Scientific Advisory Committee on Nutrition

NUTRITIONAL IMPLICATIONS OF REPEALING THE UK BREAD AND FLOUR REGULATIONS

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Background

1. Under the UK Bread and Flour Regulations 1998 (FLR) industry is required to add certain nutrients (ie iron, calcium, thiamin and niacin) to all wheat flour (except wholemeal flour) at the milling stage of processing. This legislative requirement was introduced in the 1950's in order to restore the iron, thiamin and niacin lost in the milling process to the minimum levels known to be present in flour of 80% extraction rate[1]. From 1940 until the end of food rationing in Britain in 1954, legislation enforced the milling of flour up to 80% extraction or higher in order to make full use of the nutritional value of the wheat grain. In 1953 controls on the milling of white flour were lifted and bread could again be made from flour of approximately 70% extraction rate and it was considered that restoration of nutrients removed by milling was required in order to maintain the nutritional value of a staple food. The addition of calcium was introduced in the 1940s as a means of providing more calcium in the diet at a time when dairy products were scarce and the phytate content of high extraction flour used in the wartime loaf inhibited absorption of calcium. Details of the nutrients and levels added are summarised in Table A, Appendix A.

2. As part of the Red Tape Challenge initiative to reduce regulation in all sectors, the Department for Environment Food and Rural Affairs (Defra) are reviewing the need for these regulations and will be going out to public consultation on their removal later this year.

3. This paper presents the Scientific Advisory Committee on Nutrition's (SACN's) view on the nutritional implications of removing this legislation. It has been produced at the request of the Department of Health on behalf of Defra. To support this, a modelling exercise has been carried out using the most recent National Diet and Nutrition Survey (NDNS) dataset to estimate the impact of removal of these nutrients from flour on nutrient intakes in all age groups. This paper presents the results of this modelling exercise and provides an appraisal of this evidence in relation to other considerations for specific nutrients and vulnerable groups.

4. This issue was considered by the Committee on Medical Aspects of Food Policy (COMA) in its 1981 report on the nutritional aspects of bread and flour[2]. This report recommended that the addition of calcium and the restitution of iron, thiamin and niacin to flour should no longer be mandatory, on the basis that dietary survey evidence available at the time[i] suggested that intakes of these nutrients were adequate and iron, in the case of the compound used, was poorly absorbed. The report also acknowledged that niacin can be synthesised in the body from the amino acid tryptophan and since the protein and consequently tryptophan content of the average British diet was more than adequate there was no sound reason for the mandatory addition of niacin to flour. However, their recommendation that 'the addition of calcium, iron, thiamin and niacin to flour no longer be mandatory' was never implemented. More recently COMA, in its 1998 report on Nutrition and Bone Health recommended that calcium fortification of flour should be retained[3].

5. In 2006 SACN concluded that mandatory fortification of flour with folic acid would reduce the risk of inadequate folate status in women most at risk of neural tube defect-affected pregnancies[4]. The decision whether to introduce mandatory fortification of flour with folic acid is with government Ministers.

Method

6. The most recent data from the NDNS Rolling Programme for years 1 and 2 combined[5] was used to model the impact of removing the mandatory addition of nutrients to flour on intakes of those nutrients in children, adults and older adults. The NDNS dataset was interrogated to provide a distribution of estimated flour consumption by age/sex, based on estimates of the percentage of flour in each NDNS food group (see Table B Appendix A, and Appendix B). These estimates of flour consumption were used to model the impact of removing mandatory addition of nutrients to wheat flour (other than wholemeal) on mean intakes of each nutrient and on the distribution of intakes in relation to Dietary Reference Values (DRVs) (ie mean intakes as a percentage of the Reference Nutrient Intake[ii] (RNI) and the percentage of respondents with intakes below the Lower Reference Nutrient Intake (LRNI), Estimated Average Requirement[iii] (EAR) and RNI).

[i] Based on household purchase data from the National Food Survey. National data on the nutrient intakes of individuals in the UK population was unavailable at this time.
[ii] The Reference Nutrient Intake (RNI) for these micronutrients is the amount of the nutrient that is enough, or more than enough, for about 97% of people in a group. If average intake of a group is at the RNI, then the risk of deficiency in the group is very small.
[iii] The Estimated Average Requirement (EAR) – about half will usually need more than the EAR, and half less.

7. The LRNI represents a daily level of intake for a nutrient, which, if consumed on a regular daily basis, would "almost certainly be inadequate for most individuals"[iv]. It would be expected that 2.5% of a population will have an intake below the LRNI[6]. The LRNI is not a definitive diagnostic threshold for inadequate nutrient intakes, but because consistent intakes below it are associated with functional and symptomatic nutrient deficiency disorders the LRNI represents a threshold for risk assessment and risk management in the use of NDNS data for the surveillance and management of possible nutrient deficiencies. The LRNI represents the lower end of requirements and therefore intakes were also compared with the EAR and RNI (which would be expected to meet the requirements of 50% and 97.5% of a population group respectively) to assess any shift in intakes across the population.

8. For the purposes of modelling intakes it was assumed that all flour consumed other than in wholemeal bread was plain, white flour, and that this flour was all sourced from the UK (and hence subject to the mandatory addition of nutrients). A full list of the assumptions made in the model is given at Appendix A. Details of the nutrient composition data used for flour with and without added nutrients, and DRVs applied[6,7] are also provided in Appendix A (Tables C and D).

Results

9. Table 1 shows the distribution of flour consumption (grams per day) by age and sex based on estimated flour content of NDNS food groups. Mean consumption ranged from 36g per day in children aged 1½ to 3 years to 89g per day in boys aged 11-18 years. Histograms presenting the distribution of flour consumption by sex are provided in figure 1. The majority of total flour consumed came from bread (60% for men, 58% for women).

10. Tables 2-5 show intakes of thiamin, niacin equivalents[v], calcium and iron with and without the addition of these nutrients to wheat flour (other than wholemeal). For each age/sex group the proportion with intakes below the LRNI[8], EAR[9] and RNI[10] are provided.

11. Key findings of the impact of removing added thiamin, niacin, calcium and iron from flour are as follows:

[iv] For most nutrients the LRNI is set at a notional 2 standard deviations below the Estimated Average Requirement for that nutrient in the population or group within the population. This approach is taken because there is not enough specific knowledge available for example about the nutrient's uptake and transfer by the intestine, its distribution and use in the body including how much is stored in the body, and, sometimes, about how excessive amounts of the nutrient are disposed of. However, if this information is available it can be used to refine the LRNI and to characterise better the uncertainties involved in using the LRNIs in population risk assessment. The LRNI can not identify specific individuals at risk. Whereas the distribution of daily intakes may remain the same from one day to another, the individuals consuming intakes below the LRNI will vary.

[v] Niacin equivalents = amount of preformed niacin + (1/60 X tryptophan).

a) Thiamin and Niacin equivalents

- *Children and adults (aged 1½ years upwards)*

- Mean intakes of thiamin and niacin equivalents remain above the RNI for each age/sex group. In addition, the proportion with intakes below the LRNI remains around 0-1% for niacin equivalents and 0-3% for thiamin with no more than 1% below the LRNI for niacin, and no more than 4% below the LRNI for thiamin in any group.

b) Calcium

- *Younger children (all 1½-3 years, boys and girls aged 4-10 years)*

- Mean intakes remain above the RNI for each age/sex group
- No more than 2% of children aged 1½-3 years, and boys or girls aged 4-10 years have *current* intakes below the LRNI. This would remain unchanged should calcium fortification of flour cease.

- *Older children (boys and girls aged 11-18 years)*

- *Current* mean intakes of calcium for boys and girls aged 11-18 years are 87% of the RNI. Removing calcium fortification of flour would reduce mean intakes further to 80% of the RNI for boys and girls of this age
- 15% of girls and 8% of boys aged 11-18 years *currently* have intakes below the LRNI and this would increase further (to 21% of girls and 12% of boys) should calcium fortification of flour cease.

- *Adults (aged 19-64 years)*

- Mean intakes of calcium in adults aged 19-64 years would remain above the RNI for men and at the RNI for women without the addition of calcium to flour. There would be a small increase in the proportion with intakes less than the LRNI (from 3% to 4% for men and from 6% to 9% for women should calcium fortification cease.

- *Adults (aged 65+ years)*

- Mean intakes of calcium in adults aged 65+ years would remain above the RNI and there would be a small increase in the proportion with intakes less than the LRNI (from 1% to 3% for men and from 3% to 5% for women) if added calcium was removed.

c) Iron

- *Younger children (all 1½-3 years)*

- *Current* mean intakes are 92% of the RNI and 8% *currently* have intakes below the LRNI. The removal of added iron from flour would have little impact on this.

- *Younger children (boys and girls aged 4-10 years)*

- Mean intakes remain above the RNI for boys and girls aged 4-10 years
- No more than 1% of boys and girls aged 4-10 years have *current* intakes below the LRNI. This would remain unchanged should iron restitution cease.

➢ *Older children (boys and girls aged 11-18 years)*

- *Current* mean intakes for boys aged 11-18 years are 95% the RNI and removal of added iron from flour would reduce this further to 92%. 5% have intakes below the LRNI and this would increase to 7%
- *Current* mean intakes for girls aged 11-18 years are below the RNI (58%) and would decrease further to 56% of the RNI without restitution
- Forty four percent of girls aged 11-18 years *currently* have iron intakes below the LRNI. Without restitution this proportion would increase to 50%.

➢ *Adults (aged 19-64 years)*

- Males: Mean intake of iron remains above the RNI for men and the proportion with intakes less than the LRNI is minimal and remains unchanged
- Females: *Current* mean iron intakes are below the RNI (80%) and 22% of this age group have intakes below the LRNI. Ceasing restitution would reduce mean intakes to 79% of the RNI and increase the proportion of women with intakes below the LRNI to 25%.

➢ *Adults (aged 65+ years)*

- Mean intakes of iron in adults aged 65+ years remain above the RNI. The proportion of men and women with *current* intakes less than the LRNI is small (no more than 3%) and ceasing restitution would have minimal impact.

Discussion

12. The impact of removing the four mandatory nutrients added to wheat flour (other than wholemeal) on overall intakes of these nutrients has been assessed by modelling intakes of all wheat flour (other than wholemeal) without added nutrients and comparing these with the RNI[10], EAR[9] and LRNI[8] for each micronutrient in each age/sex group. Results show the distribution of intakes after the removal of these added nutrients, average intakes as a percentage of the RNI and the percentage of the sample with intakes below the RNI, EAR and LRNI (including estimated numbers based on UK population estimates). The definition and interpretation of the LRNI, EAR and RNI are described in paragraph 7.

Thiamin

13. The effects on intakes of thiamin from modelling the removal of added thiamin from wheat flour (other than wholemeal) are small. Mean intakes remain well above the RNI and less than 5% would have intakes below the LRNI in any age/sex group. In practical terms where the population of people with intakes less than the LRNI is below 5%, this is not considered to be of concern. Concern increases as the percentage of a population with intakes rises above this level. Thiamin is widespread in the diet. Non-wheat flour sources include meat and meat products, vegetables and potatoes and breakfast cereals and clinical deficiency of thiamin is rare in the general UK population.

14. Thiamin requirements may be higher in some special groups. For example, athletes may have a higher thiamin requirement due to their high carbohydrate intakes. However, dietary intakes in this group tend to be sufficient to accommodate this[11]. High alcohol consumers have increased requirements as alcohol inhibits absorption of thiamin which is required during the metabolism of carbohydrate, fat and alcohol. Recent survey data shows that 35% of men and 27% of women aged 16-24 years consumed alcohol at twice the recommended levels on at least one day in the week prior to taking part in the survey[5]. However, it is unclear how relevant thiamin deficiency is to moderate drinkers as thiamin deficiency in the UK is most likely to occur in alcoholics, resulting in alcoholic neuropathy and Wernicke-Korsakov syndrome[12].

Niacin

15. The effects on intakes of niacin from modelling the removal of added niacin from wheat flour (other than wholemeal) are small. Mean intakes would remain well above the RNI and less than 2% would have intakes below the LRNI in any age/sex group. Niacin is widespread in the diet and non-wheat flour sources include meat and meat products, breakfast cereals, and milk and milk products. Evidence on the niacin status of the UK population is unavailable and therefore only intakes can be monitored to assess potential deficiency. Clinical deficiency of niacin is rare in the general UK population.

Calcium

16. The modelling identified that the removal of added calcium from wheat flour (other than wholemeal) would adversely affect intakes for young people aged 11-18 years and females aged 19-64 years. Current intakes for older children and young adults are already low and of particular concern. There would also be a general downward shift in population intakes of calcium except for the youngest age group (1½- 3 years) where the contribution of calcium from milk and milk products is greater compared with older age groups[13]. For example, the proportion of 11-18 year olds with intakes below the EAR would increase from 44% to 53%, and those with intakes below the RNI would increase from 71% to 78% should the addition of calcium to wheat flour (other than wholemeal) cease.

17. Mean calcium intake is currently below the RNI for the 11-18 age group (87% of the RNI) and a substantial proportion of girls (15%), and to a lesser extent boys (8%) have intakes below the LRNI. Recent NDNS data shows that milk consumption overall has fallen for all those aged 11 years and over compared with previous NDNS surveys. Consumption of milk for those aged 11-18 years has fallen by around a fifth from 171g per day in 1997 to 134g per day in 2008/10[5]. The removal of added calcium from flour would reduce mean intakes to 80% of the RNI for boys and girls aged 11-18 years. Over a fifth of girls (21%) and over a tenth of boys (12%) would have intakes below the LRNI. Data on calcium intakes for young adults (eg 19-24 years) are not yet available from the current NDNS rolling programme. However, data from the NDNS Adults survey carried out in 2000/01 shows that 8% of women and 5% of men of this age had intakes below the LRNI[14].

18. There is evidence that habitual intakes below the LRNI are not compatible with good bone health[3]. There is no biomarker available to assess inadequate calcium status so intake is the only guide available to dietary adequacy. The removal of added calcium from flour would decrease population intakes of calcium and increase the proportion with intakes below the LRNI. This implies an increased risk of deficiency which has been associated with poor bone health[3]. Older children and young adults are likely to be vulnerable to low calcium intakes at a key stage in their bone development as 90-95% of peak bone mass[15] is contributed during growth[6]. The 2011 Institute of Medicine report on dietary reference intakes for calcium and vitamin D[16] states that calcium deposition into bone is an ongoing process throughout childhood and into adolescence, reaching maximal accretion during the pubertal growth spurt. This period of bone accretion determines adult bone mass, which, in turn, is a significant predictor of fracture risk late in life. The ability to attain an optimum peak bone mass is affected by genetic background and by lifestyle factors such as physical activity but also total calcium intake[16]. Failure to achieve an optimum peak bone mass will increase the risk of osteoporosis in later life. Osteoporosis[17] is a major public health problem in the UK and this will continue because of the shifting demographics of the population as it ages. Almost half of all women and one in six men experience osteoporotic fracture before death[18].

19. Vitamin D is instrumental in the absorption of calcium and ensuring adequate calcium absorption is an important aspect of bone health. Maintaining good levels of serum 25-hydroxyvitamin D (25-OHD)[19] is essential for good bone health and there is evidence of poor vitamin D status in the UK population. Up to 20% of older children and adults have levels of serum 25-OHD below 25nmol/l which has implications for bone health in the UK, in particular increased risk of rickets and osteomalacia[20,21].

20. Bread and other products made with wheat flour subject to mandatory addition of nutrients are an important source of calcium in the diet. The latest NDNS data shows that cereals and cereal products provide around 30% of calcium intakes, the majority from bread and flour containing products[13]. Flour may be a particularly important source of calcium, especially for those who do not consume dairy products, and because milk consumption is in decline[5].

Iron

21. The modelling of the removal of added iron from wheat flour (other than wholemeal) did not identify any substantial impact on intakes for younger children, males aged 19-64 years and adults aged 65+ years. The greatest impact would be for older girls and women, who have higher iron requirements. Current intakes of iron by girls aged 11-18 years and women of childbearing age are of particular concern as a high proportion has intakes below the LRNI. The removal of iron from flour would increase the proportion of girls aged 11-18 years with intakes below the LRNI from 44% to 50% and women 19-64 years from 22% to 25%. However, the current DRVs for iron, particularly for girls and women of reproductive age may be too high, because they are based on cautious assumptions about the bioavailability of dietary iron and metabolic adaptation[22]. There would also be a general downward shift in population intakes of iron. For example, the proportion of adults aged 65 years and over with intakes below the EAR would increase from 11% to 14%, and those with intakes below the RNI would increase from 35% to 40% should the addition of iron to wheat flour (other than wholemeal) cease.

22. Overall mean iron intakes have not increased for adults and older children in the current NDNS compared with previous surveys and may have decreased slightly. The proportion of women and girls with iron intakes below the LRNI has fallen slightly from previous NDNS but remains very high (from 47% to 44% in girls aged 11-18 years and from 26% to 22% in women aged 19-64 years)[5].

23. In addition to the above data on iron intakes, survey data provide evidence of iron-deficiency anaemia (as indicated by low haemoglobin levels) and low iron stores (plasma ferritin) in a proportion of adult women and older girls in the UK (5-6% of girls aged 15-18 years and women aged 35-49 years)[22].

24. The results from the modelling exercise relate to iron intakes and not iron deficiency or adequacy and there is a poor correlation between the two. The relationship between iron intakes such as those reported in the UK population, and the risk of iron deficiency is unclear because there is insufficient information about the body's adaptation to what are currently regarded, on the basis of the DRVs, as inadequate intakes, and about loss of iron in blood loss. The current estimates of DRVs are possibly conservatively high[22]. There are no data to indicate that the bioavailability of dietary iron is a significant factor in the pathogenesis of anaemia and iron deficiency in the UK population. UK diets contain a broad range of foods containing iron and various enhancers and inhibitors of iron absorption[22].

25. Bread and other flour-containing products are major contributors to iron intake in the UK diet. The latest NDNS data show that cereals and cereal products provide nearly 40% of iron intake in adults and 50% in older children, about half of which comes from bread and other flour-containing products[5]. Although iron fortification of cereal flour (wheat and maize) and other food products is practised in several countries at varying levels as a strategy to combat iron deficiency, there is limited evidence of a beneficial effect on iron status at a population level (and

no large-scale fortification programmes have formally evaluated their impact on iron status). The limited impact of iron fortification programmes on markers of iron adequacy may be due to a number of factors including widespread use of elemental iron powders (which are poorly absorbed), insufficient intakes of the fortified food, or inadequate level of fortification. Evidence summarised in the SACN report on iron and health suggested that iron in the form added to wheat flour (and in iron-fortified foods) is poorly absorbed and may be of little practical use in improving iron status, even in individuals with increased systemic iron needs. This is probably due to the low solubility and resultant low intestinal uptake of the iron salts used[22]. The impact of iron fortification will also depend on the proportion of anaemia in the population that is due to iron deficiency[22].

26. Although the availability of iron added to wheat flour (other than wholemeal) for uptake by the intestine may be lower than other forms of iron there may be wider implications associated with its removal. There are a number of uncertainties that could potentially impact on the risk of iron deficiency of the general population should restitution of wheat flour (other than wholemeal) with iron cease. For example, wheat flour is a difficult vehicle to fortify with iron because it contains high levels of phytates. These are found in both cereals and legumes and have the ability to bind iron, restricting its availability for absorption. The iron added to wheat flour may have a separate important function by binding to phytates within the flour. Its removal could liberate these phytates, potentially decreasing the bioavailability of other dietary sources of iron. In addition, SACN has recommended that adults with relatively high intakes of red and processed meat (>90g/day) consider reducing their intakes to reduce their risk of colorectal cancer[22]. However, this advice took account of evidence from a theoretical modelling exercise to assess the potential impact of reducing red and processed meat consumption on intakes of iron and zinc. This did not allow for potential changes in iron intake from the background diet due to the removal of added iron in wheat flour (other than wholemeal).

Security of flour consumption estimates

27. The flour consumption estimates used in the modelling for this paper are in line with other data based on food purchases (see Appendix B). However, the estimate of flour consumption used in the modelling is about 30% lower than estimates based on flour production figures taking account of wastage both in the food chain and at household level. There are a number of possible reasons for the discrepancy (see Appendix B). The possibility that some sources of flour in the diet have been missed has been considered but the small number of product types excluded is unlikely to have a significant impact on the consumption estimates. Under-reporting of consumption for some flour-containing products may also be a factor. However the same methodology applied to household purchase data from the Family Food module of the Living Costs and Food Survey (LCFS)[23] produced similar estimates. It seems more likely that wastage of flour or flour-containing products in food manufacture may be higher than envisaged, especially for certain product types such as coated meat or fish.

Security of estimates of nutrient intake

28. The modelling exercise used nutrient intake data taken directly from the most recent NDNS, and the results compared with current LRNIs. Mis-reporting of food consumption, generally under-reporting, is known to be a problem in NDNS as in all dietary surveys. There may be some under-reporting of bread and flour products consumed in NDNS. However, there is some evidence that under-reporting is selective – fatty and sugary foods are more likely to be under-reported than other foods[24]. It is not possible to say the degree to which specific micronutrients are likely to be under-reported.

Trends in bread and flour consumption

29. Comparison of current NDNS data with previous surveys shows that consumption of total bread, including white bread, has declined in all age groups[5]. There is some evidence of a switch from white to brown, granary and wheatgerm breads (including bread made from a mixture of white and wholegrain flour) although the majority of bread consumed is still white. Data on household food purchases from the LCFS[23] also shows a long-term decline in bread purchases. This suggests that bread is declining over time as a contributor to nutrient intake and current NDNS data shows that consumption of other flour-based products (eg buns, cakes, pastries, fruit pies and puddings and meat pies have also declined in most age groups[5].

30. Flour and bread, including grain products, are the most commonly used vehicles in countries that have adopted mandatory fortification. Previous work carried out to evaluate the potential mandatory fortification of bread or flour with folic acid in the UK to reduce the incidence of neural tube defects showed that wheat flour and bread are consumed almost universally and in relatively equal amounts across all population groups (including various ethnic and low socio economic groups). Over 90% of women with low folate intakes consume wheat bread[25].

Imported bread and flour

31. A proportion of bread and flour products consumed in the UK are imported and potentially not fortified. However, the proportion of bread and flour products currently imported into the UK has been reported as being *minimal*[vi]. Previous data shows that an amount equal to ~1% of domestic flour is imported[25]. For the purposes of estimating current intakes and modelling intakes the assumption has been made that all flour is sourced from the UK and therefore subject to the mandatory addition of nutrients. As a proportion of flour is imported this may reduce the impact of removing the nutrients although it is not possible to say to what extent.

[vi] Personal Communication, British Retail Consortium, 2012.

Socio-economic differences in impact

32. The impact of removing the mandatory addition of nutrients to flour could be greater in low income groups, particularly for calcium and iron. This is because low income groups tend to have lower intakes of these nutrients compared with the general population and tend to consume more bread (particularly white bread).

33. Analysis of micronutrient intakes in adults in benefit compared with non-benefit households in 2000/01 shows that the proportion of women with intakes below the LRNI for iron and calcium was higher in the benefit group than in the non-benefit group (53% below LRNI for iron and 12% for calcium in the benefit group compared with 29% for iron and 4% for calcium in the non-benefit group)[14]. Similarly, the Low Income Diet and Nutrition Survey (LIDNS)[26] found that 38% of women aged 19-64 years had iron intakes below the LRNI and 13% had calcium intakes below the LRNI. Mean iron intakes are notably lower in low income groups (68% of the RNI for women in LIDNS compared with 82% for the general population).

34. Data from LIDNS[26] show that adults and children from low income groups obtain 13% of their calcium intake and 10% of their iron intake from white bread and tend to have higher consumption of bread (notably white bread). Household purchase data from the LCFS[23] show that the lowest quintile for gross household income purchased 26% more total bread and 78% more white bread than the highest income quintile. For white bread the lowest income quintile purchased 170g/week more than the highest quintile, approximately equivalent to an additional small slice of bread per day (24g). Removing the addition of nutrients to white bread alone would reduce the iron and calcium content of the diet for the lowest income quintile by 0.14mg iron and 28mg calcium per day (5% of the EAR[9] for calcium and 2% for iron). There were no income differences in purchases of sandwiches.

35. Purchases of other flour containing products such as cakes, buns, pastries and biscuits and meat pies and pastries were also highest in the lowest income quintile but the differences were smaller – about 70g/week for cakes and biscuits and 50g/week for meat pies and pastries and were partially offset by lower purchases of pizza in the lowest income quintile. There was no income difference in purchases of flour. Analysis of purchases by net equivalised income[27] shows a similar pattern except that the highest bread purchases are found in the second lowest decile rather than the lowest.

36. Analysis of Scottish data from the LCFS[28], using the Scottish Index of Multiple Deprivation (SIMD)[29] also showed that households in the most deprived quintile purchased about 20g/day more non-wholemeal bread than did households in the least deprived quintile. Analysis of the 2006 Scottish children's survey dataset[30] by SIMD found that consumers of non-wholemeal bread (subject to the mandatory addition of nutrients) in the most deprived quintile ate about 5g per day more than those in the least deprived quintile. Preliminary results from the 2010 survey are very similar.

37. Data from the 2000/01 NDNS adults 19-64 years[31], analysed by household receipt of benefits, showed that adult men, but not women, in benefit households ate about 100g more white bread per week (14g per day) than those in non-benefit households. However the same analysis on the 1997 NDNS young people 4-18 years[32] dataset showed the difference in the opposite direction with slightly lower white bread consumption in benefit households. Analysis of NDNS data by social class, where available, shows higher white bread consumption in the manual social class group[32,33,34]. Analysis by income, where available, did not show higher white bread consumption in low income groups[32,33]. Consumption of biscuits, buns, cakes and pastries tended to be lower in benefit and manual social class households while consumption of meat pies and pastries tended to be higher in these households although the differences were not consistent across all age groups[31,32,33,34].

38. Data from LIDNS[26] shows that, in addition to this, adults aged 19-64 years from low income groups also consume less breakfast cereals when compared with data for the general population. Household purchase data from LCFS also shows lower breakfast cereal purchases in lower income groups[23].

Other sources of added niacin, thiamin, calcium and iron

39. Thiamin, niacin and iron added to wheat flour (other than wholemeal) on a mandatory basis are also added to many breakfast cereals on a voluntary basis. Some brands are also fortified with calcium. The LCFS records breakfast cereal purchases as stable for the last ten years[23]. However, data from the 2008/10 NDNS compared with previous NDNS surveys[5] suggests that breakfast cereal consumption has decreased in some age groups - older children, adults and adults aged 65+ years.

40. Current survey data[5] shows that between 37-62% of the population consumed high fibre breakfast cereals[35] and between 20-64% of the population consume ‘other’ types of breakfast cereal (depending on age) over a four-day recording period. Children aged 4-10 years were more likely to consume breakfast cereal than any other age group.

41. The modelling exercise shows that young people (particularly females) would be at increased risk of low calcium and iron intakes should the mandatory addition of nutrients to wheat flour (other than wholemeal) cease. Recent survey data shows a third (33%) of girls aged 11-18 years consumed high fibre breakfast cereals and around half (49%) consumed ‘other’ types of breakfast cereals over a four-day recording period[5]. Breakfast cereals often have added thiamin, niacin, calcium and iron and can make a valuable contribution to total intakes of these nutrients.

42. Thiamin and niacin have been widely added to breakfast cereals for many years and they provide up to a quarter of intake for thiamin and up to a fifth of intake for niacin equivalents in young people[32], and 10% of niacin equivalents and 14% of thiamin in adults[14].

43. There have been increases in the levels of calcium added to some major brands of breakfast cereals since the last NDNS of young people (1997)[32] which has contributed to the higher calcium intakes seen in children in the current compared with previous NDNS, in spite of a drop in milk consumption. Today some branded breakfast cereals commonly consumed by children are typically fortified at levels of 400-500mg/100g. However NDNS data shows that the overall contribution of breakfast cereals to calcium intake is small (2-6% on average) as relatively few products are fortified[13]. Wider voluntary fortification of other products with calcium such as processed cheese, fruit juice and powdered beverages, has also contributed to the increase in intakes, especially in children.

44. Iron has also been added to a wide range of breakfast cereals on a voluntary basis for many years. There has been little change overall in levels of iron fortification in breakfast cereals as this is constrained by technological and palatability limitations. The relative contribution that cereals and cereal products make to iron intakes has decreased in children and adults (due to higher meat consumption and lower breakfast cereal consumption). Children aged 1½ to 10 years obtain a quarter of their iron intake from breakfast cereals, and older children aged 11-18 years, 18%. The contribution is lower in adults aged 19-64 years (12%)[13]. However, as stated in paragraph 25 above, iron salts used in fortified foods may be of little practical value in improving iron status.

45. The results of the modelling exercise assume that the background diet remains unchanged and that voluntary fortification of breakfast cereals remains at current levels and continues to contribute to total intakes of thiamin, niacin, calcium and iron. However, should industry decide to discontinue fortification of these products or reduce the levels added, this might increase the proportion of some groups in the population who are at risk due to low intakes. Similarly any move by industry to increase the levels added would be of concern if intakes for high consumers exceeded guidelines on safe levels of intake[36]. Should mandatory addition of nutrients to wheat flour (other than wholemeal) cease, guidance on voluntary fortification of breakfast cereals for industry should be considered as these are a notable source of these nutrients.

Regional differences in impact

46. There may also be regional differences in impact due to differences in consumption of bread and flour products. Household purchase data from LCFS[23] shows that there are differences in bread purchases by UK country and by regions of England. Households in Northern Ireland and Scotland purchased more bread than did English or Welsh households. Northern Irish households purchased 176g more total bread per week, of which 126g more white bread than did households in England. For Scotland the difference was smaller, 80g total bread per week of which 26g white bread. Within England, total and white bread purchases were highest in the West Midlands and lowest in London, with a difference of 162g/week for white bread and 170g/week for total bread. Household purchases of flour were three times as high in England as in Northern Ireland. Purchases of most other flour-containing products were lower in London than in other regions of England but there were no other clear patterns of regional or country differences.

47. NDNS data from 2000/01[31] showed that white bread consumption for men was higher in Northern England and Central and South West England and Wales than in Scotland and London and the South East. There were no differences for women and no clear pattern for other age groups. There was no clear pattern of regional differences in consumption of other flour-containing products.

48. It should be noted that apparent regional differences may be partly due to socio-economic factors.

Summary of the evidence

49. In 1981 the COMA report on the Nutritional Aspects of Bread and Flour[2] concluded that the addition of calcium and the restitution of iron, thiamin and niacin to flour should no longer be mandatory. The 1998 COMA report on Nutrition and Bone Health[3] recommended that calcium fortification of flour be retained to ensure that intakes did not fall below then current levels.

50. Modelling of NDNS data suggests that the impact of removing added thiamin and niacin from wheat flour (other than wholemeal) would be small, as these nutrients are widespread in the diet, intakes are well above DRVs and clinical deficiency is rare.

51. The effect of removing added calcium and iron from wheat flour (other than wholemeal) on total intakes of these nutrients would be far greater (particularly for calcium), and the greatest impact would be for those population groups whose intakes are already low and of particular concern, that is, older children and young adults (particularly females).

52. Low calcium intakes are already seen in a proportion of older children and young women. 15% of girls and 8% of boys aged 11-18 years currently have intakes below the LRNI[8]. Ceasing the fortification of flour with calcium would increase the proportion of these groups below the LRNI to over a fifth of girls (21%) and over a tenth of boys (12%). There would also be a general downward shift in population intakes of calcium except for the youngest age group (1½ - 3 years). The increase in the proportion with intakes below the LRNI implies increased risk of deficiency which has been associated with poor bone health. Bone accretion in childhood and adolescence is affected by total calcium intake and determines adult bone mass which is a significant predictor of fracture risk late in life. Currently almost half of all women and one in six men experience osteoporotic fracture before death. Bread and other products made with flour subject to mandatory addition of nutrients are an important source of calcium in the diet, particularly as milk consumption (a rich source of calcium) is in decline. Cereals and cereal products provide around 30% of calcium intakes, the majority from bread and flour containing products.

53. A high proportion of girls and women currently have low iron intakes and there is evidence of iron-deficiency anaemia and low iron stores in a proportion of adult women and older girls in the UK. The removal of added iron from flour (other than wholemeal) would increase the proportion of girls aged 11-18 years with intakes below the LRNI[8] from 44% to 50% and women 19-64 years from 22% to 25%.

54. The impact of low iron intakes on the risk of iron deficiency is unclear as to some extent the body is able to adapt to variation in iron intake. In addition, there is limited evidence of a beneficial effect on iron status from the addition of iron to wheat flour (other than wholemeal) at a population level to combat iron deficiency. Evidence suggests that iron in the form added to wheat flour (and in iron fortified foods) is poorly absorbed and may be of little practical use in improving iron status even in individuals with increased systemic iron needs, possibly due to low solubility and intestinal uptake[22].

55. There has been a long term decline in bread consumption but it remains an important source of the added nutrients, particularly calcium.

56. The effect of repealing the bread and flour regulations on the proportion with intakes less than the LRNI[8] will be greater for lower socio-economic groups. This is because low income groups tend to have lower intakes of these and other nutrients compared with the general population and bread makes a larger contribution to their nutrient intake.

57. There may be regional differences in impact if added nutrients were removed from wheat flour (other than wholemeal) as there are differences in bread consumption by UK country and by regions of England. There are no clear patterns in consumption of other flour-containing products. However, it should be noted that apparent regional differences may be partly due to socio-economic factors.

Conclusions

58. In 1981 the COMA report on the Nutritional Aspects of Bread and Flour[2] concluded that the addition of calcium and the restitution of iron, thiamin and niacin to flour should no longer be mandatory. The 1998 COMA report on Nutrition and Bone Health[3] recommended that calcium fortification of flour be retained to ensure that intakes did not fall below then current levels. The evidence presented in this paper shows that repealing the UK bread and flour regulations will decrease intakes of thiamin, niacin, calcium and iron, and increase the proportion of the population with intakes less than the LRNI[8] (for calcium and iron in particular). The LRNI has been set as a threshold of increased risk and therefore an increase in the proportion of the population with intakes less than the LRNI implies an increased risk of diseases associated with nutrient deficiency. The evidence also shows a downward shift in population intakes, particularly for calcium, indicating a change in risk across the population. For calcium, the evidence presented in this paper supports the assessment made previously by COMA in the 1998 Nutrition and Bone Health report[3].

59. In order of public health nutrition importance, the case for maintaining the mandatory addition of calcium to wheat flour (other than wholemeal flour) is strongest, followed by iron. Evidence to continue the mandatory addition of niacin and thiamin to wheat flour (other than wholemeal flour) is much weaker.

60. There is evidence that withdrawing calcium fortification would increase the proportion with intakes below the LRNI[8] and the corresponding risk of inadequate calcium intakes in the population particularly for women and low income groups. This implies an increased risk of deficiency which has been associated with poor bone health and subsequent osteoporotic fracture.

61. Removing iron currently added to wheat flour (other than wholemeal) would decrease iron intakes in the population and increase the proportion of the population with intakes less than the LRNI[8]. However, the impact of this is unclear due to uncertainties associated with the ability of the body to adapt to low iron intakes and low intestinal uptake of iron in the form added to wheat flour (other than wholemeal).

62. The effect of repealing the bread and flour regulations on the proportion with intakes less than the LRNI[8] will be greater for lower socio-economic groups.

63. The effect of any amendments made to the current mandatory addition of thiamin, niacin, calcium and iron to wheat flour (other than wholemeal) should be adequately monitored and evaluated to determine effects on nutrient intake and status of the general population.

64. If the Regulations are repealed guidance on voluntary fortification for industry should be considered. Voluntary fortification of breakfast cereals would require particular attention as these are a notable source of nutrients currently added to wheat flour (other than wholemeal).

65. Guidance to manufacturers on appropriate levels to be added on a voluntary basis should be considered. Discontinuing voluntary fortification of products currently fortified with nutrients added to wheat flour (other than wholemeal), or reducing the levels added would increase the proportion of those at risk due to low intakes. Conversely, an increase in the levels of voluntary fortificants added may lead to excess intakes above guidance levels.

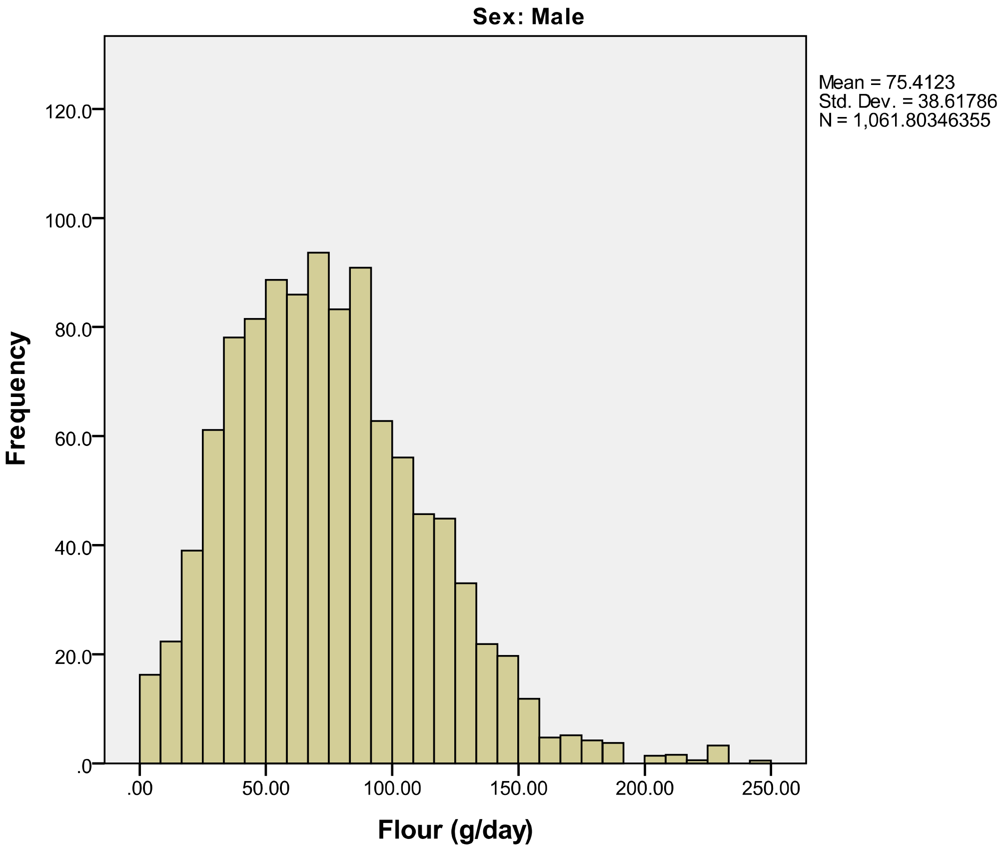
66. Bread is a widely consumed food and is thus an important vehicle for fortification with other nutrients. No other food is as universally consumed (including those already fortified voluntarily, such as breakfast cereals). Repealing the Regulations would create difficulties for extending the practice of fortification to improve population health, for example with folic acid to reduce the incidence of neural tube defects[4].

Table 1: Distribution of flour consumption (grams per day) by age and sex

	Age (Years)	N*	N**	Mean	Std Deviation	Min	Percentiles 2.5%	5%	10%	25%	50%	75%	90%	95%	97.5%	Max
Males	4-10	212	210	68.1	28.2	4.5	16.0	25.6	32.3	48.6	67.4	85.7	105.9	119.0	127.3	160.0
	11-18	267	238	88.6	37.4	8.2	29.1	33.5	41.3	60.0	84.7	115.9	137.7	152.9	177.2	228.7
	19-64	405	346	78.3	40.7	0	11.7	20.5	29.1	49.1	73.7	101.9	133.9	146.7	168.5	244.9
	65+	95	96	75.8	40.3	0	3.6	11.7	24.2	41.9	77.4	103.7	120.5	149.9	168.2	219.9
	SubTotal	**979**	**890**	**75.4**	**38.6**	**0**	**12.9**	**19.6**	**29.4**	**48.0**	**71.7**	**99.4**	**126.0**	**143.0**	**157.7**	**244.9**
Females	4-10	202	213	62.7	28.5	7.1	12.3	21.1	27.9	45.2	59.8	76.3	100.6	120.1	142.7	157.9
	11-18	253	215	66.7	31.5	0	13.1	19.3	26.2	42.9	64.1	85.6	112.2	122.7	135.2	173.2
	19-64	408	461	56.8	33.9	0	5.0	8.9	15.4	32.3	52.3	80.2	103.2	117.0	132.7	185.5
	65+	122	128	54.4	27.2	2.7	5.5	10.6	17.2	35.8	52.6	75.3	86.4	99.1	124.5	128.3
	SubTotal	**985**	**1017**	**58.4**	**31.7**	**0**	**7.6**	**11.8**	**19.6**	**35.5**	**55.6**	**78.5**	**100.9**	**116.2**	**127.8**	**185.5**
Overall	1½-3	162	219	36.3	20.9	0	3.9	8.1	12.6	21.2	32.6	49.3	63.2	76.7	90.2	119.7
	4-10	414	423	65.4	28.4	4.5	13.4	22.5	31.4	46.9	62.5	82.0	103.1	118.8	128.2	160.0
	11-18	519	453	78.0	36.3	0	18.8	25.0	33.7	51.9	75.2	100.9	125.7	140.1	154.3	228.7
	19-64	813	807	67.5	38.9	0	7.3	12.0	20.3	39.4	63.2	89.9	117.6	138.5	151.0	244.9
	65+	218	224	63.8	35.1	0	4.8	11.2	19.7	39.6	59.9	85.6	110.4	123.2	145.4	219.9
	Total	**2126**	**2126**	**66.9**	**36.3**	**0**	**8.9**	**15.4**	**22.7**	**40.3**	**62.8**	**88.1**	**116.3**	**130.9**	**148.3**	**244.9**

Note: Subtotals also include 1½ to 3 yrs
* Weighted Numbers
** Unweighted Base Numbers

Figure 1: Distributions of flour consumption by sex (as modelled)



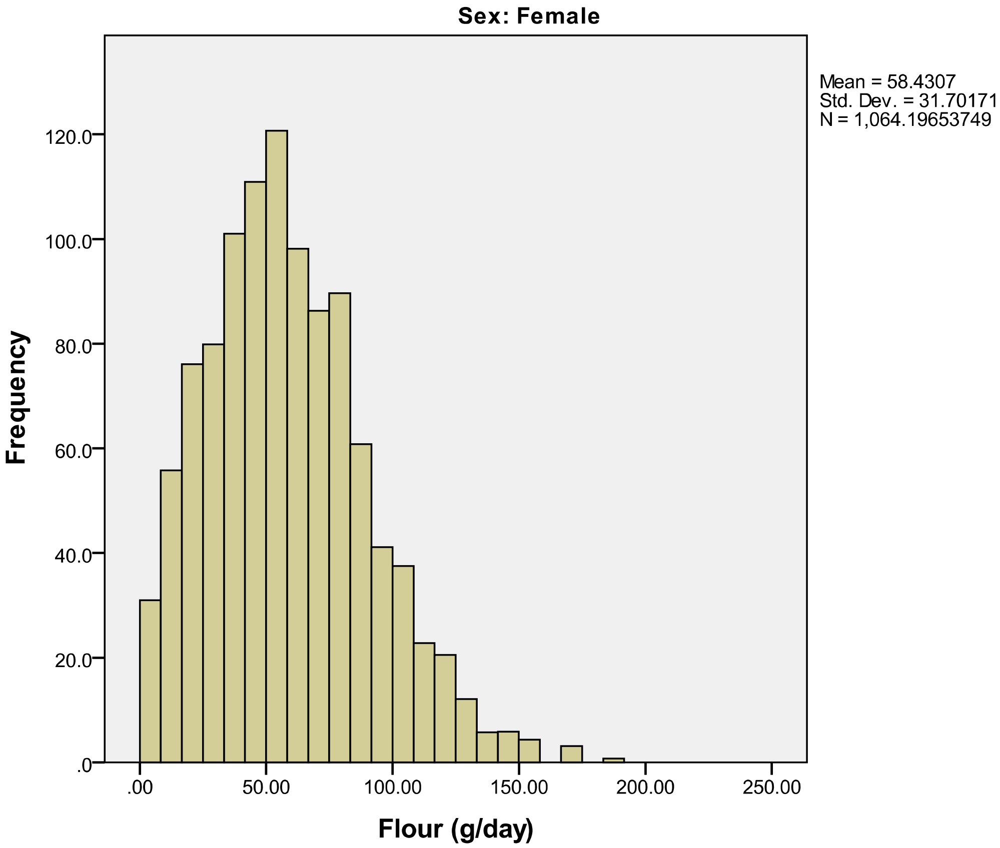


Table 2 Intake of thiamin[3] with and without addition of thiamin to wheat flour (other than wholemeal), by age and sex

	Intake with thiamin added to wheat flour (other than wholemeal)[1]					Intake without thiamin added to wheat flour (other than wholemeal)[2]				
Males aged (years)	**Mean (mg)**	**Mean intakes as a % of RNI**	**Estimated number (%) below RNI**	**Estimated number (%) below EAR**	**Estimated number (%) below LRNI**	**Mean (mg)**	**Mean intakes as a % of RNI**	**Estimated number (%) below RNI**	**Estimated number (%) below EAR**	**Estimated number (%) below LRNI**
4-10	1.33	202	14,000 (1%)	- (0%)	- (0%)	1.21	184	81,000 (3%)	6,000 (<0.5%)	- (0%)
11-18	1.60	155	460,000 (15%)	130,000 (4%)	55,000 (2%)	1.44	139	823,000 (27%)	278,000 (9%)	136,000 (4%)
19-64	1.65	156	3,130,000 (17%)	848,000 (4%)	171,000 (1%)	1.51	143	4,498,000 (24%)	1,392,000 (7%)	328,000 (2%)
65+	1.56	173	332,000 (7%)	244,000 (5%)	66,000 (1%)	1.42	158	525,000 (12%)	332,000 (7%)	154,000 (3%)
Subtotal	1.51	174	3,277,000 (11%)	985,000 (3%)	279,000 (1%)	1.38	158	5,283,000 (17%)	1,748,000 (6%)	628,000 (2%)
Females aged (years)										
4-10	1.26	193	48,000 (2%)	- (0%)	- (0%)	1.15	175	89,000 (4%)	- (0%)	- (0%)
11-18	1.25	131	575,000 (20%)	117,000 (4%)	53,000 (2%)	1.13	119	920,000 (32%)	200,000 (7%)	96,000 (3%)
19-64	1.29	156	2,189,000 (12%)	892,000 (5%)	361,000 (2%)	1.19	144	3,440,000 (18%)	1,453,000 (8%)	399,000 (2%)
65+	1.31	174	197,000 (3%)	144,000 (2%)	- (0%)	1.21	161	547,000 (9%)	144,000 (2%)	73,000 (1%)
Subtotal	1.25	164	3,134,000 (10%)	1,001,000 (3%)	413,000 (1%)	1.14	151	5,137,000 (16%)	1,564,000 (5%)	594,000 (2%)
All aged (years)										
1½ -3	0.94	236	25,000 (1%)	25,000 (1%)	25,000 (1%)	0.88	220	34,000 (1%)	25,000 (1%)	25,000 (1%)
4–10	1.30	198	62,000 (1%)	- (0%)	- (0%)	1.18	180	170,000 (3%)	6,000 (<0.5%)	- (0%)
11-18	1.43	143	1,035,000 (17%)	248,000 (4%)	108,000 (2%)	1.29	129	1,743,000 (29%)	477,000 (8%)	232,000 (4%)
19–64	1.47	156	5,319,000 (14%)	1,740,000 (5%)	532,000 (1%)	1.35	143	7,937,000 (21%)	2,845,000 (7%)	727,000 (2%)
65+	1.42	174	529,000 (5%)	387,000 (4%)	66,000 (1%)	1.30	160	1,072,000 (10%)	475,000 (5%)	227,000 (2%)
Total	1.38	169	6,414,000 (10%)	1,986,000 (3%)	691,000 (1%)	1.26	154	10,424,000 (17%)	3,315,000 (5%)	1,222,000 (2%)

Note: Subtotals also include 1½ to 3 yrs. Modelled data from the National Diet and Nutrition Survey Rolling Programme (Years 1 and 2 combined: 2008/9–2009/10) to show the effect on intakes of removing added nutrients to wheat flour (other than wholemeal flour). Mid-2010 UK population estimates. Source: http://www.ons.gov.uk/ons/rel/pop-estimate/population-estimates-for-uk--england-and-wales--scotland-and-northern-ireland/population-estimates-timeseries-1971-to-current-year/rft---table-2-quinary-age-groups-constituent-countries.zip [NB: the estimated total numbers affected in the population do not equate to individual totals exactly due to the way in which the age splits have been estimated]

[1] Based on flour with added nutrients – nutrient databank values

[2] Based on levels in flour without added nutrients. Modelling based on estimated flour consumption

[3] Excludes intake from dietary supplements

'-' = zero

Table 3 Intake of **niacin equivalents**[3] with and without addition of niacin to wheat flour (other than wholemeal), by age and sex

	Intake **with niacin added** to wheat flour (other than wholemeal)[1]					Intake **without niacin added** to wheat flour (other than wholemeal)[2]				
Males aged (years)	**Mean (mg)**	**Mean intakes as a % of RNI**	**Estimated number (%) below RNI**	**Estimated number (%) below EAR**	**Estimated number (%) below LRNI**	**Mean (mg)**	**Mean intakes as a % of RNI**	**Estimated number (%) below RNI**	**Estimated number (%) below EAR**	**Estimated number (%) below LRNI**
4-10	27.7	251	- (0%)	- (0%)	- (0%)	27.0	245	- (0%)	- (0%)	- (0%)
11-18	36.9	208	88,000 (3%)	11,000 (<0.5%)	- (0%)	36.1	203	161,000 (5%)	38,000 (1%)	- (0%)
19-64	44.6	255	49,000 (<0.5%)	49,000 (<0.5%)	49,000 (<0.5%)	43.8	250	49,000 (<0.5%)	49,000 (<0.5%)	49,000 (<0.5%)
65+	37.5	244	59,000 (1%)	29,000 (1%)	29,000 (1%)	36.7	239	59,000 (1%)	59,000 (1%)	29,000 (1%)
Subtotal	36.7	245	282,000 (1%)	74,000 (<0.5%)	48,000 (<0.5%)	36.0	240	464,000 (2%)	160,000 (1%)	48,000 (<0.5%)
Females aged (years)										
4-10	26.3	256	6,000 (<0.5%)	- (0%)	- (0%)	25.7	250	6,000 (<0.5%)	- (0%)	- (0%)
11-18	30.1	198	152,000 (5%)	103,000 (4%)	27,000 (1%)	29.4	193	159,000 (5%)	103,000 (4%)	27,000 (1%)
19-64	32.2	230	537,000 (3%)	221,000 (1%)	111,000 (1%)	31.6	226	571,000 (3%)	221,000 (1%)	111,000 (1%)
65+	29.8	241	- (0%)	- (0%)	- (0%)	29.3	236	- (0%)	- (0%)	- (0%)
Subtotal	29.3	235	791,000 (3%)	452,000 (1%)	191,000 (1%)	28.7	230	831,000 (3%)	452,000 (1%)	191,000 (1%)
All aged (years)										
1½ -3	19.4	310	25,000 (1%)	25,000 (1%)	25,000 (1%)	19.0	304	25,000 (1%)	25,000 (1%)	25,000 (1%)
4–10	27.0	254	6,000 (<0.5%)	- (0%)	- (0%)	26.4	248	6,000 (<0.5%)	- (0%)	- (0%)
11-18	33.6	203	239,000 (4%)	113,000 (2%)	27,000 (<0.5%)	32.8	198	321,000 (5%)	141,000 (2%)	27,000 (<0.5%)
19–64	38.4	242	587,000 (2%)	271,000 (1%)	160,000 (<0.5%)	37.7	238	621,000 (2%)	271,000 (1%)	160,000 (<0.5%)
65+	33.2	242	59,000 (1%)	29,000 (<0.5%)	29,000 (<0.5%)	32.5	237	59,000 (1%)	59,000 (1%)	29,000 (<0.5%)
Total	33.0	240	1,066,000 (2%)	520,000 (1%)	237,000 (<0.5%)	32.3	235	1,290,000 (2%)	608,000 (1%)	237,000 (<0.5%)

Note: Subtotals also include 1½ to 3 yrs. Modelled data from the National Diet and Nutrition Survey Rolling Programme (Years 1 and 2 combined: 2008/9–2009/10) to show the effect on intakes of removing added nutrients to wheat flour (other than wholemeal flour). Mid-2010 UK population estimates. Source: http://www.ons.gov.uk/ons/rel/pop-estimate/population-estimates-for-uk--england-and-wales--scotland-and-northern-ireland/population-estimates-timeseries-1971-to-current-year/rft---table-2-quinary-age-groups-constituent-countries.zip [NB: the estimated total numbers affected in the population do not equate to individual totals exactly due to the way in which the age splits have been estimated]

[1] Based on flour with added nutrients – nutrient databank values

[2] Based on levels in flour without added nutrients. Modelling based on estimated flour consumption

[3] Excludes intake from dietary supplements

'-' = zero

Table 4: Intake of **calcium**[3] with and without addition of calcium to wheat flour (other than wholemeal) by age and sex

	Intake **with calcium added** to wheat flour (other than wholemeal)[1]					Intake **without calcium added** to wheat flour (other than wholemeal)[2]				
Males aged (years)	**Mean (mg)**	**Mean intakes as a % of RNI**	**Estimated number (%) below RNI**	**Estimated number (%) below EAR**	**Estimated number (%) below LRNI**	**Mean (mg)**	**Mean intakes as a % of RNI**	**Estimated number (%) below RNI**	**Estimated number (%) below EAR**	**Estimated number (%) below LRNI**
4-10	838	167	247,000 (10%)	51,000 (2%)	7,000 (<0.5%)	783	156	341,000 (14%)	81,000 (3%)	39,000 (2%)
11-18	868	87	2,167,000 (71%)	1,360,000 (44%)	242,000 (8%)	796	80	2,382,000 (78%)	1,566,000 (51%)	381,000 (12%)
19-64	921	132	5,718,000 (30%)	2,317,000 (12%)	532,000 (3%)	858	123	6,941,000 (37%)	3,174,000 (17%)	815,000 (4%)
65+	964	138	983,000 (22%)	413,000 (9%)	57,000 (1%)	902	129	1,187,000 (26%)	617,000 (14%)	155,000 (3%)
Subtotal	887	136	10,097,000 (33%)	5,142,000 (17%)	974,000 (3%)	826	127	11,721,000 (39%)	6,429,000 (21%)	1,627,000 (5%)
Females aged (years)										
4-10	767	153	397,000 (16%)	107,000 (4%)	42,000 (2%)	717	143	514,000 (21%)	175,000 (7%)	42,000 (2%)
11-18	696	87	2,092,000 (72%)	1,256,000 (43%)	434,000 (15%)	642	80	2,305,000 (79%)	1,619,000 (56%)	623,000 (21%)
19-64	738	105	9,086,000 (48%)	4,148,000 (22%)	1,091,000 (6%)	692	99	10,659,000 (56%)	5,168,000 (27%)	1,748,000 (9%)
65+	799	114	2,057,000 (36%)	605,000 (10%)	156,000 (3%)	755	108	2,688,000 (47%)	1,010,000 (18%)	262,000 (5%)
Subtotal	740	119	13,412,000 (43%)	6,519,000 (21%)	2,043,000 (7%)	692	111	15,628,000 (50%)	8,516,000 (27%)	3,005,000 (10%)
All aged (years)										
1½ -3	773	221	91,000 (4%)	34,000 (1%)	25,000 (1%)	744	213	91,000 (4%)	71,000 (3%)	25,000 (1%)
4–10	804	160	643,000 (13%)	157,000 (3%)	49,000 (1%)	751	150	855,000 (17%)	255,000 (5%)	82,000 (2%)
11-18	784	87	4,259,000 (71%)	2,616,000 (44%)	676,000 (11%)	721	80	4,687,000 (78%)	3,185,000 (53%)	1,004,000 (17%)
19–64	829	118	14,808,000 (39%)	6,466,000 (17%)	1,623,000 (4%)	775	111	17,604,000 (46%)	8,344,000 (22%)	2,564,000 (7%)
65+	871	124	3,043,000 (30%)	1,019,000 (10%)	213,000 (2%)	819	117	3,879,000 (38%)	1,628,000 (16%)	417,000 (4%)
Total	813	127	23,465,000 (38%)	11,643,000 (19%)	3,002,000 (5%)	759	119	27,297,000 (44%)	14,918,000 (24%)	4,612,000 (8%)

Note: Subtotals also include 1½ to 3 yrs. Modelled data from the National Diet and Nutrition Survey Rolling Programme (Years 1 and 2 combined: 2008/9–2009/10) to show the effect on intakes of removing added nutrients to wheat flour (other than wholemeal flour). Mid-2010 UK population estimates. Source: http://www.ons.gov.uk/ons/rel/pop-estimate/population-estimates-for-uk--england-and-wales--scotland-and-northern-ireland/population-estimates-timeseries-1971-to-current-year/rft---table-2-quinary-age-groups-constituent-countries.zip [NB: the estimated total numbers affected in the population do not equate to individual totals exactly due to the way in which the age splits have been estimated]

1 Based on flour with added nutrients – nutrient databank values

2 Based on levels in flour without added nutrients. Modelling based on estimated flour consumption

3 Excludes intake from dietary supplements

'-' = zero

Table 5 Intake of **iron**[3] with and without addition of iron to wheat flour (other than wholemeal) by age and sex

	Intake **with iron added** to wheat flour (other than wholemeal)[1]					Intake **without iron added** to wheat flour (other than wholemeal)[2]				
Males aged (years)	**Mean (mg)**	**Mean intakes as a % of RNI**	**Estimated number (%) below RNI**	**Estimated number (%) below EAR**	**Estimated number (%) below LRNI**	**Mean (mg)**	**Mean intakes as a % of RNI**	**Estimated number (%) below RNI**	**Estimated number (%) below EAR**	**Estimated number (%) below LRNI**
4-10	9.1	122	724,000 (29%)	118,000 (5%)	10,000 (<0.5%)	8.8	118	819,000 (33%)	169,000 (7%)	10,000 (<0.5%)
11-18	10.8	95	1,907,000 (62%)	768,000 (25%)	167,000 (5%)	10.4	92	2,023,000 (66%)	909,000 (30%)	223,000 (7%)
19-64	12.0	138	4,011,000 (21%)	1,785,000 (9%)	253,000 (1%)	11.7	134	4,391,000 (23%)	1,906,000 (10%)	253,000 (1%)
65+	11.3	130	1,067,000 (24%)	382,000 (8%)	150,000 (3%)	11.0	127	1,297,000 (29%)	408,000 (9%)	150,000 (3%)
Subtotal	10.6	120	10,991,000 (36%)	4,246,000 (14%)	825,000 (3%)	10.3	117	11,929,000 (39%)	4,871,000 (16%)	988,000 (3%)
Females aged (years)										
4-10	8.4	113	914,000 (38%)	229,000 (10%)	26,000 (1%)	8.2	110	1,024,000 (43%)	335,000 (14%)	26,000 (1%)
11-18	8.6	58	2,854,000 (98%)	2,464,000 (85%)	1,278,000 (44%)	8.3	56	2,854,000 (98%)	2,523,000 (87%)	1,467,000 (50%)
19-64	9.8	80	14,579,000 (77%)	10,342,000 (54%)	4,212,000 (22%)	9.5	79	14,833,000 (78%)	10,613,000 (56%)	4,700,000 (25%)
65+	9.5	109	2,519,000 (44%)	764,000 (13%)	33,000 (1%)	9.3	107	2,820,000 (49%)	998,000 (17%)	89,000 (2%)
Subtotal	8.9	85	21,905,000 (70%)	14,586,000 (47%)	6,213,000 (20%)	8.7	83	22,553,000 (72%)	15,387,000 (49%)	7,036,000 (23%)
All aged (years)										
1½ -3	6.3	92	1,522,000 (66%)	742,000 (32%)	181,000 (8%)	6.2	90	1,564,000 (68%)	811,000 (35%)	193,000 (8%)
4–10	8.7	118	1,638,000 (33%)	348,000 (7%)	36,000 (1%)	8.5	114	1,844,000 (37%)	504,000 (10%)	36,000 (1%)
11-18	9.7	77	4,761,000 (80%)	3,231,000 (54%)	1,444,000 (24%)	9.4	75	4,877,000 (82%)	3,431,000 (57%)	1,689,000 (28%)
19–64	10.9	109	18,601,000 (49%)	12,137,000 (32%)	4,470,000 (12%)	10.6	106	19,235,000 (51%)	12,529,000 (33%)	4,958,000 (13%)
65+	10.3	118	3,590,000 (35%)	1,146,000 (11%)	182,000 (2%)	10.1	116	4,121,000 (40%)	1,408,000 (14%)	239,000 (2%)
Total	9.8	103	32,739,000 (53%)	18,680,000 (30%)	6,959,000 (11%)	9.5	100	34,330,000 (56%)	20,105,000 (33%)	7,935,000 (13%)

Note: Subtotals also include 1½ to 3 yrs. Modelled data from the National Diet and Nutrition Survey Rolling Programme (Years 1 and 2 combined: 2008/9–2009/10) to show the effect on intakes of removing added nutrients to wheat flour (other than wholemeal flour). Mid-2010 UK population estimates. Source: http://www.ons.gov.uk/ons/rel/pop-estimate/population-estimates-for-uk--england-and-wales--scotland-and-northern-ireland/population-estimates-timeseries-1971-to-current-year/rft---table-2-quinary-age-groups-constituent-countries.zip [NB: the estimated total numbers affected in the population do not equate to individual totals exactly due to the way in which the age splits have been estimated]

[1] Based on flour with added nutrients – nutrient databank values

[2] Based on levels in flour without added nutrients. Modelling based on estimated flour consumption

[3] Excludes intake from dietary supplements

'-' = zero

Appendix A

Table A: Mandatory Nutrients and levels to be added to wheat flour (except wholemeal flour) as set out in the Bread & Flour Regulations 1998

Nutrient	Amount per 100g flour	Form
Calcium**	235-390mg [94-156mg calcium][37]	Calcium carbonate
Iron	≥1.65mg	Any or a combination of[38]: - ferric ammonium citrate - green ferric ammonium citrate - ferrous sulphate - dried ferrous sulphate - iron powder
Thiamin	≥ 0.24mg [0.21mg thiamin][39]	Thiamine hydrochloride
Niacin	≥ 1.60mg	Nicotinic acid or nicotinamide

** Except self-raising flour which contains ≤0.2% Ca

List of assumptions in modelling

- The percentage of flour in each of the main NDNS flour containing food groups was estimated using the same approach used to model the impact of fortification of flour with folic acid on folate intakes (for the SACN Folate Report)[4]
- The percentages of flour used in the analysis are shown in Table B
- The flour content of products not covered in Table B was assumed to be zero
- This approach excludes some products that would contain flour in the recipe such as savoury flans, pies (other than meat pies and pastries), quiches and wheat flour based snack products. The contribution of these products to flour consumption was considered to be low and so they were omitted from the analysis
- Bread based on non-wheat flour is in a separate NDNS food group which is not included in the analysis
- Wholemeal bread is in a separate NDNS food group which is not included in the analysis
- All flour consumed is milled in the UK and subject to added niacin, thiamin, iron and calcium. This is based on information that imported flour represents an insignificant proportion of flour consumed in the UK
- All flour consumed (excluding wholemeal flour or non-wheat flour) is plain, white flour. We have modelled this 'worst case scenario' on the premise that:

- Wholemeal bread is the only significant source of wholemeal flour. Survey data shows that white bread is by far the most commonly consumed type of bread across all age and sex groups, particularly for those population groups where the impact of removing mandatory addition of nutrients to flour would be greater (eg young people aged 11-18 years and low income groups). All other flour-containing products are usually made with white flour.
- White self raising flour is excluded from mandatory requirement to add calcium if it already has a calcium content of not less than 0.2%. Recent data shows the majority of flour produced is used for products requiring plain flour ie white breadmaking (50%) and biscuits (12.3). The production of self raising flour is relatively low (1.6% in 1998/9)[40].

- The composition of white flour with and without added niacin, thiamin, iron and calcium is as shown in Table C

Table B: Flour content of food products

NDNS Food Group	Estimated % Flour
White Bread	63
Brown, granary and wheatgerm bread	63
Pizzas	25
Other cereals, dumplings Yorkshire puddings etc	25
Biscuits	50
Fruit pies	30
Buns Cakes & Pastries	45
Sponge type puddings	30
Other cereal based puddings (crumbles, bread pudding, pancakes, cheesecake trifle etc)	10
Meat pies and pastries	25
Coated chicken and turkey	15
Burgers and kebabs	20
Coated and battered white fish	20

Table C: Composition of white flour with and without added nutrients

Food	**Composition of food mg per 100g**			
	Calcium	Iron	Thiamin	Niacin
Wheat flour, white, plain, with added nutrients[41]	96	1.9	0.28	1.7
Wheat flour, white, plain, without added nutrients[42]	15	1.5	0.10	0.7
Difference	***81***	***0.4***	***0.18***	***1.0***

Table D: Dietary Reference Values by age and sex[6,7]

Nutrient	Age/sex	LRNI	EAR	RNI
Calcium (mg/day)	1-3 yrs M&F	200	275	350
	4-6 yrs M&F	275	350	450
	7-10 yrs M&F	325	425	550
	11-14 yrs M	480	750	1000
	11-14 yrs F	450	625	800
	15-18 yrs M	480	750	1000
	15-18 yrs F	450	625	800
	19-50 yrs M&F	400	525	700
	50+ yrs M&F	400	525	700
Iron (mg/day)	1-3 yrs M&F	3.7	5.3	6.9
	4-6 yrs M&F	3.3	4.7	6.1
	7-10 yrs M&F	4.7	6.7	8.7
	11-14 yrs M	6.1	8.7	11.3
	11-14 yrs F	8.0	11.4	14.8
	15-18 yrs M	6.1	8.7	11.3
	15-18 yrs F	8.0	11.4	14.8
	19-50 yrs M	4.7	6.7	8.7
	19-50 yrs F	8.0	11.4	14.8
	50+ yrs M&F	4.7	6.7	8.7
Thiamin (mg/day)	1-3 yrs M&F	0.2	0.3	0.4
	4-6 yrs M&F	0.3	0.4	0.6
	7-10 yrs M&F	0.4	0.5	0.7
	11-14 yrs M &F	0.5	0.7	0.9
	15-18 yrs M	0.7	0.9	1.2
	15-18 yrs F	0.6	0.7	1.0
	19-24 yrs M	0.6	0.8	1.1
	19-24 yrs F	0.5	0.7	0.9
	25-34 yrs M	0.6	0.8	1.1
	25-34 yrs F	0.5	0.7	0.9
	35-44 yrs M	0.6	0.8	1.1
	35-44 yrs F	0.5	0.6	0.8
	45-54 yrs M	0.6	0.8	1.0
	45-54 yrs F	0.5	0.6	0.8
	55-64 yrs M	0.6	0.8	1.0
	55-64 yrs F	0.5	0.6	0.8
	65-74 yrs M	0.5	0.7	0.9
	65-74 yrs F	0.4	0.6	0.8
	75+ yrs M	0.5	0.7	0.9
	75+ yrs F	0.4	0.6	0.7
Niacin equivalents (mg/day)	1-3 yrs M	4.3	5.4	6.5
	1-3 yrs F	4.0	5.0	6.0
	4-6 yrs M	6.5	8.1	9.8
	4-6 yrs F	6.1	7.6	9.1
	7-10 yrs M	8.0	10.0	12.0
	7-10 yrs F	7.5	9.3	11.2
	11-14 yrs M	10.4	13.0	15.6
	11-14 yrs F	9.6	12.0	14.4
	15-18 yrs M	13.3	16.6	19.9
	15-18 yrs F	10.7	13.4	16.1
	19-24 yrs M	12.2	15.2	18.3
	19-24 yrs F	9.6	12.0	14.4
	25-34 yrs M	12.1	15.1	18.1
	25-34 yrs F	9.6	12.0	14.4
	35-44 yrs M	11.6	14.5	17.4
	35-44 yrs F	9.3	11.6	13.9
	45-54 yrs M	11.4	14.2	17.0
	45-54 yrs F	9.3	11.6	13.9
	55-64 yrs M	11.4	14.2	17.0
	55-64 yrs F	9.1	11.4	13.7
	65-74 yrs M	10.3	12.9	15.5
	65-74 yrs F	8.4	10.5	12.6
	75+ yrs M	10.1	12.6	15.1
	75+ yrs F	8.1	10.1	12.1

Appendix B

Security of flour consumption estimates

The estimate of flour consumption for this modelling exercise was based on the estimated flour content of the most commonly consumed product types in each NDNS food group (see Appendix A). This approach gives an estimate for mean flour consumption of 67g per person per day for the population overall (see Table 1).

Flour consumption has also been estimated using UK flour production figures and applying available estimates of wastage of bread and other flour containing products through the food chain and in the household as a sense check to the modelled flour consumption estimates. Imports and exports of flour were considered to be too small to affect the overall estimate. This approach results in an estimate of around 90g/person per day as shown below.

Flour production in the UK	4 million tonnes per year[43]	Excludes flour used in production of starch and ethanol
Flour used in UK food manufacture or sold at retail	4 million tonnes per year	Estimates of flour imports (60,000 tonnes) and exports (175,000 tonnes) are relatively small so excluded[43]
Equivalent estimate per person per day	180g/person/day	
Wastage at bakery[44]	5%	
Wastage at retail level[44]	10-12%	
Wastage at household level[45]	40% for white bread	32% for total bread
Consumption estimate taking account of wastage estimates	90g/person/day	

This estimate, based on flour production is 30% higher than the estimate based on NDNS consumption data used in the modelling (67g/day). There are a number of possible reasons for the discrepancy, summarised in the table below.

Possible source of discrepancy	Comment
NDNS food group methodology does not capture all sources of flour in the diet, for example the following product types are not included but will contribute some flour: quiches and savoury tarts savoury snacks confectionery breakfast cereals	The major sources of flour consumption are captured. Consumption of quiches and savoury tarts is very low – contribution to flour consumption is negligible Few savoury snacks, breakfast cereals, confectionery products contain wheat flour. Difficult to estimate consumption but expect to be very low
Percentages used for the flour content of food groups may be under-estimates.	Proportion of flour in each food group is based on average levels of typical products taken from available recipe and product label data

Under-reporting of food consumption in NDNS, particularly for products such as biscuits and cakes	The same methodology has been applied to the purchase data from the Family Food module of the Living Costs and Food Survey (LCFS)[23], which gives similar (slightly higher) estimates. This gives reassurance that the NDNS figures are unlikely to be substantially under-estimated although there is likely to be a degree of under-reporting in this as in all dietary surveys
Wastage estimates are too low	Wastage estimates are based on information available for bread. Estimates for household waste of bread come from a WRAP survey of food waste in the home[45]. Wastage figures in the bakery and at retail level are estimates from contacts in the milling and baking industry. We are assuming no other substantial sources of wastage. We have no information on wastage other flour-containing products, either at household level or in the food chain. It seems unlikely that household waste levels for other flour-containing products are higher than those for bread. However it is possible that wastage of flour during the manufacturing process may be higher for some products, such as coated or battered meat or fish.

The NDNS estimate of flour consumption at 67g/day used in the modelling, captures the main sources of flour in the diet and is considered to be a secure estimate, especially as household purchase data from the LCFS produces a similar figure. The estimate based on flour production figures taking account, as far as possible, of sources of waste, gives an upper limit for the contribution of flour to the diet.

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[1] The extraction rate is the percentage by weight extracted from the whole grain to make flour. Theoretically, whole wheat flour contains 100% of the cleaned whole grain, contemporary brown flour is around 80-85% extraction and white flour is about 70-72% extraction. In the modern milling process, 70% extraction white flour is almost pure endosperm and will contain much lower amounts of the nutrients that are concentrated in the germ and outer layers of the grain

[2] Department of Health and Social Security. Nutritional Aspects of Bread and Flour. Report on Health and Social Subjects No. 23. Report by the Committee on Medical Aspects of Food Policy. London: HMSO, 1981

[3] Department of Health. Report on Health and Social Subjects 49. Nutrition and Bone Health. TSO (London, 1998)

[4] Scientific Advisory Committee on Nutrition. Folate and Disease Prevention. TSO (London, 2006), Available at: http://www.sacn.gov.uk/pdfs/folate_and_disease_prevention_report.pdf (accessed 25 04 12)

[5] Bates B, Lennox A, Bates C & Swan G. National Diet and Nutrition Survey: Headline results from years 1 and 2 (combined) of the Rolling Programme (2008/2009 – 2009/2010), Available at: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsStatistics/DH_128166 (accessed 17/1/12)

[6] Department of Health. Report on Health and Social Subjects 41: Dietary Reference Values for Food Energy and Nutrients for the United Kingdom. Report of the Panel on Dietary Reference Values of the Committee on Medical Aspects of Food Policy. HMSO (London: 1991)
[7] For calcium and iron, DRVs were taken directly from the 1991 DRV report. For thiamin and niacin equivalents, DRVs were calculated as %EAR using revised EARs from the SACN Dietary Reverence Values for Energy report. Available at: http://www.sacn.gov.uk/reports_position_statements/reports/sacn_dietary_reference_values_for_energy.html (accessed 11/5/12)
[8] The Lower Reference Nutrient Intake (LRNI) for these micronutrients is the amount of the nutrient that is enough for only the few people in a group who have low needs. In practical terms where the population of people with intakes less than the LRNI is below 5%, this is not considered to be of concern. Concern increases as the percentage of a population with intakes rises above this level
[9] The Estimated Average Requirement (EAR) – about half will usually need more than the EAR, and half less
[10] The Reference Nutrient Intake (RNI) for these micronutrients is the amount of the nutrient that is enough, or more than enough, for about 97% of people in a group. If average intake of a group is at the RNI, then the risk of deficiency in the group is very small
[11] Personal communication, Professor Ian Macdonald, 2012
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[14] Henderson L, Irving K, Gregory J, Bates CJ, Prentice A, Perks J, Swan G and Farron M. National Diet and Nutrition Survey: Adults Aged 19 to 64 Years. Volume 3: Vitamin and mineral intake and urinary analytes. TSO (London, 2003). Available at: http://tna.europarchive.org/20110116113217/tna.europarchive.org/20110116113217/http://www.food.gov.uk/science/dietarysurveys/ndnsdocuments/ndnspreviоussurveyreports/ndnsv303 (accessed 23/2/12)
[15] Peak Bone Mass is the maximum amount of bone that can be accumulated
[16] IOM (Institute of Medicine). 2011. *Dietary Reference Intakes for Calcium and Vitamin D.* Washington, DC: The National Academies Press
[17] Osteoporosis is a skeletal disorder characterised by compromised bone strength due to reduced bone mass and reduced bone quality
[18] Department of Health. Fracture prevention services: an economic evaluation. (2009). Available at: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_110098 (Accessed 22/3/12)
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[27] Net equivalised income adjusts household income for differences in household size and composition to take account of economies of scale for two or more adults living in a household, or children, who have lower living costs

[28] Barton K et al. Estimation of Food and Nutrient Intakes from Food Survey data in Scotland 2001-2009. Report to Food Standards Agency Scotland 2012. Available at: http://www.foodbase.org.uk/results.php?f_report_id=418

[29] SIMD is based on indicators within seven individual domains of current income, employment, housing, health, education, skills and training, geographic access to services and telecommunications and crime. SIMD is calculated from data zone level information based on postcode and census geographies. There are 6505 data zones covering Scotland ranked from least to most deprived

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[35] High fibre breakfast cereals defined as having a non-starch polysaccharide (Englyst fibre) level of 4g/100g or more

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[37] Calcium carbonate ($CaCO_3$) is 40% elemental calcium (atomic mass calcium = 40.078)

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[45] http://www.defra.gov.uk/statistics/files/defra-stats-foodfarm-food-foodwastepurchases-100727.pdf