Mercury in fish

– Background to the mercury in fish advisory statement

(March 2004)

Food regulators regularly assess the potential risks associated with the presence of contaminants in the food supply to ensure that, for all sections of the population, these risks are minimised. Food Standards Australia New Zealand (FSANZ) has recently reviewed its risk assessment for mercury in food. The results from this assessment indicate that certain groups, particularly pregnant women, women intending to become pregnant and young children (up to and including 6 years), should limit their consumption of some types of fish in order to control their exposure to mercury.

The risk assessment conducted by FSANZ that was published in 2004 used the most recent data and knowledge available at the time. FSANZ intends toreview the advisory statement in the future and will take any new data and scientific evidence into consideration at that time.

BENEFITS OF FISH

Even though certain types of fish can accumulate higher levels of mercury than others, it is widely recognised that there are considerable nutritional benefits to be derived from the regular consumption of fish.

Fish is an excellent source of high biological value protein, is low in saturated fat and contains polyunsaturated fatty acids such as essential omega-3 polyunsaturates. It is also a good source of some vitamins, particularly vitamin D where a 150 g serve of fish will supply around 3 micrograms of vitamin D – about three times the amount of vitamin D in a 10 g serve of margarine. Fish forms a significant component of the Australian diet with approximately 25% of the population consuming fish at least once a week (1995 Australian National Nutrition Survey; McLennan & Podger 1999).

The benefits of omega-3 fatty acids in the diet are becoming increasingly recognised. Omega-3 fatty acids are believed to play a role in protecting against heart disease by a number of means including discouraging blood cells from clotting and from sticking to artery walls or decreasing triglycerides and low density lipoproteins (LDL's) (Connor 2000; Sidhu 2003) and also appear to have anti-arrhythmic effects (De Caterina et al 2003). They are also believed to reduce the risk of stroke caused by blood clots (Insel et al 2003), and play a role in decreasing inflammation and benefiting people with autoimmune diseases (Simopoulos 2002). They are understood to have beneficial effects on brain and retina development in children (Connor 2000; Broadhurst et al 2002; Sidhu 2003). The National Heart Foundation recommends that fish be consumed at least twice a week for cardiovascular benefit, such as lowering blood cholesterol levels (www.heartfoundation.com.au).

Fish is also an excellent source of iodine providing from 25% to 100% of women's Recommended Daily Intake. Recent research has found that some Australians do not get enough iodine (Gunton et al 1999; McDonnell et al 2003). An adequate iodine intake is important for normal thyroid function and is also essential for critical periods in foetal development and early childhood (Eastman 1999).

AUSTRALIAN DIETARY GUIDELINES

The Australian Dietary Guidelines say to enjoy a wide variety of nutritious foods (NHMRC 2003). Any diet based primarily on one type of food might not be nutritionally balanced and may be of a health concern to any member of the population. For example, eating seafood several times a day over a long period of time to the exclusion of other foods may result in nutritional imbalances, as one food cannot provide all the nutrients needed for good health. The Australian Dietary Guidelines advise eating one or two fish meals per week, and specify a serve of fish as being between 80 to 120 grams.

Sources of Mercury

Mercury occurs naturally in the environment as metallic mercury, inorganic mercury (mercuric salts) or organic mercury. Mercury can also occur in the environment as a result of human activities. In aquatic environments, inorganic mercury is converted into methylmercury (the most common form of organic mercury) by microorganisms present in sediment. Once this occurs, the methylmercury accumulates in the aquatic food chain, including in fish and shellfish (molluscs and crustacea).

Methylmercury is the most hazardous form of mercury encountered in food, and fish is the main source of exposure to methylmercury for most individuals (NRC 2000). For the foetus, exposure comes through the maternal diet.

Methylmercury tends to accumulate in some types of fish more than others. This is due to a number of key factors, including age of the fish, natural environment, and food sources. Fish that are more likely to accumulate higher levels of methylmercury are the larger, longer living or predatory species. Examples include shark/flake, billfish (including swordfish, broadbill and marlin), catfish, and orange roughy.

Overall, the levels of methylmercury normally found in fish, even in those species known to accumulate higher levels, are not sufficient to lead to high levels of intake for the majority of the population who typically consume only moderate amounts of fish. Therefore, for the vast majority of the population, the level of methylmercury in fish does not pose any significant health risk.

EFFECTS OF METHYLMERCURY

Methylmercuryisreadilyabsorbed(>95%) from the gut following ingestion and is rapidly distributed via blood to the tissues (ATSDR 1999; NRC 2000). Methylmercury can readily cross both the blood brain barrier and the placenta, resulting in higher mercury concentrations in the foetal brain compared to that of the mother. About 10% of the total body burden of methylmercury is found in the brain where it is slowly demethylated to inorganic mercury. The daily excretion of methylmercury represents about 1% of the body burden (Clarkson et al 1988), with the whole body half-life estimated to be 70-80 days (EPA 1997). The major routes of excretion are through the bile and faeces, with lesser amounts in urine (NRC 2000).

The toxic effects of methylmercury, particularly on the nervous system, are well documented and an extensive body of literature is available from both human and animal studies. The severity of the effects observed depends largely on the magnitude of the dose with effects in adults occurring at much higher levels of exposure than that linked to effects in children following *in utero* exposure. The developing nervous system is thus considered the most sensitive target for toxicity with the critical exposure period being during *in utero* development when the foetal brain is developing very rapidly.

In the adult brain, methylmercury, at high levels of exposure, causes a loss of cells in specific areas, most commonly the cerebellum, visual cortex, and other focal areas of the brain (Clarkson 1997). The first effect observed is typically paraesthesia (numbness and tingling in lips, fingers and toes), which frequently appears some months after the exposure first occurred. In severe cases, there is progression to loss of coordination, narrowing of the visual fields, hearing loss and speech impairment.

In the foetal brain, methylmercury at high levels causes more extensive and generalised damage by disrupting normal patterns of cell migration and neuronal cell division (Choi et al 1978). The effects in the infant of such damage are similar to those of cerebral palsy. Such effects however have only been seen following large-scale poisoning episodes (e.g. contamination incidents). More typically, the foetus is exposed to low levels of methylmercury through maternal fish consumption. In such cases, attention has focussed on more subtle effects on neurodevelopment in the offspring.

Because the foetus is more sensitive than adults to the harmful effects of methylmercury, FSANZ has used two separate upper safe levels of dietary intake (known as the provisional tolerable weekly intake, or PTWI [1]) for the purposes of risk assessment — one level considered to be protective of the general population and a lower level considered to be protective of the foetus. The level set to protect the foetus is 1.6 μg methylmercury/kg body weight/week and is approximately half the level used for the general population (3.3 μg/kg body weight/week).

The PTWI used by FSANZ for the foetus is taken from a recent re-evaluation of methylmercury by the Joint FAO/WHO Expert Group on Food Additives (JECFA 2003), which considered the results of two large-scale epidemiological studies on mother-infant pairs in the Republic of Seychelles (Davidson et al 1998 & 2001; Myers et al 2003) and the Faroe Islands (Grandjean et al 1997). Both population groups have a dietary dependence on fish and marine mammals (in the case of the Faroe islands), which provide an ongoing source of exposure to methylmercury. Over 80% of the Seychellois population consumes fish at least once a day (mean methylmercury concentration 0.3 mg/kg, range 0.004-0.75 mg/kg) whereas for the Faroese exposure comes mainly from pilot whale meat (mean methylmercury concentration 1.6 mg/kg), which is eaten less frequently. Increasing *in utero* methylmercury exposure was significantly associated with poorer performance in neuropsychological function in childhood at 7 years of age in the Faroe Islands study, but not in children up to 8 years of age in the Seychelles Islands study. A recently published follow-up study in the

Faroe Islands indicates that some of the effects observed are still apparent in the children at 14 years of age (Murata et al 2004, Grandjean et al 2004).

Effects observed in childhood that have been associated with *in utero* exposure to methylmercury from maternal consumption of fish/marine mammals are quite subtle and in many ways are similar to mild learning disabilities. As such, the effects tend only to be apparent using sensitive neurobehavioural and neuropsychological testing. The largest effects in the Faroe Islands study were on attention, learning, and memory and to a lesser extent, visuospatial and fine motor activities. Such effects however were not observed in the Seychellois children, who displayed no adverse associations with increasing maternal methylmercury intake. In fact, some of the tests conducted on the Seychellois children suggested beneficial effects correlated with increasing mercury levels during pregnancy. The maternal mercury levels in the Seychelles population are closely correlated with fish consumption, therefore this finding has been attributed to the nutritional benefits of fish (Clarkson & Strain 2003).

REGULATIONS FOR MERCURY IN FISH

The *Australia New ZealandFood Standards Code* prescribes maximum levels for mercury in some foods, including fish. Two separate maximum levels are imposed for fish — a level of 1.0 mg mercury/kg for the fish that are known to contain high levels of mercury (such as swordfish, southern bluefin tuna, barramundi, ling, orange roughy, rays and shark) and a level of 0.5 mg/kg for all other species of fish. A limit of 0.5 mg/kg is also imposed for crustacea and molluscs.   These limits apply to all seafood offered for commercial sale.

Calculation of the Recommendations for Fish Consumption

The advice on the maximum number of serves of fish that can be eaten per week was determined by calculating the maximum amount of fish that could be eaten by each population group such that the respective reference health standard (PTWI) for weekly intake of methylmercury from all food sources would not be exceeded. The steps used in this calculation were as follows:

1. The total mercury levels in individual fish samples were collated and median levels for different types of fish including shark, billfish, orange roughy etc were calculated. The total mercury concentrations were assumed to be methylmercury as a worst-case scenario and to enable direct comparison to the PTWI.

2. The amount of each type of fish that could be consumed without exceeding the PTWI was calculated, **assuming people eat only this one type of fish**. The contribution of non-seafood to methylmercury exposure was taken into account in this calculation. These amounts of fish were then rounded down to the nearest number of serves of fish (one serve is equal to 150g for the general population, pregnant women and women intending to become pregnant; 75g for children up to 6 years).

Table 1 gives examples of the calculations for orange roughy to estimate the maximum serves allowed per week for each population group.

Table 1: An example of calculations to estimate the maximum number of orange roughy

serves that can be consumed per week for the Australian population groups[1] of women of childbearing age (16 – 44 years), the general population (2 years and above) and children (2 – 6 years)

	Australian women of childbearing age (16 – 44 years)	**Australian general population (2 years and above)**	**Australian children (2 – 6 years)**
PTWI for methylmercury	= 1.6 µg / kg body weight/week	= 3.3 µg / kg body weight/week	= 3.3 µg / kg body weight/week
Total permitted methylmercury intake per week	= 105.6 µg /week (1.6 x 66 kg body weight)	= 221.1 µg /week (3.3 x 67 kg body wieght)	= 62.7 µg /week (3.3 x 19 kg body weight)
Estimated methylmercury intake from non sea foods in diet(main source: spices)	= 0.94 µg /week (0.09% of total methylmercury exposure from all foods)	= 1.14 µg /week (0.09% of total methylmercury exposure from all foods)	= 3.10 µg /week (0.01% of total methylmercury exposure from all foods)
Amount of methylmercury that can safely be consumed from fish sources	= 105.6 – 0.94µg/week = 104.66 µg /week	= 221.1 – 1.14µg /week = 219.96 µg / week	= 62.7 – 3.10 µg /week = 59.60 µg /week
Maximum	= 104.66 µg	= 219.96 µg	= 59.60 µg

amount of**orange roughy**that can be consumed per week (540 µg mercury /kg orange roughy)[2]	/week ÷ 540µg/kg = 194g fish /week = 1.3 serves/week 1 serve / week	/week ÷ 540µg/kg = 407g fish /week = 2.7 serves/week 2 serves / week	/week ÷ 540 µg/kg = 110g fish /week = 1.5serves/week 1 serve / week

[1] Dietary exposure assessments for methylmercury were derived from survey data on total mercury levels in foods (assumed to be all methylmercury), submitted to FSANZ for the review of the Food Standards Code and for the 2003 review of mercury in fish, food consumption data for foods from all dietary sources and bodyweights for population groups derived from the 1995 Australian National Nutrition Survey.

[2] Concentration of mercury in orange roughy derived from survey data collated by FSANZ.

The exposure to mercury from non-seafood appears to come mainly from spices as this was the only food other than seafood where detectable concentrations of mercury were reported in recent surveys. The exposure to mercury from non-seafood for children is estimated to be much smaller than for women of childbearing age and the general population because children generally eat lower amounts of spices than other groups in the population.

The serves of fish that can be theoretically consumed such that the PTWI is not exceeded are summarised in the Advice on Fish Consumption. These calculations assume that fish contains the mid-point of the range (median) of mercury concentrations, not the maximum reported level, recognising that mercury concentration varies considerably within each type of fish, and the distribution of values is usually ‘skewed’ by a few samples with higher concentrations. After the number of serves of fish was calculated for each type of fish, the numbers were all rounded down to the nearest whole number. For example, for a calculated number of serves each week of 1.6, the recommended number of serves given in the table was 1 serve each week. This is not the conventional way of rounding numbers, however, for public health reasons, the number was not rounded up to 2 serves per week, as consuming the higher number of serves could result in consumers exceeding the PTWI.

The number of estimated serves for women of childbearing age and children (2-6 years) were usually very similar. As they are the most vulnerable groups for mercury exposure, their recommended number of serves have been grouped together in the table in the advice statement. In some cases where children may have been allowed a slightly higher number of serves (for example 2 per week) and the women of childbearing age a slightly lower number of serves (for example 1.8 per week) for the same type of fish, the number of serves for children was assigned the same number as the women of childbearing age to err on the side of caution.

Reported fish intakes in Australia

In the 1995 National Nutrition Survey (NNS) foods eaten in the last 24 hours were recorded for 13858 people aged 2 years and over. Of these, 14% people in the survey reported eating some type of fish or seafood on the day of the survey. For almost half of these consumers, this was in the form of finfish, two thirds of which was crumbed or battered. For around one third of consumers of fish or seafood, it was canned. Summary consumption amounts for finfish and canned fish from the NNS for each population group assessed are shown in Table 2.

Table 2 . Mean and high (95th percentile) consumption amounts for finfish and canned fish for the Australian population groupsof the general population (2 years and above), women of childbearing age (16 – 44 years), and children (2 – 6 years)

	All population (2+ years)		**Women 16-44 years**		**Children 2-6 years**	
	Mean Consumption (grams/day)	High Consumption (grams/day)	Mean Consumption (grams/day)	High Consumption (grams/day)	Mean Consumption (grams/day)	High Consumption (grams/day)
Finfish	115	305	95	265	60	140
Canned fish	70	185	65	155	40	*

* High consumption calculation could not be calculated for this group, as the sample size for this group was too small.

The 24-hour recall survey does not indicate how often fish was eaten during the week. From the food frequency questionnaire undertaken (on respondents aged 12 years and over) at the same time as the 24-hour recall dietary survey, 25% people in the survey reported eating fish at least once a week, and only 0.2% reported eating fish on a daily basis. It appears that those who eat fish on a daily basis have larger portion sizes than those who eat it less frequently.

In the NNS there were a few extremely high consumers of fish who ate between 600g and 1kg of fish in a 24-hour period. These consumers would be at risk of exceeding the PTWI for mercury if this level of consumption is habitual. It is advised that consumers like these who tend to eat large amounts of fish on a regular basis should reduce the number of times they eat fish each week and/or the serving size of fish they consume, according to the FSANZ 'Advice on Fish Consumption', in order to ensure they are not being exposed to too much mercury.

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