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# Dietary intake of nutrient trace elements

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Iron intakes have been quantified in Britain for more than fifty years, but now that British food composition tables show the amounts of copper, iodine, manganese, selenium and zinc in a wide range of foods, intakes of these nutrients can also be readily estimated from dietary surveys. In addition, intakes of these nutrients and of chromium, fluoride, molybdenum, vanadium, and a number of other elements which although toxic in excess may have nutritional value, have been determined by chemical analysis of whole diets. The main findings from the different methodologies are summarised and compared.

## INTRODUCTION

Food consumption patterns and the intakes of trace elements and other food constituents are influenced by many factors. Reliable and up-to-date information on these is therefore needed by Government, and by others, as an aid to the development and maintenance of effective food, agriculture, social and health policies. Examples of the need for such monitoring include:

—to determine the nutritional and other consequences of changes in agricultural, food industry, catering or domestic practice; and so to help the Ministry of Agriculture, Fisheries and Food (MAFF) in its policies to ensure that there is in this country an adequate supply of the foods that people want to eat and that they are safe, wholesome and nutritious;

—to help the Department of Health to review relationships between diet and disease, and to set reference amounts of nutrients against which diets can be assessed;

—to identify foods that are the main contributors of nutrients and other constituents in the diets of various groups; and to determine the size and nature of any population group that may be at risk from an inadequate or excessive intake of any food constituent;

—to assess the consequences of actual or potential emergencies so that appropriate action can be taken;

—to assist with the planning of diets for schools or closed communities such as hospitals, the armed forces and prisons;

—to help ensure that education material (including nutrition labelling) and advice in choosing nutritionally valuable diets is soundly based.

## TRACE ELEMENTS IN INDIVIDUAL FOODS

The first way in which individual and national intakes of trace elements can be determined is by measuring their concentrations in a wide range of foods and combining them with measurements of the amounts of each of these foods that are eaten.

There have been many analyses of trace elements in foods in the United Kingdom and elsewhere, and of the factors that affect the levels. The concentration of nutrient trace elements has been found to vary less than that of most of the contaminant elements, so it has been possible to bring many of these values together into food composition tables. The first British tables (Plimmer, 1921) included salt but no other minerals, but in the 1930s McCance and Widdowson (1940) analysed and collated the levels of a wide range of nutrients in foods including the trace elements iron and copper. Government used these values in the National Food Survey (Slater, 1991) to determine people's intakes of these elements in the difficult times during and after the Second World War, and could thus take whatever steps were necessary to ensure their adequacy. Figure 1 shows the national average intake of iron in Britain over the past 50 years.

By 1978, the 4th edition of the UK food composition tables also included values for zinc (Paul & Southgate, 1978), but during the 1970s MAFF had decided that it was necessary to know more about a much wider range of trace elements in foods. The initial emphasis was on lead, cadmium, arsenic and mercury (Ministry of

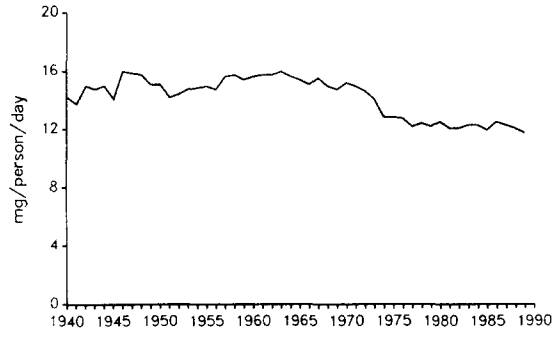


**Fig. 1.** Average household intakes of iron.

Agriculture, Fisheries and Food, 1978), but this was followed by a series of studies on elements which, while toxic in excess, are or may be essential at lower levels. These included selenium (Thorn *et al.*, 1978), manganese (Wenlock *et al.*, 1979), copper and zinc (Ministry of Agriculture, Fisheries and Food, 1981), iodine (Wenlock *et al.*, 1982), fluoride (Walters *et al.*, 1983), chromium (Smart & Sherlock, 1985), and cobalt, nickel and tin (Ministry of Agriculture, Fisheries and Food, 1985). Some of these values have subsequently been updated, and the intakes of molybdenum and vanadium have been determined (Buss & Rose, in preparation). Appropriate values have been brought together in the most recent supplements to the UK food composition tables (e.g. Holland *et al.*, 1991).

## MEASURING FOOD INTAKES

If the population's intakes of trace elements are to be calculated from the amounts in food, the amounts of each food that are eaten also need to be known. There are two main ways in which MAFF has determined food intakes by people throughout Britain.

The first is by means of the *National Food Survey*, which is a continuous survey of all the food brought into private households throughout England, Scotland and Wales. Each year, some 7500 households take part and record for a whole week an exact description of every item of food brought into their homes, the amount obtained, and what (if anything) it cost. The data are summarised in annual reports (e.g. Ministry of Agriculture, Fisheries and Food, 1990) which show nutrient intakes as well as dietary habits, not only for the nation as a whole but also in different regions and in households with different incomes, employment status, family composition, etc. Although iron is the only trace element whose intake has been routinely calculated, occasional analyses of copper, manganese and zinc intakes have been published (Spring *et al.*, 1979; Lewis & Buss, 1988). The results are summarised in Table 1.

**Table 1. Method 1: National Food Survey estimates of the average household intake of four trace elements in Britain, mg/d**

| | 1976[a] | 1986[b] |
|---|---|---|
| Copper | 1·51 | 1·25 |
| Iron[c] | 11·5 | 11·3 |
| Manganese | — | 3·43 |
| Zinc | 9·1 | 9·0 |

[a] From Spring *et al.* (1979).
[b] From Lewis and Buss (1988).
[c] From Ministry of Agriculture, Fisheries and Food (1990).

**Table 2. Method 2: Median intakes of four trace elements by British adults in 1987, from 7-day weighed dietary records[a]**

| | Men | Women |
|---|---|---|
| Copper (mg/d) | 1·49 | 1·13 |
| Iodine (μg/d) | 226 | 163 |
| Iron (mg/d) | 13·2 | 10·0 |
| Zinc (mg/d) | 10·9 | 8·2 |

[a] From Gregory *et al.* (1990).

A more detailed but more difficult way of determining food and nutrient intakes is by means of *individual dietary surveys*, in which every item of food that is about to be eaten by selected individuals is weighed (or otherwise carefully measured) over the course of, say, a week. MAFF has done several such surveys, most recently in conjunction with the Department of Health and the Office of Population Censuses and Surveys when a detailed survey was made of the diets and health of 2200 nationally representative adults between 16 and 64 years old (Gregory *et al.*, 1990). The amount of every item of food and drink eaten by each person was carefully weighed, and combined with a very detailed nutrient database developed specially for this survey and which contained values for 39 nutrients in more than 5000 separate foods. The trace elements included were iron, zinc, copper and iodine, and the median intakes of these nutrients by men and women separately are shown in Table 2.

Surveys of this kind are difficult to do well, but among their advantages is the fact that the distribution of individual intakes can be determined. Thus the proportion of individuals with excessive intakes, or with intakes below the recommended amounts, can be determined and action taken if necessary.

## ANALYSING WHOLE DIETS

The second and more direct way of measuring trace element intakes is to analyse complete diets chemically. In the *duplicate diet* method, selected individuals at possible risk from high intakes of contaminants provide for analysis an exact duplicate of everything that they eat over the course of, say, a week. Although this

**Table 3. Method 3: Intakes of trace elements as determined from the British Total Diet Study[a]**

| | |
|---|---|
| Chromium (μg/d) | 90 |
| Copper (mg/d) | 1·30 |
| Fluoride (mg/d) | 1·82 |
| Iodine (μg/d) | 277 |
| Iron (mg/d) | 12·3 |
| Manganese (mg/d) | 5·0 |
| Molybdenum (μg/d) | 113 |
| Selenium (μg/d) | 63 |
| Vanadium (μg/d) | 30 |
| Zinc (mg/d) | 9·8 |

[a] For sources, see text.

is a labour-intensive method, and not easily done in a controlled way over a wide area, it has provided important results on intakes particularly in areas of localised contamination (Ministry of Agriculture, Fisheries and Food, 1978).

Also important has been MAFF's *Total Diet Study*, which has been conducted throughout the UK for most of the past 25 years. Samples of the national average diet (primarily quantified from recent National Food Survey records) are bought every two weeks in a different part of the country, then prepared and cooked as if for eating, combined into groups of similar foods, and analysed (Peattie *et al.*, 1983). The intakes of many heavy metals and other contaminants, as well as of a number of minor trace element nutrients, cannot easily be determined in any other way. Values for iron, copper and zinc obtained in this way, as well as the trends in those intakes and the proportions of the total intakes derived from each of the main food groups, compare well with those determined from National Food Survey records. This provides a useful cross-check on the validity of each method (Buss, 1983).

Intakes of chromium, cobalt, fluoride, iodine, iron, manganese, molybdenum, selenium, vanadium and zinc and some forty other trace elements were first determined from analysis of Total Diet Study samples as long ago as 1966/67 (Hamilton & Minski, 1972/73). More recent analyses of a number of these elements have also been made, and these later results for the main nutrients are summarised in Table 3.

## CONCLUSIONS

Each of the methods described above has advantages and disadvantages, but they all give very similar results for the total intake of trace elements, the main dietary sources, and trends in intakes.

Table 4 combines the results from each to summarise the relative importance of the main groups of foods as sources of nutrient trace elements in Britain in the 1980s. These contributions reflect both the concentration of the nutrient in each type of food and, just as important, the exact dietary pattern in Britain. Thus beverages are a major source of fluoride and manganese not only because tea is rich in both but also because it is widely drunk in Britain; as tea consumption falls, so too does the intake of these nutrients, with manganese intakes dropping from 5·0 mg/d as determined from the Total Diet Study in the early 1980s to 3·43 mg as later determined from the National Food Survey (Lewis & Buss, 1988). Bread and other cereal products are still among the most important sources of a wide range of trace elements despite the steady decline in the consumption of white bread, because the increased popularity of mineral-rich wholemeal bread and of breakfast cereals has largely compensated for this. Meat and meat products (and to a lesser extent fish) are the other main sources of trace elements for most people in Britain, for they are rich in most trace elements and widely eaten.

As these studies are repeated, each indicates that the intake of trace elements is declining as we become more sedentary and eat less food. Nevertheless, intakes of most if not all of them remain above recommended amounts, and deficiencies of all these nutrients apart from iron are virtually unknown in Britain.

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**Table 4. Relative contributions made by major groups of foods to the total intake of selected trace elements[a]**

| | Cu | Cr | F | I | Fe | Mn | Mo | Se | V | Zn |
|---|---|---|---|---|---|---|---|---|---|---|
| Cereal products | ** | ** | | | *** | *** | *** | *** | *** | ** |
| Meat and fish | ** | ** | | ** | *** | | * | *** | * | *** |
| Dairy products | | | | *** | | | * | * | * | ** |
| Vegetables | ** | * | | | * | * | *** | | ** | * |
| Fruit | * | * | | * | | | | | | |
| Beverages | * | | *** | | | *** | | | | |

[a] *** more than 30% of the total; ** 20–30% of the total; and * more than 10% of the total.

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