each dose. The challenge continued until the FEV_1 decreased by ≥20% from baseline or the maximum dose of methacholine had been given. BR was expressed as the dose-reponse slope (% FEV decline/μmole methacholine). The FEV_1 following each dose of methacholine was expressed as a percent of baseline FEV_1, and a linear regression (dose-response) slope of relative FEV_1 with respect to cumulative methacholine dose was calculated for each subject and expressed in percent per micromole of methacholine. To prevent the analysis from being dominated by extreme positive and negative slopes based on small numbers of observations, we recoded all negative slopes to 0%/micromole, and all slopes above 50%/micromole to 50%/micromole, to derive a truncated slope, and then added 0.1%/micromole to these truncated slopes to derive a transformed slope, whose geometric means (GMs) and GM ratios were estimated in the statistical analysis. A higher GM denotes a greater level of bronchial responsiveness.

Maternal diet in pregnancy and dietary patterns

At 32 weeks of pregnancy mothers completed a food frequency questionnaire (FFQ). The food frequency questionnaire comprised 110 questions. Mothers were asked about their current weekly frequency of consumption of 43 food groups and food items, and about daily consumption of a further eight basic foods. The foods chosen were based on those used by Yarnell et al[30], and modified in the light of a more recent weighed dietary survey[31]. Additional questions asked about the types of certain foods used and about the ways in which food was prepared and eaten[32]. Information on portion size was not collected but as nutrient intakes were not being estimated in this study portion sizes are not relevant. Five dietary patterns in pregnancy have been previously identified in this cohort using principal components analysis: 'health conscious', 'traditional', 'processed', 'vegetarian', and confectionery'[18]. Dietary pattern scores were expressed in standard deviation units. Each mother was represented in each of these five mutually independent scores.

The five patterns loaded highly on the following foods: 'Health conscious': salad, fruit, fruit juices, rice, pasta, oat/bran based breakfast cereals, fish, pulses, cheese, non-white bread; 'Traditional': vegetables, red meat, poultry; 'Processed': meat pies, sausages, burgers, fried foods, pizza, chips, crisps, white bread, eggs, baked beans; 'Vegetarian': meat substitutes, pulses, nuts, herbal tea; 'Confectionery': chocolate, sweets, biscuits, cakes, puddings (see Table 1 for summary of highest factor loadings). Associations between these patterns and nutrient intakes have also been described previously[33].

Table 1: Factor loadings of various food items in the five principal dietary components identified (only loadings above 0.3 and -0.3 are shown)

Food item (Variance explained)	***'Health conscious'*** (10.6%)	**'Traditional'** (8.2%)	***'Processed'*** (4.9%)	***'Confectionery'*** *(4.0%)*	***'Vegetarian'*** *(3.6%)*
White bread	-0.535		0.367		
Non-white bread	0.615		-0.323		
Bran based cereal	0.365				
Biscuits				0.603	
Puddings (expand)				0.389	
Cakes/buns				0.559	
Poultry					-0.535
Red Meat					-0.596
Meat pies			0.538		
Sausages, burgers			0.565		
Fried foods			0.574		
Pizza			0.349		
Fish	0.457				
Eggs			0.403		
Cheese	0.443				
Meat substitutes (soya, Tofu etc)					0.577
Pulses	0.356				0.565
Nuts					0.531
Chips			0.561		
Roast potatoes			0.388		
Potatoes (not chips)		0.321			
Pasta	0.578				
Rice	0.543				
Baked beans			0.413		
Leafy Green vegetables		0.809			
Other Green vegetables		0.799			
Carrots		0.704			
Other Root vegetables		0.606			
Peas		0.352			
Salad	0.420				
Fresh fruit	0.518				
Fruit juice	0.488				
Herbal tea					0.302
Sweets				0.514	
Chocolate				0.717	
Chocolate bars				0.749	
Crisps				0.381	

Footnote: Table adapted from reference 18

Statistical methods

The analyses included all cohort children for whom maternal dietary pattern and childhood outcome data were available. For each dietary pattern we defined propensity scores[34], using linear regression models with each pattern as the predicted variable and a list of confounders as predictive factors. The propensity score is a summary measure of the "exposure-proneness" of a subject, based on a list of confounding variables, and is used to model out the collective and cumulative confounding effect of those confounders as completely as possible, without attempting to measure individual confounder effects on the outcome. The confounders were: maternal factors during pregnancy (energy intake, maximum smoked, infections, antibiotics and paracetamol); other maternal factors (educational level, housing tenure, financial difficulties, pre-pregnancy body mass index, ethnicity, age, parity, history of asthma, eczema, rhinoconjunctivitis, migraine); sex of child, gestational age, breast fed in first 6 months, day care at 8 months, multiple pregnancy, pets in infancy, damp/condensation/mould, child exposed to environmental tobacco smoke at weekends, season of birth, season of FFQ completion, birthweight, head circumference, birth length. For later childhood outcomes, we controlled additionally for number of younger siblings and child's BMI at age 7 (see Table E1 in online supplement for frequencies of confounders). For each propensity score the cohort was split into 64 propensity percentile groups, of roughly equal size. Dietary pattern scores were analysed separately as continuous effects (per SD of diet pattern score) using regression (logistic for binary outcomes, multinomial for wheezing phenotypes, linear on the logs for total IgE and BR slope, and untransformed linear for lung function outcomes), using Huber variances throughout. In view of the multiple exposures and outcomes, we entered the *P*-values for the adjusted analyses into the Simes procedure, controlling the false discovery rate (FDR) at 0.25, to define a discovery set that could be considered "statistically significant", given the number of associations measured[35]. We also repeated the analyses excluding birth anthropometry variables, gestational age, and child's BMI at 7 years from the calculation of the propensity scores, as it is possible that these factors may be on the causal pathway, rather than confounders[36].

Results

Table E1 shows the relation of the dietary patterns to potential confounders. All patterns except 'vegetarian' were associated with energy intake. The 'health-conscious' and 'processed' patterns were associated with maternal age, parity, educational level, housing tenure, financial difficulties, smoking in pregnancy and environmental tobacco exposure, breast-feeding and day care. Table 2 shows the prevalences of the categorical outcomes of interest. Table E2 shows the mean dietary pattern scores according to presence or absence of reported and objective outcomes as follow-up of the cohort progressed. Mothers for whom outcome data were missing for the offspring had lower mean scores for the 'health conscious' pattern, and higher scores for the 'processed' pattern.

In unadjusted analyses the 'health conscious' dietary pattern in pregnancy was associated with an increased risk of early and later eczema (Tables 3 and E3), atopy Table (Table 5), and raised total IgE (Table E4). It was also associated with a lower risk of early wheezing (Table 3), particularly the transient infant and persistent phenotypes (Table 4), a lower risk of later asthma (Tables 5), and with higher FEV_1 (Table E5) and $FEF_{25\text{-}75}$ (data not shown). In contrast, the 'processed' dietary pattern was associated with an increased risk of early wheezing (Table 3), particularly the transient infant and persistent phenotypes (Table 4), and lower FVC (Table E5). It was also associated with a lower risk of atopy (Tables 5). The vegetarian pattern was associated univariately with raised total IgE (Table E4).

On controlling for confounders, most of these effects were substantially attenuated towards the null, although a few associations were little changed or became stronger and remained significant at the 5% level. These included relations of the 'health conscious' and 'vegetarian' patterns with IgE (Table E4), and the 'processed' pattern with FVC (Table E5). However, when all the adjusted comparisons were entered into the Simes procedure, the results suggested that all of these associations could have arisen by chance. Removing variables which might be on the causal path (birth anthropometry, gestational age, child's BMI) from the adjusted models did not alter the main findings.

Table 2. Prevalence of categorical outcomes

	Outcome	*N*	*(%)*
Eczema at 2.5 years			
	No	7007	73.63
	Yes	2509	26.37
Wheezing at 3.5 years			
	No	7708	86.74
	Yes	1178	13.26
Early wheezing phenotypes			
	Never	6492	73.06
	Transient infant	1216	13.68
	Later onset	735	8.27
	Persistent	443	4.99
Outcomes at 7.5 years:			
Eczema			
	No	6447	83.80
	Yes	1246	16.20
Hay fever			
	No	7001	91.23
	Yes	673	8.77
Doctor-diagnosed asthma			
	No	6698	87.84
	Yes	927	12.16
Wheezing			
	No	6885	89.33
	Yes	822	10.67
Atopy at 7 years			
	No	4775	78.47
	Yes	1310	21.53

Table 3: Relation between dietary patterns in pregnancy and early eczema and wheezing in the offspring

	Unadjusted OR[†]	*(95%*	*CI)*	*P*	*Adjusted** OR[†]	*(95%*	*CI)*	*P*
Eczema at 2.5 years (N=9516)								
Health conscious	1.12	(1.07,	1.17)	$2.2x10^{-6}$	1.06	(0.99,	1.12)	.078
Traditional	0.99	(0.95,	1.04)	.82	1.00	(0.95,	1.05)	.96
Processed	0.95	(0.90,	1.00)	.056	0.97	(0.91,	1.03)	.28
Confectionery	1.02	(0.97,	1.07)	.43	1.03	(0.97,	1.08)	.37
Vegetarian	0.98	(0.94,	1.03)	.43	0.99	(0.94,	1.04)	.58
Wheezing at 3.5 years (N=8886)								
Health conscious	0.90	(0.84,	0.96)	.00095	0.96	(0.88,	1.05)	.37
Traditional	0.99	(0.93,	1.06)	.84	1.00	(0.93,	1.07)	.9
Processed	1.14	(1.07,	1.22)	.00012	1.02	(0.94,	1.10)	.69
Confectionery	1.00	(0.94,	1.07)	.91	0.98	(0.91,	1.06)	.61
Vegetarian	0.99	(0.93,	1.05)	.8	0.97	(0.91,	1.04)	.42

*controlling for: energy intake, maximum smoked, infections, antibiotics and paracetamol use during pregnancy; maternal educational level, housing tenure, financial difficulties, pre-pregnancy body mass index, ethnicity, age, parity, history of asthma, eczema, rhinoconjunctivitis, migraine; sex of child, gestational age, breast fed in first 6 months, day care at 8 months, multiple pregnancy, pets in infancy, damp/condensation/mould, child exposed to environmental tobacco smoke at weekends, season of birth, season of FFQ completion, birthweight, head circumference, birth length.

[†] per SD of dietary pattern score

Table 4: Relation between dietary patterns in pregnancy and early wheezing phenotypes in the offspring (N= 8886)

	Unadjusted				*Adjusted**			
	OR†	*(95%*	*CI)*	*P*	*OR*†	*(95%*	*CI)*	*P*
Transient infant wheeze								
Health conscious	0.88	(0.83,	0.94)	.00019	0.98	(0.90,	1.06)	.57
Traditional	0.94	(0.88,	1.01)	.076	0.95	(0.89,	1.02)	.16
Processed	1.12	(1.05,	1.20)	.00079	0.99	(0.91,	1.08)	.87
Confectionery	1.02	(0.96,	1.09)	.5	1.03	(0.95,	1.10)	.51
Vegetarian	1.00	(0.94,	1.07)	.93	1.00	(0.94,	1.06)	.91
Later onset wheeze								
Health conscious	0.94	(0.87,	1.02)	.13	0.93	(0.84,	1.03)	.19
Traditional	1.00	(0.93,	1.09)	.92	1.00	(0.92,	1.09)	.95
Processed	1.10	(1.01,	1.20)	.026	1.03	(0.93,	1.13)	.61
Confectionery	1.00	(0.93,	1.08)	.99	0.96	(0.87,	1.06)	.41
Vegetarian	0.94	(0.87,	1.02)	.16	0.92	(0.85,	1.00)	.059
Persistent wheeze								
Health conscious	0.78	(0.70,	0.87)	$7.3x10^{-6}$	1.00	(0.86,	1.16)	.99
Traditional	0.95	(0.85,	1.06)	.36	0.96	(0.86,	1.08)	.51
Processed	1.27	(1.15,	1.40)	$4.3x10^{-6}$	1.00	(0.88,	1.13)	.98
Confectionery	1.02	(0.91,	1.14)	.75	1.02	(0.90,	1.16)	.72
Vegetarian	1.07	(0.98,	1.17)	.14	1.06	(0.96,	1.16)	.27

*controlling for: energy intake, maximum smoked, infections, antibiotics and paracetamol use during pregnancy; maternal educational level, housing tenure, financial difficulties, pre-pregnancy body mass index, ethnicity, age, parity, history of asthma, eczema, rhinoconjunctivitis, migraine; sex of child, gestational age, breast fed in first 6 months, day care at 8 months, multiple pregnancy, pets in infancy, damp/condensation/mould, child exposed to environmental tobacco smoke at weekends, season of birth, season of FFQ completion, birthweight, head circumference, birth length.
† per SD of dietary pattern score. Reference outcome = Non-wheezers.

Table 5: Relation between dietary patterns in pregnancy and asthma, wheezing and atopy in the offspring

	Unadjusted OR†	*(95%*	*CI)*	*P*	*Adjusted** OR†	*(95%*	*CI)*	*P*
Asthma at 7.5 years (N=7625)								
Health conscious	0.90	(0.84,	0.97)	.0071	0.95	(0.86,	1.04)	.27
Traditional	0.97	(0.90,	1.04)	.39	0.96	(0.89,	1.04)	.35
Processed	1.05	(0.97,	1.13)	.23	0.98	(0.90,	1.07)	.68
Confectionery	0.98	(0.91,	1.06)	.65	1.00	(0.91,	1.08)	.93
Vegetarian	1.03	(0.97,	1.10)	.3	1.02	(0.95,	1.09)	.62
Wheezing at 7.5 years (N=7707)								
Health conscious	1.00	(0.93,	1.08)	.99	1.00	(0.91,	1.11)	.94
Traditional	1.01	(0.94,	1.09)	.75	1.00	(0.92,	1.08)	.99
Processed	0.97	(0.90,	1.06)	.54	0.92	(0.84,	1.01)	.098
Confectionery	0.99	(0.91,	1.07)	.78	1.02	(0.93,	1.12)	.7
Vegetarian	1.04	(0.97,	1.11)	.31	1.02	(0.95,	1.10)	.62
Atopy at 7 years (N=6085)								
Health conscious	1.07	(1.01,	1.14)	.029	0.95	(0.88,	1.04)	.26
Traditional	0.98	(0.92,	1.05)	.61	0.98	(0.91,	1.05)	.54
Processed	0.88	(0.82,	0.95)	.00062	0.93	(0.85,	1.01)	.083
Confectionery	1.04	(0.97,	1.10)	.26	1.07	(0.99,	1.15)	.092
Vegetarian	1.03	(0.97,	1.10)	.28	1.02	(0.96,	1.09)	.44

*controlling for: energy intake, maximum smoked, infections, antibiotics and paracetamol use during pregnancy; maternal educational level, housing tenure, financial difficulties, pre-pregnancy body mass index, ethnicity, age, parity, history of asthma, eczema, rhinoconjunctivitis, migraine; sex of child, gestational age, breast fed in first 6 months, day care at 8 months, multiple pregnancy, pets in infancy, damp/condensation/mould, child exposed to environmental tobacco smoke at weekends, season of birth, season of FFQ completion, birthweight, head circumference, birth length; number of younger siblings and child's BMI at age 7.
† per SD of dietary pattern score

Discussion
To our knowledge this is the first study to examine the relations of dietary patterns in pregnancy, identified by principal components analysis, to respiratory and atopic outcomes in childhood. Whilst we found that the ‘health conscious’ and ‘processed’ patterns were strongly associated with a number of outcomes univariately, most associations were greatly attenuated when we controlled for potential confounders. We have previously shown that these dietary patterns are clearly socially determined[18]. In particular, the ‘health conscious’ component was associated with higher socio-economic status, as indicated by higher maternal educational levels, owner-occupied housing, fewer financial difficulties and older maternal age. In contrast the ‘processed’ pattern showed associations which were the reverse of these. These two patterns also showed associations in opposite directions with parity and with smoking in the third trimester. Given that low maternal age, smoking in pregnancy and living in rented housing are associated with an increased risk of early wheezing in this cohort[24], it is not surprising that the ‘health conscious’ and ‘processed’ patterns were univariately associated negatively and positively with this outcome, respectively. Nor was it unexpected that eczema, which is associated with affluence[37], was positively associated univariately with the ‘health conscious’ pattern.

Comparison with other studies of maternal diet in pregnancy and childhood respiratory and atopic outcomes is difficult as no other studies have analysed dietary patterns using principle components analysis. However, whilst our ‘health conscious’ pattern (which loaded highly on fish, cereal, pulses, cheese, salad and fruit), has some similarities with a ‘Mediterranean’ diet, our findings for this dietary pattern are not in keeping with a previous report of a protective effect of a Mediterranean diet in pregnancy on persistent wheeze and atopic outcomes at 6.5 years of age[16]. Also, in contrast to studies suggesting that eating fish in pregnancy protects against childhood eczema and atopy[13-15], we found that the ‘health conscious’ pattern was associated univariately with an *increased* risk of eczema and atopy. We will report analyses of the relations of maternal intake of specific nutrients and foods in pregnancy to respiratory and atopic outcomes in childhood elsewhere.

As expected, attrition of the cohort during follow-up, as with other birth cohorts, was greatest amongst families of lower socio-economic status. Hence, it was unsurprising that mothers for whom outcome data were missing had lower mean scores for the ‘health conscious’ pattern and higher scores for the ‘processed’ pattern. Without outcome data for these individuals we cannot determine whether the associations measured in those with complete data are representative of those in the entire cohort. However, the potential for losses to follow-up to bias our findings is likely to be less for associations with reported outcomes such as asthma than for associations with objective outcomes such as IgE and BR, as data were more complete for the former (Table E2).

An unexpected association after controlling for confounders was the positive relation between a ‘vegetarian’ pattern and total IgE. Whilst this may have arisen by chance given the multiple exposures and outcomes analysed, it would be of interest to see whether this finding, along with the few other associations which achieved nominal significance, can be replicated in other studies. A previous study in this cohort found that vegetarian mothers were more likely to have boys with hypospadias[38] and it was suggested that this link might be explained by phyto-oestrogens. Vegetarians have a higher intake and blood levels of phyto-oestrogens than omnivores[39], and there are animal data which suggest that phyto-oestrogen exposure in early life can increase later IgE production[40], although we did not observe an association with atopy. Although the food frequency questionnaire (FFQ) that we used has not been formally calibrated against other instruments such as diet diaries, the questionnaire on which it was based had been compared against weighed records, albeit in a different population[30]. Furthermore, we have confirmed expected strong correlations between maternal intake of oily fish and maternal red blood cell n-3 fatty acid levels [41;42], and between maternal fish intake and umbilical cord concentrations of mercury[43;44], and also a weak correlation between maternal vitamin D intake and blood vitamin D levels during pregnancy (unpublished data). Studies which have compared the results of PCA using FFQs with those using diet records have found that the resulting factor loadings and dietary pattern scores were comparable[45-47]. Our dietary patterns are comparable to those identified in another large population-based study of women of fertile age in southern England. That study, which also used FFQs and PCA, identified 'prudent' and 'high energy' patterns which were very similar to our 'health-conscious' and 'processed' patterns in terms of the foods which defined these components, and also with respect to socio-demographic and nutrient associations[48;49].

In conclusion, strong univariate associations between two dietary patterns in pregnancy, identified using PCA, and respiratory and atopic outcomes in the offspring were largely explained by confounding factors. Whilst we are also planning to examine relations of a Mediterranean diet and intake of specific nutrients and foods in pregnancy on these outcomes in ALSPAC, these findings would seem to cast doubt on whether adopting healthier dietary patterns in pregnant women is likely to have a major beneficial impact in terms of asthma prevention and improving the respiratory health of children.

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None of the authors have any conflicts of interests to declare.

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Dietary patterns in pregnancy and respiratory and atopic outcomes in childhood

Seif O Shaheen, Kate Northstone, Roger B Newson, Pauline M Emmett, Andrea Sherriff, A John Henderson.

Online data supplement

Table E1. Mean dietary pattern scores (SD Units) according to potential confounders

Confounder	*N*	*Healthy*	*Traditional*	*Processed*	*Confectionery*	*Vegetarian*
Confounder						
Energy intake						
1	2389	-0.49	-0.26	-0.57	-0.61	0.10
2	2404	-0.14	-0.09	-0.26	-0.31	0.02
3	2404	0.02	-0.02	-0.02	-0.11	-0.04
4	2405	0.19	0.09	0.15	0.19	-0.03
5	2406	0.40	0.22	0.62	0.82	-0.11
Male child						
No	5831	0.00	-0.02	-0.02	0.02	-0.00
Yes	6177	-0.01	0.01	-0.01	-0.02	-0.02
Mother's age						
<25	2571	-0.49	-0.11	0.31	0.06	0.07
25-29	4706	-0.04	-0.05	0.01	0.04	-0.06
30-34	3492	0.29	0.06	-0.19	-0.05	-0.03
35+	1239	0.35	0.16	-0.28	-0.17	0.06
Parity						
0	5146	0.06	-0.09	-0.13	0.00	0.05
1	4093	0.03	0.02	0.03	0.03	-0.09
2+	2347	-0.13	0.13	0.13	-0.08	-0.02
Unknown	422	-0.35	-0.01	0.12	-0.03	0.04
Gestational age (weeks)						
<37	622	-0.07	0.01	0.01	-0.01	0.02
37-40	7855	0.01	-0.02	-0.00	-0.01	-0.02
41+	3531	-0.01	0.00	-0.04	0.00	-0.00
Prenatal tobacco exposure (max in pregnancy)						
Not exposed	4987	0.32	0.00	-0.22	-0.01	-0.08
Passive only	3923	-0.05	-0.02	0.02	0.01	-0.01
Mother 1-9/day	1046	-0.13	0.02	0.11	0.02	0.11
Mother 10-19/day	1363	-0.58	-0.02	0.32	-0.03	0.09
Mother 20+/day	638	-0.80	-0.03	0.39	0.02	0.09
Unknown	51	0.00	-0.16	0.31	0.01	0.24
Mother's education level						
<O level	3516	-0.56	-0.05	0.20	-0.02	0.03
O level	4169	-0.10	0.01	0.05	0.05	-0.11
A level +	4254	0.56	0.02	-0.27	-0.04	0.05
Unknown	69	-0.63	-0.04	0.26	-0.14	0.02
Housing tenure:						
Owned/mortgaged	8858	0.15	0.01	-0.11	0.02	-0.07
Council rented	1457	-0.68	-0.04	0.46	-0.06	0.09
Noncouncil rented	955	-0.10	-0.06	0.05	-0.09	0.32
Unknown/other	738	-0.31	-0.05	0.14	-0.03	0.07
Maternal BMI (kilos/sq metre):						
<18.5	513	-0.03	0.04	0.06	0.22	0.07
18.5-24.99	7959	0.12	-0.01	-0.06	0.02	-0.00
25-29.99	1609	-0.19	0.01	0.02	-0.07	-0.11
30+	582	-0.41	0.11	0.15	-0.19	-0.08
Unknown	1345	-0.30	-0.07	0.08	-0.08	0.05
Mother's ethnicity						
White	11569	-0.01	-0.00	-0.02	0.01	-0.02
Non-white	301	0.29	-0.12	0.03	-0.54	0.37
Unknown	138	-0.34	-0.09	0.02	-0.13	0.07

Breast-fed in first 6 months:						
No	2505	-0.47	-0.09	0.20	0.09	-0.03
Yes	7850	0.23	0.02	-0.13	-0.02	-0.02
Unknown	1653	-0.38	-0.04	0.19	-0.05	0.08
Child in day care at 8 months:						
No	9926	0.03	-0.00	-0.04	0.01	-0.03
Yes	358	0.61	-0.12	-0.31	-0.01	0.12
Unknown	1724	-0.32	-0.02	0.16	-0.08	0.08
Maternal disease unknown						
No	11463	0.02	-0.01	-0.02	-0.00	-0.02
Yes	545	-0.42	-0.04	0.19	-0.02	0.12
Maternal asthma						
No	11261	0.00	-0.01	-0.02	-0.00	-0.01
Yes	747	-0.04	-0.00	0.06	-0.02	0.02
Maternal eczema						
No	10704	-0.01	-0.01	-0.01	-0.01	-0.01
Yes	1304	0.09	-0.01	-0.05	0.08	0.01
Maternal rhinoconjunctivitis						
No	9880	-0.03	-0.01	-0.00	0.00	-0.00
Yes	2128	0.11	0.01	-0.08	-0.02	-0.04
Multiple pregnancy:						
Single	11693	-0.00	-0.01	-0.02	-0.00	-0.01
Multiple	315	0.07	0.15	0.07	-0.10	-0.09
Maternal migraine						
No	10282	0.02	-0.01	-0.02	-0.00	-0.01
Yes	1726	-0.12	0.02	0.01	-0.02	-0.03
Maternal infection unknown						
No	12000	-0.00	-0.01	-0.02	-0.00	-0.01
Yes	8	-0.73	-0.36	-0.16	-0.25	0.14
Maternal cold/flu						
No	6973	0.02	-0.04	-0.05	-0.02	-0.02
Yes	5035	-0.03	0.04	0.04	0.03	-0.00
Maternal urinary infection						
No	11248	0.01	-0.00	-0.03	-0.01	-0.02
Yes	760	-0.22	-0.10	0.25	0.06	0.07
Maternal other infections						
No	11361	-0.01	-0.01	-0.01	-0.01	-0.01
Yes	647	0.20	0.09	-0.07	0.03	0.00
Paracetamol at 20-32 weeks gestation						
Never	6701	0.09	-0.01	-0.07	-0.01	0.00
Sometimes	5109	-0.10	0.00	0.05	0.01	-0.03
Most days/daily	127	-0.50	-0.08	0.33	0.10	-0.06
Unknown	71	-0.31	-0.35	-0.09	-0.40	0.02
Antibiotics at 20-32 weeks gestation						
Not reported	11268	0.00	-0.01	-0.02	-0.01	-0.01
Reported	740	-0.03	0.03	0.01	0.10	-0.05
Pets in first year						
None	4885	0.13	-0.01	-0.10	0.00	-0.01
Cat or dog	4576	0.00	0.01	-0.01	0.01	-0.03

Other pet	997	-0.16	-0.04	0.06	0.04	-0.11
Unknown	1550	-0.34	-0.04	0.18	-0.08	0.09
Damp, condensation and mould						
No	5459	0.00	0.01	-0.09	0.00	-0.05
Yes	4983	0.10	-0.02	0.00	0.01	-0.00
Unknown	1566	-0.34	-0.04	0.18	-0.09	0.09
Child exposed to ETS at weekend						
No	7018	0.23	0.01	-0.17	-0.01	-0.04
Yes	3640	-0.31	-0.04	0.20	0.04	0.02
Unknown	1350	-0.37	-0.04	0.22	-0.07	0.09
Season of birth						
Mar-May	2769	-0.03	0.09	-0.03	0.09	-0.03
Jun-Aug	3651	0.05	-0.05	-0.01	-0.03	-0.02
Sep-Nov	3370	0.01	-0.11	-0.02	-0.07	-0.01
Dec-Feb	2218	-0.06	0.08	0.00	0.03	0.03
Season of FFQ completion						
Mar-May	3654	0.03	0.03	-0.01	0.06	-0.05
Jun-Aug	3524	0.05	-0.14	-0.05	-0.05	-0.01
Sep-Nov	2902	-0.05	0.01	0.02	-0.03	0.02
Dec-Feb	1851	-0.08	0.14	-0.01	0.03	0.01
Unknown	77	-0.13	0.04	0.07	-0.01	-0.01
Financial difficulties						
None	4298	0.22	0.01	-0.21	-0.01	-0.10
Some	4565	-0.03	-0.00	0.03	0.01	-0.00
Many	3085	-0.27	-0.04	0.20	-0.01	0.09
Unknown	60	-0.35	-0.15	-0.16	0.01	-0.10
Younger siblings at 7years						
None	4012	0.08	0.06	-0.05	0.01	-0.06
1	3203	0.15	-0.07	-0.11	0.04	-0.03
2+	806	0.11	-0.11	-0.09	0.02	0.02
Unknown	3987	-0.23	-0.01	0.11	-0.05	0.06
Child BMI at 7 years						
[0,15)	2035	0.20	0.00	-0.05	0.07	-0.06
[15,17.5)	3795	0.18	-0.00	-0.09	0.02	-0.05
[17.5,20.5)	1102	0.09	0.02	-0.15	0.02	-0.02
20.5+	307	-0.08	-0.00	-0.06	-0.09	-0.05
Unknown	4769	-0.25	-0.02	0.09	-0.05	0.05
Birthweight (grams)						
<2500	560	-0.15	-0.00	0.08	-0.01	-0.02
2500-2999	1675	-0.13	-0.02	0.05	-0.01	0.05
3000-3499	4227	0.00	-0.02	-0.04	-0.00	-0.00
3500-3999	3862	0.06	0.00	-0.03	0.01	-0.03
4000+	1535	0.04	0.01	-0.02	-0.05	-0.04
Unknown	149	-0.06	0.04	-0.01	0.16	-0.02
Head circumference (cm)						
<33	809	-0.14	0.00	0.11	0.03	0.06
33-34.99	4172	-0.02	0.00	-0.01	0.03	-0.01
35-36.99	3878	0.02	-0.02	-0.05	-0.03	-0.01

37+	549	0.05	-0.09	-0.04	-0.00	-0.01
Unknown	2600	0.03	0.01	-0.01	-0.03	-0.03
Birth length (cm)						
<48	1043	-0.17	0.00	0.02	0.02	0.07
48-50.99	3904	-0.04	-0.02	-0.00	0.01	0.00
51-53.99	3608	0.06	-0.01	-0.03	-0.02	-0.03
54+	721	0.01	-0.03	-0.08	0.06	-0.02
Unknown	2732	0.03	0.01	-0.01	-0.03	-0.03

Table E2. Mean dietary pattern scores according to presence or absence of outcome data for offspring

Outcome	*N*	*Dietary* *Health-conscious*	*pattern* *Traditional*	*score* *Processed*	*(SD units)* *Confectionery*	*Vegetarian*
Eczema at 2.5 years						
Absent	2492	-0.26	-0.02	0.13	-0.07	0.10
Present	9516	0.07	-0.01	-0.05	0.01	-0.04
Wheezing at 3.5 years						
Absent	3122	-0.24	-0.02	0.14	-0.02	0.06
Present	8886	0.08	-0.01	-0.07	0.00	-0.04
Asthma at 7.5 years						
Absent	4383	-0.24	-0.00	0.10	-0.05	0.04
Present	7625	0.14	-0.01	-0.08	0.02	-0.04
Atopy at 7 years						
Absent	5923	-0.19	-0.02	0.06	-0.04	0.03
Present	6085	0.18	-0.00	-0.09	0.03	-0.05
Total IgE at 7 years						
Absent	7189	-0.12	-0.02	0.03	-0.02	0.02
Present	4819	0.18	0.00	-0.08	0.02	-0.06
FEV_1 at 8-9 years						
Absent	5816	-0.19	-0.02	0.07	-0.03	0.02
Present	6192	0.18	-0.00	-0.10	0.03	-0.04
BR slope at 8-9 years						
Absent	7895	-0.10	-0.00	0.02	-0.02	0.00
Present	4113	0.18	-0.02	-0.09	0.03	-0.04

Table E3: Relation between dietary patterns in pregnancy and later eczema and hayfever in the offspring

	Unadjusted				*Adjusted**			
	OR†	*(95%*	*CI)*	*P*	*OR*†	*(95%*	*CI)*	*P*
Eczema at 7.5 years (N=7693)								
Health conscious	1.12	(1.05,	1.19)	.00032	1.04	(0.95,	1.13)	.38
Traditional	0.99	(0.93,	1.06)	.84	0.99	(0.92,	1.05)	.71
Processed	0.95	(0.89,	1.02)	.18	0.96	(0.88,	1.05)	.36
Confectionery	1.04	(0.97,	1.10)	.28	1.03	(0.95,	1.11)	.51
Vegetarian	1.02	(0.96,	1.08)	.54	1.01	(0.95,	1.08)	.64
Hay fever at 7.5 years (N=7674)								
Health conscious	1.06	(0.98,	1.15)	.14	1.00	(0.91,	1.11)	.95
Traditional	1.06	(0.98,	1.15)	.12	1.04	(0.96,	1.13)	.31
Processed	0.91	(0.82,	1.00)	.043	0.93	(0.83,	1.04)	.21
Confectionery	1.02	(0.94,	1.10)	.66	1.01	(0.92,	1.11)	.87
Vegetarian	0.96	(0.89,	1.05)	.36	0.97	(0.89,	1.06)	.51

*controlling for: energy intake, maximum smoked, infections, antibiotics and paracetamol use during pregnancy; maternal educational level, housing tenure, financial difficulties, pre-pregnancy body mass index, ethnicity, age, parity, history of asthma, eczema, rhinoconjunctivitis, migraine; sex of child, gestational age, breast fed in first 6 months, day care at 8 months, multiple pregnancy, pets in infancy, damp/condensation/mould, child exposed to environmental tobacco smoke at weekends, season of birth, season of FFQ completion, birthweight, head circumference, birth length; number of younger siblings and child's BMI at age 7.

† *per SD of dietary pattern score*

Table E4: Relation between dietary patterns in pregnancy and total IgE and bronchial responsiveness in the offspring

	Unadjusted GM ratio[†]	*(95%*	*CI)*	*P*	*Adjusted* GM ratio*[†]	*(95%*	*CI)*	*P*
Log total IgE at 7 years (N=4819)								
Health conscious	1.07	(1.02,	1.13)	.0044	1.07	(1.00,	1.14)	.041
Traditional	0.98	(0.93,	1.02)	.33	0.96	(0.91,	1.00)	.075
Processed	1.01	(0.96,	1.06)	.76	0.97	(0.91,	1.04)	.39
Confectionery	1.00	(0.96,	1.05)	.89	1.00	(0.94,	1.06)	.98
Vegetarian	1.05	(1.01,	1.10)	.026	1.07	(1.02,	1.12)	.0051
Log BR slope at 8-9 years (N=4113)								
Health conscious	0.99	(0.94,	1.05)	.77	1.01	(0.94,	1.08)	.82
Traditional	1.01	(0.96,	1.07)	.61	1.02	(0.97,	1.08)	.38
Processed	1.01	(0.95,	1.07)	.73	1.03	(0.96,	1.10)	.47
Confectionery	0.96	(0.91,	1.01)	.11	0.96	(0.90,	1.02)	.19
Vegetarian	1.02	(0.97,	1.08)	.41	1.03	(0.98,	1.08)	.31

*controlling for: energy intake, maximum smoked, infections, antibiotics and paracetamol use during pregnancy; maternal educational level, housing tenure, financial difficulties, pre-pregnancy body mass index, ethnicity, age, parity, history of asthma, eczema, rhinoconjunctivitis, migraine; sex of child, gestational age, breast fed in first 6 months, day care at 8 months, multiple pregnancy, pets in infancy, damp/condensation/mould, child exposed to environmental tobacco smoke at weekends, season of birth, season of FFQ completion, birthweight, head circumference, birth length; number of younger siblings and child's BMI at age 7.

[†] *per SD of dietary pattern score*

Table E5: Relation between dietary patterns in pregnancy and lung function in the offspring

	Unadjusted Difference[†]	*(95%*	*CI)*	*P*	*Adjusted* Difference*[†]	*(95%*	*CI)*	*P*
Age and height adjusted FEV_1 (SDs) at 8-9 years (N=6192)								
Health conscious	0.03	(0.01,	0.06)	.0095	0.02	(-0.01,	0.06)	.2
Traditional	0.02	(-0.00,	0.05)	.058	0.02	(-0.01,	0.05)	.13
Processed	-0.03	(-0.06,	-0.00)	.038	-0.02	(-0.06,	0.01)	.17
Confectionery	-0.01	(-0.03,	0.02)	.64	-0.01	(-0.04,	0.02)	.4
Vegetarian	0.01	(-0.02,	0.03)	.63	0.01	(-0.01,	0.04)	.31
Age and height adjusted FVC (SDs) at 8-9 years (N=6285)								
Health conscious	0.01	(-0.01,	0.04)	.29	0.01	(-0.03,	0.04)	.71
Traditional	0.02	(-0.01,	0.04)	.2	0.02	(-0.01,	0.04)	.23
Processed	-0.05	(-0.07,	-0.02)	.00083	-0.04	(-0.07,	-0.01)	.022
Confectionery	-0.01	(-0.03,	0.02)	.49	-0.00	(-0.03,	0.03)	.8
Vegetarian	0.02	(-0.01,	0.04)	.22	0.02	(-0.01,	0.05)	.13

*controlling for: energy intake, maximum smoked, infections, antibiotics and paracetamol use during pregnancy; maternal educational level, housing tenure, financial difficulties, pre-pregnancy body mass index, ethnicity, age, parity, history of asthma, eczema, rhinoconjunctivitis, migraine; sex of child, gestational age, breast fed in first 6 months, day care at 8 months, multiple pregnancy, pets in infancy, damp/condensation/mould, child exposed to environmental tobacco smoke at weekends, season of birth, season of FFQ completion, birthweight, head circumference, birth length; number of younger siblings and child's BMI at age 7.

† *per SD of dietary pattern score*