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Changes in intake of key nutrients over 17 years during adult life of a British birth cohort

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An investigation was carried out to determine whether there were significant changes in nutrient intake over 17 years of adult life. The Medical Research Council National Survey of Health and Development is a longitudinal study of a nationally representative cohort of singleton births in the UK in 1946. Of this cohort, 1253 survey members provided information on diet recorded in a 5 d diary at age 36 years in 1982, 43 years in 1989 and 53 years in 1999. The outcome measures were mean intakes of energy, macronutrients, minerals and vitamins. There were significant changes in the intake of most nutrients in 1999 compared with previous years. Intakes of fat, Na, Fe and Cu have fallen, but there was a rising trend in the intakes of Ca, P, carotene, thiamin, pyridoxine, folic acid and vitamins C, D and E in both men and women. Additionally, intakes of K, Mg and vitamin K_1 have risen in women. There were significant gender differences, women showing a higher percentage rise in the intakes of carotene, riboflavin, folic acid, vitamin C and vitamin E. These changes were related to changes in the consumption of certain key foods, such as the increased consumption of fruit and vegetables and a shift away from whole milk, butter and red meat. Most of these trends are in line with accepted nutritional guidelines. How far these changes are due to consumer choice and real changes in food composition or are due to artefacts inherent in the methodology is discussed.

Diet: Nutrients: Longitudinal change: Foods

Over the past two decades, there has been a great change in the food supply in the UK and in food habits. The growth in the agricultural production of fruit and vegetable crops in tropical and subtropical countries for export by air has provided a year-round supply of a wide range of fruit and vegetables (Food and Agriculture Organisation of the United Nations, 2001), many of which were either not available at all or were strictly seasonal in earlier years. Advances in food technology accompanied by changes in lifestyle, particularly of women, have resulted in a greatly expanded consumption of 'ready meals' either cook-chilled or frozen (Griffin & Boyle, 1996; Pettit, 2001). Holidays abroad are not only more common among all strata of the population, but are also taken in more distant countries. Together with a greatly increased rate of immigration into the UK (Office of National Statistics, 2001), this has resulted in a wide range of 'ethnic' foods being available for consumption (Pettit, 2001).

In parallel with these changes in food supply and consumption, increasing publicity is given to health claims, both true and dubious, related to nutrition. The major health problems of obesity, diabetes, CVD and cancer have all been related to diet (Block *et al.* 1992; Hooper *et al.* 2001). The British public is encouraged to eat '5 a day' of fruit and vegetables (Department of Health, 1997), reduce their intake of saturated fats and eat more complex carbohydrates (Food Standards Agency, 2004).

In order to obtain evidence that any goals identified by health authorities are being met, it is necessary to compare the results of dietary surveys carried out at two different time-points during this period. Such surveys can be cross-sectional, in which a new sample of individuals is examined at each time point, or a cohort design whereby the same individuals are followed up and surveyed on repeated occasions. In the UK, the National Food Survey has summarised changes in household food purchases (as a proxy for food consumption) and nutrient intake between 1975 and 1999 from cross-sectional surveys carried out annually during those years (Department for Environment Food and Rural Affairs, 2001). The National Diet and Nutrition Survey (NDNS) of adults can be studied to compare changes between 1986/87 and 1999 (Gregory *et al.* 1990; Henderson *et al.* 2003*a*,*b*). These reports show that there have been changes in the food consumption and nutrient intake of the population that may relate to the changes in the nutritional environment. They do not, however, show whether the nutrient intake of individual people has changed over time.

Cohort studies provide evidence of changes within a selected group of people who can be revisited on several occasions. Data on change in dietary habits have been collected from cohorts in Denmark (Osler *et al.* 1997), The Netherlands (Post *et al.* 2001), New Zealand (Fernyhough *et al.* 1999) and the USA (Norris *et al.* 1997; Millen & Quatromoni, 2001). Within the

Abbreviations: NDNS, National Diet and Nutrition Survey; NSHD, National Survey of Health and Development.

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UK, the Medical Research Council National Survey of Health and Development (NSHD) (1946 Birth Cohort) has provided a unique opportunity to investigate whether the nutrient intake of individuals changes significantly during adult life. An analysis of the dietary data collected at three time-points over 17 years can provide evidence of stability or change over nearly two decades, but it is difficult to determine whether any change is real or artefactual. Even if the method of collecting dietary data remains the same, there are several stages along the analytical route at which differences in procedure may occur, such as changes in the coding protocol and changes in the nutrient database (Guenter *et al.* 1994). It is important that the nutrient database is historically appropriate as there have been real changes in nutrient composition arising from reformulation by manufacturers, such as the fortification of breakfast cereals, or advances in plant or animal breeding resulting in reduced meat fat, for example. Improved methods of nutrient analysis, such as that for folic acid, or better sampling methods may, however, mean that, for some foods that have not actually changed in composition, the old database is no longer correct.

Our aim in this paper is to describe changes in intake of selected nutrients and foods between ages 36 and 53 years (1982–1999) in a national birth cohort study. We have attempted to avoid artificial changes, and discussion of the results will attempt to separate fact from artefact.

Methods

Subjects

The Medical Research Council NSHD, the 1946 British Birth Cohort, is a social-class-stratified random sample of 5362 singleton legitimate births in England, Scotland or Wales during the first week of March 1946. Throughout childhood and adult life, medical, social, educational and other information has been collected on twenty-one occasions. Dietary data were collected by research nurses during home visits at age 36, 43 and 53 years (in 1982, 1989 and 1999, respectively). The population interviewed at the age of 53 years was, in most respects, still representative of 53-year-olds in the native-born population (Wadsworth *et al.* 2003). Of the 3035 cohort members who were contacted in 1999, 1776 returned diet diaries, 1760 being diaries of 3 d or more. There were, however, only 1253 individuals for whom there were also diet diary records of at least 3 d collected in 1982 and 1989. This sub-sample forms the population for the current analysis.

Dietary assessment

During the interviews, the nurse asked the subjects to complete a 2 d diet recall (1982 and 1989) and a 5 d food diary, to be completed over the next 5 d. On these first two occasions, the nurse gave detailed instructions on how to complete the diary, filling in the first 2 d with the 48 h diet recall, leaving the subjects to complete the remaining 5 d and return the record by post (Braddon *et al.* 1988; Price *et al.* 1995). If the subjects in 1982 did not return the diaries, the 2 d recalls were lost, so in 1989 these were retained by the nurse, who also left a copy in the 5 d diary with the subject. On the third visit in 1999, there was no 2 d recall and the diary was filled in by the subject after the interview. The interview did not include any questions relating to motivation towards dietary change. For the purposes of this comparison, only subjects with at least 3 d of self-completed food diary data were selected, but if information was given for more days, these were included in the analysis. The results do not include the data from the 2 d recalls.

All food and drink consumed both at home and away was recorded in the diaries using household measures and estimating portion sizes according to detailed guidance notes and photographs provided at the beginning of the diary. The 1989 and 1999 diaries were coded using the in-house program DIDO (Price *et al.* 1995). This program is designed around a hierarchical food menu that offers nearly 2000 foods. These are arranged by major food groups and sub-groups, as listed in the food composition databases described later, and then by individual foods. A food item, having been selected, can be entered as the portion size corresponding to that described in the diary. The output file from the previous coding of the 1982 diaries (Braddon *et al.* 1988) was converted into a form compatible with the later DIDO output files. As it was not recognised in 1982 that tea was an important source of micronutrients, only the milk and sugar components were originally coded. The tea alone was coded on DIDO more recently and added to the converted 1982 output file.

Foods and nutrient intakes for all three assessments were calculated using the in-house suite of programs based on McCance and Widdowson's *The Composition of Foods*, fourth edition (Paul & Southgate, 1978), its supplements (Holland *et al.* 1988, 1989) and the sixth edition (Food Standards Agency, 2002). These databases are the standard reference works for the UK. Vitamin K_1 values were added from the database provided by Bolton-Smith and Shearer (Bolton-Smith *et al.* 2000) and from unpublished data. Na intakes were from foods only and do not include salt added during cooking or at the table. The nutrient contents of foods consumed that had data missing from the database were calculated from recipes, some of which were provided by the subjects and some of which were given in *The Composition of Foods*. Information was also available from the manufacturers on food labels or on websites. Vitamin and mineral supplements were coded separately, and the results of the dietary analysis described in this paper are for food sources only. The food classification system used to group certain foods together for estimating weights of foods eaten was based on the food tables used for the analysis.

Measures

Survey subjects were classified according to their occupational social class (Registrar General, 1980) at age 43 as either non-manual (managerial, professional, skilled professional ancillaries and service providers) or manual (skilled, non-skilled and agricultural workers). Three regions of residence at age 43 were defined: Scotland and the North (North, North-West, and Yorkshire), Central (Midlands, North-Midlands, East Anglia, South-West, Southern, and Wales) and London (London, and South-East).

Statistical analysis

Means and 95 % CI for nutrient intake were calculated at each adult time-point using the random effects models with random intercept. This method of modelling longitudinal data allows the participants to have different intercepts of nutrient intake over time. Adjusted means and CI were obtained by including social class and regions of residence as co-variates in the model. Logarithmic transformations of Fe, Cu, retinol, carotene, folic acid and vitamins B_{12}, C, D and K_1 intakes were performed prior to analysis to normalise their distributions. Geometric means and CI were presented for these variables. All statistical analyses were performed using PROC MIXED in SAS with the option *TYPE* = *UN* (SAS Institute Inc., Cary, NC, USA; SAS Institute Inc., 1989) and were stratified by gender.

Results

Details of the subjects for whom dietary information was available from all three adult time-points are shown in Table 1. These include occupational social class and region of residence. Of those subjects for whom there were socioeconomic data (*n* 1166) the proportions in the present study with non-manual occupations were 65 % and 68 % (weighted for the class-stratified sampling) for men and women, respectively, compared with 57 % and 70 % for those 3053 subjects who were still in the study in 1999 (Wadsworth *et al.* 2003). Of the 1253 subjects, 85 % completed 5 d of diary in 1982, 94 % did so in 1989 and 99 % achieved this in 1999.

Tables 2 and 3 show the adjusted means of daily intake of energy and nutrients from food and drink for men and women, respectively. The adjustment has been made for region and social class.

There have been significant changes in the intake of energy and most nutrients in 1999 compared with previous years, with the exception of K, nicotinic acid, vitamin B_{12} and vitamin K_1 in men, and Zn in women. The intake of some nutrients shows a clear rising trend from 1982 through 1989 to 1999: Ca, P, carotene, thiamin, pyridoxine, folic acid and vitamins C, D and E in both men and women and additionally, in women only, K, Mg and vitamin K_1. In the case of folic acid and vitamin E, most of the rise appeared to take place in the years between 1982 and 1989, but for vitamin C the change was greater between 1989 and 1999. The intake of Cu has been falling from 1982 to1999 in both men and women.

Energy intakes in men and women rose, but not significantly, from 1982 to 1989 but fell to a greater extent in 1999, as did fat intakes, which were lower in 1999 than the 1982 means for both men and women. Carbohydrate intakes in men were significantly lower in 1999 compared with 1989, but in women they remained significantly higher than in 1982. Energy from carbohydrate had, however, risen significantly in both men and women by 1999. Protein intakes, both absolute and as a percentage of energy, rose significantly in both men and women between 1989 and 1999, as did the intake of alcohol. The Fe intakes of men and women also peaked in 1989 and fell in 1999, but only in men did intakes fall below 1982 levels. When Fe intakes were energy adjusted (Willett, 1990), this rise and fall remained significant (results not shown).

There was a significant gender difference in the percentage change in intake of most of the nutrients that showed a rise during the 10 years from 1989 to 1999. The increases in carotene intake for men and women, respectively, were 7 % and 22 %; for riboflavin, 3 % and 12 %; for folic acid, 2 % and 12 %; for vitamin C, 37 % and 51 %; for vitamin E, 4 % and 9 %.

Figure 1 shows the mean intake in g/d of some key foods that relate to changes in nutrient intakes for 1982, 1989 and 1999. Figure 2 shows the mean intake in g/d of men and women separately of some foods for which there were gender differences in the extent of the changes. The consumption of fruit, fruit juices and green leafy vegetables rose, whereas that of bread and potatoes fell, the latter being replaced by pasta, rice and pizza. The type of meat changed, with a move from red meat to poultry, and there was an increased consumption of semi-skimmed milk with a corresponding fall in whole milk. There was a fall in butter consumption but a corresponding rise in other fat spreads that include low-fat spreads, polyunsaturated fat spreads and others such as those containing olive oil. Beer consumption fell but wine consumption increased. The increase in wine consumption between 1989 and 1999 was almost entirely due to red wine, and the consumption of spirits did not change over the period (results not shown). Women showed a greater increase in fruit and vegetable consumption than men. Figure 3 shows the mean intake of vitamin C (mg/d) from some important sources for 1982, 1989 and 1999. The main source of vitamin C has changed from potatoes in 1982 to citrus juices in 1999.

Table 1. Social class and regional distribution of adults in the Medical Research Council National Survey of Health and Development with dietary records at ages 36, 43 and 53 years (*n* 1253)

	Number	Percentage of 1253
Male	562	44·9
Female	691	55·1
Own occupational social class 1989		
Non-manual	849	67·8
Manual	317	25·3
Not recorded	87	6·9
Regional distribution 1989		
Scotland and the North of England	380	30·3
Midlands, Eastern and Wales	325	25·9
London, the South and Southwest	547	43·7
Not recorded	1	0·1
Total number of subjects contacted		
1982	3322	
1989	3262	
1999	3035	

Discussion

The present study shows significant changes in the intake of energy and most nutrients in a cohort of adults in the UK investigated over a period of 17 years. Many of the changes were in accordance with generally accepted nutritional guidelines. It is important to identify those changes that are due to changes in consumer preference, those that result from real changes in the nutrient composition of foods and those that are due to artefacts inherent in the survey methodology. It is difficult to separate clearly changes in food composition from changes in food choice as the two may occur in parallel and consumer choice may be influenced by a change in food composition. A study in the USA tried to separate these factors by analysing new data (1992) from a food frequency questionnaire using a database that had been used for a similar survey 5 years previously (1987) and then analysing the same data using a contemporary (1992) database (Norris *et al.* 1997). These authors thus showed which changes in nutrient intake were due to subjects' food choices rather than alterations in the nutrient database. However, their dietary data were collected using a food frequency questionnaire that was almost identical in both years and contained only fifty-nine items. Carrying out a similar comparison

Table 2. Adjusted means and 95 % CI for the nutrient intake of British men, by year of dietary survey (*n* 562)†

Nutrients	1982	1989	1999 (reference)	*P*-value
Energy (kJ)	**10 320 (10 106–10 535)**	**10 596 (10 381–10 810)**	9651 (9437–9865)	<0·0001
Energy (kcal)	**2463 (2411–2514)**	**2529 (2478–2580)**	2294 (2243–2345)	<0·0001
Protein (g)	**85 (83–86)**	89 (88–91)	88 (86–89)	<0·0001
Protein (% energy)	**14·0 (13·8–14·2)**	**14·3 (14·1–14·5)**	15·5 (15·3–15·7)	<0·0001
Fat (g)	**106 (102–108)**	**109 (107–111)**	88 (86–91)	<0·0001
Fat (% energy)	**38·5 (38·0–39·0)**	**38·4 (37·9–38·9)**	34·4 (33·9–34·8)	<0·0001
Carbohydrate (g)	**272 (266–279)**	**277 (270–284)**	263 (257–270)	<0·0001
Carbohydrate (% energy)	**44·1 (43·6–44·8)**	**43·9 (43·3–44·5)**	46·1 (45·5–46·6)	<0·0001
Alcohol (g)	**21 (19–24)**	**22 (19–24)**	24 (21–26)	0·01
Alcohol (% energy)	**5·9 (5·3–6·5)**	**5·9 (5·3–6·5)**	7·1 (6·5–7·7)	<0·0001
Na (mg)	3172 (3089–3254)	**3443 (3361–3526)**	3142 (3060–3225)	<0·0001
K (mg)	**3502 (3426–3577)**	3597 (3522–3673)	3611 (3536–3687)	0·01
Mg (mg)	**342 (334–351)**	**345 (336–353)**	327 (318–335)	<0·0001
Ca (mg)	**968 (940–996)**	1026 (998–1054)	1048 (1020–1075)	<0·0001
P (mg)	**1412 (1381–1443)**	1465 (1433–1496)	1488 (1456–1520)	<0·0001
Fe* (mg)	**12·4 (12·1–12·8)**	**13·3 (12·9–13·6)**	12·1 (11·8–12·4)	<0·0001
Cu* (mg)	**1·93 (1·86–1·99)**	**1·78 (1·72–1·84)**	1·23 (1·19–1·27)	<0·0001
Zn (mg)	**10·5 (10·2–10·8)**	11·1 (10·9–11·4)	11·1 (10·8–11·3)	<0·0001
Retinol* (μg)	**721 (671–777)**	**697 (648–750)**	467 (433–503)	<0·0001
Carotene* (μg)	**1635 (1535–1742)**	2067 (1940–2206)	2207 (2071–2351)	<0·0001
Thiamin (mg)	**1·40 (1·36–1·44)**	**1·46 (1·42–1·50)**	1·69 (1·66–1·74)	<0·0001
Riboflavin (mg)	**2·04 (1·98–2·10)**	**2·00 (1·94–2·06)**	2·10 (2·07–2·16)	0·004
Nicotinic acid (mg)	22·7 (22·1–23·3)	23·2 (22·6–23·8)	23·1 (22·5–23·7)	0·2
Pyridoxine (mg)	**1·58 (1·52–1·63)**	**1·94 (1·88–2·00)**	2·52 (2·47–2·58)	<0·0001
Folic acid* (μg)	**245 (240–252)**	305 (296–314)	311 (302–317)	<0·0001
Vitamin B_{12}* (μg)	6·1 (5·8–6·4)	6·3 (5·0–6·6)	6·3 (5·9–6·6)	0·6
Vitamin C (mg)	**68 (64–72)**	**68 (64–72)**	93 (89–97)	<0·0001
Vitamin D* (μg)	**2·4 (2·3–2·5)**	**3·3 (3·2–3·5)**	3·6 (3·4–3·7)	<0·0001
Vitamin E (mg)	**8·5 (8·1–8·7)**	11·2 (10·8–11·6)	11·6 (11·2–12·1)	<0·0001
Vitamin K_1* (μg)	**72 (69–75)**	77 (73–81)	77 (74–81)	0·02

* Geometric means. Means in bold are significantly different from the means in 1999.

†Adjusted for social class and region of residence. Since there was no difference between the crude and adjusted means, only adjusted means are presented. The *P*-value corresponds to the null hypothesis that the means, across the three time-points, are equal.

in which the dietary data have been collected in a food diary would be much more difficult as the foods described in the later diary may not have their equivalents in an older nutrient database.

Reductions in nutrient intakes over time

The fall in fat intake and, in particular, the fall in the percentage energy from fat, is in accordance with the recommendation that fat should provide 33 % total dietary energy including alcohol (Department of Health, 1991). A fall in energy intake from fat of 3 % between 1971/74 and 1999/2000 (cross-sectional) has been reported from the USA (Briefel & Johnson, 2004), and in the Netherlands there was a fall of 4 % and 2 % in adult men and women, respectively, tracked over a 20-year period (Post *et al.* 2001). Between the 1986/87 and the 2000/2001 NDNS surveys, there were falls in the intake of energy from fat of 4 % and 6 % in men and women, respectively (Gregory *et al.* 1990; Henderson *et al.* 2003*a*).

Some of this fall in the USA and in Europe was attributed to changes in the fat content of meat. Selective breeding, changes in animal feeds and modern methods of butchery have considerably reduced the fat content of meat, which is reflected in the UK food composition tables for 1978 and 2002 (Paul & Southgate, 1978; Food Standards Agency, 2002). The fat content of ham and bacon has fallen between 19 % and 35 % depending on the cut, pork by 42 %, beef by 21 % and lamb by 23 %. In the present study, there has also been a change in consumer choice towards low-fat milk, as in the USA (Briefel & Johnson, 2004), low-fat spreads and a reduced consumption of cakes and biscuits. This decline in the consumption of whole milk and the increase in low-fat spreads over a 24-year period was also reported by the UK National Food Survey (Department for Environment Food and Rural Affairs, 2001) and over a 10-year period in Denmark (Osler *et al.* 1997). Concurrent with the fall in fat intake in the present study, there was a rise in protein intake, which is to be expected if meat that is consumed is more lean; this is in agreement with the results reported from 1992 to 2000 by the UK National Food Survey (Department for Environment Food and Rural Affairs, 2001).

Negative effects on other nutrients may, however, accompany the fat-reduction trend, for example, the very marked reduction in retinol intake. Although margarine is fortified, by law, to a level comparable to butter, fat spreads, which contain between 25 % and 75 % fat, contain 49–74 % of the level of retinol found in butter. Retinol intakes were very skewed as the richest source, offal, was consumed by relatively few people. Over the period of study, the mean intake of offal halved. The consumption of lean poultry has been encouraged to reduce the intake of saturated fats; together with the health scare engendered by BSE first confirmed in cattle in 1986 (Ricketts, 2004), this has resulted in a move away from red meats. The increase in chicken consumption could also be related to the wide use of chicken in pre-prepared meals, particularly ethnic dishes. This change in the choice of meat is reflected in reduced Fe intake in men and women since 1989. This is despite the increased consumption of breakfast cereals fortified with Fe.

Table 3. Adjusted means and 95 % CI for nutrients intake of British women, by year of dietary survey (*n* 691)†

Nutrients	1982	1989	1999 (reference)	*P*-value
Energy (kJ)	**7329 (7170–7488)**	**7913 (7754–8072)**	7477 (7318–7636)	< 0·0001
Energy (kcal)	**1748 (1710–1786)**	**1887 (1849–1925)**	1775 (1737–1813)	< 0·0001
Protein (g)	**64 (63–65)**	69 (68–71)	71 (69–72)	< 0·0001
Protein (% energy)	15·0 (14·9–15·4)	15·0 (14·8–15·2)	16·1 (15·9–16·4)	< 0·0001
Fat (g)	**79 (77–81)**	**83 (81–86)**	69 (67–71)	< 0·0001
Fat (% energy)	**40·4 (39·9–40·9)**	**39·4 (38·9–39·9)**	34·4 (33·9–34·9)	< 0·0001
Carbohydrate (g)	**196 (191–201)**	215 (210–220)	218 (213–224)	< 0·0001
Carbohydrate (% energy)	**44·6 (44·0–45·0)**	**45·7 (45·1–46·3)**	49·4 (48·8–50·0)	< 0·0001
Alcohol (g)	**6 (5–7)**	**7 (6–8)**	8 (7–9)	< 0·0001
Alcohol (% energy)	**2·5 (2·1–2·9)**	**2·5 (2·1–2·8)**	3·3 (2·9–3·7)	< 0·0001
Na (mg)	**2285 (2227–2342)**	**2525 (2468–2583)**	2417 (2359–2474)	< 0·0001
K (mg)	**2674 (2614–2734)**	**2968 (2908–3028)**	3221 (3161–3281)	< 0·0001
Mg (mg)	**253 (247–260)**	**267 (260–273)**	274 (268–280)	< 0·0001
Ca (mg)	**767 (741–790)**	**849 (826–872)**	910 (888–933)	< 0·0001
P (mg)	**1093 (1068–1118)**	**1177 (1152–1203)**	1245 (1220–1270)	< 0·0001
Fe* (mg)	**9·9 (9·6–10·1)**	**10·8 (10·6–11·0)**	10·2 (10.0–10·4)	< 0·0001
Cu* (mg)	**1·26 (1·22–1·29)**	**1·27 (1·23–1·30)**	1·02 (1·01–1·04)	< 0·0001
Zn (mg)	**8·3 (8·1–8.5)**	**8·3 (8·1–8·5)**	8·5 (8·3–8·7)	0·05
Retinol* (μg)	**512 (478–548)**	**536 (501–573)**	348 (325–372)	< 0·0001
Carotene* (μg)	**1312 (1233–1396)**	**1843 (1732–1961)**	2256 (2120–2401)	< 0·0001
Thiamin (mg)	**1·06 (1·03–1·09)**	**1·20 (1·17–1·23)**	1·44 (1·40–1·47)	< 0·0001
Riboflavin (mg)	**1·54 (1·48–1·59)**	**1·61 (1·56–1·66)**	1·80 (1·75–1·84)	< 0·0001
Nicotinic acid (mg)	**16·4 (15·9–16·8)**	**17·2 (16·8–17·7)**	18·3 (17·9–18·8)	< 0·0001
Pyridoxine (mg)	**1·13 (1·09–1·17)**	**1·58 (1·54–1·62)**	2·01 (1·96–2·04)	< 0·0001
Folic acid* (μg)	**167 (162–172)**	**230 (226–237)**	257 (252–265)	< 0·0001
Vitamin B_{12}* (μg)	**4·0 (3·8–4·2)**	**4·4 (4·2–4·6)**	5·1 (4·7–5·3)	< 0·0001
Vitamin C (mg)	**60 (57–64)**	**68 (64–72)**	103 (100–107)	< 0·0001
Vitamin D* (μg)	**1·9 (1·8–2·0)**	**2·6 (2·5–2·8)**	2·8 (2·6–2·9)	< 0·0001
Vitamin E (mg)	**6·5 (6·2–6·8)**	**9·0 (8·7–9·2)**	9·8 (9·5–10·1)	< 0·0001
Vitamin K_1* (μg)	**59 (57–62)**	**72 (68–75)**	81 (77–84)	< 0·0001

* Geometric means. Means in bold are significantly different from the means in 1999.
†Adjusted for social class and region of residence. Since there was no difference between the crude and adjusted means, only adjusted means are presented. The *P*-value corresponds to the null hypothesis that the means, across the three time-points, are equal.

The fall in Cu intake was also related to the reduced consumption of offal, but other likely factors are the changed Cu content of beer and a change in drinking habits. The Cu content of beer has fallen possibly due to the change from Cu to stainless steel fermenting vessels and the decline in the use of traditional Cu pesticides on hops (Thomas *et al.* 1994). The consumption of lager, which contains only traces of Cu, has overtaken that of darker beers containing more Cu in the cohort and nationally (Department for Environment Food and Rural Affairs, 2001).

Increases in nutrient intakes over time

Many of the increased intakes of nutrients over the period can be related directly to changes in food choice that have coincided with changes in nutrient levels as a result of fortification. The fortification of breakfast cereals with vitamin B_6, folic acid and vitamin B_{12}, such that a 30 g serving provides 25 % of recommended daily intake, which occurred between the 1982 and 1989 surveys, together with the increased consumption of ready-to-eat breakfast cereals (Department for Environment Food and Rural Affairs, 2001), has resulted in an increased intake of all these vitamins. In this study, tea was another source of folic acid that, not in itself a rich source, is nevertheless important owing to the large quantities consumed, which have increased over the years. Intakes of thiamin and nicotinic acid reflect a shift away from potatoes towards a wider range of cereal foods such as pasta, pizza and rice, and an increase in wholegrain products (Department for Environment Food and Rural Affairs, 2001).

The rise in the consumption of liquid milk, yoghurt and dairy desserts from 1982 to 1999 in this cohort has increased the intake of Ca and P, particularly in women. This reflects consumer choice responding to the very greatly expanded range of these products. This rise in the consumption of Ca-rich foods by an ageing population may also be a response to health warnings about osteoporosis. This trend agrees with that found in Holland (Post *et al.* 2001) but appears to differ from that found in Denmark, where Ca intake and the consumption of dairy foods has remained static or decreased. This may be due to the conflict between reducing saturated fat intake while maintaining Ca intake. In the USA, the reduction in the consumption of whole milk did not appear to be compensated for by a corresponding increase in the quantity of low-fat milk in 1992 (Norris *et al.* 1997), but the addition of Ca to non-dairy products such as orange juice has now resulted in increased Ca intakes in adult women (Briefel & Johnson, 2004).

The rise in the intakes of carotene and vitamin C in men and women, and additionally K, Mg and vitamin K_1 in women only, would seem to indicate that the subjects were responding to the advice to increase fruit and vegetable consumption. In the case of vitamin C, it is the rise in the consumption of fruit juices that has had a major effect on intake. The consumption of fruit and green leafy vegetables has risen in both men and women, but the increase, particularly in fruit and fruit juice consumption, was greater in women, indicating that they are more responsive to health messages (Wardle *et al.* 2004). Similar differences have been reported elsewhere in the UK (Baker &

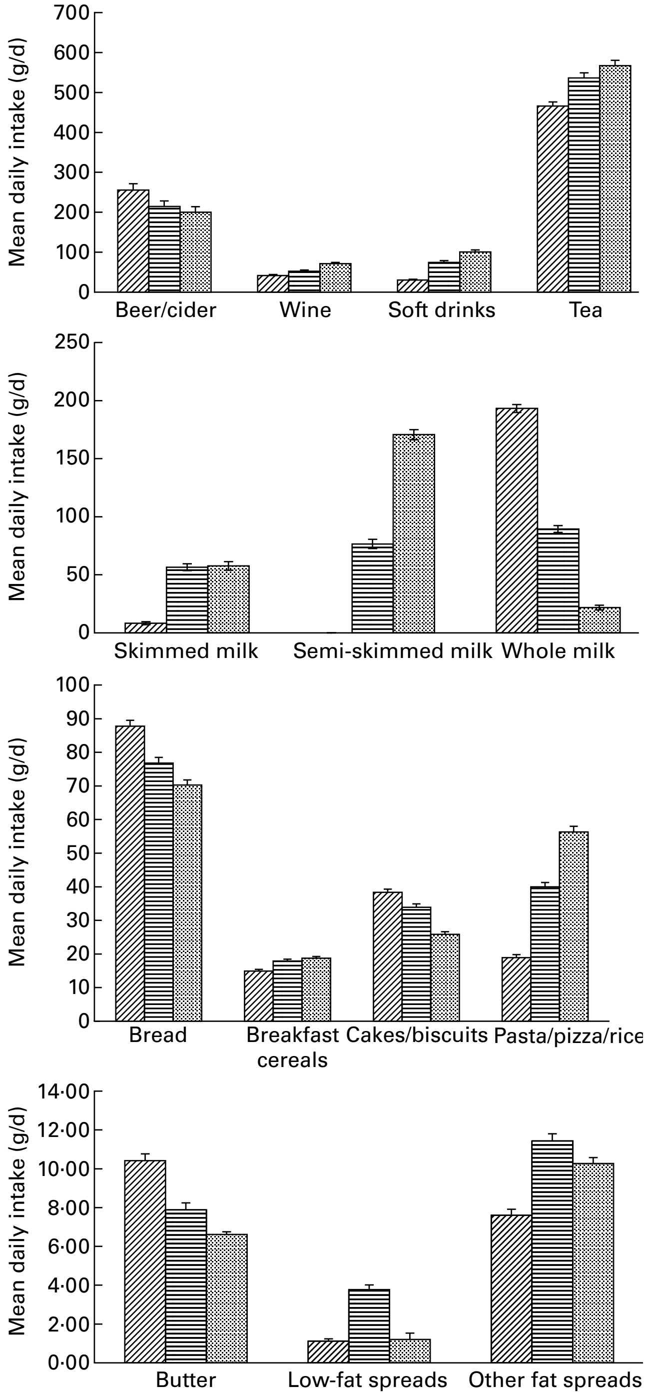

Fig. 1. Mean daily intake of key foods by year. The *y*-axis shows the mean daily intake in g/d of the foods or food groups given on the *x*-axis. The standard errors of the means are indicated by the vertical bars. The years indicated are: 1982 ▨, 1989 ▤, and 1999 ▩. Food intake data were recorded in a 5 d diary by subjects in the National Survey of Health and Development 1946 birth cohort at three time-points: 1982, 1989 and 1999. The results shown are for the 1253 subjects (men and women combined) who completed at least 3 d of records in all 3 years.

Wardle, 2003; Ashfield-Watt *et al.* 2004) and in the USA (Millen Posner *et al.* 1995).

Vitamin K_1 intakes have risen with the increasing consumption of green vegetables, but the use of vegetable oils, particularly soyabean oil and, more recently, rapeseed oil, in cooking and in manufactured foods is an important contributory factor. The change in vitamin E intake, particularly between 1982 and 1989, was also due to the rise in the use of vegetable oils, which had more than doubled between 1982 and 1999 (Food and Agriculture Organisation of the United Nations, 2001).

The small rise in alcohol intake could be a cause for concern, particularly as the intake of alcoholic drinks is very heavily skewed. However, as this rise is almost entirely due to increased red wine consumption, this could be interpreted as a response to the frequent reports in the media resulting from the publication of scientific papers describing the beneficial effects of moderate wine consumption in relation to heart disease (Constant, 1997) and cancer (Fontecave *et al.* 1998).

Fact and artefact

The problems involved in separating fact from artefact when investigating nutrient changes over time have been well covered by Guenther (Guenter *et al.* 1994). In the present study, there were three steps in the process of dietary analysis where there was the potential for differences to occur that were not real changes in nutrient intake: coding; portion size estimation; nutrient databases. Attempts to circumvent these problems have been reported with regard to INTERMAP UK (Conway *et al.* 2004). In this very large international study, in which 18 720 diet records were coded, efforts were made to minimise errors by the central training of staff and by the production of a code book that included information about coding brand items, density and portion size information, and default codes to use when only limited information was available. The rules were structured to ensure that coders did not make subjective decisions. Quality control checks were carried out at local and country level.

In most respects, the 1999 survey of the present study followed the same procedures, but when the 1999 survey was compared with the previous years, there were further complications. One of the problems with coding from food diaries is the lack of precise information given by the subject. In this event, the coder must be given clear indications of the choice of default. Over the period of years of this study, coding being carried out by different staff, even in different establishments, records of defaults used in the past were not available. The choice of default, particularly of a frequently used food, could substantially shift nutrient intake. For example, when the 1999 diaries were coded, the default milk was semi-skimmed. This was a rational choice on the basis of the National Food Survey (Department for Environment Food and Rural Affairs, 2001) but may have underestimated the number of subjects consuming skimmed milk or whole milk and thus underestimated or overestimated the fat intake.

The second step is the allocation of weights to the portion sizes built into the coding program. In 1989 and 1999, weights were decided based on the Ministry of Agriculture Fisheries and Food portion sizes (Crawley, 1988; Ministry of Agriculture Fisheries and Food, 1993). There have, however, been changes in the later edition that could account in part for nutrient changes. With regard to carrots, which are the richest source of carotene, the first edition gave 60 g as a medium portion, whereas in the second edition one medium carrot was 80 g. As many diaries specified the number of carrots rather than a portion size, this had the effect of considerably increasing the average portion size of carrots

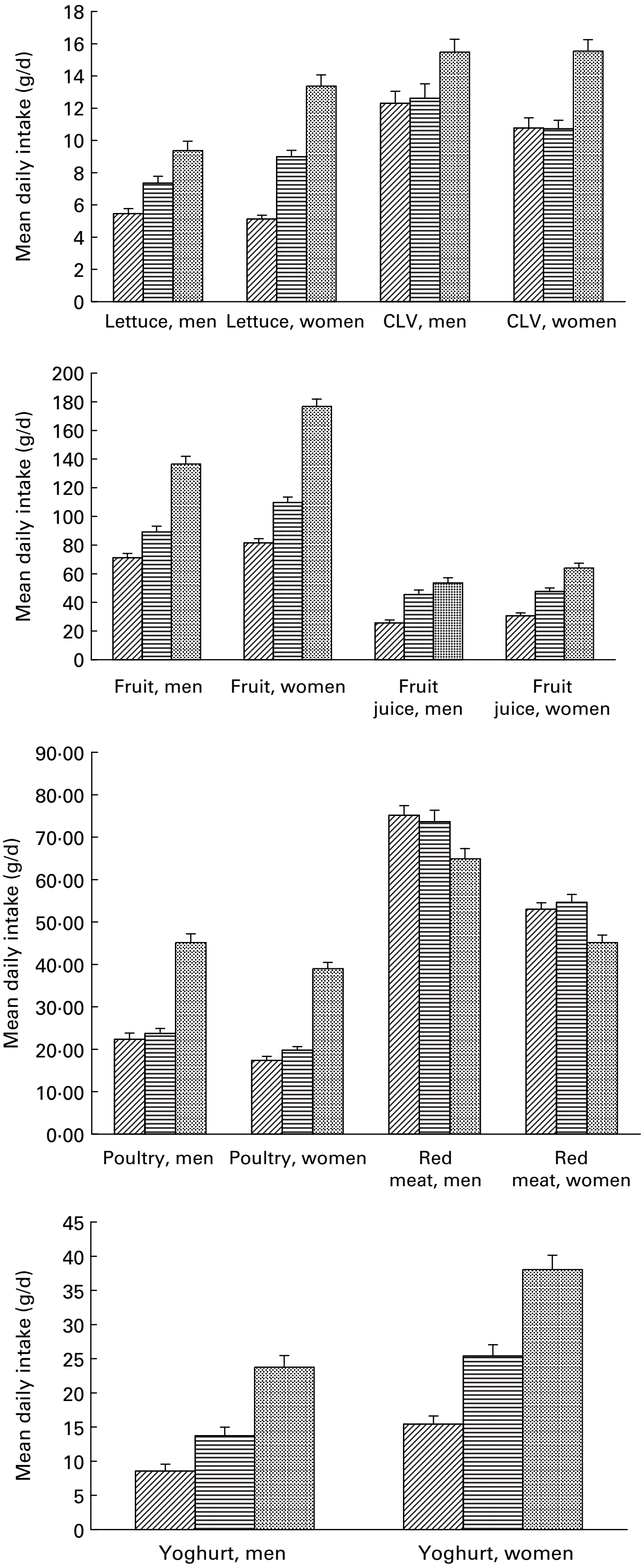

Fig. 2. Mean daily intake of key foods by year and gender. The *y*-axis shows the mean daily intake in g/d of the foods or food groups shown on the *x*-axis. The standard errors of the means are indicated by the vertical bars. The years indicated are: 1982 ▨, 1989 ▤, and 1999 ▩. Food intake data were recorded in a 5 d diary by subjects in the National Survey of Health and Development 1946 birth cohort at three time-points: 1982, 1989 and 1999. The results shown are for 562 men and 691women, who completed at least 3 d of records in all 3 years. CLV, cooked leafy vegetables.

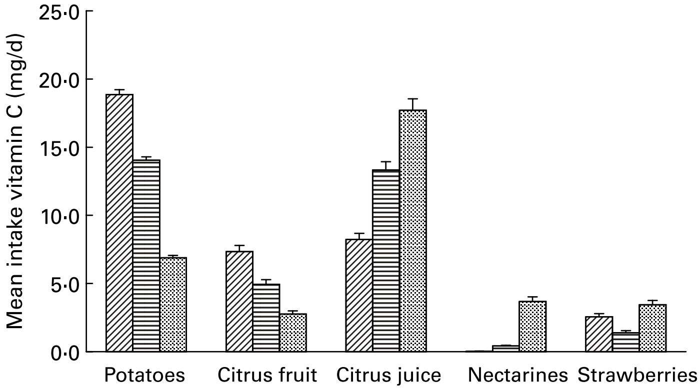

Fig. 3. Mean daily intake of vitamin C from some important sources by year. The *y*-axis shows the mean daily intake in mg/d vitamin C from the foods or food groups given on the *x*-axis. The standard errors of the means are indicated by vertical bars. The years indicated are: 1982 ▨, 1989 ▤, and 1999 ▩. Food intake data were recorded in a 5 d diary by subjects in the National Survey of Health and Development 1946 birth cohort at three time-points: 1982, 1989 and 1999. The results shown are for the 1253 subjects (men and women combined) who completed at least 3 d of records in all 3 years.

and thus the intake of carotene of those individuals. There were also more choices of portion size given to the coders of the 1999 diaries: mayonnaise, for example, was offered as a level teaspoon of 15 g, a heaped tablespoon of 33 g or an average portion of 30 g. In 1989, the choice was an average portion of 30 g or a tablespoon of 33 g. Discrepancies could also occur if the coders did not follow directions for exactly how much fat spread to put on a piece of bread if unspecified: thick, medium or thin. Cumulatively small differences in frequently consumed foods could make a difference.

The third step relates to the nutrient content database. In the present study, different date-specific databases were used for the analyses of food data from the three surveys, in contrast to the longitudinal study in the Netherlands (Post *et al.* 2001), which only used one database, making the assumption that the nutrient content was more or less identical. That study considered that the use of different systems would introduce additional errors; as has been discussed earlier, however, there have been very real changes in the nutrient content of some foods, the fat in meat and micronutrients in breakfast cereals in particular. In addition, it was necessary in the light of more recent analytical methods to make corrections to the databases of 1982 and 1989, which were based on older data (Paul & Southgate, 1978) for folic acid, and to add data that were missing from all three databases, such as that for vitamin K_1.

A limitation of the present study was the selection of the subjects. There are problems of bias within a cohort design as the people who drop out between measurements may have particular dietary characteristics, so that those who continue to contribute data over several time-points may no longer be representative of the original cohort. In the present study, by focusing only on those who completed diaries of at least 3 d at three time-points, there has been considerable attrition of the cohort of 3035 who had been followed through to 53 years of age. In terms of how far the whole cohort in 1999 was representative of the national adult population, it has been reported that the manual social classes were underrepresented compared with the non-manual, but the differences in proportions were small (Wadsworth *et al.* 2003). The subsample of men in the present study showed more of a shift towards the non-manual social classes compared with the whole cohort who responded in 1999; the subsample of women was very similar. However, in spite of the overrepresentation of the non-manual social classes, there is a remarkable agreement between the age-matched trends in nutrient intakes in the two NDNS surveys, which were designed to be representative of the general population (Gregory *et al.* 1990; Henderson *et al.* 2003*a*,*b*). When compared with age-matched men and women in the NDNS of 1986/87 and 2000/2001, the trends found in the NSHD cohort were similar, with falls in the intake of energy, fat, Na and retinol and rises in the intake of K, Ca, the B vitamins (except vitamin B_{12}), and vitamins C and D.

A problem that is intrinsic to cohort studies is the fact that the cohort is getting older and any changes that are due to the changing habits of an ageing population cannot be separated from secular changes. A comparison of nutrient intakes in the two age groups, 35–49 years and 50– 64 years, in the 1986/1987 and the 2000/2001 NDNS surveys (Gregory *et al.* 1990; Henderson *et al.* 2003*a*,*b*) showed a small fall in energy, fat and Na intakes and a rise in some B vitamins, vitamin C and carotene intakes in the older age group in both surveys. The sample in the present study were, however, only 53 years old, were not near retirement age and could not yet be described as elderly. In a study in Denmark, Osler tried to separate age effects from the secular trend by examining a cohort and repeated cross-sectional samples over a period of 10 years (Osler *et al.* 1997). The results indicated that the food habits of middle-aged Danes had changed in the direction of a more healthy diet, and the same trends were demonstrated by both the longitudinal and the cross-sectional surveys.

Despite the fact that the number of subjects in the present study represents fewer than half of the cohort that could be contacted in 1999, and the problems that arise when dietary analysis is carried out at different times by different people, it is believed that the results give a true picture of change in nutrient intake over adult life. Some change was due to changes in food composition, whereas other trends would appear to have occurred in response to health messages. The decrease in fat and Na intake, and the rise in fruit and vegetable consumption, is in line with current recommendation, and it would appear that women have increased their intake of carbohydrates, although the current results do not indicate whether this is in favour of more complex carbohydrates. Further investigation is needed to identify more clearly the changes in contribution to dietary nutrients from various foods and food groups. It is encouraging to find that health awareness is increasing in this ageing population. Future work with the cohort will provide outcome measures by which it will be possible to judge whether these trends have had the desired effect.

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