Scientific Advisory Committee on Nutrition

Paper for agreement: National Diet and Nutrition Survey Adults 19-64 Years further analysis

Agenda Item: 6

The attached paper presents the secondary analysis of micronutrient intake and status data from the NDNS adults survey 2000/01.

This paper was first discussed by the Committee at the Horizon Scanning meeting in February 2005 and a revised version was discussed at the meeting in June 2005. This version incorporates comments made at those meetings.

- The paper is presented to the Committee for agreement.

WORKING DRAFT

NATIONAL DIET AND NUTRITION SURVEY: ADULTS AGED 19 TO 64 YEARS FURTHER ANALYSIS

AIM

1) This paper reports on the further analysis of data from the recent National Diet and Nutrition Survey (NDNS) of Adults (2000/01)[1,2,3,4,5] with the aim of determining the dietary and non-dietary characteristics of those with low micronutrient intakes and/or status, with a view to providing information that could be used to help improve the micronutrient intake and/or status of this population sub-group. This secondary analysis addresses one of the targets in the Agency's Strategic Plan for 2005-2010: to seek expert advice on the health implications of low micronutrient intakes in some population groups in order to inform nutrition policy.

BACKGROUND

2) Primary analysis of data from the NDNS of adults aged 19-64 years as published[2,3] has shown that, based on a comparison of nutrient intakes with the UK Dietary Reference Values[6] (DRVs), adults are generally getting sufficient nutrients from their diets. However, some sub-groups, in particular young women, to a lesser extent young men, and people living in households in receipt of state benefits, are more likely to have low intakes of vitamins and minerals.

3) This secondary analysis of the nutrient intake and status data was undertaken to focus on the vitamins and minerals for which a relatively high[i] proportion of adults had low intakes and/or status. Low intakes[ii] were seen for vitamin A, vitamin B2, iron, calcium, magnesium, potassium, zinc and iodine. Of those for which status markers are available, evidence of low status[iii] was seen for vitamin B1, vitamin B2, vitamin B6, vitamin B12, vitamin C, folate, iron and vitamin D. The aim was to determine the dietary and non-dietary characteristics of those with intakes of vitamins and minerals classified as 'low' or 'borderline' during the seven day dietary recording period, and the dietary and non-dietary characteristics of those with 'low' or 'marginal' status for vitamins and minerals, based on the analysis of blood samples for a range of biochemical indices.

4) Two additional analyses were also undertaken to supplement the main analysis referred to in paragraph 3 above, that is, a quintile analysis, and principal component analysis (PCA).

[i] It is not possible to give a single precise figure owing to the range of nutrient intake/status indices involved. Further detail on the proportion of adults with low intakes and/or status for each nutrient can be found in the NDNS Adults reports[3,4]

[ii] 'Low' defined as intakes less than the Lower Reference Nutrient Intake (LRNI)

[iii] Blood analytes used to assess nutrient status were compared with cut-offs to identify those with low status

DETERMINATION OF THE DIETARY AND NON-DIETARY CHARACTERISTICS OF THOSE WITH LOW INTAKES/STATUS USING CUTOFFS BASED ON DRVS, AND ANALYSIS OF BLOOD SAMPLES

Method

5) Average seven-day intakes of the micronutrients listed in table 1 (from all sources ie food and dietary supplements) were compared with DRVs. 'Low' intakes were defined as below the Lower Reference Nutrient Intake[iv] (LRNI). 'Borderline' intakes were defined as at or above the LRNI but less than the Estimated Average Requirement[v] (EAR), except for iodine and potassium. 'Borderline' intakes for iodine and potassium were defined as at or above the LRNI but below the Reference Nutrient Intake[vi] (RNI) as there is no EAR set for these nutrients.

6) Table 2 shows the blood analytes used to assess nutrient status compared with cut-offs used in the NDNS Adults aged 19-64 years and literature sources[vii] to identify those with 'low' and 'marginal' status for these nutrients.

Table 1: Nutrient Intakes - Cut-offs used for 'Low' and 'Borderline' intakes used in the analysis

NUTRIENT	UNIT	AGE/SEX	INTAKE - CUT-OFFS	
			'LOW' INTAKE	*'BORDERLINE' INTAKE*
			Less than the LRNI	At or above the LRNI but less than the EAR
Vitamin A (retinol equivalents)	ug/day	Men	<300	300 to <500
		Women	<250	250 to <400
Vitamin B2	mg/day	Men	<0.8	0.8 to <1.0
		Women	<0.8	0.8 to <0.9
Total iron	mg/day	Men	<4.7	4.7 to <6.7
		Women: 19-50yrs	<8.0	8.0 to <11.4
		Women 51-64yrs:	<4.7	4.7 to <6.7
Calcium	mg/day	Men & women	<400	400 to <525
Magnesium	mg/day	Men	<190	190 to <250
		Women	<150	150 to <200
Potassium	mg/day	Men & women	<2000	[2000 to <3500][1]
Zinc	mg/day	Men	<5.5	5.5 to <7.3
		Women	<4.0	4.0 to <5.5
Iodine	ug/day	Men & women	<70	[70 to <140][1]

[1]No EARs have been set for potassium or iodine. Cut-off for 'borderline' intakes has therefore been set as at or above the LRNI but less than the RNI.

[iv] The Lower Reference Nutrient Intake (LRNI) represents the amount of a nutrient which is likely to meet the needs of 2.5% of the population

[v] The Estimated Average Requirement (EAR) is the intake which is likely to meet the needs of 50% of the population

[vi] The Reference Nutrient Intake (RNI) is the intake which is considered sufficient to meet the requirements of 97.5% of the population

[vii] All status cutoffs used as per NDNS Adults aged 19-64 years, except for EGRAC >1.8 indicating vitamin B2 deficiency: Table 7.2: Margetts & Nelson, *Design Concepts in Nutritional Epidemiology*, Oxford University Press (London: 1997)

Table 2: Status indices - Cut-offs used for 'low' or 'marginal' status used in the analysis

NUTRIENT	STATUS INDEX	'LOW' STATUS	'MARGINAL' STATUS
Thiamin (vitamin B_1)	ETKAC (Erythrocyte transketolase activation coefficient)	Levels >1.25 (indicating biochemical thiamin deficiency)	Not applicable
Riboflavin (vitamin B_2)	EGRAC (Erythrocyte glutathione reductase activation coefficient)	Levels >1.8 (indicating deficiency)	Levels >1.3 (indicating marginal status)
Vitamin B_6	EAATAC (Erythrocyte aspartate aminotransferase activation coefficient)	Levels >2.00 (indicating biochemical vitamin B6 deficiency)	Not applicable
Vitamin B_{12}	Serum vitamin B12	Levels below 118pmol/l (lower level of normality)	Not applicable
Vitamin C	Plasma vitamin C	Levels below 11umol/l (indicating biochemical depletion)	Not applicable
Folate	Red cell folate	Not applicable	Levels below <345nmol/l (indicating 'at least' marginal status)
Total iron	Serum ferritin	Levels below 20ug/l for men, and levels below 15ug/l for women (indicating low iron stores)	Not applicable
Vitamin D	Plasma 25-hydroxyvitamin D	Levels below 25nmol/l (lower limit of normal range)	Not applicable

7) Basic summary data was calculated to ascertain how many adults had low/borderline intakes and/or low/marginal status for each variable. Chi-squared analysis was carried out on pairs of the intake variables to find the statistical association between them. Similarly, Chi-squared analysis was conducted on pairs of the status variables, and finally on pairs of variables where there was data available on both intake and status (ie vitamin B2 and iron) to ascertain whether those people with low intakes also had low status.

8) As the aim of this analysis was to determine where the differences lay between people who had 'low/borderline' levels of intake and/or 'low/marginal' status, and people who had intakes/status above these levels, the smaller of these groups had to have a minimum subset size, to give meaningful results. This was set at 100. Two groups of 100 or more individuals were identified with either low, or borderline, intakes of vitamin A, magnesium and potassium together. In addition, three separate groups of 100 or more individuals were identified with low/marginal status levels for vitamin B2, B6 or D, giving a total of five groups for analysis (see paragraph 10).

9) In addition, because vitamin D can be obtained through the action of sunlight on the skin, a separate analysis was undertaken to look at the characteristics of those adults with low status for vitamin D during the winter months compared with those adults with adequate status at this time of year, to minimise the influence of sunlight. Because of the effect of sunlight on vitamin D status we would expect a weaker relationship between intake and status for vitamin D during the summer months. This analysis was undertaken using wave 3 survey data, collected January-March. This was because,

allowing for adequate sample size for analysis, there was a significant difference between the proportion of adults who had low status, and those who did not have low status for this variable, during these particular months.

10) The six groups identified were:

Adults aged 19-64 years with:

1. 'Low' intakes of vitamin A, potassium and magnesium (ie intakes <LRNI) *(124 adults out of a total sample size of 1724)*
2. 'Borderline' intakes of vitamin A, potassium and magnesium (ie intakes at or above LRNI but below the EAR for vitamin A and magnesium, and above LRNI but below the RNI for potassium) *(328 adults out of a total sample size of 1600)*
3. Low/Marginal vitamin B2 status (EGRAC >1.3) *(801 adults out of a total sample size of 1237. Of these 801 adults, 777 had marginal status and 24 low status for vitamin B2)*
4. Low vitamin B6 status (EAATAC >2.00) *(127 adults out of a total sample size of 1237)*
5. Low vitamin D status (Plasma 25-hydroxyvitamin D <25nmol/l) *(166 adults out of a total sample size of 1232)*
6. Low vitamin D status in the winter months (January-March) (plasma 25-hydroxyvitamin D <25nmol/l) *(61 adults out of a total sample size of 304)*

- For group 1 those with 'low' intakes (less than the LRNI) were compared to those with intakes above this level.
- For group 2 those with 'borderline' intakes of vitamin A and magnesium (ie intakes at or above the LRNI but less than the EAR) were compared to those with intakes at or above the EAR, whereas for potassium those with 'borderline' intakes (ie at or above the LRNI but less than the RNI) were compared to those with intakes at or above the RNI. This is because there is no EAR set for potassium.
- For groups 3-6 those with 'low' or 'marginal' status for these vitamins (using the cut-offs given in table 2) were compared with those with status above these cut-offs.

11) Comparisons were made to identify any significant differences in dietary and non-dietary characteristics. The statistical test used on the non-dietary characteristics was the 'Comparison Between Two Proportions' (due to the categorical nature of the data) and the statistical test used on the dietary characteristics was the 'Comparison of Two Means' (continuous data). These were two-sided tests and the significance levels looked at were 95% and 99% respectively. The characteristics included in the analysis were:

Non-dietary characteristics[viii]

Age, sex, Body Mass Index (BMI), receipt of benefits, vegetarian/vegan, slimming, had a long-standing illness or disability, were unwell during the seven day dietary recording period, whether they smoke, whether they consume alcohol, reported use of supplements[ix], whether they use dentures, reported physical activity level. It was not possible to analyse the data according to ethnicity owing to small sample sizes.

Dietary characteristics[x]

The food groupings used to identify the dietary characteristics of adults with low intakes and/or status are provided in table 3. This table shows how the existing NDNS food groups were aggregated for this analysis.

[viii] Using data from the dietary interview and anthropometric assessment
[ix] Includes supplements containing micronutrients, other types of dietary supplements and herbal preparations
[x] Using data from the seven-day dietary record

The ‘dietary supplements’ food group relates to the *number of dietary supplements consumed during the survey week only* (eg number of tablets, capsules etc). The resulting data does not, therefore, account for differences in the types of supplements consumed, the nutrients these dietary supplements may contain, or dose.

Table 3: Food Groups used in analysis

Existing food groups from the NDNS databank were aggregated for this analysis, and subgroups within these aggregated groups were highlighted for separate analysis where results from the NDNS Adults indicated that significant associations between these foods, and the micronutrients highlighted for this secondary analysis, may exist

NDNS Existing Food Groups	Food Groups Aggregated for this secondary analysis, and subgroups	
1A Pasta	Cereals and cereal products	
1B Rice		
1C Pizza		Pizza
1R Other cereals		
2 White bread		Bread
3 Wholemeal bread		
4A Softgrain bread		
4R Other breads		
5 Wholegrain & high fibre breakfast cereals		Breakfast cereals
6 Other breakfast cereals		
7 Biscuits		
8A Fruit pies		
8R Buns, cakes & pastries		
9A Cereal based milk puddings		
9B Sponge puddings		
9R Other cereal-based puddings		
10 Whole milk	Milk and milk products	Milk (liquid whole, semi-skimmed & skimmed)
11 Semi-skimmed milk		
12 Skimmed milk		
13A Infant formula		
13B Cream		
13R Other milk		
14A Cottage cheese		Cheese
14R Other cheese		
15A Fromage frais		
15B Yogurt		
15R Other dairy desserts		
53R Ice cream		
16A Eggs	Eggs and egg dishes	
16B Egg dishes		
17 Butter	Fat spreads	
18A PUFA margarine		
18B PUFA oils		
19A PUFA low fat spread		
19R Low fat spread not PUFA		
20A Block margarine		
20B Soft margarine not PUFA		
20C Other cooking fats & oils not PUFA		
21A PUFA reduced fat spread		
21B Reduced fat spread not PUFA		
22 Bacon & ham	Meat and meat products	
23 Beef, veal & dishes		
24 Lamb & dishes		
25 Pork & dishes		
26 Coated chicken & turkey		
27 Chicken & turkey dishes		
28 Liver, liver products & dishes		Liver and liver products
29 Burgers & kebabs		
30 Sausages		
31 Meat pies & pastries		
32 Other meat & meat products		
33 White fish coated and/or fried	Fish and fish dishes	
34A Other white fish & fish dishes		
34B Shellfish		
35 Oily fish		Oily fish

36A Carrots, raw	Fruit and vegetables (inc potatoes & fruit juice)	Vegetables (excluding potatoes)	Carrots
37E Carrots, not raw			
36B Salad and other vegetables (raw)			
36C Tomatoes, raw			
37A Peas, not raw			
37B Green beans, not raw			
37C Baked beans			
37D Leafy green vegetables, not raw			
37F Tomatoes, not raw			
37G Vegetable dishes, not raw			
37R Other vegetables, not raw			
38A Chips		Potatoes	
38B Other fried potatoes inc fried potato products			
38R Potato products, not fried			
39 Other potatoes, potato salads and dishes			
40A Apples & pears, not canned		Fruit (including fruit juice)	Fruit (excluding fruit juice)
40B Citrus fruit, not canned			
40C Bananas			
40D Fruit canned in juice			
40E Fruit canned in syrup			
40R Other fruit, not canned			
45 Fruit juice			Fruit juice
41A Sugar	Sugar, preserves and confectionery		
41B Preserves			
41R Sweet spreads, fillings, icings			
43 Sugar confectionery			
44 Chocolate confectionery			
42 Crisps and savoury snacks	Savoury snacks		
47A Liqueurs	Alcoholic beverages		
47B Spirits			
48A Wine			
48B Fortified wine			
48C Low alcohol & alcohol free wine			
49A Beers & lagers		Beer and lager	
49B Low alcohol & alcohol free beers & lagers			
49C Cider, perry			
49D Low alcohol & alcohol free cider & perry			
49E Alco-pops			
50A Beverages (dry weight)	Miscellaneous		
50B Soups			
50R Savoury sauces, pickles, gravies, condiments			
52R Commercial toddlers foods			
52A Commercial toddlers drinks			
55 Artificial sweeteners			
51A Coffee (made up)	Tea, coffee and water		
51B Tea (made up)			
51C Herbal tea (made up)			
51D Bottled water			
51R Tap water			
54A Dietary supplements (tablets & capsules)	Dietary supplements		
54B Dietary supplements (oils & syrups)			
54C Dietary supplements (drops & powders)			
54R Nutritionally complete supplements			
56R Nuts & seeds	Nuts and seeds		
57A Concentrated soft drinks, not low calorie	Soft drinks (excluding fruit juice)		
57B Carbonated soft drinks, not low calorie			
57C Ready to drink soft drinks, not low calorie			
58A Concentrated soft drinks, low calorie			
58B Carbonated soft drinks, low calorie			
58C Ready to drink soft drinks, low calorie			

12) A very small group of adults *(12 adults out of a total sample size of 1724)* were also identified who had 'low' intakes (ie less than the LRNI) of all 8 vitamins and minerals listed in table 1.

Results

13) The Chi-squared analysis identified that all nutrient intake variables were strongly associated with each other. For status, some but not all variables were associated with each other (12 of the 36 combinations). Only for vitamin B2 and iron were both intake and status data included in this analysis. The Chi-squared analysis showed that there was no association between the group with low intake of vitamin B2 when compared to the group with low/marginal status for this nutrient. Similarly, there was no association between low intakes and low status for iron.

Non-dietary characteristics

14) Table 4 shows the non-dietary characteristics of adults with low/marginal status for vitamin B2, low status of vitamin B6 or vitamin D, and low/borderline intakes for vitamin A, potassium and magnesium.

Table 4: Non-dietary characteristics of adults with low/marginal status for vitamin B2, low status for vitamin B6 or vitamin D, and low/borderline intakes of vitamin A, potassium and magnesium

Non-dietary characteristics	Status			Intake of Vitamin A, Potassium & Magnesium	
	Low/ Marginal Vitamin B2$^{\alpha}$	Low Vitamin B6$^{\beta}$	Low Vitamin D$^{\chi}$	Low$^{\delta}$	Borderline$^{\phi}$
Higher proportion of women				√	
Higher proportion of youngest age group, 19 to 24yrs	√		√	√	√
Higher proportion of age group 25 to 34yrs	√				√
Lower proportion of age group, 50 to 64yrs	√			√	√
Less likely to drink alcohol			√	√	
Higher proportion of smokers	√		√	√	√
Less reported supplement use	√		√	√	√
Higher proportion unwell during survey week				√	√
More likely to be from household in receipt of benefits	√		√	√	√
Higher proportion vegetarian/vegan			√		
Less physically active			√		

Key:
√ = Significant at 99% confidence level (or p = < 0.01)

$^{\alpha}$ = EGRAC (Erythrocyte glutathione reductase activation coefficient) > 1.3 compared with adults with EGRAC <1.3
$^{\beta}$ = EAATAC (Erythrocyte aspartate aminotransferase activation coefficient) > 2.00 compared with adults with EAATAC < 2.00
$^{\chi}$ = Plasma 25-hydroxyvitamin D below 25 nmol/l compared with adults with level above 25 nmol/l
$^{\delta}$ = Less than LRNI compared with adults with intakes at or above the LRNI
$^{\phi}$ = At or above LRNI to less than the EAR for vitamin A and magnesium. Compared with adults with intakes at or above the EAR. At or above LRNI to less than RNI for potassium compared to adults with intakes at or above the RNI (there is no EAR set for potassium)

15) *Groups 1 and 2: 'Low'[xi] (n=124/1724) and 'Borderline'[xii] (n=328/1600) intakes of vitamin A, potassium and magnesium*

Table 4 shows that the range of non-dietary characteristics for adults in the 'low' and 'borderline' groups were similar. Compared to the groups with intakes of vitamin A, potassium and magnesium above these levels, the groups with **'low' and 'borderline'** intakes of vitamin A, potassium and magnesium contained a ***significantly higher proportion of:***

- adults aged 19 to 24 years
- smokers
- those living in benefit households
- those who reported being unwell during the survey week

and a ***significantly lower proportion of:***

- adults aged 50 to 64 years
- those who reported taking supplements

In addition, the group with **'low'** intakes of vitamin A, potassium and magnesium contained a ***significantly higher proportion of:***

- women

and a ***significantly lower proportion of:***

- those who consumed alcohol

The group with **'borderline'** intakes of vitamin A, potassium and magnesium contained ***a significantly higher proportion of:***

- adults aged 25 to 34 years

16) *Groups 3-5: Low/marginal Vitamin B2 status[xiii] (n=801/1237), low vitamin B6 status[xiv] (n=127/1237), or low vitamin D status[xv] (166/1232)*

Table 4 shows that adults with low vitamin B6 status did not have significantly different non-dietary characteristics compared with adults with vitamin B6 status above this level.

Compared to the groups with status above these levels for vitamin B2 or D, the groups with **low/marginal status for vitamin B2, or low status for vitamin D** contained a ***significantly higher proportion of:***

- adults aged 19 to 24 years
- smokers
- those living in benefit households

and ***a significantly lower proportion of:***

- those who reported taking supplements

Figures A and B provide a graphical representation of the prevalence of smoking, and of adults living in households in receipt of benefits respectively, by status.

In addition, the group with **low/marginal vitamin B2 status** contained ***a significantly higher proportion of***:

[xi] 'Low' defined as intakes <LRNI

[xii] 'Borderline' intakes defined as at or above the LRNI but below the EAR for vitamin A and magnesium, and above LRNI but below the RNI for potassium (there is no EAR set for potassium)

[xiii] Marginal vitamin B2 status defined as EGRAC >1.3

[xiv] Low vitamin B6 status defined as EAATAC >2.00

[xv] Low vitamin D status defined as plasma 25-hydroxyvitamin D <25nmol/l

- adults aged 25 to 34 years

and a ***significantly lower proportion of:***

- adults aged 50 to 64 years

Those with **low vitamin D status** contained a ***significantly higher proportion of:***

- those who reported being vegetarian/vegan

and a ***significantly lower proportion of:***

- those who consumed alcohol

and also reported being less physically active compared to adults with vitamin D status above this level.

Figure C provides a graphical representation of the prevalence of low/marginal status for vitamin B2 and low status for vitamin D for adults aged 19 to 24 years.

Figure A: Prevalence of smoking in adults by status for vitamin B2 and vitamin D

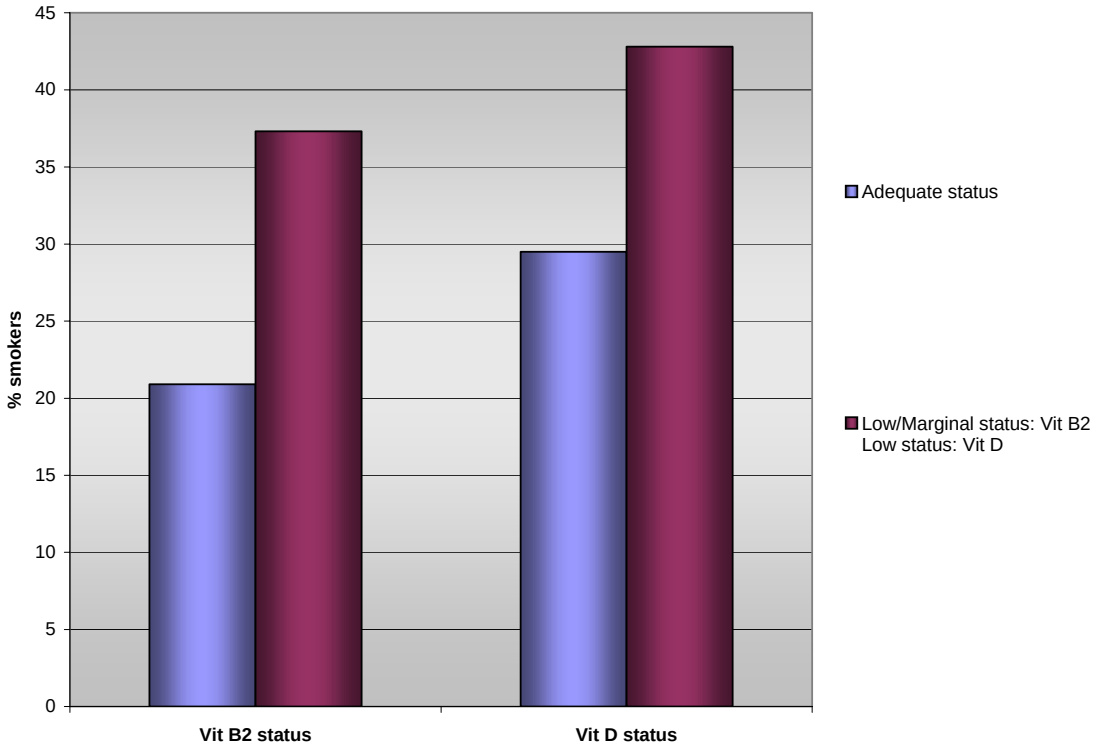


Figure B: Prevalence of adults living in benefit households by status for vitamin B2 and vitamin D

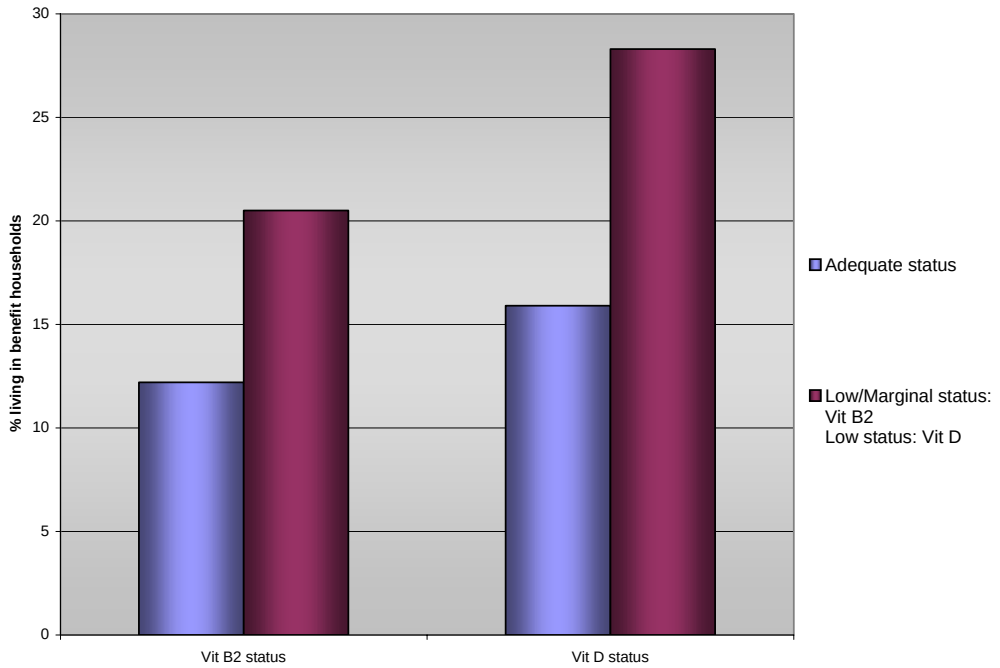
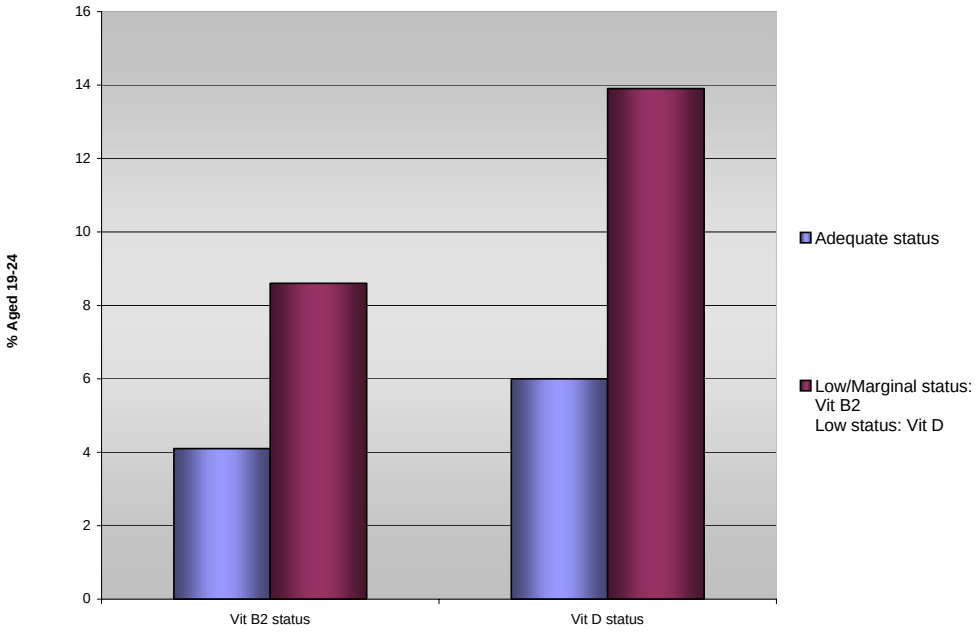


Figure C: Prevalence of adults aged 19-24 years by status for vitamin B2 and vitamin D



Dietary characteristics

17) Table 5 shows the dietary characteristics of adults with low/marginal status for vitamin B2, low status for vitamin B6 or vitamin D, and low/borderline intakes of vitamin A, potassium and magnesium.

18) The description of the dietary patterns that follow characterise the balance of foods consumed in the diets of those with low intakes and/or status. The results are organised according to whether those with low intakes/status are consuming 'less' or 'more' of a particular food group compared with those with adequate intakes/status. Some of the food groups identified are foods which are rich sources of the nutrient in question and lower consumption of these may explain, at least in part, the low intakes/status. Other food groups identified are not necessarily good sources of the nutrient, but lower consumption of these indicate a less healthy diet generally (eg fish, and fruit and vegetables). Other food groups consumed 'more' than by those with adequate intakes/status may be displacing other, more nutrient dense foods (eg savoury snacks and soft drinks excluding fruit juice).

Table 5: Dietary characteristics of adults with low/marginal status for vitamin B2, low status for vitamin B6 or vitamin D, and low/borderline intakes of vitamin A, potassium and magnesium

Dietary characteristics	Status			Intake of Vitamin A, Potassium & Magnesium	
	Low/ Marginal Vitamin B2[α]	Low Vitamin B6[β]	Low Vitamin D[χ]	Low[δ]	Borderline[ϕ]
Consume Less:					
Cereals and cereal products	√			√	√
• Pizza				√	
• Bread				√	√
• Breakfast cereals	√			√	√
Milk and Milk products	√			√	√
• Milk (liquid whole, semi-skimmed and skimmed	√			√	√
• Cheese				√	√
Eggs and Egg dishes				√	
Fat spreads			√	√	√
Meat and meat products				√	
• Liver and liver products				√	√
Fish and fish dishes	√		√	√	√
• Oily fish				√	
Fruit and Vegetables (including potatoes and fruit juice)	√		√	√	√
• Vegetables (excluding potatoes)				√	√
• Carrots				√	√
• Potatoes				√	
• Fruit (including fruit juice)	√		√	√	√
• Fruit (excluding fruit juice)	√		√	√	√
• Fruit juice				√	√
Sugar preserves and confectionery				√	
Savoury snacks					
Alcoholic beverages		√		√	√
• Beer and Lager		√		√	√
Miscellaneous[∞]					√
Tea, coffee and water	√			√	√
Dietary supplements[θ]	√		√	√	√
Nuts and seeds				√	√
Soft drinks (excluding fruit juice)					
Consume More:					
Savoury snacks	√				
Soft drinks (excluding fruit juice)	√				

Key:

√ = Consume less (significant at 99% confidence or p=< 0.01)

α = EGRAC (Erythrocyte glutathione reductase activation coefficient) > 1.3 compared with adults with EGRAC <1.3

β = EAATAC (Erythrocyte aspartate aminotransferase activation coefficient) > 2.00 compared with adults with EAATAC < 2.00

χ = Plasma 25-hydroxyvitamin D below 25 nmol/l compared with adults with level above 25 nmol/l

δ = Less than LRNI compared with adults with intakes at or above the LRNI

ϕ = At or above LRNI to less than the EAR for vitamin A and magnesium. Compared with adults with intakes at or above the EAR. At or above LRNI to less than RNI for potassium compared to adults with intakes at or above the RNI (there is no EAR set for potassium)

∞ = Includes soups, savoury sauces, pickles, gravies and condiments

θ = The 'dietary supplements' food group relates to the *number of dietary supplements consumed during the survey week only* (eg number of tablets, capsules etc)

19) *<u>Groups 1 and 2</u> 'Low'[xvi] and 'Borderline'[xvii] intakes of vitamin A, potassium and magnesium*

Table 5 shows that the dietary characteristics of these adults were very similar.

Those adults with 'low' intakes of these micronutrients (ie below the LRNI) consumed significantly less of almost every food group compared with adults who had micronutrient intakes above this level. However, there was no difference between the two groups in consumption of savoury snacks, soft drinks (excluding fruit juice) and miscellaneous foods (such as soups, savoury sauces, pickles, gravies and condiments).

Those adults with 'borderline' intakes of vitamin A, potassium and magnesium had similar dietary characteristics to those with 'low intakes'. However, there was no difference in consumption of eggs and egg dishes, meat and meat products, sugar, preserves and confectionery, savoury snacks, soft drinks (excluding fruit juice), pizza, oily fish, and potatoes between adults with 'borderline' intakes of these micronutrients and adults with intakes above this level.

20) *<u>Groups 3-5</u>: Low/marginal Vitamin B2 status[xviii], low vitamin B6 status[xix], low vitamin D status[xx]*

Table 5 shows that, compared with adults with adequate vitamin B2 status, those ***adults with low/marginal vitamin B2 status consumed significantly less***:

- cereals and cereal products
  - breakfast cereals
- milk and milk products
  - milk (liquid whole, semi-skimmed and skimmed)
- fish and fish dishes
- total fruit and vegetables (including potatoes and fruit juice)
  - fruit (both including and excluding fruit juice)
- tea, coffee and water
- dietary supplements

and consumed significantly more:

- savoury snacks
- soft drinks (excluding fruit juice)

Milk and milk products for example are a good source of vitamin B2, and some breakfast cereals are fortified with vitamin B2.

Those adults with low vitamin B6 status consumed significantly less*:*

- alcoholic beverages
  - beer and lager

[xvi] 'Low' defined as intakes <LRNI
[xvii] 'Borderline' intakes defined as at or above the LRNI but below the EAR for vitamin A and magnesium, and above LRNI but below the RNI for potassium (there is no EAR set for potassium)
[xviii] Marginal vitamin B2 status defined as EGRAC >1.3
[xix] Low vitamin B6 status defined as EAATAC >2.00
[xx] Low vitamin D status defined as plasma 25-hydroxyvitamin D <25nmol/l

Those with low vitamin D status consumed significantly less:

- fat spreads
- fish and fish dishes
- total fruit and vegetables (including potatoes and fruit juice)
  - fruit (both including and excluding fruit juice)
- dietary supplements

Consumption of fish and fish dishes overall by those with low vitamin D status was 73% of that consumed by adults with vitamin D status above this level (oily fish is a good source of vitamin D). Vitamin D is required by law to be added to margarine and is also added to most reduced and low fat spreads.

21) *<u>Group 6</u>: 'Low' vitamin D status[xxi] in the winter months*

Compared with adults who had adequate vitamin D status during the winter months (ie wave 3 of the survey: January to March), ***adults who had low vitamin D status during January to March consumed significantly less:***

- fat spreads
- dietary supplements
- potatoes
- miscellaneous foods (such as soups, savoury sauces, pickles, gravies and condiments)

22) *'Low'[xxii] intakes of all 8 micronutrients*

This group consisted of a small group of women (12 out of a total sample of 1724) who were non-vegetarian. It was not possible to look in detail at the dietary characteristics of this particular group or draw any conclusions from these results owing to the small sample size. However, compared to those who do not have low intakes of these micronutrients, this group contained a higher proportion of smokers, those who use dentures, and those who had a long-standing illness, disability or infirmity, or were unwell during the survey week. These women were also more likely to live in a household in receipt of benefits, and to be underweight (BMI <18.5). However, owing to the very small sample numbers it is important to note that it is not possible to draw any conclusions from these differences.

Discussion

23) All nutrient intake variables were strongly associated with each other. That is, individuals with low intakes of one micronutrient listed in table 1 were also likely to have low intakes of the other micronutrients listed. Those with low/borderline intakes of vitamin A, potassium and magnesium had significantly lower intakes of food energy compared to those with nutrient intakes above these levels ($p<0.01$, data not shown). They were also more likely to have, on average, lower status for ***almost all*** the status variables initially identified for inclusion in the analysis at the 99% level of significance (except vitamin B6 for those with low intakes (significant at 95% level), and vitamin B6 and serum ferritin for those with borderline intakes (not significant (ns), data not shown)).

[xxi] Low vitamin D status defined as plasma 25-hydroxyvitamin D <25nmol/l
[xxii] 'Low' defined as intakes <LRNI

24) There was some evidence of an association between status variables when pairs of these were compared (12 of the 36 combinations). There was no significant difference in intakes of food energy by those with low/marginal status for vitamin B2 or low status for vitamin B6. However those with low status for vitamin D had lower intakes of food energy compared with those with status above this level ($p<0.05$).

25) For vitamin B2 and iron, both intake and status data were included in this analysis. There were no associations between the intakes and status for these nutrients. This may partly be due to the fact that nutrient intakes have been estimated from food consumption over seven days in this survey, while many measures of nutritional status reflect nutrient intakes over the longer term. In addition, an association between nutrient intake and status is not always expected. For example, iron status is determined by key variables which have not been included in the analysis such as loss of iron through menstrual blood loss.

26) Those adults with 'low' and 'borderline' intakes of vitamin A, magnesium and potassium consumed less of almost every food group compared to adults with intakes of these micronutrients above these levels.

27) There are some consistencies in the dietary characteristics of adults with low/marginal status for vitamin B2, or low status for vitamin D. Low/marginal vitamin B2 status and low D status were independently associated with lower consumption of fish and fish dishes, total fruit and vegetables (including potatoes and fruit juice), fruit (including and excluding fruit juice) and dietary supplements. Low vitamin D status was not independently linked to oily fish (which is a good source of vitamin D), only fish and fish dishes overall. This is probably due to the low consumption of oily fish (one third of a portion per week, on average overall). In addition, low/marginal vitamin B2 status was associated with higher consumption of savoury snacks and soft drinks excluding fruit juice, suggesting that these foods may be displacing other foods rich in these nutrients eg milk. Low vitamin B6 status was associated with lower consumption of alcoholic beverages as a whole, and beer and lager.

28) Low/borderline intake of vitamin A, potassium and magnesium and/or low/marginal status for vitamin B2 and low status for vitamin D was more likely to be found in younger adults, smokers, those living in a household in receipt of benefits, and those who did not report taking supplements. It is important to note that those adults taking supplements tended to be those with higher intakes of these nutrients from food. Adults with low vitamin B6 status did not have significantly different non-dietary characteristics compared with adults with vitamin B6 status above this level.

29) Those adults with low intakes of vitamin A, potassium and magnesium and/or low status for vitamin D were less likely to drink alcohol. However, it is important to note that this reflects the higher prevalence of adults from benefit households in these groups. Adults living in households in receipt of benefits were significantly less likely than those in non-benefit households to have recorded consuming alcohol during the dietary recording period[2].

30) Those with low status for vitamin D reported being less physically active compared with those who had adequate vitamin D status. Vitamin D is produced by the action of sunlight on the skin, and therefore this finding may be linked to low levels of outdoor physical activity among this group. The results of the analysis of vitamin D status during the winter months suggest that those who undertake limited outdoor activity

would benefit from increasing the consumption of certain food groups, such as oily fish and fortified fat spreads.

31) Consideration was given to including plasma homocysteine levels in this analysis. High plasma homocysteine concentrations are moderately associated with increased risk of vascular diseases for example[7]. However, this analyte is sensitive to changes in status of certain B vitamins and will be considered separately in the SACN Folate Report which is due for publication in 2006.

ANALYSIS BY QUINTILE

Method

32) The full dataset from the original analysis outlined in paragraphs 5 and 6 were re-calculated for presentation of main findings by quintile so the data could be presented in a more continuous form, and because a wider selection of variables could be considered (as there were no restrictions relating to sample size). To manage the quantity of results produced by this method effectively, initial comparisons were made to identify any significant differences in dietary and non-dietary characteristics between those with the lowest intakes and/or status (ie quintile 1) and those with the highest (quintile 5). An initial check of the full dataset confirmed that this methodology would allow for inclusion of all key results therein. These data were scrutinised further to identify results of particular interest for further investigation. These results were subjected to more detailed comparisons to determine significant differences by quintile. The statistical tests used were those outlined above for the original analyses (see paragraph 11).

Results

Non-dietary characteristics

33) Table 6 shows the non-dietary characteristics of adults with the lowest status for nutrients (ie quintile 1) compared with those with the highest status (quintile 5). Data in the shaded boxes highlight the main findings therein. That is, those non-dietary characteristics associated with low status for the majority of nutrients included in the analysis. Similar results had also been found for the previous analysis undertaken as described in paragraph 3. The relationship between iron status and gender was highlighted separately, owing to the particularly strong association found (*sequentially* through each quintile).

Table 6: Quintile analysis: Significant differences in the non-dietary characteristics between those with the lowest vs highest status for each nutrient (p<0.01)

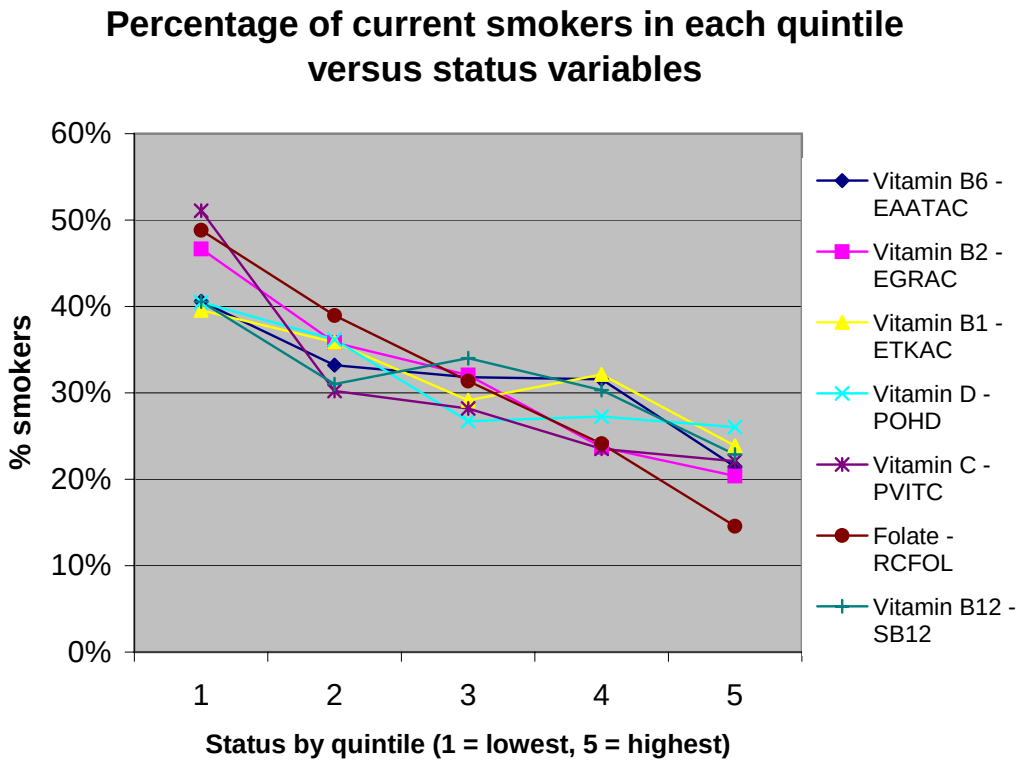
Non-dietary characteristics	Status							
	Iron	Vitamin D	Folate	Vitamin B12	Vitamin C	Vitamin B1	Vitamin B2	Vitamin B6
Compared to those with the highest status (quintile 5) those with the lowest status (quintile 1):								
Higher proportion of women	√			√				
Higher proportion of men					√	√		
Higher proportion of youngest age group, 19 to 24 years	√	√	√				√	
Higher proportion of age group 25 to 34 years	√		√				√	
Lower proportion of age group 50 to 64 years	√		√				√	
Higher proportion of vegetarian/vegan	√			√				
Less likely to drink alcohol	√	√						√
Higher proportion of smokers		√	√	√	√	√	√	√
Less likely to use dentures	√							
More likely to use dentures					√			
More likely to be from household in receipt of benefits	√	√	√	√	√		√	
Less physically active		√			√			
Less reported supplement use		√	√	√	√	√	√	√
Higher proportion unwell during survey week		√			√			

Shaded data: key findings investigated further

34) The key non-dietary characteristics associated with lower status were smoking, living in a household in receipt of benefits, and less reported supplement use. There was also evidence of low intakes/status in younger age groups for some nutrients, and, notably, lower iron intakes/status in women. These results were examined further and are presented in figures D-G).

35) These key results are also seen when the non-dietary characteristics of those with the lowest nutrient intakes are compared with those with the highest.

Figure D



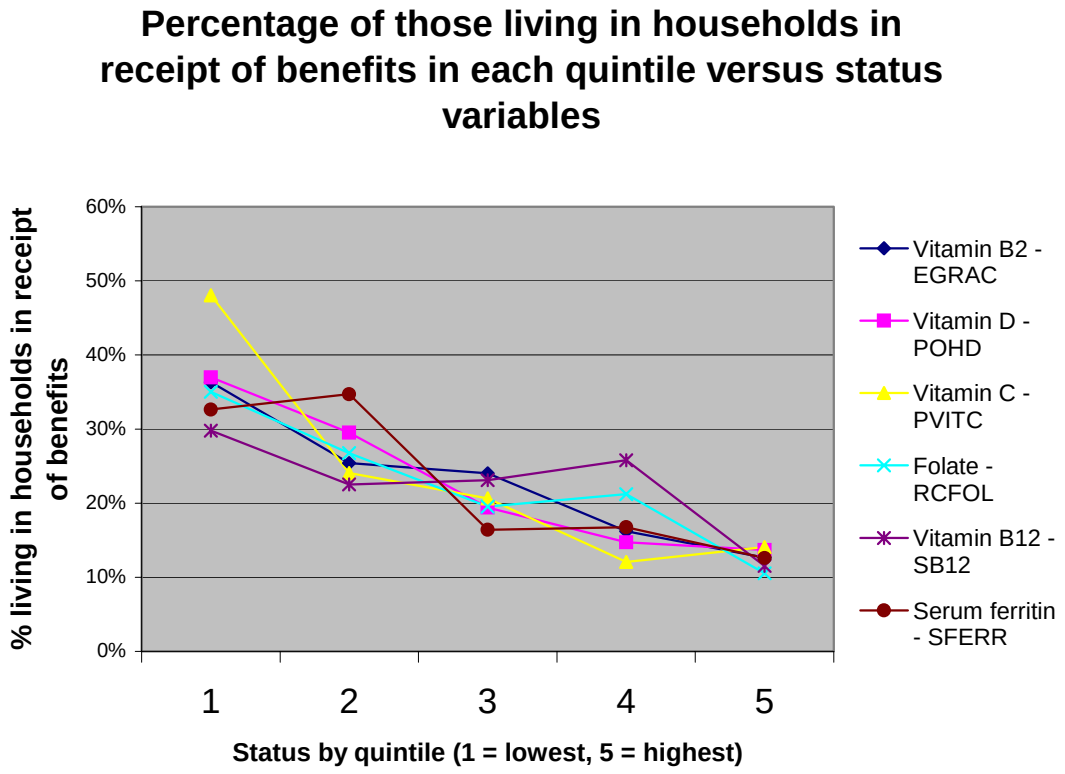
Status variables are shown only where significant associations were found

36) Figure D shows the relationship between nutrient status for vitamins B1, B2, B6, B12, folate, C and D and the percentage of smokers within each quintile for each status variable. The main statistically significant differences found were as follows:

37) For all these nutrients, the decrease in the percentage of smokers with increasing nutrient status was significant when quintile 1 was compared with quintile 5 ($p<0.01$). This was also seen when quintile 1 was compared with quintile 2 for all nutrients except vitamin B1 and vitamin D ($p<0.05$ for vitamin B6; rest $p<0.01$), when quintile 1 was compared with quintile 3 for all nutrients except vitamin B12 ($p<0.05$ for vitamin B6; rest $p<0.01$), and when quintile 3 was compared with quintile 5 for vitamin B2, B6, B12 and folate ($p<0.01$).

38) The strongest relationship was between the percentage of smokers and status for folate, where the percentage of smokers decreased sequentially by quintile from quintile 1 to 5 (1 vs 2, 4 vs 5, $p<0.01$; 2 vs 3, 3 vs 4, $p<0.05$).

Figure E

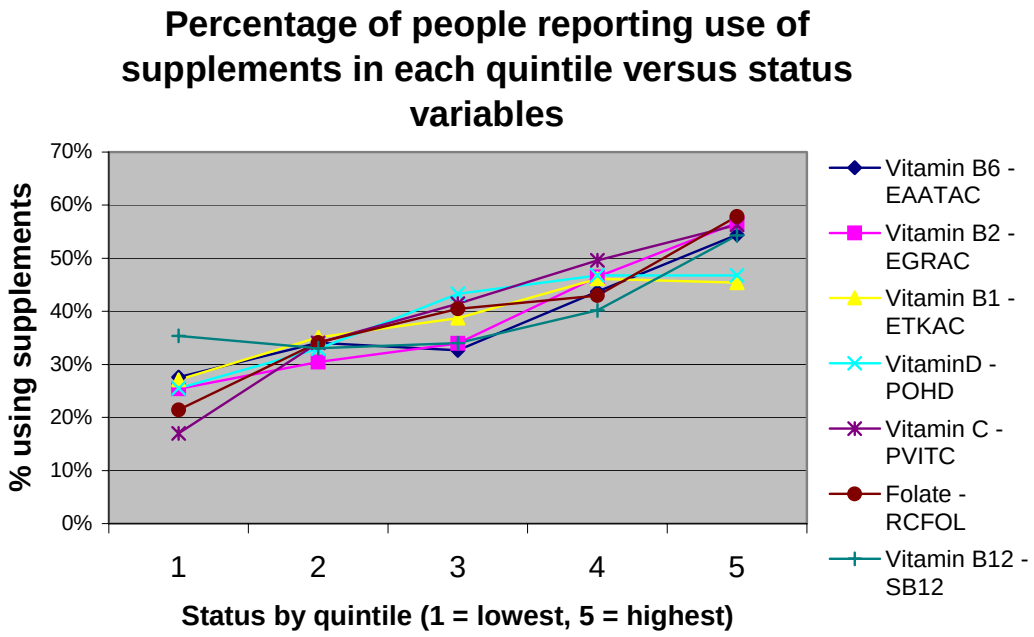


Status variables are shown only where significant associations were found

39) Figure E shows the relationship between nutrient status for vitamin B2, B12, folate, C, D and iron, and whether respondents were living in households in receipt of benefits. The main statistically significant differences found were as follows:

40) For all these nutrients, the decrease in the proportion of adults living in households in receipt of benefits with increasing status was significant when quintile 1 was compared with quintile 5 ($p<0.01$). This was also seen when quintile 1 was compared with quintile 3 for all nutrients except vitamin B12 and iron ($p<0.05$ for vitamin B2; rest $p<0.01$), and when quintile 3 was compared with quintile 5 for all nutrients except vitamins C and D, and iron ($p<0.01$).

Figure F



Status variables are shown only where significant associations were found

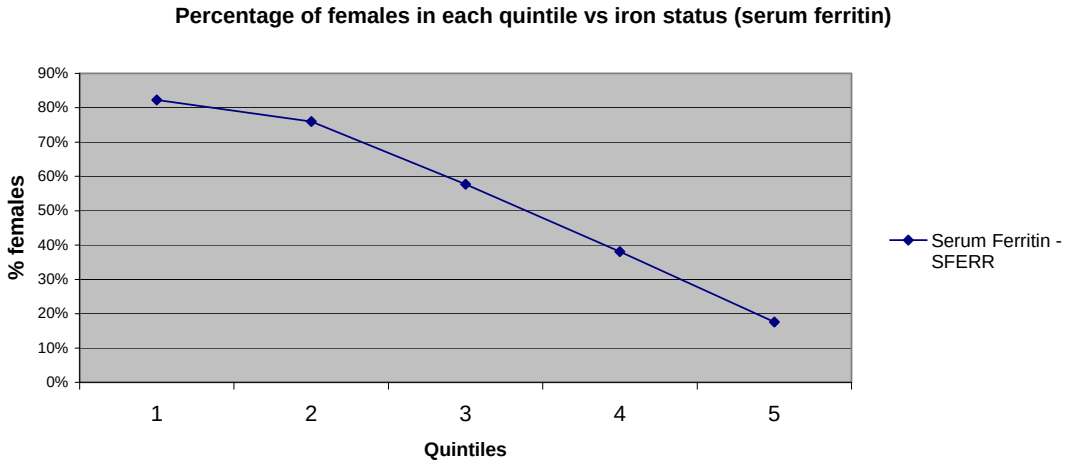
41) Figure F shows the relationship between nutrient status for vitamins B1, B2, B6, B12, folate, C and D, and whether respondents reported use of supplements, and shows an increase in the general use of supplements[xxiii] with status for these particular nutrients. However, it should be noted that those with the highest nutrient intakes from food (ie excluding supplements) were the most likely to consume supplements. With this in mind, the main statistically significant differences found were as follows:

42) For all these nutrients, the increase in reported supplement use with increasing nutrient status was significant when quintile 1 was compared with quintile 5 ($p<0.01$). This was also seen when quintile 1 was compared with quintile 3 for all nutrients except vitamin B6 and vitamin B12 ($p<0.05$ for vitamin B2; rest $p<0.01$), and when quintile 3 was compared with quintile 5 for all nutrients except vitamin B1 and vitamin D ($p<0.01$).

43) For vitamin C, reported use of supplements increased sequentially by quintile, from quintile 1 through to quintile 4 (1 vs 2, $p<0.01$; 2 vs 3 and 3 vs 4, $p<0.05$).

[xxiii] Includes supplements containing micronutrients, other types of dietary supplements and herbal preparations

Figure G



44) Figure G shows the percentage of females in each quintile by iron status. The proportion of females in each quintile decreased sequentially from quintile 1 through to quintile 5 (1 vs 2, $p<0.05$; rest $p<0.01$).

Dietary characteristics

45) Table 7 shows the dietary characteristics of adults with the lowest intakes of nutrients (ie quintile 1) compared with those with the highest intakes (quintile 5). These results show that those with the lowest nutrient intakes consumed significantly less of almost every food group. There was no difference in consumption of soft drinks (excluding fruit juice) by intake of any nutrient included in the analysis.

46) Differences in consumption levels of dietary supplements, nuts and seeds, savoury snacks, and sugars, preserves and confectionery were less marked. However, those with the lowest intakes of vitamin C consumed significantly more sugar, preserves and confectionery, and those with the lowest intakes of vitamin B12 consumed significantly more savoury snacks.

Table 7: Quintile analysis: Significant differences in the consumption of food groups between those with lowest vs highest intakes for each nutrient ($p<0.01$)

Food Group	Nutrient														
	K	Ca	Mg	Fe	Cu	Zn	I	Retinol	Vit D	Thiamin	Riboflavin	Vit C	Vit B6	Vit B12	Folate
Compared to those with the highest intakes (quintile 5) those with the lowest intakes (quintile 1) consumed significantly less:															
Cereals and cereal products	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
• Bread	√	√	√	√	√	√	√	√	√	√	√		√	√	√
• Breakfast cereals	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Milk and Milk products	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
• Milk (liquid whole, semi-skimmed and skimmed	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
• Cheese	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Eggs and Egg dishes	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Fat spreads	√	√	√	√	√	√	√	√	√	√	√		√	√	√
Meat and meat products	√	√	√	√	√	√	√	√	√	√	√		√	√	√
• Liver and liver products	√	√		√	√	√	√	√	√	√	√			√	√
Fish and fish dishes	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
• Oily fish	√		√	√	√	√	√		√	√		√	√	√	√
Fruit and Vegetables (including potatoes and fruit juice)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
• Vegetables (excluding potatoes)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
• Potatoes	√	√	√	√	√	√	√	√	√	√	√		√	√	√
• Fruit (including fruit juice)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
• Fruit (excluding fruit juice)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
• Fruit juice	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Sugar, preserves and confectionery	√	√	√		√	√	√	√			√				
Savoury snacks	√												√		
Alcoholic beverages	√	√	√	√	√	√	√		√		√		√		√
• Beer and Lager	√	√	√		√	√	√		√		√		√	√	√
Tea, coffee and water	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Dietary supplements[θ]					√										
Nuts and seeds	√		√	√	√	√	√			√		√			√
Soft drinks (excluding fruit juice)															
Compared to those with the highest intakes (quintile 5) those with the lowest intakes (quintile 1) consumed significantly more:															
Sugar, preserves and confectionery												√			
Savoury snacks														√	

[θ]The 'dietary supplements' food group relates to the *number of dietary supplements consumed during the survey week only* (eg number of tablets, capsules etc)

47) Table 8 shows the dietary characteristics of adults with the lowest nutritional status (ie quintile 1) compared with those with the highest nutritional status (quintile 5). Data in the shaded boxes highlight the main findings therein which were examined further and are presented in figures H-M. That is, those food groups associated with low status for a number of nutrients included in the analysis (ie five and above), and where similar results had been found for the previous analysis undertaken as described in paragraph 3. In addition, there appeared to be a relationship between the consumption of milk, soft drinks (excluding fruit juice) and vitamin B2 status, which warranted further investigation. Presentation of the other significant relationships between consumption of food groups and nutritional status is limited to table 8.

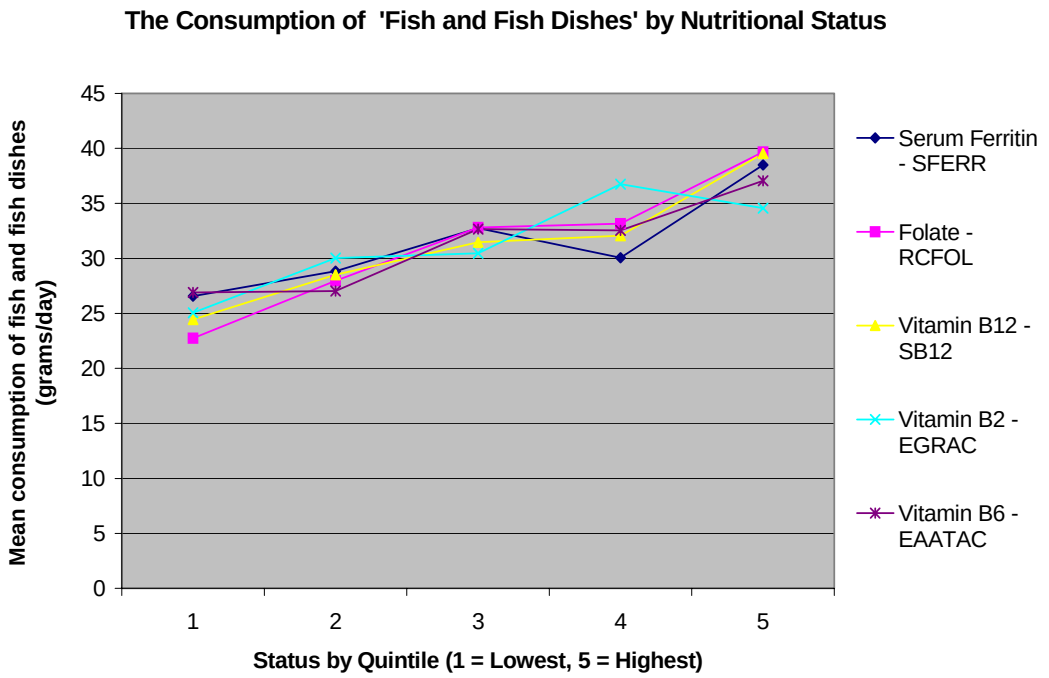
48) When considered together, the consumption of fish and fish dishes, and fruit and vegetables (particularly fruit) had clear associations with the status for all nutrients included in the analysis. Those with the lowest status for these nutrients consumed less of these foods compared to those with the highest status. In addition, those with the lowest status for iron, folate, vitamin B12 and vitamin B2 consumed more savoury snacks, and those with lowest status for folate, vitamin B1 and vitamin B6 consumed more sugar, preserves and confectionery. Finally, those with the lowest status for vitamin B2 consumed more soft drinks (excluding fruit juice), and less milk, compared to those with the highest status. These key findings were examined further and presented in the following graphs (figures H-M).

Table 8: Quintile analysis: Significant differences in the consumption of food groups between those with the lowest vs highest status for each nutrient. ($p<0.01$) Shaded data: key findings investigated further

Food Group	Status							
	Iron	Vitamin D	Folate	Vitamin B12	Vitamin C	Vitamin B1	Vitamin B2	Vitamin B6
Compared to those with the highest status (quintile 5) those with the lowest status (quintile 1) consumed significantly less:								
Cereals and cereal products			√	√			√	
• Bread	√							
• Breakfast cereals			√	√	√		√	
Milk and Milk products			√	√		√	√	
• Milk (liquid whole, semi-skimmed and skimmed			√	√			√	
• Cheese								
Eggs and Egg dishes	√							
Fat spreads								
Meat and meat products	√			√				
• Liver and liver products	√							
Fish and fish dishes	√		√	√			√	√
• Oily fish			√					
Fruit and Vegetables (including potatoes and fruit juice)		√	√		√	√	√	
• Vegetables (excluding potatoes)			√		√			
• Potatoes	√							
• Fruit (inc fruit juice)			√	√	√	√	√	√
• Fruit (exc fruit juice)		√	√	√	√	√	√	
• Fruit juice			√		√	√		√
Sugar, preserves and confectionery								
Savoury snacks								
Alcoholic beverages	√							√
• Beer and Lager	√							√
Tea, coffee and water			√	√			√	
Dietary supplements		√	√				√	
Nuts and seeds								
Soft drinks (excluding fruit juice)								
Compared to those with the highest status (quintile 5) those with the lowest status (quintile 1) consumed significantly more:								
Cereals and cereal products								√
• Bread					√			√
Fat spreads				√				
Meat and meat products					√			
• Potatoes				√				
Sugar preserves and confectionery			√			√		√
Savoury snacks	√		√	√			√	
• Beer and Lager					√			
Soft drinks (excluding fruit juice)							√	

[θ]The 'dietary supplements' food group relates to the *number of dietary supplements consumed during the survey week only* (eg number of tablets, capsules etc)

Figure H

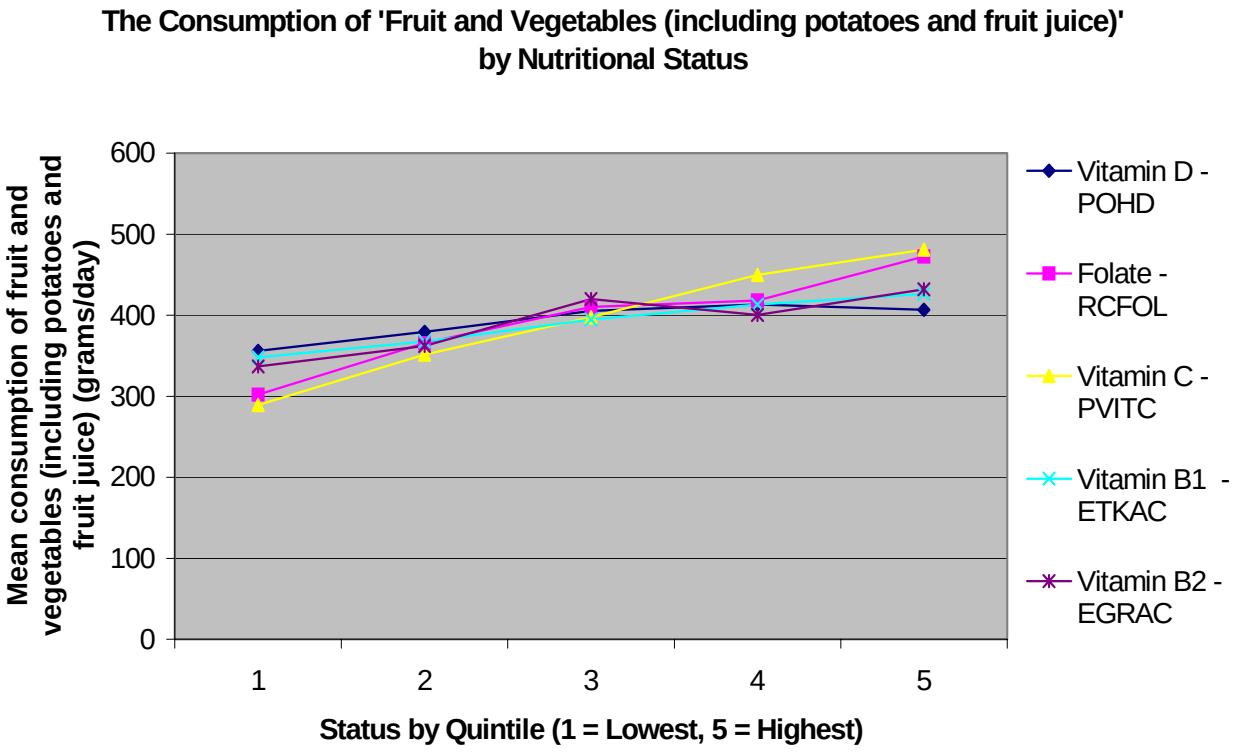


Status variables are shown only where significant associations were found

49) Figure H shows the trend in higher consumption of fish and fish dishes with increasing status for iron, folate, vitamin B2, B6 and B12. The main statistically significant differences found were as follows:

50) The increase in the amount of fish consumed with status for all these nutrients was significant when quintile 1 was compared with quintile 5 ($p<0.01$), and, for iron and folate, when quintile 1 was compared with quintile 3 (folate $p<0.01$, iron $p<0.05$). For vitamin B12, there was a significant increase in fish consumption between quintiles 1 and 3, and quintiles 3 and 5 ($p<0.05$).

Figure I



Status variables are shown only where significant associations were found

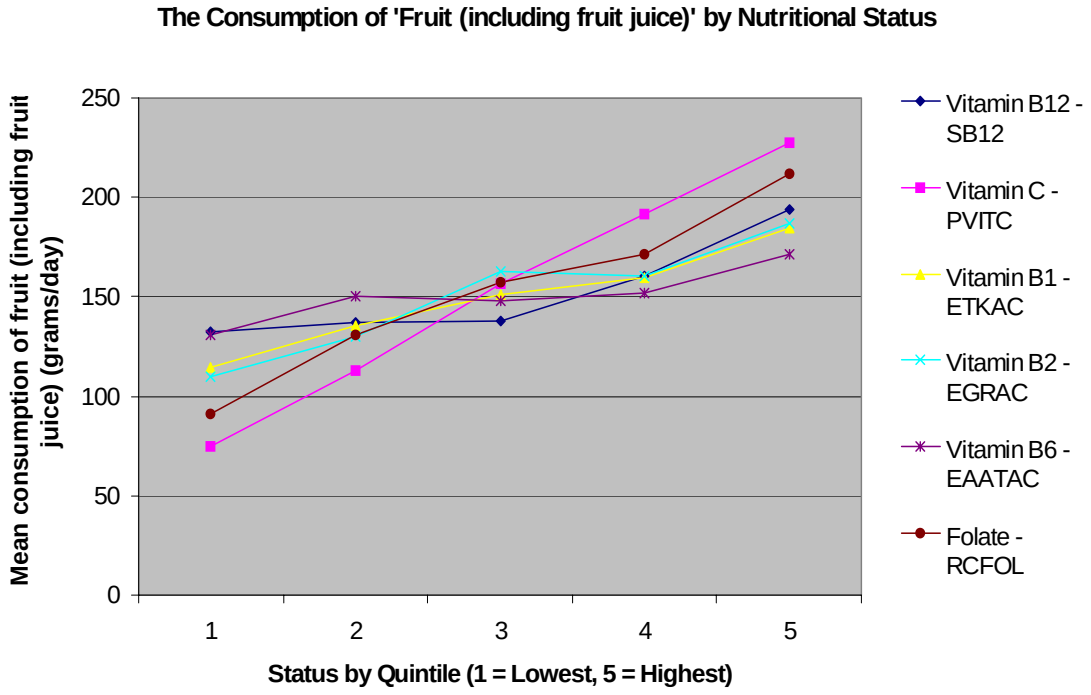
51) Figure I shows the trend in higher consumption of fruit and vegetables (including potatoes and fruit juice) with increasing status for vitamin B1, B2, C, D and folate. The main statistically significant differences found were as follows:

52) The increase in total fruit and vegetable consumption with status for all these nutrients was significant when quintile 1 was compared with quintile 5 ($p<0.01$) and when quintile 1 was compared to quintile 3 ($p<0.01$ for folate, vitamin B2 and C, $p<0.05$ for vitamin B1 and D).

53) The strongest relationships were between total fruit and vegetable consumption and status for vitamin C and folate. For vitamin C, total fruit and vegetable consumption increased sequentially by quintile from quintile 1 to 4 (2 vs 3: $p<0.05$, rest: $p<0.01$). For folate, consumption increased sequentially from quintile 1 to quintile 3, and from quintile 4 to 5 (2 vs 3: $p<0.05$, rest: $p<0.01$).

54) Table 8 showed that within this food group, fruit was a main contributor to nutrient status overall. The consumption of fruit (including fruit juice) by nutritional status is presented in figure J.

Figure J

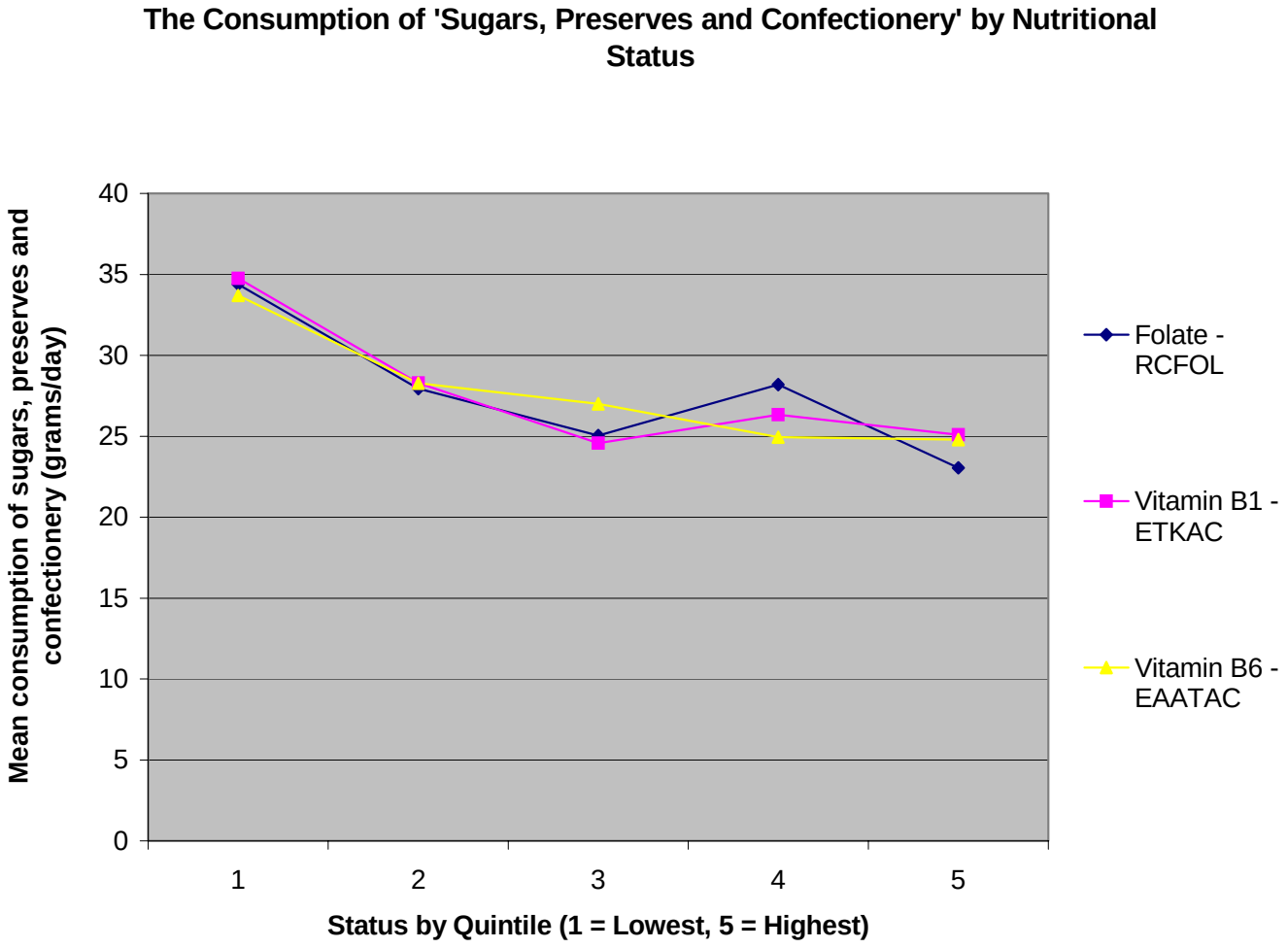


Status variables are shown only where significant associations were found

55) Figure J shows the trend in higher consumption of fruit (including fruit juice) with increasing status for vitamin B1, B2, B6, B12, C and folate. The main statistically significant differences found were as follows:

56) The increase in fruit consumption with status for all these nutrients was significant when quintile 1 was compared with quintile 5 ($p<0.01$). The strongest relationships were between fruit consumption and status for vitamin C and folate. For vitamin C, fruit consumption increased sequentially by quintile (3 vs 4 & 4 vs 5: $p<0.05$, rest: $p<0.01$). For folate, consumption increased sequentially from quintile 1 to quintile 3, and from quintile 4 to 5 (2 vs 3: $p<0.05$, rest: $p<0.01$).

Figure K

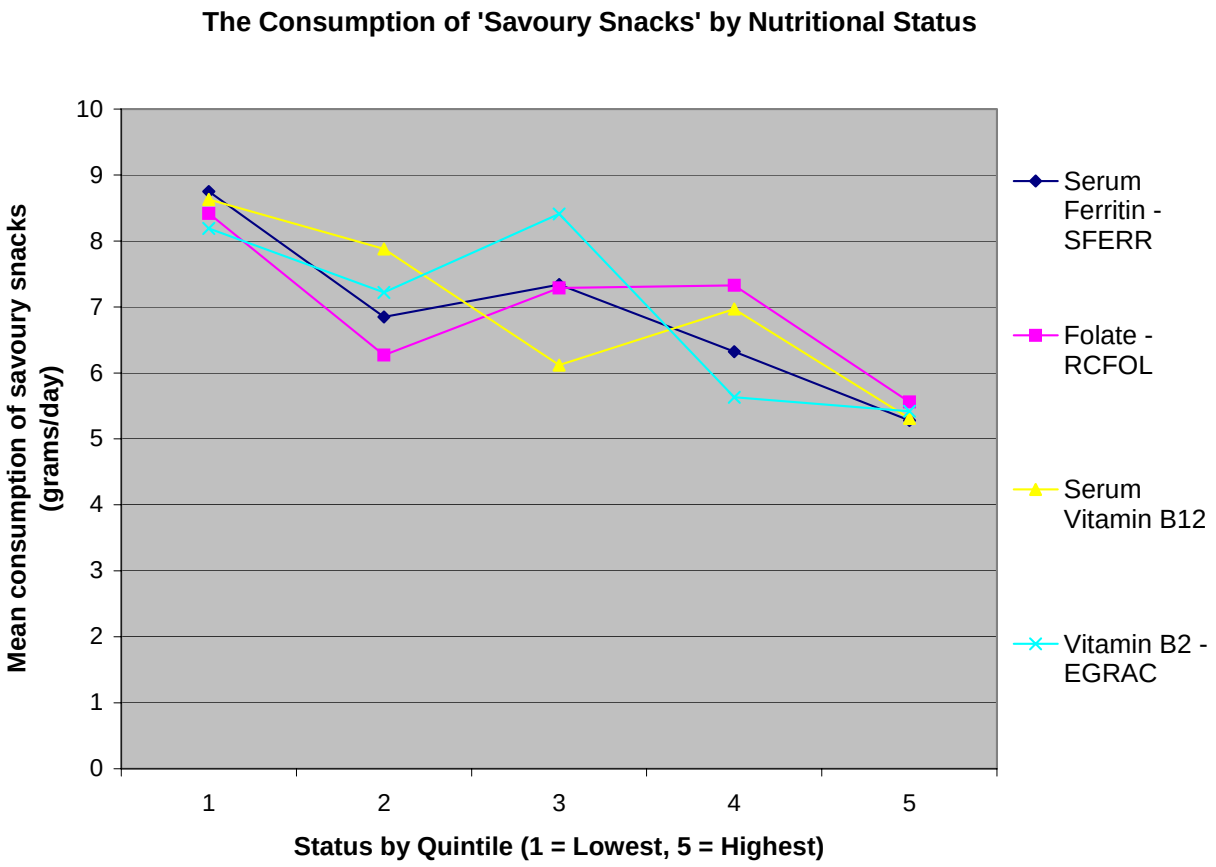


Status variables are shown only where significant associations were found

57) Figure K shows the trend in lower consumption of sugar, preserves and confectionery with increasing status for vitamin B1, B6 and folate. The main statistically significant differences found were as follows:

58) The decrease in the consumption of sugar, preserves and confectionery with increasing status for these nutrients was significant when quintile 1 was compared with quintile 5 ($p<0.01$). This was also seen when quintile 1 was compared to quintile 2 ($p<0.05$), and quintile 3 (vitamin B1 and folate $p<0.01$, vitamin B6 $p<0.05$).

Figure L

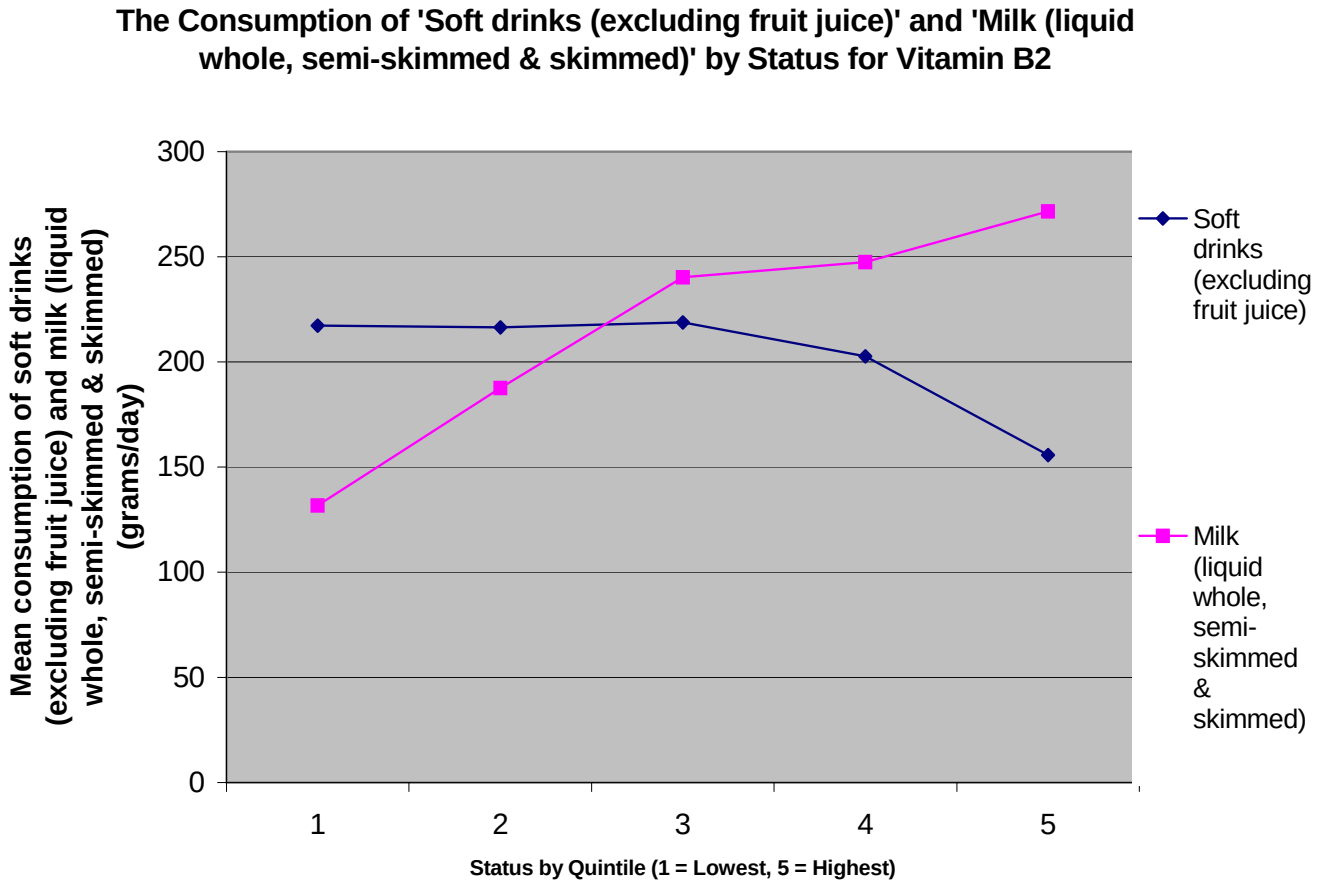


Status variables are shown only where significant associations were found

59) Figure L shows the general trend in lower consumption of savoury snacks with increasing status for vitamin B2, B12, folate and iron. The main statistically significant differences found were as follows:

60) The decrease in the consumption of savoury snacks with increasing status for all these nutrients was significant when quintile 1 was compared with quintile 5 ($p<0.01$), and when quintile 3 was compared to quintile 5 for vitamin B2 ($p<0.01$), folate and iron ($p<0.05$).

Figure M



Status variables are shown only where significant associations were found

61) Figure M shows the trends in consumption of soft drinks (excluding fruit juice) and milk (liquid whole, semi-skimmed and skimmed) by status for vitamin B2.

62) These results show a significant increase in the consumption of milk, and a significant decrease in the consumption of soft drinks with status for vitamin B2 when quintile 1 and quintile 5 are compared ($p<0.01$).

63) For milk consumption, the increase in consumption is also significant sequentially from quintile 1 through to quintile 3 ($p<0.01$). The decrease in soft drinks consumption with status is significant when quintile 3, and quintile 4 are compared to quintile 5 (quintile 3: $p<0.01$, quintile 4: $p<0.05$).

Discussion

64) These results of the quintile analysis support those produced by the original analyses presented earlier (see paragraphs 14-20).

65) Those with low intakes/status were more likely to be smokers, living in a household in receipt of benefits, and less likely to report taking supplements. These results also confirm that the younger adults were more likely to have low intakes/status for some nutrients. This analysis by quintile has also provided further detail on the proportions of women with low iron status, to support data published in the original NDNS Adults report. The quintile analysis of iron intakes/status will be considered by the SACN Working Group on Iron as part of their consideration of the iron intake and status of the British population.

66) The results of this analysis by quintile show that those with the lowest intakes of these nutrients consumed a generally unbalanced diet[8] compared with those with the highest intakes. This is characterised by consumption of significantly less of almost every food group, with some evidence of increased consumption of sugar, preserves and confectionery, and savoury snacks. In addition, lower consumption of fish and fish dishes, and fruit and vegetables (particularly fruit), and a higher consumption of sugar, preserves and confectionery, and savoury snacks, were the key indicators associated with lower nutrient status. This analysis also corroborates the earlier observation that soft drinks (excluding fruit juice) may be replacing milk in the diet for those with lower status for vitamin B2 (see paragraph 27). In addition, those with the lowest status for vitamin B2, B12, vitamin C and folate consumed less breakfast cereals (many of which are fortified with vitamins B2, B12 and folate), and breakfast cereals are usually consumed with milk (a major source of vitamin B2 in the diet).

PRINCIPAL COMPONENT ANALYSIS

Method

67) Foods are not consumed in isolation. The aim of this analysis was to obtain a summary of the different patterns of food consumption due to the large range of foods consumed in many diets. The multivariate technique, principal component analysis (PCA), is one way to characterise food consumption patterns rather than individual foods. The variation within the population is summarised into independent components that explain the greatest amount of variation.

68) The detailed methodology used to undertake this analysis is provided in annex A.

Results

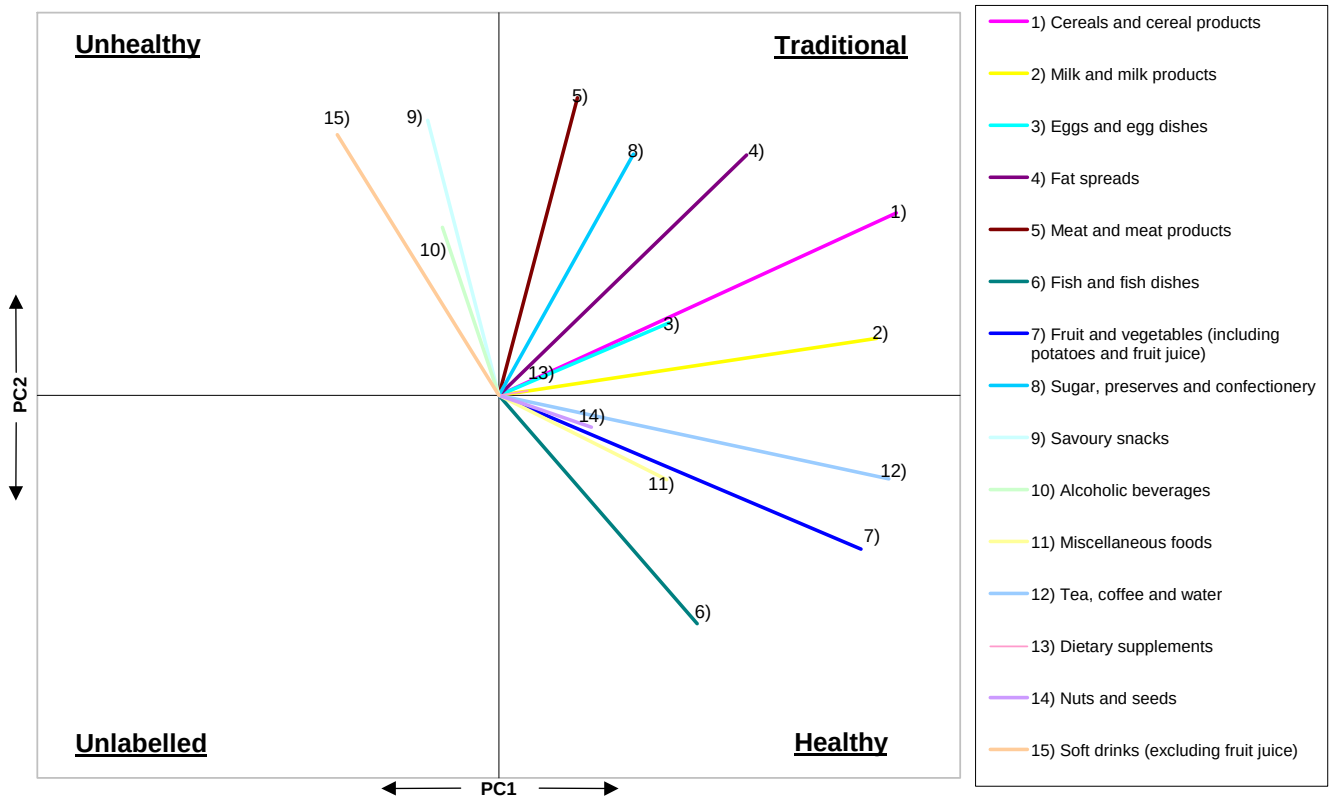
69) A summary of the key results from this analysis are presented here. For more detailed results see annex B.

70) The components identified explained approximately a quarter of the variation in food consumption when the level of aggregation was set at 15 food groupings and the results were collapsed down to 2 dimensions. Four quadrants were identified and labelled 'unlabelled', 'unhealthy', 'traditional' and 'healthy'. The dietary and non-dietary patterns identified therein are presented in table 9 and figure N.

Table 9: Summary of the dietary and non-dietary characteristics associated with the four quadrants identified using PCA

Quadrant	**Trends**
'Unlabelled'	No specific trends seen
'Unhealthy'	Highest consumption of soft drinks (exc fruit juice), savoury snacks and alcoholic beverages during the survey week across all quadrants More males than females in this quadrant Highest number of smokers across all quadrants Lowest number of supplement users across all quadrants Highest numbers who reported being unwell across all quadrants Highest number of respondents from benefit households across all quadrants Lowest mean intakes for all variables included across all quadrants Status variables: lowest in almost all, across all quadrants (ie except for iron)
'Traditional'	Highest consumption of meat and meat products; sugars, preserves and confectionery; fat spreads; cereals and cereal products; eggs and egg dishes; milk and milk products; dietary supplements during the survey week across all quadrants More males than females in this quadrant and the highest number of males across all quadrants Highest numbers in the 35-49 yr group in this quadrant Mean intake variables highest across all quadrants except for iron and vitamin D (similar to 'healthy'), thiamin, riboflavin, vitamin B6 and C (highest in 'healthy') Status variables: similar to, or less than, 'healthy' except for iron. Highest iron status across all quadrants
'Healthy'	Highest consumption of tea, coffee and water; nuts and seeds; fruit and vegetables; fish and fish dishes; miscellaneous foods across all quadrants during the survey week More females than males in this quadrant and the highest number of females across all quadrants Highest numbers in the 50-64 yr group in this quadrant Highest numbers of vegetarians/vegans (although small sample size) across all quadrants Lowest number of smokers across all quadrants Highest number of supplement users across all quadrants Mean intake variables: Iron and vitamin D similar to 'traditional'. Highest intakes of thiamin, riboflavin, vitamin B6 and vitamin C across all quadrants Status variables: Highest in almost all, across all quadrants (ie except for iron)

Figure N – Dietary characteristics associated with the four quadrants identified by Principal Components Analysis (PCA)



Discussion

71) The components identified through PCA only explained approximately a quarter of the variation in food consumption and therefore these results should be treated with some caution. However, this is of a comparable standard to existing published work in this area, both in the level of aggregation applied, and the quality of results produced[9,10]. The PCA results also provide a similar picture to that provided by the previous analyses (when nutrient intake data were compared with current dietary recommendations (DRVs), nutritional status data were compared with standard cut-offs, and the quintile analysis).

72) The 'unhealthy' quadrant had the lowest mean nutrient intakes, and the lowest status for almost all variables included in this analysis. The dietary patterns associated with this quadrant included the higher consumption of soft drinks (excluding fruit juice) and savoury snacks. This quadrant also contained the highest number of smokers and those living in households in receipt of benefits, and the lowest number of those who reported using supplements.

73) Conversely, the 'healthy' quadrant had the highest intakes of some nutrients and the highest status levels for all variables except for iron. The dietary patterns associated with this quadrant included higher consumption of fish and fish dishes and fruit and

vegetables. This quadrant also had the lowest number of smokers and the highest number of those who reported taking supplements.

74) For the 'traditional' quadrant, the numbers of smokers and supplement users were 'in between' those identified in the 'unhealthy' and 'healthy' quadrants. The dietary patterns for the 'traditional' quadrant included higher consumption of a range of general food groups, and had the highest mean intakes for the majority of nutrients included in the analysis. Results for status variables were similar to, or less than, the 'healthy' quadrant, except for iron where higher status was associated with the 'traditional' quadrant.

75) The 'Unlabelled' quadrant is unlabelled as none of the food groups are represented in this quadrant. As the naming convention is based on the types of food groups found in each quadrant, no specific name has been applied. While naming the quadrant is difficult, we do know that the foods found in the 'unlabelled' quadrant are consumed in far less quantity compared with the 'traditional' quadrant due to it's diametrically opposed position. This could be people consuming less, or might be because of under-reporting. Due to the ambiguity found in this quadrant it is harder to draw any sort of clear conclusions and so analysis of this information should concentrate on the other three quadrants.

OVERALL SUMMARY AND CONCLUSIONS

76) When nutrient intake data were compared with current dietary recommendations (DRVs) and nutritional status data were compared with standard cut-offs, the results showed that, at a population level, adults with low intakes of micronutrients consumed a generally unbalanced diet[8]. In particular, low micronutrient status was associated with lower consumption of fish and fish dishes, fruit and vegetables and dietary supplements, and a higher consumption of savoury snacks and soft drinks (excluding fruit juice), which could displace other foods rich in micronutrients. Key non-dietary characteristics associated with low nutrient intake/status were smoking, living in households in receipt of benefits and less reported supplement use. Low nutrient intakes/status were also more likely to be found in younger age groups.

77) Similar patterns were seen when the data were considered using quintile analysis and PCA. Results of the quintile analysis showed that in addition to the above findings (paragraph 76), higher consumption of sugar, preserves and confectionery was associated with low nutrient intake/status. However, the association between low nutrient intake/status and higher consumption of soft drinks (excluding fruit juice) was not seen. Results of the PCA showed that the quadrants defined as 'healthy' and 'unhealthy' concurred with the results outlined above (paragraph 76). The dietary patterns associated with the 'healthy' quadrant (which had the highest intakes of some nutrients listed in table 1 and the highest status levels for all nutrients listed in table 2 except iron) included higher consumption of fish and fish dishes, and fruit and vegetables. The dietary patterns associated with the 'unhealthy' quadrant (which had the lowest mean intakes and lowest status for almost all nutrients), were higher consumption of soft drinks excluding fruit juice) and savoury snacks. The 'healthy' quadrant had the lowest number of smokers and highest number of those taking supplements. The opposite was seen for the 'unhealthy' quadrant.

78) The results of these secondary analyses suggest that to improve the micronutrient intake/status of this population group continued promotion of the balance of foods required to maintain a healthy diet, along the lines of those provided in the Balance of

Good Health[8] is important. This would include recommendations for the consumption of fruit and vegetables and for fish, and recommendations to limit the consumption of foods high in fat and sugar such as savoury snacks, sugars, preserves and confectionery, and soft drinks. These results suggest that these foods, many of which are high in fat and sugar, could be displacing other foods rich in micronutrients from the diets of those with low micronutrient intakes and/or status. For example, consideration could be given to promote the replacement of some soft drinks in the diet with low fat milks.

79) It is important to note that those adults taking supplements tended to be those with higher intakes of these micronutrients from food. This is evidence to support the fact that adequate patterns of micronutrient intake are achievable without supplement use by a large proportion of the population.

80) The results of these analyses give strength to the promotion of dietary messages within the context of healthy lifestyle, with particular emphasis on not smoking and increasing levels of physical activity. The results also indicate that the particular groups who would benefit most from acting upon these messages include young adults, smokers and those living in benefit households. Results from the Low Income Diet and Nutrition Survey, which is due to report in 2006, will provide detailed information of the diet and nutrition of those materially deprived to help target this vulnerable population group.

Recommendation

81) It is therefore recommended that a healthy balanced diet approach is appropriate for addressing low micronutrient intakes and/or status in this population sub-group. This should be targeted at young adults, smokers and those from lower socio-economic groups. This would be integrated into current healthy lifestyle messages (eg not smoking and increasing levels of physical activity) and would, if successful, bring about improvements in the well being of this population.

ANNEX A

Principal Component Analysis: Methodology

82) The multivariate technique, Principal Component Analysis (PCA) is one way to characterise food consumption patterns rather than individual foods.

83) The basic idea of the method is to describe the variation of a set of multivariate data in terms of a set of uncorrelated variables, each of which is a particular linear combination of the original variables[11].

84) SPSS v12 was used to carry out the analysis. The various arithmetical procedures need not be described in detail because there are simple to use computer packages[12].

85) PCA was carried out on three forms of the original data. Firstly in the form it was collected in, the 111 food groups of the NDNS. It was then aggregated to the next level used in the NDNS, which comprises of 56 food groups. Finally it was aggregated into 15 'sensible' food groupings (see table 3).

86) How many of the components to extract is a common problem in PCA. There appears to be no hard and fast rule but a reasonable rule of thumb is to only retain those components that explain more the one p^{th} of the variation. If there are p variables then each variable will explain an average of $1/p$ of the variation. These important components will also have Eigenvalues greater than 1[13]. Therefore this "rule of thumb" is to be used in the analysis.

87) When displaying the results the food groups are ordered with the food group showing the strongest positive effect at the top of table with the strongest negative result at the bottom. Only values greater than +/- 0.10 in the dietary patterns are shown. The reason for this is to present the results with clarity and brevity.

ANNEX B

Principal Component Analysis: Detailed Results

88) The first PCA was carried out on the lowest level of food data in the NDNS and included 111 food groups (several were removed for having 1 or fewer entries, thus no variation). The analysis led to 45 components being extracted, which explained 58.6 % of variation. The first component accounted for 4.3% of the variation and the second component accounted for 2.7% of the variation. This result is not useful because the food groups were too diverse and there is not enough information held in the first two principal components to draw meaningful conclusions with PCA.

89) The food groups were then aggregated to the next level of NDNS food groupings. This included 56 food groups. 22 components were extracted explaining 55.8% of the variation. The first component accounted for 6.1% of the variation and the second component accounted for 4.1% of the variation. Again, there was not enough information held in the first two principal components to draw meaningful conclusions with PCA.

90) The next level of aggregation was based on food groups that are shown in Food Groups Table 3. Only food groups with no overlap were used, so this led to 15 food groups being included in the analysis. 6 components were extracted explaining 54.6% of the variation. The first component accounted for 12.4% of the variation and the second component accounted for 11.4% of the variation.

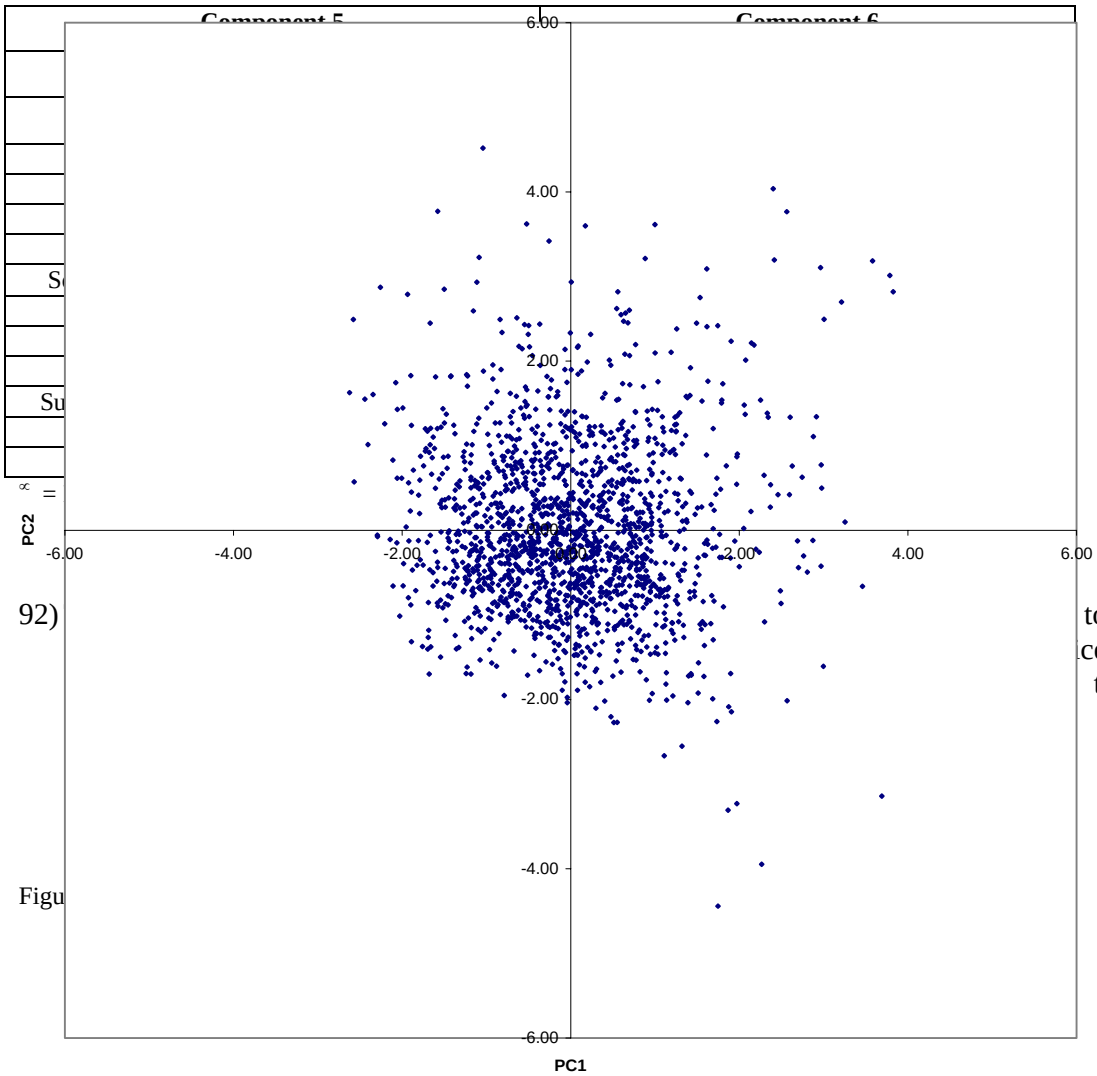
91) These tables show food groups with factor loadings derived from the Principal Components Analysis. Only values greater than+/- 0.10 in the dietary patterns are shown.

Component 1		**Component 2**	
Variance explained (%)	12.43	Variance explained (%)	11.35
More cereals and cereal products, tea, coffee and water, milk and milk products, fruit and vegetables (including potatoes and fruit juice)		***More meat and meat products, savoury snacks***	
Cereals and cereal products	0.60	Meat and meat products	0.54
Tea, coffee and water	0.59	Savoury snacks	0.50
Milk and milk products	0.57	Soft drinks (excluding fruit juice)	0.48
Fruit and vegetables (including potatoes and fruit juice)	0.55	Sugar, preserves and confectionery	0.44
Fat spreads	0.38	Fat spreads	0.44
Fish and fish dishes	0.30	Cereals and cereal products	0.33
Eggs and egg dishes	0.26	Alcoholic beverages	0.31
Miscellaneous foods$^{\propto}$	0.25	Eggs and egg dishes	0.13
Sugar preserves and confectionery	0.20	Milk and milk products	0.10
Nuts and seeds	0.14	Tea, coffee and water	-0.15
Meat and meat products	0.12	Miscellaneous foods$^{\propto}$	-0.15
Savoury snacks	-0.11	Fruit and Vegetables (including potatoes and fruit juice	-0.28
Soft drinks (excluding fruit juice)	-0.24	Fish and fish dishes	-0.42

$^{\propto}$ = Includes soups, savoury sauces, pickles, gravies and condiments

Component 3		Component 4	
Variance explained (%)	8.74	Variance explained (%)	7.86
More alcoholic beverages		***More soft drinks (excluding fruit juice)***	
Alcoholic beverages	0.53	Soft drinks (excluding fruit juice)	0.55
Fish and fish dishes	0.37	Savoury snacks	0.35
Eggs and egg dishes	0.36	Fruit and Vegetables (including potatoes and fruit juice)	0.32
Meat and meat products	0.34	Cereals and cereal products	0.30
Fruit and vegetables (including potatoes and fruit juice)	0.26	Nuts and seeds	0.29
Miscellaneous foods[∝]	0.17	Miscellaneous foods[∝]	0.25
Fat spreads	0.14	Fish and fish dishes	0.10
Soft drinks (excluding fruit juice)	0.13	Sugar, preserves and confectionery	-0.15
Savoury snacks	-0.16	Meat and meat products	-0.27
Tea, coffee and water	-0.31	Tea, coffee and water	-0.28
Milk and milk products	-0.36	Eggs and egg dishes	-0.34
Sugar, preserves and confectionery	-0.49	Alcoholic beverages	-0.34

[∝] = Includes soups, savoury sauces, pickles, gravies and condiments



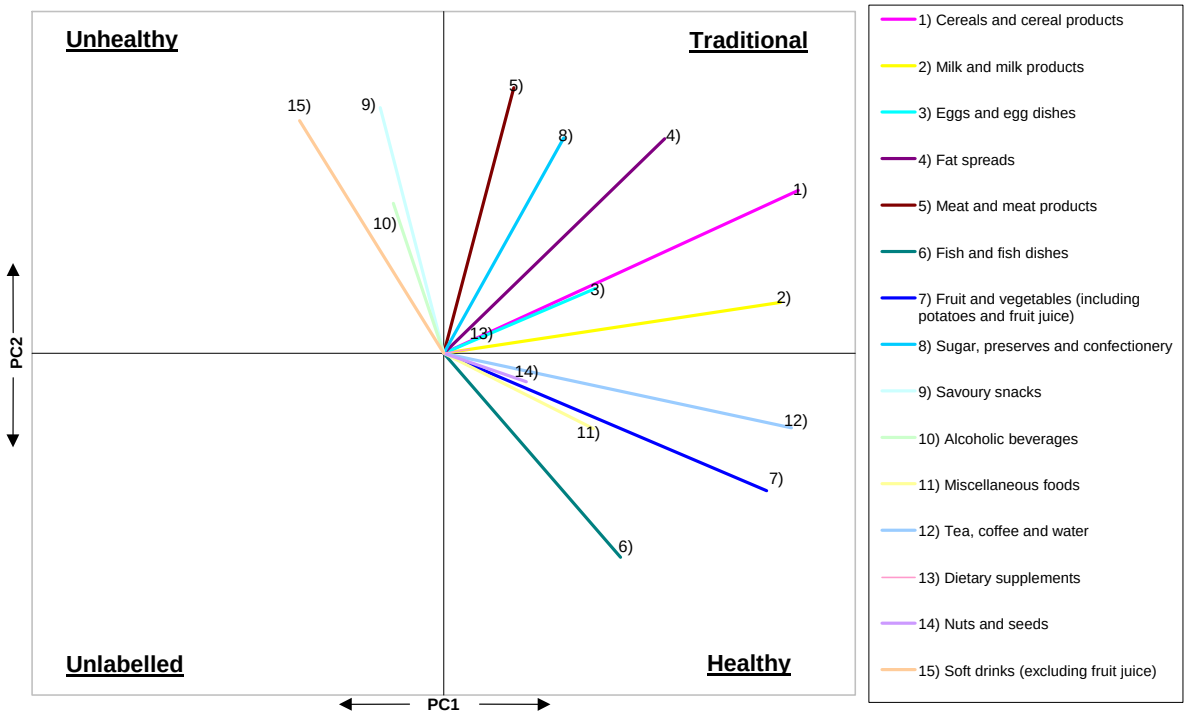
92) to 2 ce in two

Figu

The scatterplot of the individuals in relation to the first two principal components is usually a very important piece of output (see figure 1). In this case though, it is very difficult to pick out any pattern with individuals seeming to be more densely packed around the origin. (Examples of interpreting this sort of plot have a much smaller number of cases and therefore the problem here may be "not being able to see the wood for the trees"). Ideally we would like to see an elliptical pattern in the above scatterplot, but when contours of constant distance are nearly circular the sample variation is homogenous in all directions. It is not possible to represent the data well in fewer than p dimensions, where 'p' in this case equals the number of food groups[14].

93) It is possible to plot the component weights of each principal component (food group) on a graph. The lines representing each specific food group are plotted from the origin (0, 0), with the end of the line being the (X, Y) co-ordinate representing the values (weight on first component, weight on second component). For example, variables plotted to the right of the origin have positive component weights for the first Principal Component. The longer these lines are the stronger the influence this variable has. This plot can therefore be used to identify those food groups that may be having a large influence on the position of any particular point or group of points. This is a similar technique to the 'Bi-Plot', a post analysis procedure some specialist packages use.

Figure 2



94) From the above plot (figure 2) it seemed as if certain food groups were clustering in different quadrants of the plot. (NB: This is not a named style of analysis, just a way of interpreting the plot). In the top left corner we have: savoury snacks; alcoholic beverages; and soft drinks (excluding fruit juice). These could be labelled 'unhealthy'.

In the top right corner we have: cereals and cereal products; milk and milk products; eggs and egg dishes; fat spreads; meat and meat products; sugar, preserves and confectionery; and dietary supplements. These could be labelled 'traditional' as most are found in a common/traditional diet. In the bottom right corner the food groups fish and fish dishes; fruit and vegetables (including potatoes and fruit juice); miscellaneous foods; tea, coffee and water; nuts and seeds; are found. These could be considered as constituents of a 'healthy' diet. The bottom left hand corner had no lines from the Bi-Plot in it. It is therefore harder to describe the individuals in this quadrant. One way of looking at this group is to consider the points furthest away from it. For example, cereal and cereal products is probably the furthest point away from this quadrant which would suggest that the people in this quadrant do not eat much of this food group.

95) In summary, the key preliminary results of this analysis are as follows:

- The components identified only explain about a quarter of the variation in the data when the level of aggregation was set at 15 food groupings and the results collapsed down to 2 dimensions

- Notwithstanding the above, 4 quadrants have been identified, which have been labelled as:
  - 'Unlabelled'
  - 'Unhealthy'
  - 'Traditional'
  - 'Healthy'

  The resulting display is merely an approximation to the true configuration[15].

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