GUIDELINES FOR THE STUDY OF DIETARY INTAKES OF CHEMICAL CONTAMINANTS

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PREFACE

These Guidelines are designed to assist countries in initiating studies of the dietary intake of contaminants at the national level by providing detailed procedures and methods by which such studies may be conducted. National authorities are urged to review the basic approaches to the determination of contaminant intakes set forth in this book in the light of their national needs and resources, and to adopt one of the approaches for estimating dietary exposures of their country's consumers to chemical contaminants of concern. The Guidelines should be considered in conjunction with the FAO/WHO Guidelines for establishing or strengthening national food contamination monitoring programmes (1) also prepared under the Joint FAO/WHO Food Contamination Monitoring Programme. This Programme forms part of the Global Environmental Monitoring System which was established by the United Nations Environment Programme.

The present text has been prepared under the Joint FAO/WHO Food Contamination Monitoring Programme, in collaboration with the Joint FAO/WHO Food Standards Programme and the relevant committees of the Codex Alimentarius Commission.

The first draft was prepared by Dr C. F. Jelinek, Bureau of Foods, Food and Drug Administration, Department of Health and Human Services, Washington, DC, USA, and Dr D. G. Lindsay, Food Science Division, Ministry of Agriculture, Fisheries and Food, London, England. A joint FAO/WHO meeting of a working group was subsequently held in Rome, 16-21 December 1982, to review and finalize that first draft. The participants are listed in Annex 1. In addition, valuable comments were received on the first draft from the Joint FAO/WHO Collaborating Centres for Food Contamination Monitoring, a list of which is given in Annex 2. The collaboration of the Centres in this work, as well as in a variety of other work related to the occurrence of chemical contaminants in food, is gratefully acknowledged.

The Joint FAO/WHO Secretariat wishes to thank, in particular, Dr Jelinek and Dr Lindsay for their continued help in all phases of the preparation of this book.

1. INTRODUCTION

National authorities have the responsibility and obligation to ensure that toxic chemicals, such as pesticides, heavy metals, polychlorinated biphenyls, aflatoxins and other contaminants, are not present in food at levels that may adversely affect the health of consumers. Countries may set legal limits for food contaminants and monitor compliance with such limits. This type of monitoring and food control is essential for consumer protection and facilitation of trade. At the same time, governments need to assess public health risks arising from the presence of toxic chemicals in foods consumed in their countries.

To ascertain whether a consumer is at risk or not, it is necessary to estimate the actual dietary intake of a contaminant for comparison with acceptable daily intakes (ADIs) or provisional tolerable weekly intakes (PTWIs). Obtaining such an estimate is also important in determining whether there is a relationship between any observed effects in humans and the intake of a particular contaminant. The estimation of the actual dietary intake of contaminants as a measure of exposure is thus indispensable for risk assessment.

Contaminant intake estimates are equally critical for making sound decisions in the regulation of chemicals and food safety. If the actual intake of a chemical is found to approach or exceed the ADI or PTWI, national authorities should evaluate whether the use of the chemical may need to be restricted or eliminated. Dietary intake studies will provide the information that will indicate whether existing limits for contaminants in foods should be reviewed. If periodic estimates of actual exposures to chemicals are found to be well below ADIs or PTWIs, health authorities and the citizens of the country are assured of the safety of the current food supply with respect to these substances.

Three basic, practical approaches for carrying out dietary intake studies are described and the strengths and limitations of each approach are indicated. Although a preferred or recommended approach for governments to adopt is not specified, the total diet (market basket) study (see section 5) would, in general, provide a more accurate estimate of dietary intakes of contaminants for a country as a whole than either of the other methods. It is, however, a more complex and more costly approach to follow. The selective studies of individual foodstuffs (see section 6) and the duplicate portion studies (see section 7) may represent a minimum programme where resources and technical capabilities are limited.

1.1 Joint FAO/WHO Food Contamination Monitoring Programme

1.1.1 Objectives

The Joint FAO/WHO Food Contamination Monitoring Programme, initiated in 1976, is one of the major health-related activities of the Global Environmental Monitoring System, which was established by the United Nations Environment Programme. The main objectives of the Joint FAO/WHO Programme are:

(a) to collect data on levels of certain chemicals in individual foods and in total diet samples and to evaluate these data, review trends and produce and disseminate summaries, thus encouraging appropriate food control and resource management measures;

(b) to obtain estimates of the intake via food of specific chemicals, with a view to combining these data with those on intake from other sources and thus enabling the total intake of the contaminant to be estimated;

(c) to provide technical cooperation with the governments of countries wishing to initiate or strengthen food contamination monitoring programmes; and

(d) to provide the joint FAO/WHO Codex Alimentarius Commission with information on the levels of contaminants in food to support and accelerate its work on international standards for contaminants in foods.

1.1.2 Dietary intake of contaminants and risk assessment

In order to assess potential health problems from the presence of toxic contaminants in the food supply, the extent to which actual dietary intakes approach or exceed a toxicologically acceptable daily intake (ADI) or provisional tolerable weekly intake (PTWI) should be determined.

The acceptable daily intake of a chemical is the daily intake which, during an entire lifetime, appears to be without appreciable risk on the basis of all the known facts at the time. It is expressed in milligrams of the chemical per kilogram of body weight (mg/kg). For this purpose "without appreciable risk" is taken to mean the practical certainty that injury will not result even after a lifetime of exposure (2).

The Joint FAO/WHO Meeting on Pesticide Residues (JMPR) has established ADIs for a number of pesticides used in food production. Similarly the Joint FAO/WHO Expert Committee on Food Additives (JECFA) has established ADIs for food additives. Since 1972, JECFA has also evaluated several food contaminants, such as cadmium, lead and mercury, and has allocated PTWIs rather than ADIs for these contaminants. The basis for adopting this approach has been described as follows (3):

"(1) The contaminants are able to accumulate within the body at a rate and to an extent determined by the level of intake and by the chemical form of the heavy metal present in food. Consequently, the basis on which intake is expressed should be more than the amount corresponding to a single day. Moreover, individual foods may contain above-average levels of heavy metal contaminant, so that consumption of such foods on any particular day greatly enhances that day's intake. Accordingly the provisional tolerable intake is expressed on a weekly basis.

(2) The term "tolerable", signifying permissibility rather than acceptability, is used in those cases where intake of a contaminant is unavoidably associated with the consumption of otherwise wholesome and nutritious foods, or with inhalation in air.

(3) The use of the term "provisional" expresses the tentative nature of the evaluation, in view of the paucity of reliable data on the consequences of human exposure at levels approaching those with which the Committee is concerned."

For the protection of the health of the individual, the amount of a chemical residue consumed by that individual should generally not exceed the ADI or PTWI over a prolonged period of time. To ascertain whether a consumer is at risk or not, therefore, it is important to compare the estimated intake, as assessed by dietary intake studies, with the ADI or PTWI.

The estimation of the dietary intake of a chemical residue can rarely completely reflect the long-term exposure of a population (or individual) to that residue because of the difficulties inherent in determining long-term food consumption patterns. Nonetheless an initial approximate assessment of dietary intake is essential: to indicate whether current regulatory practices for a contaminant are adequate; to provide a triggering mechanism for deciding whether further, more detailed assessments of intake are required; and, ultimately, to determine whether further controls over the use of a toxic substance should be considered.

It should be recognized that a population (or individual) may also be exposed to certain contaminants from sources other than the diet. In such circumstances, the estimation of exposure to a contaminant in food should be combined with an assessment of the total exposure to that contaminant from all sources. This includes inhalation of airborne contaminants and ingestion of contaminants in drinking water, e.g., lead is both an air and a drinking-water pollutant. An objective assessment of the overall risk, in comparison to the ADI, must take into account such sources.

Since 1978, collaborating centres have submitted information, under the Joint FAO/WHO Food Contamination Monitoring Programme, on estimated daily dietary intakes of the DDT complex, total hexachlorocyclohexane (HCH) isomers, the sum of aldrin and dieldrin, the sum of heptachlor and heptachlor epoxide, hexachlorobenzene (HCB), polychlorinated biphenyls (PCBs), lead, cadmium and aflatoxins. These data have been evaluated to determine the potential risk to human health from such exposure.[1]

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[1] Summary and assessment of data received from the FAO/WHO Collaborating Centres for Food Contamination Monitoring, Global Environmental Monitoring System, 1982 (unpublished UNEP/FAO/WHO document).

1.1.3 Guidelines for conducting intake studies for contaminants

In making the above evaluation, it was recognized that, in order to further the objectives of the Joint FAO/WHO Food Contamination Monitoring Programme, guidelines were needed to encourage the submission of such data and be of assistance to collaborating centres and national regulatory authorities wishing to initiate dietary intake studies for contaminants. Therefore, under the auspices of the Programme a publication entitled Chemical contaminants in food - approaches for estimation of intake has been prepared, in a provisional edition by FAO (4). This publication describes broad approaches, whereas the present Guidelines have been developed for the purpose of describing methods and procedures by which estimates of dietary intake of contaminants may be obtained.

It is believed that these Guidelines will assist in the work of the Codex Committee on Pesticide Residues (CCPR) and the Codex Committee on Food Additives (CCFA). The prime objective of CCPR is to secure the agreement of Member States on internationally acceptable maximum residue limits (MRLs) for food commodities moving in international trade. An essential consideration in reaching such agreement is the acceptability of MRLs from a consumer safety point of view, i.e., will the use of pesticides covered by the MRLs result in dietary exposures to pesticide residues that do not exceed the ADI recommended by JMPR. CCPR therefore believes it useful to have guidelines to stimulate and assist governments in conducting pesticide residue intake studies in their countries.[1]

CCFA also has an active interest in developing guidelines to assist governments to determine the intake of specific food additives and contaminants. This interest stems from the need to determine that the dietary intake of certain additives and contaminants does not exceed acceptable levels; to assist CCFA in endorsing maximum levels for food additives and contaminants; and to enable them to determine whether the dietary intakes are within toxicologically acceptable limits.[2]

Although the approaches to the assessment of residue intakes have primarily been developed to determine the intake of food contaminants, methods that involve the analysis of whole diets or individual foods for which consumption data are available are also applicable to food additives. Whole diets can be analysed provided that they comprise representative foods containing such additives. Since additives are utilized in the production of manufactured foods, which may be consumed irregularly by some consumers but frequently and in large quantities by others, it is most important that the emphasis is placed on an assessment of the exposure of the frequent consumers. The undertaking of selective studies of individual foods (section 6) is a suitable approach when it is known, or can be reasonably estimated, which additives are likely to be used in which foods.

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[1] Guidelines on pesticide residue intake studies (unpublished working paper (XPR 82/6) prepared by the delegations of the United Kingdom and the USA for the fourteenth session of the Codex Committee on Pesticide Residues).

[2] Report of the sixteenth session of the Codex Committee on Food Additives, The Hague, 16-21 March 1982. Guidelines for food additive intake studies (unpublished FAO document ALINORM 83/12, appendix VII).

2. OBJECTIVES AND SCOPE OF THE GUIDELINES

The basic objective of these Guidelines is to aid countries with varying resources to assess the risk of possible exposure to chemical contaminants in the food supply and to aid countries in reviewing and amending current regulatory practices. This is achieved through the process of determining the estimated exposure of a population to chemical residues in the diet and comparing these dietary intakes with those that have been judged as acceptable through the work of JMPR and the Joint FAO/WHO Expert Committee on Food Additives in setting ADIs or PTWIs.

Other objectives of the Guidelines are as follows:

(a) to utilize existing monitoring data effectively in the prediction of potential exposures to toxic substances in food;

(b) to identify the criteria that may be used to decide which dietary intake assessment studies are appropriate;

(c) to provide methods for predicting likely intakes in the absence of extensive data;

(d) to assist in determining whether regulation of the use of certain chemicals is necessary and in facilitating the process of setting or accepting tolerances and residue limits;

(e) to enable more objective assessments to be made of the effects the ingestion of such toxic substances may have in man, by combining dietary intake studies with a study of the indices of clinical effect in individuals and other appropriate epidemiological information;

(f) to facilitate a comparison between the estimated daily dietary intakes of contaminants amongst the Member States participating in the Joint FAO/WHO Food Contamination Monitoring Programme.

The approach adopted in these Guidelines to meet these objectives has been:

(i) to propose certain methods that can be used to estimate average dietary intakes of contaminants in the population as a whole;

(ii) to interpret the data from such methods to decide whether more detailed studies should be undertaken; and

(iii) to identify ways of calculating potential maximum intakes of individual foodstuffs and of foodstuffs in general.

There is no single method that can be proposed for estimating the dietary intakes of toxic substances present in food, since no one method is suitable for application to the problems facing countries with widely differing resources, lifestyles and the diversity or homogeneity of food supply and food distribution networks. The relative advantages, disadvantages and overall limitations of the various approaches must be taken into account once the overall policy of a country's food safety programme has been determined.

Methods are available for broad and general estimates of food contamination risks, which may be used to determine whether more detailed and accurate assessments of risk should be applied. However, food contamination monitoring programmes may already have identified a source of contamination which is likely to comprise a substantial portion of the dietary intake of a certain contaminant. Under such circumstances the initial average assessment of intake may be unnecessary and detailed studies of individual intakes may be most appropriate.

3. FOOD CONSUMPTION DATA

3.1 Introduction

The collection of valid data on the food consumption habits of a population is the most difficult problem to be overcome before any assessment can be made of the dietary intake of a contaminant. Patterns of food consumption vary considerably within individuals and groups of individuals. This variability must not be forgotten in the choice of the method of dietary intake assessment and the interpretation to be placed on the data obtained. Some groups within the population will show patterns of food consumption that are widely different from those of the population as a whole, and include, for example:

(a) ethnic and cultural minority groups within a community;

(b) people living on subsistence diets;

(c) people whose employment or situation provides them with free food or who produce their own;

(d) members of the general population with extreme eating or drinking habits;

(e) infants and young children, the elderly;

(f) pregnant or lactating women;

(g) the sick (e.g., diabetics);

(h) people on restricted diets (low-calorie, low-sodium, vegetarian, etc.);

(i) people who live in a geographical area where the levels of a contaminant in food are unusually high.

Methods for the assessment of patterns of food consumption will provide data that may not be representative of the population as a whole but only of specific groups within the population. In utilizing data from any one approach, such limitations should be borne in mind. Too rigid an interpretation of such data as to the actual level of intake of a contaminant over a long period of time by an individual or group within the population is unjustified, since long-term food consumption habits are difficult to obtain. Once the overall objectives of the programme have been defined, the limitations of each approach should be carefully considered before any one type of approach is adopted.

This section of the Guidelines is not an attempt to review in detail all the different methods that have been utilized in determining food consumption, since this has been done already (5-9). Rather, it is to discuss in general terms the methods that are available for obtaining the food consumption data felt to be of principal benefit in estimating the dietary intake of contaminants, and their advantages and limitations.

3.2 Approaches for determining food consumption data

There are two general approaches to obtaining information on the dietary habits of a population or of individuals: (a) involving the collection of inferred data on the movement and disappearance of foodstuffs in a region or home; and (b) involving the collection of direct personal data on the actual amounts of food consumed by an individual or household. A summary of the methods that have been used generally is given in Table 1. The selection of any one method over another will depend on such factors as age, educational level and motivation of the target population, as well as the costs and resources available.

The food consumption data used to determine the dietary intake of a contaminant for a population group should reflect typical food consumption patterns of the population of concern. Ideally the data will be derived from current national food consumption surveys which use acceptable sampling techniques and methods for determining food consumption. However, surveys designed to obtain information about the food consumption habits of a group do not always identify above-optimal intakes for individuals, or allow associations between intake and effects in the individual to be determined.

Table 1. Methods for collecting food consumption data from population groups and individuals

Assessment	Method
Individual	Food diary, weighed intakes Duplicate portion studies Dietary recall Food frequency
Population	Food diary, weighed intakes Dietary recall Food frequency Food disappearance method - household - national

Nationwide programmes for the collection of food consumption data at the household level have been used to a greater extent than those based on an individual's food consumption.[1] The collection of nationally-representative data on household purchase and consumption of foodstuffs has been necessary for many governments wishing to study the overall level of nutrition of a community and the effect that social and economic factors have had on the consumption of individual foods and food in general. Provided that the data are truly representative of social class and regional differences, they are likely to reflect the long-term trends of food purchasing habits throughout the community as a whole.

The use of household budget surveys that record expenditure on food to derive the quantities consumed can lead to an under-estimation of the intake of food by some groups within the population and an over-estimation of the intake of others. Household food consumption surveys that record the movement or disappearance of food in a household provide more accurate results, but none of them is able to provide information on the distribution of the foods among the members of the families. This aspect is discussed further in section 3.6.1.

However, if such data are used in combination with data on the average levels of a contaminant found in the consumed food, and the calculated intakes are found to be well below the toxicologically-determined acceptable intake, then the fact that the intake of some individuals of the population has been under-estimated can usually be ignored. This is not the case when monitoring programmes have established that contaminants may be present at high levels in certain foods and the patterns of consumption or purchase of such foods in the community as a whole show wide fluctuations. If there is any evidence for the coincidence of these two factors, then food consumption studies based on the direct measurement of the food intake of an individual are essential.

Difficulties arise when the use of inferred methods (i.e., food disappearance methods) indicates that intakes are not substantially below an acceptable level. It must then be decided whether direct studies would be appropriate, taking into account any realistic individual consumption data already available, and any physiological constraints that will determine the total amount of food likely to be consumed on a regular basis by any one group of individuals (section 3.7).

3.3 Selection of a sample of the population for study

The sampling technique used in a food consumption survey should be based on available demographic data of the population group, area, region or country to be evaluated. Selection of the households or individuals within a population to be surveyed must take account of the following variables: age, sex, race or ethnic group, income, urbanization, geographical

[1] Review of national practices and methods of food consumption surveys. 1977 (unpublished FAO document FAO/ECELCFS: AG5/77-2).

location, pregnancy or lactation, and housing within an institution, such as a hospital, convalescent home or boarding school. The religion of the participants may also be of concern if there are several religions (with different dietary prohibitions) within a population. Other variables (occupation, water source, use of drugs or tobacco, etc.) may also be of concern depending upon the contaminants to be evaluated in the diet.

If the objective is to compare the variation in intakes between population groups and to study time trends in these variations, then the choice of an appropriate sample population must be based on available census-type information. The sample must be stratified according to the number of individuals or households within each of these distinct populations. Approaches that have been adopted for sample selection in nationwide household or individual food consumption surveys carried out in a number of countries, have been published (10,11).[1] The sampling must ensure that the dietary data are typical of the population. There should be a sufficient number of individuals within the various subcells (e.g., age, sex, race, income groups, etc.) that are to be evaluated in order to ensure that the data are valid. It must be noted that "averages" can be very misleading if a country's wealth is unevenly distributed. Thus it is important to evaluate standard deviations for mean values, means versus medians, and percentile distribution of food intakes for a population group and its subgroups.

If the objective is solely to make a once-and-for-all assessment of maximum potential risk amongst a particular population group in one specific region of the country, then biased sampling is adopted. The criteria for the selection of an appropriate sample will depend largely on the minimum sample size that has been judged to include the top percentiles of consumers within the group. In order that these can be achieved, a minimum random sample of at least 100 individuals must be selected, based on general observation of eating habits and localized knowledge of the incidence of food contamination.

3.4 Validity of food consumption estimates

A determination of the absolute validity of a set of dietary survey data is rarely possible. However, validation can be undertaken by relating the total excretion of a given component of the diet by an individual to the intake, as determined by a food-intake study, provided such a component is not stored or synthesized *in vivo* (12). As far as is known, this has never been evaluated for a food contaminant. The data can only usually be evaluated for convergent validity, i.e., the data on food intake obtained by one approach are compared with those obtained by a different approach.

For data representative of an entire population or large group, it is important, within the limit of available resources, to validate both the selection of the population sample as well as the method utilized for collecting the consumption data. Where the objective is solely to identify individuals at greatest risk and estimate their food consumption, confirmation that the data obtained are representative of such consumers should be undertaken by means of a further study on a separate sample of these consumers and the results compared.

3.4.1 Validation of representative data

The characteristics of the sample from which data have been obtained should be compared with census data. In Table 2 population data from the US Department of Agriculture (USDA) Household Food Survey and the US Census are compared for age (13). Similar comparisons should be made for sex, race, geographical area and degree of urbanization.

3.4.2 Validation of methods utilized for collecting consumption data

The inherent variability in food intakes by individuals, depending on age, sex, economic status and season, is such that all approaches to an estimation of food intake can only be a rough estimate of the real long-term food intake of an individual. Nonetheless, some methods are considerably more accurate than others. The determination of the variation between methods or the reliability of a single method is important in ensuring that the data are consistent. Consequently, whenever resources allow, compatible methods for the estimate of dietary consumption should be combined or compared. If only one approach is used then estimates should be made over spaced intervals, taking seasonal variations into account, and compared.

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[1] See also Review of national practices and methods of food consumption surveys. 1977 (unpublished FAO document FAO/ECELCFS: AG5/77-2).

Table 2. A comparison of the age of survey populations from the US Department of Agriculture (USDA) Household Survey (1965) and the US Census

Age (years)	USDA survey		% of US population	
	No. in selected sample	No. in weighted sample[a]	As selected for USDA survey	As found in US census
< 5	2 126	2 126	11.2	8.4
5 - 13	3 937	3 937	20.8	18.0
14 - 17	1 517	1 517	8.0	7.8
18 - 21	694	906	4.8	7.0
22 - 24	306	612	3.2	4.8
25 - 34	1 081	2 162	11.4	12.3
35 - 44	1 223	2 446	12.9	11.3
45 - 54	1 035	2 070	10.9	11.4
55 - 64	812	624	8.6	9.2
> 65	1 563	1 563	8.2	9.9
Total	14 294	17 963	100.0	100.0

[a] The population of those aged 20-64 was doubled, since the USDA survey was conducted on only one-half of those aged 20-64 years in each household.

3.5 Methods most suitable for individual food intake assessments

The methods most suitable for the assessment of the intake of food by individuals are: food diaries, weighed intakes; duplicate portion studies; dietary recall; and food frequency. The methods, their advantages and limitations and their validity are briefly discussed in the following sections.

3.5.1 Food diaries, weighed intakes

This method requires the individual to write down in a diary the type and amount of foods consumed over a period of time. Records of a 24-hour period have been undertaken but a record of intake over 4-10 days should give a reasonable record of actual intake. A balance must be made between the accuracy of the data and the likely degree of cooperation by the participant, since a high degree of cooperation and intelligence is required. It is not suitable for participants who regularly eat away from home. Parents or guardians must keep records for young children. This method also requires a trained supervisor who can recognize the accuracy of the subject's ability to estimate portion sizes.

The food diary approach can be used advantageously to determine food consumption for either individuals or large populations. For large survey populations in developed countries, a one-day record is felt to be sufficient to obtain reasonable data on the average consumption of foods. A sample food diary form used in the USA is shown in Annex 3. Diaries of varying degrees of complexity may be developed, and the choice of which type of diary to use will depend on local circumstances. Diaries of up to 1 month in length have been used when one or two specific items of foods in the diet are of interest. However, in some countries, where food is consumed communally and where literacy may be limited, difficulties might be encountered unless the study is under constant supervision.

The weighed food intake approach is similar to the food diary method, but requires that the foods be weighed prior to consumption. Each subject or family must be supplied with a food scale and instructed in its use. This method is not suitable for large-scale population studies because of its cost. The weighed intake method has a higher respondent burden and a lower response rate than the food diary method.

Validation of approach

These studies can be validated by comparing the intake as estimated with that determined by actual weighing of the food eaten by an individual or by other methods for the assessment of individual food intakes. The reliability can be assessed by repeating the study at intervals throughout a year, taking into account seasonal variations. The accuracy of weighing by the participant can be checked for certain items by the credibility of the weights given for certain foods, for example, eggs, bananas, soft drinks and other branded foods. Careful scrutiny of the records will highlight errors.

3.5.2 Duplicate portion studies

This approach to determining food consumption patterns is to organize the purchase and preparation of twice the usual portions of food that would be consumed by an individual within the home or institution. This duplicate is weighed and saved in a freezer or refrigerated container for the investigator.

It is of value to obtain data on the consumption of individual foods as part of a duplicate portion study. Individual foods of interest would have to be provided as a separate duplicate sample and stored as such. However, these studies may provide such data if food diaries are kept or if weighed intakes of individual foods form part of the study (see section 3.5.1).

In duplicate portion studies, the duplicate of a 24-hour food intake is homogenized and analysed. The collection of food can be undertaken for any period of time but a minimum period should be chosen that reflects the average dietary pattern. When done in a home setting, the duplicate portion technique requires reimbursement of the participant for the cost of the extra food. Account should be taken of any food consumed outside the home that has not been prepared by the householder. Ideally the participant should be provided with suitable containers in which to store a duplicate portion of the food.

Residential homes, schools, rural communities consuming food from a kitchen, and other communities contained within an institution provide an ideal base through which to organize duplicate portion studies. A representative sample of food can be obtained from the communal kitchen and the study simplified to a weighed food diary record (section 3.5.1). Usually, no participation of the individual is required since a dietitian can supervise the weighing of a portion at serving and any food that remains at the end of the meal. In addition the consumption of foods outside such institutions is often more limited than is the case with other individuals.

This method is suitable for institutional groups and for small surveys but, because of the cost and time involved, it is not appropriate for large-scale food consumption studies. Because foods are often collected and mixed together in large containers, it is not always possible to analyse for individual foods or food commodity groups with this method. Also, unless a food diary is kept in conjunction with the sample collection, there will be no written record of what foods were eaten or collected.

Since the householder must be charged with the responsibility of food purchase and duplication of the consumed portion, much closer supervision by trained personnel is essential for duplicate portion studies in the home. If individuals often consume food away from the home in restaurants, canteens, etc., the application of duplicate portion studies will be often impracticable. However, occasional consumption of such meals during the study period can be accommodated.

Validation of approach

Duplicate portion studies can be validated as described in the previous section. Food intake data from duplicate portion studies can be compared with data available from a food diary or weighed intake study.

3.5.3 Dietary recall

In the recall method, individuals are asked to recollect the types and amounts of food they have consumed at some time in the past. Recalls usually cover intake of the actual food consumed during the previous 24-hour period. The services of a trained interviewer are required.

To record a 24-hour recall, a private interview between the participant and a dietitian of approximately 20 minutes is required. The interviewer helps the subject to remember in detail the preceding day's food consumption, and records the foods and the amounts consumed. The recall may also be conducted by telephone. Parents or caretakers usually respond for children of less than five years of age. Some studies have utilized a 7-day recall method. This method can be applied to the study of food consumption for individuals in communities where the diet is monotonous (14) but poses considerable difficulties where diets are more varied. The method requires a trained interviewer who can recognize the accuracy of a respondent's recall. The 24-hour recall is the dietary survey technique with the least subject burden and the best response rate for large-scale studies. However, it requires considerable staff interviewer time.

Validation of approach

Dietary studies have shown that the 24-hour recall method does not accurately reflect the usual diet of an individual consuming a varied diet over a period of time, as individual day-to-day variations in intakes are very large. For this reason the study is only suitable for studies on populations, unless several 24-hour recalls per person are undertaken. The use of a single 24-hour recall within a large population may give a reasonable reflection of average long-term intakes of foodstuffs amongst the group as a whole, since the group mean values obtained by this approach do not appear to vary significantly on a day-to-day basis (5). The validity of the approach can also be confirmed by comparing this method with data obtained by another method suitable for large-scale studies, such as the food diary method. The resource demands are very high since it is important that both sample populations are representative of the total population with regard to the demographic variables of age, sex, income, etc. Approaches that have been used to validate the use of dietary recall studies have been reviewed (7).

3.5.4 Food frequency

This method attempts to obtain a reflection of the usual patterns of consumption for individual types of food.

The food frequency form is a list of commonly consumed foods to be completed by the subject, indicating the number of times per day, week, or month that each food is usually consumed. Each country or region may develop its own food frequency form to reflect the primary foods and food recipes in common use either nationally or regionally. Information on the quantity of food consumed is not usually requested on a food frequency form. Data on average serving sizes, obtained from previous diary or recall surveys, are used with the frequency data to produce the desired information on dietary intake. Parents or guardians must usually help young children to complete food frequency forms.

The method, which was developed by Burke (15), has been subject to various adaptations. In one of these, a specially trained interviewer uses two separate forms, filling them out in consultation with the individual or housekeeper, by help of food models, household measures and serving dishes for quantifying and expressing the usual daily or weekly food consumption. After a cross check of the data for agreement, a further check is made by enquiring about food purchases for the family. The forms must be planned to suit the population under study, and carefully pretested and evaluated.

The food frequency method does not require a high educational level of the respondent and is not a great burden. However, it should be mentioned that the recall may be subject to error as regards the consumption of foods which the respondents think they should or should not eat.

The food frequency approach is particularly useful in the collection of retrospective data on intakes of certain foods for epidemiological studies. It may also be applied to obtain information about the consumption of specific food types that are known to be contaminated and that are likely to dominate the overall contribution to intake. Unfortunately this information is often lacking and may well be the reason why a dietary study is required in the first place.

Validation of approach

Several convergent validity tests have been carried out with different results depending on the number of individual foodstuffs that have made up the recall study (6). The greater the number of foods involved, the less valid is the use of this approach.

3.6 Methods suitable primarily for population food intake assessments

The food diary, dietary recall and food frequency methods described previously can all be applied to obtain data representative of the food consumption of a population. However, additional but less suitable approaches through household or national food disappearance studies can also be used and may give an estimate of per-caput food consumption.

3.6.1 Household food disappearance method

Household food consumption data generally represent the amount of food that disappears from a home kitchen in a given time period divided by the number of persons in the home. The householder is asked to take an inventory of all the foods in the kitchen and to keep track of all food purchases for a set time period (usually one week). Another kitchen inventory is taken at the end of the time period. The food that has disappeared is assumed to reflect the food consumption of the family. The household food disappearance data are divided by the number of people in the family and the number of days of the time period to estimate the intake per person per day. A model of the questionnaire used in one such study in Tunisia is reproduced in Annex 4.

To obtain more accurate estimates of the food intakes using household data, the methodology may be modified to correct for: food waste, food fed to pets, food given away or received as gifts, food consumed away from home (restaurants and other people's homes) and food consumed by guests. A mathematical model may be developed for population groups to estimate the amount of foods consumed by individual family members. The model would be based on the typical food consumption of age-sex groups (e.g., teenage boys and adult men would get a greater percentage of the household food supply than young children, teenage girls, or older persons) (16).

In order to refine data on household food disappearance, corrections for inedible matter should be made. Some nutrient food composition tables invariably include details on the edible matter of a food as a proportion of the weight purchased (17-20). A bibliography listing sources of data on food composition on a worldwide basis, has been prepared (21).

In a number of instances food composition tables provide data on the change in weight of foods during cooking, and appropriate correction factors may be applied to provide data of most relevance to the food actually consumed in households.

3.6.2 National food disappearance method

When there are insufficient resources to conduct national food consumption surveys, data on national food availability can be estimated from food balance sheets (22). The data are calculated in the following way:

national food balance = food production

+ food imported
+ food taken from stocks
- food added to stocks
- food exported
- food used for seed
- food used for non-edible purposes
- food loss from harvest to kitchen
- animal feed.

For each food and food group the per caput food supply for human consumption is obtained by dividing the results of this calculation by the number of people living in the country.

The food disappearance method is not a real measure of food consumption since there is no correction for wastage and it is not a useful method for any population where food is grown, prepared and consumed by individuals, as home production data are generally not incorporated into national food production data. As food balance sheets represent an annual average, they do not account for seasonal variation or for the distribution of food within the population on a geographic, social or economic basis. For all these reasons the method should only be used when all other approaches have been considered to be unfeasible under the circumstances.

3.7 Consumption data for "extreme" eaters

In the assessment of risk a distinction must be drawn between average consumers and consumers who have above-average intakes of individual foods - or who consume an above-average amount of food in general. Because of physiological limitations, it is likely that the percentile variation of overall food consumption within a population is narrower than the observed percentile of variation for individual foods. Since certain contaminants are often limited primarily to a small number of food types in the diet, information on the extreme intakes of individual foods within a population is one important part of the process of risk-assessment.

Although it is possible to determine extreme intakes within a sample of the population directly through the use of nationally-representative food consumption surveys, a very large sample would need to be selected to obtain a true reflection of extreme intake, and the necessary resources may not be available. This can be overcome by deliberately seeking out people who are likely to have greater consumptions of the contaminant of concern and interviewing a group of such people to obtain data. An alternative option is to calculate likely extreme intakes knowing average intakes. The ways in which this can be achieved are outlined in section 9.3.

3.8 Procedures to be adopted for obtaining data on food consumption

The following procedures should be considered when adopting and developing an appropriate method for obtaining data on the consumption of foods:

(1) Select a method consistent with the type of information required - for the development of nationally-representative food consumption data, food diaries, dietary recalls, food frequencies or food disappearance methods may best be used.

In the case of an interest in determining individual food intakes, duplicate portion, food diary and/or weighed intake studies are suitable if data are required on current intakes of many foods; the food frequency method is of benefit, on the other hand, if data are required on past or usual intakes of foods.

A comparison of the characteristics, advantages and disadvantages of the different methods of determining food consumption data is shown in Table 3.

(2) Assess the range of economic and personnel resources available for implementation of the method chosen.

(3) Develop preliminary data collection forms and training instructions for interviewers and participants.

(4) Train and test interviewers in the method and test for interviewer variation.

(5) Test approach by means of a pilot study of a sub-sample from the proposed target population.

(6) Revise data collection forms and instructions as necessary and, if possible, monitor cooperation rates.

(7) Develop the necessary data management and analysis facilities.

None of the dietary methods discussed in Table 3 are strictly defined. They may be adapted to suit the research objectives of the investigators and the characteristics of the population being investigated. Of primary concern is that the investigators be intimately familiar with the typical foods consumed and methods of food preparation. The method selected for obtaining information for a nationally representative study of dietary intake of contaminants must be within the resource constraints and should be of a large enough scale to be representative of the population as a whole. The sampling of the participants must be valid, and the interpretation of the data from the study must take account of the limitations of the methods used.

Table 3. Methods for obtaining food consumption data: Comparison of approaches used

Method	Respondent literacy required	Data validity ranking[a]	Suitability of approach for		Individual consumption data provided	Respondent burden	Field staff burden/cost	Processing dietary data	Comments
			large-scale studies[b]	small-scale studies[c]					
National food disappearance (food balance sheets)	no	6	suitable	unsuitable	no	none	none; assume data already available	none	crude estimate; disappearance rather than consumption; waste and home-grown foods not usually considered
Household food disappearance	yes	5	suitable	suitable	no	heavy	heavy; 2 home visits	heavy[d]	food waste not usually corrected for; not applicable to age-sex groups; participation required for householder only
Food diary	yes	3	suitable	suitable	yes	heavy	medium; home visit and instruction	heavy[d]	record keeping may cause subject to eat differently; one of the more reliable methods especially when carried out over 7 days; literate participants or enumerators necessary
Weighed intake	yes	2	unsuitable	suitable	yes	heavy	heavy; home visits	heavy[d]	same as food diaries; experience with food balances necessary
Dietary recall	no	3	suitable	suitable	yes	light	heavy; individual interview	heavy[d]	honesty and memory of subject critical; skill of interviewer important factor; response rate for 24-hour recall good
Food frequency	no	3	suitable	suitable	yes	medium	medium; individual interview or self-administered questionnaire	heavy[d]	food models for quantifying intakes are useful; honesty and memory of the respondent critical; skill of interviewer important factor; response rate good
Duplicate portion	no	1	unsuitable	suitable	yes	heavy	heavy; 2 or more home visits; food storage instructions	none	subjects must be paid for cost of extra food; special modification necessary to collect data on individual foods or food commodity groups

[a] Validity: how closely the method measures daily intake (1 = most valid; 6 = least valid).

[b] Large-scale - representative of the entire population.

[c] Small scale - representative of individuals or groups of individuals including households.

[d] Computerized analysis will greatly facilitate staff burden.

4. USE OF FOOD CONSUMPTION DATA TO DERIVE INTAKES OF CONTAMINANTS

4.1 Introduction

There are three approaches that can be adopted in estimating the daily intake of a contaminant, based on the food consumption data obtained by the methods described in section 3:

(a) Total diet (i.e., market basket) studies. The sample for this type of study consists of a market basket of food reflecting a defined total diet of a consumer for a specific period of time. The foods are prepared for table-ready consumption and are analysed either individually or combined in one or more food-group composites (e.g., cereals, meat, root vegetables, etc.) in proportions based on available consumption data. Residue levels measured in the total diet samples are used in calculating the average daily intake for each composite and for the diet as a whole. A total diet study is particularly valuable in initially determining whether residues are widely distributed amongst all the broad classes of major foods, or are confined to a few general classes of foods, e.g., fruit, vegetables.

(b) Selective studies of individual foodstuffs. This approach involves measurement of residue levels in representative samples of staple foods, either raw or cooked, which, together with food consumption data, enables average daily intakes to be calculated. Such an approach is particularly useful if the intake of a contaminant is predominantly influenced by one or two commodities and/or when food contamination monitoring programmes have established average residue levels in the commodities. In combination with food consumption surveys, it is possible to obtain a reasonable assessment of exposure in selected consumer groups.

(c) Duplicate portion studies. Representative diets of individuals can be collected over a period of days by requesting that institutions or an individual provide, for residue analysis, a duplicate sample of the meals consumed. Duplicate portion studies may be part of the food diary and weighed intake studies mentioned earlier (section 3). Such an approach has been successfully used in residue intake studies in well-defined populations (23,24).

The choice of which method to adopt will depend on the objectives of the assessment and the resources available. The strengths and limitations of each approach will be discussed in sections 5, 6 and 7.

4.2 Development of a food list

Before the details of approaches 4.1(a) and 4.1(b) can be carried out as described in sections 5 and 6, it is necessary to process and select the food consumption data in order to be able to decide which foods should be purchased and analysed. This is best achieved through the development of a food list, the objective of which is to select a limited group of foods that are representative of those normally consumed by a population. This list is then used to estimate daily contaminant intakes by multiplying the content of a contaminant in the foods listed by the amount usually consumed.

The number of foods to be included in a food list will reflect the detail of the consumption data that have been obtained. Food lists derived from national food disappearance data will be necessarily short because they primarily reflect raw, agricultural commodities. Lists for household consumption data (intermediate in length) will probably contain items purchased in retail stores and markets, and will reflect unprepared food items unless specific correction factors are applied. Lists for individual consumption data will indicate foods as consumed and will contain prepared foods, mixed dishes and restaurant foods, in addition to the more traditional food items. The actual number of household records or individual food records available from national food consumption surveys may vary considerably from country to country.

The specific foods to be included in the studies described in sections 5 and 6 will depend primarily on the results from food consumption data. However, other factors such as analytical resources, the contaminants to be evaluated and the population group(s) to be studied will also influence the number and types of foods collected and analysed.

For food monitoring programmes that have generated data on the mean levels of a contaminant in a wide range of foodstuffs, a suitable approach which might be adopted in the selection of a food list is described in section 6.2.

4.2.1 Analytical resources constraints

The number of foods selected for the food list will depend largely on the number of analyses that can be completed. If only a few foods (20-40) can be analysed, the selection process becomes relatively simple as only the most commonly consumed foods are chosen. However, if, for example, 200 or more foods can be included, more complex evaluations of the population's food consumption data are needed for the selection of the foods to be included in the study.

4.2.2 Influence of the contaminants to be evaluated on the selection of foods

Interest in certain contaminants will also influence the choice of food to a degree. For example, if one of the contaminants is found primarily in animal fat, the food selection must include appropriate foods such as meats, butter, whole milk, etc. The influence of food processing on the level of a contaminant should also be considered. For example, if a substance such as lead is of concern, then it is important that the food list contains a representative number of canned foods, spices, etc. If the contaminant is known to be stored in certain tissues (e.g., liver, molluscs, etc.) it will be necessary to include some of these foods in the food list.

4.2.3 Population group(s) to be studied

The foods to be selected must be representative of those typically eaten by the population group(s) to be investigated. Representative foods may be selected for the whole population or for individual age-sex groups (e.g., young children, the elderly, teenage boys or girls, women of child-bearing age, etc.) within this population. The relative importance of some foods to specific age-sex groups may be diluted when the whole population is studied. It is also necessary to determine the average body weight in kilograms in the selected age-sex groups because contaminant intakes are usually expressed both in terms of amount per person per day and amount per kilogram of body weight per day.

4.2.4 Ranking within groups according to daily consumption

The next step in the preparation of a food list is to group the foods according to major food types, and to rank individual foods within these types according to decreasing order of daily consumption. For a list derived from national food disappearance data, categories such as cereal grains, vegetables, fruits, meat, milk and milk products, fish, and poultry products are likely to be sufficient. The Codex Alimentarius Commission's food groups used for pesticide residues (Annex 5) and food groups utilized in Thailand and Guatemala (Annexes 6a and 6b) are examples of such groups of foods. If individual agricultural products are to be selected from these broad categories, the Codex detailed classification system may be further consulted.[1] Food lists derived from household and individual data may also require such additional categories as processed grains, sugars, mixed dishes, fats, oils, soups, salads, beverages and condiments.[2]

4.2.5 First-level aggregation of similar foods

The next step (which is generally not applicable to national food disappearance data) would be to group items of the same "kind" under each category. For example, under fruits, one might find: peaches, fresh; peaches, frozen; peaches, canned; peaches, jam; and peaches, dried. One could combine the daily intakes of these items to get "peach" consumption. One might also wish to separate canned from fresh and frozen peaches. This first-level grouping or aggregation will help to reduce the number of food items with little loss in the accuracy of the food consumption data.

4.2.6 Second-level aggregation (items of low consumption)

The next step might be to aggregate foods that are similar in type but are consumed in small amounts. For example, consumption data may be available on various types of berries

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[1] Guide to Codex maximum limits for pesticide residues. Rome, 1978 (unpublished FAO/WHO Codex Alimentarius Commission document, 1st issue, CAC/PR-1-1978).

[2] FAO/WHO draft food classification system for food contamination monitoring programme 1977 (unpublished FAO document FAO-ESN: MON/77.10; unpublished WHO document WHO-FAD/FCM/77.10).

(gooseberries, raspberries, strawberries, etc.). Aggregation of these berries would result in a single berry group. It could be left to the discretion of the purchaser of the food to decide which fruit to purchase; the major berry fruit such as strawberries could be specified for purchase; or the purchaser could be given first, second, etc., choice, depending on which items are available. This second-level aggregation further reduces the size of a food list without loss in terms of total food intake, and it may be continued until the desired number of foods for a particular study is achieved. The goal is to obtain a list which is as close as possible to 100% of the weight and energy intakes of the average diet and which includes all major food types.

4.2.7 Third-level aggregation (mixed dishes)

A particular difficulty in the aggregation process concerns the use of data that reflect prepared meals and mixed dishes such as sandwiches, or soups. These foods may be aggregated with the use of standard meal formulae. The item with the highest consumption, e.g., spaghetti and meat sauce could represent an aggregate of all mixed dishes with the formula "macaroni products or grain with meat or fish in tomato sauce". The consumption figure applied to spahgetti and meat sauce would reflect consumption of all foods within this formula group. Alternatively, in some dietary studies the food purchaser would be free to choose any item of food falling within the generic description "pasta dishes" as long as it was included in an amount that reflected total pasta consumption.

4.2.8 Aggregation for age-sex groups

If more than one age-sex group is to be studied then these aggregation steps must be carried out for each age-sex group of concern, in order to estimate the daily intake of each representative food for each age-sex group to be studied. The aggregation data should be fully documented.

Application of procedures such as those described above enabled the US Food and Drug Administration to produce a practical food list for the analysis of food contaminants in the current US Total Diet Study and for the analysis of individual foods. Without aggregation it would have required 500-550 foods to comprise 90% by weight of the diet; 900 foods to constitute 95%; and 3000 foods to constitute 99% of the average diet (25).

4.3 Development of preparation guides

The next step in the organization of these studies is to develop preparation instructions for each of the foods on the food list. Some instructions are relatively simple (e.g., "use directly from container", "wash and peel", or "prepare according to package instructions"). Other foods will require detailed recipes (e.g., lasagna or chicken soup). Any item requiring the addition of two or more items should have a standardized recipe to ensure that the food will be prepared in the same way each time it is to be analysed. Food lists developed from disappearance or household purchase data may contain raw commodity items (such as flour or shortening) that require no preparation. Other items such as dry beans, dry rice, etc., should be prepared prior to analysis even if the disappearance or household purchase data indicates that these are raw commodities.

4.3.1 Use of water as a beverage and in cooking of foods

Many food consumption surveys do not include drinking water as an item in the data base. Drinking water should always be included in a dietary intake study. In some cases it will be necessary to find alternative sources of information to estimate daily consumption of drinking water *per se*. For some data, primarily those obtained from national food disappearance and household consumption studies, it will be necessary to estimate not only the quantity of water consumed *per se*, but that used for cooking (rice, oatmeal, etc.) and for making beverages (tea, coffee, lemonade, etc.). Drinking-water samples should be obtained for analysis and the consumption and analytical data included in the overall assessment of intake. Wherever possible, the water used in the reconstitution of dehydrated foods and in the cooking of food should be typical of that used by the population group under study.

Because large quantities of water are required for food preparation, its transport may present difficulties. In such circumstances preparation instructions should detail the type

of water to be used (distilled water or laboratory or household tap water). For many contaminants, if a realistic assessment of dietary intake is to be made, a local sample of drinking water must be collected and analysed. All beverages that require dilution or infusion before consumption should be prepared with appropriate samples and quantities of drinking water, and instructions should be included as guidance to the field staff laboratory.

For a discussion of the instructions to be included in the preparation guide concerning the use of water in the preparation of foods, see section 5.4.2.

4.4 Preparation of a shopping list

The shopping list is developed from the food list and recipe ingredients. Appropriate care must be given to the seasonal nature of the foods, to the recording of manufacturers' food codes, brand names etc., to the purchase and packaging of foods, and to food transport and storage prior to kitchen preparation. Enough of each food item must be purchased to allow for sample analysis and for reserve portions. If food composites rather than individual foods are to be analysed, it is necessary to purchase quantities sufficient for the composite mixture (section 5.2.3).

4.5 Selection of representative samples of food

Food samples collected should be representative of the food supply in the geographical area of concern. It is desirable to obtain food at regular intervals over a period of a year to reflect seasonal factors. It might be advisable to develop a composite sampling scheme (e.g., purchasing the same item from three different sites in a collection area and combining the three items to represent one analytical sample) for more representative samples. However, composite sampling has the disadvantage that the opportunity to highlight food contamination problems may be lost because of the averaging effect of combining the samples.

5. TOTAL DIET (MARKET BASKET) STUDIES

A previous report (1) has described, in general terms, the concept of estimating dietary intake of contaminants through so-called "total diet" or "market basket" studies. Briefly, such studies entail the analysis of a "standard" set of prepared foods or food groups that have been chosen, using one or more of the approaches described in the previous sections, to reflect the average dietary habits of the general population, or of a particular sub-set of the population, e.g., infants. Results of these analyses are then used to calculate an approximate dietary intake for a contaminant.

The following paragraphs describe in detail the practical aspects of implementing this type of study. The procedures and examples cited below may be useful as guidelines for those Member States wishing to establish a total diet study. Of course, each total diet study will differ markedly, depending upon such factors as the degree of urbanization, cultural homogeneity, population group studied, etc. Therefore, each section below must be adjusted and modified to conform to the needs, goals and resources of the individual nation.

5.1 Selection of sampling sites

Sampling of total diet market basket foods is most often performed at retail markets to ensure that the sampled products represent the foods available to the public. The nature and location of the retail outlets (urban and rural) to be sampled are dependent upon the objective of the study.

Ideally, the total diet study would encompass all geographical regions within a country. Foods representing the diets of various ethnic or socioeconomic groups within the country would be collected periodically from each geographical region. From a practical standpoint, however, it is seldom possible at the beginning of a total diet study to comprehensively sample all geographical areas of a country. Selective sampling of a few urban and rural centres within a country is a more realistic initial approach.

Alternatively, sampling may be directed toward selected segments of the population (e.g., ethnic or geographical) if necessary. Such directed sampling, however, is often not the purpose of total diet studies, which are usually carried out to determine intakes of contaminants in a "nationally-representative" diet.

5.2 Development of a standard collection procedure - the shopping guide

In order to ensure that the total diet study accurately reflects any change in contaminant intake over long time periods, the food collection procedure should be consistent from year to year. Modifications can be carried out as necessary to conform to the individual nation's dietary habits and requirements. The foods that comprise the "standard" total diet should be collected in an identical manner each time at carefully planned time intervals. To facilitate this process, it is necessary to establish a standard "shopping guide" for use by personnel in collecting the foods which comprise the total diet (the "market basket"). Such shopping guides may simply be lists of the type and quantities of each food to be collected. More appropriately, however, they may be standardized forms that make provision for relevant details concerning sampling location, type of retail outlet, etc.

5.2.1 Describing the foods to be collected

To ensure consistency in the collection procedure, it is important to clearly define the food item to be sampled. This is particularly true where the same basic food product is available in retail markets in various forms. An example of this is described in section 4.2.5, where different forms of peaches are discussed. If a shopping guide specifies only that "peaches" be collected, it is probable that each different type of the product could be sampled randomly. Such inconsistent sampling could have a significant effect on apparent contaminant levels, resulting in, for example, higher lead consumption figures when canned peaches are collected instead of the fresh product, or in higher pesticide residue levels when fresh peaches are collected instead of processed peaches. The importance of these effects in a given nation's diet, coupled with the analytical resources available, determines whether, for example, "peaches" or more precise descriptions of several different types of "peach" foods should be listed. Attention to detail in product description will obviate the need for re-collection caused by the collection of an "improper" item.

5.2.2 Ensuring efficient collection

To minimize the collection time required for each market basket, the shopping guide should group similar food classes together such as dairy products, meats, cereal products, vegetables, fruits, etc. This operation applies both in industrialized nations, where the retail requirements are common, and in the developing countries, where food is often retailed at a central market place, or at a series of smaller specialized outlets, e.g., bakery, meat market, etc.

With a shopping guide having food items grouped according to food class, the purchasers are able to plan the collection route in advance, ensuring the fewest number of stops at retail outlets to acquire the complete market basket. This is particularly important when large quantities of perishable products are to be collected, packaged, and shipped to the analysing laboratory.

5.2.3 Specifying the amount of food to be collected

In order to ensure that enough of a food commodity is collected to allow for all the necessary analyses and food preparations to be performed, careful planning must be done well in advance of the collection. It is necessary to consider: (1) the weight loss, if any, during preparation, e.g., in order to obtain 500 g of fresh fruit pulp for analysis, it may be necessary to collect 1000 g of the raw product to account for the inedible portions; (2) the amount of analytical reserve sample to be retained if repeat or future analyses are to be performed; (3) the quantity of so-called "ingredient" items that may be analysed alone, or in combination with prepared "recipe" foods - for example, butter or vegetable oil may be analysed separately but they may also be used to fry other foods such as meats or vegetables, so that sufficient quantities of the butter or oil should be acquired at the time of collection for both.

The shopping guide should clearly specify the quantity of food to be collected, e.g., "2 kg of oranges, fresh", "4 x 1-pound cans spinach, canned", or "2 x 5-pound bags flour, whole wheat", etc. It is obvious that the shopping guide must accurately reflect the degree of processing and the package sizes commonly available at the retail level. It is therefore imperative that the quantities and descriptions of foods in the shopping guide be developed carefully in accordance with the nature of retail outlet to be sampled.

5.2.4 Examples of a shopping guide

A shopping guide should be prepared for the benefit of the purchasers of total diet foods, with all items arranged according to food class, and with a complete description of the products and the amount to be collected. Important directives to the collection personnel should be prominently placed. The numbered sequence of food items allows the collector a simple means of checking that the foods are collected.

As examples, shopping lists used in total diet studies in Australia and Guatemala are shown in Annexes 7a and 7b respectively, but modifications of such formats can be performed as necessary to conform to the individual nation's dietary habits and requirements.

5.3 Collecting and transporting total diet samples

Depending upon the scope and design of the total diet study, the collection and transporting of a market basket can vary from a simple process to a very complex procedure. For a basic total diet study where relatively few food samples are analysed, the collection procedure may require little personnel time. However, as the number of foods chosen to represent the total diet and the number of collection sites are increased, the amount of resources (personnel time and funding) required for collection and shipment increases markedly. In addition, the experience and skill of the collection personnel become more important.

5.3.1 Collection

For a single total diet market basket, the collection should be performed within a relatively short time period, e.g., within a few days for a small market basket and within one month for a very large one. Rapid sampling enables the analytical laboratory to receive and prepare samples efficiently without the delays associated with the sporadic influx of samples.

Careful control of sample integrity during the collection process is essential. Obvious precautions such as the prevention of spoilage or breakage during packing/shipping should be taken. In addition, precautions against less obvious sources of post-collection contamination are very important, e.g., using contamination-free containers (1) and avoiding exposure to local sources of environmental contamination, such as agricultural chemicals or automobile exhausts. Such factors may easily be overlooked by inexperienced or untrained collection personnel.

It is essential to provide collection personnel with special total diet training to ensure that they are familiar with the purpose of the sampling, the necessary precautions that must be taken, and the importance of their role in the success of the study. Factors to be considered in the collection of water are discussed in section 4.3.1.

5.3.2 Transporting total diet samples to the laboratory

Close coordination between the collection personnel and the receiving laboratory (or laboratories, see section 8.1) is essential. This is also true in connection with selective studies of individual foods (section 6) and duplicate portion studies (section 7). All samples sent to the analysing laboratory (and to the kitchen facility) should be clearly identified as to (a) commodity, (b) place of collection, (c) date of collection, (d) purpose of collection, e.g., "total diet", to avoid confusion with other concurrent sampling programmes, and (e) identification codes to ensure a unique code for that sample. (See Annex 8 for additional information that might be required for the proper identification of total diet samples.)

Total diet samples should be transported to the laboratory by the fastest available transportation. This may be a significant problem in some sections of a country where air and ground transportation may be relatively slow. Priority transport, where available, should be used. In rural areas, mobile simple laboratories equipped with refrigeration can overcome such problems.

Timing of the shipment to the laboratory is critical for the smooth operation of the laboratory. The laboratory should know exactly when collection and shipment are to occur. This ensures that laboratory and kitchen staffs are ready to receive the incoming market basket for processing. Delays in shipment can result in idle laboratory staff, while early or unscheduled deliveries may inundate laboratory staff with samples that cannot be adequately stored or processed.

5.4 The total diet laboratory and kitchen

The total diet laboratory may serve both as an analytical facility and as a diet kitchen to cook or otherwise prepare foods for chemical analysis. In such a case, it must be staffed and equipped both for kitchen preparation and for analysis of foods. Preparation of total diet foods may range from simple rinsing to remove soil from vegetables, to the preparation of meal items such as fried meats or fish, boiled vegetables or mixed foods such as stews. The nature and complexity of the diet preparation is dependent upon the scope of the study, e.g., basic staple foods for "small" total diet studies, to more complex preparations for larger studies. In addition, the diet laboratory/kitchen must have facilities for mixing and blending prepared foods into analytical samples prior to analysis (see sections 5.5.1 and 8.2). The following sections describe the typical operations of the total diet laboratory/kitchen.

5.4.1 Receiving an incoming total diet dispatch

Upon receipt of a total diet dispatch, the laboratory/kitchen staff should record an inventory of items to ensure that all foods specified in the shopping guide have been collected. Any missing or damaged items should immediately be re-collected and shipped by the original collection official. Items that were not available at the time of collection should be noted and collected at a later date, or at an alternative sampling site. If this is not feasible, instruction should be given for the collection of a similar food item that is available. It may be important with canned food items to collect information on production codes and can types, if analyses of lead or other toxic elements are to be carried out.

Food items should first be separated according to the amount of kitchen preparation required. Items that are consumed as received, or after minimal preparation, e.g., fresh fruit, canned fruit, milk, cheeses, etc., are separated from those items requiring substantial kitchen preparation, e.g., raw meats or fish, raw vegetables, and ingredient items (if any) for kitchen prepared "recipe items" such as egg noodles or tomato paste for soups, etc. These latter items are sent to the kitchen facility and prepared in a manner that reflects typical household preparations.

Once this initial treatment of the total diet market basket has been completed, foods may be refrigerated or frozen while awaiting analysis or further preparation.

5.4.2 Kitchen preparation of total diet foods

To ensure consistency in the preparation of total diet samples, it is desirable to establish and maintain a single total diet kitchen facility. Such a facility, once established, will ensure minimal processing variability between the total diet samples.

In cases where this is not feasible, an alternative is to make arrangements with an existing food preparation kitchen near the laboratory, e.g., college, hospital, etc., for the preparation of total diet samples. The operations should be closely supervised by the laboratory staff to ensure proper preparation and minimal extraneous contamination of foods during preparation. Another approach is to prepare foods in the analytical laboratory itself. This is the least expensive approach, but the similarity to actual kitchen preparation may be sacrificed.

Food preparation should, wherever possible, be performed by experienced kitchen personnel under the guidance of laboratory staff. As with the collection staff, the kitchen personnel should be informed of the importance of the total diet samples. Special training should be given as necessary to ensure avoiding extraneous contamination of foods during preparation, e.g., from insecticides, kitchen apparatus, etc.

It should be re-emphasized here that the purpose of the total diet study is to estimate the consumption of selected chemical contaminants in prepared, ready-to-consume foods. The kitchen preparation process may alter the concentration of certain contaminants from that which might be encountered in uncooked foods, e.g., pesticide residue losses through dissolution, volatilization or degradation, or heavy metal increases due to contact with certain metal kitchen-ware. The total diet study is designed to reflect such changes in contaminant levels provided they are representative of changes that occur in "typical household" food preparations. However, undue contamination of foods from the kitchen environment or from utensils should be avoided. For the best representation of "typical household" preparations, food should be prepared in a manner consistent with cultural habits, e.g., use of stainless steel or aluminium cookware may be typical in some countries, while use of cast iron or copper may be prevalent in others. Some countries may wish to "normalize" the somewhat variable effect of cookware by using only special glass materials. Such an approach is acceptable, although there will be a built-in under-estimation of the intake of certain metals.

To assist kitchen personnel in the consistent preparation of total diet foods, it is convenient to provide them with a standard "preparation guide" which provides detailed instructions. Its function is similar to that of the shopping guide in that it ensures consistent preparation of foods from year to year. The preparation guide is essentially a "cookbook", but with additional instructions and precautions specifically for total diet foods. For example, clear and specific instructions on whether to use tap water or distilled water for boiling vegetables, etc. should be given. Annex 9 shows examples of preparation guides that describe simple procedures, such as how to prepare fresh fruits and vegetables (which may be performed in the total diet laboratory) and also provide detailed recipes for more complex meal items.

Following the actual kitchen preparation of the food, all operations such as the blending and storing of samples are potential sources of extraneous contamination. This type of post-preparation contamination must be avoided by careful choice of contamination-free blending equipment and storage containers. This is not a trivial consideration, since severe contamination can occur if proper precautions are not taken (see section 8.2.1). Such precautions are also important where kitchen-prepared foods are analysed using the selected

studies of individual foods approach or the duplicate portion studies approach (sections 6 and 7). Once prepared, food should be refrigerated or frozen, as appropriate, to await analysis or further processing.

5.5 The total diet analytical sample: food group composites or individual foods

The two basic approaches to obtaining analytical data for total diet studies are: (1) the analysis of composites of similar kitchen-prepared food types; and (2) the analysis of individual kitchen-prepared foods. The second is the simpler procedure. However, because many samples are analysed, it requires more resources than the first, in which compositing into relatively few food categories reduces the number of samples for analysis.

Although the total diet approach has certain similarities to the selected studies of individual foods (section 6), the same individual foods are obtained on a continuing basis as a market basket collection reflecting "typical" consumption of foods representative of the total diet. In selective studies of individual foods, use may be made of data obtained from analysis of foods obtained in various monitoring programmes on an irregular, even a one-time-only basis. Also, the foods analysed in the total diet approach described here are cooked or otherwise prepared as in the kitchen, whereas the samples used in the selective studies of individual foods approach are usually analysed as the uncooked commodities or as processed foods.

5.5.1 The composite approach

If the composite, or "mixed total diet", approach to formulating total diet samples is adopted, one or a series of composites of food groups are prepared from the collected/cooked foods to approximate the consumption of a "typical" segment of the population. The composites are prepared by mixing similar foods, e.g., whole milk, cheese, butter, cream, etc., into a single analytical composite, dairy products. The relative proportion of each of the individual foods that make up the composite is determined from food consumption data, as described in sections 3 and 4. As an example, if evaluation of the dietary habits of a segment of the population indicates that whole milk represents 75% by weight of the average daily consumption of dairy products, with lesser amounts of cheese, butter, cream, etc., then the total diet analytical dairy composite would be prepared to contain, by weight, 75% whole milk and, perhaps, 8% cheese, 6% cream, 2% butter and 9% other dairy products. The dairy composite would therefore be correctly proportioned to represent the average daily consumption of individual dairy products for the segment of the population under study.

Analysis of such a dairy composite allows a direct calculation to be made of average daily contaminant intake from dairy products. That is, multiplying the contaminant concentration (in µg/kg) of the composite by the average daily weight of all dairy products consumed (in kg) gives the average daily contaminant intake resulting from dairy products in that market basket. The total dietary intake of a particular contaminant is then determined by summing the daily contaminant intakes from all of the food composites chosen to represent the total diet, e.g., dairy, meats, grains and cereal products, leafy vegetables, beverages (including drinking water) etc. Annexes 10 and 11 show examples of the types of total diet composites that could be used to establish a total diet study based on the composite approach. The sample composites shown vary from country to country. An example of the compositing scheme used to prepare two of the composites shown in Annex 11 is given in Annex 12. The form shown in Annex 12 is both a collection and a compositing guide.

Advantages

The principal advantage of the composite approach to total diet analyses is the ability to determine the approximate daily intake of contaminants by analysis of a relatively small number of samples. By analysis of perhaps 6-14 representative composites, carefully prepared to represent the national, socioeconomic, regional or ethnic dietary habits of a population, an accurate approximation of contaminant intake can be obtained. Further, the small number of food composites required to represent the total diet allows larger numbers of market baskets to be collected and analysed than would be the case if individual foods were analysed. This increased sampling ability allows greater flexibility when choosing the number and location of total diet sampling sites - which would be an important advantage when geographical or cultural diversity within a nation contribute to very different dietary habits.

Disadvantages

The principal disadvantage of the composite approach is the so-called "dilution effect" inherent in the use of composites. In the composite method certain food items, consumed at a low rate by the population group upon which the composites are based, are included as a small fraction of the composite. The dietary contribution of contaminants from this food may therefore be diluted by other components of the mixture to a point where it is below the detection limit of the analytical method. This dilution effect can lead to estimates of dietary daily intakes of contaminants that are lower than is the actual case. In addition, this effect could mask an unusual source of contamination.

Another disadvantage is the inability of a single set of total diet composites to represent the varied diets of different segments of a population, e.g., various age/sex groups, ethnic groups, etc. The use of data collected on total diet composites is restricted to calculating contaminant intakes for that segment of the population represented by that diet. That is, if the total diet (a series of total diet composites) is designed around the perceived diet of an adult male (through methods described in sections 3 and 4), data from analysis of the diet can, in a strict sense, only be used to calculate the contaminant intake of an adult male. The contaminant intake of an adolescent or adult female can only be roughly approximated using these data, since the types of foods and proportions of each consumed by them may differ substantially from that of the adult male.

The disadvantage of the rigid nature of composites is more pronounced with young children and adults, whose diets are often substantially different from the "average" or "typical" diets used to construct total diet composites. This problem can be circumvented to some extent by developing separate total diet schemes for various segments of the population. The US Food and Drug Administration, for example, has used both an "adult" and an "infant/toddler" scheme for several years to adequately reflect the intakes of contaminants for young adult males (perceived to consume the largest amount of food each day) and of infants. Such a division is important, since the very young may also be more susceptible to health risks associated with food-borne contaminants. While it is possible to develop total diet compositing schemes for different segments of the population, the practical number of diets that can be studied by this approach is very limited.

Examples of total diet studies based on the composite approach

Several countries have used the composite approach for estimating dietary intake of contaminants, including Australia, Canada, Japan, the Netherlands, the United Kingdom and the USA. The type of total diets and the number of composites within each diet vary between countries. In several, but not all cases, the studies are based on the perceived diet of an "adult" or "teenage" male. Contaminant intakes for this segment of the population are frequently assumed to represent a "maximum" daily intake of contaminant because of the higher food consumption of the adult or teenage male. Other segments of the "general" population are assumed to consume less contaminant on the whole. The contaminant intakes by "high-risk" groups (pregnant or lactating females, the elderly, infants, etc.) are not assessed in the majority of ongoing total diet studies.

5.5.2 The individual food approach

As mentioned at the start of section 5.5, an alternative approach to total diet analyses of food groups is the use of individual prepared foods instead of consumption-weighted food composites. In this procedure, total diet market baskets are collected and prepared in the same manner as with the composite approach. Here, however, instead of mixing the individual food items into groups of similar foods, each prepared food is analysed separately.

Advantages

There are two major advantages of this approach over the composite method of total diet analyses: (a) much greater flexibility in calculating dietary contaminant intakes for various segments of the population, provided appropriate consumption data are available; and (b) elimination of the "dilution effect" inherent in the composite method.

The individual food approach to total diet analysis depends upon the analysis of a relatively large number of different food types, which have been chosen (again by methods

outlined in sections 3 and 4) to represent the bulk of all the foods consumed by all segments of the population. By analysis of all of these foods, it is possible to calculate, using relevant national food consumption data, the average intake of contaminants by any sub-set of the population. For example, it has been determined that in the USA approximately 240 different foods can be chosen to represent the dietary habits of essentially 100% of the population. From such a list of foods, it is possible to construct a representative diet of most segments of the population, e.g., children, adult males, adult females, adolescent males, adolescent females, the elderly, ethnic groups. Analysis of all 240 food items therefore allows calculation of contaminant intake by simply multiplying the contaminant concentration (in ug/kg) by the average daily consumption (in kg) of that food by that segment of the population. Total contaminant intake is the sum of the contributions from all individual foods consumed.

A second advantage of the individual food method is the elimination of the dilution effect inherent in the composite approach, as discussed in section 5.5.1. In the individual food approach, all foods included in the total diet will be analysed at essentially the same limit of detection for a given contaminant. Therefore, some contaminants that might be totally undetectable in, for example, a meat, fish and poultry composite because molluscs represent only 1% by weight of this composite, would be adequately detectable if molluscs alone were analysed. The contribution of contaminants from molluscs could then be accurately calculated in any diet, regardless of whether the relative consumption is high or low.

Disadvantages

The major disadvantage of this method is the large number of samples that need to be analysed in order to adequately represent all foods consumed by the population. Whereas in the composite approach a series of perhaps 6-14 composite samples could be used to represent national food consumption, the individual food approach requires analysis of perhaps 100-200 individual foods. This increased analytical burden is partially offset by the increased accuracy of the intake calculations and the increased flexibility of enabling the calculation of dietary intakes of other groups in the population to be made. However, the individual food method does require much greater analytical resources than does the composite approach, unless the dietary intakes of several population groups are to be studied.

Examples of total diet studies based on the individual food approach

Reference is made above to a version of the individual food approach used in the USA that includes approximately 240 different food items.

Recent Australian market-basket surveys have been based on an individual food approach utilizing a much more limited range of foods. A total of approximately 40 food items, including those indicated by national statistics for apparent consumption as being consumed in the greatest amounts and those with potentially high concentrations of contaminants, are selected for analysis throughout the year. A typical shopping list for one season of the year is given in Annex 7a. The results of the analyses of the individual foods are then used to calculate the total intake of certain contaminants for a number of hypothetical diets for selected groups in the community.

5.6 Advantages and disadvantages of the total diet (market-basket) method

The principal advantages of the total diet (market-basket) approach for estimating dietary intake of contaminants are:

(a) it takes into account the effect of kitchen preparation on the levels of contaminants in foods;

(b) it provides a continuous means of checking the effectiveness of regulatory systems that have been established to control the levels of the different contaminants in the food supply;

(c) it furnishes readily understandable information on the dietary intakes of contaminants for the use of regulatory agencies, lawmakers and the public;

(d) it provides information on which food groups are the chief dietary sources of the different contaminants;

(e) where analyses are carried out on individual foods collected in the market basket, it permits the assessment of the dietary intakes of either the entire population or of selected population groups on a continuing basis, as long as food consumption data are available for such groups.

The principal disadvantages of this approach are:

(a) it cannot be used to obtain contaminant intakes of individuals or of small groups who are at a particularly high risk, since the studies are based on average food consumption data;

(b) with the composite approach, it is of limited usefulness in estimating the intakes of contaminants present in very low levels, because of the "dilution effect" discussed in section 5.5.1;

(c) it requires the continuous expenditure of comparatively large resources for the analysis of comparatively few samples of a given food; these resources are required to obtain nationally-representative data on dietary intake of chemical contaminants.

6. SELECTIVE STUDIES OF INDIVIDUAL FOODS

This approach involves the measurement of contaminants in representative samples of staple foods, either unprocessed or processed with or without cooking, which together with food consumption data (section 3) enables average daily intakes to be calculated. The method is particularly useful if it is known that the intake of a contaminant is determined by a limited number of foods; when only a restricted number of staple foods are consumed by a population; and where monitoring data on these individual foods are already available.

The purpose of such studies is to obtain data about average dietary exposure to a contaminant in order to estimate average population risk. If food consumption data are not available for the community, data obtained in other countries, where patterns of consumption are judged to be reasonably similar, can be used, together with localized data on levels of contamination, to make a preliminary assessment of likely exposure. Similarly it may be possible to fill gaps in knowledge of the levels of a contaminant present in a foodstuff, by utilizing data available through the Joint FAO/WHO Food Contamination Monitoring Programme or other sources, to enable some assessment of likely exposure to be made.

6.1 Selection of population group(s)

Although this approach is most easily applied to the estimate of the intakes of contaminants of those communities with simple diets consisting of staple foods, it can also be utilized to estimate the intakes of consumers of more complex diets provided certain conditions are satisfied (see section 6.3). The approach is of particular value in the estimation of the intakes of infants and young children.

6.2 Selection of food items

Although staple items of the diet may or may not contain significant residues of a contaminant, the fact that they are consumed regularly in large amounts means that they could make an important contribution to the overall intake. For this reason, it is important that all dietary staples are included in studies of this kind. In addition, foods that are not consumed as regularly but nonetheless potentially contain high residues of a contaminant should be included.

In the case of European countries, household food disappearance studies have shown that out of a total of 120 food items in common consumption throughout the year, only bread, potatoes and milk exceed a consumption level of over 100 kg per person per annum, 19 foodstuffs were consumed in the range 10-50 kg per annum, whereas all the 98 other foods were consumed in amounts of less than 10 kg per year (26).

If, for instance, a reference level of consumption of 1 g per day is assumed, then all foods should be included in the calculation of residue intake if:

(a) they are consumed in amounts 100-1000 times or more of this reference consumption rate;

(b) they are consumed at 10-100 times the reference consumption rate and contain levels of contamination known to be 10-100 times the levels found in foodstuffs included under (a); and

(c) they are consumed at the reference rate of consumption but contain levels of contamination 100-1000 times the levels present in the foodstuffs included under (a).

Thus residue data from food monitoring programmes are an essential prerequisite for the choice of appropriate foods to include in selective studies of this type.

The assessment of realistic intakes of a contaminant must be based on the level of residues that will be present in foodstuffs when they are consumed and, therefore, if possible, should take into account the effects of food preparation and processing on residue levels. This is particularly important when it is known that:

(i) processing methods substantially change the level of a residue over those present in the basic commodity, e.g., the contamination of canned food by lead during the canning process; or

(ii) the removal of inedible parts of a foodstuff and its preparation for consumption by cooking substantially reduce the level of residues present.

6.3 Selection of a representative number of samples from selected food items

The selection of a representative number of samples of a foodstuff for residue analysis will be determined by whether the objective of the exercise is to obtain data that are representative of the population as a whole or of specific population sub-groups.

For nationally-representative data, samples must be taken from as wide a range of production or retail outlets as possible, covering all the large centres of population, and reflecting any seasonal variation in residue levels. In the selection of foodstuffs representative of the exposure of a specific population group within the community, samples should be taken from appropriate localized sources and should also cover seasonal variations, if any.

Initially a minimum number of ten nationally-representative samples should be obtained for each foodstuff to be individually analysed, in order to determine the potential range of residue levels. Where standard deviations about the mean residue limit are found to be large, further samples should be obtained, in order that the accuracy of the mean or median residue levels to be used in calculating intakes can be refined. As discussed in section 4.5, samples can be composited to cut down the number of analyses and/or provide an opportunity to increase the size of the sampling frame.

Wherever possible, statistically valid approaches should be adopted in the selection of any one sample.

6.4 Utilization of data on contaminant levels in food items from surveys undertaken in other countries

Data received from the FAO/WHO Collaborating Centres for Food Contamination Monitoring in some 22 countries have been processed and evaluated.[1] Data are available on certain chlorinated pesticides (DDT-complex, HCH-isomers, heptachlor and heptachlor epoxide, aldrin and dieldrin, HCB), polychlorinated biphenyls, lead, cadmium and aflatoxins in a variety of foods and in the diet. These data are soon to be supplemented by data on malathion, parathion, methyl parathion and diazinon in grains, vegetables and fruits of major importance.[2] In addition, there is a wealth of monitoring data available in many countries, as well as in the scientific literature, all of which may be used to supplement any gaps that may exist in the data available for foodstuffs in circulation within a country. In the case of pesticide residues, where insufficient data are available from these sources, it is possible to use figures such as maximum residue limits (MRLs) recommended by the Codex Committee on Pesticide Residues for certain pesticides and foodstuffs, even though the theoretical exposure calculated on this basis will be exaggerated. The use of such data will assist in deciding whether or not more detailed monitoring and individual dietary survey work are required.

6.5 Collection of food items not previously studied

Where it is desired to obtain national information on the levels of a contaminant in foodstuffs circulating within a country, a choice must be made of foods that are representative of those actually consumed by the population group under study. For foodstuffs distributed nationally, random samples can be taken at widely differing retail outlets. In studies on the dietary intake of contaminants by a specific population group, the samples should be chosen from sites where maximum contamination is likely to occur and have the potential to be consumed by any one family unit. This could represent samples taken

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[1] Summary and assessment of data received from the FAO/WHO Collaborating Centres for Food Contamination Monitoring. Global Environmental Monitoring System, 1982 (unpublished UNEP/FAO/WHO document).

[2] Report of the second session of the Technical Advisory Committee Meeting on the Joint FAO/WHO Food and Animal Feed Contamination Monitoring Programme. Geneva, 1981 (unpublished FAO document FAO-ESN/MON/TAC-2/81/5; unpublished WHO document WHO/EFP/81.15).

from as small a unit as a single farm or smallholding, and taken at the earliest time at which consumption is probable, i.e., when crops are at a reasonable state of maturity.

Details of how representative samples may be obtained have been described in section 6.3.

6.6 Utilization of food consumption data already available from other countries

Because of similarities in economic, physiological and sociocultural factors, there are unlikely to be large differences in the overall consumption patterns of certain groups of individuals from one country to another especially where restricted diets are consumed. It may be possible therefore, as a first approximation, to utilize data collected from the estimation of food consumption patterns in one country for other countries where food consuming habits are reasonably close. The amounts of dietary staples such as maize, wheat, rice, milk, etc., which are consumed in one country or, for one population group where such individual foods comprise the major food source, are not likely to differ widely between such groups so that calculated intakes may be possible using generally available data (Annex 13).

References to sources of household food consumption data are available (27,28). There is also a considerable effort being undertaken in various studies in developing countries to assess food consumption patterns within the family unit (29,30). These studies are primarily designed for nutritional and economic planning purposes and consist of 7-day weighed food intake records of family units, based on the raw foods consumed before cooking.

The data are carefully selected to be representative of certain areas, family sizes and socioeconomic classes, and are helpful in making an initial assessment of likely dietary intake. Such studies are possible in countries as large and diverse in dietary patterns as, for example, Brazil and indicate the relative ease with which it is possible to obtain such data for other countries. In the case of Brazil, some 50 types of standardized foodstuffs comprise almost the entire diet, and the analysis of locally-produced and representative samples of such foods is not likely to limit the application of the selective study approach.

The utilization of such data is especially valid when it is desired to estimate the intakes of young children (section 6.6.1) and "extreme" consumers (section 9.3). The use of such data could also be valid in assessing the risks to fishing communities where fish is the predominant protein source and the major source of exposure to a contaminant. Data that have already been obtained on extreme fish-eating habits worldwide may provide a basis for making an assessment of likely maximum risk if localized data are available on contaminant levels.

6.6.1 Intakes by young children

Selective studies of individual foods are particularly useful for this group within the population as food consumption habits are invariably simpler than for adults. In addition, especially for the child under two years of age, food consumption data are available that are probably widely representative of consumption patterns amongst this group on a worldwide basis. In addition, foods manufactured specifically for infants are usually from a limited range of manufacturers and sources, and relatively few analyses are needed to obtain data representative of these foods.

This approach has been used in Canada (31) using food consumption data obtained by the Nutrition Canada National Survey in 1973 on the 24-hour dietary recall of foods given by mothers to their infants. The consumption data obtained from 257 infants are shown in Table 4.

Data have recently become available from the food consumption surveys carried out in the USA in 1976-1980. In addition, intake estimates have been carried out in the USA from 14-day food consumption patterns of children from birth to five years as well as for older age groups in the population (32,33).

Studies undertaken between 1950 and 1970 in the United Kingdom (34-36) on the contribution made by certain infant foods to the energy intake of infants showed that for those aged 4-6 months 70-73% of the total energy intakes were derived from milk (cow's milk and infant milk formulae), other manufactured baby foods comprised 17% of the remaining intakes. At 6-12 months of age only 30-44% of the total energy intake was derived from milk and 10% from manufactured baby foods. The rest of the energy intake was derived from foods that comprise a part of adult diets. By 20 months of age most children were found to be sharing the food provided for the family.

Table 4. Intake of various infant foods by infants aged 1-12 months in Canada[a]

Foodstuff	Intake (g/kg of body weight per day)				
	1 month	1-3 months	3-6 months	6-9 months	9-12 months
Prepared formulae	50.5	62	25.1	12	3.9
Powdered formulae	7.2	0	1.1	0	0
Strained meats	0	0.2	8.0	10.5	
Junior meats	0				6.5
Strained vegetables	1.1	4.9	3.8	3.5	
Junior vegetables					1.1
Strained desserts	0.4	8.7	15.2	12.1	
Junior desserts					9.6
Juices and drinks	1.6	2.9	5.7	6.8	10.9
Cereals	3.9	3.9	4.6	4.2	3.1
Evaporated milk	38.3	11.6	14.0	16.2	5.0
Milk	10.9	37.2	61.7	65.1	60.4
Table foods	0.9	15.6	4.2	12.6	29.8

[a] After Kirkpatrick et al. (31).

Studies on the food consumption habits of European infants have indicated that the average consumption of milk by infants is as shown in Table 5 (26). These data can be used to calculate roughly the intakes for young babies on milk diets. However, account should be taken of the fact that large individual differences were found. For example, it was shown that approximately 30% of French children consumed approximately 900 g of milk per day.

Table 5. Average consumption of cow's milk by infants[a]

Age (months)	Average consumption in 4 European countries (g/day)
1 - 3	627
4 - 6	655
7 - 9	596
10 - 12	540

[a] After Van Schaik & Dalderup (26).

6.7 Advantages and disadvantages of utilizing selective analysis of individual foodstuffs

The principal advantages of this method of assessing exposure are that:

(a) average dietary contaminant intakes can be determined for the population as a whole or for groups of individuals potentially at greater risk, provided that consumption and contaminant data are available for such groups;

(b) the approach is likely to be more accurate in the estimate of intakes for contaminants where a food composites approach would result in reducing the concentration of the contaminant in the sample to below the limit of quantitation of the method;

(c) food monitoring data on individual foodstuffs are utilized directly[1] - the immediate identification of foodstuffs containing high residue levels also enables those consumers who are at greatest risk to be easily identified;

(d) incomplete data on food consumption or residue limits may be supplemented by data available from other sources to enable an initial risk assessment to be made.

The principal disadvantage of this approach is that greater demands may be placed initially on analytical resources than is the case when total diet, i.e., market basket studies, are utilized. Also, in cases where data are based on uncooked foods, the effects of cooking on the levels of a particular contaminant will be ignored.

6.8 Comparison of contaminant intakes between total diet studies and selected surveys of foodstuffs

Certain countries have adopted either a total diet study or the analysis of selected foodstuffs and the calculation of contaminant intakes using food consumption data. In a comparison of the consistency of the intake data arrived at by both methods, an analysis was undertaken in the United Kingdom of the average daily intakes of lead based on: (i) monitoring data on the average levels of lead found in individual foodstuffs multiplied by the average consumption of that food; and (ii) data from total diet studies.

The conclusions of the analysis were that:

(a) certain basic foodstuffs, e.g., bread and potatoes, dominated the average lead levels in composite groups of cereals and root vegetables as used in total diet studies and that these basic foodstuffs could be used to make a realistic assessment of average intakes from these composites; and

(b) there was a reasonable agreement in the calculated weighted mean lead concentration obtained whether a total diet approach or an approach based on calculation from the mean values of contaminants in staple foods of the diet was utilized. Thus the overall lead intakes will be in broad agreement using either approach. The data and calculation from which these conclusions were drawn are outlined in Annex 14. Clearly this good agreement between the two approaches is only possible when foods are included in both studies which satisfy the conditions laid down in section 6.2(a), (b) and (c).

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[1] Food control data are not suitable for this purpose since heavily biased sampling is often used in their selection.

7. DUPLICATE PORTION STUDIES

Duplicate portion studies require the production, for subsequent analyses, of an exact sample of the food eaten by an individual at a meal. This is achieved by the kitchen preparation of double the quantity of food likely to be consumed and the provision of a sample of the exact amounts of each type of food consumed by an individual. The food provided is as eaten, i.e., after preparation and cooking, over a period of time, usually 3-7 days (see also sections 3.5.2 and 4.1(c)).

7.1 Selection of population groups

The choice of an appropriate sample group within the specialized population group for whom a duplicate portion sample is to be obtained will depend on whether it was intended: (a) to obtain data representative of all such specialized groups within the country; or (b) to study any group of consumers identified as potentially most at risk either because they are exposed to a high level of a contaminant or because they are known to be extreme consumers.

In the first case, selection of a representative sample for study will require random selection of participants from some census-type source of data such as the birth register, household registers, those registered at maternity centres, etc. However, practical limitations will usually limit the sample size and the specialized group must represent a restricted group of the total population, e.g., only children between five and six months of age, immigrant groups, etc.

In the case of an isolated group potentially at risk, participation would be by direct approach and interview, and all volunteers would be accepted into the group as resources allowed, provided that interview established that the selection criteria were met.

Because of the high degree of involvement necessary on the part of the participant, samples must be selected in such a way that it is possible to immediately replace people who do not respond during the study. This is necessary because of the small sample sizes usually associated with these studies.

Cooperation is usually more successful when the purpose of the study is carefully and tactfully explained to the participant and where a personal benefit can readily be seen through cooperation. To maintain good public relations, the participation should be recognized by a letter of appreciation, which should contain general details of the conclusions of the project.

The sample group should be representative and should not normally be less than 100 people. Criteria for sample selection have been discussed previously, in section 3.3.

7.2 Period of study

Normally, a period of not less than seven days should be considered for evaluation of the overall exposure to a contaminant. Normal dietary patterns vary too considerably for any period less than this to be considered valid, except for groups on subsistence diets when a 1-3-day study may suffice.

In the case of seasonal foods, exposure may need to be assessed at various times other than from a one-week study undertaken at one time of the year. If the purpose of these studies is to assess maximum risk from the ingestion of a particular contaminant, the study should be undertaken when it is judged that the foodstuffs contributing most of the residue intake are likely to be consumed in the greatest amount.

7.3 Concurrent development of related information

In order to obtain information on the composition of the individual diets and in order to derive maximum value from the committed resources, it is of real benefit to combine the duplicate portion study with a food diary (section 3.5.1) which the participant completes concurrently with the study or, in the case of foods where consumption rates fluctuate markedly, prior to and after completion of the study. It is not practicable to undertake more than a single month's diary study and participant motivation must be high for the study to be successful.

Motivation is also increased if the study is linked to individual health assessments through the measurement of physiological parameters or clinical indices of effect. These health assessments, which may also be combined with an estimation of excretion rates, may yield valuable data for determining dose-effect relationships, and thus assist in generating data for a more accurate evaluation of appropriate acceptable daily intakes or provisional tolerable weekly intakes for man.

7.4 Preparation for the study and for analysis

Interviewers must demonstrate to each participant the procedures necessary to provide a duplicate portion of food consumed by an individual in the household or institution.

The simplest procedure is to ask the householder or other participants to provide for analysis, at the time of preparation of the meal, an exact duplicate of a composite of the meal served to the person under study. The participant's plate plus meal is weighed before consumption, and weighed again at the end of the meal. This also enables a correction to be made to the amount of food consumed for any inedible and unconsumed portions that remain.

When it is known that certain foodstuffs contribute almost entirely to the exposure to a contaminant, or where levels are such that analysis of composited foods could present problems, it is advantageous to keep such foodstuffs separate for individual analysis. This can be achieved through the use of aluminium containers, which keep portions separate, can be used directly from the oven to the table and are utilized in place of plates.

Sometimes, the 24-hour collection may be subdivided into more than one portion (e.g., liquid and solid foods) for reasons of analysis. In other cases, proportionate amounts from more than one 24-hour collection may be combined into a multi-day composite, to decrease the number of analyses required.

Special provision must be made to obtain and bring back duplicates of food consumed outside of the home or institution, but not prepared there, and to weigh the foods. This is particularly important as otherwise "snack-type" or restaurant foods would be excluded from the scope of the study.

In duplicate portion studies, the householder will have to be compensated for the purchase of extra food in order to ensure that there is a good response. Because these costs are difficult to assess, experience has shown that an ex-gratia payment, which is unlikely to leave the householder out of pocket, results in cooperation rates in excess of 90%.

A typical example of the instructions issued to both interviewers and participants is shown in Annex 15.

Foods are stored in polyethylene or other containers that have been pre-tested to ensure that contaminants are not transferred into the food from the packaging and are preferably kept in the refrigerator or deep-freeze until sample collection can be arranged. Where such equipment is not available, daily or more frequent collections of samples will be necessary, especially in hot climates and where the contaminants are known to be unstable, e.g., formed immediately after cooking or volatile.

7.5 Validity and precision of the study

Determination of the total amount of food consumed in the course of the study for each individual can be compared with the average amount of food consumed in the group. Conversion of total amount of food to a kilogram per body weight basis is probably a sounder way of comparing results. The individuals within a specialized age-sex group who do not provide duplicate portions that lie within a standard deviation of 2.5 of the population mean may not have carried out the study as required and the results should be regarded with some scepticism.

A further validation is possible when a duplicate portion study is combined with a diary study, since the data from the two can be directly compared and inconsistencies eliminated. Still further validation can be obtained if the diary study is carried out additionally prior to and after the duplicate portion study. The extent to which the food consumed during the week of the duplicate portion study differs from the monthly average recorded food consumption can be used to determine the bias that supervision or cash benefits have had on influencing the purchasing habits of the household.

In conjunction with weighed food intake records, the duplicate portion approach is the nearest practicable approach to a precise measure of actual consumption by individuals (5).

7.6 Advantages and disadvantages of the method

The advantages of this approach to determining dietary intakes are that:

(a) analysis is undertaken on a replicate of the food actually consumed by an individual;

(b) food consumption data are not necessary; and

(c) comparatively few resources are necessary for its use in estimating exposure in small groups.

The principal disadvantages of the approach are that:

(i) data are obtained only for a restricted population; and

(ii) the study can rarely be carried out for more than seven days consecutively so that the data may not be representative of long-term average consumption of food; for this reason a duplicate diet study must be combined with other methods of estimating food consumption (section 3).

8. ANALYSIS OF DIET SAMPLES

Regardless of which type of dietary intake study is undertaken, i.e., total diet (market basket), selective of individual foods or duplicate portion, chemical analysis of a substantial number of food samples must be performed to ensure that meaningful estimates of the dietary intake of a contaminant are obtained.

This section outlines some of the practical aspects of conducting the chemical analysis of a wide variety of foods. It is assumed here that the contaminants to be examined include, as in the Joint FAO/WHO Food Contamination Monitoring Programme, pesticides and their metabolites, other organic industrial chemicals such as polychlorinated biphenyls, metals and aflatoxins. The procedures below are directly applicable to these four classes of contaminants. Other contaminant classes such as nitrosamines, animal drugs, or radionuclides are not considered in detail here. However, the general analytical considerations presented may, with appropriate modifications, be applied to these classes.

8.1 Analytical facilities

It is desirable, although not always possible, to designate a single analytical centre to analyse all the samples collected for the determination of levels of contaminants in diet samples. The use of a single analytical centre would help to ensure year-to-year consistency in analytical performance. In addition, it is often logistically and economically more practical to equip a single centre with the necessary sample preparation and analytical equipment, than to equip a series of laboratories around the country.

A single centre can coordinate all phases of the dietary contaminant monitoring study, from the initial collection of food samples, kitchen preparation (if used), analysis of samples, calculation of dietary intakes, and reporting of results to the appropriate national or international authority.

If establishment of such a single centre is not feasible, a series of several centres, each performing a specific type of analysis, e.g., only pesticides, only metals, etc., is appropriate. The logistics of collecting and distributing samples, however, become more complex with such an arrangement.

Finally, the least centralized approach to sample analysis involves a series of centres around the country, each performing preparation and analyses of diet samples for all contaminants, and reporting results to a central coordinating facility. Such an arrangement for monitoring dietary contaminant intake is less desirable than the previous two, since variability between laboratories in preparation and analyses may lead to less consistency in estimates of contaminant intake, and may also obscure any year-to-year trends. Also, in this case a stronger analytical quality assurance programme should be carried out.

8.1.1 Analytical instrumentation for measuring contaminants in diet samples

The type and sophistication of analytical instrumentation used to measure contaminants in diet samples will, quite obviously, vary according to the scope of the study and the resources available to the laboratory. Large-scale studies involving analyses of several hundreds of food samples each year for a variety of contaminants will require considerably more analytical instruments (possibly highly sophisticated) than limited studies examining, for example, a single class of pesticides in a few staple foods. There is a minimum amount of analytical equipment necessary to satisfactorily monitor low levels of contaminants in foods. For the determination of residues of organochlorine, organophosphorus and chlorophenoxy acid pesticides, and polychlorinated biphenyls, a gas-liquid chromatograph equipped with an electron capture and phosphorus-selective detector is generally required. Thin-layer chromatography, while very valuable for monitoring aflatoxins and higher pesticide residue levels, is generally too insensitive for routine determination of pesticides in dietary intake studies. TLC capability, however, is very useful as a technique to complement gas-liquid chromatography and confirm identity, and should be maintained in the laboratory. High-performance liquid chromatography is also being developed for the analysis of aflatoxins and of pesticides such as carbamates.

For the analysis of foods for metals, particularly lead and cadmium, the basic equipment required is usually an atomic absorption spectrophotometer equipped for flame analysis.

However, because flame methods are generally too insensitive for routine determination of trace metal contaminants, graphite furnace devices, which provide greater sensitivity, are appropriate. Alternative equipment using polarographic measurements is also satisfactory for some metals such as lead and cadmium. Colorimetric methods such as those based on dithizone extractions, are generally not sensitive enough for accurate measurements of low levels of these metals. Analytical methods are discussed in greater detail in FAO manuals of food quality control, which provide a useful compendium of many of the methods in use (37).

Analytical methods are discussed in greater detail in sections 8.3 and 8.4.

8.2 Preparation of samples for analysis

The complex nature of diet samples, compared with simpler matrices such as fresh fruits and vegetables, necessitates extraordinary care in mixing and blending bulk samples to obtain a representative analytical sample. The problem is compounded by the fact that many different analytical determinations may be performed on a single homogenized diet sample. For pesticide or aflatoxin determination, for instance, a 100-g sample may be analysed, while for metals, only 1-10 g of sample is usually analysed. It is therefore necessary to homogenize a diet sample thoroughly to ensure its adequacy for all subsequent determinations.

Homogenization of individual or mixed prepared foods is often a time-consuming and difficult procedure. In the total diet composite approach, for example, it is often necessary to blend carefully weighed portions of as many as 25 different foods of varying fat and water content into a single homogeneous mixture of perhaps 2-5 kg. To ensure adequate bulk sample preparation, the laboratory (or kitchen facility) should be equipped with relatively large-scale cutting and blending utensils and large-capacity mixing equipment. Of course, the amount of this type of equipment needed will depend upon the scope of the study. Some facilities may find that a few blenders are adequate, while others may require more utensils to handle a large sample load.

The mixing process must be carefully monitored to ensure minimal extraneous contamination of the bulk sample. This is particularly true for metals, since most blending equipment is constructed of metal alloys. Clean stainless steel, free of corrosion, may be appropriate for blending foods for determination of lead or cadmium, but may not be appropriate for other metals. For organic contaminants, it is necessary to avoid extraneous contamination from blending equipment, such as, seals, gaskets, lubricating oils, or detergents used to clean the apparatus between samples. Thorough cleaning of blending equipment between samples, using appropriate organic solvents or detergents, is always required.

8.2.1 Storing the homogenized diet samples prior to analysis

It is important to transport the samples to the analytical centre as quickly as possible. This aspect is discussed in greater detail in section 5.3.2.

Homogenized diet samples may be stored in a refrigerator for a short time (one or two days) prior to analysis. If samples are to be stored for several weeks prior to analysis, they must be appropriately packaged and frozen at a low temperature to minimize loss or degradation, particularly in the case of certain pesticide residues. If this equipment is not available, then analyses should be carried out before degradation occurs.

The choice of an appropriate storage container is important to minimize the risk of introducing extraneous contamination. Glass containers (large-mouth jars) are preferred for storage of samples. Often such containers have caps that may introduce organic or metal contamination. These caps should be lined with an appropriate material that will not introduce organic or inorganic contaminants. Teflon liners are preferred for both organic and inorganic analyses, but they may be unavailable or too expensive for routine use. Other plastics such as polyethylene or polypropylene are preferred for metals. Some other plastics may introduce organic contaminants such as plasticizers, flame retardants, antioxidants, etc. Aluminium foil cleaned with organic solvent may be used as a cap liner for samples to be examined for organic contaminants. This liner is not acceptable for long-term storage of foods to be analysed for metals. If possible, samples to be examined for organic contaminants and metals should be stored in separate containers. Appropriate cap liners can then be used to avoid contamination.

8.3 Detection and quantification limits of the analytical method

As previously mentioned, the analytical methods used in the analysis of diet samples must be as sensitive as possible. The sensitivity of the overall analytical procedure is usually defined in terms of limit of detection (Ld) and limit of quantification (Lq) or determination.

8.3.1 Limit of detection

The limit of detection (Ld) as it applies to dietary contaminants may be defined as the minimum concentration of contaminant in a diet sample that can just be qualitatively detected, but not quantitatively determined, under a pre-established set of analysis conditions. This is necessarily a very broad definition, since it encompasses all classes of contaminants and all detection techniques. Ld defines the minimum amount of contaminant in a diet sample below which no finite value can be reported, e.g., "not detected at limit of detection of 1 µg/kg".

In many instances, particularly for the determination of pesticides, it is appropriate to place a special restriction on the term "detected". Because of the possibility that a small "detectable" signal at a particular GLC retention time could result from an interference, it is desirable to specify that the identity of a "detection" be confirmed before it is reported. A "detection" whose identity cannot be confirmed, would not be reported as a positive finding.

8.3.2 Limit of quantification

The limit of quantification (Lq) is the minimum concentration of contaminant in a diet sample that can be determined quantitatively with acceptable accuracy and consistency. For pesticide residues, Lq values are the lowest values at which quantitative determination and confirmation of contaminant identity can be achieved on a regular basis.[1]

The distinction between Ld and Lq is somewhat subjective. It can be illustrated by the following example. If an analytical method has an experimentally determined Ld of 1 µg/kg for heptachlor epoxide, samples containing no detected heptachlor epoxide would be reported as "not detected at limit of detection of 1 µg/kg" (for further discussion of reporting analytical results, see section 8.8). If the corresponding Lq is 5 µg/kg, any quantitatively detected (and qualitatively confirmed) residues of heptachlor epoxide might be reported as "detected at <5 µg/kg" or perhaps as a semi-quantitative "trace" between 1 µg/kg and 5 µg/kg (see section 8.8).

8.4 Overview of analytical methods and techniques for organic contaminants

In general, the techniques and methods used for the analysis of diet samples will have lower detection and quantification limits than those used to enforce established regulatory limits. The so-called "regulatory" methods may be designed to ensure adequate detection capability to quantify contaminants at or above a defined regulatory limit (e.g., tolerance, action level). It may not be possible, using such methods, to determine accurately the contaminant level at one or two orders of magnitude below the regulatory limits, such as might be necessary for a "typical" diet sample.

In some cases, existing "regulatory" methods can be modified to achieve lower detection capabilities through modifications of the extraction and clean-up procedures, e.g., by adjusting initial sample sizes, final dilution volumes, GLC injection volumes, etc., to achieve lower detection limits. Such modifications must, of course, be tested to ensure that the method performs satisfactorily at the lower contaminant levels.

Methods used in dietary contaminant surveys should, where possible, be "multi-residue" procedures to permit maximum efficiency and coverage of a wide range of contaminants.

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[1] The Codex Committee on Pesticide Residues employs the term "limit of determination", which is defined as "the lowest practical concentration of a pesticide residue or contaminant that can be quantitatively measured and identified in the specified food commodity or animal feedstuff with an acceptable degree of certainty by current regulatory methods of analysis".

Some nations may wish to include other classes of organic contaminants besides those mentioned below in their dietary intake programme. In addition, some nations may include other toxic elements such as tin and fluoride.

8.4.1 Separation of diet samples according to fat content

Because different methods of extraction and clean-up are used for fatty and non-fatty foods in the analysis of organochlorine and organophosphorus pesticide residues and polychlorinated biphenyls, it is necessary first to categorize diet samples according to fat content (38). Because diet samples usually contain complex mixtures of foods, preliminary fat determinations of each food or food mixture must be performed to ensure compatibility with established analytical methods. This preliminary characterization of the diet samples, while initially time-consuming, will facilitate subsequent analyses.

8.4.2 Organochlorine pesticide residues

Determination of organochlorine pesticide residues, e.g., DDT complex, hexachlorocyclohexane (HCH), heptachlor and heptachlor epoxide, aldrin and dieldrin, etc., are most frequently performed using gas-liquid chromatography (GLC) in conjunction with extraction and clean-up procedures capable of recovering many compounds, i.e., multi-residue methods. Typically, packed columns with electron-capture detectors are employed. Halogen-selective detectors are also employed, although their present use is not widespread.

For use in dietary intake studies, it is important that the method chosen has the lowest practicable Lq. For organochlorine pesticide residues, an Lq of about 2 µg/kg whole product basis as heptachlor epoxide is achievable for most foods. The Lq may be somewhat higher for foods containing fat. This value should be satisfactory for most dietary intake studies. Determination by GLC will provide Lqs varying slightly up and down from the value for heptachlor epoxide, depending upon the detection sensitivity for the particular compounds.

8.4.3 Organophosphorus pesticide residues

Organophosphorus residues are frequently determined using multi-residue extraction and clean-up procedures very similar or identical to those used for organochlorine residues. Thermionic GLC detection (nitrogen/phosphorus) is commonly employed, as is flame-photometric detection in conjunction with electron-capture detection.

An Lq of about 10 µg/kg whole product basis as parathion is generally required for diet samples.

8.4.4 Polychlorinated biphenyl residues

Polychlorinated biphenyl (PCB) residues are also determined as described in section 8.4.2 using GLC with electron-capture or halogen-selective detection.

An Lq of the order of 50 µg/kg whole product basis is attainable for diet samples. Foods of animal origin, e.g., butter, fish, etc., may have significantly higher PCB levels than plant-derived foods.

8.4.5 Chlorophenoxy acids and pentachlorophenol residues

GLC detection using electron-capture or halogen-selective detectors is generally used for 2,4-D, 2,4,5-T, and pentachlorophenol (PCP) residues. An Lq of about 2,4-D of 50 µg/kg of whole product basis is achievable using these procedures.

8.4.6 Aflatoxins

Aflatoxins B_1, B_2, G_1, G_2, and M_1 are most often determined using TLC. An Lq of about 1-5 µg/kg is commonly achieved using silica gel plates with fluorescence detection. A slightly better detection capability can be obtained using HPLC, although this technique is relatively expensive and more complex than TLC.

8.4.7 Other classes of organic contaminants

Other classes of organic contaminants present in very low concentrations, such as dioxins, generally require more sophisticated equipment for residue analysis in samples. Capillary-column gas chromatography and mass spectrometry are often essential.

8.4.8 Sources of information on analytical methods for organic contaminants

Annex 16 lists several sources of information on methods for the determination of organic contaminants in foods. The list is by no means comprehensive. Rather, it lists some organizations that have had a long and continuing involvement in establishing standardized methods for determination of pesticides and industrial organic contaminants in food materials.

8.5 Overview of analytical methods and techniques for metals

Lead and cadmium are the most frequently determined metal contaminants in diet samples. Other elements, such as mercury, arsenic and selenium are also monitored in many cases.

During the past decade, colorimetric procedures based primarily on dithizone complexes have been supplemented by atomic absorption procedures which are generally more sensitive. As with organic contaminants, methods used for monitoring metals in diet samples must have a lower Ld and Lq than "regulatory" methods. For example, mercury levels in some fish species are regulated at 0.5-1.0 mg/kg whereas most diet samples (other than fish or molluscs) contain less than 20 µg/kg mercury.

Unlike organic residue methods, most methods for metals are single-element rather than multi-element. The latter are preferred for maximum efficiency and coverage, but are not yet in common use.

Although conventional ashing procedures are used for determination of metals in diet samples, extreme care in controlling blank contamination is required (see section 8.9.2).

8.5.1 Lead

There are three commonly used techniques suitable for determining residues of lead in diet samples: (1) complexation/extraction followed by flame atomic-absorption spectrometry; (2) graphite furnace atomic-absorption spectrometry; and (3) electroanalysis, i.e., anodic stripping voltametry. Techniques (2) and (3) can provide an Lq of about 20 µg/kg; technique (1) provides an Lq of about 80 µg/kg.

8.5.2 Cadmium

The techniques for cadmium determination in diet samples are the same as for lead. The Lq is typically around 5 µg/kg for electrothermal atomic-absorption spectrometry and anodic stripping voltametry, and about 20 µg/kg for complexation/extraction atomic-absorption spectrometry.

8.5.3 Mercury

For dietary intake studies, mercury is best determined in diet samples by using "cold vapour" atomic-absorption spectrometry. An Lq of 5 µg/kg can be routinely achieved with this technique. The dithizone method is not suitable for measurement of low mercury levels typical of dietary intake samples.

8.5.4 Arsenic

Many laboratories continue to use a colorimetric procedure for arsenic based on complexation with silver diethyldithiocarbamate. This technique is satisfactory to determine arsenic levels down to about 80 µg/kg. Hydride generation and electrothermal atomic-absorption spectrometry is being used by many monitoring laboratories, with an Lq of about 10 µg/kg.

8.5.5 Selenium

The most commonly used technique for determination of selenium in diet samples is complexation/extraction followed by fluorometric detection. The selenium complex with 2,3-diaminonaphthalene allows selenium determination at levels down to about 1 µg/kg. The hydride generation technique is also used, and is less time-consuming. Its Lq is about 10 µg/kg for selenium.

8.5.6 Other metals

Many other metals, e.g., tin, copper, zinc and other nutrient metals, are most frequently determined using flame atomic-absorption spectrometry. In addition, levels of such metals may be high enough in diet samples for convenient measurement by conventional colorimetric procedures.

8.5.7 Multi-element techniques

The single-element techniques discussed above may be used for monitoring metals in diet samples. Newer, multi-element techniques are gaining acceptance in many countries. Although equipment is expensive, techniques such as plasma atomic-emission spectroscopy and neutron-activation analysis can be applied to very large numbers of samples, and can provide results for 15-30 metals in each sample.

8.5.8 Sources of information on analytical methods for metal contaminants

Annex 16 lists several sources of information for metal determinations in diet samples.

8.6 Adequacy of the analytical method

Prior to implementation of a dietary contaminant monitoring study, it is essential that the analytical method be shown to be adequate for its intended purpose. Method "verification" is therefore a fundamental first step in the analysis of diet samples.

In its simplest form, verification may consist of low-level fortification of representative foods with the contaminant(s) of interest to ensure that an existing, established method performs satisfactorily for the particular new food-types examined. For example, if a method has been previously demonstrated to recover several pesticides adequately from several raw green vegetables, a few fortification experiments on a cooked composite of green vegetables may be all that is required to verify the method's applicability to this composite. Similarly, if a procedure has been previously shown to perform well on most foods within a particular class of foods, e.g., legume vegetables, expansion to other legume vegetables not previously examined may be demonstrated by a limited number of analyses of control samples fortified at the expected contaminant level.

For implementation of a new, or previously untried, analytical method more extensive preliminary testing is necessary. This includes recovery experiments on foods chosen to be representative of the diet foods. Since it is not always possible to perform recovery experiments for all possible contaminants in all diet samples, a number of selected representative foods, e.g., high-fat, high-moisture, low-moisture, high-sugar, etc., may be selected to represent other diet foods. Fairly extensive recovery tests for a number of contaminants, e.g., mixtures of several classes of pesticides, using these foods is appropriate. Care should be taken to ensure that recovery fortifications include levels representative of those actually found (or expected) in the diet samples.

Methods used for the determination of organic contaminants such as organochlorine or organophosphorus pesticides in diet samples should, in general, provide recoveries in the range of 80-120%. This recovery range should be achievable for many compounds at fortification levels at or above the quantification limit of the method. It should be recognized, however, that certain methods may yield recoveries outside this range, but may still provide meaningful data, provided that such recoveries are relatively consistent, and are carefully determined as part of a well-designed quality assurance programme. While laboratories should attempt to use methods which provide recoveries of organic contaminants between 80-120%, they should not arbitrarily abandon use of the only available method if recoveries should fall outside this range, but within a reasonable and predictable interval.

Once preliminary method testing has been performed, the laboratory should consider additional method verification procedures including intralaboratory method trials in which the proposed method is tested by at least two analysts within the laboratory. Interlaboratory method trials (at least two laboratories) and comparison of new or modified methods with established existing procedures is always appropriate to verify method performance.

Finally, analytical methods that have been collaboratively studied by a large number of laboratories are preferred for use in measuring levels of contaminants in diet samples. Such methods have usually been applied to a variety of foods and are often directly applicable to diet samples. It is important, however, to ensure that the collaborated method is suitable for the types of foods to be examined, both in terms of food class and also in terms of adequate detection and quantification limits. Many collaborated methods, e.g., TLC methods for pesticide residues or colorimetric procedures for metals, are often not designed for the low contaminant levels typical of dietary intake samples.

8.7 Confirmation of the identity of a contaminant

8.7.1 Organic contaminants

Confirmation of the chemical identity of a detected compound by use of one or more chemical or instrumental procedures is essential to ensure the validity of the analytical results. This is particularly true for pesticides and other organic contaminants.

When a relatively high residue level (e.g., 100 µg/kg for an organochlorine pesticide) is detected by GLC, confirmation is usually straightforward and can generally be performed by use of an alternative analytical technique such as TLC.

In addition, combinations of various GLC columns (different stationary phases) and selected detectors (halogen selective, etc.) may be used to confirm the initial tentative identification. At very low levels, TLC is usually not suitable as a confirmation technique for pesticides; alternative GLC columns and detectors are generally more applicable. Other techniques, such as derivatization and use of partition coefficients, may also be useful.

More sophisticated confirmatory techniques such as coupled gas chromatography-mass spectrometry (GC-MS) are also appropriate if the level of the suspect compound is very low, e.g., at or near the detection limit of a few µg/kg.

Analytical responses are frequently obtained during a GLC analysis that cannot be identified initially by retention time or by subsequent confirmatory techniques. Such an "unidentified analytical response" (UAR) may represent either innocuous or toxic chemicals, e.g., a naturally occurring component of the food, an unusual or unapproved pesticide, an industrial organic chemical, degradation products or metabolites of pesticides, etc. The analytical laboratory may wish to establish and maintain an ongoing file of UARs to monitor frequency of occurrence, GLC response characteristics, TLC characteristics, mass spectra, etc., in the event that later identification becomes possible. If resources are available, the laboratory may wish to establish a continuing analytical project to characterize and, if possible, identify UARs.

8.8 Reporting analytical results

It is extremely important in dietary intake studies that analytical results be reported in a consistent and unambiguous manner. Often, national or international organizations that summarize the analytical results and calculate dietary intakes, must evaluate and interpret data obtained from different laboratories, each reporting results in a different format. To facilitate these evaluations, laboratories should report enough details about the detection and quantification limits of the analytical method to enable correct interpretations of the data to be made. Laboratories should ensure consistent detection and quantification limits throughout a study. Results of recovery tests for the different contaminants should also be reported. However, analytical findings should be reported as measured, without the use of correction factors that take recovery into account.

An example of the information requested in the Joint FAO/WHO Food Contamination Monitoring Programme is given in Annex 17.

8.8.1 Reporting "not detected"

The term "not detected" should be used to indicate that a diet sample(s) was analysed for a particular contaminant or class of contaminants, e.g., organochlorine pesticides, and no analytical response was observed. A "not detected" reporting should be accompanied by a "limit of detection" for the analytical method used, and a short summary of which compounds or types of compounds were amenable to the method. For example, if a leafy vegetable composite were analysed using a method capable of recovering several organochlorine pesticides, the report might state "organochlorine pesticides; not detected at detection limit of 1 µg/kg" or "heptachlor, 25 µg/kg; other organochlorine residues, not detected at detection limit of 1 µg/kg". Values of "zero" should be avoided, or at least qualified by defining the limit of detection.

8.8.2 Reporting "trace" values

Occasionally, laboratories will use the term "trace" to report the detection of a contaminant. This usually refers to an analytical response that is just above the limit of detection but below the limit of quantification, i.e., the compound is detectable (with confirmed identity), but cannot be quantified (detection limit $\lesssim$ trace $\lesssim$ quantification limit).

Laboratories should report such low-level detections, but also should clearly state the meaning of "trace", and the analytical uncertainties associated with it. Officials responsible for calculating intakes can then assign an appropriate "constant" value to the "trace" values in the calculation of dietary intakes, e.g., "trace" should be arbitrarily assigned a value of one-half the quantification limit for the purpose of dietary intake calculations.

8.8.3 Reporting values to the Joint FAO/WHO Food Contamination Monitoring Programme

For the purposes of calculating mean values for the Joint FAO/WHO Food Contamination Monitoring Programme, the analytical laboratory should report finite contaminant values at or above the limit of quantification with the understanding that such values will usually be interpreted as accurate and identified findings. Values below the limit of quantification but above the limit of detection should be reported as half the limit of quantification, and "not detected" reportings should be given the value of zero.

8.9 Quality assurance procedures

The results of a recent joint FAO/WHO analytical quality assurance study for selected organic and metal contaminants in foods were recently reported.[1] In one part of the study, 34 laboratories from 13 countries participated in the determination of organochlorine compounds in an organic solvent, in soya bean oil and in butter fat. Upon evaluation of results submitted by the laboratories, it was concluded that the exercise had revealed large differences between laboratories as regards analytical capability. Several laboratories had been unable to correctly identify certain organochlorine compounds even when present in a pure organic solvent. The data provided by these laboratories was thus of questionable value.

In another phase of the same study, in which 37 laboratories from 14 countries determined lead and cadmium in four well-characterized Standard Reference Materials from the US National Bureau of Standards (plant leaves and oyster tissue), the findings suggested that although intralaboratory variance was comparable with that exhibited by recognized standard methods of analysis for lead and cadmium, the interlaboratory variation was excessive. In addition, the mean calculated for the four samples deviated substantially from well authenticated expected values; the situation was worse for lead than for cadmium.

It is clear from these conclusions that accurate monitoring of dietary contaminants is a difficult task, requiring the utmost care and dedication by the analytical laboratory. Only through a continuing intralaboratory and interlaboratory analytical quality assurance programme can the quality and usefulness of contaminant data be evaluated and improved.

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[1] Joint FAO/WHO Food and Animal Feed Contamination Monitoring Programme. Analytical quality assurance of monitoring data. Geneva, 1981 (unpublished FAO document FAO/ESN/MON/AWA/81/8; unpublished WHO document WHO-EFP/81.17).

This section addresses several basic quality assurance procedures that may be adopted by laboratories performing dietary analyses for contaminants. These procedures are by no means the best or only quality assurance measures that may be used. The use of even more extensive quality assurance measures is encouraged for those laboratories participating in large-scale, multi-contaminant dietary monitoring programmes.

8.9.1 Analyst training

It is obviously very important that individuals who are directly responsible for analysis of diet samples be well trained in and experienced with the procedures being used. Often, because of limited resources, analysts may be responsible for performing many different types of analyses, e.g., pesticides, metals, mycotoxins, etc. In such cases the analyst should be specifically trained in each discipline. Analysts with no training, or very limited "self-training", may be unaware of potential analytical problems that could lead to inaccurate or misinterpreted results. Usually, long-term experience with a particular analytical method is required for the analyst to become proficient. This is true even for well established (collaborated) methods with which the analyst has had no previous experience.

Where possible, all analytical results should be reviewed by experienced, senior analysts to ensure accuracy and correct interpretation of the data.

Training of analysts at laboratories that are already actively conducting dietary contaminant studies is strongly encouraged. Training programmes should be considered prior to initiating dietary intake studies. Other formal analyst training programmes, or informal training by established laboratories, should also be pursued as appropriate to ensure analyst proficiency.

8.9.2 Intralaboratory quality assurance

Recovery experiments

An intralaboratory quality assurance plan for contaminants is often based on routine and frequent use of recovery experiments. In many laboratories, a series of contaminant fortifications of diet samples is performed for each series of samples analysed. For example, for every 10 or 15 samples to be analysed, one or more similar samples is fortified with the contaminant(s) of interest. Samples and recovery fortifications are then analysed concurrently. Those recovery data (if satisfactory) may simply serve to indicate that the method and analyst performance was acceptable for this group of samples. If the recovery data were poor for this group of samples, indicating an isolated method failure or analyst error, the group of samples may be reanalysed. A series of poor recoveries could indicate a more serious problem with method adequacy, laboratory contamination or analyst proficiency. In such cases, method changes, laboratory or reagent clean-up, or additional analyst training may be necessary.

Recovery experiments should be performed routinely for organic or metal contaminants. The frequency of these recoveries, e.g., one fortification for every 10 or 20 samples, is necessarily a compromise between the number of recoveries necessary to ensure a reasonably acceptable method and analyst performance, and the increased sample load incurred by such analyses.

Reagent and method blanks

Frequent analysis of reagent and method blanks is necessary; two or three reagent and method blanks should be analysed with each group of 10-15 samples.

Reagent and method blanks are particularly important for metal analyses, where the amount of contaminant in the reagents and laboratory environment may (and, without adequate precautions, frequently does) exceed the concentration in the diet samples.

In cases where concentrations of contaminants in reagent and method blanks are greater than 20% of the concentration of contaminant in the diet samples, the results should be considered to be only marginally reliable, and steps should be taken to reduce the level of extraneous contamination through use of reagents of higher purity and reduction of laboratory environment contamination. In general, the concentration in reagent and method blanks should not exceed 10% of that in the total sample.

Extreme caution should be exercised in reporting results for samples for which the analytical blank is within the same order of magnitude, i.e., a lead value of 50 µg/kg has little meaning when the corresponding blank-equivalent is 40 µg/kg.

Analysis of standard reference materials

In addition to frequent analysis of fortified samples and blanks, many laboratories routinely analyse standard reference materials. These materials are well characterized standards consisting either of pure materials,[1] mixtures of chemicals in simple matrices such as water or organic solvents, or complex biological matrices. The chemical compositions of these materials have been established and certified by internationally recognized organizations.

Normally, these materials are used to verify method and analyst performance. Often, such as in the case of metals in the US National Bureau of Standards Biological Reference Materials, they may be analysed in the same manner as a typical food sample. Accurate analysis of such materials lends validity to results obtained for concurrently analysed diet samples.

International agencies such as FAO may be of assistance in locating or obtaining materials that can be used to verify analytical performance.

To date, reference materials in biological matrices, e.g., plant or animal tissue, are certified primarily for metals. Relatively few biological materials are certified for pesticides or other organic contaminants.

Documenting results from an intralaboratory quality assurance programme

Laboratories should keep a written description of all the analytical methods used in measuring contaminant levels in samples. All method changes, including minor modifications to existing methods, or implementation of new methods, should be documented completely. This provides a continuous record of the analytical methods used over time, and enables officials to determine whether an apparent change in contaminant intake with time is an actual trend, or is due to a change to a different (perhaps more reliable) method. Such false "trends" often result when new, less interference-prone methods are implemented.

It is desirable for the laboratory to maintain an up-to-date file detailing all information on recoveries, blank levels, results obtained for reference samples, etc. This central file enables laboratory managers to review such data, and where necessary take steps to improve laboratory performance.

In addition, an ongoing quality assurance file can be conveniently summarized and submitted to national or international organizations to provide evidence that the concurrently obtained dietary contaminant intake data are of high quality and comparable to data obtained in other laboratories.

8.9.3 Interlaboratory quality assurance

Quality assurance checks between laboratories are usually accomplished through sample exchange programmes as described in a recent report.[2] Participation of a laboratory in an interlaboratory quality assurance check is usually the most direct means of a performance

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[1] Reference standards for a number of pesticides are available, free of charge, upon request to: R. E. Thompson, Pesticides and Industrial Chemicals Repository, NSI, Environmental Sciences Group, Mail Drop 8, US Environmental Protection Agency, Research Triangle Park, NC 27711, USA.

The International Agency for Research on Cancer, Lyons, France, provides reference standards of mycotoxins only as part of their International Check Sample Programme. A list of commercial suppliers of mycotoxin standards is available from the Organic and Biological Chemistry Branch (HFF-454), Bureau of Foods, Food and Drug Administration, 200 C Street, S.W., Washington, DC 20204, USA.

[2] See footnote on page 47.

evaluation. Good performance by the laboratory should indicate the reliability of the data obtained. Marginal or poor performance with test samples, on the other hand, is evidence of method or analyst problems that should be remedied.

Laboratories should be encouraged to participate in sample exchange or other types of quality assurance tests, and this is particularly important for laboratories involved in dietary contaminant monitoring. The possibility of poor performance in such an analysis should not be considered as a reason to avoid participation. Rather, if a laboratory performs poorly relative to other laboratories, it should consult with the other laboratories to uncover the problem area, and then take appropriate corrective action.

8.9.4 Additional information on laboratory quality assurance

A recent report entitled Optimizing chemical laboratory performance through application of quality assurance principles is available for purchase through the Association of Official Analytical Chemists, 1111 North 19th Street, Suite 210, Arlington, VA 22209, USA. Also, the Codex Committee on Pesticide Residues has discussed quality assurance in Good analytical practice (Annex II to Appendix II of unpublished FAO document ALINORM 81/24).

The US Environmental Protection Agency, Environmental Research Center, Research Triangle Park, NC 27711, USA, will supply free of charge to government-affiliated organizations, the manual entitled Analytical quality control for pesticides.

8.10 Chemical aspects and examples of analytical methodology appropriate for measurement of trace contaminants in the diet

A recent review of chemical aspects of trace constituents of the diet (39) provides additional information on the general aspects of monitoring diet samples for trace organic and inorganic constituents. This review should be most interesting and appropriate to those laboratories currently, or soon to be, involved in dietary contaminant intake surveys. In addition, Annex 18 lists several analytical methods as examples of the types of procedures appropriate for diet analyses. These are only examples and are not intended as recommendations.

9. CALCULATING AND REPORTING OF DIETARY INTAKES OF CONTAMINANTS

After the levels of a given contaminant in composites or individual foods in total diet (market basket) studies (section 5), in selective studies of individual foods (section 6), or in duplicate portion studies (section 7) have been determined as described in section 8, it is necessary to convert these levels to daily dietary intakes. For example, the Joint FAO/WHO Food Contamination Monitoring Programme at present requests participating countries to express their dietary contaminant intakes in terms of µg per person per day arithmetical mean contaminant intake, and, if available, median and 90th percentile contaminant intake (see Annex 17). As discussed below, it is probably more feasible to report median and 90th percentile intakes from total diet (market-basket) studies than from the other two types of studies.

9.1 Conversion of contaminant levels to daily dietary intakes

9.1.1 Total diet (market-basket) studies

Where composites of food groups are employed, the contaminant concentration for a given composite (in µg/kg) in each total diet market basket is multiplied by the weight (in kg) of that composite consumed in the daily diet chosen to be representative of the whole population to give the contaminant intake for that composite. The total daily dietary contaminant intake in µg per person for that particular market basket is obtained by adding the daily contaminant intakes (in µg) from all the composites in the total diet. Examples of the different amounts of each food composite selected for total diet studies are shown in Annexes 10 and 11.

Where individual foods are analysed, the same procedure is used to calculate the total daily dietary intake of a contaminant from a particular total diet market basket, except that the daily contaminant intake for each food is calculated and then added to give the total daily contaminant intake for the market basket.

To obtain the mean daily dietary intake of a contaminant over a particular period of time, the daily intakes (in µg per person) of each of the total diet market baskets analysed during this period are added together, and the total divided by the number of market baskets.

The median and 90th percentile levels can be obtained by arranging the daily dietary intakes of the market baskets in descending order and selecting the values that represent the 50th and 90th percentile levels. The 90th percentile level can only be expressed where at least 10 market baskets have been analysed during the time period concerned.

9.1.2 Selective studies of individual foods

As described in section 6, in this type of study a different number of samples of the different foods from a variety of monitoring programmes may have been analysed at different periods in time. Because of the extremely variable nature of this approach, only the mean daily intake of contaminant should be calculated from the data obtained.

For each food, the mean levels (in µg/kg) of a given contaminant in a food should be determined, taking into account the total number of samples of the particular food analysed. The mean intake (in µg per person per day) for this contaminant in a given food can then be obtained by multiplying the level of contaminant by the daily dietary intake (in kg) represented by that food. The estimated total mean daily dietary intake of the contaminant can be obtained by adding the mean intakes calculated for all the foods studied, if they can be used to represent the entire diet, by employing techniques such as those described in section 4 to develop a list of representative foods.

9.1.3 Duplicate portion studies

As described in section 7, duplicate portion studies can be carried out over different periods of time, very often over one week. In some cases a homogeneous composite (or composites) representative of each day's diet for each person is analysed for the contaminant(s) of concern. In other cases, the composite(s) representative of a week or of the entire period of the study might be analysed. Because of the design of duplicate portion studies, only the mean daily intake of a contaminant should be routinely calculated from duplicate portion studies for comparison with other studies.

The mean daily intake of a contaminant by each individual can be calculated by taking into account the number of analyses carried out for each contaminant for each individual's consumption of food. The mean daily intake (in µg per person) of the contaminant is obtained by adding together the mean daily intakes calculated for each individual and dividing by the number of persons who participated in the study.

Because knowledge of the range of intakes of a given contaminant by the different individuals is useful information for risk assessment, data on the standard deviation and percentage distribution found should be provided.

9.2 Conversion of daily dietary intake to intake per kilogram of body weight

In order to compare the estimated daily dietary contaminant intakes (in µg per person) obtained as described in sections 9.1.1, 9.1.2 and 9.1.3 with the acceptable daily intakes (ADIs) (in mg/kg of body weight) for pesticides and the provisional tolerable weekly intakes (PTWIs) (in mg/kg of body weight) for certain metals, these recommended limits should first be converted to µg/kg of body weight values.

The estimated daily dietary contaminant intakes should then be converted from µg per person to µg/kg of body weight by dividing the former value by the kilogram body weight representative of the particular age/sex population group studied, using reference weights appropriate to the country. In the case of adults, a body weight of 60-70 kg has often been used as the conversion factor; this has been done by FAO/WHO expert groups in developing ADIs or PTWIs. It is important that each country should use its own appropriate mean body weight. For example, Guatemala and Japan use a body weight of 55 kg and 50 kg respectively.

9.3 Calculation of "extreme" intakes

As was pointed out in section 3, the consumption of food by "extreme" eaters can be determined by the selection of an appropriate group of these consumers for study by the methods outlined in that section, or through extrapolation from data that may be available for average food consumption habits.

The following paragraphs describe the experimental data that lend support to the adoption of this alternative approach, and how the calculation should be approached for a given set of circumstances.

9.3.1 Extreme intakes of individual foods

Table 6 summarizes some of the data recently produced through the US Department of Agriculture's Nutrition Food Consumption Survey 1977-1978. The data record the average daily intakes of almost 38 000 individuals who participated in the survey, and provide information on the amounts consumed of 200 of the most commonly-consumed foods in the USA. The tabulated data were not obtained from a constant population size since they related only to those people who were consumers of the given food during the period of the study.

A roughly constant ratio between the mean and the 95th percentile of consumption of particular foods is indicated and an extreme consumption of a particular food appears to be roughly three times the average for the mean consumption. The relationships discussed here hold true for a wide range of individual foods, for example, those consumed by a small proportion of the population (such as liver), and those consumed by a very large proportion of the population, such as bread, milk and carcass meat.

Similar results have been obtained from more limited surveys of individual food consumption habits carried out in the United Kingdom and from average per caput food consumption data obtained by means of the National Food Survey (41). The data are summarized in Annex 19. The data from the United Kingdom show that the constancy of the ratio between extreme consumption and mean consumption holds good regardless of whether the values are derived from very skewed distributions, such as that seen for shellfish, or nearly normal distributions, such as that seen for cabbage.

The results are not influenced by the size of family surveyed; for a given food, data from single-person families show the same relationships as data from all families. The relationships are the same for data collected from different years of the National Food Survey, from duplicate portion studies which measured the consumption of a single dietary component, and from a water consumption study.

Table 6. Foods commonly eaten by individuals in the United States of America[a]

Food	Consumption (g/day)		
	Average	95th percentile	95th percentile/ average
Carbonated soft drinks	274	733	2.7
Non-carbonated soft drinks	216	559	2.6
Beer and ale	455	1321	2.9
Eggs	47	109	2.3
Butter	8	26	3.2
Margarine	9	28	3.1
Fresh oranges	78	180	2.3
Orange juice	133	290	2.2
Raw apples	75	184	2.4
Yeast breads	62	137	2.2
Pies	57	135	2.4
Rice	71	229	3.2
Cooked cereals	107	245	2.3
Ready-to-eat cereals	23	58	2.5
Carcass meat	85	211	2.5
Liver	43	90	2.1
Poultry	57	132	2.3
Fish and shellfish	48	128	2.7
Canned tuna	28	66	2.3
Fluid whole milk	282	752	2.7
Fluid low-fat milk	279	735	2.6
Natural and processed cheese	22	57	2.6
Ice cream and ice milk	57	133	2.3
White potatoes	78	202	2.6
Lettuce and tossed salads	40	113	2.8
Raw tomatoes	44	123	2.8

[a] After Pao et al. (40).

A similar analysis has been carried out for fish and shellfish consumption data taken from a nationwide US National Marine Fisheries Service Survey of 24 652 individuals (42). The 90th percentile of consumption was found to be 2.2 times the average fish consumption. Exact comparison with the data from the United Kingdom is not possible as 10% of the USA population sample were non-consumers of fish.

It is important to stress that the estimated extreme consumption data, whilst correct for a population, are likely to be over-estimates of what happens in practice for any individual. The assumption is made that the consumption recorded by an individual during a single survey week will be continued all the year round. It is unrealistic to suppose that a person whose consumption is at the 95th and 99th percentile of the consumption distribution for a given food in any one week will eat as much of that food every week of the year. While the mean consumption recorded in any one week may well reflect mean continuous consumption of a population, the higher levels of continuous consumption of an individual are likely to be lower than the population percentiles given in Annex 19. Nonetheless the utilization of such an approach for the estimate of potential risk to extreme consumers is useful in deciding whether or not individual risk assessments based on actual consumption data are necessary.

9.3.2 Extreme intakes of food in general

The total food intake of an individual will be related to his energy requirements. The requirements are determined by (a) physical activity, (b) body size and composition, (c) age, and (d) climate. These requirements have been defined as a result of the work of a Joint FAO/WHO Expert Committee (43) and are summarized for children, male and female adolescents, and moderately active men and women in Table 7.

Energy requirements for adult males who are exceptionally active are 1.3-1.4 times those for moderately active people, whereas the energy requirements of an exceptionally active 80-kg male adult are 1.65 times those of the moderately active 65-kg male (20.8 MJ).

This range of energy requirements is borne out from studies of individuals' energy expenditures. In a survey of the energy intakes from food carried out in the USA in the period 1971-1974 (44), data were collected for nearly 20 000 people aged 1-74 years. Table 8 summarizes the data obtained according to age and sex.

Comparison of the average energy intake for a particular age-sex class with the 95th percentile of energy intake for the same class gave a fairly constant ratio that never exceeded 2. This situation is confirmed by similar studies carried out by Durnin and Passmore (45) on adult men and women with various occupations from sedentary to extremely active. A similar situation has been found in surveys of individual children's diets (35,46,47).

9.3.3 Estimation of "extreme" intakes

The studies reviewed above indicate that, as a rough rule-of-thumb, extreme consumers of food in general are unlikely to have an intake of food that exceeds twice the average consumption of the population as a whole. This factor should be applied whenever an assessment of the exposure to a contaminant of such consumers is required and only average consumption data are available.

If a contaminant is mostly confined to an individual foodstuff within the diet, then "extreme" consumers of that foodstuff within the population are unlikely to consume more than three times the amount consumed on average by the population. This factor should be applied to the average data to determine the likely range of intake of the population.

Table 7. Energy requirements according to age[a]

Age (years)	Body weight (kg)	Energy per kg per day		Energy per person per day	
		($kcal_{th}$)	(kJ)	($kcal_{th}$)	(MJ)
Children					
<1	7.3	112	470	820	3.4
1-3	13.4	101	424	1 360	5.7
4-6	20.2	91	382	1 830	7.6
7-9	28.1	78	326	2 190	9.2
Male adolescents					
10-12	36.9	71	297	2 600	10.9
13-15	51.3	57	238	2 900	12.1
16-19	62.9	49	205	3 070	12.8
Female adolescents					
10-12	38.0	62	259	2 350	9.8
13-15	49.9	50	209	2 490	10.4
16-19	54.4	43	179	2 310	9.7
Adult man (moderately active)	65.0	46	192	3 000	12.6
Adult woman (moderately active)	55.0	40	167	2 200	9.2

[a] Reproduced from the report of a Joint FAO/WHO Ad Hoc Expert Committee on Energy and Protein Requirements (43).

Table 8. Energy intake for persons aged 1-74 years, United States of America, 1971-1974[a]

Age (years)	No. of persons examined	Energy intake ($kcal_{th}$)		Ratio 95th percentile: mean
		Mean	95th percentile	
Male				
1	286	1 316	2 251	1.71
2-3	606	1 563	2 581	1.65
4-5	577	1 826	2 952	1.62
6-7	343	2 061	3 308	1.61
8-9	321	2 173	3 448	1.59
10-11	362	2 261	3 613	1.60
12-14	548	2 519	4 345	1.72
15-17	516	2 981	5 189	1.74
18-19	259	2 949	5 118	1.74
20-24	513	2 888	5 007	1.73
25-34	804	2 739	4 769	1.74
35-44	665	2 554	4 392	1.72
45-54	765	2 301	3 856	1.68
55-64	597	2 076	3 682	1.78
65 and over	1 657	1 805	3 158	1.75
Female				
1	267	1 207	1 883	1.56
2-3	564	1 412	2 321	1.64
4-5	595	1 628	2 548	1.56
6-7	345	1 829	3 068	1.68
8-9	323	1 864	3 056	1.64
10-11	363	2 023	3 457	1.71
12-14	559	1 932	3 196	1.65
15-17	503	1 756	3 114	1.77
18-19	281	1 739	3 395	1.95
20-24	1 243	1 691	3 047	1.80
25-34	1 896	1 638	2 937	1.79
35-44	1 663	1 558	2 739	1.76
45-54	836	1 533	2 714	1.77
55-64	670	1 382	2 303	1.67
65 and over	1 822	1 307	2 238	1.71

[a] Based on data from a survey carried out by the US National Center for Health Statistics (44).

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Annex 1

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Annex 2

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[1] This list is correct as of 1 January 1984. It should be noted, however, that the heads of the centres are liable to change.

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Annex 3

A DIARY FORM USED IN THE USA

The questionnaire shown below is an abbreviated version of that used in the 1977-78 Nationwide Food Consumption Survey by the US Department of Agriculture[1] to establish a record of individual intake of food and beverages. The answers were recorded on a form that is not reproduced here.

1. At about what time did you begin eating/drinking this?

2. What do you usually call this?

   1. Breakfast
   2. Brunch
   3. Lunch
   4. Dinner
   5. Supper
   6. Coffee (beverage) break
   7. Snack
   8. Other

3. With whom did you eat/drink this?

   1. Alone
   2. With other household member(s)
   3. With non-household member(s)
   4. With both household member(s) and non-household member(s)

4. What did you eat or drink on this occasion?

5. Describe this item further.

6. How much did you actually eat or drink?

FOR EACH ITEM LISTED:

7. Was this from your home food supply? Home food supply includes food brought into the home, or taken from the home and eaten elsewhere.

   1. Yes, and eaten at home
   2. Yes, but eaten away from home
   3. No, obtained and eaten elsewhere

8. Where did you get this food/beverage which was not from home food supplies?

   1. Restaurant
   2. Fast-food place
   3. Other public eating place
   4. Dining room or cafeteria at work
   5. Other place at work
   6. School
   7. Day-care centre
   8. Summer day camp
   9. Community feeding programme for senior citizens
   10. Grocery or other food store
   11. Drugstore, or other store
   12. Someone else's home
   13. Other

---

[1] See ref. 11 in list of references, p. 57.

9. What kind of service was used to deliver the food/beverage you had at this time?

   1. Served at a table (waiter/waitress)
   2. Counter service
   3. Cafeteria or buffet style (include fast-food eaten on premises)
   4. Vending machine
   5. Carry out
   6. Car service
   7. Other

10. Did you or any member of your household pay for <u>any</u> of the food or beverage you had?

    1. Yes
    2. No

11. How much did you or the household member pay? Include tax and tip, if any.

12. Did you drink any water on this day (other than in coffee, fruitade, etc.)?

    If <u>yes</u>, about how many cups? (8 fl.oz.)

13. Did you chew any gum on this day?

    If <u>yes</u>, how many sticks or pieces?

14. Did you consume any cough drops on this day?

    If <u>yes</u>, how many pieces?

15. Was your food/drink consumption on this day typical of what you usually eat/drink on this day of week (Sunday, Monday, etc.)?

    If <u>no</u>, why was it different?

    Ill
    Short of cash
    Travelling
    Social occasion
    Holiday
    Not enough time to eat
    Other reason (EXPLAIN)

16. Did anyone help you keep this record?

    If <u>yes</u>, who helped?

    Interviewer
    Household member, first name _____
    Non-household member

17. What was the month, day, and year of your birth?

18. What is your height?

19. What is your weight?

20. Are you on a special diet?

    If <u>yes</u>, how would you describe it?

    Doctor prescribed what I should or should not eat
    Group diet programme such as Weight Watchers or Tops
    Diet I read or heard about elsewhere
    Other (PLEASE DESCRIBE)

21. Do you take any vitamin, mineral, or other supplement by mouth (such as tablets, capsules, oil)?

No
Yes, regularly
Yes, irregularly

If yes, circle the number following each supplement taken:

Multiple vitamins
Multiple minerals
Multiple vitamins and minerals
Vitamin A
Vitamin C
Vitamin D
Vitamin E
B vitamins/B-complex
Iron
Calcium
Zinc
Fluoride
Other (WHICH?)

22. Have you eaten any of the following the past 30 days? (IF YOUR ANSWER IS YES, PLEASE INDICATE HOW MANY TIMES IN THE PAST 30 DAYS YOU HAVE EATEN THAT KIND OF FOOD)

Liver: beef or calf's
Liver: chicken
Liver: pork
Kidney: beef, lamb or veal
Heart: beef or calf's
Sweetbreads
Brains
Other organ meats (WHICH?)

23. Are you a vegetarian?

If yes, indicate which of the following foods you eat

Poultry
Fish
Eggs
Dairy products
Fruits
Nuts
Dried beans or peas
Vegetables
Cereal or grain products
Vegetable based meat substitute

24. These are some things that might affect what a person eats and drinks. Indicate which ones, if any, pertain to you

I'm on a diet to lose weight
I'm on a diet to put weight on
I have a chewing problem because of teeth
I have a medical problem like diabetes or allergy
Some foods do not agree with me
I don't feel like eating breakfast early in the morning
I have no interest in cooking for one person
I do not like certain foods
Other (EXPLAIN)

25. As of now, how would you describe your health?

Excellent
Good
Fair
Poor

26. Do you have any disability or handicap that limits your activities?

Annex 4

A HOUSEHOLD FOOD DISAPPEARANCE QUESTIONNAIRE AND DIARY FORM USED IN TUNISIA

This is a modified version of a questionnaire and diary form used by the Ministry of Planning in the National Survey on Consumption and Family Budgets, 1974-1975.

Location of household

Governorship ..... Delegation ..... Stratum .....
Commune or Omda .....
Identification of the primary unit .....
Household No. .....

Identification of household

Name and first name of head of household .....
.....
Address .....
Occupation .....
No. of children below the age of two .....

Household constituting the food unit

(1) Does the household regularly prepare food with other households? Yes No

- If yes, state:
(a) The name and first name of the head of the household in question
.....
(b) The relationship .....
(c) The nature of the meals prepared in common: Lunch Dinner
(d) Are these meals taken in common: Yes No

(2) If the household only prepares the dishes, are they shared with other households that have come to be associated with it at the time of consumption: Yes No

- If yes, state:
(a) The name and first name of the head of the associated household
.....
(b) The relationship .....
(c) The nature of the meal consumed in common: Lunch Dinner

(3) Further, if the household only prepares the dishes, does it visit other households at the time of consumption to share these dishes with them? Yes No

- If yes, state:
(a) The name and first name of the head of the household visited
.....
(b) The relationship .....
(c) The nature of the meal consumed in common: Lunch Dinner

Number of meals	Time and duration of preparation		
	Time when preparation begins	Time that preparation takes	Time when consumption begins
(1) Breakfast			
(2) Lunch			
(3) Dinner			
(4) Other meals prepared			

Interviewer's remarks .....
.....
Interviewer's name ..... Date of survey .....
Name of field controller ..... Date of verification .....
Office verification by ..... Date of verification .....

Composition of the food unit

Serial No.	Name and first name	Relationship	Permanent or visitor	Activity		Sex	Age	Weight	Height	Remarks
				Main	Secondary					

Detailed list of persons over the age of 1 taking meals

Serial No.	Name	1st day			2nd day			3rd day			4th day			5th day			6th day			7th day			Calculations
		B	L	D	B	L	D	B	L	D	B	L	D	B	L	D	B	L	D	B	L	D	

B = breakfast; L = lunch; D = dinner.

Meals prepared in the house

Day ..... Date .....

BREAKFAST: Name of dish .....

Designation of food product	State	Origin	Weight as bought	Weight of edible portions	Remarks

LUNCH: Name of dish .....

Designation of food product	State	Origin	Weight as bought	Weight of edible portions	Remarks

DINNER: Name of dish .....

Designation of food product	State	Origin	Weight as bought	Weight of edible portions	Remarks

SPECIAL PREPARATION: Child over the age of 2, sick .....

Nature of product	Weight	Nature of product	Weight

LEFTOVERS: Day .....

Name of dish	Weight

DISHES RECEIVED AND SENT

Nature of dish sent	Quantity	Nature of dish received	Quantity

FOODS CONSUMED BETWEEN MEALS

Serial No. of person receiving food	Time of day[a]	Name of foodstuff	Quantity	Unit	Weight	Cost

[a] Morning, noon or evening.

Feeding of children below the age of 2

Surname and first name of child 1..... Age .....
2..... Age .....
Date ..... Day .....

1. Breast-feeding: Yes/No

If yes, indicate hours of feeds / / / / / / / / / / / / / /

2. Breast-milk substitutes: Yes/No If yes: bottle/other
complete the table

Nature of milk	1st prep. amount	2nd prep. amount	3rd prep. amount	4th prep. amount	5th prep. amount	Remarks
Fresh milk						
Sweetened condensed milk						
Unsweetened evaporated milk						
Powdered milk						
Sugar						
Other milk product						
Hour						

3. Special preparations: Yes/No If yes, complete the table

Food group	Nature of product	1st prep. amount	2nd prep. amount	3rd prep. amount	4th prep. amount	5th prep. amount	Remarks
Cereals							
Pulses							
Vegetables							
Potatoes							
Fruit							
Meat							
Fish							
Oil							
Sugar							
Eggs							
Other							
Hour							

4. Preparation for the whole of the food unit: Yes/No (delete as appropriate)

Annex 5

FAO/WHO GUIDE TO CODEX MAXIMUM LIMITS FOR PESTICIDE RESIDUES.

FOOD GROUPS FOR COMMON PESTICIDES RESIDUE TOLERANCES

COMMODITY GROUP

VEGETABLES

Code	
A01.0100	ROOT AND TUBER VEGETABLES
A01.0200	BULB VEGETABLES
A01.0300	LEAFY VEGETABLES (EXCEPT BRASSICA VEGETABLES)
A01.0400	BRASSICA (COLE) VEGETABLES
A01.0500	STEM VEGETABLES
A01.0600	LEGUME VEGETABLES
	I. VEGETABLES - KIDNEY BEANS
	II. LIMA BEANS - LENTILS
A01.0700	FRUITING VEGETABLES - EDIBLE PEEL
A01.0800	FRUITING VEGETABLES - INEDIBLE PEEL

FRUITS

A02.0900	CITRUS FRUITS
A02.1000	POME FRUITS
A02.1100	STONE FRUITS
A02.1200	SMALL FRUITS AND BERRIES
A02.1300	ASSORTED FRUITS - EDIBLE PEEL
A02.1400	ASSORTED FRUITS - INEDIBLE PEEL

GRASSES

A03.1500	CEREAL GRAINS
A03.1600	FODDERS AND STRAWS

LEGUMES

A04.1700	LEGUME OILSEED
A04.1800	LEGUME ANIMAL FEEDS

NUTS AND SEEDS

A05.1900	TREE NUTS
A05.2000	OILSEED
A05.2100	TROPICAL SEED

HERBS, SPICES AND TEAS

A06.2200	HERBS
A06.2300	SPICES
A06.2400	TEAS

MAMMALIAN PRODUCTS

Code	
B07.2500	CARCASS MEATS
B07.2600	ANIMAL FATS
B07.2700	MEAT BYPRODUCTS (EDIBLE OFFAL)
B07.2800	MILK AND MILK PRODUCTS

POULTRY PRODUCTS

B08.3000	POULTRY MEATS
B08.3100	POULTRY FATS
B08.3200	POULTRY BYPRODUCTS (EDIBLE OFFAL)
B08.3300	EGGS

AQUATIC ANIMAL PRODUCTS

B09.3400	FISH

COMMODITIES NOT CLASSIFIED IN GROUPS

CEREAL PRODUCTS
  MILLED CEREAL PRODUCTS
  BREAD AND COOKED CEREAL PRODUCTS
MISCELLANEOUS FOODS NOT SPECIFIED
VEGETABLE OILS
OLIVES
MISCELLANEOUS COMMODITIES
  RAW AGRICULTURAL PRODUCTS (PLANTS)
  DRIED FOOD
  ALMOND HULLS
  APPLE POMACE
  CITRUS PRODUCTS
  COCOA PRODUCTS
  GRAPE POMACE
  HOPS
  MUSHROOMS
  SUGARCANE
  TOBACCO

Annex 6

INDIVIDUAL AVERAGE DAILY INTAKES OF FOOD IN THAILAND AND GUATEMALA

(a) Thailand

Table 1. Average amount of foods (in grams) consumed per person per day in five provinces of Thailand (September-November 1975)[a]

Foods	Provinces										Average for the 5 provinces		Average for the whole country
	Chiengmai		Nakorn Rajasima		Suphanburi		Chanthaburi		Nakornsrithamaraj				
	sub-urban	rural	sub-urban	rural	sub-urban	rural	sub-urban	rural	sub-urban	rural	sub-urban	rural	
Cereals	397	458	385	528	313	320	371	355	306	271	362	386	374
Animal foods:													
meat	53	15	27	15	45	20	20	12	34	24	36	17	27
fish	18	59	23	32	58	58	80	148	62	44	50	68	59
eggs	7	5	9	1	16	21	15	29	15	12	13	14	14
milk	-	-	-	-	-	-	2	-	-	-	-	-	-
Total	78	79	59	48	119	99	117	189	111	80	99	99	100
Pulses	1	1	-	-	10	15	4	7	1	3	3	5	4
Vegetables:													
leafy	36	78	33	24	38	46	19	12	17	14	29	35	32
other	71	58	60	106	49	81	86	37	91	92	73	75	74
Total	107	136	93	130	87	127	105	49	108	106	102	110	106
Fruits	38	9	4	11	59	55	43	16	41	67	40	32	36
Fats:													
animal fat	4	2	3	-	13	13	9	7	1	6	6	6	6
vegetable fat	15	1	9	-	25	12	33	16	37	66	24	19	22
Total	19	3	12	-	38	25	42	23	38	72	30	25	28
Condiments	8	5	3	-	6	14	10	7	22	10	10	7	9
Sugar	3	1	1	-	14	4	14	12	9	8	9	5	7
Salt	2	4	-	2	-	-	-	-	2	1	1	1	1
Nampla (fish sauce)	2	1	21	7	13	19	17	24	7	5	12	11	12
Miscellaneous	-	-	-	-	-	-	-	-	1	-	-	-	-

[a] From Food consumption surveys and nutritional surveillance. Asia and Far East Commission on Agriculture Statistics - 7th Session, Bangkok, Thailand, 17-23 August 1978 (unpublished Department of Health, Ministry of Public Health document ESS:AGS/FE/7/78/REF).

(b) Guatemala

Table 2. Consumption of foods (in grams, edible portion) per person per day in rural and urban areas, 1965-1967

Food	Consumption	
	Rural areas[a]	Urban areas[a]
Milk products (fluid equivalent)	84	246
Eggs	13	31
Meat, poultry, fish	44	85
Beans	54	49
Vegetables	66	150
Fruits	14	58
Bananas and plantains	20	64
Starchy roots and tubers	14	34
Cereal products (as grain, meal)	(412)	(339)
Corn (subtotal as grain)	(359)	(150)
Tortillas and tamales	544	228
Degerminated corn	0	0
Toasted meal (pinol)	0	0
Rice	16	34
Wheat bread	36	169
Wheat flour and pastes	4	5
Other cereals	2	5
Sugars	52	74
Fats and oil	4	24

[a] Rural areas: No. of families, 203; persons per family, 6.5. Urban areas: No. of families, 103; persons per family, 6.2.

Annex 7

EXAMPLES OF SHOPPING GUIDES USED FOR THE COLLECTION OF TOTAL DIET SAMPLES IN AUSTRALIA AND GUATEMALA

(a) Australia

Shopping list for the Market Basket Survey 1982 - Winter season:

Grocery lines

White bread (sliced)	1 loaf (680 g)
Wholemeal bread (sliced)	1 loaf (450 g)
Cornflakes	1 packet (250 g)
Wholewheat breakfast cereal	1 packet (375 g)
White rice	1 packet (500 g)
Canned tuna	1 can (180 g)
Eggs (55 g)	6 units
Table margarine	1 tub (500 g)
Blended vegetable oil	1 bottle (750 ml)
Milk, full cream	1 carton (600 ml)
Powdered skim milk	1 packet (375 g)
Canned evaporated milk	1 can (375 g)
Ice cream (vanilla)	1 container (2 l)
Butter	1 packet (250 g)
Cheddar cheese	1 packet (250 g)
Strained infant chicken dinner	1 can (125 g)
Salted peanuts	1 packet (375 g)
Tea	1 packet (250 g)
Coffee (instant)	1 jar (100 g)
Sugar (white)	1 kg
Chicken pieces	500 g
Peanut butter	3 jars (375 g) (different brands if possible)
Frozen peas	1 packet (500 g)

Meat

Minced steak	250 g
Lamb chump chops	2 units
Pork chops	2 units
Lamb's or calf's liver	250 g

Fish

Battered fried fish	1 piece

Fresh vegetables and fruit

Potatoes	1 kg
Onions	500 g
Carrots	500 g
Beans	500 g
Pumpkin	500 g
Apples	5 units
Oranges	5 units
Bananas	5 units
Pears	250 g
Peaches	5 units

Alcoholic beverages

Beer	1 can (370 ml)
Wine (red)	1 bottle
Wine (white)	1 bottle

Chemist

Liquid infant formula, canned	1 can (375 ml)
Infant cereal	1 packet (200 g)

(b) Guatemala

Shopping list and quantities used for composite diet:

	Purchase	Composite
Milk and milk products		
Milk	1/4 l	82 g
Cream	4 oz	31 g
Cream cheese	4 oz	12 g
Cheese, cheddar type	4 oz	12 g
Yoghurt	1 small pot	6 g
		143 g
		(fluid equivalent 246 g)
Boiled eggs		31 g
Meat		
Chicken	4 oz	17 g
Fish	4 oz	5 g
Beef for soup	1/2 lb	17 g
Beef for broiling	4 oz	18 g
Pork	4 oz	18 g
Liver	4 oz	10 g
		85 g
Black beans, boiled	1/2 lb	49 g
Vegetables		
Tomatoes	3 units	25 g
Peas	4 oz	25 g
Carrots	1 unit	25 g
Saltwort	1 bunch	25 g
Spinach	4 oz	25 g
Pumpkin	1/4 of large pumpkin	25 g
		150 g
Fruits		
Papaya	1 slice	15 g
Water-melon	1 slice	15 g
Mango	1 unit	14 g
Pineapple	1 slice	14 g
		58 g

		Purchase	Composite
Bananas and plantains			
Bananas		2 units	32 g
Plantains		1 unit	32 g
			64 g
Roots and tubers			
Sweet potatoes		1 unit	11 g
Potatoes		1 lb	11 g
Yucca		1 unit	12 g
			34 g
Cereals			
Tortillas		12 units	228 g
Rice		1/2 lb	34 g
Wheatbread	sweet type	10 units	169 g
	french type	10 units	
Oatmeal		1/2 lb	5 g
Spaghetti		1/2 lb	5 g
			441 g
Sugars			
Crude sugar		1/2 lb	15 g
Honey		1/2 lb	15 g
Sugar		1/2 lb	44 g
			74 g
Oil		4 oz	24 g
Beverages			
Soft drinks		1 bottle	100 ml
Fruit drinks		1 bag	100 ml
Tea		1 tea-bag	100 ml
Coffee		2 oz	100 ml
			400 ml

Annex 8

SOME OF THE MORE IMPORTANT DATA TO BE RECORDED WHEN TAKING SAMPLES IN THE FIELD AND TO BE SENT WITH SAMPLES TO THE ANALYTICAL LABORATORY[1]

1. Name and address of the person collecting the samples.
2. Date, place and time of sampling.
3. Reason(s) for sampling - if part of a specific monitoring project, project reference number.
4. Nature of the food.
5. Name of the manufacturer, importer, wholesaler, retailer, etc., as appropriate.
6. Number and size of units constituting the lot.
7. Number and marking of the lot.
8. Origin of lot.
9. Destination of lot.
10. Method of sampling (random throughout the lot, random throughout accessible units, etc.).
11. Size, number and reference number of field samples.
12. Date of despatch and means of transportation to analytical laboratory.
13. Name and address of analytical laboratory.
14. Analysis to be performed.
15. Any other relevant information regarding the condition of the lot or the field sample, e.g., details of processing.

[1] Not all data may be relevant in all cases. Unless the monitoring project is also a food control exercise, it may not be necessary to record all the data listed here.

Annex 9

EXAMPLES OF PROCEDURES FOR PROCESSING FOODS FOR ANALYSIS IN SURVEYS TO DETERMINE DIETARY INTAKES OF CONTAMINANTS IN GUATEMALA AND AUSTRALIA

(a) Guatemala

A kitchen preparation guide:

1. Preparation of raw products

Egg - hardboil and cut into small pieces

Tomato, saltwort and spinach - rinse in cold water

Peas - remove from hulls

Carrot, potato, sweet potato and yucca - rinse in cold water and peel

Pumpkin - rinse in cold water, cut and remove big seeds

Banana and plantain ("platano") - remove peel

Papaya and water-melon - remove rind and seeds

Pineapple - remove outer part and "heart"

Mango - peel

2. Weighing

For each food, weigh out the quantities indicated on the preparation list.

3. Water

Measure out 2000 ml. Use it all for cooking and for the preparation of beverages.

4. Preparation of soup

Put chicken, beef and yucca in pot. Add 2 cups of water, 1 teaspoonful of salt, 1 bay leaf, 1 branch each of parsley, mint and coriander ("culantro").

Bring to the boil and simmer under cover for 20 minutes. Add the following vegetables cut into pieces: tomato, peas, carrot, potato, sweet potato, pumpkin and plantain ("platano"). Add rice, pasta and oatmeal. Add more water if necessary. Simmer under cover for 20 more minutes.

5. Beans

Remove damaged seeds and wash in cold water. Put beans in pot. Add water, 1 teaspoonful of salt and 3 cloves of garlic, and boil until tender (about 2 hours). Add water as necessary. When ready, remove garlic.

6. Meat

Heat weighed quantity of oil in saucepan. Fry fish, beef, pork and liver. Remove fried food and boil out pan with water. Save water for composite.

7. Beverages

Soft drink - use a cola beverage

Fruit drink - dissolve half a packet of fruit concentrate preparation in 100 ml of water

Tea - prepare tea from 1 tea-bag and 100 ml boiling water. Remove tea-bag after 3 minutes

Coffee - use 100 ml of prepared coffee from the cafeteria

Composite: Rinse meat-cutter bowl with solvents and weigh. Quantitatively transfer all food items on the list to bowl. Weigh bowl again to obtain the daily food consumption (include water). Homogenize by mixing thoroughly.

Analysis: Analyse immediately or store portions in a sealed container in the freezer.

(b) Australia

Procedure for processing foods in Group 1, grain products, and Group 2, meat and poultry, for the Market Basket Survey, 1982:

Group 1. Grain products

White bread

1. Weigh 100 grams from each sample of white bread.
2. Blend these together.
3. Weigh 200 grams of blended bread into sample container and label "white bread - Group 1".

Wholemeal bread

1. Weigh 100 grams from each sample of wholemeal bread.
2. Blend these together.
3. Weigh 200 grams of blended bread into sample container and label "wholemeal bread - Group 1".

Infant cereal

1. Weigh 100 grams of cereal from each sample.
2. Blend these together.
3. Weigh 200 grams of blended cereal into sample container and label "infant cereal - Group 1".

Cornflakes

1. Weigh 100 grams of cornflakes from each of the three samples.
2. Blend these together.
3. Weigh 200 grams of blended cornflakes into sample container and label "cornflakes - Group 1".

Wholewheat breakfast cereal biscuits

1. Weigh 100 grams of cereal biscuits from each of the three samples.
2. Blend these together.
3. Weigh 200 grams of blended biscuits into sample container and label "biscuits - Group 1".

White rice

1. Weigh 60 grams from each sample of rice.
2. Cook together in boiling water. Drain. Weigh and record weight.
3. Blend the drained rice.

Group 2. Meat and poultry

Minced steak

1. Weigh 200 grams from each of the three samples.
2. Place these together in a saucepan.
3. Add 150 ml of water, bring to the boil and simmer for 5-10 minutes.
4. Weigh the cooked mince and water mixture and record weight. Blend mixture. Weigh 200 grams of blended meat into sample container and label "minced steak - Group 2".

Lamb, chump chops

1. Weigh the three samples of lamb, chump chops and record total weight.
2. Grill the three samples (i.e., 6 chops).
3. When cooked, cut all the meat away from the bone.
4. Weigh and record weight of cooked meat.
5. Blend the cooked meat.
6. Weigh 200 grams of blended meat into sample container and label "lamb, chump chops - Group 2".

Pork chops

1. Weigh the three samples of pork chops and record total weight.
2. Pan-fry the three samples of pork chops (i.e., 6 chops).
3. When cooked, cut all the meat away from the bone.
4. Weigh and record weight of cooked meat.
5. Blend the cooked meat.
6. Weigh 200 grams of blended meat into sample container and label "pork chops - Group 2".

Chicken

1. Weigh the three samples of chicken and record total weight.
2. Place chicken pieces in pan, cover with foil and bake in a moderately hot oven.
3. Strip all edible meat from each piece of cooked chicken.
4. Weigh and record total weight of cooked chicken.
5. Blend the cooked chicken.
6. Weigh 200 grams of blended chicken into sample container and label "chicken - Group 2".

Similar details are supplied for processing the other food groups in the study, i.e., seafoods, eggs and offal, fats and oils, dairy foods, infant formulae, root vegetables, other vegetables, fruits and miscellaneous foods.

Annex 10

FOOD COMPOSITES, CATEGORIES AND EXAMPLES OF FOOD ITEMS AND WEIGHTS IN THE TOTAL DIET STUDY IN JAPAN, 1980
(On a daily basis for an average person)

Composite	Category	Examples of food items	Weight (g)
I RICE	1. Enriched rice	Enriched rice	-
	2. Rice	Rice husked, rice milled	220
	3. Rice products	Boiled rice, rice gruel, rice cake, ricemeal	6
II CEREAL, GRAIN, POTATO	4. Barley	Barley, rye grain, rye flour, oats, oatmeal	0.7
	5. Wheat flour	Wheat flour	5.8
	6. Breads	Bread, raisin bread, French roll	42
	7. Buns	Bean jam bun, cream bun, jam bun	6.2
	8. Noodles (raw and boiled)	Japanese noodle, Chinese noodle, buckwheat noodle	30
	9. Noodles (dried)	Dried Japanese noodle, dried Chinese noodle, vermicelli, macaroni, spaghetti	5
	10. Quick noodles	Quick noodle	3
	11. Other grains	Maize grain, maize flour, cornmeal, foxtail millet, proso millet, buckwheat, wheat bran	0.8
	12. Nuts and seeds	Almonds, cashews, walnuts, groundnuts, sesame	1.3
	13. Sweet potatoes	Sweet potatoes	10
	14. Potatoes	Potatoes	23
	15. Other taros	Taros, yams, Jerusalem artichoke	17
	16. Potatoes and taros products	Potato chip, mashed-potato flake, devil's tongue jelly	13
III SUGAR, CAKE	17. Sugars	Sugars, starch sugars, honey	11.4
	18. Jams	Strawberry jam, apricot jam, marmalade	0.6
	19. Candies	Caramels, candies, drops, nougat	0.8
	20. Rice crackers	Rice crackers	3.7
	21. Cakes	Spongecake, shortcake, fancy cake	4.2
	22. Biscuit	Biscuit, cookie, cracker	1.9
	23. Other pastries	Rice-cake stuffed with bean paste, dumpling, sweet bean jelly, cream puffs, pie, doughnut, waffle	14.5
IV FAT, OIL[a]	24. Butter	Butter	1.4
	25. Margarine	Margarine, shortening	1.6
	26. Vegetable oil	Soybean oil, rapeseed oil, sesame oil	9.8
	27. Animal fats	Beef tallow, pork tallow	0.1
	28. Mayonnaise	Mayonnaise, salad dressing	4.0

[a] Does not include the amount used for cooking, etc.

V SOYBEAN PRODUCTS	29. Miso	Miso (fermented salty soybeans)	17
	30. Soybean curd	Soybean curd	32
	31. Soybean curd products	Nama-age (fried soybean curd)	7.8
	32. Other soybean products	Dried soybean, soymilk, ground roasted soybeans	6.0
	33. Other bean products	Dried azuki beans, bean jam, dried kidney beans, dried peas, dried cowpeas	2.2
VI FRUIT	34. Citrus fruits	Satsuma mandarin, Japanese summer orange, orange, grapefruit, lemon	67
	35. Apples	Apples	35
	36. Bananas	Bananas	7.6
	37. Strawberries	Strawberries	0.3
	38. Other fruits	Apricot, cherry, Japanese persimmon, plum, watermelon, Japanese pear, grape, peach	39
	39. Fruit juice	Fruit juice	6.3
VII VEGETABLES	40. Carrots	Carrots	15
	41. Spinach	Spinach	16
	42. Sweet peppers	Sweet peppers	3.1
	43. Other green vegetables	Broccoli, lettuce, celery, parsley, pakchoi, leaf mustard	17
VIII VEGETABLE, SEAWEED	44. Radish	Japanese radish	37
	45. Onion	Onion	19.5
	46. Tomato	Tomato	7.6
	47. Cabbage	Cabbage	23
	48. Cucumbers	Cucumbers	10
	49. Chinese cabbage	Chinese cabbage	22
	50. Other vegetables	Edible burdock, peas with pod, sweet corn, egg plant, Welsh onion, Indian lotus, bean sprouts, asparagus	42
	51. Pickled leaf vegetables	Pickled nozawana, pickled pakchoi	16
	52. Pickled radish and other pickles	Pickled radish, pickled egg plant, pickled cucumber, pickled turnip	15
	53. Mushrooms	Shiitake mushroom, matsutake mushroom	8.1
	54. Seaweeds	Green laver, tangle, wakame seaweed agar	5.1
IX SEASONING, BEVERAGE	55. Soy sauce	Soy sauce	22.5
	56. Sauce	Tomato ketchup, Worcester sauce	3.8
	57. Salt	Salt	1.7
	58. Sake	Sake (rice wine)	20.6
	59. Beer	Beer	25
	60. Liquors and other alcoholic drinks	Whisky, wine, ume liquor	4.5
	61. Other drinks	Coffee, cocoa, tea, cola, cider	32

X FISH, MOLLUSCS, CRUSTACEANS	62. Tunas	Tuna, skipjack, swordfish	6.7
	63. Sea bream and flatfish	Sea bream, flatfish, bastard halibut, cod	8.4
	64. Jack mackerels and sardines	Jack mackerels, sardines, chub mackerel, Pacific saury, Pacific herring	11
	65. Salmon	Chum salmon, pink salmon	2.6
	66. Other fish	Grunt, Japanese eel, barracuda, shark, sand borer, hairtail, goby, puffer, mullet, pond smelt, tongue soles	13
	67. Molluscs, crustacea	Octopus, sea cucumber, crab, shrimp, cuttlefish, opposum shrimp	15
	68. Shellfish	Ark shell, short necked clam, abalone, Oyster, topshell, hard clam	3.7
	69. Salted fish	Salted salmon, salted cod, salted sardine	7.1
	70. Dried fish	Dried Jack mackerel, dried sardine, dried cuttlefish	6.6
	71. Canned fish	Boiled sardine, boiled salmon, seasoned sardine, oiled skipjack	1.7
	72. Fish boiled down in soy	Opossum shrimp, goby, crucian carp	0.6
	73. Fish meat products	Boiled fish-paste, backed fish-paste, fried fish-paste	15
	74. Fish-meat ham and fish-meat sausage	Fish-meat ham, fish-meat sausage	1.2
XI MEAT, EGG	75. Beef	Meat, liver, tongue, kidney, heart	14
	76. Pork	Meat, liver, kidney, stomach	27
	77. Chicken	Meat, entrails, skin	15
	78. Whale	Meat, canned whale meat	0.8
	79. Other meats	Rabbit, wild boar, pheasant, horse	1.4
	80. Ham and sausage	Ham, bacon, sausage	8.9
	81. Eggs	Egg, duck's egg, quail's egg	38
XII DAIRY PRODUCTS, MILK	82. Milk	Cow's milk raw and pasteurized whole fluid	108
	83. Cheeses	Natural and processed cheese	1.4
	84. Other milk products	Yoghurt, cream, ice cream, condensed milk, milk powder	6.0
XIII COOKED MEAL	85. Chao-tsu	Chao-tsu	1.7
	86. Shao-mai	Shao-mai	1.2
	87. Croquette	Croquette	3.2
	88. Salad	Salad	0.8
	89. Other foods		7.0
XIV DRINKING WATER[a]	90. Drinking water	Tap water, well water	600

[a] Does not include the amount used for cooking, etc.

Annex 11

FOOD GROUPS AND CONSUMPTION DATA USED FOR A TYPICAL TOTAL DIET STUDY BASED ON THE COMPOSITE APPROACH TO ESTIMATING DIETARY CONTAMINANT INTAKE IN THE USA

	Food group (composite)	Adult total diet (daily basis)	
		Average (g/day)	% (by weight) of total diet
I.	Dairy	753	25.5
II.	Meat, fish and poultry	262	8.4
III.	Grains and cereals	418	15.0
IV.	Potatoes	159	6.0
V.	Leafy vegetables	58	2.0
VI.	Legume vegetables	74	2.5
VII.	Root vegetables	32	1.4
VIII.	Garden fruits	75	3.2
IX.	Fruits	219	7.5
X.	Oils and fats	73	3.0
XI.	Sugars and adjuncts	81	3.0
XII.	Beverages (including water)	671	22.5
	Total	2 875	100.0

Annex 12

COMBINED COLLECTION AND COMPOSITING INSTRUCTIONS FOR TWO OF THE COMPOSITES LISTED IN ANNEX 11 (USA)

(a) Composite I. Dairy

Subsample number	Food item	Investigational (instructions:collection)		Analytical			Remarks
		amount purchased by inspector[a]	insp. list, check below as collected	28-day consumption[b] (g)	cooking required?	weight to composite (g)	
1	Milk, fresh fluid	8 quart		13 800	no	2 760	
2	Evaporated milk	10 fl. oz		576	no	115	
3	Nonfat dry milk	0.5 lb		227	no	45	
4	Ice cream	1 quart		816	no	163	
5	Cottage cheese	12 oz		624	no	125	
6	Processed cheese, American	3 oz		170	no	34	
7	Natural cheese	6 oz		340	no	68	
8	Butter	0.5 lb		227	no	45	
9	Skim milk	1/2 gal		2 520	no	504	
10	Ice millk	1 pint		448	no	90	
11	Buttermilk	none		none	no	none	
	Totals			19 748		3 949[c]	

[a] 1 US gallon = 3.785 litres; 1 US liquid quart = 0.946 litre; 1 US liquid pint = 0.473 litre; 1 US fluid ounce = 29.57 ml; 1 pound = 0.453 kg; 1 ounce = 28.35 g.

[b] Consumption data upon which the compositing scheme is based.

[c] Total weight of composite available for analysis.

(b) Composite V. Leafy vegetables

Subsample number	Food item	Investigational (instructions:collection)		Analytical			Remarks
		amount purchased by inspector	insp. list, check below as collected	28-day consumption[a] (g)	cooking required?	weight to composite (g)	
58	Spinach, collards, or mustard greens, fresh or frozen	6 lb		188	yes	376	
59	Celery	3 lb		181	no	362	
60	Lettuce	10 lb		756	no	1 512	
61	Cabbage, raw	4 lb, divide 80% raw		218	no	436	
62	Cabbage, cooked	20% cooked		58	yes	116	
63	Broccoli, fresh or frozen	12 oz		49	yes	98	
64	Asparagus, canned	10 oz		41	yes	82	
65	Asparagus, fresh or frozen	20 oz		94	yes	188	
66	Cauliflower, fresh or frozen	10 oz		41	yes	82	
	Totals			1 626		3 252[b]	

[a] Consumption data upon which the compositing scheme is based.

[b] Total weight of composite available for analysis.

Annex 13

CONSUMPTION OF FOODS PER PERSON PER DAY (GRAMS, EDIBLE PORTION) IN RURAL AND URBAN AREAS IN CENTRAL AMERICA, 1965-1967[a]

Foods	Guatemala	El Salvador	Honduras	Nicaragua	Costa Rica	Panama
Rural areas						
(No. of families)	(203)	(293)	(331)	(355)	(456)	(361)
(Persons per family)	(6.5)	(6.0)	(7.1)	(6.3)	(6.9)	(6.3)
Milk products (fluid equiv.)	84	190	194	243	193	73
Eggs	13	10	13	12	15	11
Meat, poultry, fish	44	37	41	58	40	90
Beans	54	59	56	72	57	20
Vegetables	66	53	51	27	66	25
Fruits	14	17	40	41	7	50
Bananas and plantains	20	16	43	72	47	99
Starchy roots and tubers	14	13	22	33	46	82
Cereal products (as grain, meal)	(412)	(411)	(276)	(240)	(199)	(261)
corn (subtotal as grain)	(359)	(352)	(224)	(139)	(41)	(32)
tortillas and tamales	544	533	340	190	62	6
determinated corn	0	0	0	0	0	29
toasted meal (pinol)	0	0	0	14	0	0
rice	16	27	29	54	100	186
wheat bread	36	26	12	28	54	37
wheat flour and pastes	4	0	8	7	12	10
other cereals	2	6	5	16	0	0
Sugars	52	41	39	58	89	51
Fats and oil	4	15	16	19	19	26
Urban areas						
(No. of families)	(103)	(100)	(99)	(98)	(98)	(96)
(Persons per family)	(6.2)	(5.8)	(7.0)	(6.9)	(5.8)	(5.5)
Milk products (fluid equiv.)	246	237	289	377	350	163
Eggs	31	31	21	21	23	19
Meat, poultry, fish	85	77	87	90	74	134
Beans	49	52	47	50	48	19
Vegetables	150	90	56	74	126	68
Fruits	58	71	54	52	60	99
Bananas and plantains	64	49	47	75	57	75
Starchy roots and tubers	34	12	24	24	55	70
Cereal products (as grain, meal)	(339)	(281)	(264)	(213)	(206)	(228)
corn (subtotal as grain)	(150)	(164)	(134)	(82)	(14)	(6)
tortillas and tamales	228	249	203	84	21	0
degerminated corn	0	0	0	0	0	6
toasted meal (pinol)	0	0	0	26	0	0
rice	34	55	50	80	103	150
wheat bread	169	66	74	51	80	65
wheat flour and pastes	5	0	9	0	16	9
other cereals	5	5	7	7	4	7
Sugars	74	38	45	63	77	42
Fats and oil	24	37	21	29	41	35

[a] From Nutritional Evaluation of the Population of Central America and Panama 1965-67. Department of Health, Education and Welfare Publication No. (HSM) 72-8120.

Annex 14

AN ANALYSIS OF AVERAGE DAILY INTAKE OF LEAD IN THE UNITED KINGDOM

Table 1. Average daily intake of lead from data taken from mean lead levels in common items of food in the United Kingdom in selected food groups[a]

Item	Weight (g)	Mean lead content (mg/kg)	Lead intake (µg)
CEREALS TOTAL	500	0.12	62.9
of which:			
Bread	295	0.15	44.2
Flour/cakes/biscuits	159	0.06	9.5
Breakfast cereals, oats, rice	42	0.21	8.8
Canned baby food	4	0.08	0.3
FATS TOTAL	500	0.10	50.1
of which:			
Butter	104	0.04	4.2
Margarine	69	0.12	8.3
Lard	46	0.21	8.7
Cheese	79	0.12	9.5
Condensed milk	94	0.06	5.6
Dried milk	28	0.08	2.2
Ice cream	30	0.14	5.2
Cooking oils	30	0.10	3.0
Cream	20	0.12	2.4
FRUITS TOTAL	500	0.10	51.1
of which:			
Citrus fruits	51	0.02	1.0
Apples	71	0.10	7.1
Bananas	28	0.02	0.6
Other fresh fruit	32	0.10	3.2
Canned fruit	46	0.50	23.0
Dried fruit and nuts	13	0.10	1.4
Fruit juice	15	0.10	1.5
Jams	24	0.10	2.5
Sugar	154	0.01	1.6
Chocolate, confectionary	66	0.14	9.2
ROOT VEGETABLES TOTAL	500	0.06	32.0
of which:			
Potatoes and products	397	0.04	15.9
Carrots	21	0.02	0.4
Onions, leeks	20	0.06	1.2
Other root vegetables	17	0.02	0.3
Pickles, sauce	22	0.10	2.2
Canned soup	23	0.51	11.7

Table 1 (continued)

GREEN VEGETABLES TOTAL	500	0.10	50.9
of which:			
Cabbage, cauliflower	128	0.09	11.5
Brussel sprouts	49	0.05	2.5
Peas, beans, total	165	0.15	24.1
of which:			
Peas, beans canned	112	0.21	23.0
Peas, beans other	53	0.02	1.1
Tomatoes	66	0.06	4.0
Leafy salads	21	0.09	1.9
Other green vegetables	71	0.09	6.4

[a] The food consumption data were obtained from the United Kingdom National Food Survey 1973 (Ministry of Agriculture, Fisheries and Food. Household food consumption and expenditure 1973. London, Her Majesty's Stationery Office, 1975). They give the relative importance of the food items within the food groups after conversion to a common basis of 500 g per food group.

Table 2. Weighted means obtained from the levels found in individual foods and from total diet studies

Food group	Year[a]	Weighted mean lead values (mg/kg)	
		In individual foods	In total diet study
Cereals	1966	0.12	0.17
	1973	0.12	0.13
Fats	1966	0.10	0.08
	1973	0.10	0.08
Fruits	1966	0.09	0.12
	1973	0.10	0.08
Root vegetables	1966	0.08	0.20
	1973	0.06	0.08
Green vegetables	1966	0.17	0.24
	1973	0.10	0.14

[a] The year refers to the coverage of the National Food Surveys providing the food consumption data. The lead values used were those taken from Survey of lead in food (1972), giving data obtained in 1971, and from Survey of lead in food: First supplementary report (1975), respectively. Both reports were issued by the Ministry of Agriculture, Fisheries and Food (United Kingdom) and published by Her Majesty's Stationery Office, London.

Annex 15

EXCERPTS FROM INSTRUCTIONS FOR A DUPLICATE PORTION STUDY IN THE UNITED KINGDOM

1. INTRODUCTION

This study is a continuation of a study carried out in England and Wales by the Ministry of Agriculture, Fisheries and Food (MAFF), the Department of the Environment, and the Department of Health and Social Security. The objective of the study will be to assess the dietary intake of lead from food eaten by infants at about 2-3 months of age, and to see how this is affected by lead levels in tap water.

2. PUBLICITY

Lead is an emotive subject and interviewers should be careful to maintain a low profile when dealing with the housewife.

3. SUPPLIES

The following items will be supplied to one clinic in each area:

(a) Participation questionnaire
(b) Mother's Guide to the Study
(c) Mother's Food Diary
(d) Instructions to interviewers
(e) Home visit questionnaire
*(f) 2-litre screw-cap polythene jars for collecting the food samples
(g) Self-adhesive labels for the food sample jars
(h) Addressed envelopes for returning the questionnaires to MAFF
(i) Invitation letters to hand to the mothers
(j) Twine, adhesive paper, gem markers for use in marking jar labels and in packing the jars
(k) 100 x 1-litre bottles for collecting water samples, each bottle marked in 4 sections (these bottles will be delivered by the Water Authority).

4. INITIAL SURVEY REQUIREMENTS

4.1 The study will cover a minimum of 50 households with a new-born child and ( ) of those households will be selected from your area.

4.7 Each mother should receive 7 sample jars, all labelled with the sampling area code, her participant number, and day number 1-7.

5. SAMPLING OF TAP WATER

5.1 The tap water in every mother's home is to be sampled in two ways:

(a) A "snap" sample - when a representative of the local water authority will call and take a sample;

(b) Mothers will be supplied with two bottles, both of which will be marked into four sections. The mother should fill one section with tap water on each of the seven days.

6. CASH PAYMENT

6.1 Each mother who participates in this study will be given £20.

6.2 Each mother should have the above explained to her at the recruitment interview.

---

* Please keep the cardboard boxes in which the sample jars arrive since these are to be used for packing the jars at the end of the survey. (Method of collection to be discussed.)

7. THE HOME VISIT

7.1 Show some form of identification with the survey.

7.3 Discuss in detail what will be required of the mother when supplying duplicate diet samples, and go through the "Guide to the Study" and the "Diary" with her. In particular:

(a) Explain the need to carefully duplicate everything consumed by the child in the week, including water, both in and outside the home; all foods needing reconstituting should be reconstituted before being added to the sample jar.

(b) Explain that the two feeds (actual and duplicate) should be prepared identically and simultaneously (if possible).

(c) Show her how to fill in the diary and how to adjust for food spillage, etc.

(d) Emphasize the importance of using the sample jars in the correct order, i.e., starting with day number 1 and finishing with day number 7, and using a new jar every day.

(e) Remind the mother of the day she should begin and when to attend the clinic.

(f) Ensure that the mother begins collecting the food samples on the day after your visit, starting with the first feed of the day, and continues for seven full days, finishing with the last feed on day 7 (unless the jars are all full). It is preferable, but not necessary, to keep the jars in a refrigerator.

(g) Ask the mother if any points are still unclear.

(h) Hand over the nine containers, the "Guide to the Survey" and the "Diary". Please ensure that all the jars are fully labelled.

8. HOME VISIT QUESTIONNAIRE

8.1 The completed questionnaire (i.e., when the baby's weight has been recorded) should be sent to:

9. ACTION AT THE CLINIC

9.1 Sample jars.

9.2 Blood samples.

9.3 The baby should be weighed (kg).

10. YOUR EXPENSES

11. QUERIES

HOME VISIT QUESTIONNAIRE

(Excerpts)

Date of Interview:

Baby's Date of Birth:

Baby's Sex:

Enter the appointment date for the clinic visit ....

Baby's weight in kilograms .... (to be completed at the clinic).

Q1. How are you feeding your baby?

(a) Breast milk only;
(b) Bottle feed only;
(c) A combination of breast and bottle;
(d) Infant foods only.

Q2. Is the baby your:

1st 2nd 3rd 4th 5th 6th more

Q3. Occupation of Household Members

The following questions have been designed to determine whether the person's employment brings them into contact with lead. The third question should be put as part of the general enquiry about the person's work. It should not be put so as to cause alarm to the person. If the household member is unemployed, please indicate this. All answers will, of course, be in confidence.

	MOTHER	OTHER HOUSEHOLD MEMBERS			
		1	2	3	4
1. What type of work is your employer engaged upon?					
2. What is your actual occupation?					
3. Does the person's employment bring him/her into contact with lead (IF KNOWN)?					
4. How long has the person been in his/her present occupation (years)?					

PARTICIPANT'S DIARY

Instructions for the use of this diary

1. As well as keeping a sample of everything your baby eats or drinks for one week (except breast milk), we would like you to keep a record of the type of food eaten by your baby.

2. This book is a diary in which you should show everything (except breast feeds) taken by your baby for one week.

3. Use two opened-out pages for each day. Start with the page for Day 1, Feed 1, and put a tick against the item(s) of food or drink taken at that feed.

4. Do the same each time your baby eats or drinks, using up all the columns for Day 1. Next day, turn the page over and start a new page. Do the same on each day of the survey.

5. If your baby eats or drinks something which is not on the list, please write it down in the space marked others, and tick the column in the right place.

6. If anything is not eaten or is wasted during a feed, write it down in the space at the bottom of the right-hand page each day.

7. Please fill in the diary as soon as baby's feed is finished - otherwise you may forget exactly what it was.

8. If anyone else feeds your baby during the survey, ask them to fill in the diary.

9. Two pages have been filled in to show you how to do it. These are just an example.

10. Please write your baby's full name (including surname) and your address on the outside cover.

DIARY

(Excerpts)

Type of feed	Feed number					
	1	2	3	4	5	6
Milk						
- cow's						
- powdered (made up with water)						
- tinned evaporated or condensed (diluted with water)						
Baby foods						
- in cans						
- in jars						
- in packets (made up with water)						
Rusks						
Cereals						
Fruit squash, cordial or other						
- in plastic bottles (and diluted)						
- in cans						
- in glass bottles (and not diluted)						
- in glass bottles (and diluted)						
Fruit juice						
- fresh						
- concentrated (and diluted)						
- in cans						
- in bottles						
Rose-hip syrup						
Vitamin drops						
Gripe water						
Sugared water						
Glucose water						
Glucose syrup						
Others						

FOOD WASTED DURING FEED

Please try to estimate food wasted (teaspoon amounts will do) for Feeds 1 to 6.

Annex 16

SOURCES OF INFORMATION ON ANALYTICAL METHODS
FOR MONITORING DIETARY CONTAMINANT INTAKE

1. Pesticide analytical manual, Volumes I and II, obtainable from Office of the Associate Commissioner for Compliance, US Food and Drug Administration, 5600 Fishers Lane, Rockville, MD 20852, USA.

2. International Union of Pure and Applied Chemistry (IUPAC): Secretary, Bank Court Chambers, 2/3 Pound Way, Cowley Centre, Oxford, England.

3. Nordic Committee on Food Analysis: Secretariat, c/o Swedish National Food Administration, Box 622, S-751 26 Uppsala, Sweden.

4. Codex Committee on Pesticide Residues and Codex Committee on Methods of Analysis and Sampling: Information on the work of these Committees can be obtained via the National Codex Contact Points.

5. Manual of methods, pesticide residues and environmental samples, obtainable from NSI, Environmental Sciences Group MD 8, US Environmental Protection Agency, Environmental Research Center, Research Triangle Park, NC 27711, USA.

6. The Association of Official Analytical Chemists, Suite 210, 1111 North 19th Street, Arlington, VA 22209, USA.

7. Recommendations for Methods of Analysis for Pesticide Residues, 1981, available as unpublished FAO/WHO Codex Alimentarius Commission document ALINORM 83/24-Add.1.

8. International Organization for Standardization (ISO): Central Secretariat, 1 rue de Varembé, Case postale 56, CH-1211 Geneva 20, Switzerland.

9. US National Bureau of Standards, Analytical Chemistry Division, Institute of Materials Research, Department of Commerce, Washington, DC 20234, USA.

10. Manuals of food quality control 2. Additives, contaminants, techniques, Rome, 1980, Food and Agriculture Organization of the United Nations (FAO Food and Nutrition Paper 14 part 2).

Annex 17

JOINT FAO/WHO FOOD CONTAMINATION MONITORING PROGRAMME.
DIETARY INTAKE OF CONTAMINANTS DATA FORM

leave blank

Serial Number: T D 0 11 5 1

Date: _____

1. COLLABORATING CENTRE (country) _____
2. SAMPLING PERIOD_____month_____year to_____month_____year.
3. TYPE OF TOTAL DIET_____composite food groups (give number____),
   or___major food items coupled with amounts consumed,
   or___sample meals, or___other (give details in item 15).
4. TOTAL NUMBER OF FOOD ITEMS INCLUDED _____
5. BEVERAGES INCLUDED___coffee/tea/soft drinks, ___drinking water,
   and/or___alcoholic drinks.
6. PREPARATION OF TOTAL DIET___cooked,___uncooked or___both.
7. DESCRIPTION OF PERSONS CONSUMING DIET _____
   _____
8. DAILY CONSUMPTION OF TOTAL DIET_____g/person/day
9. CONTAMINANT_____
10. NUMBER OF TOTAL DIETS ANALYSED_____
11. MEDIAN CONTAMINANT INTAKE_____µg/person/day
12. 90TH PERCENTILE CONTAMINANT INTAKE_____µg/person/day
13. MEAN CONTAMINANT INTAKE_____µg/person/day
14. PUBLISHED RESULTS_____
    _____
    _____
15. REMARKS ON DIET SAMPLES OR RESULTS_____
    _____
    _____

Annex 18

EXAMPLES OF OFFICIAL METHODS OR OTHER PUBLISHED METHODS USED IN DIETARY CONTAMINANT INTAKE MONITORING[1]

1. Official methods of analysis of the Association of Official Analytical Chemists, 13th ed., 1980 (aflatoxins, pesticides and metals).

2. Pesticide analytical manual, Volumes I and II, revised January 1982, US Food and Drug Administration (includes polychlorinated biphenyls).

3. KRAUSE, R. T. Multiresidue method for determining N-methyl-carbamate insecticides in crops, using high performance liquid chromatography. Journal of the Association of Official Analytical Chemists, 64(5): 1114 (1980).

4. EVANS, W. H. ET AL. Evaluation of a method for the determination of total cadmium, lead, and nickel in foodstuffs using measurement by flame atomic-absorption spectrophotometry. Analyst, 103: 580 (1978).

5. GAJAN, R. J. ET AL. Determination of lead and cadmium in foods by anodic stripping voltammetry. II. Collaborative study. Journal of the Association of Official Analytical Chemists, 65(4): 978-986 (1982).

6. FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS. Manuals of food quality control 2. Additives, contaminants, techniques, Rome, 1980 (FAO Food and Nutrition Paper 14, part 2).

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[1] Listing here does not imply a recommendation. These methods are only examples of the types of procedures and techniques that can be considered for use in dietary intake studies.

Annex 19

ANALYSIS OF EXTREME INTAKES

Some of the data which have been obtained in the United Kingdom both through the National Food Survey (NFS) - a nationally-representative household survey of food purchases - and duplicate diet studies (DDS) on specialized groups for the consumption of particular items of the diet are summarized in Tables 1 and 2. Although the data from the NFS are the best estimate of average per-caput food consumption on any one day, as derived from food acquisitions per family, the duplicate diet data are actual food consumption data. However, the NFS data were reprocessed to ensure that the only data used were those from households known to have acquired, or consumed the foods during the time of the survey.

The NFS raw data were processed as the number of families in each of 11 family size classifications who acquired a particular food within ascending intervals of weights of food consumed. Using the data on the number of families in eight weight intervals and the family composition, the distribution of purchases per person were derived. A wastage factor, but not including plate waste, was then applied, where appropriate, to convert the data to amount consumed per person. This method of calculating consumption from acquisitions assumes that each member of each family consumed the food in equal amounts and that all the acquired food was consumed during the week it was acquired. This method of calculation will tend to overestimnate consumption, particularly for the highest acquisitions and especially for items such as canned food which are usually stored for periods of longer than one week.

The method used to derive the fruit and vegetable consumption data differs somewhat from that explained above. The intention was to derive a probable maximum figure for consumption of individual crops and total fruit and vegetables. On the assumption that persons who have access to gardens and allotments will consume most, all diaries in the 1978 NFS from families in this category for the third quarter of 1978 from certain areas of the United Kingdom were examined. The time of year, and locations of the participants were chosen to maximize overall consumption. The figures presented are therefore not a year round average and may not represent high consumption for some seasonal crops.

There appears to be a roughly constant ratio between the mean, and the 95th percentile of consumption. The linear equation $Y = 2.0 x + 111$ fits the data for the mean (x) and the 95th percentile (y) with a correlation coefficient of 0.950. This relationship appears to hold whether or not NFS or DDS data are used.

From a combined plot of the tails of the distributions derived for some of the foods studied, it was apparent that the tails of each distribution were very similar. In view of these correlations there appears to be a fundamental relationship between mean and extreme consumptions of individual foods.

Table 1. Summary of consumption data (for consumers only)

Food	Consumers	Consumption g/person/week[a]			
		Mean	90th percentile	95th percentile	99th percentile
Kidney	1 287	44	90	115	156
Kidney	1 201	47	98	148	219
Liver	3 916	116	195	244	395
Liver	4 014	116	219	254	411
Lettuce	613	112	209	270	381
Lettuce	9 684	71	151	191	319
Shellfish	566	91	223	281	387
Shellfish	737	100	198	252	442
Shellfish	197	132	255	327	659
Fish	6 222	168	298	397	695
Fish	7 401	170	325	400	748
Fish	100	494	773	886	1 127
Cabbage	9 063	204	400	499	780
Cabbage	459	258	435	529	672
Canned food	16 642	550	1 056	1 348	2 038
Fresh veg.	1 026	878	1 585	1 941	2 844
Potatoes	16 395	1 164	2 189	3 856	6 261
Bread	21 418	823	1 492	1 751	2 428
Milk	21 595	2 347	3 802	4 153	5 557
Water	3 559	6 720	10 990		18 200
Canned food	17 662	522	1 041	1 310	2 061
Cabbage	126	116	256	336	606
Lettuce	128	60	130	167	237
Potatoes	162	686	1 085	1 244	1 835

[a] Mean - arithmetic mean; the total consumption by the sample population divided by the number of consumers only.

90th (95th) percentile etc. - That value of consumption recorded by the nth individual in a consecutive arrangement of p recorded consumers, where:

$$\frac{n}{p} = 0.9 \text{ (or } 0.95).$$

Table 2. Description of high levels of consumption

Food	Centile of consumption equivalent to		99th centile as proportion of mean
	2.5 x mean	3 x mean	
Kidney	94.3	97.3	3.55
Kidney	93	94	4.66
Liver	98	98	3.40
Liver	97.3	98.6	3.54
Lettuce	95	98	3.40
Lettuce	94	96.9	4.49
Shellfish	94	95	4.25
Shellfish	94.7	97.1	4.42
Shellfish	96	96	4.99
Fish	96	97	4.14
Fish	96	97	4.40
Fish	100	100	2.28
Cabbage	95.3	97.9	3.82
Cabbage	99	99	2.60
Canned food	94	97	3.70
Fresh veg.	97	98	3.24
Potatoes	92.8	93.9	5.37
Bread	97.5	99.1	2.95
Milk	99.2	99.7	2.37
Water			2.71
Canned food	94.9	97.0	3.95
Cabbage	93.0	95.5	5.22
Lettuce	92.4	95.9	3.95
Potatoes	98.4	99.5	2.68
Average (SD)	95.7(2.2)	97.3(1.7)	3.75(0.9)