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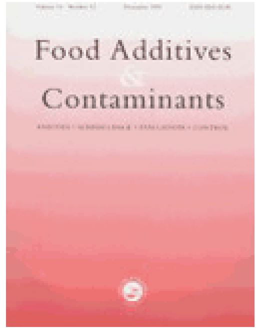

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Dietary exposure to metals and other elements in the 2006 UK Total Diet Study and some trends over the last 30 years

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Summary

Concentrations of 24 elements including metals in the 2006 UK Total Diet Study (TDS) have been measured and dietary exposures were estimated. Composite samples for the 20 TDS food groups (bread, fish, fruit etc) were collected from 24 UK towns and analysed for their levels of aluminium, antimony, arsenic, barium, bismuth, cadmium, chromium, copper, germanium, indium, lead, manganese, mercury, molybdenum, nickel, palladium, platinum, rhodium, ruthenium, selenium, strontium, thallium, tin and zinc. Concentrations of each of the elements in the food groups were lower than or similar to those reported in the previous TDS survey, conducted in 2000, with the exception of aluminium, barium and manganese. Dietary exposures to the 24 elements were estimated for UK consumers and compared with previous estimates made over the last 30 years, in order to examine any trends in exposure to these elements in the typical UK diet. Population exposures to the elements have generally declined over time, and exposures to most of these elements remain at low levels. The independent UK Government scientific Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) commented on the estimated dietary exposures, taking into account their previous evaluations (COT, 2003a and b, 2008), and identified no major concerns for the health of consumers, but did advise that there was a need for more information on aluminium and barium, and also commented that dietary exposure to inorganic arsenic and to lead should continue to be reduced.

Key words: trace elements, heavy metals, dietary intake, risk assessment, consumer exposure, total diet study

Introduction

The Total Diet Study (TDS)

The Total Diet Study (TDS) is a continuous market basket-type survey in which foods representing the average UK diet (based on Defra's Expenditure and Food Survey and trade statistics) (Defra, 2009) are purchased, prepared and combined into groups of similar foods for analysis. The TDS has been run on an annual basis since 1966 and has been used as a part of the UK monitoring programme for chemicals in food. It allows the general UK population's average exposure to non-nutrients (i.e. contaminants such as heavy metals, dioxins and pesticides), as well as intakes of some nutrients to be estimated. Used in conjunction with the Expenditure and Food survey, the TDS has enabled trends over time to be established and assessments on the safety and quality of the food supply to be made.

Food samples representative of the UK diet are purchased throughout the year in 24 towns covering the UK, and 119 categories of foods were combined into 20 groups of similar foods (e.g. Bread, Poultry, Milk etc) for analysis. The relative proportion of each food category within a group reflects its importance in the average UK household diet. Foods are grouped so that commodities known to be susceptible to contamination (e.g. offal, fish) are kept separate, as are foods which are consumed in large quantities (e.g. bread, potatoes, milk) (Peattie et al, 1983; MAFF, 1994). The quantities and relative proportions of each food that make up the total diet are largely based on data from the Expenditure and Food Survey (Defra, 2009) and are updated annually to reflect changing eating habits. The estimated average weight of food eaten is given in Table 1. The element concentrations for each food group are used together with data on the consumption of these food groups to estimate dietary exposure for both the average UK population and for the mean and high level (97.5th percentile) consumer.

Previous TDS studies on trace elements

The last time trace elements were analysed in samples from the Total Diet Study was in 2000 when 12 elements – aluminium, arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, tin and zinc were measured (FSA, 2004). Prior to this, 1997 Total Diet Study samples were analysed for the same elements (except manganese) (Ysart et al, 2000), and 1994 samples were analysed for 30 different elements (Ysart et al, 1999). Some elements, such as copper, chromium, selenium and zinc are essential to health but may be toxic at high levels of exposure. Other elements such as mercury and lead have no known beneficial biological function and long-term, high-level exposures may be harmful to health.

Sources of trace elements in the diet

Environmental sources are the main contributors to contamination of food with most metals and other elements. Some elements, such as arsenic, are present naturally, but the major sources of other elements, such as lead, are a result of environmental pollution from industrial and other anthropogenic activities. The presence of metals and other elements in food can also be the result of contamination by certain agricultural practices, such as cadmium from phosphate fertilisers, or from manufacturing and packaging processes as from aluminium and tin in canned foods. The platinum group of metals, which have been used in catalytic converters in all new petrol-engine vehicles in the UK since 1993, could contaminate food crops as a result of vehicle emissions.

Metals and other elements may enter the food chain at any point during growth and harvesting, through to storage and processing. Food is a major contributor to consumers' overall exposure to metals and other elements, although other routes may also be significant, for example, oral exposure via the drinking water, or inhalation exposure from some occupational environments. Certain food groups are known to naturally accumulate some elements and consequently these can contain relatively high concentrations of these elements. For example, fish and shellfish are known to accumulate arsenic and mercury and cereals can accumulate cadmium.

This study gives an up to date assessment of exposure and risk associated with trace elements in the diet and gives an analysis of time trends by comparison with previous studies where these exist.

Materials and methods

Samples

The foods making up the 20 groups were bought from retail outlets in 24 randomly selected towns throughout the UK. The food samples were prepared and cooked according to normal consumer practice at LGC (Teddington, London). Equal quantities of samples from each town were mixed for each food group to obtain the national composite samples. These composite samples for each food group were homogenised and supplied frozen at -20ºC for laboratory analysis. The methods for producing the TDS samples is described in detail in Peattie et al, 1983.

Analysis

Samples (0.5 - 3.0 g) were digested with a concentrated nitric/hydrochloric acid mixture in a sealed quartz microwave digestion system. The concentrations of most of the target metals and other elements in the various food groups were then determined using inductively coupled plasma mass spectrometry (ICP-MS). Inductively coupled plasma high-resolution mass spectrometry (ICP-HR-MS) was used for the analysis for Cr, Ge, As, Se, Ru, Rh, Pd, In, Pt and Bi. Samples were analysed in batches containing reagent blanks, both spiked reagent blanks and spiked samples (for recovery estimate purposes), plus four certified reference materials.

Analysis of Inorganic Arsenic:

The inorganic form of arsenic was separated from the organic form by dissolving the samples in hydrochloric acid, followed by reacting with hydrobromic acid and hydrazinium sulphate, and then extracting into chloroform. This was followed by back-extraction into hydrochloric acid and analysis by ICP-HR-MS.

Quality Control

Quality control checks using reference material data and replicate agreement were performed to assess instrument stability and spike recovery. All work was performed using methods accredited to the ISO 17025 standard. The limits of detection (LODs) achieved are shown in Table 2. The method used is subject to regular interlaboratory trials and the laboratory participate in regular proficiency tests such as FAPAS and those organised by the EU Community Reference Laboratory for assessing the performance of National Reference Laboratories, with consistent good performance.

Consumer exposure estimates

Consumption data from the British National Diet and Nutrition Survey (NDNS) (Henderson et al, 2002; Gregory et al, 1990) were used to estimate dietary exposures for individuals in the general population who eat average amounts of each food group (i.e. mean consumers) and those who eat significantly more than average amounts (i.e. high level, 97.5th percentile consumers). Total consumer dietary exposures are derived from an average of the individual consumer's exposure patterns with regard to individual foods.

Dietary exposures to the 24 elements from the TDS were estimated for average and high level consumers under the following categories: adults (16 - 64 years), toddlers (1.5 - 4.5 years), young people (4 - 18 years), elderly (over 64 years, free living and institutional) and self-described vegetarians (including some who consume fish) using consumption data from the relevant NDNS (Henderson et al, 2002; Gregory et al, 1990). Consumer dietary exposures are expressed on a microgram per kilogram body weight per day (µg/kg bw/day) basis and are summarised in Tables 4a to 4d. Results are expressed as lower bound and upper bound concentrations; that is, where individual sample analyses were less than the limit of detection, the result is expressed as zero (lower bound), or as equal to the limit of detection (upper bound) and the exposure calculated by combining the concentration found together with the food intake data. Where only one value is shown, this is either because all samples contained concentrations above the LOD (therefore the upper and lower bound mean values are equal) or because the difference between them is negligible (similar to differences caused by rounding errors when calculating exposures).

The estimated dietary exposures for toddlers were in general higher than those for other age groups due to their proportionally higher food consumption on a body weight basis. A comparison of intakes by adults, toddlers and young people calculated from the 1997 and 2000 survey results is shown in Tables 5a and 5b.

Population exposure estimates

Population exposure estimates can be used to follow trends in exposure as they take into account changes in both consumption of the various foods making up the UK diet and the concentrations of elements in these foods. Comparable approaches were applied to this study as used in previous years meaning that trends could be noted. Population dietary exposures have been estimated by multiplying the amounts of food consumed (based on consumption data from the Expenditure and Food Survey (Defra, 2009) as shown in Table 1) by the corresponding upper and lower bound elemental concentrations in each food group. Comparisons of population dietary exposures for each element from the UK TDS from 1976 to 2006 are given in Tables 6a and 6b (upper bound results can be used as a precautionary worst case figure and upper bound means are the figures that have been consistently recorded in previous years – lower bound are reported here primarily to give an indication of uncertainty surrounding the estimates). Population dietary exposures are expressed on a milligram per person per day basis (mg/day). The percentage contribution to the population exposure by each food group is shown in Tables 7a and 7b.

Dietary Exposures and Risk Assessment

The dietary exposure to metals and other elements can be used to assess the safety of foods consumed. The TDS approach allows estimates to be made for some sub-groups of the population such as vegetarians, by replacing the meat containing food groups with higher intake estimates for other groups. The risk to health is assessed by comparing the estimated dietary exposure with recommended safe guideline levels such as Provisional Tolerable Weekly Intakes (PTWIs) set by the Joint FAO/WHO Expert Committee on Food Additives (JECFA). The PTWI is used by JECFA in identifying tolerable intakes of food contaminants with cumulative properties. In Tables 5a and 5b and in the rest of the discussions, the PTWI has been divided by 7 to provide a tolerable daily intake (TDI) for comparison with the estimated daily dietary exposures. The independent UK Government scientific Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) commented on the estimated dietary exposures, taking into account their previous evaluations (COT, 2003a and b, 2008). Dietary exposures were compared against the reference nutrient intake (RNI) from the Dietary Reference Values (DRV) where these were available.

Results

A summary of the concentrations of metals and other elements in each food group is shown in Table 3. These figures were used to estimate dietary exposures for the average UK population. Two kinds of dietary exposures were estimated: consumer exposures and population exposures as described above.

The presence of each element in the different food groups, the concentrations detected and dietary exposures are discussed below:

Aluminium

Aluminium is the most abundant metal in the Earth's crust and it has many industrial as well as domestic applications. As a result of environmental changes due to intensified agriculture and industrialisation, the availability of aluminium has increased and consequently its uptake by plants and animals has also increased. In addition, it has been used extensively to make cooking and food storage utensils and in food packaging (e.g. aluminium foil); aluminium compounds are also used as food additives.

In the 20 food groups of the TDS samples, most groups had aluminium concentrations lower or similar to those reported in the 2000 TDS (FSA, 2004a) the exceptions being Bread, Meat Products and Other Vegetables groups. The Miscellaneous Cereals group had the highest concentration of aluminium (17.5 mg/kg). This was lower than the concentration in the 2000 TDS (19 mg/kg) but was three times more than the value from the 1997 TDS (5.2 mg/kg; Ysart et al, 2000). The levels of aluminium in this food group have varied from 4.8 mg/kg (1988 TDS) to 78 mg/kg (1994 TDS) (Ysart et al, 1999).

The Miscellaneous Cereals groups was the most significant contributor to the population dietary exposure (42%) (Table 7a). The relatively high aluminium concentration found in this group could be from naturally present aluminium, aluminium-containing additives which are permitted for use in some bakery products (HMSO, 1995a and b), or as a result of processing and storage of food in aluminium containing utensils. Medicinal antacid preparations can provide much larger aluminium doses, of up to 5 g per day

The population dietary exposure to aluminium was 5.4 mg/day, which was higher than the estimates from the 2000 and 1997 TDS (4.7 and 3.4 mg/day, respectively) but lower than previous estimates for 1994 and 1991 (11 mg/day and 10 mg/day, respectively, as shown in Table 6a).

In 2006, JECFA reduced the PTWI for all forms of aluminium in food from 7 to 1 mg/kg bw because of new evidence that aluminium could have effects on the reproductive system and developing nervous system (WHO, 2006). The European Food Safety Authority (EFSA) evaluated the safety of aluminium from dietary intake in 2008, basing its evaluation on the combined evidence from several studies showing adverse effects on testes, embryos and the developing and mature nervous system following dietary administration. EFSA derived the same TWI of 1 mg/kg body weight (EFSA, 2008). The estimated dietary exposure to aluminium for mean adult consumers was 71 µg/kg bw, and 144 µg/kg bw for high-level consumers. Table 4a shows that with the exception of toddlers, the mean level consumers of all the population groups had intakes within the PTWI of 1 mg/kg bw (equivalent to a daily exposure of 143 µg/kg bw). The estimates of high-level dietary exposure of toddlers, young people, the elderly and vegetarians exceeded the PTWI by up to 2.4 fold.

The results of the 2006 TDS show an apparent increase in dietary exposure to aluminium, although the estimated population dietary exposure is within the mean dietary exposure of European adults (1.6-13 mg/day; EFSA, 2008) Variations in dietary exposure may be accounted for by differences in soil composition in the regions where food is produced, in individual dietary patterns and in consumption of foods with aluminium-containing food additives. It is acknowledged throughout Europe, that for certain groups of the population, exposure to aluminium will exceed the PTWI. This includes infants and young children, who have a higher food intake than adults when expressed relative to body weight.

The COT noted that whilst the estimates of dietary exposure to aluminium were not markedly higher than previous estimates, they present uncertainty with regard to the safety of aluminium in food in light of new data that led to the recent reduction in the PTWI, which was exceeded by some population subgroups. A need for further information on possible sources and forms of aluminium in the diet and on its bioavailability was identified (COT, 2008).

Arsenic

Arsenic is also widely distributed in the Earth's crust and is present in the environment from natural sources, such as rocks and sediments and as a result of activities such as coal burning, copper smelting and the processing of mineral ores. It occurs in soil, waters (both marine and fresh), and in almost all plants and animal tissues. Levels of arsenic are higher in the aquatic environment than in most areas of land as it is fairly water-soluble and may be washed out of arsenic-bearing rocks. As a consequence, levels of arsenic in fish and seafood are usually high, because fish absorb arsenic from the water.

The toxicity of arsenic is dependent on the chemical form in which it is present. Most arsenic in the diet is present in the less toxic, organic form. The inorganic form is the more toxic species and is a known genotoxic carcinogen. Arsenic occurs in a wide range of foods and the majority of arsenic in the diet comes from fish and fish products; however, more than 97% of the total arsenic in fish is in the less toxic organic form. In the 2006 TDS, the levels of total arsenic present in the various food groups as well as the inorganic form were measured.

Total Arsenic:

As expected, the Fish group contained considerably higher total arsenic concentrations than any other food group (3.99 mg/kg). This was marginally higher than the values reported for total arsenic in fish in the 2000 TDS (3.4 mg/kg) (FSA, 2004a) and in the 1999 TDS (3.2 mg/kg) (FSA 2004b), but lower than the value reported in the 1997 TDS (4.4 mg/kg; Ysart et al, 2000). As in the previous TDS, the Poultry group contained the second highest concentration of total arsenic (0.022 mg/kg) (Table 3), although this was almost half that reported in the 2000 TDS (0.043 mg/kg; FSA, 2004a).

The population dietary exposure to total arsenic in the 2006 TDS was estimated to be 0.061 - 0.064 mg/day which was slightly higher than that found in the 2000 TDS (0.055 mg/day) and the 1999 TDS (0.05 mg/day), but slightly lower than the 1997 TDS (0.065 mg/day; Ysart et al, 2000) (Table 6a). The Fish group contained the highest concentration of total arsenic and was the most significant contributor to dietary exposure (88%). This contribution was higher than the 2000 TDS (83%), comparable to the 1999 TDS (87%) but lower than the 1997 TDS (94%). Miscellaneous Cereals made the second most significant contribution accounting for 4% of arsenic dietary exposure (Table 7a).

Inorganic Arsenic:

The levels of inorganic arsenic were below the LOD of 0.01 mg/kg in most of the food groups. Inorganic arsenic was detected only in the case of the Miscellaneous Cereals (0.012 mg/kg) and Fish (0.015 mg/kg) food groups. These values were similar to those reported in the 1999 TDS (FSA, 2004b; upper bound mean values of 0.012 and 0.016 mg/kg, respectively). Even though the Fish group had the highest concentration of total arsenic, only a very small fraction (0.36%) was present as the more toxic inorganic form of arsenic. In the case of the Miscellaneous Cereals food group, although the percentage of inorganic arsenic was greater, the concentration of total arsenic in these foods was much lower.

The population dietary exposure to inorganic arsenic was 0.0014 - 0.007 mg/day and was comparable to the range reported in 1999 (0.0009 - 0.005 mg/day) (FSA, 2004b). In the estimation of lower bound consumer dietary exposures, the contribution from the Miscellaneous Cereals and Fish groups alone were considered. In the calculation of upper bound exposures, the concentration of inorganic arsenic in the rest of the food groups was assumed to be equal to the concentration of total arsenic (since this was lower than the LOD for inorganic arsenic) except in the case of the Poultry food group where it was considered to be equal to the LOD. The dietary exposures to inorganic arsenic for the various population groups are given in Table 4a. It can be seen that the dietary exposures for all the population groups were well below the PTWI set by JECFA for inorganic arsenic in 1989, which is equivalent to 2.1 µg/kg bw/day (WHO, 1989). Tables 5a, 5b and 8 show the comparison of estimated dietary exposures to arsenic from the 1997, 1999, 2000 and 2006 TDS studies.

Inorganic arsenic is genotoxic and a known human carcinogen and therefore exposure should be as low as reasonably practicable (ALARP) (COT, 2003b). The estimated total dietary exposure to inorganic arsenic from the 2006 TDS is comparable to that from the 1999 TDS for all population groups.

The COT concluded that the data on arsenic was consistent with previous surveys of total and inorganic arsenic in food, which was reviewed in 2003 (COT, 2003b and 2008). The Committee reaffirmed its previous conclusions that current dietary exposure to organic arsenic was unlikely to constitute a risk to health, and that exposure to inorganic arsenic should be ALARP (COT, 2008).

In October 2009 EFSA published its scientific opinion on arsenic in food. New data subsequent to the JECFA evaluation has established inorganic arsenic to cause cancer of the lung and urinary tract in addition to skin, as well as indicating a range of adverse effects at exposures lower than those reviewed by JECFA. EFSA concluded that the PTWI set by JECFA was no longer appropriate. Due to the limitations of the epidemiological data, EFSA concluded that it would be appropriate to identify a range of total dietary exposures from key epidemiological studies, rather than use a single reference point in the risk characterisation for inorganic arsenic. Dose-response data from the key epidemiological studies were modelled and a range of values for the 95% lower confidence limit of the benchmark dose of a 1% extra risk ($BMDL_{01}$) were identified for each endpoint. The overall range of $BMDL_{01}$ values identified were 0.3 to 8 µg/kg bw/day. The estimated dietary exposures to inorganic arsenic for average and high level consumers in Europe were within the range of the $BMDL_{01}$ values identified and hence there is little or no margin of exposure between the identified reference points from the human data and the estimated dietary exposure to inorganic arsenic. EFSA therefore recommended that dietary exposure to inorganic arsenic should be reduced (EFSA, 2009a).

Cadmium

Cadmium has accumulated in the environment as a result of agricultural practices such as the use of cadmium-containing fertilisers and also from historic mining activities. A major use of cadmium is in nickel - cadmium dry cell batteries; the metal also finds some use in the automobile industry.

Cadmium was present at low concentrations in eleven of the food groups, and was below the LOD in Carcase Meat, Poultry, Oils and Fats, Eggs, Fresh Fruits, Beverages, Milk and Dairy Products. Cadmium concentrations were highest in the Offal (0.084 mg/kg) and Nuts (0.065 mg/kg) groups (Table 3) and were similar to previous years. High level exposure can result from a combination of both a high concentration in the food along with a high level of consumption of the food group, i.e. food that is consumed in larger quantities makes a larger contribution to the dietary exposure. Table 7a gives the percentage contribution by each food group. The high contributors were Potatoes (24%), Miscellaneous Cereals (21%) and Bread (19%). The population dietary exposure to cadmium was 0.011 - 0.013 mg/kg and was similar to those reported for previous years (Table 6a). There has been little change in the dietary exposure of the general UK population to cadmium over the last 20 years, although consumption of offal, one of the main contributors to cadmium in the diet, has declined over this period.

A PTWI of 7 µg/kg bw was set by JECFA in 1989 (WHO, 1989) and this was maintained in 2003 (WHO, 2003a). The estimated mean and high-level dietary exposures to cadmium for each consumer group (Table 4b) were within the JECFA PTWI (equivalent to 1 µg/kg bw/day).

In 2009, EFSA published its scientific opinion on cadmium in food (EFSA, 2009b) and established a revised tolerable weekly intake (TWI) for cadmium of 2.5 µg/kg bw (equivalent to 0.36 µg/kg bw per day). The mean dietary exposure across European countries was estimated to be 2.3 µg/kg bw per week and the high level exposure was estimated to be 3.0 µg/kg bw per week. EFSA concluded that although adverse effects on kidney function are unlikely to occur at exposures 2-fold greater than the TWI, exposure to cadmium at the population level should be reduced.

The COT revisited the estimated dietary exposures to cadmium from the 2006 TDS following publication of the EFSA opinion and acknowledged that the approach used by EFSA to derive the TWI was appropriate, although conservative. Given the conservative manner in which the TWI was derived, and that exceedances from dietary exposure are modest (generally less than 2-fold) and only for a limited part of the lifespan, the COT concluded that they do not indicate a major concern (COT, 2009). Nevertheless, in view of the uncertainties, the COT advised that it would be prudent to reduce dietary exposures to cadmium at the population level where this is reasonably practical (COT, 2009).

Chromium

Chromium is widely distributed in the Earth's crust and has many industrial uses. It usually exists in either the tri-valent or hexa-valent state. Tri-valent chromium is essential to human life and plays an important role in carbohydrate, lipid and protein metabolism. Hexa-valent chromium compounds do not occur naturally in the environment and are more toxic than tri-valent chromium compounds.

Chromium was detected in the various food groups but the concentrations of some were below the LODs (Bread, Offal, Poultry, Beverages and Milk). The Sugars and Preserves group contained the highest chromium concentration (0.08 mg/kg), and made the greatest contribution (16%) to the population dietary exposure. The other main contributors were the Miscellaneous Cereals, Potatoes and Beverages groups (13%, 12% and 13%, respectively) because of their relatively high level of consumption (Table 7a). Chromium concentrations have continued to decrease since the 1994 TDS was undertaken, with population dietary exposure down to less than a tenth (from 0.34 mg/day in 1994 to 0.029 mg/day in 2006, Table 6a).

Although there is no RNI for chromium, an adequate intake is believed to be above 25 µg/day for adults and between 0.1 and 1.0 µg/kg bw/day for children and adolescents (Department of health, 1991). There is no upper limit for chromium and intakes of up to 10 mg per day are not thought to cause any harm. The dietary exposures reported in this study were above these values for adults, adolescents and children and were well below the Expert Group on Vitamins and Minerals (EVM) guidance level of 150 µg/kg bw/day for total dietary intake of trivalent chromium (EVM, 2003).

The COT concluded that these dietary exposures to chromium were unlikely to be of toxicological concern (COT, 2008).

Copper

Copper has been mined and used since ancient times and its ores are widely distributed throughout the world. Copper and its alloys have widespread domestic, pharmaceutical, industrial and agricultural applications. Copper is an essential element with food being the major source.

Copper was found to be present in all the food groups of the 2006 TDS and Offal (52.5 mg/kg) and Nuts (9.15 mg/kg) contained the highest concentrations. The concentration of copper in Offal was higher than the level measured in the 2000 TDS (40 mg/kg). As shown in Table 3a, the concentrations in the other groups ranged from 0.05 mg/kg (Milk group) to 2.21 mg/kg (Miscellaneous Cereals group) and are fairly comparable to the 2000 TDS values.

Miscellaneous Cereals made the most significant contribution (23%) to population dietary exposure to copper, followed by the Bread group (14%) (Table 7a). The population dietary exposure to copper (1.24 mg/kg) has changed only marginally since 1982 (Table 6a) and is comparable to the RNI of 1.2 mg/kg set by the Committee on Medical Aspects of Food and Nutrition Policy (COMA) (EVM, 2003). The estimated copper dietary exposures for consumers of all age groups and vegetarians are well below the JECFA PMTDI of 500 µg/kg bw/day (WHO, 1982a) and the EVM Safe Upper Level of 160 µg/kg bw/day for total dietary intake (EVM, 2003).

The COT concluded that current dietary exposures to copper were not of toxicological concern (COT, 2008).

Lead

Lead is found everywhere in the environment. Food is one of the major sources of lead exposure in the UK. The Offal group had the highest lead concentration (0.065 mg/kg) and the greatest contributions to the population dietary exposure were made by the Beverages food group (17%) and the Bread and Other Vegetables groups (16%) (Table 7a). The population dietary exposure to lead was 0.006 mg/day and was similar to the value reported in 2000 (0.007 mg/day). Dietary exposures of the general UK population have declined from 0.12 mg/day estimated in the 1980 TDS to 0.006 mg/day in the 2006 TDS (Table 6a), possibly in part due to declining offal consumption and as a result of less lead in the environment following the removal of lead from petrol.

All the reported dietary exposures in this survey were well below the JECFA PTWI, which is equivalent to 3.6 µg/kg bw/day (WHO, 1993), and were similar to or lower than the exposure levels reported in previous years. There is evidence that the PTWI is not sufficiently protective. Lead accumulates in the body, and can cause various adverse health effects, the most important of which at low levels is impairment of intellectual and cognitive development in the fetus and child. Blood lead levels in children exposed pre- and post-natally are inversely associated with IQ, and there is no identified threshold for this effect.

The COT noted that estimates of dietary exposure to lead had not increased since the previous survey in 2000 and that this is a decrease compared with 1980. At these dietary intakes, the COT concluded that adverse effects, if any, were likely to be very small. However, since it is not possible to identify a threshold for the association between lead exposure and decrements in intelligence quotient, the COT advised that efforts should continue to reduce lead exposure from all sources (COT, 2008).

Manganese

Manganese is present both naturally and as a result of contamination in soils, sediments and water. It is an essential element and is present in most foods, particularly green vegetables. Manganese was present in all the food groups with the highest concentration found in the Nuts group (24.9 mg/kg). The concentration in other groups ranged from 0.022 mg/kg (Milk) to 8.01 mg/kg (Bread) as shown in

Table 3b. The concentrations reported were broadly similar to those reported in the 1994 and 2000 TDS studies (FSA, 2004a; Ysart et al, 1999).

The Beverages group made the highest contribution to the population dietary exposure (41%) followed by the Miscellaneous Cereals (20%) and Bread (16%) groups. The population dietary exposure was 5.24 mg/day (Table 6b). The Expert Group on Vitamins and Minerals concluded that, for guidance purposes, it could be assumed that total manganese intakes up to 200 µg/kg bw/day in the general population, or 150 µg/kg bw/day in older people, were unlikely to result in adverse effects (EVM, 2003). The dietary exposure to manganese for the mean level consumers of all population groups were within these guidelines. The estimated high level toddler exposure exceeded the guidance level by about 50% (305 µg/kg bw/day). Taking into account the precautionary approach taken by the EVM, this small excursion above the guidance level is not expected to be a toxicological concern.

The population dietary exposure to manganese in 2006 (5.24 mg/day) was shown to have increased marginally since the 1994 and 2000 TDS (4.9 mg/day), however, the overall results indicated that dietary exposures to manganese had remained fairly constant since monitoring began in 1983.

The COT concluded that there was insufficient information to determine whether there were risks associated with dietary exposure to manganese. However population dietary exposures to manganese had remained fairly constant since monitoring began in 1983, and the COT therefore concluded that there was no basis for assuming any concern for health (COT, 2008).

Mercury

The sources of mercury contamination are environmental, industrial and agricultural. Exposure to mercury is mainly from the diet and dental amalgam. Mercury can exist in inorganic and organic forms in food, with the organic forms, such as methylmercury, being more toxic following ingestion. In this study, only total mercury was estimated and was detected only in the Offal (0.0004 mg/kg), Fish (0.056 mg/kg) and Other Vegetables (0.0007 mg/kg) food groups; the concentration was below the LODs in all other categories (Table 3b). The Fish group was the major contributor (25%) to the population dietary exposure to mercury (Table 7b), which was calculated to be 0.001 - 0.003 mg/day. The mean adult dietary exposure to mercury was 0.05 µg/kg bw/day.

In 2003 JECFA set a PTWI of 1.6 µg/kg bw for methylmercury (equivalent to 0.23 µg/kg bw/day) (WHO, 2003b) to protect against neuro-developmental effects in the embryo and fetus. Inorganic mercury is not absorbed as well as methylmercury by the oral route, and therefore comparing dietary exposure to total mercury with the PTWI for methylmercury is a worst case scenario. Taking into account uncertainty related to food groups in which mercury was below the limit of detection, the estimated high-level dietary exposure of children aged 1.5 - 4.5 years was within the range of 0.17 - 0.26 µg/kg bw/day, and therefore was in the region of the PTWI. The estimates of dietary exposure to mercury (mean and high-level) for all consumer groups were clearly within the PTWI.

The COT concluded that dietary exposures to mercury were unlikely to be of toxicological concern (COT, 2008).

Molybdenum

Molybdenum is a relatively rare element and is an essential constituent of several enzymes in the human body. Foodstuffs from above ground plant material contain higher concentrations of molybdenum compared with foods from tubers or animals (Tsongas et al, 1980; EC, 2000b). Molybdenum was detected in all food groups of the 2006 TDS except Oils & Fats and Beverages groups. The highest concentration was in the Nuts group (1.26 mg/kg) and this was slightly higher than the value reported in the 1994 TDS (0.96 mg/kg). The Offal group had the next highest concentration (1.10 mg/kg) and the concentrations of all other food groups were below 0.243 mg/kg (Canned Vegetables). The major contributors to molybdenum intake in the UK diet were the Miscellaneous Cereals (33%) and Bread (19%) food groups.

The population dietary exposure to molybdenum was estimated to be 0.123 - 0.125 mg/day and this was slightly higher than the exposures reported in 1994, 1991 and

1985 (0.11 mg/day). These were well within the guidance level for molybdenum (0.23 mg/day) as stated in the EVM report and the WHO estimated daily requirement for molybdenum of 0.1 - 0.3 mg/day for adults (EVM, 2003). The mean dietary exposure for adults was estimated to be 1.61 - 1.64 µg/kg bw/day and the high level exposure was 3.03 - 3.08 µg/kg bw/day.

The COT concluded that population dietary exposures to molybdenum were similar to previous studies and although there was uncertainty, the sparse data on the oral toxicity of molybdenum do not suggest that the estimated intakes gave cause for toxicological concern (COT, 2008).

Nickel

Nickel is another metal that is widely present in the Earth's crust. It has several industrial applications and is used in the manufacture of batteries, alloys and jewellery. Nickel is present in most foods. It was detected in most of the food groups except Carcase Meat, Poultry, Oils and Fats, Eggs and Milk. Concentrations of nickel in the other food groups varied from 0.02 mg/kg for the Offal group to 3.2 mg/kg for the Nuts group (Table 3b). These concentrations were broadly similar to those reported in the 2000 TDS (FSA, 2004a). The population nickel dietary exposure was estimated to be 0.13 mg/day and this is the same as that previously reported in 1994, 1997 and 2000 (Table 6b). The Beverages group contributes the most (21%) to the population dietary exposure followed by the Miscellaneous Cereals group (16%). Mean and high level adult dietary exposures to nickel were 1.49 - 1.63 µg/kg bw/day and 3.01 - 3.08 µg/kg bw/day, respectively, and were similar to the values reported in 2000 (Tables 5a and 5b).

Population exposures to nickel from food have decreased since 1976 (0.33 mg/day), and have been relatively stable since 1982 (0.13 mg/day in the 2006 TDS). Whilst the estimates of dietary exposures to nickel were below or in the region of the WHO TDI (5 µg/kg bw/day) (WHO, 1996), for high-level consumers aged 1.5 - 4.5 years the estimate exceeded the TDI by about 60%.

The COT had previously noted that ingested nickel may exacerbate contact dermatitis/eczema in pre-sensitised individuals and that toddlers were less likely than adults to be sensitised (COT, 2003a). The COT therefore concluded that these dietary exposures to nickel were unlikely to be of toxicological concern (COT, 2008).

Selenium

Selenium is widely distributed in the Earth's crust and finds use in the electronic, pharmaceutical and agricultural industries. It plays important roles in some enzymes and is an essential element to human health. The Expert Group on Vitamins and Minerals set a Safe Upper Level for total selenium intake of 0.45 mg/day (EVM, 2003).

In the 2006 TDS, selenium was detected in most food groups ranging from 0.77 mg/kg for the Offal group to less than the limit of detection (LOD) in Oils and Fats, Sugar and Preserves, Potatoes, Fresh Fruit, Fruit Products and Beverages groups. The Miscellaneous Cereals group (16%) and the Meat Products group (15%) made the greatest contribution to the population dietary exposure (Table 7b). Selenium concentrations in most food groups were slightly higher than those reported in the 2000 TDS (FSA, 2004) and the concentration in Offal (0.77 mg/kg) was nearly twice the value reported in the previous survey (0.46 mg/kg).

The population dietary exposure of 0.048 - 0.058 mg/day was slightly higher than the values estimated for the previous years (0.032 – 0.034 mg/day in 2000, 0.039 mg/day in 1997, 0.043 mg/day in 1994) (Table 6b). The reported estimated exposures were well below the WHO upper limit of the safe range for selenium intake (0.4 mg/day for adults only) (WHO,1996b), the Tolerable Upper Level (UL) of 0.3 mg/day set by EFSA (EC, 2000) and the EVM Safe Upper Level of 0.45 mg/day (EVM, 2003). Estimated exposures were above the lower limit of the WHO safe range of the population mean intake of 0.040 mg selenium/day needed to meet requirements but lower than the RNIs of 0.075 and 0.060 mg selenium/day for males and females respectively, and 0.075 mg selenium/day for lactating women set by the COMA (COMA, 1991).

The COT concluded that these dietary exposures to selenium were not of toxicological concern (COT, 2008).

Tin

Tin has been used to make utensils since ancient times - bronze and pewter are two well-known alloys of tin that have been used to make dishes and other culinary equipment. Tin cans have been used for canning food for nearly 200 years and these cans are made from steel sheets with a coating of tin to prevent rusting.

In the 2006 TDS samples, most of the food groups were found to contain very low concentrations of tin with the concentration of eleven groups below the LOD. As in the previous TDS results, canned foods contained higher concentrations of tin presumably as a result of the slow dissolution of the tin coating. Tin concentrations in a majority of the food groups were below 0.04 mg/kg, except for the Canned Vegetables (36.1 mg/kg) and Fruit Products (11.1 mg/kg) which also include some canned products (Table 3b). The concentration of tin in the Canned Vegetables group is higher than the 2000 TDS result (25.06 mg/kg) but lower than the value reported for the 1997 TDS and a previous survey of tin in canned fruit and vegetables (mean 44 mg/kg) (FSA, 2002). Canned Vegetables (65%) and Fruit Products (34%) also made the greatest contribution to the population dietary exposure to tin (Table 7b).

The population dietary exposure was estimated at 1.80 - 1.81 mg/day, higher than the previous TDS (FSA, 2004) (1.4 mg/day) (Table 6b) but comparable to the 1997 TDS. The highest estimated dietary exposure to tin was for high-level consumers aged 1.5 - 4.5 years (341.5 µg/kg bw/day). This was lower than the PTWI of 2000 µg/kg bw/day (WHO, 2001a), but exceeded the EVM guidance level of 220 µg/kg bw/day (EVM, 2003).

The COT concluded that the small exceedance of the EVM guidance level is within an area of uncertainty but that the estimated dietary exposures to tin were unlikely to be of toxicological concern (COT, 2008).

Zinc

Zinc is an essential element for human health, and is present in plants and animals. It is the key component of a large number of enzymes many of which are important in human metabolism. Zinc was present in all the food groups reported in this survey with concentrations ranging from 0.13 mg/kg for the Beverages group to 64.8 mg/kg for the Carcase Meat group (Table 3b). Zinc concentrations were broadly similar to those reported in the earlier TDS surveys (FSA, 2004; Ysart et al, 2000; Ysart et al, 1999). Bread (12%), Miscellaneous Cereals (14%), Carcase Meat (15%), Meat Products (16%) and Milk (10%) were the major contributors to the population dietary exposure (Table 7b).

The population dietary exposure was 8.83 mg/day, marginally higher than the two previous TDSs (8.4 mg/kg; Table 6b). This was in good agreement with dietary exposures reported by the NDNS on vitamins and minerals, with mean intakes for men of 10.2 mg/day and for women of 7 mg/day (Henderson et al, 2003), as well as the RNI ranges of 5.5 - 9.5 mg/day for males and 4.0-7.0 mg/day for females, set by the COMA (EVM, 2003). The estimated dietary exposure for all consumer groups was within the JECFA Provisional Maximum Tolerable Daily Intake (PMTDI) of 0.3 - 1 µg/kg bw/day (WHO, 1982b).

The COT concluded that these dietary exposures to zinc were unlikely to be of toxicological concern (COT, 2008).

Platinum group metals - Platinum, Palladium, Rhodium and Ruthenium

Since 1993 the internal combustion engines of all new petrol-engined vehicles have been fitted with catalytic converters to control the levels of exhaust emissions. Platinum, palladium and rhodium are used as catalysts and research has shown an increase in the concentration of these metals in roadside dust. There is little information about the biological effects of platinum group metals in food and at present there is no evidence for any adverse health effects from these metals in the general environment (Farago et al, 1998; Ravindra, 2004). In order to find out if these metals have found their way into the food chain and to monitor their levels in various components of the diet, they were included in the most recent TDS. This is the second time these metals have been included in the TDS, the earlier one being the 1994 TDS (Ysart et al, 1999).

The concentrations of platinum and rhodium were below the levels of detection in all the food groups. The concentrations of palladium were also very low, with a couple below the LOD and other values ranging from 0.00003 mg/kg (Milk) to 0.002 mg/kg (Offal). Similarly, the concentrations of ruthenium were below the LOD in all the food groups with the exception of the Other Vegetables and Canned Vegetables groups where the concentration was 0.0002 mg/kg. These values are comparable to those reported for the 1994 TDS.

Taking into account uncertainty related to samples in which these elements could not be detected, the population dietary exposures for these metals have been estimated to be in the region of 0 - 0.002 mg/day for platinum and rhodium, 0.0007 mg/day for palladium and 0.00003 - 0.00081 mg/day for ruthenium. The percentage contribution by each of the food groups to the total population dietary exposures to the platinum group metals is given in Table 7b. No safety guidelines have been established for these metals, but considering the very low levels and that their intake has not increased since 1994, establishing safety guidelines is not considered to be a high priority.

The COT noted that the toxicological database on palladium metal and its compounds is extremely limited. However, based on the limited database and the evidence that exposure had not increased since 1994, they concluded that there was no reason to believe that current intakes of palladium from the diet pose a risk to health (COT, 2008). Regarding the other platinum metals, the COT concluded that despite a dearth of information on the effects of low doses of platinum, rhodium and ruthenium, current dietary exposures do not suggest a reason for concern as the levels present in the food samples tested were very low or undetectable (COT, 2008).

The Alkaline Earth Metals - Barium and Strontium

Barium and strontium, like calcium, are in Group II of the periodic table and have widespread domestic and medicinal applications. This is the first time these metals have been analysed since the 1994 TDS.

Barium and strontium were detected in all the food groups at varying concentrations. The highest concentration was in the Nuts group with a barium concentration of 131 mg/kg and a strontium concentration of 15.7 mg/kg. The concentrations of barium and strontium were comparable to the 1994 TDS in all the food groups other than the Nuts group where the concentration was approximately two times the levels reported in 1994.

The mean adult dietary exposure for barium was 9.4 µg/kg bw/day and 45.3 µg/kg bw/day for a high level consumer. The population dietary exposure to barium was 0.847 mg/day. This has increased from 0.58 mg/day reported in the 1994 TDS. The percentage contribution from various food groups to the population dietary exposures to barium is given in Table 7b; the Nuts food group being the major contributor (46%).

A TDI of 20 µg/kg bw/day was derived by the WHO to set guideline limits for drinking water (WHO, 2001b). The mean-level exposures for all population sub-groups were below or in the region of the WHO TDI. However the exposure could be up to four times the TDI in high level consumers. The TDI was derived from studies in which no effects were observed and therefore, it is possible that the TDI is highly conservative.

The COT noted that the TDI for barium is based on studies in which no effects were observed and thus may be over-precautionary (COT, 2008). Therefore, they concluded that the estimated exposures were not necessarily a toxicological concern. They recommended that further research be carried out to allow a TDI to be set with more confidence and to investigate the bioavailability of barium; especially from foods with relatively high levels such as nuts (COT, 2008).

In the case of strontium, the population dietary exposure was 1.20 mg/day and was lower than the value reported in the 1994 TDS (1.3 mg/day). The mean adult dietary exposure was 15.6 µg/kg bw/day and that of the high level exposure adult was 30.6 µg/kg bw/day. The percentage contribution from various food groups to the population dietary exposure is given in Table 7b with Bread making the greatest contribution to dietary intake (20%).

The COT concluded that these dietary exposures to strontium were unlikely to be of toxicological concern (COT, 2008).

Indium and Thallium

These two metals, along with aluminium, belong to Group III of the periodic table. They are used in semi-conductors, liquid crystal displays (LCDs) alloys, pigments and dyes. These metals were found to be present in small quantities in the various food groups. The concentration of indium was below the LOD in all cases except Canned Vegetables and Fruit Products (0.096 and 0.031 mg/kg, respectively). Thallium was present at varying levels (0.00008 mg/kg in Milk to 0.0028 mg/kg in Poultry). The results for thallium were lower than or comparable to the 1994 TDS values (Ysart et al, 1999). The mean adult dietary exposure to indium was 0.06 - 0.24 µg/kg bw/day and 0.22 - 0.47 µg/kg bw/day for the high level consumer. The population dietary exposure was 0.005 - 0.019 mg/day. The COT concluded that population dietary exposures to indium were similar to previous studies and although there was uncertainty, the sparse data on the oral toxicity of indium did not suggest that the estimated intakes gave cause for toxicological concern (COT, 2008).

For thallium, the adult dietary exposure was 0.01 µg/kg bw/day for the mean level consumer and 0.02 µg/kg bw/day for the high level consumer. The percentage contribution from various food groups to the population dietary exposure is given in Table 7b. The COT concluded that current dietary exposures to thallium were unlikely to be of toxicological concern (COT, 2008).

Antimony, Bismuth and Germanium

Antimony and bismuth belong to Group V of the periodic table, like arsenic. Antimony is used in alloys and fireproofing materials, paint, glazes and pigments. A TDI of 6 µg/kg bw/day was set by the WHO in 2003 (WHO, 2003c). Bismuth is also used in alloys and paints as well as in some pharmaceutical and cosmetic products. Germanium, which belongs to the same group as tin and lead, has been used extensively in electronic and optical devices; and is present in trace amounts in a wide range of foods including beans, tomato juice, oysters, tuna and garlic.

Antimony was detected in most of the food groups except the Oils and Fats, Eggs and Milk groups where the concentration was below the LOD. The values ranged from below the LOD to 0.0099 mg/kg. The mean adult dietary exposure to antimony was found to be 0.03 µg/kg bw/day and the high level exposure was 0.06 µg/kg bw/day, both below the TDI set by WHO (6 µg/kg bw/day) (WHO, 2003c). The population dietary exposure was 0.0025 mg/day, slightly lower than the value reported in the 1994 TDS (0.003 mg/day). The Meat Products group, which had the highest concentration of antimony, contributed the highest percentage (24%) to the total population dietary exposure.

The COT concluded that these dietary exposures to antimony were not of toxicological concern (COT, 2008).

Bismuth was detected in eleven of the food groups with concentrations ranging from below the LOD to 0.0064 mg/kg in the Dairy Products food group. The population dietary exposure was 0.002 mg/day (Table 6a), which was higher than the value reported for the 1994 TDS (0.0004 mg/day). Dairy Products and Milk contributed most to bismuth exposure (25% and 24%, respectively). The mean adult dietary exposure was 0.015 - 0.022 µg/kg bw/day and 0.034 - 0.044 µg/kg bw/day for the high level consumer (Table 4a).

Germanium was detected only in the Offal and Meat Products categories of the TDS samples at concentrations of 0.002 mg/kg and 0.001 mg/kg, respectively. The population dietary exposure was 0.0001 - 0.0015 mg/day, which was much lower than the value reported for the 1994 TDS (0.004 mg/day). The mean adult dietary exposure was 0.001 - 0.018 µg/kg bw/day and 0.002 - 0.033 µg/kg bw/day for the high level consumer.

The COT concluded that these dietary exposures to bismuth and germanium were unlikely to be of toxicological concern (COT, 2008).

Conclusions

The results from this survey indicated that population dietary exposures to most of the 24 metals and elements analysed in the 2006 TDS were not of specific concern for the health of consumers, but that there was a need for more information on aluminium and barium. In line with current COT advice, efforts should continue to reduce dietary exposure to inorganic arsenic and lead in the UK.

Future priorities for research and surveys of elements in food should be directed to the following: (i) information on the forms of aluminium in food and their bioavailability; (ii) clarification of the large variability in aluminium concentrations in food and whether these represent an increasing trend; (iii) assessment of the bioavailability of barium in nuts compared to barium chloride in water; (iv) a long-term human study with a large number of subjects to examine the effect of barium on blood pressure and to investigate renal end-points following oral exposure to barium in drinking water, to allow a TDI to be set with more confidence; and (v) information on the bioavailability of manganese, particularly from beverages (the principal contributing food group). It would also be useful to compare the UK data with trends in other countries and to gather more detail as regards speciation for some elements such as tin, arsenic and chromium etc.

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Table 1. Average weight of food eaten as estimated by the Expenditure and Food Survey

Food Group	Contribution to household diet as purchased (kg/person/day)	Loss/gain in preparation and cooking (%) (to nearest 5%)	Estimated average weight of food as eaten (kg/person/day)
Bread	0.107	0	0.107
Miscellaneous Cereals	0.123	5	0.129
Carcase meat	0.033	-40	0.020
Offal	0.001	-35	0.001
Meat products	0.081	-25	0.061
Poultry	0.035	-45	0.019
Fish	0.022	-35	0.014
Oils and fats	0.022	0	0.022
Eggs	0.013	-10	0.013
Sugar & preserves	0.058	0	0.058
Green vegetables	0.043	-30	0.030
Potatoes	0.126	-15	0.107
Other vegetables	0.106	-15	0.090
Canned vegetables	0.041	-20	0.033
Fresh fruit	0.111	-25	0.083
Fruit products	0.055	0	0.055
Beverages	0.298	+320	1.252
Milk	0.246	0	0.246
Dairy products	0.082	0	0.082
Nuts	0.003	0	0.003

Table 2. Limits of detection (LOD) for the 2006 Total Diet Study

Element	LOD (mg/kg)
Aluminium	0.01 -0.05
Antimony	0.0001 - 0.0005
Arsenic (Total)	0.001 - 0.005
Arsenic (Inorganic)	0.01
Barium	0.007 0.04
Bismuth	0.0002 - 0.001
Cadmium	0.001 - 0.005
Chromium	0.003-0.02
Copper	0.007-0.04
Germanium	0.0003 - 0.002
Indium	0.003-0.02
Lead	0.001 - 0.006
Manganese	0.002-0.01
Mercury	0.005 - 0.003
Molybdenum	0.002-0.01
Nickel	0.007-0.04
Palladium	0.00003 - 0.0002
Platinum	0.0005-0 003
Rhodium	0.0005 -0.003
Ruthenium	0.0002 - 0.001
Selenium	0.005-0.03
Strontium	0.003-0.02
Thallium	0.00007 - 0.0004
Tin	0.003-0.02
Zinc	0.02-0.1

Notes
Ranges are shown because the sample mass taken for analysis varied between the different food matrices examined.

Table 3a. Concentrations (in milligrams per kilogram) of aluminium (Al), antimony (Sb), arsenic (As), barium (Ba), bismuth (Bi), cadmium (Cd), chromium (Cr), copper (Cu), germanium (Ge), indium (In) and lead (Pb) in the 20 food groups of the 2006 UK Total Diet Study

Food Group	**Al**	**Sb**	**As**		**Ba**	**Bi**	**Cd**	**Cr**	**Cu**	**Ge**	**In**	**Pb**
			Inorganic	Total								
Bread	3.59	(0.0014)	<0.01	<0.005	0.81	<0.001	0.023	<0.02	1.66	<0.002	<0.02	(0.011)
Misc. Cereal	17.5	0.0020	(0.012)	0.018	0.74	<0.001	0.021	(0.03)	2.21	<0.002	<0.02	(0.007)
Carcase Meat	0.24	(0.0008)	<0.01	(0.006)	(0.03)	<0.0005	<0.003	(0.03)	1.44	<0.001	<0.01	<0.003
Offal	0.22	(0.0008)	<0.01	(0.008)	0.09	<0.0005	0.084	<0.01	52.5	(0.002)	<0.01	0.065
Meat Product	2.50	0.0099	<0.01	(0.005)	0.33	<0.0005	(0.007)	0.037	1.16	(0.001)	<0.01	(0.005)
Poultry	0.20	(0.0008)	<0.01	0.022	(0.03)	<0.0005	<0.003	<0.01	0.72	<0.001	<0.01	<0.003
Fish	0.81	0.0026	(0.015)	3.99	0.14	(0.0006)	0.015	0.04	0.91	<0.0007	<0.007	(0.004)
Oils & Fats	0.27	<0.0005	<0.01	<0.005	<0.04	(0.001)	<0.005	0.02	(0.08)	<0.002	<0.02	<0.006
Eggs	<0.03	<0.0003	<0.01	<0.003	0.33	<0.0005	<0.003	0.01	0.57	<0.001	<0.01	<0.003
Sugar & Preserves	2.73	0.0044	<0.01	(0.009)	0.49	0.005	(0.006)	0.08	1.80	<0.002	<0.02	<0.006
Green Vegetables	1.12	0.0005	<0.01	0.004	0.465	(0.0005)	0.006	(0.008)	0.580	<0.0003	<0.003	0.004
Potatoes	0.98	(0.0004)	<0.01	(0.005)	0.17	(0.0005)	0.028	0.031	1.12	<0.0007	<0.007	(0.003)
Other Vegetables	2.84	0.0055	<0.01	0.005	0.533	(0.0004)	0.007	0.024	0.808	<0.0004	<0.004	0.013
Canned Vegetables	1.02	0.0005	<0.01	(0.001)	0.249	0.0009	0.006	0.039	1.29	<0.0004	0.096	0.006
Fresh Fruits	0.48	0.0004	<0.01	(0.001)	0.422	(0.0003)	<0.001	(0.007)	0.786	<0.0003	<0.003	(0.002)
Fruit Products	1.17	0.0004	<0.01	(0.003)	0.212	(0.0003)	0.004	0.017	0.544	<0.0003	0.031	0.007
Beverages	1.49	0.0004	<0.01	<0.001	0.036	<0.0002	<0.001	<0.003	0.074	<0.0003	<0.003	(0.001)
Milk	(0.01)	<0.0001	<0.01	<0.001	0.070	0.0020	<0.001	<0.003	0.050	<0.0003	<0.003	(0.001)
Dairy Products	0.50	(0.0004)	<0.01	<0.003	0.22	0.0064	<0.003	(0.01)	0.33	<0.001	<0.01	<0.003
Nuts	3.81	(0.0007)	<0.01	(0.007)	131	<0.001	0.065	(0.03)	9.15	<0.002	<0.02	<0.006

Brackets indicate the measured values are below the LOQ; LODs and LOQs for a given element will vary according to the weight of sample taken.

Table 3b. Concentrations (in milligrams per kilogram) of manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), palladium (Pd), platinum (Pt), rhodium (Rh), ruthenium (Ru), selenium (Se), strontium (Sr), thallium (Tl), tin (Sn) and zinc (Zn) in the 20 food groups of the 2006 UK Total Diet Study

Food Group	Mn	Hg	Mo	Ni	Pd	Pt	Rh	Ru	Se	Sr	Tl	Sn	Zn
Bread	8.01	<0.003	0.22	(0.07)	0.0008	<0.003	<0.003	<0.001	(0.06)	2.27	(0.0005)	<0.02	9.9
Misc. Cereal	7.98	<0.003	0.32	0.16	0.0007	<0.003	<0.003	<0.001	(0.07)	1.28	<0.0004	<0.02	9.4
Carcase Meat	0.129	<0.002	(0.016)	<0.02	0.0005	<0.0015	<0.0015	<0.0005	0.14	0.05	(0.0004)	(0.01)	64.8
Offal	2.65	(0.004)	1.10	(0.02)	0.0022	<0.0015	<0.0015	<0.0005	0.77	0.10	0.0023	<0.01	46.5
Meat Product	2.75	<0.002	0.085	0.07	0.0006	<0.0015	<0.0015	<0.0005	0.14	0.61	(0.0006)	0.04	23.0
Poultry	0.180	<0.002	0.050	<0.02	0.0003	<0.0015	<0.0015	<0.0005	0.17	0.16	0.0028	<0.01	16.3
Fish	0.722	0.056	0.024	(0.04)	0.00046	<0.001	<0.001	<0.0003	0.42	2.50	0.0010	(0.021)	7.67
Oils & Fats	0.08	<0.003	<0.01	<0.04	<0.0002	<0.003	<0.003	<0.001	<0.03	0.11	<0.0004	<0.02	0.22
Eggs	0.307	<0.002	0.124	<0.02	<0.0001	<0.0015	<0.0015	<0.0005	0.19	0.38	(0.0003)	<0.01	11.4
Sugar & Preserves	2.05	<0.003	0.06	0.31	(0.0002)	<0.003	<0.003	<0.001	<0.03	1.06	(0.0005)	<0.02	6.49
Green Vegetables	2.06	<0.0005	0.143	0.086	0.00023	<0.0005	<0.0005	<0.0002	(0.007)	2.06	0.00150	<0.003	3.26
Potatoes	1.58	<0.001	0.068	0.07	0.00070	<0.001	<0.001	<0.0003	<0.01	0.625	0.0014	<0.007	3.66
Other Vegetables	1.54	(0.0007)	0.066	0.079	0.00030	<0.0006	<0.0006	(0.0002)	(0.018)	1.39	0.00066	(0.012)	2.62
Canned Vegetables	1.71	<0.0006	0.243	0.338	0.00042	<0.0006	<0.0006	(0.0002)	(0.014)	0.618	(0.00023)	36.1	3.33
Fresh Fruits	1.56	<0.0005	0.019	0.036	(0.00004)	<0.0005	<0.0005	<0.0002	<0.005	0.859	0.00045	(0.005)	0.89
Fruit Products	4.56	<0.0005	0.011	0.066	0.00020	<0.0005	<0.0005	<0.0002	<0.005	0.689	0.00031	11.1	0.61
Beverages	1.71	<0.0005	<0.002	(0.022)	0.00011	<0.0005	<0.0005	<0.0002	<0.005	0.063	(0.00015)	<0.003	0.13
Milk	0.022	<0.0005	0.034	<0.007	(0.00003)	<0.0005	<0.0005	<0.0002	(0.014)	0.273	(0.00008)	<0.003	3.71
Dairy Products	0.224	<0.002	0.065	(0.04)	0.0018	<0.0015	<0.0015	<0.0005	(0.03)	0.83	<0.0002	(0.02)	9.66
Nuts	24.9	<0.003	1.26	3.02	0.0019	<0.003	<0.003	<0.001	0.30	15.7	(0.0012)	(0.02)	31.0

Brackets indicate the measured values are below the LOQ; LODs and LOQs for a given element vary according to the weight of sample taken.

Table 4a. Estimated total dietary exposure to aluminium (Al), antimony (Sb), arsenic (As, total and inorganic), barium (Ba) and bismuth (Bi) from the 2006 Total Diet Study

	Estimated dietary exposure (µg/kg bw/day)[1-3]											
	Al		Sb		Total As		Inorganic As		Ba		Bi	
Population Group	Mean	High-Level (P97.5)	Mean	High-Level (P97.5)	Mean	High-Level (P97.5)	Mean	High-Level (P97.5)	Mean	High-Level (P97.5)	Mean	High-Level (P97.5)
Adults	71	144	0.032-0.033	0.059-0.060	1.65-1.68	6.83-6.85	0.028-0.093	0.071 - 0.165	9.40	45.29	0.015-0.022	0.034 0.044
Toddlers 1.5-4.5 years)	187	345	0.075-0.077	0.132-0.135	2.71 - 2.80	12.27-12.34	0.075-0.246	0.174-0.402	22.21 - 22.22	85.01	0.086-0.104	0.201 - 0.217
Young (4-18 years)	123	246	0.049-0.050	0.096-0.097	1.91 - 1.95	8.19-8.24	0.055-0.158	0.128-0.291	14.36-14.37	64.75-64.76	0.034-0.046	0.090-0.107
Elderly (free living)	59	135	0.027	0.054	1.72-1.75	6.40-6.43	0.024-0.079	0.066-0.149	6.38-6.39	24.53	0.016-0.022	0.037-0.046
Elderly (institutional)	58	167	0.023-0.024	0.062	1.18-1.20	5.02-5.05	0.025-0.072	0.082-0.173	4.64	11.72	0.018-0.024	0.049-0.061
Vegetarians[4]	87	151	0.035-0.036	0.06	1.56-1.59	8.68-8.70	0.035-0.100	0.079-0.163	14.21	63.31 - 63.32	0.020-0.027	0.048 - 0.056

Notes

1. Exposures have been estimated for the lower and upper bound concentrations and these have been included as ranges where they apply.
2. The dietary exposure (mean and high level) for all foods combined is not equal to the sum of the exposure from the individual food. It refers to the dietary exposure by a consumer consuming one or any combination of the foods containing the metals. These values are derived from a distribution of the individual consumer's consumption patterns with regards to the individual foods.
3. All figures have been rounded off as appropriate.
4. Some of the vegetarian respondents were consumers of fish.

Table 4b. Estimated total dietary exposure to cadmium (Cd), chromium (Cr), copper (Cu), germanium (Ge), indium (In) and lead (Pb) from the 2006 Total Diet Study

	Estimated dietary exposure (µg/kg bw/day)[1-3]											
	Cd		Cr		Cu		Ge		In		Pb	
Population Group	Mean	High-Level (P97.5)	Mean	High-Level (P97.5)	Mean	High-Level (P97.5)	Mean	High-Level (P97.5)	Mean	High-Level (P97.5)	Mean	High - Level (P97.5)
Adults	0.14 - 0.17	0.25 - 0.29	0.28- 0.37	0.50 - 0.62	17.23	34.47	0.001 - 0.018	0.002 - 0.033	0.06 - 0.24	0.22 - 0.47	0.09- 0.10	0.17 - 0.18
Toddlers 1.5-4.5 years)	0.37 - 0.45	0.65 - 0.75	0.81 - 1.03	1.38- 1.67	44.71	77.82	0.002- 0.053	0.006 - 0.085	0.24- 0.75	0.93- 1.48	0.21 - 0.25	0.38 - 0.42
Young people (4-18 years)	0.27 - 0.31	0.50 - 0.57	0.51 - 0.65	1.03 - 1.22	29.41	54.92	0.001 - 0.032	0.004 - 0.058	0.13 - 0.44	0.51 - 0.97	0.13- 0.15	0.26 - 0.30
Elderly (free living)	0.13 - 0.15	0.26 - 0.29	0.25- 0.32	0.48 - 0.59	16.09	45.70	0.001 - 0.016	0.002 - 0.029	0.05 - 0.21	0.25- 0.46	0.08- 0.09	0.16 - 0.17
Elderly (institutional)	0.11 - 0.13	0.30 - 0.35	0.27- 0.28	0.56 - 0.70	13.38	43.36	0.001 - 0.015	0.002 - 0.036	0.04 - 0.18	0.19 - 0.45	0.06- 0.07	0.17 - 0.19
Vegetarians[4]	0.17 - 0.20	0.30 - 0.32	0.31 - 0.40	0.54 - 0.68	18.34	29.96	0 - 0.020	0 - 0.032	0.10 - 0.29	0.36 - 0.57	0.12	0.20 - 0.21

Notes

1. Exposures have been estimated for the lower and upper bound concentrations and these have been included as ranges where they apply.
2. The dietary exposure (mean and high level) for all foods combined is not equal to the sum of the exposure from the individual food. It refers to the dietary exposure by a consumer consuming one or any combination of the foods containing the metals. These values are derived from a distribution of the individual consumer's consumption patterns with regards to the individual foods.
3. All figures have been rounded off as appropriate.
4. Some of the vegetarian respondents were consumers of fish.

Table 4c. Estimated total dietary exposure to manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), palladium (Pd) and platinum (Pt) from the 2006 Total Diet Study

	Estimated dietary exposure (µg/kg bw/day)[1-3]											
	Mn		Hg		Mo		Ni		Pd		Pt	
Population Group	Mean	High - level	Mean	High - level	Mean	High - level	Mean	High - level	Mean	High - level	Mean	High - level
Adults	67	124	0.02 - 0.05	0.10 - 0.13	1.61 - 1.64	3.03 - 3.08	1.49 - 1.63	3.01 - 3.08	0.009	0.015 - 0.016	0 - 0.029	0 - 0.051
Toddlers (1.5-4.5 years)	168	305	0.04 - 0.12	0.17- 0.26	4.80 - 4.87	7.54 - 8.32	4.17 - 4.87	7.54 - 8.32	0.027	0.055 0.056	0 - 0.082	0 - 0.130
Young people (4-18 years)	106	201	0.03 - 0.08	0.11 - 0.18	3.01 - 3.05	5.77 - 5.82	2.62 - 3.05	5.27 - 5.82	0.016	0.032	0 - 0.048	0 - 0.089
Elderly (free living)	56	112	0.02 - 0.05	0.09- 0.12	1.43 - 1.46	3.00 - 3.03	1.25 - 1.46	2.58 - 3.03	0.008	0.015	0 - 0.025	0 - 0.045
Elderly (institutional)	50	121	0.02- 0.04	0.07- 0.12	1.33 - 1.36	3.46 - 3.54	1.11 - 1.36	2.80 - 3.54	0.007	0.018	0 - 0.023	0 - 0.055
Vegetarians[4]	78	135	0.02 - 0.05	0.12 - 0.15	2.01 - 2.05	3.34 - 3.37	1.88 - 2.05	3.49 - 3.37	0.010	0.018	0 - 0.031	0 - 0.050

Notes

1. Exposures have been estimated for the lower and upper bound concentrations and these have been included as ranges where they apply.
2. The dietary exposure (mean and high level) for all foods combined is not equal to the sum of the exposure from the individual food. It refers to the dietary exposure by a consumer consuming one or any combination of the foods containing the metals. These values are derived from a distribution of the individual consumer's consumption patterns with regards to the individual foods.
3. All figures have been rounded off as appropriate.
4. Some of the vegetarian respondents were consumers of fish.

Table 4d. Estimated total dietary exposure to rhodium (Rh), ruthenium (Ru), selenium (Se), strontium (Sr), thallium (Tl), tin (Sn) and zinc (Zn) from the 2006 Total Diet Study

	Estimated dietary exposure (µg/kg bw/day)[1-3]													
	Rh		Ru		Se		Sr		Tl		Sn		Zn	
Population Group	Mean	High - level	Mean	High - level	Mean	High - level	Mean	High - level	Mean	High - level	Mean	High - level	Mean	High - level
Adults	0 - 0.029	0 - 0.051	0.0004 - 0.0101	0.001 - 0.0183	0.83 - 0.95	1.65 - 1.79	15.6	30.6	0.011 - 0.012	0.020 - 0.021	23.3 - 23.4	82.1 - 82.2	140.7	267.8
Toddlers (1.5-4.5 years)	0 - 0.082	0 - 0.130	0.0008 - 0.0291	0.0022 - 0.0468	1.97 - 2.27	3.77 - 4.10	42.8	71.1	0.024 - 0.027	0.043 - 0.046	89.3 - 89.8	341.2 - 341.5	387.0	775.7
Young people (4-18 years)	0 - 0.048	0 - 0.089	0.0005 - 0.0169	0.0013 - 0.0315	1.27 - 1.44	2.60 - 2.84	25.9	51.0	0.016 - 0.018	0.032 - 0.035	48.2 - 48.5	191.3 - 191.5	232.3	478.0
Elderly (free living)	0 - 0.025	0 - 0.045	0.0003 - 0.0087	0.0009 - 0.0159	0.73 - 0.82	1.48 - 1.60	14.0	26.6	0.009 - 0.010	0.017 - 0.018	19.7 - 19.9	93.2 - 93.4	121.7	261.2
Elderly (institutional)	0 - 0.023	0 - 0.055	0.0002 - 0.0081	0.001 - 0.0196	0.59 - 0.68	1.58 - 1.74	12.0	29.2	0.007 - 0.008	0.017 - 0.019	13.1 - 13.2	68.3 - 68.4	103.5	251.5
Vegetarians[4]	0 - 0.031	0 - 0.050	0.0007 - 0.0109	0.0015 - 0.0180	0.64 - 0.76	1.43 - 1.54	20.5	35.9	0.010 - 0.011	0.018 - 0.019	35.0 - 35.1	131.5 - 131.7	93.4	161.6

Notes

1. Exposures have been estimated for the lower and upper bound concentrations and these have been included as ranges where they apply.
2. The dietary exposure (mean and high level) for all foods combined is not equal to the sum of the exposure from the individual food. It refers to the dietary exposure by a consumer consuming one or any combination of the foods containing the metals. These values are derived from a distribution of the individual consumer's consumption patterns with regards to the individual foods.
3. All figures have been rounded off as appropriate.
4. Some of the vegetarian respondents were consumers of fish.

Table 5a. Comparison of the mean and high-level intake of metals and other elements by adult consumers from the 2006, 2000 and 1997 Total Diet Studies with recommended safety guidelines

Element	PTWI or PMTDI[#] (ug/kg bw /day)	Total Dietary Intake (µg/kg bw/day)					
		2006[1-3,5]		2000[1-3,5]		1997[3-6]	
		Mean	High-level	Mean	High-level	Mean	High-level
Aluminium	143	71	144	67-68	134-135	45.6	81.3
Antimony	6*	0.03	0.06	-	-	0.043	0.057
Arsenic (total)		1.65 - 1.68	6.83 - 6.85	1.5-1.6	5.8	1.71	6.00
Arsenic (inorganic)	2.1	0.028	0.071	-	-	-	-
Cadmium	1	0.14 - 0.17	0.25 - 0.29	0.12	0.21	0.20	0.34
Chromium	150[‡]	0.28 - 0.37	0.50 - 0.62	0.66 - 0.67	1.0 - 1.1	1.43	2.43
Copper	50-500;160[†]	17.2	34.5	18	33	20.0	45.6
Lead	3.6	0.09 - 0.10	0.17 - 0.18	0.1	0.18	0.34	0.61
Manganese	200 or 150[‡]	67	124	67	118	-	-
Mercury (methyl mercury)	0.23	0.02 - 0.05	0.10 - 0.13	0.03 - 0.04	0.12 - 0.13	0.04	0.09
Nickel	4.3[‡]	1.49-1.63	3.01 - 3.08	1.5	2.9	1.71	3.00
Selenium	5[†]	0.83 - 0.95	1.65 - 1.79	0.63 - 0.67	1.2 - 1.3	0.77	1.43
Tin	220[‡]	23.3 - 23.4	82.1 - 82.2	20	70	27.1	89.9
Zinc	300-1000	140.7	267.8	141	252	157	286

The numerical values shown are the tolerable daily intake for a 60 kg person derived from PTWIs or PMTDIs recommended by JECFA unless mentioned otherwise.

* TDI derived by WHO

‡ Expert Group on Vitamins and Minerals - guidance level

† Expert Group on Vitamins and Minerals - safe upper level

Table 5b. Comparison of the mean and high-level intake of metals and other elements by toddlers and young people from the 2006 and 2000 Total Diet Studies with recommended safety guidelines

Element	PTWI or PMTDI#	Total Dietary Intake (µg/kg bw/day)[1-3,5]							
		Toddlers (1.5 - 4.5 years)				Young people (4 -18 years)			
		2006		2000		2006		2000	
		Mean	High-level	Mean	High-level	Mean	High-level	Mean	High-level
Aluminium	143	187	345	165	327	123	246	120-121	244-245
Antimony	6*	0.075 - 0.077	0.132- 0.135			0.049- 0.050	0.096 - 0.097		
Arsenic (total)		2.71 - 2.80	12.27 - 12.34	2.7	12	1.91 - 1.95	8.19 - 8.24	1.7	7.0
Arsenic (inorganic)	2.1	0.075 - 0.246	0.174 - 0.402			0.055 - 0.158	0.128 - 0.291		
Cadmium	1	0.37 - 0.45	0.65 - 0.75	0.31 - 0.32	0.56	0.27 - 0.31	0.50 - 0.57	0.22	0.42
Chromium	150‡	0.81 - 1.03	1.38 - 1.67	1.7	2.7 - 2.8	0.51 - 0.65	1.03 - 1.22	1.14 - 1.15	2.1
Copper	50-500;160†	44.71	77.82	46	81	29.41	54.92	30	56
Lead	3.5	0.21 - 0.25	0.38 - 0.42	0.25	0.47	0.13 - 0.15	0.26 - 0.30	0.17	0.32
Manganese	200‡	168	305	132	235	106	201	101	195
Mercury (methyl mercury)	0.23	0.04 - 0.12	0.17 - 0.26	0.06 - 0.07	0.26 - 0.27	0.03 - 0.08	0.11 - 0.18	0.04 - 0.05	0.15 - 0.16
Nickel	4.3‡	4.17 - 4.87	7.54 - 8.32	3.9	7.2	2.62 - 3.05	5.27 - 5.82	2.6	5.3
Selenium	5†	1.97 - 2.27	3.77 - 4.10	1.3 - 1.4	2.6 - 2.7	1.27 - 1.44	2.60 - 2.84	0.86 - 0.92	1.9 - 2.0
Tin	220‡	89.3 - 89.8	341.2 - 341.5	70	283	48.2 - 48.5	191.3 - 191.5	38	150
Zinc	300-1000	387.0	775.7	386	759	232.3	478.0	226	453

The numerical values shown are the tolerable daily intake for a 60 kg person derived from PTWIs or PMTDIs recommended by JECFA unless mentioned otherwise.
* TDI derived by WHO
‡ Expert Group on Vitamins and Minerals - guidance level
† Expert Group on Vitamins and Minerals - safe upper limit

Notes for tables 5a and 5b

1. Exposures have been estimated for the lower and upper bound concentrations and these have been included as ranges where they apply.
2. Consumption data taken from the National Diet and Nutrition Survey: adults aged 19 to 64 years. Volume 1: Types and quantities of foods consumed. Henderson L, Gregory J and Swan G. (2002). The Stationery Office, London and Gregory, J., Foster, K., Tyler, H. and Wiseman, M. (1990). The Dietary and Nutritional Survey of British Adults. The Stationery Office, London.
3. The exposure to elements by the mean and high-level (97.5%) consumer for all foods combined is not equal to the sum of the exposure from the individual food. It refers to the dietary exposure by a consumer consuming one or any combination of the foods containing the elements. These values are derived from a distribution of individual consumer's consumption patterns with regards to the individual foods.
4. Exposures have been estimated from upper bound mean concentrations only. Exposures have been converted into µglkg bw/day (for a 70.1 kg adult) from the 1997 Total Diet Study-Aluminium, Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Tin and Zinc. Food Surveillance Information Sheet No. 191. Ministry of Agriculture, Fisheries and Food (1999). The Stationery Office, London.
5. All figures have been rounded off as appropriate.
6. Consumption data taken from the Dietary and Nutritional Survey of British Adults. J Gregory, K Foster, H Tyler, M Wseman. (1990). The Stationery Office, London.

Table 6a. Comparison of population dietary exposures of aluminium (Al), antimony (Sb), arsenic (As), barium (Ba), bismuth (Bi), cadmium (Cd), chromium (Cr), copper (Cu), Germanium (Ge), Indium (In) and lead (Pb) from UK Total Diet Studies 1976 to 2006.

	Population dietary exposure (mg/day)[1-3]											
Year	Al	Sb	Total As	Inorganic As	Ba	Bi	Cd	Cr	Cu	Ge	In	Pb
1976	NM	NM	0.075	NM	NM	NM	0.02	0.13	1.8	NM	NM	0.11
1977	NM	NM	0.1	NM	NM	NM	0.018	0.17	1.8	NM	NM	0.1
1978	NM	NM	0.081	NM	NM	NM	0.02	0.1	1.6	NM	NM	0.11
1979	NM	NM	NM	NM	NM	NM	0.017	NM	NM	NM	NM	0.09
1980	NM	NM	NM	NM	NM	NM	0.026	NM	NM	NM	NM	0.12
1981	NM	NM	NM	NM	NM	NM	0.019	NM	NM	NM	NM	0.08
1982	NM	NM	0.09	NM	NM	NM	0.018	NM	1.3	NM	NM	0.069
1983	NM	NM	0.07	NM	NM	NM	0.018	NM	1.2	NM	NM	0.067
1984	NM	NM	NM	NM	NM	NM	0.019	0.073	1.4	NM	NM	0.065
1985	NM	NM	NM	NM	NM	NM	0.018	NM	1.3	NM	NM	0.066
1986	NM	NM	NM	NM	NM	NM	0.017	NM	NM	NM	NM	0.06
1987	NM	NM	NM	NM	NM	NM	0.018	NM	NM	NM	NM	0.06
1988	3.9	NM	NM	NM	NM	NM	0.019	NM	NM	NM	NM	0.06
1991	10	NM	0.07	NM	NM	NM	0.018	0.25	1.4	NM	NM	0.028
1994	11	0.003	0.063	NM	0.58	0.0004	0.014	0.34	1.2	0.004	NM	0.024
1995	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
1997	3.4	NM	0.065	NM	NM	NM	0.012	0.1	1.2	NM	NM	0.026
1999	NM	NM	0.05	0.0009 - 0.005	NM	NM	NM	NM	NM	NM	NM	NM
2000	4.7	NM	0.055	NM	NM	NM	0.009	0.046	1.3	NM	NM	0.0073 - 0.0074
2006 [a]	5.4	0.0025	0.061 - 0.064	0.0014 - 0007	0.847 - 0.848	0.002	0.011 - 0.013	0.022 - 0.029	1.24	0.0001 - 0.0015	0.005 - 0019	0.006 - 0,007

Table 6b. Comparison of population dietary exposures of manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), palladium (Pd), platinum (Pt), rhodium (Rh), ruthenium (Ru), selenium (Se), strontium (Sr), thallium (Tl), tin (Sn) and zinc (Zn) from UK Total Diet Studies 1976 to 2006

Year	Population dietary exposure (mg/day)[1-3]												
	Mn	Hg	Mo	Ni	Pd	Pt	Rh	Ru	Se	Sr	Tl	Sn	Zn
1976	NM	0.005	NM	0.33	NM	NM	NM	NM	NM	NM	NM	4.4	10
1977	NM	0.005	NM	0.26	NM	NM	NM	NM	NM	NM	NM	4.2	10
1978	NM	0.005	NM	0.27	NM	NM	NM	NM	NM	NM	NM	3.6	10
1979	NM	0.004	NM	NM	NM	NM	NM	NM	NM	NM	NM	3.2	NM
1980	NM	0.005	NM	0.27	NM	NM	NM	NM	NM	NM	NM	NM	NM
1981	NM	NM	NM	0.23	NM	NM	NM	NM	NM	NM	NM	2.4	NM
1982	NM	0.003	NM	0.15	NM	NM	NM	NM	NM	NM	NM	3.1	10
1983	4.6	NM	NM	0.15	NM	NM	NM	NM	NM	NM	NM	2.3	10
1984	5.3	NM	NM	0.16	NM	NM	NM	NM	NM	NM	NM	2.7	10
1985	5.0	NM	0.11	0.14	NM	NM	NM	NM	0.063	NM	NM	1.7	10
1986	NM	NM	NM	0.13	NM	NM	NM	NM	NM	NM	NM	2.2	NM
1987	NM	NM	NM	0.15	NM	NM	NM	NM	NM	NM	NM	2.0	NM
1988	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
1991	6.2	0.002	0.11	0.17	NM	NM	NM	NM	0.060	NM	NM	5.3	10
1994	4.9	0.004	0.11	0.13	0.001	0.0002	0.0003	0.004	0.043	1.3	0.002	2.4	8.4
1995	NM	NM	NM	NM	NM	NM	NM	NM	0.039	NM	NM	NM	NM
1997	NM	0.003	NM	0.13	NM	NM	NM	NM	0.039	NM	NM	1.8	8.4
2000	4.9	0.0012-0.0015	NM	0.13	NM	NM	NM	NM	0.032-0.034	NM	NM	1.4	8.4
2006[4]	5.24	0.001 - 0.003	0.123 - 0.125	0.127 - 0.129	0.0007	0 - 0.0023	0 - 0.0023	0.00003 - 0.00081	0.048 - 0.058	1.20	0.0007 - 0.0008	1.80 - 1.81	8.8

Notes for tables 6a and 6b

1. The population dietary exposures in the previous years were estimated using upper bound mean concentrations for each food group and consumption data taken from the National Food Survey 1997, Ministry of Agriculture, Fisheries and Food (1998). The Stationery Office, London. The exception to this is the 2000 TDS where exposures have been estimated from the lower and upper bound mean concentrations and included as ranges where they apply.
2. Changes in the organisation of the TDS from 1981 onwards mean that exposures from TDSs before 1981 and from 1981 onwards are not directly comparable (Peattie, M.E., Buss, D.H., Lindsay, D.G. and Smart, G.Q. (1983). Reorganisation of the British Total Diet Study for Monitoring Food Constituents from 1981. *Food and* Chemical Toxicology 21, 503-507).
3. For those years where no values are given, these elements were not included in TDSs for metals and other elements i.e. NM= not measured.
4. Dietary exposure estimates for the 2006 TDS and for selenium from the 1995 TDS and are not directly comparable with those from other years as they are based on analyses of composite samples of each food from all the towns in the TDS rather than the upper bound mean concentrations of analyses of each food group from each town.

Table 7a. Contribution (%) by each food group to total population dietary exposures to aluminium (Al), antimony (Sb), arsenic (As), barium (Ba), bismuth (Bi), cadmium (Cd), chromium (Cr), copper (Cu), germanium (Ge), indium (In) and lead (Pb) estimated from the 2006 UK TDS.

	Contribution to dietary exposure (%)											
Food Group	Al	Sb	Inorganic As	Total As	Ba	Bi	Cd	Cr	Cu	Ge	In	Pb
Bread	7	6	8	1	10	5	19	7	14	15	11	16
Miscellaneous	42	10	23	4	11	6	21	13	23	18	13	12
Carcase meat	<1	1	2	<1	<1	<1	<1	2	2	1	1	1
Offals	<1	<1	≤1	<1	<1	<1	<1	<1	2	<1	<1	<1
Meat products	3	24	5	<1	2	1	3	8	6	4	3	4
Poultry	<1	1	3	1	<1	<1	<1	1	1	1	1	1
Fish	<1	1	3	88	<1	<1	2	2	1	1	1	1
Oils and fats	<1	<1	2	<1	<1	1	1	2	<1	3	2	2
Eggs	<1	<1	1	<1	1	<1	<1	<1	1	1	1	1
Sugars and	3	10	8	1	3	14	3	16	8	8	6	5
Green vegetables	1	1	2	<1	2	1	1	1	1	1	<1	2
Potatoes	2	2	8	1	2	3	24	12	10	5	4	4
Other vegetables	5	20	7	1	6	2	5	8	6	2	2	16
Canned vegetables	1	1	<1	<1	1	1	2	4	3	1	16	3
Fresh fruit	1	1	1	<1	4	1	1	2	5	2	1	2
Fruit products	1	1	2	<1	1	1	2	3	2	1	9	5
Beverages	34	20	19	2	5	12	10	13	7	26	20	17
Milk	<1	1	4	<1	2	24	2	3	1	5	4	3
Dairy products	1	1	4	<1	2	25	2	3	2	6	4	3
Nuts	<1	<1	<1	<1	46	<1	2	<1	2	<1	<1	<1
Total	100	100	100	100	100	100	100	100	100	100	100	100

Table 7b. Contribution (%) by each food group to total population dietary exposures to manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), palladium (Pd), platinum (Pt), rhodium (Rh), ruthenium (Ru), selenium (Se), strontium (Sr), thallium (Tl), tin (Sn) and zinc (Zn) estimated from the 2006 UK TDS.

	Contribution to dietary exposure (%)												
Food Group	Mn	Hg	Mo	Ni	Pd	Pt	Rh	Ru	Se	Sr	Tl	Sn	Zn
Bread	**16**	**10**	**19**	**6**	**12**	**14**	**14**	**13**	**11**	**20**	7	<1	**12**
Miscellaneous cereals	**20**	**12**	**33**	**16**	**13**	**17**	**17**	**16**	**16**	**14**	6	<1	**14**
Carcase meat	<1	1	<1	<1	1	1	1	1	5	<1	1	<1	**15**
Offals	<1	<1	<1	<1	<1	<1	<1	<1	1	<1	<1	<1	<1
Meat products	3	4	4	3	5	4	4	4	**15**	3	5	<1	**16**
Poultry	<1	1	1	<1	1	1	1	1	6	<1	7	<1	4
Fish	<1	**25**	<1	<1	1	1	1	1	**10**	3	2	<1	1
Oils and fats	<1	2	<1	1	1	3	3	3	1	<1	1	<1	<1
Eggs	<1	1	1	<1	<1	1	1	1	4	<1	<1	<1	2
Sugars and	2	6	3	**14**	2	8	8	7	3	5	4	<1	4
Green vegetables	1	<1	3	2	1	1	1	1	<1	5	6	<1	1
Potatoes	3	3	6	6	**11**	5	5	4	2	6	**19**	<1	4
Other vegetables	3	2	5	6	4	2	2	2	3	**10**	7	<1	3
Canned vegetables	1	1	6	9	2	1	1	1	1	2	1	**65**	1
Fresh fruit	2	1	1	2	<1	2	2	2	1	6	5	<1	1
Fruit products	5	1	<1	3	2	1	1	1	<1	3	2	**34**	<1
Beverages	**41**	**20**	2	**21**	**20**	**27**	**27**	**31**	**11**	7	**23**	<1	2
Milk	<1	4	7	1	1	5	5	6	6	6	2	<1	**10**
Dairy products	<1	5	4	3	21	5	5	5	4	6	2	<1	9
Nuts	1	<1	3	7	1	<1	<1	<1	2	4	<1	<1	1
Total	100	100	100	100	100	100	100	100	100	100	100	100	100

Note

The results for food group(s) given in bold are those which contribute 10% or more to the total production dietary exposure for each element. Percentage contribution to population dietary exposure was estimated using upper bound means only.

Table 8. Comparison of the estimated dietary exposures (pg/kg bw/day) to arsenic (total and Inorganic) from previous TDSs

Population Group	Estimated total dietary exposure									
	Total arsenic (pg/kg bw/day)[1,2]						Inorganic arsenic (pg/kg bw/day)[1,2]			
	Mean			High level			Mean		High level	
	1999 TDS[3]	2000 TDS	2006 TDS	1999 TDS[3]	2000 TDS	2006 TDS	1999 TDS[3]	2006 TDS	1999 TDS[3]	2006 TDS
Adults	1.30	1.5-1.6	1.65-1.68	4.37	5.8	6.83-6.85	0.02-0.08	0.03-0.09	0.05-0.10	0.07-0.17
Toddlers (1.5-4.5 years)	2.43-2.46	2.7	2.71-2.80	11.31 -11.34	12	12.27-12.34	0.05-0.20	0.08-0.25	0.10-0.30	0.17-0.40
Young people (4-18	1.60-1.61	1.7	1.91-1.95	6.65-6.66	7.0	8.19-8.24	0.03-0.10	0.06-0.16	0.08-0.20	0.13-0.29
Elderly (free living)	1.60-1.61	1.7	1.72-1.75	5.33-5.34	5.6	6.40-6.43	0.02-0.07	0.02-0.08	0.04-0.10	0.07-0.15
Elderly (Institutional)	1.44-1.46	1.6	1.18-1.20	4.62-4.64	4.9	5.02-5.05	0.02-0.09	0.03-0.07	0.05-0.10	0.08-0.17
Vegetarians[4]	1.24-1.25	1.4	1.56-1.59	6.98-6.99	7.4	8.68-8.70	0.02-0.07	0.04-0.10	0.05-0.10	0.08-0.16

Notes

1. Exposures have been estimated for the lower and upper bound concentrations and these have been included as ranges where they apply.
2. The dietary exposure (mean and high level) for all foods combined is not equal to the sum of the exposure from the individual food. It refers to the dietary exposure by a consumer consuming one or any combination of the foods containing metals. These values are derived from a distribution of the individual consumer's consumption patterns with regard to individual foods.
3. Food Standards Agency. 1999 Total Diet Study: Total and inorganic arsenic in food. *Food Surveillance Information Sheet 51104.* 4. Some of the vegetarian respondents were consumers of fish.

Table 1. Average weight of food eaten as estimated by the Expenditure and Food Survey

Food Group	Contribution to household diet as purchased (kg/person/day)	Loss/gain in preparation and cooking (%) (to nearest 5%)	Estimated average weight of food as eaten (kg/person/day)
Bread	0.107	0	0.107
Miscellaneous Cereals	0.123	5	0.129
Carcase meat	0.033	-40	0.020
Offal	0.001	-35	0.001
Meat products	0.081	-25	0.061
Poultry	0.035	-45	0.019
Fish	0.022	-35	0.014
Oils and fats	0.022	0	0.022
Eggs	0.013	-10	0.013
Sugar & preserves	0.058	0	0.058
Green vegetables	0.043	-30	0.030
Potatoes	0.126	-15	0.107
Other vegetables	0.106	-15	0.090
Canned vegetables	0.041	-20	0.033
Fresh fruit	0.111	-25	0.083
Fruit products	0.055	0	0.055
Beverages	0.298	+320	1.252
Milk	0.246	0	0.246
Dairy products	0.082	0	0.082
Nuts	0.003	0	0.003

Table 2. Limits of detection (LOD) for the 2006 Total Diet Study

Element	LOD (mg/kg)
Aluminium	0.01 -0.05
Antimony	0.0001 - 0.0005
Arsenic (Total)	0.001 - 0.005
Arsenic (Inorganic)	0.01
Barium	0.007 0.04
Bismuth	0.0002 - 0.001
Cadmium	0.001 - 0.005
Chromium	0.003-0.02
Copper	0.007-0.04
Germanium	0.0003 - 0.002
Indium	0.003-0.02
Lead	0.001 - 0.006
Manganese	0.002-0.01
Mercury	0.005 - 0.003
Molybdenum	0.002-0.01
Nickel	0.007-0.04
Palladium	0.00003 - 0.0002
Platinum	0.0005-0 003
Rhodium	0.0005 -0.003
Ruthenium	0.0002 - 0.001
Selenium	0.005-0.03
Strontium	0.003-0.02
Thallium	0.00007 - 0.0004
Tin	0.003-0.02
Zinc	0.02-0.1

Notes

Ranges are shown because the sample mass taken for analysis varied between the different food matrices examined.

Table 3a. Concentrations (in milligrams per kilogram) of aluminium (Al), antimony (Sb), arsenic (As), barium (Ba), bismuth (Bi), cadmium (Cd), chromium (Cr), copper (Cu), germanium (Ge), indium (In) and lead (Pb) in the 20 food groups of the 2006 UK Total Diet Study

Food Group	**Al**	**Sb**	**As**		**Ba**	**Bi**	**Cd**	**Cr**	**Cu**	**Ge**	**In**	**Pb**
			Inorganic	Total								
Bread	3.59	(0.0014)	<0.01	<0.005	0.81	<0.001	0.023	<0.02	1.66	<0.002	<0.02	(0.011)
Misc. Cereal	17.5	0.0020	(0.012)	0.018	0.74	<0.001	0.021	(0.03)	2.21	<0.002	<0.02	(0.007)
Carcase Meat	0.24	(0.0008)	<0.01	(0.006)	(0.03)	<0.0005	<0.003	(0.03)	1.44	<0.001	<0.01	<0.003
Offal	0.22	(0.0008)	<0.01	(0.008)	0.09	<0.0005	0.084	<0.01	52.5	(0.002)	<0.01	0.065
Meat Product	2.50	0.0099	<0.01	(0.005)	0.33	<0.0005	(0.007)	0.037	1.16	(0.001)	<0.01	(0.005)
Poultry	0.20	(0.0008)	<0.01	0.022	(0.03)	<0.0005	<0.003	<0.01	0.72	<0.001	<0.01	<0.003
Fish	0.81	0.0026	(0.015)	3.99	0.14	(0.0006)	0.015	0.04	0.91	<0.0007	<0.007	(0.004)
Oils & Fats	0.27	<0.0005	<0.01	<0.005	<0.04	(0.001)	<0.005	0.02	(0.08)	<0.002	<0.02	<0.006
Eggs	<0.03	<0.0003	<0.01	<0.003	0.33	<0.0005	<0.003	0.01	0.57	<0.001	<0.01	<0.003
Sugar & Preserves	2.73	0.0044	<0.01	(0.009)	0.49	0.005	(0.006)	0.08	1.80	<0.002	<0.02	<0.006
Green Vegetables	1.12	0.0005	<0.01	0.004	0.465	(0.0005)	0.006	(0.008)	0.580	<0.0003	<0.003	0.004
Potatoes	0.98	(0.0004)	<0.01	(0.005)	0.17	(0.0005)	0.028	0.031	1.12	<0.0007	<0.007	(0.003)
Other Vegetables	2.84	0.0055	<0.01	0.005	0.533	(0.0004)	0.007	0.024	0.808	<0.0004	<0.004	0.013
Canned Vegetables	1.02	0.0005	<0.01	(0.001)	0.249	0.0009	0.006	0.039	1.29	<0.0004	0.096	0.006
Fresh Fruits	0.48	0.0004	<0.01	(0.001)	0.422	(0.0003)	<0.001	(0.007)	0.786	<0.0003	<0.003	(0.002)
Fruit Products	1.17	0.0004	<0.01	(0.003)	0.212	(0.0003)	0.004	0.017	0.544	<0.0003	0.031	0.007
Beverages	1.49	0.0004	<0.01	<0.001	0.036	<0.0002	<0.001	<0.003	0.074	<0.0003	<0.003	(0.001)
Milk	(0.01)	<0.0001	<0.01	<0.001	0.070	0.0020	<0.001	<0.003	0.050	<0.0003	<0.003	(0.001)
Dairy Products	0.50	(0.0004)	<0.01	<0.003	0.22	0.0064	<0.003	(0.01)	0.33	<0.001	<0.01	<0.003
Nuts	3.81	(0.0007)	<0.01	(0.007)	131	<0.001	0.065	(0.03)	9.15	<0.002	<0.02	<0.006

Brackets indicate the measured values are below the LOQ; LODs and LOQs for a given element will vary according to the weight of sample taken.

Table 3b. Concentrations (in milligrams per kilogram) of manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), palladium (Pd), platinum (Pt), rhodium (Rh), ruthenium (Ru), selenium (Se), strontium (Sr), thallium (Tl), tin (Sn) and zinc (Zn) in the 20 food groups of the 2006 UK Total Diet Study

Food Group	Mn	Hg	Mo	Ni	Pd	Pt	Rh	Ru	Se	Sr	Tl	Sn	Zn
Bread	8.01	<0.003	0.22	(0.07)	0.0008	<0.003	<0.003	<0.001	(0.06)	2.27	(0.0005)	<0.02	9.9
Misc. Cereal	7.98	<0.003	0.32	0.16	0.0007	<0.003	<0.003	<0.001	(0.07)	1.28	<0.0004	<0.02	9.4
Carcase Meat	0.129	<0.002	(0.016)	<0.02	0.0005	<0.0015	<0.0015	<0.0005	0.14	0.05	(0.0004)	(0.01)	64.8
Offal	2.65	(0.004)	1.10	(0.02)	0.0022	<0.0015	<0.0015	<0.0005	0.77	0.10	0.0023	<0.01	46.5
Meat Product	2.75	<0.002	0.085	0.07	0.0006	<0.0015	<0.0015	<0.0005	0.14	0.61	(0.0006)	0.04	23.0
Poultry	0.180	<0.002	0.050	<0.02	0.0003	<0.0015	<0.0015	<0.0005	0.17	0.16	0.0028	<0.01	16.3
Fish	0.722	0.056	0.024	(0.04)	0.00046	<0.001	<0.001	<0.0003	0.42	2.50	0.0010	(0.021)	7.67
Oils & Fats	0.08	<0.003	<0.01	<0.04	<0.0002	<0.003	<0.003	<0.001	<0.03	0.11	<0.0004	<0.02	0.22
Eggs	0.307	<0.002	0.124	<0.02	<0.0001	<0.0015	<0.0015	<0.0005	0.19	0.38	(0.0003)	<0.01	11.4
Sugar & Preserves	2.05	<0.003	0.06	0.31	(0.0002)	<0.003	<0.003	<0.001	<0.03	1.06	(0.0005)	<0.02	6.49
Green Vegetables	2.06	<0.0005	0.143	0.086	0.00023	<0.0005	<0.0005	<0.0002	(0.007)	2.06	0.00150	<0.003	3.26
Potatoes	1.58	<0.001	0.068	0.07	0.00070	<0.001	<0.001	<0.0003	<0.01	0.625	0.0014	<0.007	3.66
Other Vegetables	1.54	(0.0007)	0.066	0.079	0.00030	<0.0006	<0.0006	(0.0002)	(0.018)	1.39	0.00066	(0.012)	2.62
Canned Vegetables	1.71	<0.0006	0.243	0.338	0.00042	<0.0006	<0.0006	(0.0002)	(0.014)	0.618	(0.00023)	36.1	3.33
Fresh Fruits	1.56	<0.0005	0.019	0.036	(0.00004)	<0.0005	<0.0005	<0.0002	<0.005	0.859	0.00045	(0.005)	0.89
Fruit Products	4.56	<0.0005	0.011	0.066	0.00020	<0.0005	<0.0005	<0.0002	<0.005	0.689	0.00031	11.1	0.61
Beverages	1.71	<0.0005	<0.002	(0.022)	0.00011	<0.0005	<0.0005	<0.0002	<0.005	0.063	(0.00015)	<0.003	0.13
Milk	0.022	<0.0005	0.034	<0.007	(0.00003)	<0.0005	<0.0005	<0.0002	(0.014)	0.273	(0.00008)	<0.003	3.71
Dairy Products	0.224	<0.002	0.065	(0.04)	0.0018	<0.0015	<0.0015	<0.0005	(0.03)	0.83	<0.0002	(0.02)	9.66
Nuts	24.9	<0.003	1.26	3.02	0.0019	<0.003	<0.003	<0.001	0.30	15.7	(0.0012)	(0.02)	31.0

Brackets indicate the measured values are below the LOQ; LODs and LOQs for a given element vary according to the weight of sample taken.

Table 4a. Estimated total dietary exposure to aluminium (Al), antimony (Sb), arsenic (As, total and inorganic), barium (Ba) and bismuth (Bi) from the 2006 Total Diet Study

	Estimated dietary exposure (µg/kg bw/day)[1-3]											
	Al		**Sb**		**Total As**		**Inorganic As**		**Ba**		**Bi**	
Population Group	Mean	High-Level (P97.5)	Mean	High-Level (P97.5)	Mean	High-Level (P97.5)	Mean	High-Level (P97.5)	Mean	High-Level (P97.5)	Mean	High-Level (P97.5)
Adults	71	144	0.032-0.033	0.059-0.060	1.65-1.68	6.83-6.85	0.028-0.093	0.071 -0.165	9.40	45.29	0.015-0.022	0.034 0.044
Toddlers 1.5-4.5 years)	187	345	0.075-0.077	0.132-0.135	2.71 -2.80	12.27-12.34	0.075-0.246	0.174-0.402	22.21 -22.22	85.01	0.086-0.104	0.201 -0.217
Young (4-18 years)	123	246	0.049-0.050	0.096-0.097	1.91 -1.95	8.19-8.24	0.055-0.158	0.128-0.291	14.36-14.37	64.75-64.76	0.034-0.046	0.090-0.107
Elderly (free living)	59	135	0.027	0.054	1.72-1.75	6.40-6.43	0.024-0.079	0.066-0.149	6.38-6.39	24.53	0.016-0.022	0.037-0.046
Elderly (institutional)	58	167	0.023-0.024	0.062	1.18-1.20	5.02-5.05	0.025-0.072	0.082-0.173	4.64	11.72	0.018-0.024	0.049-0.061
Vegetarians[4]	87	151	0.035-0.036	0.06	1.56-1.59	8.68-8.70	0.035-0.100	0.079-0.163	14.21	63.31 -63.32	0.020-0.027	0.048 -0.056

Notes

1. Exposures have been estimated for the lower and upper bound concentrations and these have been included as ranges where they apply.
2. The dietary exposure (mean and high level) for all foods combined is not equal to the sum of the exposure from the individual food. It refers to the dietary exposure by a consumer consuming one or any combination of the foods containing the metals. These values are derived from a distribution of the individual consumer's consumption patterns with regards to the individual foods.
3. All figures have been rounded off as appropriate.
4. Some of the vegetarian respondents were consumers of fish.

Table 4b. Estimated total dietary exposure to cadmium (Cd), chromium (Cr), copper (Cu), germanium (Ge), indium (In) and lead (Pb) from the 2006 Total Diet Study

	Estimated dietary exposure (µg/kg bw/day)[1-3]											
	Cd		Cr		Cu		Ge		In		Pb	
Population Group	Mean	High-Level (P97.5)	Mean	High-Level (P97.5)	Mean	High-Level (P97.5)	Mean	High-Level (P97.5)	Mean	High-Level (P97.5)	Mean	High - Level (P97.5)
Adults	0.14 - 0.17	0.25 - 0.29	0.28- 0.37	0.50 - 0.62	17.23	34.47	0.001 - 0.018	0.002 - 0.033	0.06 - 0.24	0.22 - 0.47	0.09- 0.10	0.17 - 0.18
Toddlers 1.5-4.5 years)	0.37 - 0.45	0.65 - 0.75	0.81 - 1.03	1.38- 1.67	44.71	77.82	0.002- 0.053	0.006 - 0.085	0.24- 0.75	0.93- 1.48	0.21 - 0.25	0.38 - 0.42
Young people (4-18 years)	0.27 - 0.31	0.50 - 0.57	0.51 - 0.65	1.03 - 1.22	29.41	54.92	0.001 - 0.032	0.004 - 0.058	0.13 - 0.44	0.51 - 0.97	0.13- 0.15	0.26 - 0.30
Elderly (free living)	0.13 - 0.15	0.26 - 0.29	0.25- 0.32	0.48 - 0.59	16.09	45.70	0.001 - 0.016	0.002 - 0.029	0.05 - 0.21	0.25- 0.46	0.08- 0.09	0.16 - 0.17
Elderly (institutional)	0.11 - 0.13	0.30 - 0.35	0.27- 0.28	0.56 - 0.70	13.38	43.36	0.001 - 0.015	0.002 - 0.036	0.04 - 0.18	0.19 - 0.45	0.06- 0.07	0.17 - 0.19
Vegetarians[4]	0.17 - 0.20	0.30 - 0.32	0.31 - 0.40	0.54 - 0.68	18.34	29.96	0 - 0.020	0 - 0.032	0.10 - 0.29	0.36 - 0.57	0.12	0.20 - 0.21

Notes
1. Exposures have been estimated for the lower and upper bound concentrations and these have been included as ranges where they apply.
2. The dietary exposure (mean and high level) for all foods combined is not equal to the sum of the exposure from the individual food. It refers to the dietary exposure by a consumer consuming one or any combination of the foods containing the metals. These values are derived from a distribution of the individual consumer's consumption patterns with regards to the individual foods.
3. All figures have been rounded off as appropriate.
4. Some of the vegetarian respondents were consumers of fish.

Table 4c. Estimated total dietary exposure to manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), palladium (Pd) and platinum (Pt) from the 2006 Total Diet Study

	Estimated dietary exposure (µg/kg bw/day)[1-3]											
	Mn		Hg		Mo		Ni		Pd		Pt	
Population Group	Mean	High - level	Mean	High - level	Mean	High - level	Mean	High - level	Mean	High - level	Mean	High - level
Adults	67	124	0.02 - 0.05	0.10 - 0.13	1.61 - 1.64	3.03 - 3.08	1.49 - 1.63	3.01 - 3.08	0.009	0.015 - 0.016	0 - 0.029	0 - 0.051
Toddlers (1.5-4.5 years)	168	305	0.04 - 0.12	0.17- 0.26	4.80 - 4.87	7.54 - 8.32	4.17 - 4.87	7.54 - 8.32	0.027	0.055 0.056	0 - 0.082	0 - 0.130
Young people (4-18 years)	106	201	0.03 - 0.08	0.11 - 0.18	3.01 - 3.05	5.77 - 5.82	2.62 - 3.05	5.27 - 5.82	0.016	0.032	0 - 0.048	0 - 0.089
Elderly (free living)	56	112	0.02 - 0.05	0.09- 0.12	1.43 - 1.46	3.00 - 3.03	1.25 - 1.46	2.58 - 3.03	0.008	0.015	0 - 0.025	0 - 0.045
Elderly (institutional)	50	121	0.02- 0.04	0.07- 0.12	1.33 - 1.36	3.46 - 3.54	1.11 - 1.36	2.80 - 3.54	0.007	0.018	0 - 0.023	0 - 0.055
Vegetarians[4]	78	135	0.02 - 0.05	0.12 - 0.15	2.01 - 2.05	3.34 - 3.37	1.88 - 2.05	3.49 - 3.37	0.010	0.018	0 - 0.031	0 - 0.050

Notes

1. Exposures have been estimated for the lower and upper bound concentrations and these have been included as ranges where they apply.
2. The dietary exposure (mean and high level) for all foods combined is not equal to the sum of the exposure from the individual food. It refers to the dietary exposure by a consumer consuming one or any combination of the foods containing the metals. These values are derived from a distribution of the individual consumer's consumption patterns with regards to the individual foods.
3. All figures have been rounded off as appropriate.
4. Some of the vegetarian respondents were consumers of fish.

Table 4d. Estimated total dietary exposure to rhodium (Rh), ruthenium (Ru), selenium (Se), strontium (Sr), thallium (Tl), tin (Sn) and zinc (Zn) from the 2006 Total Diet Study

	Estimated dietary exposure (µg/kg bw/day)[1-3]													
	Rh		Ru		Se		Sr		Tl		Sn		Zn	
Population Group	Mean	High - level	Mean	High - level	Mean	High - level	Mean	High - level	Mean	High - level	Mean	High - level	Mean	High - level
Adults	0 - 0.029	0 - 0.051	0.0004 - 0.0101	0.001 - 0.0183	0.83 - 0.95	1.65 - 1.79	15.6	30.6	0.011 - 0.012	0.020 - 0.021	23.3 - 23.4	82.1 - 82.2	140.7	267.8
Toddlers (1.5-4.5 years)	0 - 0.082	0 - 0.130	0.0008 - 0.0291	0.0022 - 0.0468	1.97 - 2.27	3.77 - 4.10	42.8	71.1	0.024 - 0.027	0.043 - 0.046	89.3 - 89.8	341.2 - 341.5	387.0	775.7
Young people (4-18 years)	0 - 0.048	0 - 0.089	0.0005 - 0.0169	0.0013 - 0.0315	1.27 - 1.44	2.60 - 2.84	25.9	51.0	0.016 - 0.018	0.032 - 0.035	48.2 - 48.5	191.3 - 191.5	232.3	478.0
Elderly (free living)	0 - 0.025	0 - 0.045	0.0003 - 0.0087	0.0009 - 0.0159	0.73 - 0.82	1.48 - 1.60	14.0	26.6	0.009 - 0.010	0.017 - 0.018	19.7 - 19.9	93.2 - 93.4	121.7	261.2
Elderly (institutional)	0 - 0.023	0 - 0.055	0.0002 - 0.0081	0.001 - 0.0196	0.59 - 0.68	1.58 - 1.74	12.0	29.2	0.007 - 0.008	0.017 - 0.019	13.1 - 13.2	68.3 - 68.4	103.5	251.5
Vegetarians[4]	0 - 0.031	0 - 0.050	0.0007 - 0.0109	0.0015 - 0.0180	0.64 - 0.76	1.43 - 1.54	20.5	35.9	0.010 - 0.011	0.018 - 0.019	35.0 - 35.1	131.5 - 131.7	93.4	161.6

Notes

1. Exposures have been estimated for the lower and upper bound concentrations and these have been included as ranges where they apply.
2. The dietary exposure (mean and high level) for all foods combined is not equal to the sum of the exposure from the individual food. It refers to the dietary exposure by a consumer consuming one or any combination of the foods containing the metals. These values are derived from a distribution of the individual consumer's consumption patterns with regards to the individual foods.
3. All figures have been rounded off as appropriate.
4. Some of the vegetarian respondents were consumers of fish.

Table 5a. Comparison of the mean and high-level intake of metals and other elements by adult consumers from the 2006, 2000 and 1997 Total Diet Studies with recommended safety guidelines

Element	PTWI or PMTDI[#] (ug/kg bw /day)	Total Dietary Intake (µg/kg bw/day)					
		2006[1-3,5]		2000[1-3,5]		1997[3-6]	
		Mean	High-level	Mean	High-level	Mean	High-level
Aluminium	143	71	144	67-68	134-135	45.6	81.3
Antimony	6*	0.03	0.06	-	-	0.043	0.057
Arsenic (total)		1.65 - 1.68	6.83 - 6.85	1.5-1.6	5.8	1.71	6.00
Arsenic (inorganic)	2.1	0.028	0.071	-	-	-	-
Cadmium	1	0.14 - 0.17	0.25 - 0.29	0.12	0.21	0.20	0.34
Chromium	150‡	0.28 - 0.37	0.50 - 0.62	0.66 - 0.67	1.0 - 1.1	1.43	2.43
Copper	50-500;160†	17.2	34.5	18	33	20.0	45.6
Lead	3.6	0.09 - 0.10	0.17 - 0.18	0.1	0.18	0.34	0.61
Manganese	200 or 150‡	67	124	67	118	-	-
Mercury (methyl mercury)	0.23	0.02 - 0.05	0.10 - 0.13	0.03 - 0.04	0.12 - 0.13	0.04	0.09
Nickel	4.3‡	1.49-1.63	3.01 - 3.08	1.5	2.9	1.71	3.00
Selenium	5†	0.83 - 0.95	1.65 - 1.79	0.63 - 0.67	1.2 - 1.3	0.77	1.43
Tin	220‡	23.3 - 23.4	82.1 - 82.2	20	70	27.1	89.9
Zinc	300-1000	140.7	267.8	141	252	157	286

\# The numerical values shown are the tolerable daily intake for a 60 kg person derived from PTWIs or PMTDIs recommended by JECFA unless mentioned otherwise.
* TDI derived by WHO
‡ Expert Group on Vitamins and Minerals - guidance level
† Expert Group on Vitamins and Minerals - safe upper level

Table 5b. Comparison of the mean and high-level intake of metals and other elements by toddlers and young people from the 2006 and 2000 Total Diet Studies with recommended safety guidelines

Element	PTWI or PMTDI[#]	Total Dietary Intake (µg/kg bw/day)[1-3,5]							
		Toddlers (1.5 - 4.5 years)				Young people (4 -18 years)			
		2006		2000		2006		2000	
		Mean	High-level	Mean	High-level	Mean	High-level	Mean	High-level
Aluminium	143	187	345	165	327	123	246	120-121	244-245
Antimony	6*	0.075 - 0.077	0.132- 0.135			0.049- 0.050	0.096 - 0.097		
Arsenic (total)		2.71 - 2.80	12.27 - 12.34	2.7	12	1.91 - 1.95	8.19 - 8.24	1.7	7.0
Arsenic (inorganic)	2.1	0.075 - 0.246	0.174 - 0.402			0.055 - 0.158	0.128 - 0.291		
Cadmium	1	0.37 - 0.45	0.65 - 0.75	0.31 - 0.32	0.56	0.27 - 0.31	0.50 - 0.57	0.22	0.42
Chromium	150[‡]	0.81 - 1.03	1.38 - 1.67	1.7	2.7 - 2.8	0.51 - 0.65	1.03 - 1.22	1.14 - 1.15	2.1
Copper	50-500;160[†]	44.71	77.82	46	81	29.41	54.92	30	56
Lead	3.5	0.21 - 0.25	0.38 - 0.42	0.25	0.47	0.13 - 0.15	0.26 - 0.30	0.17	0.32
Manganese	200[‡]	168	305	132	235	106	201	101	195
Mercury (methyl mercury)	0.23	0.04 - 0.12	0.17 - 0.26	0.06 - 0.07	0.26 - 0.27	0.03 - 0.08	0.11 - 0.18	0.04 - 0.05	0.15 - 0.16
Nickel	4.3[‡]	4.17 - 4.87	7.54 - 8.32	3.9	7.2	2.62 - 3.05	5.27 - 5.82	2.6	5.3
Selenium	5[†]	1.97 - 2.27	3.77 - 4.10	1.3 - 1.4	2.6 - 2.7	1.27 - 1.44	2.60 - 2.84	0.86 - 0.92	1.9 - 2.0
Tin	220[‡]	89.3 - 89.8	341.2 - 341.5	70	283	48.2 - 48.5	191.3 - 191.5	38	150
Zinc	300-1000	387.0	775.7	386	759	232.3	478.0	226	453

The numerical values shown are the tolerable daily intake for a 60 kg person derived from PTWIs or PMTDIs recommended by JECFA unless mentioned otherwise.
* TDI derived by WHO
‡ Expert Group on Vitamins and Minerals - guidance level
† Expert Group on Vitamins and Minerals - safe upper limit

Notes for tables 5a and 5b

1. Exposures have been estimated for the lower and upper bound concentrations and these have been included as ranges where they apply.
2. Consumption data taken from the National Diet and Nutrition Survey: adults aged 19 to 64 years. Volume 1: Types and quantities of foods consumed. Henderson L, Gregory J and Swan G. (2002). The Stationery Office, London and Gregory, J., Foster, K., Tyler, H. and Wiseman, M. (1990). The Dietary and Nutritional Survey of British Adults. The Stationery Office, London.
3. The exposure to elements by the mean and high-level (97.5%) consumer for all foods combined is not equal to the sum of the exposure from the individual food. It refers to the dietary exposure by a consumer consuming one or any combination of the foods containing the elements. These values are derived from a distribution of individual consumer's consumption patterns with regards to the individual foods.
4. Exposures have been estimated from upper bound mean concentrations only. Exposures have been converted into µglkg bw/day (for a 70.1 kg adult) from the 1997 Total Diet Study-Aluminium, Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Tin and Zinc. Food Surveillance Information Sheet No. 191. Ministry of Agriculture, Fisheries and Food (1999). The Stationery Office, London.
5. All figures have been rounded off as appropriate.
6. Consumption data taken from the Dietary and Nutritional Survey of British Adults. J Gregory, K Foster, H Tyler, M Wseman. (1990). The Stationery Office, London.

Table 6a. Comparison of population dietary exposures of aluminium (Al), antimony (Sb), arsenic (As), barium (Ba), bismuth (Bi), cadmium (Cd), chromium (Cr), copper (Cu), Germanium (Ge), Indium (In) and lead (Pb) from UK Total Diet Studies 1976 to 2006.

	Population dietary exposure (mg/day)[1-3]											
Year	Al	Sb	Total As	Inorganic As	Ba	Bi	Cd	Cr	Cu	Ge	In	Pb
1976	NM	NM	0.075	NM	NM	NM	0.02	0.13	1.8	NM	NM	0.11
1977	NM	NM	0.1	NM	NM	NM	0.018	0.17	1.8	NM	NM	0.1
1978	NM	NM	0.081	NM	NM	NM	0.02	0.1	1.6	NM	NM	0.11
1979	NM	NM	NM	NM	NM	NM	0.017	NM	NM	NM	NM	0.09
1980	NM	NM	NM	NM	NM	NM	0.026	NM	NM	NM	NM	0.12
1981	NM	NM	NM	NM	NM	NM	0.019	NM	NM	NM	NM	0.08
1982	NM	NM	0.09	NM	NM	NM	0.018	NM	1.3	NM	NM	0.069
1983	NM	NM	0.07	NM	NM	NM	0.018	NM	1.2	NM	NM	0.067
1984	NM	NM	NM	NM	NM	NM	0.019	0.073	1.4	NM	NM	0.065
1985	NM	NM	NM	NM	NM	NM	0.018	NM	1.3	NM	NM	0.066
1986	NM	NM	NM	NM	NM	NM	0.017	NM	NM	NM	NM	0.06
1987	NM	NM	NM	NM	NM	NM	0.018	NM	NM	NM	NM	0.06
1988	3.9	NM	NM	NM	NM	NM	0.019	NM	NM	NM	NM	0.06
1991	10	NM	0.07	NM	NM	NM	0.018	0.25	1.4	NM	NM	0.028
1994	11	0.003	0.063	NM	0.58	0.0004	0.014	0.34	1.2	0.004	NM	0.024
1995	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
1997	3.4	NM	0.065	NM	NM	NM	0.012	0.1	1.2	NM	NM	0.026
1999	NM	NM	0.05	0.0009 - 0.005	NM	NM	NM	NM	NM	NM	NM	NM
2000	4.7	NM	0.055	NM	NM	NM	0.009	0.046	1.3	NM	NM	0.0073 - 0.0074
2006 a	5.4	0.0025	0.061 - 0.064	0.0014 - 0007	0.847 - 0.848	0.002	0.011 - 0.013	0.022 - 0.029	1.24	0.0001 - 0.0015	0.005 - 0019	0.006 - 0,007

Table 6b. Comparison of population dietary exposures of manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), palladium (Pd), platinum (Pt), rhodium (Rh), ruthenium (Ru), selenium (Se), strontium (Sr), thallium (Tl), tin (Sn) and zinc (Zn) from UK Total Diet Studies 1976 to 2006

Year	Population dietary exposure (mg/day)[1-3]												
	Mn	Hg	Mo	Ni	Pd	Pt	Rh	Ru	Se	Sr	Tl	Sn	Zn
1976	NM	0.005	NM	0.33	NM	NM	NM	NM	NM	NM	NM	4.4	10
1977	NM	0.005	NM	0.26	NM	NM	NM	NM	NM	NM	NM	4.2	10
1978	NM	0.005	NM	0.27	NM	NM	NM	NM	NM	NM	NM	3.6	10
1979	NM	0.004	NM	NM	NM	NM	NM	NM	NM	NM	NM	3.2	NM
1980	NM	0.005	NM	0.27	NM	NM	NM	NM	NM	NM	NM	NM	NM
1981	NM	NM	NM	0.23	NM	NM	NM	NM	NM	NM	NM	2.4	NM
1982	NM	0.003	NM	0.15	NM	NM	NM	NM	NM	NM	NM	3.1	10
1983	4.6	NM	NM	0.15	NM	NM	NM	NM	NM	NM	NM	2.3	10
1984	5.3	NM	NM	0.16	NM	NM	NM	NM	NM	NM	NM	2.7	10
1985	5.0	NM	0.11	0.14	NM	NM	NM	NM	0.063	NM	NM	1.7	10
1986	NM	NM	NM	0.13	NM	NM	NM	NM	NM	NM	NM	2.2	NM
1987	NM	NM	NM	0.15	NM	NM	NM	NM	NM	NM	NM	2.0	NM
1988	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
1991	6.2	0.002	0.11	0.17	NM	NM	NM	NM	0.060	NM	NM	5.3	10
1994	4.9	0.004	0.11	0.13	0.001	0.0002	0.0003	0.004	0.043	1.3	0.002	2.4	8.4
1995	NM	NM	NM	NM	NM	NM	NM	NM	0.039	NM	NM	NM	NM
1997	NM	0.003	NM	0.13	NM	NM	NM	NM	0.039	NM	NM	1.8	8.4
2000	4.9	0.0012-0.0015	NM	0.13	NM	NM	NM	NM	0.032-0.034	NM	NM	1.4	8.4
2006[4]	5.24	0.001 - 0.003	0.123 - 0.125	0.127 - 0.129	0.0007	0 - 0.0023	0 - 0.0023	0.00003 - 0.00081	0.048 - 0.058	1.20	0.0007 - 0.0008	1.80 - 1.81	8.8

Notes for tables 6a and 6b

1. The population dietary exposures in the previous years were estimated using upper bound mean concentrations for each food group and consumption data taken from the National Food Survey 1997, Ministry of Agriculture, Fisheries and Food (1998). The Stationery Office, London. The exception to this is the 2000 TDS where exposures have been estimated from the lower and upper bound mean concentrations and included as ranges where they apply.
2. Changes in the organisation of the TDS from 1981 onwards mean that exposures from TDSs before 1981 and from 1981 onwards are not directly comparable (Peattie, M.E., Buss, D.H., Lindsay, D.G. and Smart, G.Q. (1983). Reorganisation of the British Total Diet Study for Monitoring Food Constituents from 1981. *Food and* Chemical Toxicology 21, 503-507).
3. For those years where no values are given, these elements were not included in TDSs for metals and other elements i.e. NM= not measured.
4. Dietary exposure estimates for the 2006 TDS and for selenium from the 1995 TDS and are not directly comparable with those from other years as they are based on analyses of composite samples of each food from all the towns in the TDS rather than the upper bound mean concentrations of analyses of each food group from each town.

Table 7a. Contribution (%) by each food group to total population dietary exposures to aluminium (Al), antimony (Sb), arsenic (As), barium (Ba), bismuth (Bi), cadmium (Cd), chromium (Cr), copper (Cu), germanium (Ge), indium (In) and lead (Pb) estimated from the 2006 UK TDS.

	Contribution to dietary exposure (%)											
Food Group	Al	Sb	Inorganic As	Total As	Ba	Bi	Cd	Cr	Cu	Ge	In	Pb
Bread	7	6	8	1	10	5	19	7	14	15	11	16
Miscellaneous	42	10	23	4	11	6	21	13	23	18	13	12
Carcase meat	<1	1	2	<1	<1	<1	<1	2	2	1	1	1
Offals	<1	<1	≤1	<1	<1	<1	<1	<1	2	<1	<1	<1
Meat products	3	24	5	<1	2	1	3	8	6	4	3	4
Poultry	<1	1	3	1	<1	<1	<1	1	1	1	1	1
Fish	<1	1	3	88	<1	<1	2	2	1	1	1	1
Oils and fats	<1	<1	2	<1	<1	1	1	2	<1	3	2	2
Eggs	<1	<1	1	<1	1	<1	<1	<1	1	1	1	1
Sugars and	3	10	8	1	3	14	3	16	8	8	6	5
Green vegetables	1	1	2	<1	2	1	1	1	1	1	<1	2
Potatoes	2	2	8	1	2	3	24	12	10	5	4	4
Other vegetables	5	20	7	1	6	2	5	8	6	2	2	16
Canned vegetables	1	1	<1	<1	1	1	2	4	3	1	16	3
Fresh fruit	1	1	1	<1	4	1	1	2	5	2	1	2
Fruit products	1	1	2	<1	1	1	2	3	2	1	9	5
Beverages	34	20	19	2	5	12	10	13	7	26	20	17
Milk	<1	1	4	<1	2	24	2	3	1	5	4	3
Dairy products	1	1	4	<1	2	25	2	3	2	6	4	3
Nuts	<1	<1	<1	<1	46	<1	2	<1	2	<1	<1	<1
Total	100	100	100	100	100	100	100	100	100	100	100	100

Table 7b. Contribution (%) by each food group to total population dietary exposures to manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), palladium (Pd), platinum (Pt), rhodium (Rh), ruthenium (Ru), selenium (Se), strontium (Sr), thallium (Tl), tin (Sn) and zinc (Zn) estimated from the 2006 UK TDS.

	Contribution to dietary exposure (%)												
Food Group	Mn	Hg	Mo	Ni	Pd	Pt	Rh	Ru	Se	Sr	Tl	Sn	Zn
Bread	**16**	**10**	**19**	**6**	**12**	**14**	**14**	**13**	**11**	**20**	7	<1	**12**
Miscellaneous cereals	**20**	**12**	**33**	**16**	**13**	**17**	**17**	**16**	**16**	**14**	6	<1	**14**
Carcase meat	<1	1	<1	<1	1	1	1	1	5	<1	1	<1	**15**
Offals	<1	<1	<1	<1	<1	<1	<1	<1	1	<1	<1	<1	<1
Meat products	3	4	4	3	5	4	4	4	**15**	3	5	<1	**16**
Poultry	<1	1	1	<1	1	1	1	1	6	<1	7	<1	4
Fish	<1	**25**	<1	<1	1	1	1	1	**10**	3	2	<1	1
Oils and fats	<1	2	<1	1	1	3	3	3	1	<1	1	<1	<1
Eggs	<1	1	1	<1	<1	1	1	1	4	<1	<1	<1	2
Sugars and	2	6	3	**14**	2	8	8	7	3	5	4	<1	4
Green vegetables	1	<1	3	2	1	1	1	1	<1	5	6	<1	1
Potatoes	3	3	6	6	**11**	5	5	4	2	6	**19**	<1	4
Other vegetables	3	2	5	6	4	2	2	2	3	**10**	7	<1	3
Canned vegetables	1	1	6	9	2	1	1	1	1	2	1	**65**	1
Fresh fruit	2	1	1	2	<1	2	2	2	1	6	5	<1	1
Fruit products	5	1	<1	3	2	1	1	1	<1	3	2	**34**	<1
Beverages	**41**	**20**	2	**21**	**20**	**27**	**27**	**31**	**11**	7	**23**	<1	2
Milk	<1	4	7	1	1	5	5	6	6	6	2	<1	**10**
Dairy products	<1	5	4	3	21	5	5	5	4	6	2	<1	9
Nuts	1	<1	3	7	1	<1	<1	<1	2	4	<1	<1	1
Total	100	100	100	100	100	100	100	100	100	100	100	100	100

Note

The results for food group(s) given in bold are those which contribute 10% or more to the total production dietary exposure for each element. Percentage contribution to population dietary exposure was estimated using upper bound means only.

Table 8. Comparison of the estimated dietary exposures (pg/kg bw/day) to arsenic (total and Inorganic) from previous TDSs

Population Group	Estimated total dietary exposure									
	Total arsenic (pg/kg bw/day)[1,2]						Inorganic arsenic (pg/kg bw/day)[1,2]			
	Mean			High level			Mean		High level	
	1999 TDS[3]	2000 TDS	2006 TDS	1999 TDS[3]	2000 TDS	2006 TDS	1999 TDS[3]	2006 TDS	1999 TDS[3]	2006 TDS
Adults	1.30	1.5-1.6	1.65-1.68	4.37	5.8	6.83-6.85	0.02-0.08	0.03-0.09	0.05-0.10	0.07-0.17
Toddlers (1.5-4.5 years)	2.43-2.46	2.7	2.71-2.80	11.31 -11.34	12	12.27-12.34	0.05-0.20	0.08-0.25	0.10-0.30	0.17-0.40
Young people (4-18	1.60-1.61	1.7	1.91-1.95	6.65-6.66	7.0	8.19-8.24	0.03-0.10	0.06-0.16	0.08-0.20	0.13-0.29
Elderly (free living)	1.60-1.61	1.7	1.72-1.75	5.33-5.34	5.6	6.40-6.43	0.02-0.07	0.02-0.08	0.04-0.10	0.07-0.15
Elderly (Institutional)	1.44-1.46	1.6	1.18-1.20	4.62-4.64	4.9	5.02-5.05	0.02-0.09	0.03-0.07	0.05-0.10	0.08-0.17
Vegetarians[4]	1.24-1.25	1.4	1.56-1.59	6.98-6.99	7.4	8.68-8.70	0.02-0.07	0.04-0.10	0.05-0.10	0.08-0.16

Notes

1. Exposures have been estimated for the lower and upper bound concentrations and these have been included as ranges where they apply.
2. The dietary exposure (mean and high level) for all foods combined is not equal to the sum of the exposure from the individual food. It refers to the dietary exposure by a consumer consuming one or any combination of the foods containing metals. These values are derived from a distribution of the individual consumer's consumption patterns with regard to individual foods.
3. Food Standards Agency. 1999 Total Diet Study: Total and inorganic arsenic in food. *Food Surveillance Information Sheet 51104.* 4. Some of the vegetarian respondents were consumers of fish.