

Compilation of EU Dioxin Exposure and Health Data

Task 4 - Human Exposure

Report produced for
European Commission DG Environment
United Kingdom Department of the Environment,
Transport and the Regions (DETR)

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Executive Summary

The exposure of EU citizens to dioxins and related compounds has been assessed to provide a basis for the development of possible future policies aimed at meeting recommended guidelines for acceptable exposure. The data in this study have been collected through a wide ranging literature search and through many contacts within research institutions, Government Departments and Agencies. In view of the broad scope of the work, it has been necessary to consider only dioxins and not cover PCBs in detail, although conclusions relating to dioxins have been interpreted in the broader context of dioxin-like compounds.

The most important route for human exposure to dioxins is food consumption, contributing 95-98% of total exposure, with products of fish and animal origin making the greatest contribution to this exposure. Data on concentrations of dioxins in foodstuffs are available for most EU Member States. The most comprehensive data sets are available for Finland, Germany, the Netherlands, Spain, Sweden and the United Kingdom. Although some data are available on concentrations in foods from areas of contamination in other countries, no data on background concentrations in foods were identified for Austria, France, Greece, Luxembourg or Portugal. Data on total dietary exposure are available for eight Member States, with none available for Austria, Belgium, Greece, Ireland, Italy, Luxembourg and Portugal.

Estimates of total dietary exposure to dioxins for average consumers has been found to vary from 69 pg I-TEQ/day in the Netherlands to 210 pg I-TEQ/day in Spain, equal to 0.93-3.0 pg I-TEQ/kg body weight/day respectively, assuming an average body weight of 70 kg. The Tolerable Daily Intake (TDI) recommended by the WHO is 1-4 pg I-TEQ/kg bw/day, which includes exposure to dioxin-like PCBs. A selection of data on PCBs in food and total dietary exposure in the United Kingdom, the Netherlands and Sweden has been analysed. It was found that dioxin-like PCBs and dioxins each contribute roughly 50% of total dietary exposure measured as TEQ. Therefore, in many countries the average total TEQ exposure is likely to be within the range of, or higher than, the WHO TDI, indicating that a large proportion of the population will receive exposure above the TDI.

Variations in exposure within countries have been considered in three dimensions, where data are available: by age and sex; through time; and for specific sub-populations or "at risk groups". In general, total exposure increases with age in childhood. However, when normalised by body weight exposure is found to decrease with childhood age due to increasing bodyweight.

Exposure has been shown to have fallen over time in all countries where data are available. In the United Kingdom exposure has fallen by 71% between 1982 and 1992 (equivalent to 12% per year), and in Germany it has fallen by 45% between 1989 and 1995 (9% per year).

High level consumers (95 or 97.5 percentile) have been shown to be exposed to 3.1 pg I-TEQ/kg bw/day in the Netherlands and 1.7-2.6 pg I-TEQ/kg bw/day in the United Kingdom. Once again, these figures only include exposure to dioxins and they therefore

indicate that total TEQ exposure is likely to exceed the WHO recommended TDI, of 1-4 pg TEQ/kg bw/year, for some high level consumers.

The following recommendations are made with the objective of improving the information available for establishing levels of exposure to dioxins across the EU and reducing human exposure:

- It is clear that many citizens of EU Member States may have a daily intake of dioxins and dioxin-like PCBs in excess of the WHO recommended TDI. As dioxins and dioxin-like PCBs can contribute equally to total TEQ intake, future policy measures should be focused equally on reducing human exposure to both groups of pollutants, in order to protect the health of the European population.
- In view of the importance of PCBs in the total TEQ exposure, it is recommended that a more detailed study of concentrations of PCBs in foodstuffs and total exposure to these compounds across Europe is undertaken.
- Maximum Tolerable Concentrations of dioxins and dioxin-like PCBs should be established for key foodstuffs in Member States, with a view to setting limit or guideline values to be met by the food producers. Country specific action is needed in order to ensure that MTCs are set at suitable levels for the exposed populations.
- Information on the risks associated with exposure to dioxins and dioxin-like PCBs should be made available to the public, via a suitable public awareness campaign. This could include information on particular foodstuffs, the actions already taken to limit the concentrations of dioxins and dioxin-like PCBs in these and guidance, where necessary, on levels of consumption of particular foods.
- Further analysis is required of the major contributors to dietary exposure in Member States, especially for the Southern European countries. In particular, confirmation is needed of the recent analysis of Spanish breads, cereals, fruit and vegetables that found higher than expected concentrations of dioxins.
- 'At risk' individuals can be defined as those consuming higher than average amounts of fatty foods, particularly fatty fish and fish products but also meats and dairy products all of which can contain high concentrations of dioxins and dioxin-like PCBs. More information is required on the dietary habits of the various cultural, religious and ethnic groups across the EU before specific 'at risk' groups can be identified

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REFERENCES

1. Introduction

1.1 DIOXINS IN THE FOODCHAIN

Humans can be exposed to dioxins through a number of routes - through inhalation of air, dermal absorption, ingestion of soil, and consumption of drinking water and food. However, as has been quoted many times in the literature, 95-98% of the daily dioxin intake is from food. Due to the lipophilic character of polychlorinated dibenzo-*p*-dioxins (PCDDs) and dibenzofurans (PCDFs), foodstuffs rich in fat are particularly important. In general, dioxins biomagnify up the foodchain, i.e. concentrations increase with progressively higher levels up the foodchain, and fatty foodstuffs have higher concentrations than vegetables and fruits. As a result of variations in the metabolism of different congeners in animals, all foodstuffs of animal origin shows a characteristic pattern of dioxin congeners, predominantly composed of 2,3,7,8-substituted congeners. The full spectrum of PCDD and PCDF congeners can be found in foodstuffs of plant origin. The actual pattern of congeners in any sample will also be influenced by the original source(s) of environmental contamination.

A number of foodchain routes have received particular attention in research and analysis. The dairy industry, producing meat and milk products, has been studied in great detail; both in terms of the fate and transport of the various dioxin congeners (see Task 3 - Environmental Fate and Transport), variations in environmental contamination measured by considering concentrations in cows' milk, and human exposure as a result of eating these foods. A second foodchain of importance, particularly in Scandinavia, is that of fish, especially in regions with contaminated sediments.

1.2 STUDY SCOPE, METHODOLOGY AND REPORT STRUCTURE

The term 'dioxin' is used in this report in the broad sense, covering both polychlorinated dibenzo-*p*-dioxins (PCDDs) and dibenzofurans (PCDFs). The data in this study have been collected through a wide ranging literature search and many contacts with research and Government organisations across Europe. In view of the broad scope of the work, initially, only dioxins were analysed in detail. Towards the end of the study it was considered important to undertake a brief analysis of the contribution of PCBs to total TEQ exposure. This has allowed conclusions relating to dioxins to be interpreted in the broader context of dioxin-like compounds. Also, this report considers only the human dietary exposure route in detail, as the other routes are of minor importance.

Section 2 considers the methods used in determining exposure of populations to dioxins; Section 3 summarises the data available on concentrations of dioxins in foodstuffs; Section 4 makes comparisons of total dietary exposure estimates across the EU Member States; and in Section 5 the implications for future policy development and measures to further reduce human exposure to dioxins are presented under the headings of Conclusions and Recommendations.

Two annexes are also included: the first contains the data on dioxins in foods and total dietary

exposure estimates obtained from each country, the second considers the issue of dioxin-like PCBs in more detail, and their contribution to total TEQ exposure.

2. Methods of Exposure Estimation

Many factors need to be taken into account in assessing human exposure to dioxins, and in evaluating data generated by the various studies undertaken. These are outlined in the following section: the various methods which can be employed, with a number of examples of practical applications, and issues which have to be taken into account when seeking to compare and apply the results obtained.

2.1 METHODS FOR THE ESTIMATION OF DIETARY EXPOSURE

Data on the exposure of humans to dioxins through food consumption can be collected and calculated in a variety of ways. There are two procedures for data collection - on an individual food basis and on a composite total diet basis. Furthermore, there are two alternative methods of collecting total diet data. The first is the collection of duplicates of all meals eaten by a group of individuals, in order to measure a total diet exposure figure for each person. Second is the collection of data on consumption habits and the combination of this with data on levels of dioxins in individual food types or composite samples of foods in categories such as 'dairy products' or 'poultry'. The first method is more likely to give accurate results for exposure of specific groups within the population, but gives no indication of the relative contribution of certain foods to the total dioxins exposure. The second method gives a better indication of the average exposure across the whole population, but relies on large amounts of data and costly analysis.

The resulting total dietary exposure data can be presented in a variety of ways: such as individual typical consumer exposures (average or high level) or by using various population statistics, such as the median value and the 95th percentile of the total exposure distribution.

2.1.1 Examples of methods used across Europe

As an illustration of the variety of methods used across the EU, brief descriptions are given here of a sample of studies. Data from these studies are given in the appropriate sections of Annex 1.

In Finland the National Food Administration has undertaken a survey of a variety of food types, and combined this with food consumption data. Food samples were collected in June 1991 from sites of production (dairies, slaughter-houses, egg producers) representative of Finland. Further work is underway to analyse concentrations of dioxins in vegetables and more cows' milk samples.

In Germany a very wide ranging survey has been carried out, including more than a thousand food samples. Estimates of exposure have been made at two different times, using two different food consumption data sets, in 1992 and 1995, giving an indication of changes in exposure through time.

In the United Kingdom, the Ministry of Agriculture, Fisheries and Food has undertaken analysis of dioxins in the Total Diet Survey (TDS) samples that are routinely collected at roughly five year intervals. TDS food samples are composites of similar food types, the individual components being purchased at retail outlets. The components are prepared as for consumption then combined in amounts reflecting their relative importance in the United Kingdom diet. Dietary exposure to dioxins has been quantified for 3 time periods (1982, 1988 and 1992). The results for 1997 should be available soon.

In the Netherlands two separate methods have been used. A wide ranging survey of retail foods has been undertaken and combined with the Dutch National Food Consumption Survey to estimate the distribution of exposure across the whole Dutch population. Duplicate diets have also been analysed in the Netherlands, to estimate changes in exposure over the period 1978 to 1994.

2.1.2 Problems with exposure data comparison

Methods of calculating dioxin concentrations in foods vary, and the methods of combining these with consumption data also vary. Analytical methods and quality assurance vary between laboratories, raising issues of comparability of base data. In the calculation of exposure, problems can be caused by the use of fat basis data rather than fresh weight data, the former requiring knowledge of the proportions of fats in foods for conversion. Potentially there are differences in the concentrations of dioxins in foods tested in raw and cooked form. However, this has been shown to have little effect on total exposure. Furthermore, concentrations in samples may be time dependent, either by season or in the longer term, and temporal changes in concentrations or diet habits may cause errors in results.

The very low levels of dioxin contamination in some food samples means that there are often some congeners that are not detected. Assumptions are therefore required about the existence of these congeners below the limit of detection. Upper and lower bounds are therefore quoted representing two assumptions: that non-detects are not present in the sample (lower bound result) or that all non-detects are present at the limit of detection (upper bound). Where these assumptions are not known, or are different between sample sets, comparison is difficult.

Variations in TEF systems are not considered to be an important factor in this analysis. Uncertainty due to other factors, such as how representative the samples are of a whole country, and analytical variations through time, cause much greater concern.

The extent to which the food samples analysed represent foods actually consumed is very important. There are two main issues here. First is that local contamination may influence exposure locally, and this probably will not be identified in a national survey. However, if samples are sourced from an area of unrecognised contamination the results of the exposure analysis may be over estimated. The second issue is that a large amount of food is imported, or transported within countries. The analysis of retail foods should include this factor, but analysis of foods sampled at source, such as from individual farms, may not.

Methods for calculating consumption of foods vary in their sampling framework or levels of data aggregation. A lack of knowledge of assumptions and methodology means that the results of certain surveys may be of limited use for comparison or extrapolation. In particular, samples pooled from across a wide geographic region will be useful in determining an

average contamination estimate but will hide any local areas of contamination. Also related to this is the problem of transferability of consumption data across social, cultural and national borders. For example, the diets of nationals and recent immigrant populations in a country may be very different. Dietary surveys need to be able to differentiate between dietary groups within a population.

Lastly, the concept of an 'average diet' is not necessarily very useful for analysing the risk of exposure, as particular 'at risk' groups may be lost in the averaging process. A distribution of diets across the population is needed, and therefore in some studies the 95th or 97.5th percentile is used as an indicator of the extreme cases of exposure.

These factors should be borne in mind when considering the data presented in the following chapter. More detail will be provided on these issues in the Generic Issues report.

2.1.3 Application of Exposure Data

Exposure data can be used for a number of different analyses. Background dioxin exposure estimates can be used to assess the risks to the general population, and such data can be compared across different regions and countries. A background exposure estimate can also be used as a 'baseline scenario' for assessing the potential impact of contamination from certain food types. For example, the added risk of exposure to dioxins from fish oil dietary supplements can be assessed by calculating the average exposure plus the additional exposure from this individual source. Equally, this data can be used to compare the potential risk of dioxins with the risks posed by other contaminants in food, such as PCBs.

If the distribution of exposure across a population is known, an assessment can be made of the number and characteristics of people likely to be exceeding recognised levels for the tolerable daily intake (TDI). Exposure to dioxins from individual foods could also be used in the calculation of a Maximum Tolerable Concentration in that food type, but this is beyond the scope of this study.

2.2 EXPOSURE FROM SOURCES OTHER THAN FOOD

Other exposure routes have been quantified, in particular those associated with risk assessments concerned with sites of contamination. Some specific examples are given here to illustrate these exposure routes.

A risk assessment of exposure to dioxin in soil in the neighbourhood of two MSW incinerators in Spain was undertaken. Exposure estimates were made using models of exposure from contaminated soils, based on assumptions about rates of ingestion of soil by children and adults, and factors relating to the exposure pathway. The resulting estimated exposures are in the range 0.0001-0.16 pg I-TEQ/kg bodyweight/day.

The Danish EPA has estimated exposure to inhalation of air and ingestion of soil. Assuming typical outdoor air concentrations of 0.01-0.4 pg I-TEQ/m³ and respiration of 20 m³/day a typical daily exposure is 0.2-8 pg I-TEQ/day. Absorption in the lungs can be estimated at 75% of the intake, giving a daily intake of 1.5-6 pg I-TEQ/day, or 0.02-0.09 pg I-TEQ/kg bw/day assuming a bodyweight of 70 kg.

Exposure from soil ingestion has also been estimated for young children, who are likely to ingest soil as a result of playing outside. The Danish EPA has assumed that children consume 200 mg soil per day. Average soil contains about 20 pg I-TEQ/g (see Task 2), therefore this represents an intake of 4 pg I-TEQ/day. A WHO working party has assumed a consumption rate of 100 mg/day and calculated a total intake of 5 pg I-TEQ/day.

3. Concentrations in Foodstuffs

3.1 DATA AVAILABILITY

Table 1 below shows the availability in the EU Member states of data concerning the concentrations of dioxins in various foodstuffs. Finland, Germany, the Netherlands, Spain, Sweden and the United Kingdom have the most comprehensive coverage of data. No data could be identified for Greece, Luxembourg or Portugal. The table obviously conceals variations in the quantity and quality of data. In summary, Finland, the Netherlands, Germany and the United Kingdom have the largest amount of numerical data, while the Spanish data set consists of a small number of samples for each food type and the Swedish data is now quite old (1991) but is being updated. Details of all of the data obtained in this study are given in Annex 1.

Table 1 Foodstuff concentration data availability in the EU Member States

	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain	Sweden	United Kingdom
Foodstuffs concentrations															
Cows' milk		*	*	*		*		*	*		*		*	*	*
Dairy products			*	*		*			*		*		*	*	*
Eggs				*		*					*		*	*	*
Fish			*	*		*			*		*		*	*	*
Meat			*	*		*					*		*	*	*
Poultry						*					*		*	*	*
Fats and oils											*		*		*
Breads and Cereals				*							*		*		*
Fruits and vegetables				*		*			*		*		*		*
Fish oil dietary supplements													*		*
Foodstuffs in areas of contamination															
Cows' milk	*	*			*	*		*			*				*
Other					*						*				*

A lot of data are available on concentrations of dioxins in cows' milk. This is because cows' milk gives a good indication of environmental contamination, and is easy to sample, both locally at farms and regionally through dairies or retail supply. Likewise, there is a relatively good coverage for dairy products, meats and fish. These are the fatty foods that are likely to contain higher concentrations of dioxins. Numbers of samples of cereals, fruits and vegetables are lower, because of the assumption that levels would be insignificant because fat levels are low. However, these foods have been found to contribute significantly to exposure in some regions because consumption rates are quite high, especially in the Mediterranean diet. Therefore, analysis of these food types is increasing, and is becoming more reliable as analysis techniques continue to improve.

3.2 CONCENTRATIONS IN FOODSTUFFS

Figure 1 shows the measured concentrations of dioxins in foodstuffs across Europe. The graph is plotted on a logarithmic scale in order to be able to directly compare all of the different concentrations in food. All data are presented as pg I-TEQ/g fat except for the bread and cereals and fruit and vegetables categories which are as fresh weight. The data in this graph are compiled from the data on background concentration presented in Annex 1, and include the most recent data for each foodstuff in each country, where available. The data points represent mean or median values for samples sets. The graph does not include foods from areas of known contamination.

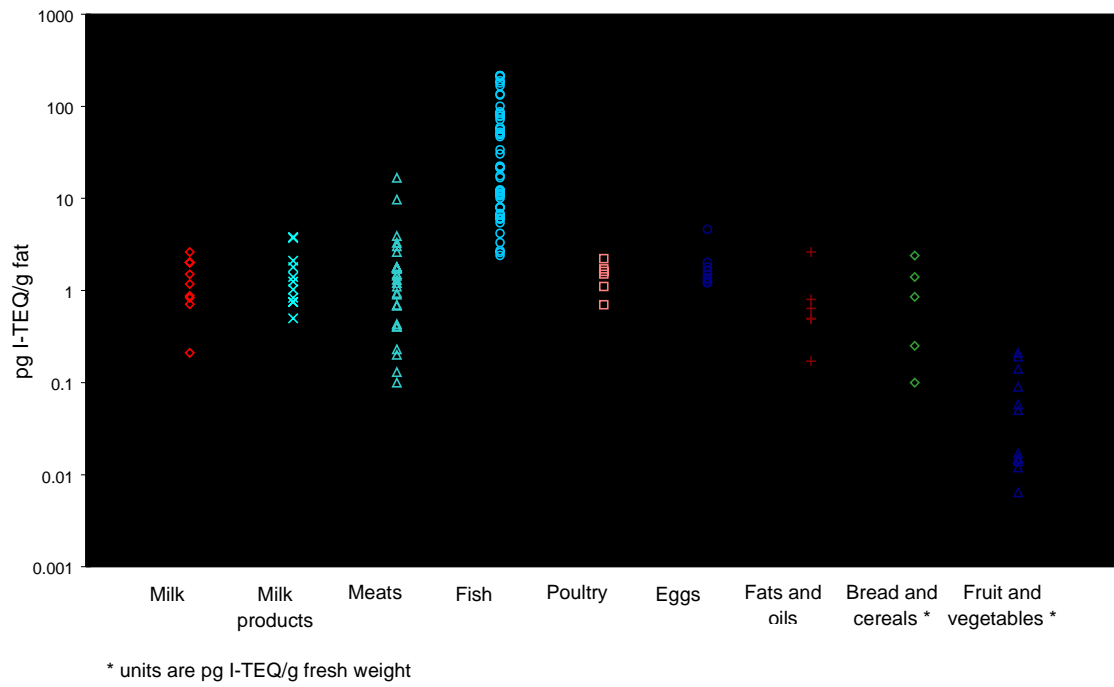
The pattern is as is expected, in view of the preceding discussion in section 1.1, with foods of animal origin having higher concentrations than those of plant origin. Concentrations in fish and meat are the highest, but these food types also have the largest ranges of concentrations. The fish data in particular have a very wide range because of the very wide differences in fat content and ages of fish analysed. Fruits and vegetables have the lowest concentrations. Milk and milk products, poultry and eggs have similar concentrations with mid points in the ranges of about 1-2 pg I-TEQ/g fat, and the fats and oils, and bread and cereals categories have slightly lower concentrations. However, there is considerable uncertainty concerning the concentrations in bread and cereals.

From a simple analysis of these data by country, no clear pattern of geographical variation in concentration across Europe can be seen. However, there are not enough data points to be able to undertake a statistical analysis of this variation. Some comments can be made: fish concentrations in Sweden seem to be high in comparison to others, and eggs in Germany also show higher than average concentrations. However, the data are skewed by the nature of the analysis that has been undertaken. The eggs analysed in Germany included free-range eggs, which contain higher concentrations because of the greater ingestion of soil by the hens. In Sweden much emphasis has been put on marine fish because of high values found in these and their importance in the Swedish diet. These fish are therefore over represented in this chart. Removing the Swedish data from the set reduces the range from 2-214 to 2-50 pg I-TEQ/g fat, and the median from 21 to 10. However, these results are still higher than those for the meats.

Contamination from packaging by dioxins, and the transfer of this into food has been a matter of debate in the past. Analysis has been undertaken in several countries of the influence of packaging on concentrations in cows' milk. In the majority of cases the influence has been shown to be insignificant, and this issue is no longer considered important. Examples of this analysis have been presented in Annex 1 in the Sections for Sweden and the United Kingdom.

Many foodstuffs analysed for dioxins are used in their raw form, rather than being cooked first. This may mean that the concentrations measured are not truly representative of the food that is eaten. Analysis of herrings in Sweden found that wet weight concentrations changed as a result of cooking, but only in the same proportion to the loss of water, therefore not causing any change in I-TEQ consumed. Other research in Germany and the USA has also found that cooking has no significant effect on dioxin consumption.

Figure 1 Concentrations of dioxins in foods



4. Total Dietary Exposure Estimates

4.1 TOTAL EXPOSURE

Table 2 provides a summary of the total exposure data available in the individual Member States. Data are available for Denmark, Finland, France, Germany, Netherlands, Spain, Sweden and the United Kingdom. No data have been identified for Austria, Belgium, Greece, Ireland, Italy, Luxembourg or Portugal.

Table 2 Data availability of exposure estimates across the EU

	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain	Sweden	United Kingdom
Total diet exposure estimate			*	*	*	*					*		*	*	*
Variations in exposure within the population											*		*	*	*
Time trends in dietary exposure						*					*				*
Other exposure route estimates			*								*		*	*	*

Table 3 shows the estimates of average total dietary exposure for various countries across Europe. The total dietary exposure estimate per kg body weight is shown graphically in Figure 2. The second row of figures have been re-calculated assuming an average bodyweight of 70 kg to provide a more reliable comparison. The range of estimates is 0.93-3.0 pg I-TEQ/kg bw/day, with Spain having the highest exposure estimate, and the Netherlands the lowest. However, these values only include exposure to dioxins and not PCBs. Data presented in Annex 2 shows that PCBs contribute a roughly equal amount to total TEQ as dioxins and therefore it is likely that for many consumers exposure will be above the WHO recommended range of tolerable daily intake of 1-4 pg TEQ / kg bw / day.

In section 2.1.3, some concerns were raised over the comparability of exposure estimates. This should be considered when comparing the data presented here. Firstly the data are not all for the same year, and secondly the estimates are calculate using different methods and with data of varying qualities. For example, the Spanish exposure estimate includes data on concentrations of dioxins in cereals, fruit and vegetables, and these foods contribute a total of 43% of this exposure, as a result of their importance in the Mediterranean diet. Until recent years these foodstuffs have rarely been included in dioxin analysis and, therefore, this may be part of the reason for the higher exposure estimate in Spain. If these foodstuffs are removed from the Spanish data, the total dietary intake for the categories of fish and seafood, meat, eggs, dairy products, milk and oils is 117 pg I-TEQ/day. The French data is based on very few samples, and is considered to be a preliminary estimate of exposure. Further French data should become available soon.

Only in the Netherlands, France and the United Kingdom have high-level consumer exposure

rates been estimated. These are also shown in Table 3 and are considered in more detail in Section 4.3.3. The values have been converted to a standard 70kg bodyweight for easy comparison. In Annex 1 these figures are given as quoted from original references using the original bodyweight assumptions. The range quoted for the United Kingdom represents the lower and upper bounds and Figure 2 shows the mid-point.

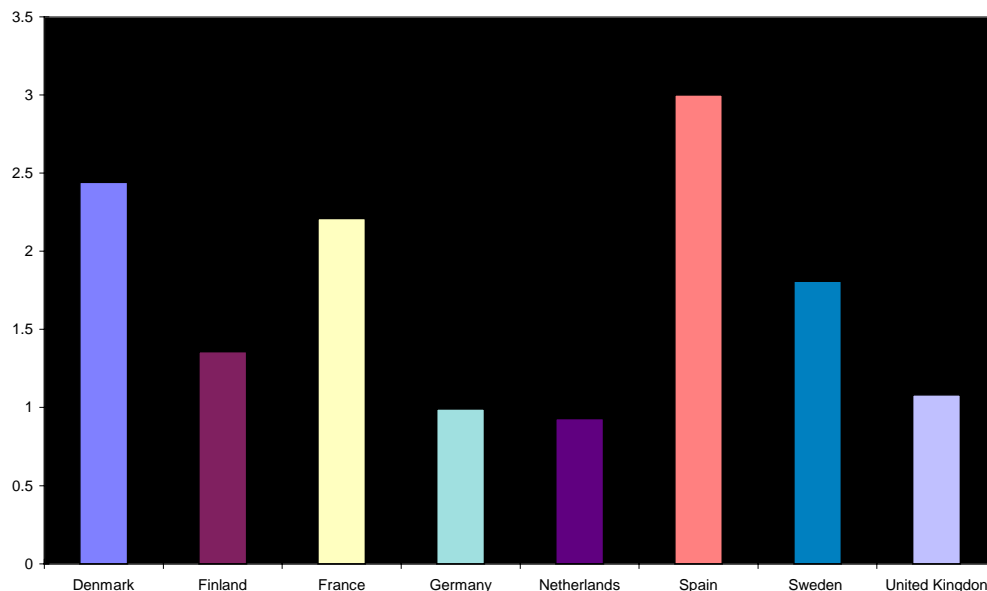
Table 3 Total dietary exposure estimates across the EU

	Denmark	Finland	France	Germany	Netherlands	Spain	Sweden	UK
Year	1995	1991	nd	1995	1991	1996	1990	1992
Average total diet exposure estimate pg I-TEQ/day	171	95	nd	69.6	65	210	126.5	69
Average total diet exposure estimate pg I-TEQ/kg bw /day (assuming 70 kg bw)	2.44	1.36	2.21 *	0.99	0.93	3.0	1.81	0.86–1.3
High level consumer exposure pg I-TEQ/kg bw /day			5.66 *		2.3			1.5-2.2

* unknown average bodyweight assumption;

nd = no data available / not known

Figure 2 Average total diet exposure estimates (pg I-TEQ/kg bw /day)

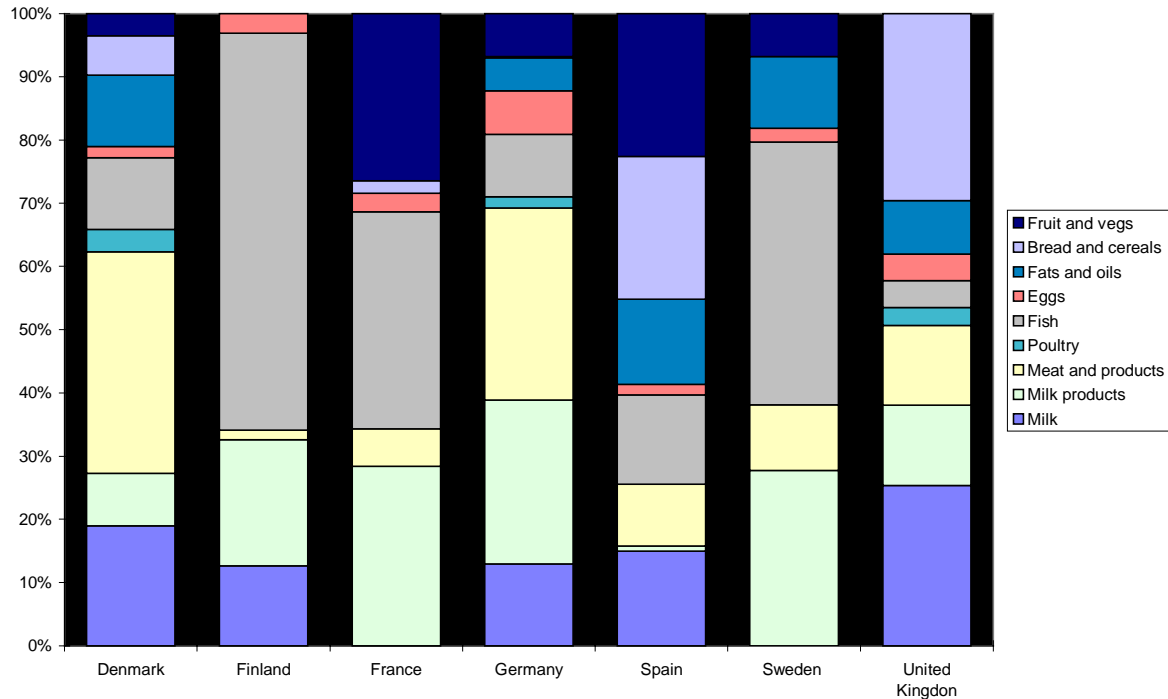


4.2 COMPONENTS OF EXPOSURE

Figure 3 shows the relative contributions of different food types to overall dietary exposure to

dioxins in the countries where these data are available. The chart shows the dominance in most countries of fish, meat products, milk and milk products. Fruit and vegetables are also important in France and Spain, and cereals in the United Kingdom. Full details of the data underlying this chart are provided in Annex 1.

Figure 3 Breakdown of total dietary exposure by food type



4.3 VARIATION IN EXPOSURE

4.3.1 Variations with age and sex

Variations in exposure within populations have been analysed in some countries. In the Netherlands the distribution of exposure has been considered in detail, both in terms of consumption patterns and by age. The median intake was found to increase with age in childhood from 36.4 pg I-TEQ/day at the age of 1 to 70.4 pg I-TEQ/day at the age of 20. Intakes remained roughly constant in adult life. However, intake per kg bodyweight decreased with age in childhood, because of increasing bodyweight.

In Spain a similar pattern was found although with higher values, with an increase in daily intake from 179 pg I-TEQ at 3-6 years to 184-214 pg I-TEQ at 16-20 years. A slight decrease in intake occurred after the age of 50. Intake in males was the same or higher than that of females in all age groups, perhaps due to higher rates of consumption. These figures are considerably higher than those for the Netherlands, possibly because of the inclusion of additional food categories, particularly cereals, fruit and vegetables.

For France provisional data are available for wider age ranges. Children and adolescents have higher intakes per kg bodyweight than the general population (3.31 and 2.41 pg I-TEQ/kg bw/day respectively compared to 2.21 pg I-TEQ/kg bw/day). Of the adults, females have a

higher intake than males, but the reason for this is unknown.

In the United Kingdom variations in consumption and age have also been analysed and presented in relation to hypothetical individual consumers. Intakes by bodyweight were again found to decrease with age, with those children of 1.5-2.5 years and 10-15 years having average intake ranges at 2.4-3.7 and 1.1-1.8 pg I-TEQ/kg bw/day respectively, compared with adults' exposure which was estimated at 1.0-1.5 pg I-TEQ/kg bw/day.

In general, total exposure increases with age in childhood, but when normalised by body weight it is found to decrease with age. In relation to the Tolerable Daily Intake (TDI), which considers body weight, this implies that children may be at risk of over exposure at a young age. Further information is available on this issue in the Task 5 report, in relation to exposures of breast-fed infants.

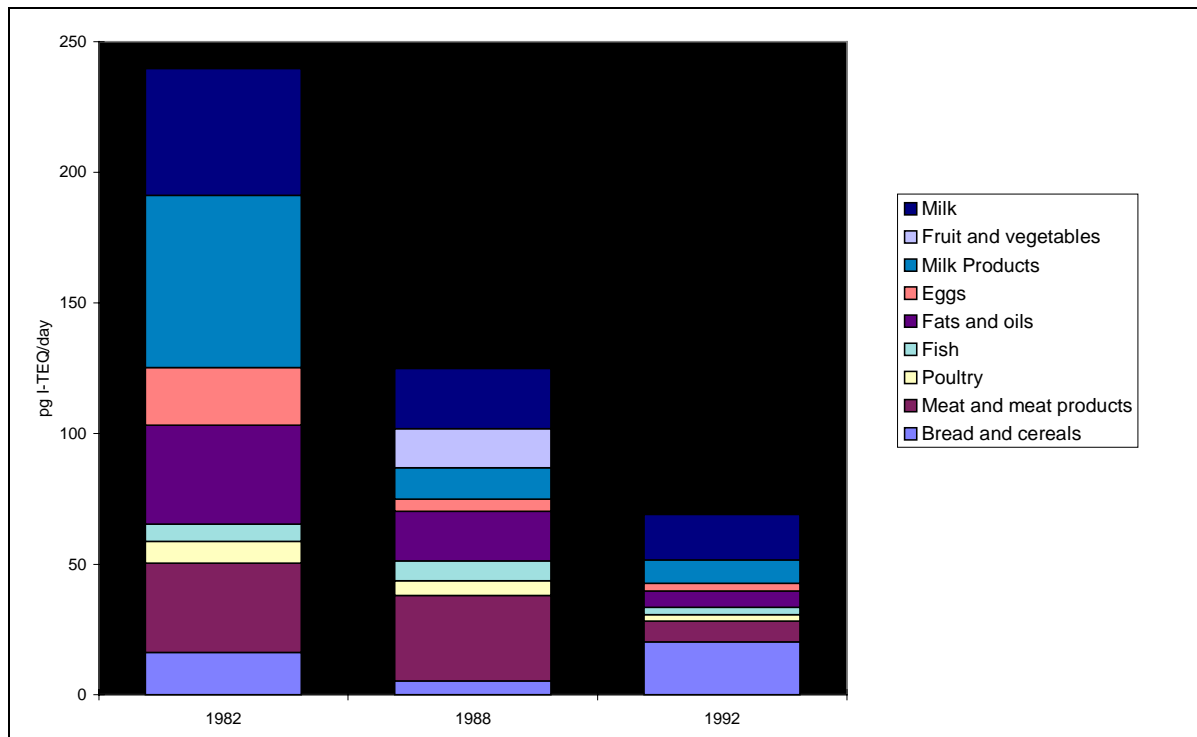
4.3.2 Variations with time

For Germany, the Netherlands and the United Kingdom data are available for a number of years, allowing time trend analysis. In the Netherlands a duplicate diets survey was undertaken. Preserved samples of 24-hour duplicate diets collected by adults in the periods 1978, 1984-1985 and 1994 were used. Statistically different exposure was found in the different time periods, with a significant downward trend through time. There was a constant decrease of 50% of the intake of I-TEQ/kg bw/day over each interval of 5.5 years over the period 1978 to 1994. The regression line of I-TEQ was used to predict the intake in 1990, of 0.8 pg I-TEQ/kg bw/day, which compares with 1.1 pg I-TEQ/kg bw/day calculated in the food consumption survey.

For Germany, two separate total dietary intake studies were undertaken, using different sets of consumption and concentration data. Daily intake was found to have fallen by 45% from 127 pg I-TEQ in 1989 to 70 pg I-TEQ in 1995.

In the United Kingdom, three data points are currently available, for 1982, 1988 and 1992. Exposure has also fallen in the United Kingdom from 240 pg I-TEQ/day in 1982, to 125 in 1988 (48% fall from 1982) and has fallen further to 69 pg I-TEQ/day in 1992 (45% fall from 1988). These data relate to average population exposure rather than by individual consumer. The decline has been explained by changes in the relative contributions of food types, with a decrease in the consumption of fats and oils and an increase in the consumption of cereals and milk. Concentrations of dioxins have also declined in many of the foodstuffs sampled. These data are shown in Figure 4.

Figure 4 Average Total Dietary Intake of dioxins in the United Kingdom in 1982, 1988 and 1992



4.3.3 Population sub-groups

High level consumers in the population are an obvious “at risk” group to identify, although any actual definition of this group is difficult, as they do not occur as a particular population sub-group in any other socio-economic analysis. Examples of these individuals may be those with very physically demanding occupations, requiring high levels of energy intake, or people with eating disorders. Therefore instead of considering “at risk” groups, a generic “at risk” individual can be suggested. This individual eats higher than average amounts of fatty foods, particularly fatty fish and fish products but also meats and dairy products.

In the Netherlands, the United Kingdom and France some analysis of distributions in consumption has been considered, in order to assess elevated levels of exposure in high consumers. In the Netherlands this high estimate is the 95th percentile in the distribution of exposures calculated. The median daily exposure in the general Dutch population in 1991 was 0.93 pg I-TEQ/kg bw, and the 95th percentile is 2.3 pg I-TEQ/kg bw (assuming average 70 kg bodyweight). In the United Kingdom, the high consumption estimate of 2.2 pg I-TEQ/kg bw in 1992 corresponds to the upper bound 97.5 percentile. This is based on consumption data for high level adult consumers. Exposure of the average adult is 1.3 pg I-TEQ/kg bw (upper bound). In France, preliminary data for 95th percentiles has been provided for various age groups. For the population as a whole the 95th percentile exposure was 5.7 pg I-TEQ/kg bw/day, compared with the average exposure of 2.2 pg I-TEQ/kg bw/day.

In Sweden, fishermen have been studied because of the high concentrations of dioxins found in some fish, particularly in those from the Baltic Sea. The higher contamination of the Baltic

Sea fish has a very significant impact on overall exposure, because of the importance of fish in the Swedish diet (as shown in Figure 3). The exposure of Baltic Sea fishermen resulting from fish consumption is over ten times that for the average Swede, and the total dietary intake of this group is calculated to be 6.3 times that of the per capita mean, at 11.7-12.5 pg N-TEQ/kg bw/day. This clearly shows that, in extreme cases, the consumption of high levels of fatty fish can lead to very high dietary intakes of dioxins. In comparison, the west coast fishermen actually have a lower intake of dioxins from fish, even though levels of fish consumption are high. This is because the fish are leaner, and contamination levels are lower on the west coast.

In the Netherlands, the Dutch Turks were analysed because of their different consumption patterns compared with the general Dutch population. The data obtained are shown in Table 4. This shows that the median intake of the Dutch Turks is higher than that of the general population, but that intakes per kg bodyweight are very similar because of a higher average bodyweight among the Turks. The reason for the difference in intake is that the consumption of mutton, butter and beef is higher in the Dutch Turk population.

Table 4 Median daily intake of I-TEQ for the Dutch population and Dutch Turks

	Sample size	pg I-TEQ / day	pg I-TEQ /kg bw/day
Dutch population (adults only)	3508	71	1.0
Dutch Turks (adults only)	83	82	1.1

Vegetarians and vegans have been identified as possibly having lower than average intake of dioxins, because of the absence of foods of animal origin. However, the evidence available is not conclusive. In the Swedish Dioxin Survey report a calculation was made in which it was assumed that all animal fat was replaced by equal quantities of milk fat and fats from eggs, and this resulted in an increase in exposure to 109-170 pg TEQ/day, owing to the higher concentrations of dioxins found in these foodstuffs than in meat. However, it is likely that the vegetarian diet contains less fat, and therefore these figures are an over estimate.

Few analyses have been undertaken on foods of other than animal or fish origin, therefore the exposure of vegetarians to dioxins is uncertain. In Spain, where small samples of these foods have been studied, it has been shown that cereal, fruit and vegetables can contribute significantly to exposure because consumption levels are high. Further analysis is therefore necessary to confirm these findings.

This Task has not addressed the issues of occupational exposure nor exposure of infants to breast milk.

4.4 CONTRIBUTION OF PCBs TO TOTAL TEQ EXPOSURE

The analysis undertaken in this project did not include collection of detailed data on PCBs in foods and total diet. However, data on concentrations of PCBs in foodstuffs measured in the United Kingdom, the Netherlands and Sweden are presented in Annex 2 and summarised here.

In the Netherlands the contributions of dioxins and PCBs to total TEQ exposure has been shown to be roughly equal, with the median daily exposure of adults at 71 and 77 pg TEQ for dioxins and PCBs respectively. Similar results were found in Spain, where the PCB intake contributed 48-62% of the total TEQ intake, in Sweden this contribution was 49-57% of TEQ, and in the United Kingdom it is 38-43%. The total exposures to PCBs therefore represent roughly 50% of total TEQ exposure.

5. Conclusions and Recommendations

The most important route for human exposure to dioxins is food consumption, contributing 95-98% of total exposure, with products of fish and animal origin making the greatest contribution to this exposure.

Data on concentrations of dioxins in foodstuffs are available for most EU Member States. The most comprehensive data sets are available for Finland, Germany, the Netherlands, Spain, Sweden and the United Kingdom. No background concentration data were identified for Austria, France, Greece, Luxembourg or Portugal.

The ranges of concentrations in the various food types from background locations or retail sources are shown below in Table 5. The 'median' figures given are medians of the summary data values for the various sample sets from all countries. They are not true medians of the complete sets of all analytical results.

Table 5 Ranges of concentrations of dioxins found in foodstuffs across the EU
(pg I-TEQ/g fat; * pg I-TEQ/g fresh weight)

	Milk	Milk products	Meat and products	Poultry	Fish	Eggs	Fats and oils	Bread and cereals *	Fruit and vegetables *
Min.	0.2	0.5	0.1	0.7	2.4	1.2	0.2	0.1	0.01
'Median'	1.3	1.3	1.3	1.6	21.2	1.5	0.6	0.9	0.02
Max.	2.6	3.8	16.7	2.2	214.3	4.6	2.6	2.4	0.2

Data on total dietary exposure are available for eight Member States, equivalent data do not exist for Austria, Belgium, Greece, Ireland, Italy, Luxembourg and Portugal.

Estimates of total dietary exposure to dioxins for average consumers has been found to vary from 69 pg I-TEQ/day in the Netherlands to 210 pg I-TEQ/day in Spain, equal to 0.93-3.0 pg I-TEQ/kg bw/day respectively, assuming an average body weight of 70 kg. The Tolerable Daily Intake (TDI) recommended by the WHO is 1-4 pg I-TEQ/kg bw/day, which includes exposure to dioxin-like PCBs. A selection of data on PCBs in food and total dietary exposure in the United Kingdom, the Netherlands and Sweden has been analysed. It has been found that dioxin-like PCBs and dioxins each contribute roughly 50% of total dietary exposure measured as TEQ. Therefore, in many countries the average total TEQ exposure is likely to be within the range of, or higher than, the WHO TDI, indicating that a large proportion of the population will receive exposure above the TDI.

Generalisations can be made about variations in diet across the EU. For example, fish are important in Scandinavia and higher proportions of fruit, vegetables and cereals are consumed in Mediterranean countries.

Variations in exposure within countries have been considered in three dimensions, where data are available: by age and sex; through time; and for specific sub-populations or "at risk groups". In general, total exposure increases with age in childhood. However, when

normalised by body weight exposure is found to decrease with childhood age due to increasing bodyweight. In relation to the Tolerable Daily Intake (TDI), which considers body weight, this implies that children may be at risk of over exposure at a young age.

Exposure has been shown to have fallen over time in all countries where data are available. In the United Kingdom exposure has fallen by 71% between 1982 and 1992 (equivalent to a 12% decline per year), and in Germany it has fallen by 45% between 1989 and 1995 (9% decline per year).

High level consumers (95 or 97.5 percentile) have been shown to be exposed to 3.1 pg I-TEQ/kg bw/day in the Netherlands and 1.7-2.6 pg I-TEQ/kg bw/day in the United Kingdom. Once again, these figures only include exposure to dioxins and they therefore indicate that total TEQ exposure is likely to exceed the WHO recommended TDI, of 1-4 pg TEQ/kg bw/year, for some high level consumers.

“At risk” individuals have been defined as those people consuming higher than average amounts of fatty foods, particularly fatty fish and fish products but also meats and dairy products. An example population sub-group that has been identified as being possibly at risk is the fishing community on the Baltic Sea coast of Sweden. Fish consumption has been highlighted in Sweden and Finland as a major contributor to exposure, and guidance has been given to limit this exposure.

5.1 RECOMMENDATIONS

The following recommendations are provided with the objective of improving the information available for establishing levels of exposure to dioxins across the EU and reducing this exposure to within the recommended TDI.

- It is clear that many citizens of EU Member States may have a daily intake of dioxins and dioxin-like PCBs in excess of the WHO recommended TDI. As dioxins and dioxin-like PCBs can contribute equally to total TEQ intake, future policy measures should be focused equally on reducing human exposure to both groups of pollutants, in order to protect the health of the European population.
- In view of the importance of PCBs in the total TEQ exposure, it is recommended that a more detailed study of concentrations of PCBs in foodstuffs and total exposure to these compounds across Europe is undertaken.
- Maximum Tolerable Concentrations of dioxins and dioxin-like PCBs should be established for key foodstuffs across Europe, with a view to setting limit or guideline values to be met by the food producers.
- Information on the risks associated with exposure to dioxins and dioxin-like PCBs should be made available to the public, via a suitable public awareness campaign. This could include information on particular foodstuffs, the actions already taken to limit the concentrations of dioxins and dioxin-like PCBs in these and guidance, where necessary, on levels of consumption of particular foods.

- Further analysis is required of the major contributors to dietary exposure in Member States, especially for the Southern European countries. In particular, confirmation is needed of the recent analysis of Spanish breads, cereals, fruit and vegetables that found higher than expected concentrations of dioxins.
- 'At risk' individuals can be defined as those consuming higher than average amounts of fatty foods, particularly fatty fish and fish products but also meats and dairy products all of which can contain high concentrations of dioxins and dioxin-like PCBs. More information is required on the dietary habits of the various cultural, religious and ethnic groups across the EU before specific 'at risk' groups can be identified.