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Longitudinal changes in dietary patterns during adult life

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Despite the growing interest in dietary patterns, there have been few longitudinal investigations. The objective of the present study was to extend an earlier method of dietary pattern assessment to longitudinal binary data and to assess changes in patterns over time and in relation to socio-demographic covariates. A prospective national cohort of 1265 participants completed a 5 d food diary at three time-points during their adult life (at age 36 years in 1982, 43 years in 1989 and 53 years in 1999). Factor analysis identified three dietary patterns for women (fruit, vegetables and dairy; ethnic foods and alcohol; meat, potatoes and sweet foods) and two patterns in men (ethnic foods and alcohol; mixed). Trends in dietary pattern scores were calculated using random effects models. Marked changes were found in scores for all patterns between 1989 and 1999, with only the meat, potatoes and sweet foods pattern in women recording a decline. In a multiple variable model that included the three time-points, socio-demographic variables and BMI time-dependent covariates, both non-manual social class and higher education level were also strongly associated with the consumption of more items from the ethnic foods and alcohol pattern and the mixed pattern for men ($P < 0{\cdot}0001$) and the fruit, vegetables and dairy pattern and the ethnic foods and alcohol pattern for women ($P < 0{\cdot}01$). In conclusion, longitudinal changes in dietary patterns and across socio-economic groups can assist with targeting public health initiatives by identifying stages during adult life when interventions to improve diet would be most beneficial to health.

Dietary patterns: Longitudinal studies: Food diary: Socio-economic position: Body mass index

There is increasing interest in overall dietary patterns, rather than individual foods or specific nutrients, because of the association between food intakes and the biological interactions that occur between nutrients (Newby & Tucker, 2004).

Dietary pattern assessment using multivariate statistical techniques such as factor and cluster analysis is becoming increasingly common. One of the difficulties associated with patterns obtained from such data-specific techniques is that they cannot be reproduced in different populations. Schulze *et al.* (2003) proposed a simplified dietary pattern variable score that is less population-dependent. It is the sum of unweighted standardised food variables that load highly on a specific pattern of interest.

Dietary intake may vary substantially across the life-course. Epidemiological studies often measure diet at only one time-point, assuming that this represents long-term diet or the relevant time-frame for the development of disease. Cross-sectional studies have shown differences in dietary patterns according to gender, social class and education level (Pryer *et al.* 2001; Mishra *et al.* 2002, 2004; Greenwood *et al.* 2003; Martikainen *et al.* 2003). However, changes in dietary patterns over time in relation to these covariates have not previously been considered. Similarly, issues surrounding the use of multivariate methods to analyse repeated measures of diet (Greenwood *et al.* 2003; Schulze *et al.* 2003; Mishra *et al.* 2004) and how to characterise changes in dietary patterns have not been investigated.

The Medical Research Council National Survey of Health and Development, with repeated, detailed assessments of dietary intake during adult life (Wadsworth, 1991), provides an ideal opportunity to extend the simplified dietary pattern score method (Schulze *et al.* 2003) for the assessment of dietary patterns to longitudinal data and to assess changes in dietary patterns over time and in relation to important socio-demographic covariates.

Materials and methods

The Medical Research Council National Survey of Health and Development (also known as the 1946 British Birth Cohort) is a longitudinal study based on a social-class stratified, random sample of 5362 singleton births in England, Scotland or Wales during the first week of March 1946. Medical, social, educational and other information has been collected throughout the life-course (Wadsworth *et al.* 2003), and dietary intake was assessed in 1982, 1989 and 1999 when the subjects were aged 36, 43 and 53 years, respectively (Braddon *et al.* 1988; Price *et al.* 1995; Prynne *et al.* 2005). At the most recent interview, the population was shown to be still representative of 53-year-olds in the native-born population (Wadsworth *et al.* 2003).

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Subjects were classified according to their social class and region of residence. Four regions of residence were defined: Scotland; North (North, North-West, Yorkshire); Central, South-West and Wales (Midlands, North Midlands, Eastern, Southern, South-West, Wales); London and South-East. Categories of occupational social class in 1999 were defined as non-manual (managerial, professional, skilled professional ancillaries, service providers) and manual (skilled, non-skilled, agricultural workers; Registrar General, 1980).

The highest educational qualification achieved by 26 years of age was classified into three groups: advanced secondary education (A levels or equivalent, usually attained at 18 years of age) and higher education (degree level or equivalent); ordinary secondary qualifications (O levels or equivalent, usually attained at 16 years of age); less than secondary qualifications (Richards *et al.* 2002). At each of the three ages (36, 43, 53 years), a physical examination was conducted with height and weight measured using a standardised protocol, and BMI was calculated as weight/height^2 to form four categories: <20, 20–24·9, 25–29·9, $\geq 30\,kg/m^2$ (Wadsworth *et al.* 2002).

Dietary assessment

Diet was assessed at each time-point using a 5 d food diary. Participants were asked to record information on their food and beverage intake over five consecutive days, including brand names, food preparation methods and any recipes used, and to record the amounts eaten in household measures, using photographs to aid in the estimation of portion size (Price *et al.* 1995). At all three ages, the diaries were completed between spring and autumn (1989, April–September; 1989, June–October; 1999, May–November).

Food intake at age 43 and 53 years of age was coded using a computerised in-house data entry program at the Medical Research Council Human Nutrition Research, Cambridge (Braddon *et al.* 1988; Price *et al.* 1995). Data at age 36 years were originally coded manually and later converted to appropriate format for use with the in-house analysis programs. All foods and beverages consumed at each time-point were allocated to one of 126 individual food groups (Appendix 1). Food groupings were devised to create small, mutually exclusive groups suitable for tracking foods, and therefore dietary patterns, across the three time-points, taking into consideration the types of food commonly consumed in the UK and foods potentially relevant for the development of chronic disease and of specific interest with respect to public health nutrition. Guidance on the allocation of foods to the groups was sought from previously published work and existing advice on the development of food groups (Food and Agriculture Organisation, 1994; Smith *et al.* 1995; Food Standards Agency, 2002; Mishra *et al.* 2004).

Statistical analysis

The distribution of the consumption of the food and beverage items was highly skewed, so a binary variable for each food group was created and respondents were dichotomised as a consumer or non-consumer. Factor analysis for binary variables using the Mplus statistical package was conducted to determine the dietary patterns (Muthen & Kaplan, 1998–2004). This method was preferred as standard factor analysis in most statistical packages assumes normally distributed data. Rather than maximising the variance, the exploratory factor analysis for binary variables in Mplus attempts to reproduce the tetrachoric correlations between the food items. Dietary patterns were determined separately for men and women.

In order to assess the change in dietary pattern over time, the analysis required the following steps. First, exploratory factor analysis of food intake data collected at age 53 years was conducted to obtain food and beverage items that loaded highly (factor loading $\geq 0{\cdot}25$) on a particular factor. The number of factors determined was based on their interpretability, their having an eigenvalue of more than 1, a change point in the Scree plot and a root mean square residual of less than 0·05. These factors were identified (labelled) as distinct dietary patterns. Cross-sectional analysis at age 36 and 43 years was also conducted and cross-checked against dietary patterns determined at age 53 for consistency.

For each dietary pattern identified at age 53 years, we derived a simplified dietary pattern score $= X_1 + X_2 + \cdots + X_r (r < 126)$ for the r food items with high loadings present in the dietary pattern, and where items with negative loadings were subtracted. The respondents' dietary pattern scores at age 53 years were then obtained as the summation of items consumed from each dietary pattern equation (Schulze *et al.* 2003). These same equations for the dietary patterns at age 53 were then used to obtain the respondents' dietary pattern scores for ages 36 and 43. This method of scoring for dietary patterns assumes that all food items loading highly on the pattern contribute equally to it (Schulze *et al.* 2003). Such an approach is conceptually meaningful and pragmatic in that the consumption of specific food items is either present as part of the dietary pattern or is not (compared with interpreting differential weighting of items across patterns), particularly in assessing patterns across studies or over time where weightings or factor loadings will inevitably change.

The longitudinal analysis was conducted by using the three repeat measures of dietary pattern scores of each pattern modelled simultaneously as outcome variables in a mixed model, with random effects and random intercepts. Adjusted means and 95 % CI were obtained by including time (year at data collections), social class and region of residence, time-varying BMI, smoking status and highest educational qualification attained as covariates in the model. This analysis was performed using PROC MIXED with the option TYPE = UN in SAS program software version 8·0 (SAS Institute, Cary, NC, USA).

In order to assess the stability of dietary patterns over time, thirds of dietary scores were calculated for each dietary pattern and at each of the ages. Agreement between these thirds at different time-points was assessed using weighted kappa statistics and evaluated using standard cut-offs (kappa $< 0{\cdot}2$, poor; 0·2–0·4, fair; 0·41–0·6, moderate; 0·61–0·8, good; $>0{\cdot}81$, very good; Landis & Koch, 1979). All statistical analyses were stratified by sex.

Results

Table 1 presents the socio-demographic and lifestyle profile of respondents in the National Survey of Health and Development who provided dietary data at each age. The proportion (weighted for social-class stratified sampling) of subjects in

Table 1. Socio-demographic and lifestyle profile of respondents in the Medical Research Council National Survey of Health and Development at each of the time-points in adult life when dietary data were collected*

	All three time-points†
	n
Number of subjects in the study	2605
Number of subjects in the study who provided dietary data	1265
	%
Region of residence	
Scotland	8
The North‡	22
Central, South-West and Wales§	36
London and South-East	33
Social class	
Non-manual	72
Manual	28
Highest level of education	
Below ordinary secondary level	28
Ordinary secondary level	30
Advanced secondary level and above	43
Ever smoked	
No	84
Yes	16
BMI (kg/m^2)	
<20	2
20–24·9	36
25–29·9	42
>30	19

* N varies for individual covariates due to missing values.
† Socio-demographic and lifestyle profile based on 1999 data except for region of residence, which was based in 1989 data.
‡ Includes the following regions: North, North-West, Yorkshire.
§ Includes the following regions: Midlands, North Midlands, Eastern, Southern, South-West, Wales.

this study who had manual occupations were 35 % and 32 % for men and women, respectively, compared with 43 % and 30 % for those 3053 subjects who were still in the study in 1999 (Wadsworth *et al.* 2003).

Eigenvalues for women dropped substantially from the first factor (9·6) to the second (4·8) and then to the third (4·5), with further small declines for subsequent factors. Eigenvalues for men exhibited a similar sharp decline from the first factor (11·8) to the second (5·6) and then the third (5·0), again with lesser declines thereafter. Based on the interpretability of the factors, and root mean square residuals of less than 0·5, three factors (factor loadings $\geq 0·25$) or dietary patterns were revealed for women and two dietary patterns for men (Tables 2 and 3).

In women, the ethnic foods and alcohol pattern contained twenty-six food items and was characterised by Indian and Chinese meals, rice and pasta, oily fish and shellfish, olive oil, some vegetables and alcoholic beverages. The meat, potatoes and sweet foods pattern contained nineteen items including red meat, bacon and ham, all types of potato and potato dishes, sweet pies, cakes, puddings and desserts with negative loadings for pasta and skimmed milk. The fruit, vegetables and dairy pattern contained thirty-two items such as low-fat/reduced-fat dairy products, fruit, some vegetables and wholemeal bread, with negative loadings for meat, meat products and white bread. In men, the ethnic foods and alcohol pattern contained twenty-four items and was characterised by Indian and Chinese meals, rice and pasta, shellfish, olives, some vegetables and legumes, and alcoholic beverages with negative loadings for meat pies, fried chips and animal fats. In men, there was a mixed pattern containing twenty-three items including many fruits and vegetables, low-fat/low-calorie yoghurt and soya milk and a range of sweet foods including cakes, sweet biscuits, sweet pies, puddings, desserts, confectionery and ice cream. A cross-sectional analysis of dietary patterns at ages 36 and 43 years showed that similar dietary patterns existed at each time (results not shown).

For women, there was a clear trend over time showing an increased number of items consumed in the ethnic foods and alcohol pattern and the fruit, vegetables and dairy pattern, and a decrease in the meat, potatoes and sweet foods pattern (Table 4). With respect to education, those with advanced secondary level or above had higher scores for the ethnic foods and alcohol pattern and the fruit, vegetables and dairy pattern. Similar results were found for those in the non-manual social class. Significant regional differences in the fruit, vegetables and dairy pattern scores were also shown, with women from London and the South-East having a significantly higher pattern score than those living in the North, and a significantly higher score than those in Scotland for the meat, potatoes and sweet foods pattern. The relationship between BMI and the fruit, vegetables and dairy pattern score showed an inverted U trend, women in the ≤ 20 category and in the ≥ 30 category having lower scores for the fruit, vegetables and dairy pattern than others.

For men, the number of items consumed from both patterns increased significantly over time (Table 5). Non-manual social class and higher education levels were associated with significantly higher scores on both dietary patterns. Men living in London and the South-East had higher ethnic foods and alcohol dietary pattern scores than those from other regions. The relationship with BMI was significant, with higher scores for the mixed dietary pattern recorded by men with a BMI of 20–24·9 kg/m^2 compared with other groups. Non-smokers also recorded higher scores for the mixed pattern compared with smokers.

Across all time-points, scores for the fruit, vegetables and dairy pattern for women had the greatest agreement, with a poor agreement found in scores for the meat, potatoes and sweet foods pattern (Table 6). For men, there was little variation in the degree of agreement for dietary pattern scores between each time-point, with values of kappa ranging from 0·38 to 0·44.

Discussion

This longitudinal study of dietary patterns using factor analysis identified three dietary patterns among women (labelled fruit, vegetables and dairy; ethnic foods and alcohol; and meat, potatoes and sweet foods) and two dietary patterns in men (labelled ethnic foods and alcohol; and mixed). A method for tracking each subject's dietary patterns during adult life was demonstrated by using simplified scores to measure the number of items consumed from each dietary pattern (rather than the quantity consumed), resulting in dietary pattern scores that reflected the variety of the subject's diet. This method forms an alternative approach to investigating changes in dietary patterns and complements previous

Table 2. Foods loading* on the three dietary patterns identified in women and percentage of consumers across three time-points

Ethnic foods and alcohol				Meat, potatoes and sweet foods				Fruit, vegetables and dairy			
	% Consumers				% Consumers				% Consumers		
Food items and factor loadings	1982	1989	1999	Food items and factor loadings	1982	1989	1999	Food items and factor loadings	1982	1989	1999
Fried Indian and Chinese foods 0·51	1	5	8	Red meat and game 0·45	38	74	64	Meat alternatives 0·50	2	2	6
Indian dishes 0·35	5	4	15	Bacon and ham 0·36	75	71	69	Other legumes 0·40	9	14	14
Indian breads 0·30	3	1	4	Meat pies 0·29	38	34	23	Nuts and seeds 0·38	27	34	28
Chinese dishes 0·29	2	2	6	Fried potato and potato products 0·51	2	30	37	Wholemeal bread 0·36	38	49	42
Rice dishes 0·50	3	6	17	Cooked potato and potato products 0·27	95	84	88	Other breads 0·32	21	14	29
Pasta and noodles 0·29	14	22	34	Savoury bread and cereal products 0·27	24	27	31	Muesli 0·37	13	19	17
Other cereals and flours 0·26	15	3	7	Carrots 0·40	51	59	66	Porridge 0·27	6	7	15
Oily fish 0·31	24	40	46	Peas 0·30	65	57	50	Low-fat/low-calorie yoghurt 0·36	8	38	44
Shellfish 0·38	23	18	21	Sauces and dressings 0·47	82	86	89	Low-fat/reduced-fat cheese 0·49	12	15	19
Spinach 0·38	3	4	7	Animal fats 0·35	49	0	4	Soya milk 0·76	0	0	1
Lettuce 0·37	65	73	68	Other fats 0·29	41	28	3	Tomatoes 0·29	84	86	86
Onions 0·34	48	51	55	Semi-skimmed milk 0·29	0	40	78	Broccoli 0·28	6	18	34
Avocados and olives 0·58	1	2	9	Cakes 0·27	59	46	46	Potato dishes 0·29	5	6	7
Other vegetables 0·52	79	88	87	Sweet pies 0·33	32	38	34	Bananas 0·41	35	46	70
Melon 0·25	5	10	18	Puddings and desserts 0·29	61	52	47	Apples 0·40	56	60	62
Olive oil 0·35	3	3	21	Cream 0·35	31	33	34	Berries and currants 0·40	24	24	27
Mineral water 0·44	0	0	25	Pasta and noodle dishes (−0·29)	13	12	25	Citrus fruits 0·36	18	15	23
Vegetable juice 0·41	2	2	2	Skimmed-milk beverages (−0·31)	0	8	1	Pears 0·35	14	21	24
Red wine 0·59	12	15	30	Meat alternatives (−0·34)	2	2	6	Tropical fruit 0·34	10	16	17
White wine 0·53	26	40	41					Stone fruit 0·33	22	39	39
Spirits and liqueurs 0·38	24	26	29					Other fruit 0·42	14	20	29
Beer 0·31	22	21	17					Dried fruit 0·49	18	20	24
Fortified wines 0·33	27	20	15					Fruit juice 0·37	39	55	61
Coffee 0·34	94	89	85					Powdered beverages 0·26	26	15	22
Whole-milk beverages −0·30	0	7	1					Sugars, preserves and spreads 0·31	87	81	78
White fish, fried in batter/crumbed −0·30	1	17	17					Water 0·41	3	49	63
								Bacon and ham −0·27	75	71	69
								Meat pies −0·27	38	34	23
								White bread −0·27	87	81	84
								Meat products, burgers and kebabs −0·31	1	0	2
								Red meat and game −0·33	38	74	64
								Fried chips −0·36	9	50	50

Foods with negative loadings for the dietary patterns are indicated by minus signs. The simplified pattern score for each dietary pattern was calculated by summing the consumption of the items with positive loadings (above), whereas the consumption of items with negative loadings was subtracted from the score.

* Factor loading ≥0·25.

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Table 3. Foods loading* on the two dietary patterns identified in men and percentage of consumers across three time-points

Ethnic food and alcohol				Mixed			
	% Consumers				% Consumers		
Food items and factor loadings	1982	1989	1999	Food items and factor loadings	1982	1989	1999
Fried Indian and Chinese foods 0·52	1	7	8	Soya milk 0·50	0	0	2
Indian dishes 0·35	9	5	19	Other vegetables 0·49	75	82	82
Rice dishes 0·47	3	8	14	Fruit juice 0·45	30	46	49
Pasta and noodles 0·40	14	23	31	Skimmed-milk beverages 0·45	0	5	1
Rice 0·39	26	36	33	Sweet biscuits 0·45	67	67	60
Shellfish 0·37	14	16	22	Sauces and dressings 0·43	81	84	85
Avocados and olives 0·57	1	2	9	Lettuce 0·42	62	58	58
Spinach 0·47	4	4	6	Tomatoes 0·41	77	81	82
Wholemeal bread 0·30	31	39	35	Carrots 0·40	50	60	62
Muesli 0·28	14	17	18	Broccoli 0·39	6	15	29
Other legumes 0·58	12	13	14	Other breads 0·38	18	12	25
Mineral water 0·54	0	0	15	Ice cream 0·44	43	44	37
Vegetable juice 0·34	1	1	2	Puddings and desserts 0·38	62	53	45
Coffee 0·29	91	87	84	Confectionery 0·38	18	20	21
Cider 0·35	6	5	4	Low-fat/low-calorie yoghurt 0·37	4	26	31
Red wine 0·62	17	20	36	Apples 0·36	48	56	54
White wine 0·53	24	32	30	Cream 0·36	33	33	29
Fortified wines 0·27	15	10	9	Starchy snacks 0·36	1	1	5
Spirits and liqueurs 0·34	27	28	32	Sweet pies 0·35	41	40	34
				Other fats 0·34	44	34	1
Peas −0·31	70	59	53	Cakes 0·33	52	45	41
Fried chips −0·31	8	60	49				
Meat pies −0·33	52	42	34	Meat dishes −0·32	33	35	25
Animal fats −0·39	46	1	4	Indian dishes −0·28	9	5	19
Other fats −0·38	44	34	1				

Foods with negative loadings for the dietary patterns are indicated by minus signs. The simplified pattern score for each dietary pattern was calculated by summing the consumption of the items with positive loadings (above), whereas the consumption of items with negative loadings was subtracted from the score.

* Factor loading ≥0·25.

Table 4. Adjusted* means and 95 % CI of factor scores for the three identified dietary patterns in women

	Ethnic foods and alcohol			Fruit, vegetables and dairy			Meat, potatoes and sweet foods		
Covariates	Mean	95 % CI	*P* value†	Mean	95 % CI	*P* value	Mean	95 % CI	*P* value†
Time			<0·0001			<0·0001			<0·0001
1982	4·5	4·2, 4·8		2·3	1·9, 2·7		7·6	7·3, 7·9	
1989	4·8	4·5, 5·1		3·8	3·4, 4·2		7·4	7·1, 7·7	
1999	6·4	6·1, 6·6		5·8	5·4, 6·2		7·1	6·8, 7·4	
Region of residence‡			0·08			0·009			<0·0001
Scotland	4·9	4·4, 5·5		3·5	2·8, 4·3		6·5	6·0, 7·0	
The North	5·2	4·8, 5·6		3·6	3·1, 4·2		7·6	7·3, 8·0	
Central, South-West and Wales	5·2	4·9, 5·5		4·2	3·7, 4·6		7·6	7·3, 7·9	
London and South-East	5·6	5·3, 5·9		4·6	4·2, 5·1		7·7	7·3, 8·0	
Social class‡			0·002			0·001			0·7
Non-manual	5·6	5·3, 5·8		4·5	4·2, 4·8		7·4	7·2, 7·6	
Manual	4·9	4·5, 5·3		3·5	2·9, 4·0		7·3	6·9, 7·7	
Highest educational level			<0·0001			<0·0001			0·3
Below ordinary secondary level	4·5	4·1, 4·8		2·9	2·5, 3·4		7·5	7·2, 7·8	
Ordinary secondary level	5·1	4·7, 5·4		3·5	3·1, 4·0		7·4	7·1, 7·7	
Advanced secondary level and above	6·1	5·7, 6·5		5·5	5·0, 6·0		7·2	6·8, 7·5	
Ever smoked			0·3			0·3			0·3
No	5·1	4·9, 5·4		4·1	3·7, 4·5		7·4	7·2, 7·7	
Yes	5·3	5·0, 5·6		3·9	3·4, 4·3		7·3	7·0, 7·6	
BMI (kg/m^2)§			0·02			<0·0001			0·5
<20	5·3	4·8, 5·8		3·8	3·1, 4·5		7·6	7·0, 8·1	
20–24·9	5·3	5·1, 5·6		4·6	4·3, 5·0		7·2	7·0, 7·5	
25–29·9	5·4	5·1, 5·7		4·4	4·0, 4·8		7·3	7·0, 7·6	
30	4·8	4·3, 5·2		3·1	2·5, 3·7		7·4	6·9, 7·8	

* Adjusted for all the covariates listed above.
† *P* value for test of heterogeneity across groups.
‡ Region of residence and social class are based on 1989 data.
§ Time-dependent BMI was used in the model.

Table 5. Adjusted* means and 95 % CI of factor scores for the two identified dietary patterns in men

	Ethnic foods & alcohol			Mixed		
	Mean	95 % CI	*P* value†	Mean	95 % CI	*P* value†
Time			<0·0001			<0·0001
1982	1·4	1·0, 1·7		11·0	10·5, 11·6	
1989	2·0	1·7, 2·4		12·1	11·5, 12·6	
1999	3·4	3·0, 3·7		12·9	12·3, 13·4	
Regions of residence‡			<0·0001			0·6
Scotland	2·1	1·4, 2·9		11·6	10·5, 12·8	
The North	1·9	1·5, 2·4		11·9	11·2, 12·7	
Central, South-West, Wales	2·0	1·6, 2·4		12·0	11·4, 12·7	
London and South-East	3·0	2·6, 3·4		12·4	11·7, 13·0	
Social class‡			<0·0001			<0·0001
Non-manual	3·0	2·6, 3·3		13·0	12·5, 13·6	
Manual	1·5	1·1, 2·0		10·9	10·2, 11·6	
Highest educational level			<0·0001			<0·0001
Below ordinary secondary level	1·4	0·9, 1·9		11·0	10·2, 11·8	
Ordinary secondary level	2·3	1·8, 2·8		11·8	10·9, 12·6	
Advanced secondary level and above	3·2	2·8, 3·6		13·2	12·6, 13·9	
Ever smoked			0·1			<0·0001
No	2·1	1·7, 2·5		12·6	11·9, 13·2	
Yes	2·5	2·1, 2·8		11·4	10·8, 12·0	
BMI (kg/m^2)§			0·7			<0·0001
<20	2·6	1·8, 3·4		12·2	11·0, 13·4	
20–24·9	2·2	1·9, 2·5		12·5	12·0, 13·0	
25–29·9	2·2	1·9, 2·5		11·6	11·1, 12·0	
30	2·1	1·5, 2·6		11·7	10·9, 12·5	

* Adjusted for all the covariates listed above.
† *P* value for test of heterogeneity across groups.
‡ Region of residence and social class are based on 1989 data.
§ Time-dependent BMI was used in the model.

methods used to investigate changes in key nutrients and specific food groups (Prynne *et al.* 2005).

For both men and women, increases were found in scores for all dietary patterns between 1989 and 1999, with only the traditional dietary pattern score for women recording a decline. This reflects a greater variety of items consumed that form these dietary patterns in 1999 compared with 1989. Although this is a birth cohort study and therefore subject to cohort effects, the decline in meat, potatoes and sweet foods score over time and the increase in most other dietary pattern scores are consistent with other UK data (Ashfield-Watt *et al.* 2004; Wardle *et al.* 2004). The trends detected using dietary pattern scores are also supported by earlier research from the National Survey of Health and Development study that compared the mean intake of food groups and nutrients (Prynne *et al.* 2005).

Socio-demographic factors, such as non-manual social class and higher education level, were also strongly associated with the consumption of more items from the ethnic foods and alcohol pattern for men and women, the mixed pattern for men and the fruit, vegetables and dairy pattern for women. Kappa statistics indicated that, of all the patterns, the meat, potatoes and sweet foods pattern in women had the least stability (poor agreement) across all three time-points.

The identification of a common ethnic foods and alcohol pattern for both men and women, while other patterns were distinct, is similar to findings in other studies (Pryer *et al.* 2001; Schulze *et al.* 2001; Mishra *et al.* 2002; Balder *et al.*

Table 6. Agreement (weighted kappa statistics and 95 % CI) between thirds of dietary pattern score between 1982 and 1989, between 1982 and 1999, and between 1989 and 1999*

	1982 *v.* 1989		1989 *v.* 1999		1982 *v.* 1999	
	Weighted kappa	95 % CI	Weighted kappa	95 % CI	Weighted kappa	95 % CI
Women						
Fruit, vegetables and dairy	0·41	0·36, 0·47	0·39	0·34, 0·44	0·36	0·31, 0·42
Ethnic foods and alcohol	0·32	0·26, 0·37	0·36	0·31, 0·41	0·28	0·23, 0·34
Meat, potatoes and sweet foods	0·14	0·08, 0·20	0·20	0·14, 0·26	0·14	0·09, 0·20
Men						
Mixed	0·41	0·35, 0·46	0·44	0·38, 0·50	0·38	0·32, 0·44
Ethnic foods and alcohol	0·38	0·32, 0·44	0·41	0·35, 0·46	0·39	0·33, 0·45

* Standard cut-offs for kappa statistics are: <0·2, poor; 0·2–0·4, fair; 0·41–0·6, moderate; 0·61–0·8, good; >0·81, very good (Landis & Koch, 1979).

2003; Correa Leite *et al.* 2003; Togo *et al.* 2003). Perhaps surprisingly, we did not identify a meat, potatoes and sweet foods pattern among men. The mixed pattern identified in men contains some of the sweet foods of the women's meat, potatoes and sweet foods pattern but not the savoury or main dishes (such as red meat, bacon, and the fried and cooked potato items). Dietary pattern analysis reflects the variation in food intake, which suggests that there is little variation in consumption of these food items among men.

The strong association between higher education level and social class with raised scores for the ethnic foods and alcohol pattern and the fruit, vegetable and dairy pattern in women, and the ethnic foods and alcohol pattern and the mixed pattern in men, is consistent with findings from previous cross-sectional studies (Schulze *et al.* 2001; Mishra *et al.* 2002; Van Dam *et al.* 2003).

The present study investigated longitudinal measures of dietary pattern and BMI, and identified an inverted-U-shaped relationship between BMI and the fruit, vegetables and dairy pattern in women. For men, those with a BMI in the range of 20–24·9 kg/m^2 had higher scores for the mixed pattern. Associations between BMI and dietary patterns have been mixed. Our results are consistent with those of Maskarinec *et al.* (2000) and the longitudinal study by Newby *et al.* (2003). In contrast, in a cross-sectional study, Kerver *et al.* (2003) found no consistent or interpretable relationship between BMI and dietary pattern. These inconsistencies may reflect the less than optimal temporal relationships between diet and BMI in cross-sectional studies and possible bias as a result of changes in dietary behaviour and underreporting of dietary intake among subjects with higher BMI (Buzzard, 1998).

Many epidemiological studies rely on one assessment of diet and assume that dietary patterns remain stable over time, with little investigation of intra-individual changes in diet over time. Few studies have assessed stability of dietary patterns over time. Mulder *et al.* (1998) calculated a dietary score incorporating seven behaviours, including the number of meals eaten, takeaways, sweet snacks, salty snacks, fruit, fat and fibre intake. Stability in the dietary score after 4 years was moderate (correlations of 0·61), but stability varied according to the behaviour, with 90 % of people showing no change in the number of meals eaten and the number of sweet or salty snacks consumed.

The present study showed fair-to-moderate stability in the fruits, vegetables and dairy and mixed dietary patterns in women and men, whereas the meat, potatoes and sweet foods dietary pattern, identified only in women, showed poor stability over the 17 years studied. This suggests that healthier eating behaviours track more than other behaviours, but it highlights the importance of including repeat measures of dietary assessment over time to incorporate individual changes in complex dietary behaviour. Greenwood *et al.* (2003) assessed dietary patterns in women using cluster analysis at baseline and after 5 years. Kappa statistics indicated that there was moderate stability (kappa = 0·5) in dietary patterns, whereas nutrient intakes (such as energy, fat and vitamin C) showed much lower stability (kappa = 0·18–0·21). In contrast to the results of the present study, Van Dam *et al.* (2002) found moderate-to-high correlations between dietary pattern scores over 4 and 8 years, with the 'Western' pattern showing higher correlations (0·64–0·72) than the 'prudent' dietary pattern (0·55–0·60).

Simplified pattern scores are particularly useful in longitudinal studies as they only require the derivation of dietary patterns at one time-point and scores can be easily calculated for all time-points. In addition, the simplified dietary pattern scoring may be applied to other studies for cross-population comparisons without the need for confirmatory factor analysis (Schulze *et al.* 2003).

A strength of this study relates to the dietary assessment method used. The majority of studies investigating dietary patterns have used food-frequency questionnaires rather than food diaries. Only the work by Newby *et al.* (2003, 2004*a*,*b*) has utilised food records, but this was with a smaller sample. Food diaries provide detailed information regarding the types of food and beverage consumed. Measuring changes in dietary patterns using an food-frequency questionnaire may be difficult as respondents are often asked to report the frequency of consumption of a group of foods, and it may therefore be difficult to detect changes in the intake of specific foods.

Seasonal variation within each survey period has been minimised as, at all three ages, the diaries were completed over a large portion of the year but always excluded winter (1982, April–September; 1989, June–October; 1999, May–November) when shortages of fresh fruits and vegetables would be most apparent. Seasonal variation in food supplies may, however, have been greatest in 1982 as a subsequent growth in the importation by air of produce from tropical and subtropical countries has provided a year-round supply of a wide range of fruit and vegetables (Prynne *et al.* 2005).

A possible disadvantage of the dietary pattern analysis in this study is the use of the consumption *v*. non-consumption of foods in the factor analysis. This was necessary due to the relatively large number of individual food items incorporated into the analysis and the highly skewed distribution of the consumption of the food and beverage items. This represents a trade-off between using the amount of food consumed of a small number of very broad food groups, as used in most studies (Van Dam *et al.* 2002; Kerver *et al.* 2003), and a much larger number of individual foods, with loss of the amount consumed and a resulting focus on the types of food consumed. An advantage of this approach is that we identified differences between the food patterns that would not have emerged with broader food groups (for example, the different types of vegetables consumed; Newby & Tucker, 2004). McCann *et al.* (2001) evaluated the impact of varying the number of food groups used in dietary pattern analysis, from thirty-six broad food groups to 168 single food items. Whereas the number and type of dietary patterns did not change, the relationship between the dietary patterns and endometrial cancer risk was substantially attenuated, suggesting that greater detail in food groupings is important.

Another limitation of the present study was the selection of the subjects who provided dietary data at all the three time-points. Even though this group comprised about 50 % of those in the whole cohort who responded in 1999, there was a remarkable agreement between the age-matched trends in food and nutrient intake in the two nationally representative National Diet and Nutrition surveys and another birth cohort study (Gregory *et al.* 1990; Henderson *et al.* 2003*a*,*b*; Parsons *et al.* 2004; Prynne *et al.* 2005).

The multivariate assessment of dietary patterns offers a unique way to capture and describe the complex nature of dietary intake and reflects behavioural as well as biological dietary exposures. Very few studies have investigated changes in dietary pattern over time. We used a method involving simplified dietary pattern scores and identified dietary patterns in men and women that showed significant changes over time in this cohort. Simplified pattern scores are particularly useful in longitudinal studies as they can be applied to each subsequent measure of dietary intake. Similarly, they are advantageous in relation to cross-population comparisons. This technique should allow a further investigation of dietary patterns within and between cohorts.

In this birth cohort study, whereas the identifiable dietary patterns were associated with sex, the magnitude of change in most dietary pattern scores over time was strongly associated with socio-demographic and lifestyle characteristics. These data suggest that healthier eating behaviours track more than other eating behaviours. The present results highlight the role for timing and targeting of the public health message.

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Appendix 1. List of food groups used in dietary pattern analysis

White bread
Brown bread
Granary bread
Wholemeal bread
Indian breads
Other breads
Muesli
Medium- and high-fibre breakfast cereals
Low-fibre breakfast cereals
Porridge
Buns and pastries
Cakes
Sweet biscuits
Savoury biscuits
Savoury breads and cereals
Plain cereals and flours
Rice
Rice dishes
Pasta and noodles
Pasta and noodle dishes

Whole milk
Semi-skimmed milk
Skimmed milk
Cheese
Low-fat/reduced-fat cheese
Yoghurt and fromage frais
Low-fat yoghurt and fromage frais
Beverages made with whole milk
Beverages made with semi-skimmed milk
Beverages made with skimmed milk
Soya milk

Red meat
Poultry
Sausages
Offal
Bacon and ham
Meat pies
Burgers and kebabs
Other meat products
Meat alternatives
Poultry dishes
Chinese meat dishes
Indian meat dishes
Meat and vegetable dishes
White fish
White fish dishes and products
White fish in batter/breadcrumbs
Oily fish
Oily fish dishes and products
Shellfish
Eggs
Egg dishes

Apples
Bananas
Oranges
Pears
Berries and currants
Melons
Stone fruit
Fruit salad
Avocados and olives
Other citrus fruit
Other tropical fruit
Dried fruit
Other fruit
Sweetened fruit juice
Unsweetened fruit juice

Broccoli
Brussels sprouts
Cabbage
Carrots
Green beans
Lettuce
Onions
Peas
Spinach
Tomatoes
Potatoes and potato products
Fried potatoes and potato products
Fried chips
Oven chips
Other cruciferous vegetables
Other green leafy vegetables
Other vegetables
Potato dishes
Salads
Vegetable dishes
Vegetable juice
Baked beans
Other legumes

Low-fat spreads
Fat spreads
Animal fats
Butter
Other fats
Olive oil
Sunflower oil
Other oils
Cream

Beer
Cider
Red wine
White wine
Fortified wines
Spirits and liqueurs

Carbonated beverages
Low-calorie carbonated beverages
Cordials and squash
Plain water
Mineral water
Tea
Coffee
Powdered beverages

Sugars
Chocolate
Confectionery
Crisps
Starchy snack foods
Nuts and seeds
Savoury sauces and dressings
Sweet puddings and sauces
Sweet pies
Ice cream and ice cream desserts

Pizza
Fried Indian and Chinese foods
Meat soups
Other soups