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Meat consumption after disaggregation of meat dishes in a cohort of British adults in 1989 and 1999 in relation to diet quality

Celia J. Prynne[1], **Jessie J.M.F. Wagemakers**[1], **Alison M. Stephen**[1], and **Michael E.J. Wadsworth**[2]

[1]MRC Human Nutrition Research, Elsie Widdowson Laboratory, Fulbourn Road, Cambridge CB1 9NL, UK

[2]MRC National Survey of Health and Development, University College and Royal Free Medical School, 1-19 Torrington Place, London WC1E 6BT, UK

Abstract

Objectives—The aim of the study was to quantify more precisely the meat intake of a cohort of adults in the UK by disaggregating composite meat dishes.

Subjects/Methods—Subjects were members of the MRC National Survey of Health and Development, 1946 birth cohort. Five-day diaries were collected from 2256 men and women in 1989 and 1772 men and women in 1999. From the details provided, composite meat dishes were broken down into their constituent parts and the meat fraction added to meat only portions. Meat intake was classified as red meat, processed meat and poultry.

Results—Meat consumption without disaggregation of meat dishes resulted in a mean over-estimation of 50% in men and 33% in women. Red meat consumption fell between 1989 and 1999 from 51.7 to 41.5g/day in men and 35.7 to 30.1g/day in women. Poultry consumption rose from 21.6 to 32.2g./day in men and 18.2 to 29.4 g/day in women. Re-calculating red meat intakes resulted in the percentage of subjects in 1999 consuming more the recommendation of the World Cancer Research Fund falling from 30% to 12 %. Increasing consumption of red and processed meat was associated with increased intakes of energy, fat, haem iron, zinc and vitamin B_{12} and lower intake of fibre. Increased sodium intake was associated with increased consumption of processed meat.

Conclusions—Disaggregation of meat dishes provided a more precise estimate of meat consumption. The quantity of red or processed meat in the diet was reflected in the nutrient content of the entire diet.

Keywords

Diet; Meat and meat products; Composites; Disaggregation; Nutrients

Correspondence to: Dr CJ Prynne MRC Human Nutrition Research, Elsie Widdowson Laboratory, Fulbourn Road, Cambridge CB1 9NL, UK. Tel: 01223 426356 Fax: 01223 437515 celia.greenberg@mrc-hnr.cam.ac.uk.
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Introduction

Since the end of meat rationing in 1954, the consumption of meat and meat products has risen in the UK in parallel with rising prosperity, reaching a peak in 1979/1980 (Department for Environment Food and Rural Affairs 2000). High quality animal protein was thought to be essential for a healthy diet and the traditional main meal was considered to be incomplete without meat or, less frequently, fish. However, more recently, there have been reports that the consumption of meat, in particular red meat, is associated with several chronic diseases including cardiovascular disease (Snowdon *et al.* 1984; Hu *et al.* 1999), diabetes (van Dam *et al.* 2002; Fung *et al.* 2004) and colon cancer (Chao *et al.* 2005; Norat *et al.* 2005; Lewin *et al.* 2006). Data from the National Food Survey (NFS), obtained from documentation on household purchases for one week, show that consumption of meat and meat products has declined by 20% since 1979 (Department for Environment Food and Rural Affairs 2000). However, meat consumption may have been over-estimated in earlier reports as more meat was purchased on the bone and meat and meat products as measured by the NFS included the weight of non-meat components of meat products; e.g. the pastry in meat pies.

In recent years many changes have taken place in the way meat is incorporated into a meal. Many meat products and dishes are traditional, such as bacon and pork pies, but there are many new meat products now available, particularly frozen or cook-chilled “ready meals”. Variable quantities of meat are included in ethnic dishes such as stir-fries and curries that may contain considerably larger vegetable and/or rice components than the meat. Nevertheless many dietary surveys include all these mixed foods in the “meat category” thus resulting in an over-estimation of actual meat consumption. The National Diet and Nutrition Survey (NDNS) of British adults in 2000 (Henderson and Gregory 2002), while separating out the types of meat (beef, pork, lamb, poultry), included composite dishes with steaks, joints and chops. If epidemiological work is to be carried out to examine the relationships between meat and health there is clearly a need to quantify more precisely the intake of actual meat consumed from meat dishes and products, and this can be achieved by disaggregating these dishes into their component parts. The impact of disaggregation of composite foods on estimates of meat consumption has already been demonstrated in a representative sample of adults from the Republic of Ireland (Cosgrove *et al.* 2005a) but a similar analysis of meat consumption data has not been carried out in the UK.

The MRC National Survey of Health and Development (NSHD) 1946 Birth Cohort is a longitudinal survey, which has collected medical, social, educational, and other information at several time points during childhood and adult life (Wadsworth *et al.* 2003). Data on the consumption of meat and meat products in 1989 and 1999 were re-examined by disaggregating the products and dishes that contain other food components as well as meat. In addition, the meats consumed were divided by type into red meat, poultry and processed meat in order to investigate the consumption levels of these three types in relation to total dietary nutrient intake.

Methods

Subjects

Subjects were men and women of the MRC NSHD, also known as the 1946 British Birth Cohort. This cohort is a social-class-stratified random sample of 5362 singleton legitimate births in England, Scotland and Wales during the first week of March 1946. Subjects who responded in 1989 and 1999 were representative of the native born population of a similar age. (Wadsworth *et al.* 1992; Wadsworth *et al.* 2003). For the present study the dietary data collected from 2256 subjects in 1989 and 1772 subjects in 1999 were examined.

Dietary assessment

Details of the subjects and the dietary assessment procedures have been reported previously (Prynne *et al*. 2005). All food and drink consumed both at home and away was recorded in 5-day diaries using household measures and estimated portion sizes according to detailed guidance notes and photographs provided at the beginning of the diary. For the analysis, the self-completed food diaries with at least three days information were used. The diaries were coded using the in-house program DIDO (Price *et al*. 1995).

Weights of meat, meat dishes, meat products and total intake of some key nutrients were calculated from the coded food diaries using the in-house suite of programs based on McCance and Widdowson's *The Composition of Foods*, fourth and sixth edition (Paul and Southgate 1978; Food Standards Agency 2002). In 1989, 140 food codes that contained meat were recorded. 56% of these codes were from individual meat portions and 44% were from meat products and mixed dishes. In 1999, 215 food codes were meat-containing of which 56% were from composite dishes. Total meat intakes were estimated by adding the individual meat portions to the meat content from meat products and mixed dishes consumed by each subject.

The composite dishes containing red meat or poultry included pasta dishes such as lasagne, curry with vegetables and/or rice, stir-fries, stews with vegetables and possibly potatoes, shepherd's pie, meat pies with pastry, meat with legumes such as chilli con carne. Composite foods containing processed meats included sausages, sausage rolls, beef burgers in a bun, pork pies, pasta dishes with ham, black pudding and corned beef hash. The meat content was derived in 74% of the composite foods by using recipes given in the food tables (Paul and Southgate 1978; Chan *et al*. 1996; Food Standards Agency 2002). Ingredients listed on the packages of supermarket products and ready-made meals were used to quantify the meat in 13% of meat products and mixed dishes. The remaining 13% were quantified by comparing the haem iron content in the composite food and the haem iron content of similar individual meat.

The analyses were based on the consumption of three individual meat categories:

1. Red meat: beef, lamb, pork, veal and mutton.
2. Processed meat: ham, bacon, sausages (including salami and frankfurters), processed meat cuts and processed minced meat (beefburgers and kebabs).
3. Poultry: chicken, turkey, goose and duck.

The intake of offal and game was very low for both years, so these weights have not been included.

Statistical analysis

Descriptive data are presented as means and standard deviation (SD) for continuous variables. Since the meat consumption differed significantly by gender, all analyses were done separately for men and women. Total meat consumption was calculated both as the weight of meat plus meat dishes and as the weight of meat plus the fraction of meat contained in the dishes. Paired sample T tests were carried out to show the difference between total meat consumptions when meat dishes were or were not disaggregated. Poultry, processed meat and red meat were divided into thirds, based on the mean intake per day in 1989 and 1999 for these meat categories. The lowest third of each meat category therefore represented low or non-consumers while the highest third represented high consumers.

ANOVA with *post hoc* Bonferroni comparisons was performed to show significant differences in the intake of selected nutrients from the whole diet according to consumption levels of the three classes of meat. Logarithmic transformations of folate, vitamins B_{12} and C were carried out prior to analysis to normalise their distributions. Geometric means were presented for these variables. Data analysis was by SPSS for MS Windows 10.

Results

Results are from 2256 individuals at age 43 years and from 1772 individuals at age 53 years for whom there were dietary records of at least 3days, analysed according to gender and year of data collection. 99% of the men and 98 % of the women were meat consumers in 1989 and 98% and 96% were consumers in 1999. The results are reported for consumers and non-consumers.

Tables 1 and 2 show the mean daily intakes of red meat, processed meat and poultry in 1989 and 1999 for men and women respectively estimated by two methods. The first weight is that of the weight of individual meat portions plus the weight of the meat fraction contained in composite dishes. The second weight is that estimated by adding individual meat portions to the total weight of meat-containing dishes. For all types of meat and in both years there was a significant difference ($p<0.001$) between the two totals that would result in a large overestimation of meat consumption if composite dishes were not disaggregated. This overestimation varied according to the type of meat but in 1999 red meat was over-estimated by 54% and 50% for men and women respectively. The last columns of tables 1 and 2 show the percentage of each type of meat eaten that was part of a composite dish in 1989 and 1999. While the percentage of total beef eaten that derived from composite dishes has remained nearly constant, that of processed meats has fallen from 33% to 28% and that of poultry has nearly doubled, from 13.6% to 25% (men and women combined).

Trends in meat consumption can also be deduced from tables 1 and 2. Between 1989 and 1999 there was a significant fall in red meat consumption by both men and women and a corresponding rise in poultry consumption. There was also a fall in the consumption of processed meat. In both 1989 and 1999 men consumed more red and processed meat but poultry consumption did not differ significantly between the sexes. Despite this increase in over-all poultry consumption, 21 % of subjects in 1999 consumed no poultry at all, compared to 35% of all subjects in 1989 (results not shown).

Table 3 shows the percentage of men and women in 1989 and 1999 who consumed more than 71g/day of red meat calculated with and without disaggregation of composite meat-containing dishes. This is the quantity of red meat that the World Cancer Research Fund recommends should not be exceeded (World Cancer Research Fund 1997). Without disaggregation 54% of the men and 33% of the women in 1989 ate more than 71g/day but after disaggregation only 26% of the men and 13% of the women. The percentages in 1999 were lower before disaggregation than in 1989 but again much reduced when recalculated.

Tables 4 and 5 show the dietary intake of energy and selected nutrients by men and women in 1989 and 1999 divided by thirds of red meat and processed meat consumption. In 1989 men and women who were high consumers of red meat had significantly higher intakes of energy, fat, vitamin B_{12}, haem iron and zinc compared to those who were low consumers but lower intakes of fibre. Those who were high consumers of processed meat had significantly higher intakes of energy, fat, sodium, vitamin B_{12}, haem iron and zinc compared to those who were low consumers. Results were very similar in 1999; in addition female high consumers of processed meat had significantly lower intakes of vitamin C.

Vitamin C intakes of the highest male consumers of processed meat were also lower but the difference was not significant due to the wide distribution of intakes.

Nutrient intakes according to thirds of poultry intake are not shown as there were few significant differences between high consumers and low or non-consumers of poultry. In all subjects high consumers of red meat were more likely to be low consumers of poultry but there was a significant inverse relationship between poultry consumption and red meat consumption only in women. In 1989 vitamin C intakes of both men and women were significantly higher in high poultry consumers but this was not found in 1999 (results not shown).

Discussion

The consumption of red, processed and poultry meat by the NSHD cohort in 1989 and 1999 has been calculated with greater precision by disaggregating meat dishes. By so doing it has been demonstrated that there was a significant over-estimation in total meat consumption by members of the NSHD 1946 birth cohort investigated in 1989 and 1999 when meat consumption was calculated without disaggregating meat dishes. After categorising disaggregated meat into three types; red meat, processed meat and poultry, significant differences in nutrient intakes from the whole diet were found between high and low consumers of these meat types.

It has already been reported that the consumption of red meat by the NSHD cohort fell between 1989 and 1999 while that of poultry increased (Prynne *et al.* 2005). Several factors could be responsible for these changes. Of particular importance is the epidemic of bovine spongiform encephalopathy (BSE) among cattle in the UK from 1990 that resulted in a sharp fall in beef consumption by 1996. There was also a continuing downwards trend in the consumption of lamb (Department for Environment Food and Rural Affairs 2000). This and other factors impacting on red meat consumption over this period are discussed more fully by Johnston *et al.* (Johnston *et al.* 2007). These include the replacement of red meat with lean poultry due to the perceived unhealthy saturated fat content of the former. There was also a fall in consumption of processed meat between 1989 and 1999. With the cohort reaching mid-life they may have become more aware of the risks to health that consumption of processed meats presented (Department of Health 1998). The more precise calculation of meat intake does not change these trends which are in agreement with those reported from the NDNS (Gregory *et al.* 1990; Henderson and Gregory 2002).

To our knowledge this study is the first to report actual meat consumption of adults in the UK. This analysis was carried out on the detailed dietary information recorded in 5-day diaries and would not have been possible if a food frequency questionnaire had been used. Non-disaggregated red meat and poultry consumption from the NSHD cohort in 1999 matched very closely that reported from the NDNS for the equivalent age group (50-64 years) in 2000/2001 (Henderson and Gregory 2002). However, after disaggregation, it was found that red meat consumption by the NSHD cohort in 1999 was 32% lower and poultry consumption was 26% lower than the non-disaggregated meat consumption from the NDNS. It was not possible to compare processed meat as these foods had been grouped together differently. Cosgrove *et al.* have disaggregated composite meat dishes consumed by the 958 adults aged 18-64 years in the Republic of Ireland between 1997 and 1999 and reported that meat intake was over-estimated by 43% if meat dishes were not disaggregated (Cosgrove *et al.* 2005a). This percentage varied widely according to meat category being greatest for meat products and lowest for poultry dishes. In the present study the mean over-estimation for all categories, men and women, was 38% in 1989 and 42.5% in 1999. The latter is very close to the mean over-estimate reported from Ireland (Cosgrove *et al.* 2005a) despite the fact that

the NSHD cohort were all aged 53 years while the Irish survey was of adults between 18 and 65 years. Of the 3 types of meat red meat was the most overestimated category for the NSHD cohort in both 1989 and 1999. Poultry consumed in composite dishes rose between 1989 and 1999 likely caused by the expanding market in “ready meals”, many of which are chicken based (Griffin and Boyle 1996).

The accurate estimation of meat intake has implications not only for assessing national food consumption but also for epidemiological studies. The finding that red and processed meat consumption can be over-estimated to such an extent is of significance as it is these meats, in particular, that have been associated with the incidence of disease, particularly colon cancer (Norat *et al.* 2005; Lewin *et al.* 2006). The World Cancer Research Fund recommends that intake of red meat should not be greater than 71g/day (World Cancer Research Fund 1997) but we have shown that the percentage of subjects consuming above 71g/day in 1999 more than doubled when meat consumption included composite dishes that were not disaggregated. Conversely, the non-meat component of composites may include significant quantities of vegetables that are generally accepted to be protective against cancer but may not be included when vegetable consumption is reported (O’Brien *et al.* 2003).

Meat is a key food in the diet and as such its nutrient composition is reflected in that of the diet as a whole. Meat is an important source of haem iron, zinc and vitamin B_{12} and intakes of these nutrients were greater in high consumers of red and processed meat. However, total energy intakes and fat intakes were also higher. In addition, we have shown that the consumption of particular types of meat may be associated with levels of nutrients that are not provided by the meat itself, thereby indicating a certain dietary pattern. High consumption of red meat was associated with lower fibre intakes and, in 1999, intakes of vitamin C were also lower although the range was very wide. A high consumption of processed meats was associated with high intakes of sodium from the addition of salt that is an almost inevitable consequence of the manufacturing process. Together with the elevated fat intake this category may therefore represent a risk factor for cardiovascular disease (Department of Health 1994). There was some evidence that high poultry consumers in 1989 were making healthier dietary choices in that their vitamin C intakes were higher than those of the non or low consumers but this was not seen in 1999 possibly because more of the chicken consumed would have been in manufactured dishes.

Many of the findings in this study are in agreement with other reports. High consumers of meat (undefined) in Sweden were reported to have lower intakes of fibre and anti-oxidant nutrients (Elmstahl *et al.* 1999). In the Irish study referred to above high consumers of red and processed meat had higher intakes of energy and fat and a less fibre dense diet (Cosgrove *et al.* 2005b).

Using data from the NSHD 1946 birth cohort we have shown that the disaggregation of composite meat dishes is important if precise quantitative data on meat intake are to be reported. As the commercial production and consumption of meat containing “ready meals” is increasing there is likely to be an even greater over-estimation of meat consumption in the future and this will be of significance for nutritional epidemiology. Using our more precise estimates of meat consumption we have also demonstrated how consumption levels of different meat types impinge on the total diet quality. This emphasises the need to make dietary recommendations with reference to particular types of meat and to avoid identifying any one particular type as totally undesirable, since there are both positive and negative attributes of meat consumption.

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Table 1

Meat consumption (g/day, mean (SD)) of men of the 1946 birth cohort by 2 methods of calculation showing the possible overestimation.

		Wt. total meat 1 (g) after disaggregation	Wt. total meat 2 (g) without disaggregation	% over-estimation	Wt. meat eaten alone (g)	Wt. meat fraction of composite dishes (g)	Wt. total meat composites (g)	% of total meat 1 from composites
1989 aged 43	Red meat	51.7 (41.7)	86.2 (65.3)	66.7	37.5 (38.2)	14.2 (19.3)	48.7 (55.5)	27.5
n = 1111	Processed meat	43.3 (33.7)	58.4 (45.8)	34.8	28.7 (27.7)	14.6 (17.2)	29.7 (35.3)	33.7
	Poultry	21.5 (25.9)	25.9 (32.0)	20.5	18.9 (25.1)	2.6 (6.9)	7.0 (19.9)	12.0
1999 aged 53	Red meat	41.4 (34.8)	64.1 (57.7)	54.8	28.9 (29.6)	12.5 (17.3)	35.2 (48.2)	30.1
n = 825	Processed meat	32.0 (26.9)	47.3 (35.9)	47.8	22.4 (22.4)	9.6 (12.6)	24.9 (29.1)	29.9
	Poultry	32.2 (30.6)	46.0 (47.5)	42.8	23.4 (26.0)	8.8 (14.7)	22.6 (40.1)	27.3

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Table 2

Meat consumption (g/day, mean (SD)) of women of the 1946 birth cohort by 2 methods of calculation showing the possible overestimation.

		Wt. total meat 1 (g) after disaggregation	Wt. total meat 2 (g) without disaggregation	% over-estimation	Wt. meat eaten alone (g)	Wt. meat fraction of composite dishes (g)	Wt. total meat composites (g)	% of total meat1 from composites
1989 aged 43	Red meat	35.7 (31.0)	61.2 (49.5)	71.4	25.8 (27.6)	9.9 (15.8)	34.4 (42.7)	27.7
n = 1145	Processed meat	27.2 (22.8)	35.2 (29.9)	29.4	18.4 (18.8)	8.8 (11.9)	16.8 (23.3)	32.3
	Poultry	18.3 (19.6)	22.5 (25.8)	22.9	15.5 (18.9)	2.8 (7.0)	7.0 (19.0)	15.3
1999 aged 53	Red meat	30.1 (28.1)	45.3 (45.3)	50.4	21.5 (23.7)	8.6 (13.6)	23.8 (38.2)	28.6
n = 947	Processed meat	19.6 (17.9)	28 (25.0)	42.8	14.7 (15.5)	4.9 (8.5)	13.3 (20.5)	25.1
	Poultry	29.4 (27.0)	38.9 (36.9)	32.3	22.4 (24.0)	7.0 (12.2)	16.5 (29.2)	23.8

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Table 3

Percentages of men and women of the 1946 Birth Cohort who consumed more than 71g/day* of red meat in 1989, aged 43 years, and 1999, aged 53 years

		Men 1989 n=1111, 1999 n=825	Women 1989 n=1145, 1999 n=947
Without disaggregation of composites	1989 aged 43 years	54	33
After disaggregation of composites	1989 aged 43 years	26	13
Without disaggregation of composites	1999 aged 53 years	37	23
After disaggregation of composites	1999 aged 53 years	18	8

*World Cancer Research Fund (2007) recommends an intake of not more than 500g/week (71g/day) of red meat

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Table 4

Daily intake (mean, 95%CI) of selected nutrients by thirds of red meat and processed meat consumption by members of the 1946 Birth Cohort in 1989, aged 43 years

	Thirds	Men n=1111 Red meat	ANOVA *p*	Women n=1145 Red meat	ANOVA *p*	Men n=825 Processed meat	ANOVA *p*	Women n=947 Processed meat	ANOVA *p*
Energy MJ	1	9.64 (9.4,9.88)	<0.001	7.38 (6.97,7.37)	<0.001	9.25 (9.03,9.47)	<0.001	7.17 (6.97,7.37)	<0.001
	2	10.18 (9.92,10.43)		7.61 (7.42,7.80)		10.08 (9.84,10.32)		7.76 (7.59,7.94)	
	3	10.85 (10.58,11.12)		8.22 (8.01,8.44)		11.34 (11.06,11.61)		8.27 (8.05,8.49)	
Fibre (NSP) g	1	14.3 (13.7,15.0)	0.02	12.6 (12.1,13.1)	0.015	13.7 (13.1, 14.4)	NS	12.5 (12.0, 13.0)	0.05
	2	13.1 (12.6,13.6)		11.9 (11.5,12.4)		13.2 (12.6, 13.7)		11.8 (11.4, 12.2)	
	3	13.1 (12.6,13.7)		11.7 (11.3,12.1)		13.6 (13.1, 14.1)		11.9 (11.4, 12.3)	
Fat g	1	98 (95,101)	<0.001	76 (73,78)	<0.001	91.8 (89.0, 94.6)	<0.001	72 (70, 75)	<0.001
	2	104 (101,107)		79 (76,81)		103.3 (100.2, 106.5)		82 (80, 84)	
	3	113 (110,117)		89 (86,92)		119.7 (116.5, 122.9)		89 (86, 92)	
Sodium mg	1	3240 (3138,3343)	NS	2445 (2373,2516)	NS	2743 (2661, 2824)	<0.001	2146 (2083, 2208)	<0.001
	2	3296 (3194,3398)		2489 (2417,2560)		3127 (3050, 3204)		2439 (2378, 2501)	
	3	3320 (3216,3425)		2558 (2479,2637)		3987 (3882, 4092)		2904 (2828, 2981)	
Folate μg*	1	293 (283,302)	NS	233 (226,240)	NS	284 (274,293)	0.002	227 (220,234)	NS
	2	290 (282,299)		226 (219,233)		295 (286,304)		234 (227,241)	
	3	303 (293,313)		233 (227,240)		308 (299,317)		232 (226,239)	
Vit. B_{12} μg*	1	5.6 (5.2,6.0)	<0.001	4.0 (3.7,4.2)	<0.001	5.7 (5.3,6.0)	0.001	4.1 (3.8,4.3)	0.013
	2	6.1 (5.8,6.4)		4.2 (4.0,4.4)		6.3 (5.9,6.7)		4.5 (4.2,4.8)	
	3	6.8 (6.5,7.1)		5.1 (4.8,5.3)		6.5 (6.2 ,6.9)		4.6 (4.3,4.9)	
Vit. C* mg	1	59 (56,63)	NS	60 (57,64)	NS	58 (55,62)	NS	62 (59,64)	NS
	2	55 (52,59)		61 (58,64)		55 (52,58)		59 (56,62)	
	3	57 (54,60)		57 (54,60)		58 (55,61)		57 (54,61)	
Vit. E mg	1	11.5 (11.0, 12.1)	0.055	9.3 (8.9, 9.7)	NS	10.3 (9.8, 10.7)	0.04	8.8 (8.4, 9.2)	NS
	2	10.8 (10.3, 11.3)		8.9 (8.5, 9.3)		10.9 (10.4, 11.4)		9.1 (8.7, 9.5)	
	3	10.6 (10.1, 11.1)		8.9 (8.5, 9.3)		11.9 (11.3, 12.4)		9.2 (8.8, 9.6)	
Haem iron, mg	1	0.82 (0.75,0.88)	<0.001	0.87 (0.81,0.93)	<0.001	0.58 (0.53,0.63)	<0.001	0.59 (0.55,0.63)	<0.001
	2	1.12 (1.06,1.18)		1.131 (1.06,1.21)		0.74 (0.7,0.78)		0.79 (0.74,0.84)	
	3	1.54 (1.45,1.63)		1.47 (1.38,1.565)		1.07 (1.01,1.12)		1.00 (0.95,1.07)	

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	Thirds	Men n=1111 Red meat	ANOVA *p*	Women n=1145 Red meat	ANOVA *p*	Men n=825 Processed meat	ANOVA *p*	Women n=947 Processed meat	ANOVA *p*
Non-haem iron ,mg	1	12.7 (12.3,13.2)	NS	112.4 (12.0,12.9)	<0.001	10.5 (10.2,10.9)	NS	10.5 (10.1,10.8)	NS
	2	12.5 (12.1,12.8)		12.3 (11.9,12.7)		10.9 (10.5,11.3)		10.7)10.3,11.0)	
	3	13.0 (12.63,13.4)		13.4 (13.0,13.9)		10.4 (10.5,11.2)		11.0 (10.7,11.4)	
Zinc mg	1	9.4 (9.2, 9.7)	<0.001	7.4 (7.2, 7.6)	<0.001	9.7 (9.5, 10.0)	<0.001	7.7 (7.5, 8.0)	<0.001
	2	10.5 (10.3, 10.8)		8.3 (8.1, 8.5)		10.6 (10.3, 10.9)		8.4 (8.2, 8.6)	
	3	12.5 (12.2, 12.8)		9.7 (9.4, 9.9)		12.1 (11.9, 12.4)		9.3 (9.0, 9.5)	

*Geometric means, back transformed from natural logs

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Table 5

Daily intake (mean, 95%CI) of selected nutrients by thirds of red meat and processed meat consumption by members of the 1946 Birth Cohort in 1999, aged 53 years

	Thirds	Men n=1111 Red meat	ANOVA *p*	Women n=1145 Red meat	ANOVA *p*	Men n=825 Processed meat	ANOVA *p*	Women n=947 Processed meat	ANOVA *p*
Energy MJ	1	9.01 (8.82,9.36)	0.009	7.32 (7.14,7.49)	0.03	9.01 (8.75,9.27)	<0.001	7.19 (7.01,7.36)	0.003
	2	9.48 (9.23,9.74)		7.25 (7.08,7.42)		9.34 (9.10,9.58)		7.34 (7.17,750)	
	3	9.64 (9.40,9.88)		7.57 (7.39,7.74)		9.86 (9.60,10.1)		7.60 (7.43,7.79)	
NSP g	1	15.6 (14.9,16.3)	0.03	14.8 (14.3,15.4)	<0.001	15.6 (14.9,16.3)	NS	14.4 (13.9,14.9)	NS
	2	14.8 (14.2,15.3)		14.0 (13.5,14.5)		14.9 (14.3,15.4)		14.0 (13.5,14.4)	
	3	14.5 (13.9,15.1)		13.3 (12.8,13.7)		14.0 (13.9,14.9)		13.7 (13.2,14.2)	
Fat g	1	82 (79,85)	0.02	64 (62,67)	<0.001	81 (78,84)	<0.001	63 (61,66)	<0.001
	2	87 (83,90)		66 (63,67)		85 (82,88)		67 (64,69)	
	3	88 (85,91)		72 (69,74)		92 (89,95)		72 (70,74)	
Sodium mg	1	2933 (2837,3030)	0.02	2386 (2318,2454)	NS	2688 (2597,2780)	<0.001	2141 (2073,2209)	<0.001
	2	3117 (3018,3216)		2412 (2337,2486)		2956 (2878,3033)		2361 (2300,2422)	
	3	3072 (2975,3169)		2386 (2317,2456)		3479 (3380,3579)		2681 (2611,2751)	
Folate μg*	1	301 (289,313)	NS	271 (262,280)	0.003	294 (284,306)	NS	264 (254,274)	NS
	2	306 (296,316)		257 (249,266)		309 (299,321)		262 (254,270)	
	3	305 (294,316)		251 (243,259)		308 (297,319)		253 (246,261)	
Vit. B_{12} μg*	1	5.7 (5.3,6.0)	0.01	4.7 (4.4,5.0)	0.002	5.6 (5.3,6.0)	0.03	4.9 (4.6,5.2)	NS
	2	6.0 (5.7,6.3)		5.1 (4.9,5.4)		6.3 (5.9,6.7)		5.0 (4.8,5.3)	
	3	6.4 (6.1,6.8)		5.4 (5.2,5.6)		6.1 (5.7,6.5)		5.3 (5.0,5.6)	
Vit. C mg*	1	77 (71,83)	NS	97 (91,104)	0.002	80 (74,87)	NS	96 (91,103)	0.001
	2	81 (76,87)		88 (83,94)		78 (73,84)		91 (85,96)	
	3	73 (68,79)		83 (78,88)		73 (67,78)		82 (77,87)	
Vit. E mg	1	12.2 (11.6,12.9)	0.001	10.2 (9.8,10.6)	0.014	11.6 (11,12.3)	NS	9.7 (9.3,10.1)	NS
	2	11.8 (11.2,12.4)		9.6 (9.2,10.0)		11.3 (10.7,11.9)		9.8 (9.4,10.2)	
	3	10.6 (10.1,11.1)		9.3 (8.9,9.7)		11.7 (11.1,12.3)		9.6 (9.2,10.0)	
Haem iron, mg	1	0.57 (0.50,0.63)	<0.001	0.64 (0.58,0.69)	<0.001	0.37 (0.34,0.41)	<0.001	0.44 (0.41,0.49)	<0.001
	2	0.80 (0.75,0.85)		0.84 (0.76,0.92)		0.54 (0.51,0.58)		0.56 (0.52,0.59)	
	3	1.09 (1.02,1.17)		0.99 (0.93,1.05)		0.79 (0.74,0.84)		0.70 (0.64,0.75)	

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	Thirds	Men n=1111 Red meat	ANOVA *p*	Women n=1145 Red meat	ANOVA *p*	Men n=825 Processed meat	ANOVA *p*	Women n=947 Processed meat	ANOVA *p*
Non-haem iron ,mg	1	11.7 (11.3,12.2)	NS	11.6 (11.2,12.1)	NS	10.4 (10.0,10.7)	NS	10.2 (9.8,10.5)	NS
	2	11.8 (11.4,12.4)		11.8 (11.3,12.2)		10.0 (9.7,10.3)		10.2 (9.8,10.5)	
	3	11.7 (11.3,12.1)		11.8 (11.4,12.1)		10.0 (9.3,10.3)		10.1 (9.8,10.4)	
Zinc mg	1	9.2 (8.8,9.5)	<0.001	7.5 (7.3,7.8)	<0.001	9.5 (9.2,9.8)	<0.001	7.8 (7.6,8.0)	<0.001
	2	10.1 (9.8,10.4)		8.1 (7.9,8.3)		10.2 (9.9,10.6)		8.3 (81,8.5)	
	3	11.6 (11.2,11.9)		9.2 (9.0,9.5)		11.1 (10.8,11.4)		8.8 (8.6,9.0)	

*Geometric means, back transformed from natural logs