

Original article

Dietary patterns and adult asthma: population-based case-control study

Background: Epidemiological studies of diet and asthma have focused on relations with intakes of individual nutrients and foods and evidence has been conflicting. Few studies have examined associations with dietary patterns.

Methods: We carried out a population-based case-control study of asthma in adults aged between 16 and 50 in South London, UK. Information about usual diet was obtained by food frequency questionnaire and we used principal components analysis to define five dietary patterns in controls. We used logistic and linear regression, controlling for confounders, to relate these patterns to asthma, asthma severity, rhinitis and chronic bronchitis in 599 cases and 854 controls.

Results: Overall, there was weak evidence that a 'vegetarian' dietary pattern was positively associated with asthma [adjusted odds ratio comparing top vs bottom quintile of pattern score 1.43 (95% CI: 0.93–2.20), *P* trend 0.075], and a 'traditional' pattern (meat and vegetables) was negatively associated [OR 0.68 (0.45–1.03), *P* trend 0.071]. These associations were stronger amongst non-supplement users (*P* trend 0.030 and 0.001, respectively), and the association with the 'vegetarian' pattern was stronger amongst whites (*P* trend 0.008). No associations were observed with asthma severity. A 'prudent' dietary pattern (wholemeal bread, fish and vegetables) was positively associated with chronic bronchitis [OR 2.61 (1.13–6.05), *P* trend 0.025], especially amongst nonsupplement users (*P* trend 0.002).

Conclusions: Overall there were no clear relations between dietary patterns and adult asthma; associations in nonsupplement users and whites require confirmation. The finding for chronic bronchitis was unexpected and also requires replication.

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Epidemiological studies of diet and asthma have focused largely on relations with intakes of individual nutrients and foods or food groups and evidence has been conflicting (1). Furthermore, despite observational evidence implicating low intakes of vitamin C, vitamin E, magnesium and selenium in asthma, trials of supplementation with these nutrients in adults have been unsuccessful at reducing the severity of established disease (2–4). This may be because apparent effects in the observational studies were confounded by lifestyle factors or by other dietary components. A conceptual disadvantage of this approach is that people do not eat individual nutrients, but meals which form a dietary pattern. There are also methodological problems: intakes of dietary components are highly correlated, and chance findings may arise from indiscriminate multiple statistical testing. An alternative approach is to explore associations using dietary patterns. Typically this is performed using principal components analysis (PCA) (5). 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 (6). The method has been used to study relations between diet and a number of chronic diseases, including coronary heart disease and colon cancer (7, 8) but to date few studies have related dietary patterns, identified using PCA, to respiratory disease in adults. One prospective study in a Singapore Chinese population found that a 'meat-dim sum' dietary pattern was associated with an increased risk of developing cough with phlegm (9). Two prospective studies in the USA have reported that a 'prudent' dietary pattern was associated with a reduced risk, and a 'western' dietary pattern with an increased risk, of chronic obstructive pulmonary disease in men (10) and women (11). None of these studies found significant associations between dietary patterns and risk of incident asthma, although asthma was not the primary outcome of interest, and the populations studied were predominantly

middle-aged and elderly adults. A recent large prospective study of French women also found no relation between three dietary patterns ('prudent', 'western' and 'nuts and wine') and adult onset asthma, asthma ever, or current asthma, although the third pattern was associated with a decreased risk of frequent asthma attacks (12). By contrast, in a cross-sectional study of Japanese female university students, five dietary patterns were identified, two of which ('fast food, juice and soft drinks' and 'butter and rapeseed oil') were related to wheeze (13).

We have investigated associations between dietary patterns and asthma, rhinitis and chronic bronchitis in a population-based case-control study of young adults in the UK.

Methods

Details of our case-control study of dietary antioxidants and adult asthma have been described previously (14). Briefly, the study sample comprised adults aged between 16 and 50 living in Greenwich, South London, UK, who took part in a population-based asthma survey in 1996 and a dietary survey in 1997. We identified 1438 cases of asthma by positive responses to questions about attacks of asthma or waking with shortness of breath in the last 12 months, or current use of asthma medication. These questions have been used previously in this age group (15) and predict bronchial hyper-responsiveness (16). We identified a random sample of 2000 controls by negative responses to these questions. Asthma severity amongst cases was measured according to the frequency of waking at night with asthma symptoms (3+ times per week *vs* <3 times per week), and by an asthma quality of life score (a higher score indicates worse quality of life) (17). Individuals who reported that they usually produced phlegm in the winter (first thing in the morning and/or during the day or night) on most days for at least 3 months each year were defined as having chronic bronchitis. Rhinitis was defined by a positive response to a question about nasal allergies including hayfever.

Cases and controls were mailed a food frequency questionnaire (FFQ), based on one used previously (18), which asked about usual dietary intake in the past 12 months, and included over 200 items of food and drink. The modified FFQ was calibrated against a 7-day weighed record and repeatability of the FFQ was tested in a subsample (14). Replies were received from 720 cases and 980 controls. After allowing for likely wrong addresses, the overall response rate was 55% (19). Prior to coding, we excluded 76 individuals for whom information on 46 or more food items (equivalent to two pages) was missing. In the remainder, items were coded as 'never eaten' if a frequency of consumption was not specified. We estimated weekly intake (g) of foods and food groups by multiplying frequency of consumption by the weight of standard portion sizes. Total energy intake was estimated from food intakes using British food composition tables (20). We used Schofield equations to estimate basal metabolic rate (BMR) (21) and excluded subjects from the analysis if their ratio of energy intake to BMR was below the 0.5th sample centile or above the 99.5th sample centile (22).

Statistical analysis

Principal component analysis was applied to the FFQ data to identify dietary patterns. This was performed in controls only to

avoid potential bias. A varimax rotation was applied to improve the interpretability of the patterns obtained. The number of patterns was determined by examination of the screen plot of the eigenvalues. This is a plot of the eigenvalues *vs* the component number. The aim was to identify an 'elbow' which corresponds to the point after which the addition of more components explains relatively little more of the variance. We extracted the first five components (dietary patterns), which explained 17% of the variance in the original 216 items. A component score was created for each individual for each of the principal components identified. It is possible for individuals who score highly for one dietary pattern to also score highly for another dietary pattern. Thus the dietary patterns do not identify mutually exclusive clusters of individuals. Individual foods that correlated >0.3 or <-0.3 with the varimax rotated dietary patterns (principal components) are shown in Table 1.

We identified the following five patterns: 'Prudent', characterized by a high intake of wholemeal bread and rolls, yoghurt, cheese, fish, salad vegetables, pasta, couscous, vegetable dishes and different types of dressing; 'Vegetable and Fruit', which loaded highly on vegetables and fruits; 'Western', associated with a high intake of white bread and rolls, chips, roast potatoes, baked beans, processed meats, bacon, ham, crisps, meat dishes, fried snacks, chocolate bars, sponge puddings and cakes, ketchup, coke; 'Vegetarian', which loaded highly on cream crackers, crème fraîche, macaroni cheese chick peas, houmous, lentils, nut roast, vegetables, nuts and seeds; 'Traditional', associated with a high intake of vegetables, pork, beef, liver and lamb, and a low intake of naan paratha and Bombay mix.

The component scores were considered as our exposure variables. Associations between dietary patterns and asthma (primary outcome), frequent waking at night, chronic bronchitis and rhinitis (secondary outcomes) were analysed using logistic regression. Analyses of chronic bronchitis and rhinitis used sampling weights with inverse probability weighting to allow for the fact that asthmatic individuals had a higher probability of inclusion in the study than nonasthmatic individuals (23). Linear regression was used to investigate associations between dietary patterns and asthma quality of life score. Analyses controlled for age, sex, body mass index, social class, housing tenure (owned/rented or mortgaged), employment status, whether a single parent, smoking (never/ex/current), passive smoke exposure at home, total energy intake, ethnicity, number of siblings, paracetamol use and supplement use. Dietary pattern scores were analysed in quintiles, and the effect of each pattern was adjusted for the others, as although principal components are uncorrelated, rotations (even orthogonal ones) can introduce correlations between the patterns. We used Simes' method to adjust for multiple comparisons, controlling the false discovery rate at 25% (24). All analyses were carried out using STATA 10 (StataCorporation, College Station, TX, USA). To assess the robustness of our findings, we carried out secondary analyses, excluding individuals who said that they avoided foods or took supplements because of asthma or allergy, all supplement users, and nonwhites. Supplements included vitamins (A, C, E), folate, iron and other minerals, eicosapentaenoic acid, docosahexaenoic acid, gamma-linolenic acid and garlic.

Results

The main analyses were restricted to 1453 individuals (599 cases and 854 controls) with complete information on diet and confounders. The mean age of cases and controls combined was 35.5 years. Of the 1453 in the study, 866 (59.6%) were female, 179 (12.3%) were nonwhite, 422 (29.0%) were of manual social class, 487(33.5%) were

Table 1. Correlations between food items and dietary patterns (only correlations >0.30 or <−0.30 are included)

Food item	Pattern				
	Prudent	Vegetable and fruit	Western	Vegetarian	Traditional
White bread and rolls	—	—	0.39	—	—
Wholemeal bread and rolls	0.33	—	—	—	—
Chapattis, naan, paratha	—	—	—	—	−0.42
Cream crackers, cheese biscuits	—	—	—	0.46	—
White pasta	0.42	—	—	—	—
Wholemeal pasta	0.33	—	—	—	—
Macaroni cheese	—	—	—	0.45	—
Couscous	0.36	—	—	—	—
Chips	—	—	0.47	—	—
Roast potatoes	—	—	0.30	—	—
Baked beans	—	—	0.36	—	—
Butter beans/broad beans	—	—	—	0.42	—
Chick peas, chanas	—	—	—	0.64	—
Hummus	—	—	—	0.73	—
Lentils, dals	—	—	—	0.42	—
Tofu – bean curd	0.30	—	—	—	—
Nut roast, nut cutlets	—	—	—	0.77	—
Vegeburgers	0.31	—	—	—	—
Mixed bean casserole/ratatouill	0.45	—	—	—	—
Vegetable – lasagne/moussaka	0.43	—	—	0.42	—
Vegetable pizza	0.46	—	—	—	—
Vegetable pies/samosas	0.39	—	—	—	—
Beansprouts	0.30	—	—	—	—
Broccoli	0.38	—	—	—	0.43
Brussel sprouts	—	—	—	—	0.48
Cabbage	—	—	—	0.46	0.51
Spring greens/kale	—	—	—	—	0.44
Spinach	0.38	—	—	0.30	—
Carrots	0.33	—	—	—	0.38
Cauliflower	—	—	—	—	0.47
Celery	0.30	—	—	0.31	—
Courgettes, marrow, squash	0.47	—	—	0.31	—
Garlic	0.49	—	—	—	—
Green beans, runner beans	0.37	—	—	—	0.41
Leeks	0.42	—	—	0.37	0.32
Lettuce	0.46	0.38	—	—	—
Mushrooms	0.44	—	—	—	—
Onions	0.49	0.35	—	—	—
Parsley – flat leaf	0.37	—	—	0.35	—
Parsnips and turnips	0.34	—	—	—	0.35
Peppers – red, green, yellow	0.52	—	—	—	—
Swedes	—	—	—	—	0.36
Sweetcorn	0.39	—	—	—	—
Tomatoes – raw, canned, sauce	0.39	0.47	—	—	—
Watercress, mustard and cress	0.33	—	—	—	—
Apples	—	0.44	—	—	—
Apricots	—	0.72	—	—	—
Avocado	0.37	—	—	—	—
Bananas	—	0.42	—	—	—
Blackberries, gooseberries	—	0.63	—	—	—
Blackcurrants	—	0.41	—	—	—
Cherries	—	0.69	—	—	—
Grapes	—	0.56	—	—	—
Guavas	—	0.58	—	—	—
Kiwi fruit	—	0.43	—	—	—
Mangoes	—	0.63	—	—	—
Melon	—	0.63	—	—	—
Nectarines	—	0.65	—	—	—
Oranges, satsumas, grapefruit	—	0.48	—	—	—

Table 1. (continued)

Food item	Pattern				
	Prudent	Vegetable and fruit	Western	Vegetarian	Traditional
Peaches	—	0.70	—	—	—
Pears	—	0.58	—	—	—
Pineapple	—	0.50	—	—	—
Plums	—	0.52	—	—	—
Raspberries	—	0.39	—	—	—
Redcurrants	—	—	—	0.43	—
Rhubarb	—	0.33	—	—	—
Strawberries	—	0.53	—	—	—
Currants, raisins, sultanas	0.40	—	—	—	—
Beef stew, casserole, mince, curry	—	—	0.34	—	0.38
Beefburger, hamburger	—	—	0.53	—	—
Pork – roast, chops	—	—	0.32	—	0.46
Pork stew, casserole	—	—	0.32	—	0.33
Lamb – roast, chops	—	—	—	—	0.46
Chicken/turkey – roast, slices	—	—	—	—	0.34
Breadcrumbs e.g. chicken nuggets	—	—	0.41	—	—
Bacon	—	—	0.40	—	—
Ham	—	—	0.31	—	—
Corned beef, spam, luncheon meat	—	—	0.37	—	—
Sausages – beef, pork	—	—	0.48	—	—
Pies/pasties/sausage rolls/meat	—	—	0.53	—	—
Offal – liver, kidney	—	—	—	—	0.38
Liver – pate, sausage, salami	—	—	—	—	0.33
Meat pizza	—	—	0.46	—	—
Fried fish in batter/breadcrumb	—	—	0.35	—	—
White fish not fried	0.38	—	—	—	—
Fresh oily fish	0.40	—	—	—	—
Tinned oily fish	0.33	—	—	—	—
Omelette/scrambled egg	—	—	0.32	—	—
Fried egg	—	—	0.40	—	—
Greek yoghurt	0.30	—	—	—	—
Fromage frais/creme fraiche	—	—	—	0.31	—
Ice cream	—	—	0.31	—	—
Cheese – cheddar, brie, edam	0.31	—	—	—	—
Crisps	—	—	0.41	—	—
Other fried snacks	—	—	0.46	—	—
Bombay mix	—	—	—	—	–0.35
Almonds	—	—	—	0.63	—
Brazil nuts	—	—	—	0.33	—
Cashew nuts	—	—	—	0.31	—
Pistachio nuts	—	—	—	0.73	—
Walnuts, pecan nuts	—	—	—	0.44	—
Mixed nuts and raisins	—	—	—	0.50	—
Sunflower/sesame seeds	—	—	—	0.53	—
Chocolate snack bars	—	—	0.44	—	—
Milk chocolate	—	—	0.40	—	—
Chocolate biscuits	—	—	0.36	—	—
Sandwich/cream biscuits	—	—	0.36	—	—
Sponge cakes	—	—	0.34	—	—
Fruit pies, tarts, crumbles	—	—	0.32	—	—
Sponge puddings	—	—	0.41	—	—
Mayonnaise	0.35	—	—	—	—
French type dressing	0.54	—	—	—	—
Tomato ketchup	—	—	0.42	—	—
Fizzy Soft Drinks e.g. Coke	—	—	0.39	—	—

Number of controls = 856.

current smokers, 619 (42.6%) were taking supplements, 108 (7.4%) were vegetarian and 193 (13.3%) were avoiding foods or taking supplements because of asthma or allergies.

Table 2 shows associations between asthma and the five dietary patterns. The 'prudent', 'western' and 'traditional' patterns were univariately associated with asthma overall, but after controlling for confounders there was weak evidence for a positive and negative associations with the 'vegetarian' and 'traditional' patterns respectively. These associations were similar when we excluded individuals who avoided foods or took supplements because of asthma or allergy. However, on exclusion of supplement users, these associations became stronger (P trend 0.030 and 0.001 for the 'vegetarian' and 'traditional' patterns respectively). The association with the 'vegetarian' pattern was also stronger on exclusion of nonwhites (P trend 0.008). A highly significant univariate positive association between the 'traditional' dietary pattern and asthma quality of life

score amongst cases became weaker and no longer conventionally significant after controlling for confounders (Table 3). Similarly, there was no evidence for associations between any of the dietary patterns and frequent waking at night with asthma symptoms (data not shown).

After controlling for confounders, there was evidence for a positive association between the 'prudent' dietary pattern and chronic bronchitis overall (Table 4). This relation persisted when we excluded nonwhites or individuals who avoided foods or took supplements because of asthma or allergy, and became much stronger when we excluded all supplement users ($P = 0.002$). The 'vegetable and fruit' pattern was positively associated with rhinitis overall, with weak evidence of a trend, after controlling for confounders (Table 5). This association persisted on exclusion of supplement users and nonwhites, but became weaker and nonsignificant on exclusion of those who avoided foods or took supplements because of asthma or allergy.

Table 2. Association between quintile (Q) of dietary patterns and asthma

Pattern (no. individuals = 1453)	Unadjusted odds ratio (95% CI)	Adjusted odds ratio* (95% CI)	Adjusted odds ratio† (95% CI)
Prudent			
Q1	1.00	1.00	1.00
Q2	0.80 (0.57, 1.11)	0.77 (0.55, 1.09)	0.92 (0.63, 1.33)
Q3	0.80 (0.57, 1.11)	0.80 (0.56, 1.14)	1.10 (0.73, 1.65)
Q4	0.73 (0.53, 1.02)	0.74 (0.51, 1.09)	1.03 (0.66, 1.62)
Q5	0.63 (0.45, 0.88)	0.65 (0.42, 1.00)	0.91 (0.53, 1.56)
P for trend	0.009	0.078	0.98
Vegetable and fruit			
Q1	1.00	1.00	1.00
Q2	1.33 (0.96, 1.86)	1.44 (1.02, 2.02)	1.37 (0.95, 1.97)
Q3	1.15 (0.82, 1.60)	1.37 (0.97, 1.95)	1.26 (0.85, 1.84)
Q4	0.89 (0.64, 1.25)	1.14 (0.79, 1.65)	1.05 (0.71, 1.57)
Q5	1.05 (0.75, 1.47)	1.43 (0.97, 2.11)	1.24 (0.81, 1.92)
P for trend	0.44	0.26	0.71
Western			
Q1	1.00	1.00	1.00
Q2	1.10 (0.78, 1.54)	1.05 (0.74, 1.50)	1.11 (0.76, 1.62)
Q3	1.32 (0.94, 1.84)	1.28 (0.90, 1.83)	1.29 (0.86, 1.94)
Q4	1.43 (1.03, 2.01)	1.37 (0.96, 1.96)	1.41 (0.88, 2.24)
Q5	1.43 (1.02, 2.00)	1.44 (1.01, 2.04)	1.30 (0.75, 2.27)
P for trend	0.009	0.014	0.20
Vegetarian			
Q1	1.00	1.00	1.00
Q2	1.28 (0.92, 1.79)	1.38 (0.98, 1.94)	1.40 (0.98, 1.99)
Q3	1.24 (0.89, 1.73)	1.35 (0.96, 1.90)	1.51 (1.05, 2.16)
Q4	1.07 (0.77, 1.49)	1.22 (0.86, 1.74)	1.46 (0.99, 2.13)
Q5	0.94 (0.67, 1.32)	1.20 (0.81, 1.77)	1.43 (0.93, 2.20)
P for trend	0.45	0.43	0.075
Traditional			
Q1	1.00	1.00	1.00
Q2	0.93 (0.67, 1.29)	0.91 (0.65, 1.28)	0.96 (0.66, 1.39)
Q3	0.68 (0.48, 0.94)	0.62 (0.44, 0.87)	0.69 (0.47, 1.01)
Q4	0.88 (0.63, 1.22)	0.81 (0.58, 1.14)	0.85 (0.58, 1.25)
Q5	0.71 (0.51, 0.99)	0.66 (0.46, 0.94)	0.68 (0.45, 1.03)
P for trend	0.051	0.018	0.071

*Adjusted for all other dietary patterns.

†Adjusted for all other dietary patterns, age, sex, body mass index, social class, housing tenure, employment status, whether a single parent, smoking, passive smoke exposure at home, total energy intake, ethnicity, number of siblings, paracetamol and supplement use.

Table 3. Association between quintile (Q) of dietary patterns and asthma quality of life score

Pattern (no. individuals = 578)	Unadjusted regression coefficient (95% CI)	Adjusted regression coefficient* (95% CI)	Adjusted regression coefficient† (95% CI)
Prudent			
Q1	0.00	0.00	0.00
Q2	-0.07 (-0.23, 0.08)	-0.08 (-0.24, 0.07)	0.04 (-0.12, 0.21)
Q3	-0.01 (-0.16, 0.15)	-0.06 (-0.23, 0.09)	0.11 (-0.06, 0.30)
Q4	-0.05 (-0.20, 0.11)	-0.14 (-0.32, 0.03)	0.02 (-0.17, 0.22)
Q5	-0.15 (-0.31, 0.01)	-0.29 (-0.51, -0.08)	-0.07 (-0.32, 0.17)
P for trend	0.16	0.013	0.73
Vegetable and fruit			
Q1	0.00	0.00	0.00
Q2	-0.17 (-0.33, -0.01)	-0.17 (-0.33, -0.01)	-0.15 (-0.31, 0.01)
Q3	-0.11 (-0.27, 0.04)	-0.09 (-0.26, 0.07)	-0.13 (-0.30, 0.04)
Q4	-0.02 (-0.19, 0.14)	0.01 (-0.17, 0.19)	0.02 (-0.16, 0.21)
Q5	0.01 (-0.14, 0.18)	0.01 (-0.17, 0.20)	0.002 (-0.20, 0.19)
P for trend	0.33	0.40	0.50
Western			
Q1	0.00	0.00	0.00
Q2	0.01 (-0.15, 0.18)	0.0003 (-0.17, 0.17)	0.07 (-0.10, 0.24)
Q3	-0.04 (-0.21, 0.12)	-0.06 (-0.24, 0.10)	-0.01 (-0.20, 0.17)
Q4	0.05 (-0.11, 0.22)	-0.01 (-0.18, 0.16)	0.04 (-0.17, 0.26)
Q5	0.09 (-0.07, 0.26)	0.01 (-0.16, 0.17)	0.09 (-0.15, 0.34)
P for trend	0.21	0.91	0.63
Vegetarian			
Q1	0.00	0.00	0.00
Q2	-0.08 (-0.24, 0.08)	-0.08 (-0.25, 0.07)	-0.12 (-0.29, 0.04)
Q3	-0.08 (-0.24, 0.08)	-0.09 (-0.26, 0.06)	-0.09 (-0.26, 0.07)
Q4	-0.02 (-0.19, 0.13)	-0.05 (-0.23, 0.11)	-0.06 (-0.24, 0.11)
Q5	-0.10 (-0.27, 0.06)	-0.05 (-0.25, 0.14)	-0.13 (-0.33, 0.07)
P for trend	0.44	0.58	0.36
Traditional			
Q1	0.00	0.00	0.00
Q2	-0.02 (-0.17, 0.13)	-0.05 (-0.21, 0.10)	-0.06 (-0.22, 0.10)
Q3	-0.07 (-0.24, 0.08)	-0.08 (-0.25, 0.08)	-0.11 (-0.29, 0.05)
Q4	0.14 (-0.01, 0.30)	0.14 (-0.01, 0.30)	0.04 (-0.13, 0.21)
Q5	0.25 (0.08, 0.41)	0.25 (0.08, 0.42)	0.13 (-0.06, 0.32)
P for trend	0.001	0.001	0.13

*Adjusted for all other dietary patterns.

†Adjusted for all other dietary patterns, age, sex, body mass index, social class, housing tenure, employment status, whether a single parent, smoking, passive smoke exposure at home, total energy intake, ethnicity, number of siblings, paracetamol and supplement use.

After entering the adjusted comparisons in the main analyses into the Simes procedure to allow for multiple testing, three associations could still be regarded as significant, namely, between the 'traditional' pattern and asthma, and between the 'prudent' pattern and chronic bronchitis, amongst nonsupplement users; and between the 'vegetarian' pattern and asthma amongst whites.

Discussion

In this population-based case-control study, we have not found any significant relation between five distinct dietary patterns and asthma in adults overall, after controlling for confounders. Whilst a recent cross-sectional study of Japanese young women reported associations between two out of five dietary patterns and wheezing (13), our findings are consistent with a large prospective study of

French women, which found no relation between three dietary patterns and asthma (12). Similarly, prospective studies of older adults in Singapore and the USA, which were primarily examining other respiratory outcomes, have not reported associations between dietary patterns and incident asthma (9–11). In contrast to the French study, we found no relation between any dietary pattern and asthma severity. As in our study, the studies from France, Singapore and the USA all used PCA to derive dietary patterns. Furthermore, there were similarities between the 'prudent' and 'vegetable and fruit' patterns in our study and the 'prudent' pattern reported in the French and US studies, and between our 'western' dietary pattern and the 'western' pattern in those studies. We did find some evidence for associations between the 'vegetarian' and 'traditional' dietary patterns and asthma after exclusion of supplement users and nonwhites. Clearer associations amongst whites may be because the FFQ was

Table 4. Association between quintile (Q) of dietary patterns and chronic bronchitis

Pattern (no. individuals = 1404)	Unadjusted odds ratio (95% CI)	Adjusted odds ratio* (95% CI)	Adjusted odds ratio† (95% CI)
Prudent			
Q1	1.00	1.00	1.00
Q2	0.89 (0.55, 1.42)	0.98 (0.61, 1.58)	1.46 (0.84, 2.53)
Q3	0.94 (0.58, 1.51)	1.13 (0.67, 1.88)	2.27 (1.23, 4.18)
Q4	0.65 (0.39, 1.06)	0.77 (0.44, 1.35)	1.76 (0.88, 3.51)
Q5	0.65 (0.39, 1.06)	0.76 (0.39, 1.49)	2.61 (1.13, 6.05)
<i>P</i> for trend	0.039	0.36	0.025
Vegetable and fruit			
Q1	1.00	1.00	1.00
Q2	0.63 (0.39, 1.01)	0.63 (0.39, 1.00)	0.70 (0.41, 1.16)
Q3	0.49 (0.30, 0.79)	0.53 (0.33, 0.87)	0.64 (0.38, 1.10)
Q4	0.59 (0.37, 0.95)	0.65 (0.39, 1.07)	0.88 (0.50, 1.55)
Q5	0.56 (0.34, 0.91)	0.63 (0.37, 1.06)	0.84 (0.46, 1.52)
<i>P</i> for trend	0.022	0.10	0.74
Western			
Q1	1.00	1.00	1.00
Q2	0.93 (0.54, 1.59)	0.86 (0.48, 1.53)	0.87 (0.47, 1.61)
Q3	1.66 (1.00, 2.76)	1.51 (0.86, 2.64)	1.33 (0.68, 2.62)
Q4	1.43 (0.86, 2.37)	1.31 (0.76, 2.25)	1.23 (0.60, 2.52)
Q5	1.87 (1.14, 3.07)	1.73 (1.00, 2.99)	1.94 (0.79, 4.75)
<i>P</i> for trend	0.003	0.014	0.11
Vegetarian			
Q1	1.00	1.00	1.00
Q2	1.09 (0.67, 1.79)	1.13 (0.69, 1.86)	1.11 (0.64, 1.94)
Q3	1.06 (0.64, 1.73)	1.19 (0.72, 1.97)	1.05 (0.61, 1.80)
Q4	1.06 (0.65, 1.74)	1.28 (0.75, 2.19)	1.10 (0.60, 1.99)
Q5	0.98 (0.60, 1.61)	1.35 (0.74, 2.49)	1.00 (0.51, 1.98)
<i>P</i> for trend	0.93	0.29	0.96
Traditional			
Q1	1.00	1.00	1.00
Q2	0.90 (0.55, 1.47)	0.90 (0.54, 1.48)	0.87 (0.49, 1.53)
Q3	0.90 (0.55, 1.48)	0.89 (0.53, 1.47)	0.91 (0.48, 1.69)
Q4	0.79 (0.48, 1.31)	0.77 (0.46, 1.30)	0.70 (0.38, 1.31)
Q5	0.92 (0.56, 1.48)	0.89 (0.53, 1.47)	0.84 (0.43, 1.61)
<i>P</i> for trend	0.61	0.53	0.48

*Adjusted for all other dietary patterns.

†Adjusted for all other dietary patterns, age, sex, body mass index, social class, housing tenure, employment status, whether a single parent, smoking, passive smoke exposure at home, total energy intake, ethnicity, number of siblings, paracetamol and supplement use.

less appropriate for use in ethnic minorities in this population. Whilst such sub-group analyses should be interpreted cautiously and need to be replicated in other populations, the level of statistical significance suggests that these findings are unlikely to have arisen by chance. However, we do not have an obvious explanation for why nonmeat eaters would be at increased risk, and meat-eaters at decreased risk of asthma.

Unexpectedly, we found a positive association between chronic bronchitis and the 'prudent' dietary pattern I. The only previous report of an association between a dietary pattern and chronic bronchitis symptoms is from a study in Singapore, which reported an increase in symptoms in relation to a 'meat-dim sum' pattern, but it is difficult to compare a South East Asian diet with a British diet. Again, it is not clear why a 'healthier' dietary pattern should be associated with more chronic bronchitis symptoms, and this may be a chance finding, although

amongst nonsupplement users at least, the *P*-value would suggest that this may not be the case. We also found some evidence for a positive association between the 'vegetable and fruit' dietary pattern and rhinitis. This pattern would be expected to reflect a high intake of dietary antioxidants. It has been suggested, contrary to the prevailing antioxidant paradigm, that a higher intake of antioxidants might promote the development of allergic disease (25), and there is evidence that a higher intake of beta carotene is associated with a higher prevalence of rhinitis in our study (unpublished data) and hayfever (26). However, this association may have arisen by chance, given the *P*-value. Furthermore, given the cross-sectional nature of the study, and the weakening of the relation between the 'vegetable and fruit' pattern and rhinitis when we excluded individuals who avoided foods or took supplements because of asthma or allergy, it is possible that this relation might be partly explained by 'reverse

Table 5. Association between quintile (Q) of dietary patterns and rhinitis

Pattern (no. individuals = 1429)	Unadjusted odds ratio (95% CI)	Adjusted odds ratio* (95% CI)	Adjusted odds ratio† (95% CI)
Prudent			
Q1	1.00	1.00	1.00
Q2	1.39 (0.93, 2.07)	1.21 (0.80, 1.84)	1.16 (0.73, 1.83)
Q3	1.27 (0.85, 1.90)	1.07 (0.69, 1.66)	1.06 (0.64, 1.75)
Q4	1.24 (0.83, 1.86)	1.01 (0.63, 1.62)	0.98 (0.56, 1.73)
Q5	1.60 (1.08, 2.37)	1.27 (0.77, 2.11)	1.38 (0.72, 2.65)
<i>P</i> for trend	0.065	0.65	0.59
Vegetable and fruit			
Q1	1.00	1.00	1.00
Q2	1.54 (1.03, 2.31)	1.60 (1.06, 2.41)	1.63 (1.05, 2.52)
Q3	1.58 (1.06, 2.35)	1.62 (1.06, 2.46)	1.64 (1.05, 2.57)
Q4	1.70 (1.15, 2.52)	1.70 (1.11, 2.61)	1.76 (1.11, 2.80)
Q5	1.75 (1.18, 2.60)	1.71 (1.08, 2.70)	1.75 (1.03, 2.96)
<i>P</i> for trend	0.006	0.030	0.046
Western			
Q1	1.00	1.00	1.00
Q2	0.86 (0.59, 1.26)	0.95 (0.63, 1.41)	0.89 (0.58, 1.35)
Q3	0.88 (0.60, 1.29)	1.02 (0.67, 1.55)	1.05 (0.66, 1.67)
Q4	0.59 (0.40, 0.88)	0.67 (0.44, 1.03)	0.70 (0.41, 1.20)
Q5	1.01 (0.69, 1.48)	1.13 (0.75, 1.70)	1.30 (0.69, 2.46)
<i>P</i> for trend	0.45	0.93	0.80
Vegetarian			
Q1	1.00	1.00	1.00
Q2	1.07 (0.72, 1.60)	1.12 (0.75, 1.67)	1.10 (0.72, 1.70)
Q3	1.33 (0.90, 1.96)	1.38 (0.92, 2.08)	1.42 (0.92, 2.17)
Q4	1.26 (0.86, 1.87)	1.20 (0.79, 1.83)	1.34 (0.85, 2.11)
Q5	1.21 (0.82, 1.79)	1.02 (0.65, 1.62)	1.00 (0.60, 1.65)
<i>P</i> for trend	0.22	0.67	0.59
Traditional			
Q1	1.00	1.00	1.00
Q2	1.26 (0.85, 1.85)	1.33 (0.89, 1.99)	1.28 (0.83, 1.98)
Q3	0.84 (0.56, 1.24)	0.84 (0.56, 1.25)	0.88 (0.57, 1.36)
Q4	0.82 (0.55, 1.22)	0.79 (0.53, 1.19)	0.90 (0.57, 1.42)
Q5	1.19 (0.81, 1.76)	1.08 (0.72, 1.62)	1.28 (0.79, 2.08)
<i>P</i> for trend	0.94	0.48	0.79

*Adjusted for all other dietary patterns.

†Adjusted for all other dietary patterns, age, sex, body mass index, social class, housing tenure, employment status, whether a single parent, smoking, passive smoke exposure at home, total energy intake, paracetamol, ethnicity, number of siblings and supplement use.

causation'. Whilst we cannot exclude the possibility of bias or confounding influencing our results, response rates were similar between cases and controls (14), and we controlled for an extensive number of potential confounding factors, particularly different indicators of socio-economic status.

Strengths and limitations of dietary patterns

There are conceptual and methodological advantages in favour of using dietary patterns in nutritional epidemiology instead of analysing individual foods and nutrients. A conceptual advantage is that people do not eat individual foods, but meals, which form a dietary pattern. Arguably, individuals might interpret the concept of a dietary pattern and incorporate that into their diet more readily, so that changes in public health policy could be implemented more easily. One methodological disadvan-

tage of analysing individual nutrients and foods 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. By contrast, 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 (27–29).

On the other hand, PCA involves several arbitrary decisions which depend on the subjective judgment of the researcher (such as deciding how many patterns can be identified), although there were similarities between the five dietary patterns that we derived and dietary patterns defined in a number of other UK studies using PCA (30–32). In contrast to traditional approaches to nutritional

epidemiology (investigating the association of individual nutrients or foods with disease), this approach cannot be specific about which of the particular foods or nutrients that form the dietary pattern are responsible for associations with disease outcomes, and specifically which biological relationships exist. Therefore if the effect is caused by a specific food or nutrient, this is likely to be diluted in the dietary pattern approach (27, 28).

In conclusion, and in keeping with recent evidence, we have not found evidence to suggest that dietary patterns influence adult asthma overall, although our findings after exclusion of nonwhites and supplement users require replication. The unexpected finding for chronic bronchitis should be interpreted with caution.

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Conflict of interest

None of the authors have any conflicts to declare.

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