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an iterative value-of-information approach

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Introduction

In BENERIS it is the general objective to create a framework for handling complicated benefit-risk situations. The objectives for the developing risk-benefit methods are:

- To develop Bayesian belief networks (BBN) to handle complicated benefit-risk situations and to develop a decision support system (DSS) based on BBN.

- To develop improved methods for dose-response assessment, combining epidemiological and toxicological data, and apply them in combining epidemiological and toxicological information on fish contaminants (esp. dioxins and PCBs).

- To develop an integrated repository of surveillance, nutrient and food consumption data that is capable of receiving, analyzing, and disseminating the accumulated data for benefit-risk analysis and to key stakeholders.

The first work example in BENERIS is the risk-benefit of eating fish and to do a risk-benefit analysis the intakes of relevant contaminants and nutrients have to be performed. To do an intake estimation data on both concentration and consumption need to be available. The quality of the estimation depends very much on the quality of the data you put into the model. Probabilistic modelling will be used to perform the intake calculations. Therefore, information on single samples for the different substances as well as the consumption for each person on each day in the dietary surveys should be available. It is the objective to integrate the data from the different countries and to study the applicability of the data to other countries; e.g. it is well known that salmon from the Baltic Sea are more contaminated than salmon from other waters.

In this paper the availability of data on consumption as well on content, primarily from three of the participating countries Ireland, Finland and Denmark will be described. Finally, other data sources as well as projects in other European countries about fish and risk/benefit are presented.

Food consumption data and surveys

Selection of dietary assessment method

Data on food consumption can be assessed by national, household or individual level food consumption surveys with the resulting data expressed in terms of foods and/or nutritents. Data on the individual level facilitate estimation of the adequacy of dietary intake and studying the relationship of diet and health (Bingham, 1988; Willet, 1998). Therefore, for the assessment of dietary exposure to specific categories of potentially hazardous or beneficial substances, data collected at the individual level are preferred.

The choice of an appropriate dietary assessment method depends on the level at which the food or nutrient intakes are going to be used (Gibson, 2005). Table 1 summarizes the most appropriate methods for assessing food or nutrient intakes in relation to four possible levels of how the intake data are used. The higher the level of use, the higher demands are required for the dietary assessment method. Thus, usual intakes for individuals (level three) require data collected for a longer period while a single day's diet for each individual is sufficient for information about mean intake of a group.

To determine the percentage of the population "at risk" of inadequate or excess nutrient intakes, estimates of the usual intakes of the participants are required. This, in turn, requires that the food consumption of participants be assessed over more than one day. Hence, repeated 24-h recalls, replicate weighed or estimated food records, dietary history, or semiquantitative food frequency questionnarires are the appropriate methods to be chosen.

Table 1 Appropriate methodologies to assess food and nutrient intakes to meet four possible levels of use (Cameron and Staveren, 1988; Gibson, 2005)

Level	Use	Preferred dietary assessment method
One	Mean intake of a group	A single 24-h recall, or single weighed or estimated food record, with large number of participants and adequate representation of all days of the week, or direct analysis.
Two	Proportion of population "at risk"	Replicate observations on each individual or a subsample using 24-h recalls, or weighed or estimated 1-d dietary records or direct analysis
Three	Usual intakes in individuals for ranking within a group	Multiple replicates of 24-h recalls or food records or a semiquantitative food frequency questionnaire
Four	Usual intakes in individuals	Even larger number of recalls or records for each individual. Alternatively, a semiquantitative food frequency questionnaire or a dietary history can be used

No dietary assessment method perfectly fulfils the requirements of an ideal method. Table 2 summarizes the uses and limitations of methods commonly used to assess the food consumption of individuals. Every measurement of dietary intake is associated with both random and systematic error. Errors arise from the use of food composition tables, food coding, portion size estimation, daily variation, reporting error, change in diet, response bias, and sampling bias (Bingham, 1987). Different methods of dietary assessment have different types of error. For instance, recall and retrospective methods such as 24-h recall and food frequency questionnaire relying on memory are prone to conscious or unconscious underreporting (Willet, 1998). Underreporting can be selective to food groups (Gibson, 2005) and can vary between normal weight and overweight participants (Macdiarmid & Blundell, 1998). On the other hand, in prospective methods such as weighed records and direct analysis, participants may change their usual eating pattern to simplify the measuring process (Cameron & van Staveren, 1988). Dietary intake assessment of population subgroups such as children and the elderly may present special problems.

Table 2 Uses and limitations of methods commonly used to assess the food consumption of individuals (mod. from Gibson, 2005)

Method	Uses and limitations
24-h recall Participant recalls food intake of previous 24-h in an interview. Quantities estimated in household measures using food models or photographs as memory aid or to assist in quantifying portion sizes.	Useful for assessing average usual intakes of a large population, provided that the sample is representative. Used for international comparisons of relationship of nutrient intakes to health and susceptibility to chronic disease. Single or few replicated 24-h recalls likely to omit foods consumed infrequently. Food intakes can be underestimated as the method relies on memory. Unsatisfactory for the elderly and young children. Multiple replicate 24-h recalls used to estimate usual intakes of individuals.
Estimated food record Record of all food and beverages "as eaten" (including snacks), over periods from one to seven days. Quantities estimated in household measures.	Used to assess actual or usual intakes of individuals, depending on number of measurement days. Data on usual intakes used for diet counselling and statistical analysis. Accuracy depends on the conscientiousness of participant and ability to estimate quantities. Longer time frames result in a higher respondent burden.
Weighed food record All food consumed over a defined period is weighed by the participant, caretaker or assistant.	Used to assess actual or usual intakes of individuals, depending on the number of measurement days. Accurate but time consuming. Setting must permit weighing. Participants may change their usual eating pattern to simplify weighing or to impress investigator.
Dietary history Interview method consisting of a 24-h recall of actual intake, plus information on overall usual eating pattern, followed by a food frequency questionnaire to verify and clarify initial data. Usual portion sizes recorded in household measures.	Used to describe usual food or nutrient intakes over a relatively long time period, which can be used to estimate prevalence of inadequate intakes. Such information is used for national food policy development, for food fortification planning, and to identify food patterns associated with inadequate intakes.
Food frequency questionnaire Uses comprehensive or specific food item list to record intakes over a given period (day, week, month, year). Record is obtained by	Designed to obtain qualitative, descriptive data on usual intakes of foods or classes of foods over a long time period. Useful in epidemiological studies for ranking participants into broad

interview or self-administered. Questionnaire can be semiquantitative when participants asked to quantify usual portion sizes of food items, with or without the use of food models or photographs.	categories of low, medium, and high intakes of specific foods, food components, or nutrients, for comparison with the prevalence of mortality statistics of a specific disease. Can also identify food patterns associated with inadequate or excess intakes of specific nutrients or compounds. Accuracy is lower than for other methods.

Validation of food and nutrient consumption data

Validity describes the degree to which a dietary method measures what it is intended to measure (Block and Harman, 1989). This information about accuracy is important for all food consumption studies. Generally, methods are compared with results from food records and sometimes with biomarkers such as doubly labelled water to validate energy intake or urinary nitrogen excretion to validate protein intake (Bingham and Cummings, 1985). Furthermore, energy intake is often easily validated by use of estimated physical activity (energy intake/basal metabolic rate)(Goldberg et al., 1991). Two different approaches are possible, when energy intakes below accepted cut-off values are identified: the individual's intake is excluded from analysis or the intake is adjusted arithmetically (Willet et al., 1997). As underreporting can be selective to food groups (Gibson, 2005), adjustment cannot be recommended in studies including nutrients and substances, which are not assumed evenly distributed.

Recommendations

For the assessment of dietary exposure to specific categories of potentially hazardous or beneficial substances, data from national representative food consumption surveys are preferred. If there are no data from a national food consumption survey in specific subgroups of interest (e.g. children or elderly), it is recommended to investigate usability of data from other studies with special emphasis on representativity on relevant factors. National food consumption surveys are often carefully and critically validated and designed to post-hoc analyses. Documentation of procedures is often comprehensive, although sometimes only written in the nation's own language, and sampling procedures have been carried out to ensure a representative national sample with respect to explicit factors. Furthermore, that national food consumption surveys are often carried out by the same few institutions or research groups, make it feasible to retrieve raw data for analyses of potentially hazardous or beneficial substances.

National food consumption surveys in Denmark, Finland and Ireland since 1990

National food consumption surveys at individual level in Europe from 1985 to 2001 have been described elsewhere (Verger et al., 2002). A summary of surveys in Denmark, Finland and Ireland since 1990 is given in Table 3 and described in the following.

In Denmark, the national food consumption studies were carried out in 1995 (Andersen et al., 1996). Since 2000, the study of Danish dietary habits has been a continuously ongoing survey (Andersen et al., 2005) and from 2003, 800 individuals are sampled every year for participation. The first round of consumption data in the continuing survey were collected and reported for 2000-02. In 1985, a retrospective dietary history method was used to assess the Danish diet. In 1995, a 7-day food record was used. Since 2000, the same 7-day food record has been used.

In Finland, the national food consumption studies (Findiet) are carried out every five years on adults (Kleemola et al., 1994; Anttolainen et al., 1998; Männistö et al., 2003). The aim is to assess the diet of Finnish adults aged 25-64 years. The studies provide information about consumption of nutrients, food and food groups. The national Findiet studies in 1997 and 2002 were carried out in five areas in Finland: Helsinki and Vantaa (the metropolitan area), the area of Turku and Loimaa, the provinces of North Karelia, North Savo and Oulu (Männistö et al., 2003). Random samples of individuals stratified by sex, age groups in 10-year intervals, and area was drawn from the population register. A 3-d record was used in 1992, a 24-h recall method was used in 1997 and a 48-h dietary recall by interview was used in 2002 to assess the diet of Finnish adults.

In Ireland, four national representative food consumption surveys for different age groups have been carried out since 1990: in 1990 (Lee & Cunningham, 1990), 1997-99 (Harrington et al., 2001;
Kiely, 2001), 2003-04 (Irish Universities Nutrition Alliance, 2005) and 2005-06 (Joyce et al., 2008). The 2005-06 survey have not yet been validated with respect to energy intake and BMR (Joyce et al., 2008). In 1990, 2003-04 and 2005-06 food consumption surveys have been carried out on children and adolescents, respectively at the ages of 8-18, 5-12 and 13-17 years. Food consumption of adults (18-64 years) was assessed in 1997-99 in the North/South Ireland Food Consumption Survey. In all Irish surveys, sampling was done to represent sex, social class and location. In 1990, a retrospective dietary history method was used. Prospective 7-day diaries have been used in surveys later than the Irish National Nutrition Survey in 1990, where food consumed have been quantified by use of portable food scales and/or estimated portion sized.

Table 3 Characteristics of national food consumption surveys in Denmark, Finland and Ireland

Country	Year	Survey	Sex	Age	Sample size (response %)	Dietary method	Food composition data	Reference
Denmark	1995	Dietary Habits in Denmark	M+F	1-80	3098(66%)	7-d record	Danish food composition database	Andersen et al., 1996
Denmark	2000-02	Dietary Habits in Denmark	M+F	4-75	4120(53%)	7-d record	Danish food composition database	Andersen et al., 2005
Denmark	2003-04	Dietary Habits in Denmark	M+F	4-75	1731	7-d record	Danish food composition database	Unpubl.
Finland	1992	The National Findiet study	M+F	25-64	1861(60%)	3-d record	Finnish food composition database	Kleemola et al., 1994
Finland	1997	The National Findiet study	M+F	25-64	2862(72%)	24-h recall	Finnish food composition database (Fineli®)	Anttolainen et al., 1998
Finland	2002	The National Findiet study	M+F	25-64	2007(64%)	48-h dieary interview	Finnish food composition database (Fineli®)	Männistö et al., 2003
Ireland	1990	Irish National Nutrition Survey	M+F	8-18+	1214	Dietary history	McCance&Widdowson 4th ed.	Lee and Cunningham, 1990
Ireland	1997-99	North-South Food Consumption Survey	M+F	18-64	1379 (66%)	7-d estimated food diary	McCance&Widdowson 5th ed.	Harrington et al., 2001 Kiely, 2001
Ireland	2003-04	National Children's Food Survey	M+F	5-12	594 (66%)	7-d weighed food diary	McCance&Widdowson 6th ed. + supplemental volumes	Irish Universities Nutrition Alliance, 2005
Ireland	2005-06	National Teen Food Survey	M+F	13-17	441	7-d weighed and estimated diary	McCance&Widdowson 6th ed. + supplemental volumes	Joyce et al., 2007

Content of nutrients and contaminants in fish

The data are first evaluated according to country presenting what each of the three countries, Ireland, Finland and Denmark, have delivered to the project. The data are also presented according to the compounds and a conclusion on the availability and quality of the content data is presented. In table A in annex 1 is shown for which combinations of fish and chemical the three countries have submitted data. If more than one country has submitted data for a combination of chemical and fish the summarised data are shown in tables in annex 1. There has not been performed any analysis of differences in concentrations between species and/or catching waters.

Products as fish oil, mollusc and shellfish are not included in the inventory.

Content data availability on country basis

In annex 1 is shown tables for summarised data submitted from Ireland, Finland and Denmark.

Ireland

Ireland has forwarded data for mercury and dioxins to the project.

For dioxins fish has been analysed in 2004 and all together 11 different kind of fish and fish products were analysed. The fresh samples are caught in the Irish Sea or from farms while samples of tinned products and smoked salmon are taken at retail. Each sample is a pooled sample of between 1 and 20 fish. The total number of samples is 69 and the number of samples for each group is between 2 and 15. The content of the lower bound (LB) and upper bound (UB) for PCDD/F WHO-TEQ, PCBB WHO-TEQ, 7 marker PCBs and total-TEQ as well as the fat content is given for every single sample.

For mercury Ireland has delivered data for the years 2002 to 2006. In the years all together 28different species of fresh fish have been analysed. Also here each sample is a pooled sample of individual fish. For each species the total number of samples for all the years is between 1 and 18 samples. Length as well as moisture content is also determined in the samples. The landing ports in Ireland are stated but no the catching area but most probably the fish have been caught in the Irish Sea or Atlantic Ocean. In the calculations of mean etc. LOQ is used as content for samples where the content is given as less than LOQ

On the webpage: http://nfrd.teagasc.ie a lot of information about studies for contaminants as mercury, cadmium, lead, dioxins PCBs can be found. Individual analytical results are not given, however. Analytical information on dioxin levels in fish is available on the FSAI webpage:

www.fsai.ie, while information on levels of metals including mercury in fish are available in publications from the Irish Marine Institute, www.marine.ie/home.

Data have been submitted for fatty acids and fat but because the data are not published yet the summarised data are not shown in this inventory. As can be seen in table A in annex 1 salmon (wild, farmed, smoked), tuna (wild and tinned), herring, mackerel, tinned sardines as well as tinned red and pink salmon have been analysed. The samples have been analysed for omega-3 and omega-6 fatty acids, fat, total trans-fatty acids, as well as saturated, monounsaturated and polyunsaturated fatty acids.

Data for iodine and selenium are very limited in Ireland and have not been forwarded to the project.

Denmark

Dioxins and dioxins like PCBs have been analysed in fish in the period 2000-2003. It has not been possible to get access for data for the single samples but the summarised data for WHO-TEQ for dioxins, WHO-TEQ for dioxin-like PCBs, the sum, as well as of the indicator PCB 153 are shown in the report. Fat content is not given for the single samples. The results are published in the report "Food Contaminants, Food monitoring 1998-2003" by Fromberg et al. (http://www.foedevarestyrelsen.dk/fdir/publications/2005001/rapport1.asp)

In the studies farmed trout, herring, eel, blue mussels and fish supplements were analysed. For herring and eel the results was stated according to catching area and the results show a clear relation between content of dioxins and catching water with the highest content in herrings from Baltic east of Bornholm and lowest content in herrings from the North Seas and Belts.

Besides PCBs and chloropesticides (e.g. DDT, lindane, chordan, beta-HCH) have been analysed in more than 900 samples of wild fish, farmed fish, canned and smoked well as fish oils in the period 1998-2003. The samples are distributed among 12 different species and for herring and cod liver the results are given according to catching waters. The summarised results can be found in the report "Food Contaminants, Food monitoring 1998-2003"

Denmark has delivered results from two studies about the content of heavy metals in fish (Rohkjaer et al., 2004). In the two projects mercury, lead, cadmium, arsenic, selenium, and tin were determined in all together 190 samples in 19 different fish species, including cod roe and tinned products. In these projects the fat content are not determined. The samples are taken at fish auctions, producers and importers. As the analytical method for selenium is the same as for heavy metals the results, although selenium is a nutrient, is reported as part of the projects for heavy metals. Results below LOQ are included in the calculations with the quantified content even though they are less than LOQ[1].

Denmark has delivered results for nutrients in fish from the latest study for nutrients in 1996 (Danish Food Administration, 1999). All together 149 samples of herring (fresh and tinned), mackerel (smoked, fresh and tinned), trout, plaice, flounder, cod, cod roe, and tinned tuna was analysed. The number of samples was between 6 and 32 for the different categories. All samples were examined for the proximate nutrients, vitamin B_{12} and iodine. The fat fish (herring, mackerel, and trout) were also analysed for vitamin A, vitamin D, and fatty acids. Eighteen different fatty acids were determined in the fish as well as a group called "others". For the fresh fish the month and water for catching is noted. Content of fat, protein and dry matter is determined for each sample. The fresh samples are taken at fish auction/sales while the tinned/prepared products are taken in retail.

Data for many proximate nutrients and vitamins from many different studies in different fish species are available in the Danish Food Composition Databank (http://www.foodcomp.dk/fcdb_default.asp). Data are taken mainly from Danish studies but also other studies are included. Mean and variations in the content are given as well as references to the studies.

Finland

Finland has delivered very detailed data for dioxins congeners. There are data for LB and UB for 17 different dioxin congeners as well as the sum of the congeners and content in total WHO-TEQ. All together 175 samples, distributed on 16 different species of fish (fresh, farmed, and prepared), have been analysed. The samples are analysed in the period 2002-2004 and are either from inland lakes or the Baltic Sea. For Baltic herring also the time of year for catching is indicated. For many of the species there are both samples from inland lakes and the Baltic Sea. The numbers of samples are between 3 and 11 except for Baltic herring where the numbers of samples are 47.

For heavy metals Finland has published data for lead, cadmium, arsenic and inorganic mercury in fish from open waters and inland lakes. The report is in Finnish and shown I annex 1 with a translation of names for fish and metal.

The National Health Institute has published a lot of data for nutrients in a database on the homepage http://www.fineli.fi/food.php?foodid=848&lang=en. Here data for more than 2000 raw and prepared foods and 52 nutrition factors can be found. The data are both from studies by

[1] LOQ is an expression of the certainty of the quantification of content. Contents below LOQ can be quantified but the uncertainties on the results are rather high.

the National Health Institute but also from other sources. For fish data for 23 different foods are given. In the database there are data for proximate nutrients, fatty acids (e.g. total, saturated, unsaturated, 4 fatty acids), minerals and vitamins as Se, I, vitamin A, D and B_{12}

Content data availability on compound basis

Dioxins

Only Finland has delivered data for many different congeners (both LB and UB) as well as the total WHO-TEQ for 16 fish species, however for some of the species only a few samples has been analysed. The data are given on a single sample basis. Ireland has also delivered data at the level of a single sample. The data are given for the LB and UB of total PCDD/F, total DL-PCB as well as the sum all in WHO-TEQ.

Denmark has only delivered summarised data (e.g. mean, median, lowest value, highest value) from the year 2000-2003.

In the EU a monitoring system for dioxins in fish is taking place. Each Member State is going to sample a certain number of samples. The results are forwarded to the EU Commission but the data are not published.

Heavy metals

The primary compound of interest is methyl mercury as this compound is much more toxic than inorganic mercury and it can be found in fish. Most of the mercury in fish exists as Me-Hg. Both Denmark and Ireland have delivered data to the project but the mercury is determined as inorganic mercury. In intake calculations the inorganic mercury therefore has to be recalculated to organic mercury and in generals it is assumed that 95 % of mercury in fish is organic mercury.

Nutrients

Denmark has delivered data for selenium, iodine, fatty acids, and some vitamins on a single sample basis. Besides values for nutrients can be found in the Danish Composition Databank but there it is only a single value for each food group. In Finland data for nutrients can be found in the database Fineli, where values a given as single values for each nutrient in each kind of fish. In the database there are references to the source of information. Many of the data are from the National Health Institute or other Finnish reports, so single data must be available for Finland.

Conclusion for data for contents

For dioxins Finland, Ireland, and Denmark have delivered data. All together there are data for many different species of fish. The amount and quality of the data are however very different.

Finland has delivered data on many different fish species, also on fish with a low fat content. Data for Denmark and Ireland is only on fish species with a high fat content e.g. salmon.

Considerations always need to be taken in performing intake calculations whether data from one country can be used in another country or data can be merged. This consideration is especially important for chemicals where the content is known or can be expected to depend on the breeding place or catching water for fish. For dioxins it is well known that the content depends very much on the catching water, and that especially herrings and salmons from the Baltic Sea are contaminated.

For inorganic mercury Denmark and Ireland have delivered data for individual samples. Finland has delivered summarised data for fish that are caught both in open sea and in lakes. Most mercury in fish con be found as organic mercury and this is much more toxic than inorganic mercury these data has to recalculated to organic mercury to be used in intake calculations. The data cover many different fish species for all countries. The samples from Denmark and Finland are also analysed for other heavy metals. Selenium has also been analysed in the samples from Denmark.

Denmark and Ireland has submitted data for individual samples for fatty acids but the Irish data cannot be published in the BENERIS project yet.

There is not included any descriptions of the analytical methods to the data. However, it is assumed that all the data are from laboratories that are accredited or have similar quality assurance systems, as it is demand from the EU to the public control. It also seems to that the lower results are in the same order, indicating that the limits of quantifications are similar.

Other data and projects concerning fish and/or risk/benefit

In the context of the EU Commission the SCOOP project on heavy metals took place and in 2004 a report was published. In the project concentration data from Member States for Hg, Cd, Pb and As were collected and the intakes were estimated. Consumption data were submitted by the Member States However there were great differences in the amount of data forwarded both for consumption and concentration. The concentration data were given for rather broad food groups, e.g. saltwater fish, freshwater fish for each of the elements and for each food group number of samples, sampling year, min, max, mean and median are given. The intake was calculated on even more broad food groups e.g. fish, milk and dairy products.

A SCOOP project concerning dioxin has also taken place. The data are given on food commodity level e.g. trout, plaice and for each combination of food commodity and country a mean value is given for PCDD/F and dioxin-like PCBs are given in WHO-TEQ. The consumption data are from surveys in the participating Member States. A SCOOP report about PAH is also published.

EFSA has published an opinion on wild and farmed fish where as well as beneficial (nutrients) as non-beneficial (contaminants) compounds in fish are evaluated on a compound by compound basis. On of the conclusions in the report is that:
“At present there is no agreed methodology for taking into account risk and benefit in a quantitative way. The Panel recommends that for future purpose a framework should be developed allowing a quantitative comparison of human health risks and benefits of food based on a common scale of measurement.”

In Denmark the report “The total view of fish and fish products” was published in 2003 (National Food Administration, 2003). The report is in Danish with an English 5-paged summary. In this report all relevant nutrients and contaminants that can be found in fish are evaluated and the intake of each compound is estimated. Finally, a total view is performed and advices on fish eating are given. The data are primary from Danish studies of dietary habits and contents of nutrients and contaminants.

A total view of seafood has been published by the Norwegian Science Committee for Food Safety in 2006. Also here a final conclusion and recommendations for eating fish is reached on the background of an evaluation of each compound separately. Data for consumption are taken from Norvegian surveys while data for concentrations primarily are from Norwgian studies but also data from other sources are included. The report is in Norwegian.

In 2006 a Belgium scientific report on the integrated evaluation of marine food items were published (Willems et al.). In this report probabilistic modelling of the intake of both beneficial and non-beneficial compounds have been done. Concentration data were taken both from the per-reviewed literature and from national reports. The frequencies of the intake of different compounds as dioxins, fat, iodine, EPA&DHA, MeHg are then correlated to each other in scatter plots and in this way a sort of combined risk-benefit is performed. The highest correlations are found between several fat-soluble compounds e.g. total TEQ for dioxin versus fat intake.

Renwick et al. (2004) have published a paper where a approach is proposed to compare beneficial and adverse effects across intake levels for micronutrients. The approach will not be described in this report the paper is mentioned in the References for further reading. In this approach the intake-incidences curves are plotted for the benefit and risk situation. Benefit is here defined as a decrease in risk of deficiency, or a decrease in risk of absence of the health benefit. Where the toof absence of benefit and risk of toxicity and where the two curves cross each other is the optimal intake for the nutrient.

In the SAFEFOOD project an approach to compare the risk of more chemicals has been developed and the approach will be published in a paper in a special issue of Food and Chemical Toxicology. For example is it a risk both to eat pesticides and mycotoxins. Fungicides can be used to decrease the content of a mycotoxin and by that the intake of the mycotoxin which is a benefit. The question is however if it is better to eat less mycotoxin and more fungicide that the other way around.

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Annex 1. Tables with summarised content data from each country

Table A. Shows in which fish each country have analysed for different kind of chemicals and where single data are known to be available

Finland, dioxins	Ireland, dioxins	Denmark, dioxins	Finland, heavy metals	Ireland, mercury	Denmark, heavy metals	Ireland, fatty acids + fat	Denmark, nutrients
Arctic char	Herring	Herring	Bream (IL)	Anglerfish	Anglerfish	Herring	Cod
Bream (IL+BS)	Herring, tinned	Trout, farmed	Burbot (IL+OS)	Black sole	Catfish	Mackerel	Cod roe
Burbot (IL+BS)	Mackerel	Eel	Flounder (OS)	Bill	Coalfish	Pink salmon, tinned	Flounder
Flounder (BS)	Pink salmon, tinned		Herring (OS)	Cod	Cod roe	Red salmon, tinned	Herring
Herring (BS)	Red salmon, tinned		Perch (IL+OS)	Conger eel	Escolar	Salmon, farmed	Herring, marinated
Herring, fried (BS)	Salmon, farmed		Pike (IL+OS)	Dab	Greenland halibut	Salmon, wild	Mackerel
Herring, marinated (BS)	Salmon, wild		Pike-Perch (IL+OS)	Gurnard	Haddock	Salmon, smoked	Mackerel, smoked
Herring, smoked (BS)	Salmon, smoked		Slmon (OS)	Haddock	Hake	Sardine, tinned	Mackerel, tinned in tomato
Perch (IL+BS)	Sardines, tinned		Sprat (OS)	Hake	Halibut	Tuna	Mackerel, tinned in water
Pike (IL+BS)	Tuna		Vendace (IL)	Herring	Mackerel	Tuna, tinned	Plaice
Pike-Perch (IL+BS)	Tuna, tinned		Whitefish (IL+OS)	John Dory	Mackerel in tomato		Rainbow trout, farmed
Rainbow trout, farmed				Lemon Sole	Pike		Tuna, tinned in water
River lamprey				Ling	Rainbow trout		
Roach (BS)				Mackerel	Ray		
Salmon (BS)				Megrim	Redfish		
Signal crayfish				Monk	Salmon		
Smelt (IL)				Plaice	Shark		
Sprat (BS)				Pollock	Porbeagle		
Vendace (IL+BS)				Ray	Swordfish		
Whitefish (IL+BS)				Saithe	Tuna		
				Salmon	Tuna, tinned in oil		
BS= Baltic Sea IL = inland lakes			OS = open sea	Spurdog	Tune, tinned in water		
				Turbot	Zander		
				Whiting			
				White sole			
				Witch			

Tabe B. Mecury, Ireland. All results are in mg/kg fresh weight

Fish	n	Min	Max	Average	Std	Median
Anglerfish	2	0.08	0.09	0.09	0.01	0.09
Black Sole	11	0.03	0.11	0.06	0.03	0.04
Brill	3	0.03	0.05	0.04	0.01	0.04
Cod	10	0.03	0.17	0.09	0.05	0.09
Codling	2	0.08	0.1	0.09	0.01	0.09
Conger Eel	1	0.19				
Dab	1	0.04				
Dog fish	3	0.26	0.6	0.43	0.17	0.43
Gurnard	3	0.08	0.26	0.18	0.09	0.21
Haddock	15	0.04	0.19	0.08	0.05	0.06
Hake	12	0.03	0.2	0.06	0.05	0.04
Herring	1	<0.03				
John Dory	3	0.04	0.11	0.06	0.04	0.04
Lemon Sole	12	0.03	0.13	0.07	0.04	0.06
Ling	4	0.1	0.46	0.24	0.16	0.20
Mackerel	6	0.03	0.08	0.05	0.02	0.04
Megrim	9	0.03	0.39	0.11	0.11	0.06
Monk (L Pisc.)	14	0.05	0.16	0.10	0.04	0.11
Plaice	15	0.03	0.08	0.05	0.02	0.04
Pollack (white)	2	0.04	0.04	0.04	0.00	0.04
Ray	7	0.04	0.11	0.08	0.02	0.08
Saithe (black pollack)	3	0.05	0.07	0.06	0.01	0.06
Salmon	1	0.1				
Spurdog	3	0.43	0.73	0.58	0.15	0.59
Tub Gurnard	1	0.18				
Turbot	4	0.04	0.06	0.05	0.01	0.05
Tusk	1	0.19				
White sole(witch)	1	0.16				
Whiting	17	0.05	0.21	0.09	0.05	0.07
Witch	5	0.05	0.22	0.10	0.07	0.08

Table C. Heavy metals and selenium, Denmark. All results are in **µg/kg** fresh weight.

Fish		Cd	Hg	Pb	Se	As	Sn
Angler	No	8	8	8	8	8	8
	Min	0	78	1.5	4010	207	0
	Max	0.2	246	27	32600	357	8.8
	Mean	0.09	149	6	14149	265	3
	Std.	0.10	72	9	8940	53	4
	Median	0.05	114	3	10695	270	0
Catfish	No	8	8	8	8	8	8
	Min	0	18.1	0.2	2210	168	0
	Max	3.8	228	4.63	15300	453	7.6
	Mean	0.73	71	1.5	6539	300	2.7
	Std.	1.29	72	1.5	4607	90	3.0
	Median	0.15	42.55	1.25	4390	301.5	1.75
Coalfish	No	10	10	10	10	10	
	Min	0.21	39.6	0	196	71	
	Max	3.2	277	22	326	6264	
	Mean	0.94	98	4.4	253	1357	
	Std.	0.85	73	6.4	36	1809	
	Median	0.755	61.45	2.8	250	896	
Cod roe	No	10	10	10	10	10	10
	Min	0	0.43	0.56	321	108	0
	Max	3	13	11	699	957	0.89
	Mean	1.73	5.42	4.77	489	486	0.22
	Std.	1.05	4.76	3.51	121	263	0.33
	Median	2.00	3.90	4.10	471	443	0.00
Escolar	No	4	4	4	4	4	4
	Min	11	272	0.9	495	388	0
	Max	28	898	8.1	1150	508	19
	Mean	16	627	3.2	844	450	7.3
	Std.	7.9	260	3.3	293	50	8.7
	Median	13	670	1.9	866	451	5.1
Greenland halibut	No	11	11	11	11	11	11
	Min	0.1	23	0	1050	157	0
	Max	4.2	169	13	6500	405	15.3

	Mean	0.9	75	2.7	3038	258	5.2
	Std.	1.2	50	3.8	1908	90	5.1
	Median	0.5	69.3	1.8	2400	232	4.1
Haddock	No	10	10	10	10	10	
	Min	0	6.09	0	176	46	
	Max	4.7	116	12	386	15906	
	Mean	0.6	37	5.6	270	8378	
	Std.	1.4	41	4.0	57	5181	
	Median	0.22	14	5.6	268	10002	
Hake	No	10	10	10	10	10	
	Min	0	11	0	238	73	
	Max	13	198	9.2	402	1862	
	Mean	3.8	58	2.7	307	532	
	Std.	5.1	60	2.9	61	636	
	Median	0.8	34	2.2	285	96	
Halibut	No	7	7	7	7	7	7
	Min	0	30	0	3540	263	0.5
	Max	0.8	160	6.81	10000	516	2.3
	Mean	0.1	116	1.9	6626	405	1.3
	Std.	0.3	49	2.4	2337	102	0.6
	Median	0	134	1	6400	416	1.2
Mackerel	No	2	2	2	2	2	2
	Min	0.2	74.8	0	32	183	1.7
	Max	0.3	102	0.9	52	341	5
	Mean	0.25	88	0.45	42	262	3.35
	Std.	0.07	19	0.64	14	112	2.33
	Median	0.25	88.4	0.45	42	262	3.35
Mackerel in tomato	No	11	11	11	11	11	11
	Min	1.1	22	0	151	44	0
	Max	15	53.1	7.6	1082	1094	0.61
	Mean	9.75	31	2.33	301	587	0.07
	Std.	3.52	10	2.83	262	472	0.18
	Median	10	26	1.2	243	873	0
Pike	No	2	2	2	2	2	2
	Min	0.2	74.8	0	32	183	1.7

	Max	0.3	102	0.9	52	341	5
	Mean	0.25	88.4	0.45	42	262	3.35
	Std.	0.07	19	0.64	14.14	112	2.33
	Median	0.25	88	0.45	42	262	3.35
Rainbow trout	No	10	10	10	10	10	
	Min	0	27	0	157	55	
	Max	1.4	75	3.8	198	2522	
	Mean	0.366	47	1.122	179	1128	
	Std.	0.41	15	1.32	15	785	
	Median	0.29	45	0.62	179	1037	
Ray	No	4	4	4	4	4	4
	Min	0.2	177	8.2	118000	409	0
	Max	3.3	451	27	257000	486	8.9
	Mean	1.2	271	15	195000	446	2.2
	Std.	1.4	123	8	67077	40	4.5
	Median	0.7	228	13	202500	444	0
Redfish	No	21	21	21	21	21	
	Min	0	1.5	0	92.9	15	
	Max	89.7	898	27	257000	15906	
	Mean	6	106	4	2145	735	
	Std.	20	189	6	3220	909	
	Median	0.39	30.2	1.6	620	461	
Salmon	No	14	14	14	14	14	
	Min	0	24	0	196	162	
	Max	2.1	111	11	317	2363	
	Mean	0.25	50	2	241	1214	
	Std.	0.56	28	3	37	595	
	Median	0	40	1.3	230	1254	
Shark	No	10	10	10	10	10	
	Min	0	181	0.7	234	143	
	Max	30.7	3475	25	940	17309	
	Mean	10	1071	6	387	3572	
	Std.	12	1087	7	203	5134	
	Median	4	513	5	308	1834	
Porbeagle	No	2	2	2	2	2	2

	Min	3.3	1860	4.9	1280	306	2.2
	Max	14	2570	5.7	2720	318	5.2
	Mean	8.65	2215	5.3	2000	312	3.7
	Std.	8	502	0.6	1018	8	2.1
	Median	8.65	2215	5.3	2000	312	3.7
Swordfish	No	7	7	7	7	7	7
	Min	9	221	0	436	397	0
	Max	66	985	5.7	2820	947	8.5
	Mean	11	980	5	744	2222	3.29
	Std.	20	278	2	837	201	2.98
	Median	19	340	2	625	613	1.90
Tuna	No	10	10	10	10	10	10
	Min	5	138	0	384	426	0
	Max	17.2	536	6.1	4120	777	29
	Mean	10	289	2.0	1369	680	8
	Std.	4	148	1.9	1164	106	10
	Median	9	249	1.6	1083	704	5
Tuna in oil	No	6	6	6	6	6	6
	Min	14	35	0.24	403	139	0
	Max	33	156	3.6	772	1264	4.2
	Mean	22	74	1.8	554	642	0.8
	Std.	7	42	1.1	132	510	1.7
	Median	22	64	1.7	537	620	0.2
Tuna in water	No	8	8	8	8	8	7
	Min	13	41.6	0	513	146	0
	Max	44.7	430	6.2	980	1134	0.98
	Mean	25	139	2.9	613	512	0.3
	Std.	12	130	2.2	154	429	0.4
	Median	21	75	2.6	568	284	0.0
Zander	No	5	5	5	5	5	5
	Min	0	42.4	0	30	107	0.9
	Max	44.7	430	8	980	1134	58.9
	Mean	0.2	120	0.1	47	128	14
	Std.	0.2	95	0.1	18	25	25
	Median	0.3	90.9	0.0	42	121	2.8

Table D. Heavy metals, Finland. All results are in mg/kg fresh weight.

	Merialue					Järvialue			
	vaihteluväli	ka	sd	n		vaihteluväli	ka	sd	n
Arseeni					**Arseeni**				
Silakka	0,16-1,08	0,39	0,18	55					
Kilohaili	0,47-0,67	0,56	0,07	6					
Kampela	0,42-0,43	0,43	0,003	2	Muikku	0,04-0,10	0,06	0,02	7
Lohi	0,36-0,96	0,72	0,24	8	Lahna	0,02-0,05	0,04	0,01	6
Siika	0,07-0,25	0,14	0,09	3	Siika	0,01-0,04	0,03	0,02	5
Made	0,05-0,15	0,09	0,05	3	Made	0,03-0,15	0,06	0,06	4
Kuha	0,09-0,22	0,16	0,08	4	Kuha	0,01-0,03	0,02	0,01	6
Ahven	0,02-0,29	0,13	0,09	9	Ahven	0,01-0,04	0,02	0,01	8
Hauki	0,05-0,17	0,12	0,04	6	Hauki	0,02-0,07	0,05	0,02	6
Elohopea					**Elohopea**				
Silakka	<0,005-0,11	0,03	0,02	55					
Kilohaili	0,02-0,03	0,02	0,01	6					
Kampela	0,04-0,05	0,05	0,01	2	Muikku	0,02-0,14	0,08	0,04	7
Lohi	0,05-0,10	0,07	0,02	8	Lahna	0,04-0,09	0,06	0,02	6
Siika	0,02-0,03	0,03	0,01	3	Siika	0,06-0,10	0,08	0,01	5
Made	0,20-0,35	0,26	0,08	3	Made	0,12-0,37	0,22	0,10	4
Kuha	0,06-0,18	0,11	0,06	4	Kuha	0,22-0,37	0,30	0,07	6
Ahven	0,08-1,35	0,34	0,39	9	Ahven	0,06-0,31	0,14	0,08	8
Hauki	0,15-0,85	0,40	0,24	6	Hauki	0,27-0,58	0,38	0,12	6
Kadmium					**Kadmium**				
Silakka	0,002-0,019	0,009	0,004	55					
Kilohaili	0,006-0,038	0,015	0,012	6					
Kampela	0,001	0,001	0	2	Muikku	0,003-0,024	0,008	0,007	7
Lohi	0,001	0,011	0	8	Lahna	0,001-0,006	0,003	0,002	6
Siika	<0,001-0,003	0,002	0,001	3	Siika	0,001-0,005	0,004	0,002	5
Made	<0,001			3	Made	<0,001-0,001	0,001	0	4
Kuha	0,001	0,001	0	4	Kuha	<0,001-0,002	0,001	0,0004	6
Ahven	<0,001-0,003	0,002	0,001	9	Ahven	0,001-0,007	0,003	0,002	8
Hauki	0,001-0,002	0,001	0,0004	6	Hauki	0,001-0,002	0,001	0,0005	6
Lyijy					**Lyijy**				
Silakka	<0,01-0,03	0,01	0,006	55					
Kilohaili	<0,01			6					
Kampela	<0,01			2	Muikku	0,01-0,03	0,01	0,01	7
Lohi	<0,01-0,01	0,01	0	8	Lahna	<0,01-0,01	0,01	0	6
Siika	<0,01-0,01	0,01	0	3	Siika	<0,01-0,01	0,01	0	5
Made	<0,01			3	Made	<0,01			4
Kuha	<0,01			4	Kuha	<0,01-0,01	0,01	0	6
Ahven	<0,01-0,02	0,02	0,01	9	Ahven	<0,01-0,01	0,01	0	8
Hauki	<0,01-0,02	0,02	0,01	6	Hauki	<0,01			6

Elohopea = mercury
Lyijy = lead
Ka = mean
Merialue = open sea
Järvialue = lake

Silakka = herring
Kilohaili = sprat
Kampela = flounder
Lohi = salmon
Siika = whitefish
Made = burbot
Kuha = pike-perch
Ahven = perch
Hauki = pike
Muikku = vendace
Lahna = bream

Table E. Dioxins, total TEQ (upper bound), Ireland. All results are in µg/kg fresh weight

Fish	n	Min	Max	Mean	Std	Median
Farmed Salmon	15	1.21975	2.855901	2.152465	0.459348	2.141462
Herring	4	0.931509	1.084424	1.017498	0.065892	1.027029
Herring, tinned	2	0.812932	0.81901	0.815971	0.004298	0.815971
Mackerel	4	0.973049	1.583891	1.238686	0.278751	1.198901
Mackerel, tinned	3	1.020526	2.127511	1.401217	0.629234	1.055613
Pink salmon, tinned	3	0.068225	0.098726	0.080944	0.015868	0.075881
Red salmon, tinned	2	0.341424	0.607842	0.474633	0.188386	0.474633
Salmon	10	0.410085	1.294823	0.800939	0.25546	0.76359
Salmon, smoked	11	0.974462	1.757837	1.272839	0.205329	1.269707
Sardines, tinned	1					
Tuna	5	0.61276	1.116782	0.904504	0.209445	0.988661
Tuna, tinned	5	0.042381	0.061299	0.050779	0.008674	0.050058

Also data for total TEQ lower bound as well as LB and UB for PCDD/F, dioxin like dioxins, and 7 marker PCBs are available.

Table F. Dioxins, dioxin-like PCBs and total TEQ, Denmark. All results are in µg/kg fresh weight

Fish	Catching place	No. Of samples	Minimum	Maximum	Mean	Median
Dioxins						
Farmed trout		20	0.07	0.75	0.29	0.17
Herring	North Sea and Belts	13	0.36	2.89	1.08	0.99
Herring	South Baltic Sea west of Bornholm	10	0.95	2.76	1.79	1.65
Herring	South Baltic Sea east of Bornholm	4	2.79	7.78	5.71	6.13
Eel	The Sound	5	1.11	3.94	2.29	2.12
Eel	The Kattegat west of Hirsholmen	5	0.65	1.19	0.89	0.93
Dioxin like PCBs (mono and ortho PCB)						
Farmed trout		20	0.17	0.78	0.45	1.92
Herring	North Sea and Belts	13	0.31	1.21	1.04	1.86
Herring	South Baltic Sea west of Bornholm	10	1.29	2.18	2.07	3.04
Herring	South Baltic Sea east of Bornholm	4	2.65	5.17	5.3	7.09
Eel	The Sound	5	2.44	6.02	6.79	7.88
Eel	The Kattegat west of Hirsholmen	5	1.83	2.43	2.31	2.91
Total TEQ						
Farmed trout		20	0.26	1.07	0.59	2.74
Herring	North Sea and Belts	13	0.68	2.3	2.04	7.58
Herring	South Baltic Sea west of Bornholm	10	2.3	3.97	3.6	5.94
Herring	South Baltic Sea east of Bornholm	4	5.44	10.88	11.43	15.22
Eel	The Sound	5	3.56	8.31	9.38	12.24
Eel	The Kattegat west of Hirsholmen	5	2.48	3.33	3.28	4.05

Tabel G. Dioxins, total TEQ (lower bound). All results are in µg/kg fresh weight

Year	2004	2002	2002	2002	2003	2002	2002	2002	2002/2003
Fish	Farmed Rainbow trout	IL Burbot	BS Burbot	IL Bream	BS Bream	IL Pike-perch	BS Pike-perch	IL Perch	BS Perch
Mean	0.440	0.252	0.191	2.005	2.011	0.427	1.298	0.249	2.292
Median	0.369	0.165	0.178	1.359	2.239	0.296	1.217	0.271	1.845
Standard Deviation	0.132	0.248	0.066	1.628	1.110	0.279	0.654	0.139	1.482
Minimum	0.360	0.059	0.132	0.370	0.805	0.141	0.720	0.076	0.529
Maximum	0.592	0.532	0.262	4.583	2.990	0.813	2.038	0.440	5.230
No. Of samples	3	3	3	6	3	6	4	6	11

Year	2002	2002	2002	2003	2002	2002	2003	2003	2003
Fish	IL Pike	BS Pike	IL Vendace	BS Vendace	IL Whitefish	BS Whitefish	IL Smelt	BS Roach	River lamprey
Mean	0.430	0.903	0.898	0.602	0.832	2.803	0.514	0.506	7.379
Median	0.204	0.827	0.746	0.569	0.583	2.705	0.514	0.399	7.623
Standard Deviation	0.581	0.382	0.660	0.218	0.919	1.756	0.122	0.188	1.403
Minimum	0.068	0.447	0.364	0.402	0.163	1.196	0.428	0.396	5.870
Maximum	1.597	1.388	2.302	0.835	2.623	7.068	0.600	0.724	8.643
No. Of samples	6	6	9	3	6	10	2	3	3

Year	2002	2002	2002/2003	2002	2002	2002	2002
Fish	BS Sprat	BS Salmon	BS Flounder	Baltic Herring	Baltic Herring, fried	Baltic Herring, marinated	Baltic Herring, smoked
Mean	2.153	10.293	1.595	5.424	10.539	12.660	14.693
Median	2.377	10.242	1.422	3.124	10.625	13.009	14.676
Standard Deviation	0.940	5.529	0.458	5.021	0.913	1.440	4.787
Minimum	0.875	2.310	1.267	0.686	9.586	11.077	9.458
Maximum	2.980	17.372	2.271	17.715	11.405	13.893	19.964
No of samples	4	8	4	47	3	3	4