

Dietary Mercury Exposure
in selected Norwegian
Municipalities
The Norwegian Fish and
Game Study, part C

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Dietary Mercury Exposure in selected Norwegian Municipalities. The Norwegian Fish and Game Study,
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BACKGROUND

Improved and detailed knowledge regarding dietary mercury exposure in the Norwegian population is considered important as part of a national monitoring of exposure to hazardous environmental contaminants. Mercury is still regarded an important pollutant in Norway, reflected in the priority list for the Norwegian Pollution Control Authority (Norwegian: Statens forurensningstilsyn, SFT) from 1996. This priority list, defined politically by the Norwegian Parliament, includes about 30 different chemical pollutants and is aimed at ending, or substantially decreasing, emissions of the chemicals listed. Mercury is also found on the “obs-list”, which is the environmental authorities’ list of health and environment threatening chemicals that may represent a particular problem on a national level. The proclaimed goal by the Norwegian environmental authorities concerning mercury is that emissions should be “substantially decreased, at latest by the year 2010” (SFT 2004).

Mercury is a metal that may be released from both natural and anthropogenic sources. It is estimated that less than half of the mercury pollution in Norway is released from national sources, the rest being depositions from atmospheric transportation from abroad (Berg et al. 2003). As mercury is able to circulate in the atmosphere probably as long as one year, it may be transported very long distances and is thus an issue of international concern. Even though many western countries (Norway included) have decreased their mercury releases during the last decade, countries in both Asia and Africa have had a substantial increase in their emissions (Fjeld & Rognerud 2003). This means that international agreements are necessary for an effective handling of the problem, and the United Nations are currently working on efforts to reach international agreements regarding the use of mercury (UNEP 2002).

This does not negate, however, that local industrial emissions have been of great importance for local contamination in some parts of Norway. In the year 2000 it was estimated that about 290 kg of mercury were released from national sources in Norway, and about 50 % of this was discharged directly into sea and lakes (Berg et al. 2003). The most important sources in Norway is offshore industry (about 42 % of national releases in 2000), garbage disposals and renovation systems (21 %) and metal production (12 %) (Berg et al. 2003).

One important implication of the long-distance atmospheric mercury transportation is that increased levels of mercury have been found in many lakes in the Scandinavian countries (Fjeld & Rognerud 2003). Studies have shown a north-south gradient of mercury levels in Norway, with higher levels in lake sediments and soils in the southern parts (Berg et al 2003).

Internationally, the major concern regarding mercury in the environment is dietary exposure through the consumption of freshwater and marine fish (WHO 1996). Also in Norway, several studies have shown that mercury concentrations in pike, perch and trout in some locations may be above the maximum level permitted on the commercial market (defined by the Norwegian Food Control Authority: 0.5 mg/kg generally and 1.0 mg/kg for pike) (Fjeld et al. 2001). However, although it is evident that especially freshwater fish may contain higher concentrations than what is considered safe for human consumption, no detailed monitoring of mercury concentrations exist for Norwegian lakes. Thus fish consumption restrictions for freshwater fish have been given on a general basis, and include avoiding consumption of pike, of perch above 25 cm, and trout and charr weighing more than 1 kg. These advises are primarily directed against pregnant and breast-feeding women, although the general

population is recommended not to eat these fishes more than once a month on a yearly basis (Matportalen 2004a)

Some fjords have also been affected by local industrial pollution, and currently the Norwegian Food Safety Authority (Norwegian: Mattilsynet) recommend avoiding consumption of fish from Sørkjøya due to the high levels of mercury found in fish from this fjord (last evaluated in 2003) (Matportalen 2004b).

Mercury as a public health problem

In the general population, the most important source of mercury exposure is food consumption. The most important chemical form of exposure is organic mercury (UNEP 2002).

Of the various organic mercury forms found, methylmercury is the most important and most toxic. This is also the predominant chemical form of mercury found in seafood (UNEP 2002). It is known that all types of mercury in the environment may be transformed by micro-organisms into organic (mainly methyl-) mercury when released into aquatic systems (Clarkson 2002). This methylation process is the first step for entering the food chain, as organic mercury is easier accumulated than inorganic mercury. Organic mercury reaches fish and shellfish as it is easily taken up by plankton, and thus starts bioaccumulating in the aquatic food chains until it reaches the highest levels in predatory fish or marine mammals at the upper end of the chains (WHO 1996). Due to this bioaccumulation, the highest levels may be found in fish that are higher predators or get very old and big. This means that fish like pike, perch, halibut, tuna and lake trout are among the fish species that may accumulate potentially high levels of mercury. As humans are on the top of the food chain, people who consume a lot of fish and seafood may be exposed to potentially high levels of mercury (WHO 1996).

The amount of methylmercury in relation to total mercury in fish is varying, but is estimated to be in the order of about 90 – 95 % or more (Fjeld & Rognerud 2003). Other researchers calculate with methylmercury variations in fish between 70 and 90 % of total mercury concentrations (Sanzo et al. 2001), or with 80 – 100 % (Claisse et al. 2001). In other types of food the amount of methylmercury is generally lower, with inorganic mercury being the predominant form. Data on this is less available than for seafood, but according to Claisse et al. (2001), the amount of methylmercury is 10 – 30 % in plants, 20 – 80 % in invertebrates and 80-100 % in fish and higher predators (like birds and mammals).

Mercury and health

In humans, about 95 % of the methylmercury from fish is absorbed in the gastrointestinal tract (National Research Council 2000). Methylmercury is water-soluble, but may cross the blood-brain barrier by forming a mercury-cysteine-complex (Clarkson 2002). It may also cross the placenta and thus reach the foetus. The whole-body half-life of methylmercury in humans has been estimated to be 70-80 days (National Research Council 2000). However, this depends on several factors, and according to Hightower, the average half-life for methylmercury in children is 90 days and in lactating women 46 days (Hightower & Moore 2003). Excretion of

methylmercury happens mainly through the bile and faeces, at a daily rate of about 1 % of the body burden (National Research Council 2000). Additionally, mercury has also been found in breast milk among mothers with a diet high in fish and/or marine mammals (Oskarsson et al. 1996, Grandjean et al. 1995). Methylmercury may constitute a substantial part of mercury found in breast milk (Grandjean et al. 1994).

About 10 % of the body burden of methylmercury is found in the brain, where it is slowly converted to inorganic mercury compounds. The inorganic mercury has a very long half-life in the brain. No consensus have been reached yet regarding whether it is the organic, the inorganic or both chemical forms that causes the damages seen in brain tissues (National Research Council 2000). Approximately 5 % of the total body burden of methylmercury is found in blood, and more than 90 % of this is bound to the red blood cells.

Regarding inorganic mercury from food, only about 7–15 % is absorbed from the gastrointestinal tract. The primary target organ is the kidneys where it may cause renal damage (National Research Council 2000).

The health effects of mercury depend on the chemical form the exposure occurs in. Methylmercury is considered the most toxic form, and may cause damages in several organs like kidneys, the liver and the reproductive organs (JECFA 2003). However, there is general agreement about the brain being the most critical organ for methylmercury toxicity (National Research Council 2000, JECFA 2003). The developing nervous system has been identified as more sensitive to exposure than the mature organ. This means that the foetal stage and the early postnatal period are the most critical periods for exposure.

The first symptom appearing in adults after toxic levels of methylmercury exposure is paresthesia (numbness), followed by loss of co-ordination, loss of articulation, constriction of the visual field and loss of hearing. Eventually it may lead to paralysis and death. These neurological effects are results from the loss of neuronal cells in specific parts of the brain. There may be a latency period of weeks or months from exposure to the onset of symptoms, depending on the dose and the exposure period (Clarkson 2002).

The last decade there has also been an increased interest in the effects of methylmercury exposure on cardiovascular disease. A Finnish study among 1 833 men found a more than 2-fold increased risk of having an acute myocardial infarct among men consuming more than 30 g of fish per day (Salonen et al. 1995). The conclusion in this study was that mercury from freshwater fish was the possible cause of this increased risk. Other studies have also indicated a positive relationship between mercury exposure and markers for cardiovascular disease (Guallar et al. 2002) (National Research Council 2000). On the other hand, an American study showed no significant relationships between total mercury exposure and risk of coronary heart disease (Yoshizawa et al. 2002). However, when a subgroup of dentists was excluded from these analyses, a weak association was found and the conclusion was that a possible relation could not be ruled out. Also in a recently published follow-up study of a Faeroes birth cohort of 813 children now 14 years of age, it was concluded that methylmercury exposure was associated with effects on the autonomic function of the heart (Grandjean et al. 2004).

In their meeting in June 2003, JECFA (the Joint WHO and FAO Expert Committee for Food Additives and Contaminants) concluded that the evidence is still not clear regarding potential

effects on the cardiovascular system and that further studies are required (JECFA 2003). However, some researchers like Clarkson (2002) have suggested that the issue of methylmercury exposure and cardiovascular disease may challenge the currently dominating view of the brain being the most sensitive organ for mercury toxicity.

Defining tolerable levels of mercury intake

An important characteristic of environmental contaminants is that they have a very long half-life, and thus need a long time to “break down” once they have entered nature. It is increasingly evident today that human activities create excess products that do not disappear when disposed neither into the air, the soil or the oceans. This means that public health authorities need to work on defining what may be called tolerable exposure levels, as it seems inevitable to avoid human exposure at least for many decades still.

Another important characteristic of environmental contaminants, mercury included, is that even very low doses of exposure may cause adverse health effects. However, no general consensus has yet been reached internationally regarding safe intake levels and the effects of long-time, low-level exposure of mercury. Evidence from epidemiological studies are contradictory regarding the levels of exposure needed before the eventual onset of symptoms (Jacobson 2001). In a cohort study in the Faeroe Islands, associations have been found between prenatal methylmercury exposure and impaired function in function-fine motor, sustained attention, short-term memory, vocabulary and learning in 917 children at 7 years age (Jacobson 2001). However, in a Seychelles cohort of 711 children that were evaluated at 5.5 years of age, no associations have been found between prenatal mercury exposure and developmental outcome. Later investigations and follow-ups at older ages of the Seychelles cohort have not altered the conclusions drawn at the first investigation (Myers et al. 2003).

The previous WHO definition of tolerable exposure levels of mercury were from 1972, based on data from the poisoning incidents in Minamata Bay, Japan, in the 1950s and 60s (Myers & Davidson 2000). They have been reaffirmed several times, in spite of a general agreement that these levels may not sufficiently protect the vulnerable foetus. However, in their meeting in June 2003, JECFA re-evaluated the most recent data from the above mentioned epidemiological studies in the Seychelles and the Faeroes Islands. Due to the contradictory findings in these studies, the committee chose to use the average of the two studies to estimate the exposure level without observable effects (JECFA 2003). The tolerable weekly intake level (PTWI) is now set at 1.6 µg/kg bodyweight (0.23 µg/kg/day) for methylmercury, a level presumed to be safe also for the developing foetus. The new evaluation from JECFA reduced the previously defined safe intake level from 3.3 µg/kg/week (0.47 µg/kg/day) for methylmercury, but did not change the upper safe intake level of total mercury, which is still defined as 5 µg/kg/week (0.71 µg/kg/day) (JECFA 2003).

The Norwegian Food Safety Authority uses the definitions set by JECFA as guidelines for protecting the Norwegian population. However, other public health agencies have defined lower levels of tolerable exposure doses. The U.S. Environmental Protection Agency defined an oral reference dose of 0.1 µg/kg/day for intakes of methylmercury. The U.S. Food and Drug Administration has defined a tolerable level of 0.5 µg/kg/day for total mercury exposure, while the Agency for Toxic Substances and Disease Registry has set a safe level of 0.3 µg/kg/day for total mercury intake (Clarkson 2002).

Assessing dietary mercury exposure

An important part of the risk assessment of any chemical is assessing the exposure, i.e. producing a quantification of the exposure levels in a defined population. However, doing risk assessment of environmental contaminants on a population basis in Norway has not been easy. This has partly been due to the lack of precise knowledge about the intakes in the Norwegian population of foods that may have high levels of contaminants. These foods are typically different species of fish, crustaceans, game, offal of game and wild mushrooms. The consumption of these types of food is low in the general Norwegian population, which means that they are normally not included in dietary surveys (Meltzer et al. 2002). Hence it has been difficult to estimate dietary intake levels of environmental contaminants, mercury included, on a population level.

As a consequence of the lack of detailed information on this, the Norwegian Food Control Authority (now named the Norwegian Food Safety Authority) and the Norwegian Institute of Public Health started a project in 1998 with the intention of describing the consumption of fish and game in the Norwegian population. The project was called the Norwegian Fish and Game Study, and has been conducted in three parts, A, B and C. Part C, of which this study is a part, started in January 2003. The practical parts of part A and B are now finished.

The Norwegian Fish and Game Study aims to get information about dietary intake levels of environmental contaminants in the Norwegian population. The main focus is on mercury, cadmium, PCB and dioxins. The objectives of the study are to give a better description of exposure to these contaminants in the population, to reveal eventual unknown highly exposed groups, and to give estimates of exposure levels in particularly vulnerable groups.

Part A of the study was a national survey of consumption frequencies of specific foods considered having potentially high levels of environmental contaminants. 10 000 persons were invited, of which 60 % responded. One of the main findings in this part is that regional differences is the main factor explaining differences in consumption of fish and game (Meltzer et al. 2002). The study also confirmed that the consumption of high-risk foods was skewed in the population. This means that even though most people consume high-risk foods seldom or never, there are a number of people who consume these types of foods frequently and may thus be highly exposed to environmental contaminants.

Part B was a regional survey in 27 selected inland and coastal municipalities with good access to hunting and fishing locations. The selection of municipalities was based on hunting statistics and questionnaires distributed to all municipal food control agencies in the country (described in Bergsten 2004). Due to the ample supply of seafood and/or game in these municipalities, it was expected that consumption of relevant foods would be higher than in the normal population. The questionnaire used in part B was more detailed both concerning frequencies and types of foods than in part A. 10 000 persons were invited, of which 55 % responded. The report from part B is still in-press, but has been released electronically on the website of the Norwegian Food Control Agency (www.mattilsynet.no). One of the main findings from Part B supports the one from part A that regional differences are the main factor explaining consumption of seafood and game (Bergsten 2004).

Part C is the ongoing project of which this study is a part. The aim of part C in general is to do an exposure assessment of people being high consumers of foods that may contain high

levels of environmental contaminants. The exposure assessments will be based on both intake estimates from food consumption data and analyses of blood and urine samples. The data collected in part C will eventually be used to investigate whether it is possible to establish a dose-response relationship between food intake and blood levels of mercury, cadmium and PCB/dioxins. Part C is conducted in the same municipalities as part B.

This study will be focusing on mercury intakes related to food consumption data. These data are important because they provide estimates of dietary mercury exposure based on a comprehensive survey of the diets, and are as such differing from part A and B where only intakes from selected, presumed high-risk foods were investigated. The study will therefore give a contribution to the exposure-assessment in the selected municipalities, and provide information about dietary mercury exposure in parts of Norway where consumption of high risk foods are believed to be high. This information will as such contribute to a risk-assessment of dietary mercury intakes in Norway, based on the complete datasets from all the three parts A, B and C of the Norwegian Fish and Game Study.

AIM

The overall aim of the study is to get more detailed knowledge about levels and sources of dietary mercury exposure in Norway. Specifically, this study aims at estimating dietary mercury exposure among both high-end consumers of potential high-risk foods and the general population in selected Norwegian municipalities.

Research focus

- Estimate dietary mercury intakes in a sample of high consumers of seafood and game and in a reference group.
- Investigate whether dietary mercury exposure is related to sex, age groups, education or geographic location in the two consumer groups.
- Describe which foods contribute most to mercury intake in the two consumer groups.
- Investigate if high-consumers of mercury—rich foods will exceed the Tolerable Weekly Intake of mercury as defined by WHO.

When the term “Seafood” is used as a category in the following text, it includes all the questions in the questionnaire regarding consumption of both unprocessed fish, fish products, crustaceans, blue mussels, fish for sandwich, roe and fish liver.

METHOD

This is an in-depth study, which is part of a follow-up of the data collected in the two preceding parts A and B of the Norwegian Fish and Game Study. A retrospective design is used, with 12-months recall of dietary consumption among two different fish- and game consumer groups.

Selection procedures

The participants in this study were mainly selected among the 5502 participants from part B of the Fish and Game Study. Additionally, 6 persons were specially invited, as they were somehow known by the project group to have very high intakes of relevant seafood. 5 of them agreed to participate.

Part B was conducted in 14 coastal and 13 inland municipalities (map, appendix 1), selected due to their good access to hunting and fishing locations and therefore with a presumed high intake of fish, crustaceans and/or game (Meltzer et al. 2002). Hence the part C participants were also selected from these municipalities, except for the 6 specially invited.

The participants in part C were selected as two different samples; one of individually selected persons based on the consumption-data in part B and the other as a random sample of part B participants. This method was chosen to secure enough participants with a presumed high intake of mercury, while at the same time aiming at getting data from a sample with a range of intake levels of the contaminants in question. This was desirable as the main aim of part C is to investigate whether it is possible to make a dose-response relationship between food consumption data and blood/urine samples.

Selection of high consumers

The individual selections of presumed high consumers were based on consumption data from part B. Estimates of mercury intakes were calculated, based on preliminary estimates of average mercury content in the foods included in the part B questionnaire. High consumers of mercury were selected from the 95th percentile and above, ending up with a group of 196 persons selected on this basis (Table 1).

The same procedures were performed for cadmium and PCB/dioxins, thus selecting additionally 242 persons from the 97.5 percentile and above as potential high consumers of one these two contaminants. As many of the foods included in this survey may have high levels of more than one of the contaminants in question, people were recognised as being in two or even all three of the high intake groups. This overlapping between intake groups was not formally registered, but was substantial for the high consumers of mercury especially in relation to the high consumer group of PCB/dioxins. The group of individually selected participants is therefore treated as one sample, having in common that they are high consumers of contaminant-rich foods, i.e. seafood and game.

Although the primary source of individual selections was intakes of the different contaminants, attention was also directed on getting a balanced distribution in the sample with respect to sex and age group. As part A of the Norwegian Fish and Game Study showed that the youngest and the oldest age groups had the lowest response rates (Meltzer et al. 2002), special attention was given to include the highest possible number in these two groups.

Selection of reference group

The other group was selected by random sampling (by SPSS) from the part B participants, ending up with even distributions regarding the variables sex and age groups and a symmetric distribution of intake levels of the three contaminants. 267 persons (38%) were selected using this procedure (Table 1).

The number of participants invited to this study reflected the considerations connected to the aim of part C in general, which included the necessity of performing a number of blood- and urine analyses. As this is very expensive, the number of participants had to take account of these economic considerations, and was balanced against the number required to perform adequate statistical analyses.

Sample

121 of the high consumers and 78 persons from the reference group returned their questionnaires (in total 199 persons, which give an overall response rate of 28 %). The response rate in the group of high consumers is 28 %, and in the reference group 29 % (Table 1). There are slightly more participants in the mercury-group than in the other two high-intake groups.

Table 1. Invited and participants in the different intake groups, absolute number and percent, with response rates in the respective groups.

	Invited		Participants		Response rate
	N	% of the invited	N	% of the participants	%
Mercury	196	28	48	24	24
Cadmium	157	22	39	20	25
PCB/ dioxin	137	19	45	23	33
High-consumer group, total	438	62	121	61	28
Reference group	267	38	78	39	29
Total	705		199		28

In the group of high consumers, there are a few more women (52 %) than men (48 %) (Table 2). There are also less people in the youngest age group (21-40), with only 17 % compared to the oldest age group (61+) which constitutes 45 %.

Method

More of the high consumers live in the coastal municipalities, 57 % versus 43 % in inland municipalities. Regarding education, there are only small differences in size between the three different educational levels, varying from 31 to 34 % of the group.

In the reference group, the distribution of sex is similar to the high consumer group with a few more women (54 %) than men (46 %). Regarding age, the group 41-60 has the highest share with 44 % of the group. There are only small differences between the other two age groups.

Concerning geographical area, 60 % of the reference group live inland municipalities and 40% in coastal municipalities, a distribution that differs from the high consumer group where there are more people living in coastal municipalities.

Regarding education in the reference group, the distribution is more skewed than in the high consumer group, with more of the participants having higher education in the reference group.

Table 2. The distribution of sex, age groups, geographic location and educational level among invited and respondents, with response rates, in the two consumer groups.

	High Consumers			Reference Group		
	Invited	Participants	Response rate	Invited	Participants	Response rate
	N (%)	N (%)	%	N (%)	N (%)	%
Men	222 (51)	58 (48)	26	133 (50)	35 (45)	26
Women	216 (49)	63 (52)	29	134 (50)	43 (55)	32
Coast	252 (58)	69 (57)	27	127 (48)	31 (40)	24
Inland	186 (42)	52 (43)	28	140 (52)	47 (60)	34
Age 21-40	119 (27)	20 (17)	17	91 (34)	20 (27)	22
Age 41-60	170 (39)	48 (39)	28	113 (42)	34 (44)	30
Age 61 +	148 (34)	53 (45)	36	63 (24)	24 (30)	38
Primary level	121 (28)	41 (34)	34	62 (23)	16 (21)	26
Upper secondary level	172 (39)	37 (31)	22	114 (43)	28 (36)	25
University level	129 (29)	37 (31)	29	77 (29)	31 (40)	40
Missing educational information	16 (4)	6 (5)	38	14 (5)	3 (4)	21
Total	438	121	28	267	78	29

There are more women than men in both consumer groups, and the distribution of sex related to other background variables are shown in Table 3. There are a few more women than men in both consumer groups who live in the inland municipalities, while there are only small differences between men and women in the coastal municipalities. Regarding educational level, more women tend to have higher education in both consumer groups.

Method

In the different age groups, the difference between number of women and men is biggest in the youngest age group in the reference group. Among high consumers, there are more women than men in the oldest age group, while among the references there are a few more men than women.

Table 3. Distribution of sex related to background variables, in the group of high consumers and in the reference group

	High consumers N = 121			Reference group N = 78		
	Men	Women	Total	Men	Women	Total
Coast	34	35	69	15	16	31
Inland	24	28	52	20	27	47
Age 21-40	9	11	20	5	15	20
Age 41-60	25	23	48	16	18	34
Age 61 +	24	29	53	14	10	24
Primary level	21	20	41	7	9	16
Upper secondary level	18	19	37	13	15	28
University	15	22	37	13	18	31
Mercury	26	22	48			
Cadmium, PCB/dioxin	32	41	73			
References				35	43	78

Data collection

Data regarding food consumption were collected using two self-administered questionnaires, distributed by mail. This was done during spring 2003.

During February 2003 an invitation letter was distributed to 233 high consumers and 267 references, together with a thorough description of the background and purpose of part C of the Fish and Game Study (appendix 2). During the first week of March, a reminder letter was sent to the 374 persons that had not given any response yet (positively or negatively). At this point, the response rate was only about 25 % and it was thus decided to invite more persons to the study. Invitations were distributed to 205 persons more, all in the high-consumer group. A reminder letter was sent to the second group of invited by the end of March. Deadline for inclusion of participants was set at the end of April, and by this time 133 high consumers and 82 references had agreed to participate.

During March and April the two questionnaires were distributed to the 215 who agreed to participate. A new reminder letter regarding the questionnaires was distributed during April and May.

By mid June 199 persons (121 high-consumers and 78 references) had returned their questionnaires, and deadline for inclusion of returned questionnaires was decided at this point. However, no questionnaires were received after this date.

The questionnaires were self-administered. As questionnaire I is large and may be experienced as quite complex to fill in, telephone assistance was offered in the instruction letter distributed together with the questionnaires. However, only one person used this opportunity.

A symbolic reward of 400 Norwegian kroner in the form of a gift voucher was used to motivate the invited for participating in the study, and were given to all those who completed both the blood and urine samples and the questionnaires, all together 196 persons.

Data from part B regarding educational level have been used in this study, as this information was not collected in part C. This was possible due to a common identification number used in part B and C.

Description of instrument

Two questionnaires have been used for collecting the data; a 1-page questionnaire asking mainly for demographic and other background information, and the main 12-page food-frequency questionnaire (FFQ).

The 1-page questionnaire was designed especially for part C of the Fish and Game Study. This form contains 9 questions concerning demographic data, eventual breast-feeding, smoking habits and if any additional foods are consumed that have not been revealed in the main questionnaire (appendix 3).

The main 12-page questionnaire is a modified version of a questionnaire used in The Norwegian Mother and Child Cohort Study, which has the purpose of assessing dietary habits during pregnancy. The original questionnaire is found electronically on the web-site of the Norwegian Institute of Public Health (Den Norske mor og barn undersøkelsen 2004). The modifications mean that the original questions addressing diet during pregnancy are replaced by questions concerning the diet during the last 12 months. One question about changes in intakes of dairy products have been replaced by changes in consumption of foods more relevant for the environmental toxicants in question, i.e. fish species, crustaceans and game (question 31). Finally, seven questions concerning pregnancy related health problems were excluded in the version used in the Fish and Game Study (questions 32-38).

The Mother and Child questionnaire was originally developed at the Norwegian Institute of Public Health in 2001, and is currently in the process of being validated. The decision to use an already existing questionnaire was based on both practical and economic considerations. The Mother and Child questionnaire covers a wide variety of foods, and therefore includes information on frequencies of fish and game consumption. Thus the potential advantages of designing a form especially for this study were not seen as outweighing the economic and timesaving effects of using the above described modification.

The FFQ used has a semi-quantitative design. This means that portion sizes are collected only for foods that are consumed in typical portions, like bread slices or cups of coffee (Serdula et al. 2001). The frequencies for the other foods have been transformed into food consumption using standardised, gender specific portion sizes. A total of 327 questions concerning food intake are included in the questionnaire, of which 34 are related to consumption of seafood. All the questions ask for mean consumption frequencies of the last 12 months, and with three exceptions, they are all presented as closed questions.

Mercury database

The collection of a database on mercury contents in different foods was done during August and September 2003 (Appendix 4). This work consisted of searching for available and relevant data on analyses of mercury content in all the food items listed in the food frequency questionnaire. The search quickly revealed that these kinds of data did not exist for all food items listed. It was therefore attempted to make the most comprehensive list possible, based on both Norwegian analyses and, when necessary, analyses from other Nordic countries. Part of this work was done in co-operation with project members from the Norwegian Food Safety Authority.

Norwegian analyses were only available for different types of seafood. As seafood anyhow is considered the most important source of dietary mercury exposure (due to both the chemical form and the high concentrations found), it was considered being most important to use Norwegian data for these. For other foods than fish, crustaceans and bivalves, it was decided to use Finnish data (Koivistoinen (ed.) 1980).

For foods with a mercury content that was below the limit of detection, two different approaches were used. For milk, milk products, cheese etc, one tenth of the detection limit was set as the value. For meat and mixed dishes such as lasagne etc, half the detection limit was used.

Analyses

During June 2003 the FFQs were optically scanned at the Medical Birth Registry in Bergen. The data from the 1-page questionnaires were manually punched in an SPSS-file.

All data analyses have been conducted using SPSS, version 11.0. As the intake data of mercury proved to be non-symmetric and the samples are considered to be of medium sizes, the empirical intake estimates are displayed using percentiles.

Logarithmic transformations to the base e were performed on mercury data to obtain a more symmetric distribution, as described in literature of medical statistics (Altman 1991). Assumptions of normality were assessed as sufficiently met after inspection of residuals plot (Altman 1991). T-tests and One-Way ANOVA tests were conducted on the transformed data to reveal eventual statistical significant differences between groups, and Univariate General Linear Model to test for interactions between variables. Standard multiple regression analyses has been performed to investigate relationships between different variables of interest.

Non-parametric tests (Mann-Whitney and Kruskal Wallis test) on the empirical mercury data were also performed to investigate differences between groups, and no discrepancies were found compared to the parametric tests.

5% is chosen as the accepted level of statistical significance to assess whether observed differences are due to random chance or not. Missing values in the questionnaire have been interpreted as “no consumption”.

Validity

In all surveys the researcher has to make choices and priorities on how much information one should ask for. In the FFQ used in this study, no information on portion sizes has been obtained from the participants themselves. According to a review made by Cade (Cade et al. 2002), research has shown that individuals have difficulties when they are supposed to estimate portion sizes themselves. In this study, gender specific, standardised portion sizes have been used. The portion sizes have been estimated by two nutritionists who are members of the project group, based on portions sizes from a national dietary survey conducted in 1997 (Norkost 1997).

The intakes of several of the foods of most interest in this study are to a high extent depending on seasonal variations, like crustaceans. The participants have explicitly been reminded in the questionnaire to remember eventual seasonal food items consumed, to diminish the extent of recall bias among the respondents. However, recall bias may never completely be ruled out as a source of a misinformation in a retrospective study.

To be able to make estimates of mercury intakes in this study, it has been necessary to estimate average contents of mercury in each of the food items asked for. There may be big variations in how much mercury one fish specie contains, due to geographic location, age, size and trophic level. This means that when estimating average intake of mercury for one person based on food consumption data, it is not likely that this is the exact actual intake for this specific person. However, we have chosen to use average contents of samples, as this still may give a relevant indication of possible intakes on a population level. One of the aims with later phases of part C is to make analyses of the collected blood and urine samples, and this will be a way of evaluating and validating the intake estimates in this study.

The 1-page questionnaire asked if any extra foods had been consumed that had not been mentioned in questionnaire I. About 30 % filled in foods in this question. These answers have been a useful quality check of the main questionnaire as we can see that the majority of foods mentioned had already been asked for in the FFQ. However, these answers have not been taken into account in any analyses.

External validity is connected to the generalizability of a study and to whom the study has relevance. The participants in this study come from 27 selected municipalities in Norway, as described above. Hence the results obtained from the two consumer groups are representing only the municipalities included in the survey.

However, these municipalities were selected because of high availability of high-risk foods. This means it is possible to interpret the sample of high consumers as being among the high-

end consumers also on a national level. In this regard, the results from the high consumer group are relevant also in a national perspective as indications of upper exposure levels.

Concerning the reference group, there is no obvious reason to believe that a random sample from the selected municipalities is very different from the general Norwegian population. This means that even though the reference group is selected from the 27 municipalities included in the study, the intake estimates are relevant to interpret at least as suggestions of exposure levels also for the general Norwegian population. Nevertheless, due to the low response rate in the study, the generalizability of the findings in this study is further explored in the discussion of the results later in the paper.

Ethical considerations

The Ethical Committee and the Norwegian Data Inspectorate approved the study in 2002. All data have been treated confidentially, and ID numbers have been used through all analyses to make sure that all information is treated anonymously.

Co-operation

The project group attached to the Norwegian Fish and Game Study consists of Helle Margrete Meltzer (project leader), Hein Stigum, Georg Becher, Catherine Thomsen, Helle Knutsen, Margaretha Haugen (Norwegian Institute of Public Health), Christina Bergsten, Marie Louise Wiborg (Norwegian Food Control Authority), Kerstin Trygg (Departement of Nutrition, University of Oslo), Helen E. Kvalem, Ingrid Fange and Gunhild Mangerud (students).

Kvalem, Mangerud and Meltzer have conducted the practical work of Part C of the study, while Haugen has been responsible for the development of the computer program processing the FFQ.

RESULTS

Intake of mercury

The results in this study confirm that the intakes of both total mercury (Hg) and seafood Hg are significantly higher in the group defined as high consumers than in the reference group ($p < 0.0005$ for both variables, by independent samples T-test). Still, a wide range of intake levels of both total Hg and seafood Hg is found both among those selected as high consumers and in the reference group (Table 4). It was therefore considered to make all analyses based on treating the participants as one group. However, using a mixed sample would have had severe effects on the generalizability of the results, and hence the grouping of the two samples were kept as originally defined.

The distribution of intake levels in both intake groups is skewed as illustrated by the histograms in Figure 1a and 1b. The tales to the right illustrates a few respondents having a higher exposure level to Hg than the rest of the sample, and when comparing the two figures it is clear that the reference group has a slightly more symmetric distribution in Hg intake than the group of high consumers.

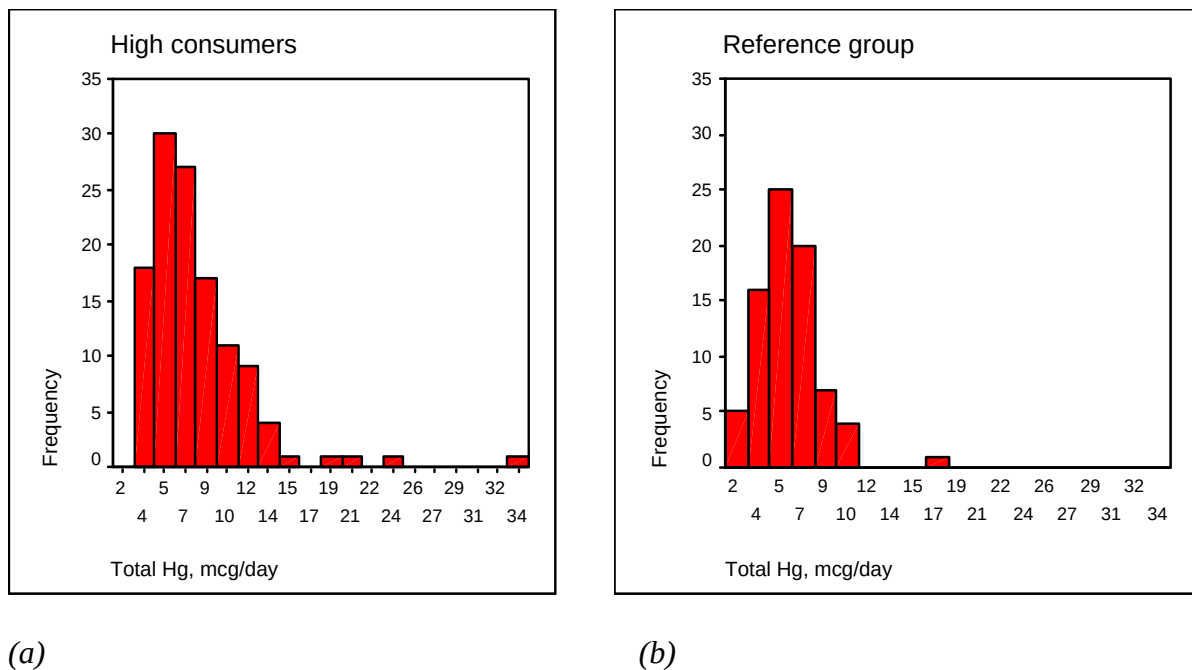


Figure 1. Histograms illustrating intakes of total Hg in $\mu\text{g/day}$ (empirical data), in the groups of high consumers ($N = 121$) and references ($N = 78$).

In the high consumer group, the estimated median intake of total Hg is $6.8 \mu\text{g/day}$, and the intake levels in this group range from $2.8 \mu\text{g/day}$ to $33.4 \mu\text{g/day}$ (Table 4). In the reference group, the estimated median intake level is $5.4 \mu\text{g/day}$, ranging from 1.8 to $17.1 \mu\text{g/day}$.

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The Hg intakes from seafood only is displayed separately in table 4, showing a median intake of 4.5 µg/day among high consumers and 3.6 µg/day in the reference group.

Table 4. Estimated intakes of total Hg and Hg from seafood in the groups of high consumers and references. Intakes are shown as percentiles in µg/day, with the minimum and maximum intake level.

	N		5	10	25	50	75	90	95	97.5	Min - Max
High consumers	121	Total Hg	3,5	4,0	5,3	6,8	9,3	12,7	14,2	21,1	2,8 – 33,4
Reference group	78	Total Hg	2,6	3,2	4,2	5,4	7,0	8,8	10,2	11,0	1,8 – 17,1
High consumers	121	From seafood	1,8	2,0	3,1	4,5	6,8	9,6	11,1	18,9	1,0 – 31,5
Reference group	78	From seafood	1,0	1,5	2,0	3,6	4,6	6,2	8,0	8,7	0,1 – 15,2

Two-way ANOVA tests did not reveal any significant interactions between any of the variables educational level, geographical location, age group or sex regarding total Hg intake (data not shown). This was tested in both the high consumers group and the reference group, and all p-values for possible interaction effects were above 0.2. As no interactions between the different variables were detected in the ANOVA analyses, the intake estimates are shown in separate tables for each of these grouping variables (Appendix 5). Intakes of Hg from seafood are displayed separately in all tables.

The results show that men have a significantly higher intake than women of both total Hg and seafood Hg in the group of high consumers (t-test $p < 0.0005$ for both variables). The highest single value is found among the men, being 33.4 µg/day. A significantly higher Hg intake level is also found in coastal municipalities compared to inland municipalities for both total Hg ($p = 0.002$) and for seafood Hg ($p = 0.001$). The median intake of total Hg is 7.8 µg/day among the responders living in the coastal municipalities and 5.8 µg/day among those living in the inland municipalities. However, high Hg intakes are found both in the coastal and the inland municipalities, which is seen from the high intake levels found in and above the 90 percentile (Appendix 5).

In the reference group, no significant differences between men and women are found for neither total Hg ($p = 0.34$) nor for seafood Hg ($p = 0.67$). The highest estimated value in the reference group is from a woman, who has an estimated dietary intake of 17.1 µg/day. Neither are significant differences found between people living in coastal municipalities and people living in inland municipalities for total Hg ($p = 0.3$) nor for seafood Hg ($p = 0.4$). The median intake in this group is 6.1 µg/day in the coastal and 4.9 µg/day in the inland municipalities (Appendix 5).

When investigating intakes in the different age groups, no significant differences are found in intakes of total Hg, neither among high consumers (One-Way ANOVA $p = 0.09$) nor in the reference group (One-Way ANOVA $p = 0.1$) (Tukey post hoc tests also performed).

In the group of high consumers there are significantly higher intakes of seafood Hg in the group of 61+ than in the group 21-40 ($p = 0.006$). The median intake is 5.2 µg/day in the

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group 61+ and 3.6 µg/day in the group 21-40. The highest 95 percentile is found in the oldest age group with more than 15 µg/day. No difference for intakes of Hg from seafood is found in the group 41 – 60 compared to the other two groups (Appendix 5).

Also in the reference group there is a significant difference in intake of Hg from seafood between the group 21 – 40 and 61+ ($p = 0.007$). The median intake is 3.9 µg/day in the oldest age group and 3.1 µg/day in the youngest. No significant differences are detected between the other age groups for intakes of seafood Hg.

For the different educational groups, significant differences are found among the high consumers regarding intakes of total Hg ($p = 0.001$). The group with university level education have significantly lower intakes than both the group with primary level education ($p = 0.003$) and the group with upper secondary level education ($p = 0.002$). No significant difference is found between the groups with primary and upper secondary education ($p = 0.97$).

Regarding intakes of Hg from seafood, there is also a significant difference between the participants with university level education and the other two groups ($p < 0.0005$), whereas no difference is found between the groups with primary and upper secondary level education ($p = 0.9$).

In the reference group, no significant differences are detected between the educational groups for intakes of total Hg ($p = 0.2$), nor from seafood Hg ($p = 0.2$).

Standard multiple regression analyses show that the strongest single predictor for total Hg intake is sex, followed by geographical location. Educational level also gives a significant contribution in explaining Hg intake, but less than the other two variables. However, the differences are very small and the model explains only 27 % of the variance in Hg intake in the high consumer group (Adjusted R square = 0.274 (SE 0.3409)).

Table 5. Fitted multiple regression model showing relation between geographical residence, sex and education and total Hg intake among the high consumers.

	Unstandardised Coefficients B	Std. Error	t	Sig.
(Constant)	2,938	,152	19,275	,000
Geographic location	-,259	,066	-3,920	,000
Sex	-,271	,065	-4,141	,000
Education	-,114	,040	-2,848	,005

Dependent Variable: ln total Hg µg/day

Contributions to mercury intake

Contribution from different food groups

The results of the intake estimates from different food groups confirm that seafood is by far the most important contributor to total Hg intake among both high consumers and in the

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reference group (Table 6). The mean intake of Hg from seafood among high consumers is 5.6 µg/day, which corresponds to 71 % of the total Hg intake. The second most important group is vegetables with a mean of 0.8 and 0.7 µg/day, corresponding to 10 % and 12 % of total Hg intake in the two consumer groups. However, this food group does not differ significantly from the food group of bread, cereals and pastas in any of the two intake groups. For all other food groups than fish and seafood, the mean intakes are below 1.0 µg/day.

Table 6. Estimated contribution to Hg intake from different food groups among high consumers (N = 121) and the reference group (N = 78), means in µg/day and as percentages of total Hg intakes.

Food groups	High consumers (N = 121)		Reference group (N = 78)	
	Mean, µg/day	%	Mean, µg/day	%
Seafood	5.6	71	3.7	64
Vegetables	0.8	10	0.7	12
Bread, cereal products, pastas	0.6	7	0.5	9
Potatoes	0.2	3	0.2	4
Meat, meat products	0.2	2	0.2	4
Fruit, berries	0.2	3	0.2	3
Egg	0.1	2	0.1	2
Fat	0.05	1	0.05	1
Soft drinks	0.04	0	0.04	1
Milk, cream, ice cream	0.03	0	0.04	1
Cakes	0.03	0	0.03	0
Sugar, sweets	0.02	0	0.02	0
Cheese	0.01	0	0.01	0
Chips, snacks, fatty fruit	0.00	0	0.01	0
All food groups	7.9	100	5.8	100

Different types of seafood

Table 7 shows the contribution from different food groups of fish and crustaceans. The category “Fish total” includes the seven questions from the questionnaire about non-processed fish; perch/pike, cod/saithe/haddock/pollack, tuna, halibut/plaice, salmon/trout, mackerel/herring and “other fish”. The group of fat fish consists of halibut/plaice, salmon/trout, and mackerel/herring, while the others are grouped as lean and semi-fat fish. “Fish products” are the four questions regarding fish fingers, pasta with seafood, fish cakes and fish au gratin. “Crustaceans” include the five question concerning crab, shrimps and blue mussels. “Fish for sandwich” covers seven questions including pickled herring, pate of liver and roe, mackerel/sardines in tomato sauce, smoked mackerel/salmon/trout, caviar, sardines and other sandwich spread. Liver and roe is estimated from the two questions about roe and liver of fish.

The results show that for both consumer groups, the lean and semi-fat fishes have the highest mean contribution to total Hg intake with 44 % and 37 % of total intake. Fish for sandwich is the second most important group, contributing with a mean of 13 % and 12 % respectively.

Results

The high-end consumers of fish for sandwich in the high consumer group get 5.5 µg of Hg from these foods, which corresponds to consuming nearly 180 gram of this per day.

Table 7. Estimated contribution to Hg intake from different groups of seafood in the high consumer group (N = 121) and the reference group (N = 78), µg/day and % of total Hg intake. Mean and the 97.5 percentile are shown, together with fish consumption in gram per day.

		Mean			97.5 percentile	
		Hg, µg/day	%	Seafood, gram/day	Hg, µg/day	Seafood, gram/day
High consumers	Fish total	3,5	44	54	10,0	148
	lean, semi-fat fish	2,3	29	32	9,5	100
	fatty fish	0,7	9	16	2,0	33
	Fish products	0,5	6	19	1,6	54
	Fish for sandwich	1,0	13	33	5,5	179
	Crustaceans	0,7	9	10	3,5	59
	Liver and roe	0,0	0,2	2	0,1	12
Reference group	Fish total	2,2	37	38	7,3	107
	lean, semi-fat fish	1,3	23	23	5,9	69
	fatty fish	0,5	9	11	1,7	29
	Fish products	0,5	9	18	1,3	45
	Fish for sandwich	0,7	12	23	4,0	105
	Crustaceans	0,4	8	8	2,1	33
	Liver and roe	0,0	0,1	2	0,0	8

Table 8 shows the contributions to dietary Hg intake in the group of high consumers from the different seafood asked for in the questionnaire. The highest mean intake of Hg comes from the group cod, saithe, pollack and haddock, estimated to 1.4 µg/day. This corresponds to 18 % of the total mean Hg intake in this group, and to a mean consumption of these fishes of 29 gram per day. The 97.5 percentile report consuming nearly 100 gram of cod, saithe, pollack and haddock per day, which leads to an estimated mercury intake of 4.9 µg/day.

Looking at the whole group of high consumers, the second most important contributor to mercury intake is perch and pike. The mean consumption is only 1.6 gram per day, although the mean contribution to the total intake is 9 %. However, the importance of perch and pike as sources to mercury intake is evident from the high estimates in the 97.5 percentile, giving more than 8 µg/day of mercury when consuming 18 gram per day of these fishes.

As table 8 shows, the mean contribution from each of the different types of seafood are small. Regarding the high-end consumers of the different seafood, the table shows that perch and pike are the most important sources of mercury, followed by cod, saithe, pollack and haddock, and crab.

80 persons in the high consumer group report eating cod, saithe, pollack and haddock more than once a week, which makes these fishes the most frequently consumed fish species. 114 people report being consumers of these fishes, whereas only 15 persons in the group report

Results

being consumers of perch and pike. 56 persons are consumers of crab, which contributes with 6% of the mean Hg intake in the high consumer group.

Table 8. Estimated contribution to Hg intake from different types of seafood among high consumers (N =121), $\mu\text{g/day}$ and % of total Hg intake. Mean and the 97.5 percentile are shown, together with fish consumption in gram per day.

Types of seafood	Mercury, mean, $\mu\text{g/day}$	%	Food consumption, mean, gram/day	97.5 percentile hg $\mu\text{g/day}$	97.5 percentile gram per day
Cod, saithe, pollack, haddock	1,4	18	29	4,9	100
Perch, pike	0,7	9	2	8,1	18
Crab, total	0,5	6	4	2,9	25
Other fish	0,4	6	5	2,5	31
Halibut, plaice	0,4	5	3	1,6	13
Salmon, trout	0,3	3	9	0,9	29
Pickled herring	0,3	3	7	2,7	74
Fish cakes, , fish pudding, fish balls	0,3	3	9	0,8	26
Fish au gratin, soup, fish casserole	0,2	3	8	1,0	36
Shrimps total	0,2	3	6	1,2	32
Mackerel, sardines in tomato sauce	0,2	3	9	1,2	50
Smoked mackerel, trout, salmon	0,2	2	6	1,5	50
Caviar	0,2	2	3	1,5	30
Tuna, total	0,1	2	2	1,4	18
Mackerel, herring	0,1	2	4	0,6	20
Fish for sandwich, other	<0,1	1	3	1,1	39
Sardines in oil	<0,1	<1	4	0,9	49
Fish fingers, breaded fish	<0,1	<1	2	0,3	10
Fish pasta	<0,05	<1	1	0,1	10
Roe	<0,05	<1	2	<0,1	9
Blue mussels	<0,05	<1	<1	<0,1	2
Pate of liver and roe	<0,05	<1	1	0,1	15
Liver	<0,05	<1	<1	<0,05	3

The results displayed in table 9 show that cod, saithe, haddock and pollack are the most important contributors to total Hg intake also in the reference group, with a mean contribution of 1 μg per day or 17 % of total Hg intake. This corresponds to a mean consumption of 20 grams of these fishes per day. The mean contributions from the other foods are all 0.3 μg per day or less.

75 persons in the reference group report being consumers of cod, saithe, haddock and pollack, and 43 of these consume this more than once a week. Salmon and trout are the second most frequently consumed fish species, with 7 persons in the reference group reporting to eat these fishes at least once a week. Still, the high-end consumers of these fishes get only 0.7 μg per day from this source.

The high-end consumers in the reference group get the highest Hg intake from tuna, with 4 μg per day coming from consuming 50 grams per day. This consumption is estimated from the total tuna consumption, i.e. from both dinner meals and the tuna used as sandwich spread. The

Results

high-end consumers of cod, saithe, haddock and pollack have an estimated intake of 3 µg or more, corresponding to consuming more than 60 gram per day of these fishes.

Table 9. Estimated intakes of Hg from different types of seafood in the reference group (N =78) in µg/day and as percent of total Hg intake. Mean and the 97.5 percentile are shown, together with fish consumption in gram per day.

Types of seafood	Mercury, mean, µg/day	%	Food consumption, mean, gram/day	97.5 percentile hg µg/day	97.5 percentile gram/day
Cod, saithe, pollack, haddock	1,0	17	20	3,0	61
Other fish	0,3	5	4	1,8	23
Halibut, plaice	0,3	5	2	1,5	12
Shrimps total	0,3	4	7	1,2	31
Fish cakes, fish pudding, fish balls	0,2	4	8	0,8	26
Tuna, total	0,2	4	3	4,0	50
Salmon, trout	0,2	4	7	0,7	23
Crab, total	0,2	3	2	1,6	13
Fish au gratin, soup, fish casserole	0,2	3	6	0,5	17
Mackerel, sardines in tomato sauce	0,2	3	7	1,2	50
Caviar	0,2	3	3	3,5	70
Smoked mackerel, trout, salmon	0,1	2	5	1,5	51
Perch, pike	0,1	2	<1	2,2	5
Pickled herring	0,1	2	3	1,8	50
Fish fingers, breaded fish	<0,1	2	3	0,5	18
Mackerel, herring	<0,1	1	2	0,4	13
Sardines in oil	<0,1	<1	3	0,2	10
Fish for sandwich, other	<0,05	<1	1	0,3	10
Fish pasta	<0,05	<1	<1	0,1	8
Roe	<0,05	<1	1	<0,1	7
Pate of liver and roe	<0,05	<1	<1	0,1	15
Blue mussels	<0,05	<1	<1	<0,1	2
Liver	<0,05	<1	<1	<0,1	<1

Tolerable levels of mercury exposure

For total Hg the PTWI is set at 5.0 µg/kg/week (0.71 µg/kg/day). Of this, no more than 1.6 µg/kg/week (0.23 µg/kg/day) should be in the form of methylmercury (JECFA 2003). This is the amount of total mercury and methylmercury considered safe to consume every week during the whole lifetime without causing any adverse health effects. The figures below show the intake (per week) related to bodyweight of total mercury (Figure 2) and of mercury from seafood only (Figure 3) in the two different consumer groups.

All the respondents in this study have an intake of total mercury well below the defined tolerable level of exposure to total mercury of 5.0 µg/kg/week, with the maximum estimated value being 2.7 µg/kg/week (Figure 2).

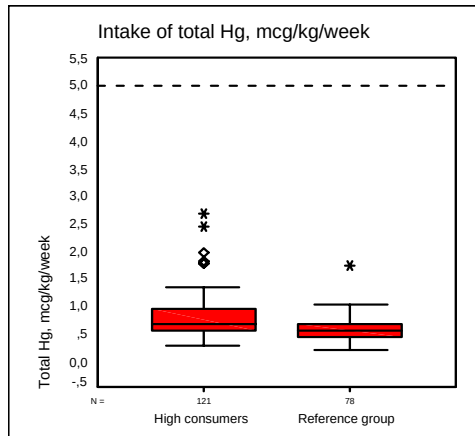


Figure 2. Distribution of estimated intakes of total mercury, $\mu\text{g/kg/week}$. The stipulated line across the inner frame indicates the PTWI for total mercury of $5.0 \mu\text{g/kg/week}$. The upper and lower ends of the red boxes indicate the 25th and 75th percentile levels of the observations. The lines across the boxes represent the median values. Points outside the whiskers represent extreme values in the data set.

When estimating the intake of mercury from seafood separately, there are two persons having an intake above $1.6 \mu\text{g/kg/week}$, while three more persons have an intake above $1.5 \mu\text{g/kg/week}$ (Figure 3). One of them is in the reference group, the rest from the group of high consumers. If anticipating that methylmercury make up 90 % of the total mercury content in seafood, the same two persons still exceed the tolerable exposure level defined by WHO.

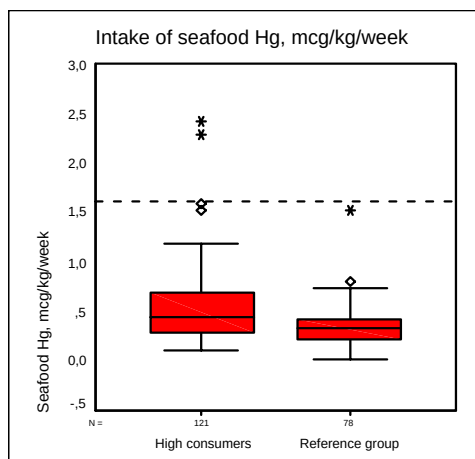


Figure 3. Distribution of estimated intakes of methylmercury, $\mu\text{g/kg/week}$. The stipulated line across the inner frame indicates the PTWI for methylmercury of $1.6 \mu\text{g/kg/week}$.

DISCUSSION

Methodological considerations

The food frequency questionnaire

A self-administered, semi-quantitative questionnaire has been used for assessing food consumption in this study. Food frequency questionnaires (FFQ) have become the most commonly used method for assessing dietary intakes in epidemiological studies of large populations (Caan et al. 1999), and the most important benefits of this instrument are the low economic expenses and the relatively uncomplicated administration needed.

As the use of FFQs is very common, a number of different validation studies have been performed for different types of FFQs, with varying results. For self-administered FFQs, different validation studies have shown correlation coefficients ranging from 0.24 to 0.81 between the FFQs and food records or serial 24-hours diet recalls (Caan et al. 1999). The validity in a particular study is of course depending on the actual FFQ used, and it is always recommended to use a pre-validated FFQ when performing a study (Cade et al. 2002). Nevertheless, in this study we have chosen to use a questionnaire that is still in the process of being validated, which may be considered a drawback of the study design. The original questionnaire was developed after the model of a Danish semi-quantitative questionnaire (Overvad et al. 1991; Tjønneland et al. 1991), and is currently being used in one of the largest epidemiological studies conducted in Norway, the Norwegian Mother and Child Cohort study. The aim of that study is to collect data of the general diet of the participating mothers, as the aim of this study is to collect data of the general diet of the participants. It was therefore considered to be justifiable, even if not optimal in a methodological perspective, to use a still-not validated questionnaire for the data collection in part C of the Fish and Game Study.

However, no method for assessing food consumption are without errors (Cade et al. 2002). There are thus several important issues to consider when using and interpreting results of an FFQ regarding dietary consumption assessment.

An important issue is related to the number of food items listed. Several studies have shown that the number of foods reported as being eaten is related to the number of foods listed in the questionnaire used (Caan et al. 1998; Cade et al. 2002; Smith-Warner et al. 2001). According to Tjønneland et al. (1991), FFQs tend to overestimate the consumption of single food items. Listing too many may therefore lead to an overestimation, while too few food items may lead to an underestimation. This is thus a general scientific problem in nutritional research that has to be dealt with one way or the other.

In the validation study by Tjønneland, the use of adjustment related to global questions of frequencies (in the questionnaire used as the model for our questionnaire) is described (Tjønneland et al. 1991). The study performed adjustments using global questions as the standard, due to the presumption that single food items tend to be over-reported in FFQs. After the adjustment were made, correlation coefficients for different nutritional parameters between the FFQ and dietary recording were between 0.17 and 0.64 for men and slightly lower for women. Both overestimation and underestimation from the FFQ occurred when compared to the dietary record method in that study.

In this study, the consumption data have been adjusted in two steps. First, global questions to adjust for the number of reported specified dinners per week were used. For example, when the sum of the different specified fish meals for a participant has become more or less than the reported mean number of fish meals per week or month, adjustments have been made. This approach has led to adjustments being made for red meat, chicken and fish consumption, either downward or upward. Secondly, adjustment for intake of more than 400 dinners per year was made.

Two basic assumptions have thus been taken here. One is that the global questions are more capable of telling the true mean frequencies of food consumption than the lists of single food items are. The second assumption is that people do not eat more than one dinner per day as a mean frequency through the year. This is presumed to still be the normal eating pattern in the Norwegian population today. However, some tolerance for variance in this has been accepted and 400 has thus been chosen as a cut-off for the number of dinner meals in a year.

The scatterplots in Figure 4a and 4b below show the relation between estimated intakes of total mercury in $\mu\text{g/kg/week}$ between the adjusted and the unadjusted data, and how the use of the correction factor have influenced the estimates. The figures show that on the individual level, the effects for a few participants have been increased mercury estimates, while for most of the participants estimates have been adjusted downwards.

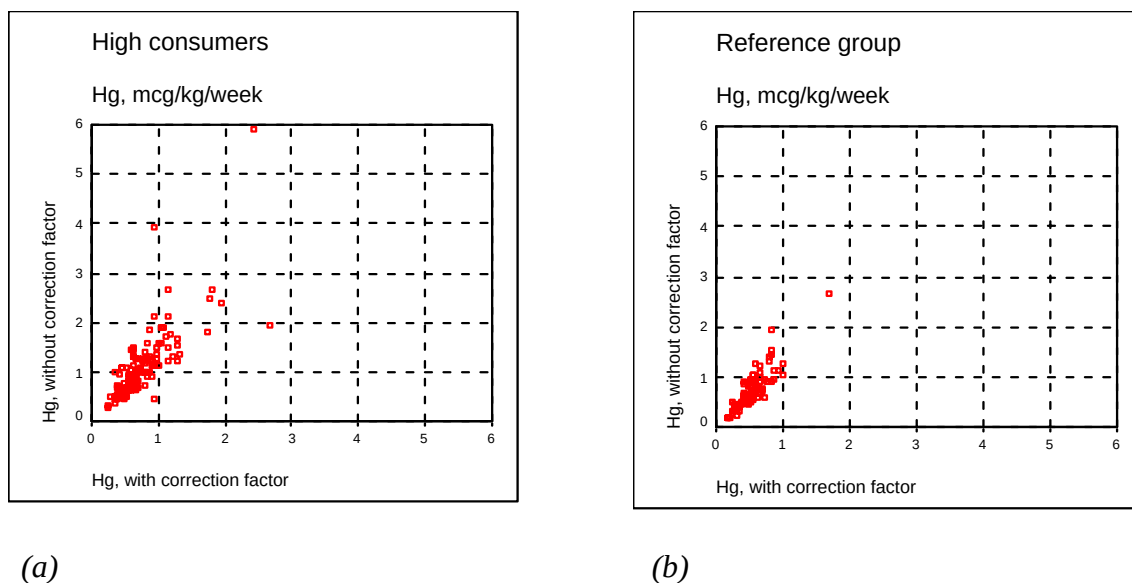


Figure 4. Scatterplots showing the relation between the adjusted data and the raw data of estimated Hg intakes in $\mu\text{g/kg/week}$ in the two consumer groups.

The crucial question to ask then, is which one of the data sets get closest to describing the “true” exposure among the participants? The problem in using this adjustment is that it has a global effect on the data. It is virtually impossible to say whether it is consumption of perch or of crab that has been over- or underreported by the participants, although this difference of course is crucial for knowing the true mercury exposure of a real person. The adjustment anticipates that all types of the food category have been over- or underestimated

proportionally. Nevertheless, this approach has been chosen as it seems clear that many of the participants have a discrepancy in their answers that possibly is due to the complex design of the questionnaire.

The best comment to the validity of the assumptions made here may possibly come from the biological samples collected together with the food consumption data, which are still being analysed in the laboratory. Also the validation study of the Mother and Child Cohort study questionnaire that is currently being performed may hopefully give indications of how to optimally use and interpret results from the questionnaire.

Portion sizes

The issue of portion sizes is another point of uncertainty in dietary research, which has been subject to a lot of validation studies. According to a review made by Cade (2002), it has proven difficult for individuals to estimate the portion sizes of their own meals, independent of the method being used. Nevertheless, there seems to be a small qualitative advantage by letting the study subjects estimate their own portion sizes, rather than using standardised portions. This minor advantage, however, is not clearly outweighed by the extra costs required for the individual estimates (Cade et al. 2002).

However, in a questionnaire that tries to cover most of the diet of the participant, the need for information has to be balanced against the time and resources required for the participants to fill in their answers. A pedagogical principle of not making the questionnaire too cognitively demanding, should be the basis for a questionnaire. It is probably quite demanding to fill in our questionnaire, for at least two reasons. One is that it includes a lot of different foods, a total of 338 questions in total, and thus requires a dedication of time to fill in. The other reason is that the participants are asked to report the food consumption as mean frequencies of the last 12 months, which actually require both some mathematical skills and cognitive capacity from the participant.

The use of standard portion sizes may therefore be justifiable in this perspective. Two trained nutritionists estimated the gender-specific portions, and the portion estimates were mainly based on the portions used in the earlier mentioned Norkost survey.

One issue that became clear during the process of this study, is that there are greater uncertainties connected to the “normal” portion sizes of the foods of particular interest in this study i.e. fish and game, than other foods that are more frequently used in the Norwegian diet. This has led to another follow-up study, which aims at investigating portion sizes of foods like freshwater fish, crab, and offal of fish and game through weighing of portion sizes by some of the participants. The results of this study will probably be ready some time during 2004, and is part of a Master thesis in nutrition conducted by a student at the University of Oslo.

Mercury database

One of the challenges in this study has been to collect a database with estimates of the mercury content in the various foods included in the study. The development of this database

is of course crucial for the levels of intake estimates in the study population. Published reports from the Norwegian Food Safety Authority were used as the basis for this data collection. Only the most recent data and reports were used, when possible. Due to the large variability for mercury within species, the median could arguably have been used in the database. However, it was judged desirable to also take into consideration the possible high concentrations of mercury that actually are found in some species, depending on both trophic level and geographical locations. Additionally, the analyses from the Norwegian Food Safety Authority are also meant to represent food samples that are consumed by many Norwegians, and very polluted areas are not presented in these reports. Therefore, the mean mercury concentration was chosen as the measure for the estimates.

For other foods than fish, crustaceans and bivalves, it was decided to use Finnish data. These data are relatively old, the report was published in 1980 (Koivistoinen (ed.) 1980), and the relevance of applying these Finnish data may therefore be questioned. Generally, mercury releases in the Nordic countries have decreased the last decades. Nevertheless, in a report published by Fjeld (2003) it was not possible to find any consistent increase or decrease of mercury levels in analyses of different fish species from the period 1978 – 1992. There may also be variations in mercury concentrations between Finnish and Norwegian foods, although the sizes of these are probably not very important. A further complication of this is that Norwegians also consume a lot of imported foods, an issue this study has not addressed. Nevertheless, as Norwegian data were not available for food groups such as vegetables, dairy products and meat, it was still considered an improvement for the intake estimates to use the Finnish data.

Unfortunately, it is very difficult to predict the direction and degree of the over- or under-estimation of mercury intake this may have lead to. Still, it should be noted that the degree of uncertainties is partly reflected in the importance of the food items as sources of dietary mercury exposure. More precisely, the food analyses done in Norway have been chosen because they have high concentrations of mercury, and are eaten relatively frequently on a population basis. Consequently, the estimates for seafood may therefore have a higher potential for predicting the true intake among its consumers than the other food groups, which is important as this constitutes the main source of the dietary exposure.

It was not possible to create a complete database for all the foods asked for in the questionnaire. For some of the missing values, estimates were made on the basis of analyses performed in presumed comparable foods. This is made explicit in the reference list of the database. It was regarded as optimal to use at least trace levels of mercury in these foods, as the alternative would be to leave this background exposure levels out of the picture. These estimates, however, affects the low consumers most, as they will constitute a relatively larger amount of the estimated mercury exposure for these people. The lower end of the percentile estimates will therefore be most affected by this.

In the questionnaire, grouping of some of the different foods together into one question makes it difficult to know precisely how much a person eats of each of the foods. The mercury value had thus to be estimated as a mean value of the two or three foods in the question. Still, there were generally not large variations in mercury content between the different food items, and this should therefore probably not influence the results to a critical degree.

In a detailed survey of general diets like this one, it would also have been interesting to differentiate between different chemical forms of mercury, i.e. methylmercury compared to total mercury. Methylmercury is the most critical chemical form of exposure, and the presumed tolerable intake levels are much lower for this than for total mercury. A crude attempt to distinguish these in the intake estimates has been done by showing the estimates for mercury from seafood separately in all tables. However, the food analyses techniques normally applied in Norway do not distinguish between the different forms, so at this point it is not possible to differentiate between this in the database.

Generalizability of the study

The response rate in this study is 28 %. This is a very low rate, also compared to the two preceding parts of the Norwegian Fish and Game Study which had response rates of 60 and 55 % (Meltzer et al. 2002, Bergsten 2004). However, although not described in detail here, part C included the collection of samples of blood and urine from all participants, which means the respondents had to see medical personnel to comply with the study. Logically, this meant spending more time and energy on the study than a more conventional study design would have demanded (all doctoral fees and extraordinary travel expenses were refunded by the study). Hence it is probable that less people are interested in and/or have the time to participate in a study using such a demanding methodology, which may explain the low response rate.

Nevertheless, the low response rate deserves some special comments as this may be considered a threat to the generalizability of the study. The non-responders of a particular study often tend to be different from those who agree to participate in the study in several ways (Hennekens 1987). These differences may include differences in motivation and attitudes towards health, and also differences in risk factor status (ibid).

In this study, one might suspect that the responders have a special interest in fishing and hunting activities, and/or consume a lot of seafood or game. It could therefore be assumed that the non-response affects the results in the two samples differently. The aim of the sample of high consumer is to get information about Hg intake levels among high consumers, and a bias against those eating most will therefore not influence the results negatively. For the reference group, this will be different, as the aim is to get information about the general population in the selected municipalities. A bias against people eating more seafood and game may therefore lead to an overestimation of intake levels. This means that if the assumption about the non-responders is true, this may have lead to an overestimation of intake levels in the reference group, while the effect on the group of high consumers has not been very important.

A possible method for getting an indication of how the low response rate affects the results is to compare baseline characteristics of the responders and non-responders and make judgements based on this. However, it is obviously impossible to get any exact information on the intake levels of the non-responders (which is the parameter of interest here), whether the non-respondents are suspected to be different or not. Formal analyses of the non-responders have therefore not been performed here, as it was regarded not to give any decisively higher level of certainty for the conclusions to be drawn.

Discussion of the results

Intakes of mercury

The results of this study show that the median intake of total mercury is close to 7 µg/day in the group of high consumers, while the high-end consumers of mercury-rich foods, represented by the 97.5 percentile, have estimated intakes of total mercury above 21 µg/day (Table 4). In the reference group, the median mercury level is about 5.5 µg/day. The high-end consumers in the reference group have an intake of 11 µg/day, which is considerably lower than in the high consumer group. This difference is of course not surprising as the participants in one of the groups were selected on the basis of their presumed high intake of mercury. However, this result confirms the finding from part A of the Norwegian Fish and Game Study; There is a group in the Norwegian population having a high consumption of foods that may lead to high intakes of mercury, whereas the general Norwegian population does not have very high dietary intakes of this contaminant.

Regarding the intake levels in the reference group, there is one person that obviously is differing from the rest of the group by having a higher estimated mercury intake (Figure 1b). This probably shows that the size of the random sample is too small to be able to detect the “true” incidence of the rare high consumers in the selected municipalities, which in its turn affects the estimated high-end intake levels in the reference group. This also shows that the rationale for using the different selection procedures as described earlier has been justified.

Additionally, the low response rate is important when considering the relevance of the intake estimates in the reference group. The level of influence of the non-responders in a study is, as discussed above, impossible to assess. However, it may not be too unreasonable to suspect that the estimated mercury intakes in the upper end of the reference group are low compared to the “true” intakes in this population due to the small sample size. This is also why the percentiles are useful tools for indicating the dietary exposure levels in the population, as these measures are less vulnerable to the absence of high-exposed persons in the reference group. Due to the relatively symmetric distribution of intake levels in the reference group, it is possible to have more confidence to the middle-level intake estimates in this group.

As the Norwegian Fish and Game Study is the first of its kind in Norway it is not possible to validate the intake estimates of mercury directly against similar Norwegian studies. However, in an intervention study conducted among students and employees at the Institute of Nutritional Research at the University of Oslo, mean intake of mercury was 3.1 µg/day (range 1.2 - 8) in the control group (N= 10), and 17.9 µg/day (range 9.8 - 24) in a group consuming fish daily (N=11). The method in this study was based on collection of duplicate portions of all food eaten during 4 days, and analyses of total mercury content in this food (Meltzer et al. 1994). Assuming that a duplicate portion study give a good indication of mercury levels found in the diets of the participants, the study may indicate that the levels estimated in both the reference group and in the high consumer group are within a possible range of exposure in the two samples investigated in this study.

However, as the food frequency questionnaire applied in this study is covering the general diet of the participants, the estimated intakes of different foods measured in gram per day may partly be an indicator of the validity of the relevant food consumption. And as different types of seafood are the most important source of mercury, the exposure estimates may be relevant

Discussion

to discuss in the light of other national food surveys of consumption of fish and other types of seafood.

The reported intake of seafood when all types of relevant foods are included is high in this study (Table 10). The mean intake is about 118 gram per day in the high consumer group, and 90 gram in the reference group. The 5 % with the highest seafood consumption report consuming 243 gram per day in the high consumer group and 164 gram per day in the reference group. As a comparison, published data from part A show a mean intake for all types of seafood (fish, fish products, crustaceans, sandwich spread, liver and roe) of 70 gram per day, whereas the 5 % with the highest consumption have an intake of more than 139 gram per day (Meltzer, Bergsten, & Stigum 2002) (Table 10).

Also compared to the national food consumption survey Norkost 1997, the mean consumption is higher in the reference group in this study. The mean intake of all types of seafood in Norkost is reported to be 65 (SD 51) gram per day (reported from Meltzer et al 2002).

Table 10. Reported intake of some types of seafood (gram per day) in part A and C of the Norwegian Fish and Game Study, and in Norkost 1997.

	Part C, high consumers	Part C, reference group	Part A (1999)	Norkost (1997)
All types of seafood				
Mean	118	90	70	65 (SD 51)
95 percentile	243	164	139	,
Lean and semi-fat fish*				
Mean	32	16	26	23 (SD 29)
95 percentile	84	60	62	,
Fish for sandwich				
Mean	33	23	3	9 (SD 13)
95 percentile	138	71	,	,

*lean and semi-fat fish in Part A included 10 species

When looking into consumption of different groups of seafood, the most striking difference is seen between the intakes of fish for sandwich in different studies. The mean intake of fish for sandwich in this study is 33 gram per day among the high consumers and 23 gram per day for the reference group (Table 7). From part A of the Fish and Game Study the mean intake is found to be 3 gram (SD 4) (Meltzer et al. 2002). There are participants in both the reference group and the high consumer group in this study who report a very high intake of fish for sandwich.

The high consumption of different types of seafood reported in both the high consumer group and the reference group in this study may possibly be explained by a true higher intake of seafood in these specially selected municipalities. However, it does not seem likely that this is the only explanation. The variations may indicate not only different intake levels due to variations in the study populations, but also that different methods or questionnaires used for dietary assessment may give different results. The number of questions listed in the different surveys may therefore partly explain the differences found.

This may be an example of the problem discussed earlier, of people tending to overestimate their consumption of foods when there are many choices at hand. The problem of overestimation may be particularly important when people are allowed to report frequencies per day (Cade et al. 2002). In part A of the Norwegian Fish and Game Study, only one question was asked about fish for sandwich. In this study, however, 8 questions have been asked about fish for sandwich (10 including crab and shrimps).

The influence of this possible over-reporting on the mercury estimations has to a certain extent been adjusted in the analyses due to the use of ln-transformed data, although these transformations have not influenced the crude intake estimates. However, it is also important to remember that what may seem like a response-error to the researcher may still be what the participant actually consumes of the particular food. One person in this study has reported to eat perch and/or pike more than six times per week. This could very well have been suspected to be an overestimation of consumption frequency. However, as this person is also participating in a further deepening of the study by measuring portion sizes, this persons responses have been supported and is thus illustrating the limitations in the ability of the researcher to know the truth about unusual consumption patterns among the respondents.

Compared to other countries, studies have shown that the Norwegian population generally has a high consumption of seafood. In a study comparing food consumption in the Nordic and the Baltic countries, Norway had the highest mean consumption frequency of fish and shellfish (Similä et al. 2003). In this study, it was found that Norwegians consume fish and shellfish 9.9 times per month, while countries like Iceland and Sweden consume fish and shellfish 8.6 and 7.1 times per month, respectively.

Regarding estimations of mercury intakes, few studies solely based on individual food consumption data have been conducted in other countries. In a study conducted in Spain, estimation of mercury intakes based on individual fish consumption data gave arithmetic mean intake levels of 48.3 µg/week (6.9 µg/day) among men and 32.8 µg/week (4.7 µg/day) among women in a sample from the Basque country (Sanzo et al. 2001). A study from an island off the Croatian coast has estimated the mean mercury intake among 92 participants to be 194 µg/week (27.7 µg/day), in a sample consuming a mean of 991 gram per week (142 gram per day) of fish (Buzina et al. 1995). Mercury intakes in both these studies were determined by analyses of the foods reported consumed by the study samples, combined with dietary food record methods.

The median levels for mercury from seafood among men and women in this study is 5.8 and 4.0 µg/day, which indicates an intake level not very different from the Spanish study. However, the intake estimates from this study are much lower than in the Croatian study (where the reported fish consumption was exceptionally high). Median levels are not reported in the two studies.

Several Total Diet studies have been conducted in different countries to monitor intake levels and trends for dietary mercury intakes on a population basis. The methods of these studies are based on average food consumption data from the country or region of interest, and analyses of mercury content in foods. The levels of intake estimates from these studies are varying. A total diet study in Spain gave estimated dietary mercury intake of 21.22 µg/day among male adults, 16.71 µg/day among female adults and 16.95 µg/day among people above 65 years old (Llobet et al. 2003).

The total diet study from the UK has provided considerably lower estimates of dietary mercury intakes of 3 µg/day (97.5th percentile 6.4 µg/day) (Ysart et al. 2000). A total diet study from Denmark have provided estimated mean mercury intakes of 3.5 µg/day (95th percentile 5.8 µg/day) (Larsen et al. 2002). These estimates are lower than what is found in this study. However, as these studies are based on population level data, they are not directly comparable to the intake estimates made in this study. Hence it is difficult to give interpretations of whether intake levels in the samples of this study are different from the UK or from Denmark, although it is probable that methods using individually based estimates would produce better but also higher intake estimates than population based studies.

Regarding the demographic variables, significant differences are found between groups for both total mercury and mercury from seafood in the group of high consumers. It has been shown that sex, education and geographical residence is related to dietary mercury exposure in this consumer group, while there is a weaker association to age groups. However, all these three variables together only account for about 27 % of the mercury intake in this group, and the differences found are actually quite small.

In the reference group, no significant differences have been found in intakes of total mercury between men and women, different age groups, educational groups or geographical residence. Regarding intakes of mercury from seafood, the only significant difference found in the reference group is between the youngest and the oldest age group. It was rather unexpected that no differences were seen in the reference group regarding exposure to mercury. However, it can not be ruled out that the reference group was too small to be able to detect any important differences.

On the basis of this study, it is therefore not possible to find any strong risk factor for mercury exposure. On the general level the demographic variables are investigated here, no strong predictors of dietary mercury exposure have been found. A possible improvement when studying this might have been to use a more detailed level of the variable geographical residence (not only coast – inland which is a rather crude measure), which could have led to a stronger relation to mercury intake in both consumer groups.

Contribution to mercury intake

The results of this study confirm that seafood is the most important contributor to dietary mercury exposure, as shown in Table 6, where the contribution from this food group corresponds to 71 % of total mercury intake for the high consumers and 64 % in the reference group. The contribution from the other food groups does not seem to be of very high relevance, when also taking into account that the amount of methylmercury in other types of food only is between 10-30 % of total mercury (Claisse et al. 2001).

Mushroom is included in the group called vegetables, which is the vegetable being of most concern as it may accumulate mercury easily. However, in the sample we have studied, none of the respondents have reported eating amounts of this that have contributed substantially to a high mercury intake (these data are not shown).

Regarding different types of seafood, the lean and semi-fat fishes were found to be the most important contributors to mercury intake (Table 7). However, fish for sandwich is also

reported to be frequently consumed by many of the participants, and is therefore found to be an important contributor to mercury intake in this study. This may indicate that awareness should be paid to this type of fish consumption, as it may be important for monitoring intake levels of both mercury and other environmental contaminants.

It is also clear from this study that the group of cod, saithe, haddock and pollack are the species contributing most to dietary mercury exposure in both the reference group and in the group of high consumers, in spite of the low mercury concentrations these fishes normally have. This is a result of these fishes being the most commonly consumed species in both groups. In the group of high consumers, the 97.5 percentile of cod consumers receive more than about 5 µg/day of mercury from these species (Table 8), while the high consumers from the reference group receives about 3 µg/day (Table 9). However, it is also shown here that not even the most frequent consumers of the cod group reaches critically high levels of mercury exposure from this source.

The fish species that are subject to consumption restrictions by the Norwegian Food Safety Authority are as previously mentioned perch, pike, trout and charr. From the sample studied here, 21 persons have reported being consumers of perch and/or pike, 6 persons from the reference group and 15 persons from the high consumer group. In the group of high consumers, perch and pike are clearly the fishes having the highest contribution to mercury exposure among the high-end consumers (Table 8). Regarding the contribution of mercury from trout and charr, this is not possible to distinguish in this study as trout is grouped together with salmon in the questionnaire and charr is not specifically mentioned. As these fishes have the highest mercury concentrations when living in lakes, the mercury content may vary a lot in these species. However, this is not included in the estimate of mean mercury concentrations in salmon and trout, and the importance of lake trout and charr as a source of mercury exposure is therefore not fully reflected in this study.

In a study conducted among pregnant women in Sweden, the general conclusion was that cord blood levels of methylmercury and hair levels of total mercury were significantly related to fish consumption. When investigating the types of fish that contributed most, it was found significant correlation to the intake of deep-frozen fish (as cod), pickled herring, canned fish (as tuna), salmon, fresh marine fish, spawn and shellfish with both hair mercury and cord blood mercury (correlation coefficient r between 0.2 - 0.3) (Bjørnberg et al. 2003). It will therefore be very interesting to see if the high intake estimates from perch and pike and the other fish species in this study will be reflected in the blood samples collected.

Tolerable weekly intake

The estimates in this study show that none of the participants in this study reaches the level for tolerable exposure to total mercury of 5 µg/kg/week (Figure 2). Only two of the participants have reported dietary habits giving estimated mercury intakes from seafood above the currently defined tolerable level of 1.6 µg/kg/week (Figure 3). For both these participants, perch and pike have been their primary source of mercury exposure. One of the two reports eating perch and/or pike more than six times per week (about 90 % this persons' mercury exposure come from perch/pike), while the other person report eating this once a week (about 75 % of mercury intake from perch/pike).

As discussed earlier, there is no general consensus internationally regarding the critical levels for dietary mercury exposure, neither for total mercury nor for methylmercury. JECFA reduced their definition of the PTWI for methylmercury last summer, from 3.3 to 1.6 $\mu\text{g}/\text{kg}/\text{week}$, an action that was primarily aimed at protecting the foetus. This means that the intakes among the two persons found in this study are below the previously JECFA definition of tolerable level for methylmercury exposure which were believed to be safe for the adult population.

Although not presented here, levels of mercury intakes were also explored among the women in fertile age, i.e. below 45 years of age. All of the women in this age group reported to have a food consumption giving mercury levels well below the defined tolerable weekly intake.

Due to the design of this study, it is not possible to predict the number of people consuming more than the defined tolerable level of mercury in the municipalities where this study is conducted. However, the results should suggest that the general levels of intakes are below the level of concern following the WHO guidelines, as was expected. Regarding the two high-consumers, the blood analyses may be a way of further assessing the extent of the mercury exposure for these persons, and to what extent their bodies have accumulated the mercury ingested.

CONCLUDING REMARKS

This study provides information about levels and sources of dietary mercury exposure in two samples living in areas of Norway where the supply of high-risk foods is known to be high. If assuming that the consumption of high-risk foods is higher in these municipalities than in the normal Norwegian population, the results of this study suggest that there are few persons in Norway who have a dietary intake of mercury exceeding the PTWI as defined by WHO/FAO. However, due to the design of this study, it is not possible to quantify the amount of people in Norway or in the municipalities investigated here that might exceed the intake level considered safe.

This study has a very low response rate. To predict how this has affected the results can only be a matter of judgement, as discussed above. Taking this aspect in consideration, the conclusions from this study must be drawn carefully. Still, the results may suggest that even though the Norwegian population generally consumes a lot of seafood, the dietary mercury exposure seems to be within acceptable levels as the fish species most commonly consumed generally contain low levels of mercury. It also has to be taken into account, though, that variations of mercury content in different foods are largely depending on the local environment, and that the estimates made in this study are not representative for people living in the most polluted areas.

In a public health perspective, it is still important that mercury levels in food continue to be followed closely, especially as the new definitions of safe intake levels have decreased substantially and therefore leads to a higher number of persons getting closer to the upper safe intake levels. The further analyses of the blood and urine samples collected in the study will in this perspective be very interesting and important as a follow up to see how intake of mercury is reflected in biological material.

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Appendixes

Appendix 1: Map from Bergsten 2004, showing the municipalities included in part B and C of the Norwegian Fish and Game Study.

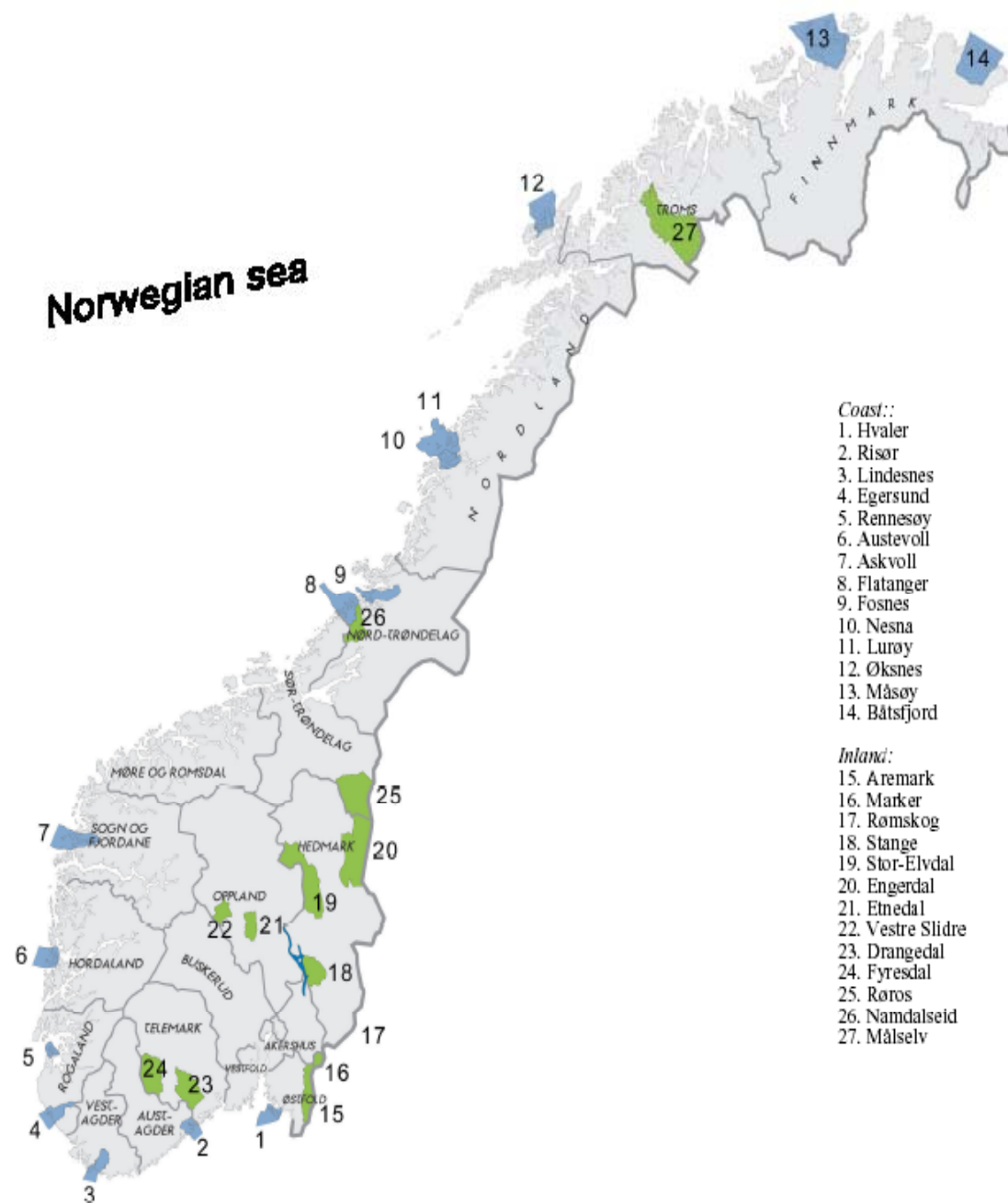


Figure 1. Map of Norway showing the investigated municipalities.

Appendix 2: Invitation letter for Part C, the Norwegian Fish and Game Study



Oslo mars 2003

Invitasjon til utvidet samarbeid i Fisk- og viltundersøkelsen

Høsten 2000 var du en av ca. 5500 personer som svarte på en undersøkelse om inntaket ditt av forskjellige matvarer, med hovedvekt på inntaket av fisk og vilt. En generell beskrivelse av prosjektet finner du på vedlagte ark.

Vi takker hjertelig for svaret ditt, som i disse dager blir bearbeidet statistisk (og anonymt) sammen med alle de andre svarene, og som vil bidra til ny og viktig kunnskap om inntaket vårt av fisk og vilt.

Med dette inviterer vi deg til å delta i en **fordypningsundersøkelse**. Vi ønsker at du skal svare på et grundigere spørreskjema enn sist. Denne gangen vil vi også be deg gi oss en blodprøve og en urinprøve. Du er en av 700 fra den forrige undersøkelsen som får denne invitasjonen. Du er valgt enten fordi vi trenger deg som kontrollperson, eller fordi du hører til blant dem som spiser mye fisk og/eller vilt.

Hvis du er villig til å delta må du fylle ut og returnere den vedlagte svarlappen. Deretter sender vi deg spørreskjema og en liten boks til innsamling av urinprøven. Rør til blodprøven sender vi direkte til legen din.

Hva innebærer det å være med?

Når vi har mottatt brevet om at du ønsker å være med, får du tilsendt et nytt brev fra oss. Det vil inneholde følgende:

- Et spørreskjema om kostholdet.
- Et ekstra én sides skjema med noen generelle spørsmål.
- En beholder til å samle urinprøven i.
- Kopi av brevet til lege eller helsepersonell som skal ta blodprøven.

Spørreskjemaene tar omtrent 30 – 40 minutter i alt å fylle ut. Vi ber deg kontakte en helsestasjon eller nærmeste lege for å ta blodprøven. Urinprøven tar du om morgenen den dagen du skal til legen. Legen/helsestasjonen sender så prøvene til oss. Du betaler selvsagt ikke noe for dette legebesøket .

Navn og adresse til lege/helsestasjon skal du føre inn på svarslippen, slik at vi kan kontakte dem på forhånd og informere om undersøkelsen. Vi gir ingen opplysninger om deg, men generell informasjon om undersøkelsen og om hvor/hvordan de skal sende prøvene. Da vil de være forberedt når du kommer.

Appendix

Hva får du igjen for å delta?

Hvis du sier ja til å delta vil du bidra til forskningen om fremmedstoffer i mat. Dessuten vil vi gjerne gi deg en symbolsk gave, i form av en gavesjekk på kr 400,-. Hvis du får store utgifter med transport til lege/annet helsepersonell for å få tatt blodprøven, vil vi refundere disse utgiftene. I så fall ber vi deg sende oss kvitteringer/billetter som dokumentasjon. Hvis du ønsker det, kan vi også sende deg generelle resultater fra undersøkelsen den dagen disse er klare.

For å gjennomføre undersøkelsen, trenger vi din hjelp. **Deltakelse er frivillig**, og selv etter at du har samtykket i å delta kan du når som helst trekke deg fra undersøkelsen ved å kontakte oss.

Anonymitet

Opplysningene du gir oss vil ikke bli benyttet til andre formål enn denne undersøkelsen og vil bli behandlet konfidensielt. Spørreskjemaet er nummerert for at vi skal kunne ha oversikt over innkomne skjemaer. Ingen enkeltperson vil kunne identifiseres i sluttrapporten.

Bruk svarkonvolutten som ligger vedlagt, og **sva innen to uker**. Portoen er betalt.

Nærmere opplysninger om undersøkelsen kan fåes ved henvendelse til ernæringsfysiolog Helen Engelstad, tlf. 90040589, sykepleier Gunhild Mangerud, tlf. 93484210, eller prosjektleder Helle Margrete Meltzer tlf. 22 04 23 37 ved Folkehelseinstituttet, Postboks 4404 Nydalen, 0403 Oslo.

På forhånd tusen takk for hjelpen!

Helle Margrete Meltzer
Prosjektleder

Nasjonalt folkehelseinstitutt
Divisjon for miljømedisin
Postboks 4404 Nydalen
0403 Oslo

E-post: helle.margrete.meltzer@fhi.no, helen.engelstad@fhi.no eller gunhild.mangerud@fhi.no

SVARLAPP

Legges i vedlagte svarkonvolutt med porto betalt

Ja, jeg ønsker å delta i ny del av Fisk- og viltundersøkelsen

Navn: _____

Adresse: _____

Telefon/mobil: _____

Helsestasjon eller fastlege som kan ta blodprøve av deg

Navn: _____

Adresse: _____

Telefon: _____

- ☐ Ja, jeg ønsker å få tilsendt generelle resultater fra undersøkelsen den dagen disse er klare.

Tusen takk for at du vil være med!

Om Fisk- og viltundersøkelsen

Fisk og vilt er svært verdifulle matvarer i kostholdet. I enkelte tilfeller kan slike matvarer inneholde miljøgifter. Vi mangler kunnskap om hvor mye fisk og vilt som spises i Norge. For å kunne vurdere den helsemessige betydningen av disse matvarene, har Statens næringsmiddeltilsyn (SNT) i samarbeid med Nasjonalt folkehelseinstitutt (tidligere: Statens institutt for folkehelse) startet en omfattende undersøkelse av inntaket av fisk og vilt.

Hvilke spørsmål ønsker vi å få besvart?

- Hvor ofte spises fisk og vilt i befolkningen generelt og i utvalgte områder.
- Kan konsumet av disse matvarene føre til et så høyt inntak av miljøgifter at de utgjør en helserisiko?

Gjennomføring av undersøkelsen

Undersøkelsen blir gjennomført i tre til dels uavhengige spørreundersøkelser på tre ulike nivåer:

Del A. En landsdekkende undersøkelse som ble gjennomført høsten 1999. 6000 personer svarte på et 2-siders spørreskjema. De første resultatene ble publisert sommeren 2002 (SNT Rapport 6/2002). Flere resultater vil bli publisert i løpet av 2003.

Del B: En regional undersøkelse som ble gjennomført høsten 2000. 5500 personer i et utvalg kyst- og innlandskommuner svarte på et 4-siders spørreskjema, deriblant deg. Resultatene fra denne undersøkelsen er under bearbeiding.

Del C: Lokal dybdeundersøkelse som skal gjennomføres våren 2003. **Det er denne undersøkelsen vi ber deg ta del i nå.** Her vil vi gå i dybden både når det gjelder kostholdet ditt og ved å be om blod og urinprøve. Formålet er å foreta en risikovurdering basert på beregninger av matvareinntak og analyser av blod og urin. Vi mangler basisdata for å kunne foreta slike risikovurderinger både nasjonalt og internasjonalt. Deltakerne er valgt blant svarene i del B, se over.

Nærmere opplysninger om undersøkelsen kan fåes ved henvendelse til ernæringsfysiolog Helen Engelstad, tlf. 90040589, sykepleier Gunhild Mangerud, tlf 93484210 eller prosjektleder Helle Margrete Meltzer tlf 22 04 23 37 ved Folkehelseinstituttet, Postboks 4404 Nydalen, 0403 Oslo

Appendix 3: The 1-page questionnaire

ID:

Fisk og viltundersøkelsen

Lite spørreskjema. Sett kryss i ruten ved svaret som passer best for deg, skriv tall der det er stiplede linjer i teksten.

' Mann ' Kvinne

Fødselsår.....

Høyde (cm).....

Vekt (kg).....

Dersom kvinne: Har du født barn ' Nei ' Ja
Hvis ja, hvor mange barn har du født, ...

Ammet du barna dine ja ' nei '

Dersom du ammet, omtrent hvor lenge ammet du

- ' En måned eller mindre pr. barn
- ' 2 – 4 måneder
- ' Mer enn 4 måneder

Røykevaner. Spørsmålene gjelder også pipe, snus, skråtobakk med mer.

- ' Har aldri røyket
- ' Har røyket tidligere, sluttet for år siden
- ' Røyker nå, av og til, ... sigaretter/pipe/snus pr. uke
- ' Røyker daglig, ... sigaretter/pipe/snus i gjennomsnitt pr. dag

Er det noen matvarer du spiser i spesielle sesonger, og som det derfor ikke passet å svare på i det store spørreskjemaet om kostholdet ditt?

Matvare 1 Spist ' ' ganger i forrige sesong

Matvare 2..... Spist ' ' ganger i forrige sesong

Har du utfyllende kommentarer, så skriv gjerne på baksiden av dette arket.

Takk for at du svarer på disse tilleggsspørsmålene.

Legg arket i svarkonvolutten sammen med kostholdsskjemaet.

Appendix

Appendix 4: List of reference values for mercury concentrations in foods

Referanseverdier for Hg beregninger			
MATVARENAVN	Hg	Forklaring	Referanse
	Gjennom- snitt, µg/hg		
Helmelk	0.01	1/10 deteksjon	Koivistoinen 1980
Lettmelk	0.01	1/10 deteksjon	Koivistoinen 1980
Skummetmelk	0.01	1/10 deteksjon	Koivistoinen 1980
Fløte 35%	0.01	1/10 deteksjon	Koivistoinen 1980
Is fløteis	0.02	1/10 deteksjon	Koivistoinen 1980
Sjokoladepudding			
Camembert TINE	0.02	1/10 deteksjon	Koivistoinen 1980
Vaniljesaus, Piano			
Norvegia F45 sk.fri	0.02	1/10 deteksjon	Koivistoinen 1980
Norvegia H30 sk.fri	0.02	1/10 deteksjon	Koivistoinen 1980
Gudbrandsdalsost G35	0.02	som annen ost	
Prim	0.02	som annen ost	
Gudbrandsdal/prim	0.02	som annen ost	
Seterrømme	0.01	1/10 deteksjon	Koivistoinen 1980
Lettømme 20%	0.01	1/10 deteksjon	Koivistoinen 1980
Yoghurt TINE lett frukt	0.01	1/10 deteksjon	Koivistoinen 1980
Go`morgen jordbær	0.01	1/10 deteksjon	Koivistoinen 1980
Yoghurt TINE frukt	0.01	1/10 deteksjon	Koivistoinen 1980
Cultura Bringebær	0.01	1/10 deteksjon	Koivistoinen 1980
Sjokolademelk, Litago	0.01	som annen melk	
Grand Brie F60	0.02	1/10 deteksjon	Koivistoinen 1980
Biola (melk+drikk+yoghurt)	0.01	1/10 deteksjon	Koivistoinen 1980
Fetaost	0.02	1/10 deteksjon	Koivistoinen 1980
Ekstra lett lettmelk	0.01	som annen melk	
Yoghurtis	0.01	som youghurt	
Permesan	0.02	1/10 deteksjon	Koivistoinen 1980
Lett_Norvegia_Smørbar9% 50/50	0.02	1/10 deteksjon	Koivistoinen 1980
Cottage cheese_Græddost 50/50	0.1	som cottage cheese	
Soyamelk			
Havre/rismelk			
Tomatsuppe tillaget	0.01	som melk	
Bernaisesaus tillaget			
Brun saus tillaget			
Pastarett tillaget	0.1	1/2 for pasta	Koivistoinen 1980
Lever i fløtesaus 12 mnd Nestle			
Sennep	0.2		Koivistoinen 1980
Saltstenger			
Popcorn	0.04	1/10 deteksjon	Koivistoinen 1980
Brus cola solo		all drikke satt lik 0	
Brus kunstig søtet			
Farris			
Kaffe tillaget			
Te tillaget			
Grønn te tillaget			
Brennevin 40 vol % alk			
Energy drikk (Battery)			
Likør 35 vol % alk			
Rødvin 12 vol % alk			
Pils 4.4 vol % alk			
Alkoholfritt øl			
Nypete, urtete			

Appendix

Vann på flaske			
Vann (Nypete)			
Kaffe, pulver, tillaget			
Kaffe, koke, presskanne			
Leskedrikk, kunstig søtet, drikkeferdig			
Cappucino, caffè latte	0.01	som melk	
Espresso			
Koffeinfri kaffe			
Kornkaffe hentet fra USA			
Møllers dobbel 1 kapsel			
Sanasol per100 g(Nycomed)			
Biovit per 100 (Nycomed)			
Floradix			
Vitaplex per tablett A/L			
Kostpluss per tablett			
Vitamineral per tablett (Dumex)			
Spektro			
Ferro C per tablett			
Hemoferr per tablett			
Duroferon durerter per tablett			
E-vitamin IDO-E per tablett			
Folat per tablett			
Kalktabletter			
B-vitaminer			
C-vitamin			
D_vitamin			
Egg hele	0.7		Koivistoien 1980
Måseegg hele	0,7	estimert som hønseegg	
Kalv, kotelett rå	0.1	1/2 deteksjon	Koivistoien 1980
Elg stek	0.1	1/2 deteksjon	Koivistoien 1980
Rein, steik rå	1,9		Koivistoien 1980
Elg,-reingryte	0.2	estimat fra elg, hjort, rådyr	
Lever fra sau	0.3		Koivistoien 1980
Lever fra rein	0,3		Koivistoien 1980
Lever, storfesvin	0,7		Koivistoien 1980
Kjøttkaker stekt	0.2	som karbonader	
Karbonader, okse stekt	0.2		Koivistoien 1980
Grillpølse kokt	0.1	1/2 deteksjon	Koivistoien 1980
Kjøttpølse kokt røkt/urøkt	0.1	1/2 deteksjon	Koivistoien 1980
Wienerpølse 0ortswiener kokt	0.1	1/2 deteksjon	Koivistoien 1980
Fårepølse	0.4		Koivistoien 1980
Kalverull	0.1	som pølse	
Leverpostei	0.5		Koivistoien 1980
Serelat	0.1	som pølse	
Skinke kokt	0.2		Koivistoien 1980
Blodpudding/lungemos 70/30	0.2	innmat fra vilt	Koivistoien 1980
Reinsdyrkaker	1	estimat kjøtt/2	Koivistoien 1980
Pizza m/kjøtt fryst	0.05	estimat	
Kalkun, btyst, kjøtt uten skinn	0.1	1/2 deteksjon	Koivistoien 1980
Kokt høne	0.2		Koivistoien 1980
Gryterett med kjøttdeig	0.1	1/2 deteksjon	Koivistoien 1980
Lammerull	0.1	som annet kjøttpålegg	
Kalkun-, kyllingpølse	0.1	som kylling	
Kyllingschnitzel, nuggets	0.1	som kylling	
Gås stekt med skinn	0.1	som kylling	
Kyllingfilet stekt i fett	0.1	1/2 deteksjon	Koivistoien 1980
Grillet kylling med skinn	0.1	1/2 deteksjon	Koivistoien 1980
Rype, stekt uten skinn	0.1	som annen fugl	
Moussaka med kjøttdeig	0.1	Som gryterett	

Appendix

Får i kål	0.02		Koivistoinen 1980
Lasagne	0.1	Som gryterett	
Biff stroganoff	0.1	Som gryterett	
Pizza, hj.laget m kjøttdeig	0.05	estimat fra gryterett	
Lam, lårstek med mørbrad, ovnstekt	0.1	1/2 deteksjon	Koivistoinen 1980
Storfe, entrecotkam ,stekt	0.1		Koivistoinen 1980
Storfe, yttrefilet, stekt	0.1		Koivistoinen 1980
Svin, flatbiff stekt	0.3		Koivistoinen 1980
Svin kotelett, kam med fettrand	0.3		Koivistoinen 1980
Svin , bacon med svor, stekt	0.4		Koivistoinen 1980
Svin, familieribbe, stekt	0.3		Koivistoinen 1980
Svin, sideflesk, lettsaltet, stekt	0.3		Koivistoinen 1980
Lys lappskaus med stofekjøtt, 10% fett	0.1	1/2 deteksjon	Koivistoinen 1980
Gryterett med svinestek	0.1	1/2 deteksjon	Koivistoinen 1980
Sommerkotelett, kotelett uten fett	0.3		Koivistoinen 1980
Taco med kjøtt	0.05	estimat fra kjøtt/2	
Leverpostei 3 % fett	0.5		Koivistoinen 1980
Gjedde	45	gjedde 50%, abbor 50%	Scoop-rapport, upublisert, C.Bergsten, personlig kommunikasjon
Laks røkt	3	analyser av laks	SNT-rapport 4 1997
Krabbe, kokt	11,7	forhold mellom kjøtt og klør, 59% versus 41%	SNT-rapport 9 1996
Reker	3,8		4 1997, 2 1998
Fiskekaker	2,9	60% av torsk	
Fiskepinner	2,9	60% av torsk	
Blåskjell herm	3,8	samme som for reker	
Gaffelbiter	3,6	samme som for sild	SNT 4 1997, 4 1999
Kaviar av torskerogn	0,5	halv deteksjon for rogn	SNT-rapport 4 1997
Krabbe naturell herm	11,7	som annen krabbe	SNT-rapport 9 1996
Makrellfilet i tomat	2,4	80 % makrell	
Rognleverpostei	0,8	Estimat 50% lever + 50% rogn av torsk	
Sardiner i tomat	1,9	som sardiner i olje	Koivistoinen 1980
Tunfisk i olje herm, avrent	8		SNT-arbeidsrapport 4, 2002
Tunfisk i vann herm	8		SNT-arbeidsrapport 4, 2002
Kveite, kokt	12		SNT-arbeidsrapport 4, 2002
Laks, oppdrett, skiver, kokt	3		SNT-rapport 4 1997
Makrell, juli-sept, kokt	3,1		Scoop-rapport, upublisert, C.Bergsten, personlig kommunikasjon
Makrell, mai-juni, stekt i fett	3,1		Scoop-rapport, upublisert, C.Bergsten, personlig kommunikasjon
Sei, filet, melpanert, stekt i soyaolje	4,9	som torsk	
Steinbitfilet, melpanert og stekt	8	verdi for "annen fisk"	SNT-arbeidsrapport 4, 2002
Torsk, skiver kokt	4,9		SNT-rapport 4 1997
Fiskepate av mager fisk	2,9	60% torsk	
Fiskegrateng, med egg og makaroni	2,9	60% torsk	
Fiskegrateng, uten egg, ovnstekt, industri	2,9	60% torsk	
Sardin i olje avrent	1,9		Koivistoinen 1980
Makrell, kaldrøkt	3,1		Scoop-rapport, upublisert, C.Bergsten, personlig kommunikasjon
Lever, torsk, kokt	1		SNT-rapport 4, 1999
Torskrogn, hermetisk, stekt i fett	0,5	1/2 deteksjon	SNT-rapport 4 1997
Fiskepinner stekt i udef. Fett	2,9	60% torsk	

Appendix

Reker kokt, i lake 50/50	3,8		
Pastarett med fisk/skalldyr	1,3	estimat på 1/3 reker	
Reker +Krabbe 5:1	5,1		
Corn Flakes	0.2	1/2 deteksjon	Koivistoine 1980
Frokost-/kornblanding usøtet	0.2	som annet korn/mel	
Loff	0.2	1/2 deteksjon, finsk	Koivistoine 1980
Hamburgerbrød	0.2	som annet brød	
Rundst baguette finbakstmel	0.2	som annet brød	Koivistoine 1980
Knekkebrød husman	0.2	1/2 deteksjon	Koivistoine 1980
Klibrød	0.2	som annet brød	
Kornmo	0.2	1/2 deteksjon kjeks	Koivistoine 1980
Vafler m egg			
Julekake	0.2	1/2 deteksjon kake	Koivistoine 1980
Sjokoladekake fylt	0.2	1/2 deteksjon kake	Koivistoine 1980
Skolebrød	0.2	1/2 deteksjon hvitt brød	Koivistoine 1980
Smultringer	0.2	1/2 deteksjon hvitt brød	Koivistoine 1980
Wienerbrød	0.2	1/2 deteksjon kake	Koivistoine 1980
Ris parboiled kokt	0.2	1/2 deteksjon	Koivistoine 1980
Havregrøt m vann	0.1	1/2 deteksjon	Koivistoine 1980
Risgrøt	0.1	1/2 deteksjon	Koivistoine 1980
Makaroni kokt	0.2	1/2 deteksjon	Koivistoine 1980
Kjeks søt m havre og sjokolade	0.2	1/2 deteksjon kjeks	Koivistoine 1980
Kneippbrød, Bakers	0.2	1/2 deteksjon	Koivistoine 1980
Cous-cousgryn kokt	0.2		
Pasta, fersk, kokt med ketchup	0.2	som makaroni	
Kornbl. med frukt, nøtter, søtet	0.2	som frokostblanding	
Pannekaker stekt i fett			
Grovbrød uten sirup	0.2	som annet brød	Koivistoine 1980
Pastarett med grønnsaker	0.1	makaroni/2	
Pommes frites fryst	0.2	som potet	
Potetchips	0.2	som potet	
Potetmos ferdig tillaget pulver	0.2	1/2 deteksjon	Koivistoine 1980
Potet ringer skruer	0.2	som potet	
Agurk slange	0.05	1/2 deteksjon	Koivistoine 1980
A0arges	0.2	som hermetisk	
Aubergine			
Blomkål	0.1		Koivistoine 1980
Brokkoli	0.6		Koivistoine 1980
Bønner hvite i tomatsaus herm	0.05	1/2 deteksjon	Koivistoine 1980
Erter fryst	0.05	1/2 deteksjon	Koivistoine 1980
Grønnkål	0.05	1/2 deteksjon	Koivistoine 1980
Gulrot	0.2		Koivistoine 1980
Hodekål	0.05	1/2 deteksjon	Koivistoine 1980
Hvitløk			
Kinakål	0.1		Koivistoine 1980
Kålrot	0.05	som annen kål	
Løk	0.05	1/2 deteksjon	Koivistoine 1980
Maiskolbe			
Paprika grønn	0.05	1/2 deteksjon	Koivistoine 1980
Paprika rød	0.05	1/2 deteksjon	Koivistoine 1980
Rosenkål fryst			
Salat bladsalat	0.1		Koivistoine 1980
Salat issalat	0.1		Koivistoine 1980
Sopp	5	Gj.snitt av finske og svenske tall	Falandysz et al (King bolete) + Koivistoine 1980
Sopp sjampinjong herm	5	Gj.snitt av finske og svenske tall	Falandysz et al (King bolete) + Koivistoine 1980
Spinat, fryst	0,05	1/2 deteksjon	Koivistoine 1980
Stangselleri			

Appendix

Tomat	0.05	1/2 deteksjon	Koivistoinen 1980
Tomatjuice	0.05	som tomat	
Gulrot erter brekkbønner blomkål fryst	0.05		Koivistoinen 1980
Tomatketchup	0.1		Koivistoinen 1980
Squash			
Poteter lagring0oteter kokte u skall saltet vann	0.2		Koivistoinen 1980
Poteter lagring0oteter kokte m skall	0.2		Koivistoinen 1980
Bønner, grønne	0.05	1/2 deteksjon	Koivistoinen 1980
Skogssopp	5	Gj.snitt av finske og svenske tall	Falandysz et al (King bolete) + Koivistoinen 1980
Blåbær	0.05	som andre bær	
Jordbær	0.05	1/2 deteksjon	Koivistoinen 1980
Appelsin	0.05	1/2 deteksjon	Koivistoinen 1980
Aprikos tørkede			
Avocado			
Banan	0.1		Koivistoinen 1980
Drue	0.05	1/2 deteksjon	Koivistoinen 1980
Eple	0.05	1/2 deteksjon	Koivistoinen 1980
Fersken	0.1		Koivistoinen 1980
Fruktcocktail i egen saft herm	0.05		Koivistoinen 1980
Fruktcocktail i sukkerlake herm	0.05		Koivistoinen 1980
Grapefrukt	0.05	1/2 deteksjon	Koivistoinen 1980
Kiwi			
Mango			
Plomme	0.05	1/2 deteksjon	Koivistoinen 1980
Pære	0.1		Koivistoinen 1980
Rosiner	0.3		Koivistoinen 1980
Svisker	0.3		Koivistoinen 1980
Mandler	0.2	1/2 deteksjon	Koivistoinen 1980
Oliven grønne pickled			
Peanøtter saltet	0.2	1/2 deteksjon	Koivistoinen 1980
Peanøttsmør	0.2	som peanøtter	
Syltetøy 500 g suk/kg bær	0.1	1/2 deteksjon	Koivistoinen 1980
Syltetøy 750 g sukker/kg bær	0.1	1/2 deteksjon	Koivistoinen 1980
Appelsinjuice	0.05	1/2 deteksjon	Koivistoinen 1980
Eplenektar	0.05	1/2 deteksjon	Koivistoinen 1980
Solbærsirup drikkeferdig	0.05	1/2 deteksjon	Koivistoinen 1980
Papaya			
Melon honning			
Fruktcocktail- frisk frukt	0.05		
Grønnsaksrøre med tomat	0.05		
Bønnegryte, vegetarisk	0.05	som bønner	
Pastarett med grønnsaker	0.1	makaroni/2	
Soyaburgere stekt i olje			
Tartex			
Paprika rød kokt	0.05		
Gulrot kokt	0.2		
Blomkål, kokt	0.1		
Hodekål, kokt	0.05		
Kålrot, kokt	0.05		
Løk, kokt	0.05		
Purre	0.2		Koivistoinen 1980
Brokkoli, kokt	0.6		
Mais, hermetisk			
Pommes frites, gatekjøkken	0.2	som poteter	
Gratinerte poteter	0.1	poteter/2	
Banan + eple 50/50	0.1		
Tomat + agurk + syltagurk 30/30/30	0.05		

Appendix

Smør	0.2	1/2 deteksjon margarin	Koivistoinen 1980
Olje mais			
Olje soya			
Tran			
Majones ekte			
Lettmajones 50 %fett			
Lettmajones 40 %fett			
Salatdressing Thousand Island			
Salatdressing u fett			
Olje oliven			
Tran Møllers omega-3			
Bremykt	0.2	1/2 deteksjon margarin	
Brelett	0.2	1/2 deteksjon margarin	
Olje solsikke			
Fransk dressing			
Frokostsalat			
Majonessalat, ekte majones 35%fett			
Dressing majonestype 15% fett			
Dressing majonestype 30% fett			
Margarin, Melange, Per	0.2	1/2 deteksjon margarin	
Margarin, Oliven, beger	0.2	1/2 deteksjon margarin	
Margarin, Olivero, beger	0.2	1/2 deteksjon margarin	
Margarin, oliven, folio	0.2	1/2 deteksjon margarin	
Margarin, omega, beger	0.2	1/2 deteksjon margarin	
Margarin, Soft, beger	0.2	1/2 deteksjon margarin	
Margarin, Soft, soya, folio	0.2	1/2 deteksjon margarin	
Margarin, Soft light, beger	0.2	1/2 deteksjon margarin	
Margarin, Solsikke, beger	0.2	1/2 deteksjon margarin	
Margarin, Vita, beger	0.2	1/2 deteksjon margarin	
Margarin, Vita lett, beger	0.2	1/2 deteksjon margarin	
olje, raps			
Annen margarin	0.2	1/2 deteksjon margarin	
Smør_Bremyk 50/50	0.2	1/2 deteksjon margarin	
Tran, omega-3 per 100ml			
Valnøttolje, fra usda			
Yoghurtdressing	0.01	som yoghurt	
Sukker farin raffinade	0.2		Koivistoinen 1980
Honning	0,04	1/10 deteksjon	Koivistoinen 1980
Nøttepålegg			
Sjokoladepålegg	0,04	1/10 deteksjon sjokolade	Koivistoinen 1980
Lakris	0,04	1/10 deteksjon	Koivistoinen 1980
Marsipan	0,04	som mandler	
Sjokolade	0,04	1/10 deteksjon	Koivistoinen 1980
Sjokolade m nøtter	0,04	1/10 deteksjon	Koivistoinen 1980
Pastiller	0,04		Koivistoinen 1980
Blandet smågodt	0,04		
Sorbet			
Pastiller u sukker	0.04		Koivistoinen 1980
Sjokolade m karamell	0,04	1/10 deteksjon	Koivistoinen 1980
Gelefrukter seigmenn etc	0,04	1/10 deteksjon	Koivistoinen 1980
Kunstig søtstoff			
Honning/sjokolade/nøttepålegg	0,04	som sjokolade	

Appendix

Appendix 5: Tables showing distribution of Hg intakes related to sex, geographical residence, age and educational level.

Estimated intakes of total Hg and seafood Hg among men and women in the group of high consumers and references. Percentiles in $\mu\text{g/day}$, with the range in each group.

HIGH CONSUMERS	Sex	N	5	10	25	50	75	90	95	Min - Max
Total Hg	Men	58	4,2	4,9	6,4	7,9	10,7	13,4	18,3	2,9 - 33,4
	Women	63	3,3	3,7	4,5	5,9	8,0	11,2	12,7	2,8 - 23,6
From seafood	Men	58	2,3	2,5	4,0	5,8	8,6	10,6	14,3	1,6 - 31,5
	Women	63	1,8	1,9	2,2	4,0	5,1	7,3	9,5	1,0 - 21,5
REFERENCE GROUP										
Total Hg	Men	35	2,8	3,2	4,6	6,1	7,1	8,7	10,3	2,1 - 10,9
	Women	43	2,3	2,9	3,9	4,9	6,9	9,2	10,4	1,8 - 17,1
From seafood	Men	35	1,1	1,7	2,0	3,8	4,7	6,1	7,4	0,1 - 8,6
	Women	43	0,9	1,0	1,9	3,4	4,4	7,2	8,4	0,4 - 15,2

Estimated intakes of total Hg and seafood Hg in coastal and inland municipalities among high consumers and references. Percentiles in $\mu\text{g/day}$, with the range in each group.

HIGH CONSUMERS	Geographical residence	N	5	10	25	50	75	90	95	Min - Max
Total Hg	Coast	69	4,1	4,8	6,0	7,8	9,6	12,7	15,0	3,3 - 33,4
	Inland	52	3,1	3,5	4,3	5,8	7,4	12,5	14,8	2,8 - 23,6
From seafood	Coast	69	2,0	2,3	4,0	5,2	7,1	9,0	12,4	1,8 - 31,5
	Inland	52	1,6	1,9	2,2	3,6	5,2	10,1	12,1	1,0 - 21,5
REFERENCE GROUP										
Total Hg	Coast	31	2,3	3,0	4,7	6,1	7,6	8,7	9,4	1,8 - 10,1
	Inland	47	2,4	3,2	3,9	4,9	6,8	9,5	10,7	2,1 - 17,1
From seafood	Coast	31	0,7	1,7	2,9	3,7	4,8	6,1	6,7	0,4 - 7,1
	Inland	47	1,0	1,3	1,9	3,2	4,2	7,7	8,5	0,1 - 15,2

Appendix

Estimated intakes of total Hg and seafood Hg in different age groups among high consumers and references. Percentiles in $\mu\text{g/day}$, with the range in each group.

HIGH CONSUMERS	Age groups	N	5	10	25	50	75	90	95	Min – Max
Total hg	21-40	20	3,2	3,4	4,6	6,3	7,5	9,6	10,7	3,2 – 10,8
	41-60	48	3,4	3,8	5,1	6,6	9,2	11,7	13,3	2,9 – 33,4
	61+	53	3,9	4,0	5,7	7,5	10,7	13,2	19,1	2,8 – 23,6
From seafood	21-40	20	1,0	1,9	2,0	3,6	4,9	7,9	8,8	1,0 – 8,8
	41-60	48	1,8	2,1	3,1	4,4	6,4	9,1	10,1	1,6 – 31,5
	61+	53	1,9	2,3	4,0	5,2	8,2	11,0	15,6	1,6 – 21,5
REFERENCE GROUP										
Total hg	21-40	20	2,1	2,2	3,8	5,1	7,0	7,3	7,4	2,1 – 7,4
	41-60	34	2,9	3,1	4,1	5,0	6,8	8,7	9,3	2,6 – 10,6
	61+	24	2,2	3,4	4,8	6,2	7,9	10,5	15,5	1,8 – 17,1
From seafood	21-40	20	0,1	0,5	1,7	3,1	3,8	5,0	5,3	0,1 – 5,3
	41-60	34	1,3	1,7	1,9	3,1	4,5	6,4	7,2	1,0 – 7,6
	61+	24	1,1	1,7	3,4	3,9	5,4	8,5	13,6	0,9 – 15,2

Estimated intakes of total Hg and seafood Hg in different educational groups, among high consumers and references. Percentiles in $\mu\text{g/day}$, with the range in each group.

HIGH CONSUMERS	Educational level	N	5	10	25	50	75	90	95	Min – Max
Total Hg	Primary school	41	3,8	4,6	5,6	7,6	9,7	12,8	13,3	3,8 – 14,3
	Upper secondary	37	4,0	4,2	5,9	7,9	10,6	11,8	16,2	3,9 21,2
	University level	37	2,9	3,3	4,1	5,8	7,3	9,2	13,6	2,8 – 18,1
	Missing information	6	,	,	,	,	,	,	,	4,1 – 33,4
From seafood	Primary school	41	1,9	2,4	3,9	5,2	7,5	9,7	10,8	1,8 – 11,1
	Upper secondary	37	2,3	2,5	4,0	5,6	8,1	9,4	14,6	2,3 19,2
	University level	37	1,5	1,7	2,0	3,1	4,6	5,9	7,9	1,0 14,1
	Missing information	6	,	,	,	,	,	,	,	1,8 – 31,5
REFERENCE GROUP										
Total Hg	Primary school	16	1,8	3,1	4,6	6,5	9,6	10,7	,	1,8 – 10,9
	Upper secondary	28	2,3	3,0	4,3	5,4	6,9	8,1	13,4	2,1 – 17,1
	University level	31	2,5	3,0	3,9	5,1	6,9	7,9	8,9	2,2 – 9,5
	Missing information	3	,	,	,	,	,	,	,	3,5 – 6,8
From seafood	Primary school	16	0,9	1,2	2,8	4,3	6,4	8,2	,	0,9 – 8,6
	Upper secondary	28	0,3	1,6	1,8	3,6	4,5	5,6	11,6	0,1 – 15,2
	University level	31	1,0	1,1	2,0	3,3	4,1	5,3	7,1	1,0 – 8,5
	Missing information	3	,	,	,	,	,	,	,	1,7 – 4,2

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