A Quantitative Model for Risk Benefit Assessment of Seafood Consumption

David James – FAO – November 2011

Growing public concern regarding the presence of chemical contaminants in fish
- Multiple nutritional benefits of including fish in the diet have become increasingly clear

Brain Fudge? Brain Washed?

Mercury is such a potent neurotoxin that it can cross the placental barrier, causing brain damage in the developing fetal brain.

Did you see this fishy ad last week?

Outrageous claim:

“600,000 born annually with brain damage due to fish-eating mothers”

Don’t let the government tell you a fish story.

Expert Consultation on the Risks and Benefits of Fish Consumption

- Request from Codex Alimentarius
- Held in Rome
  January 2010
Task

- Review data on nutrient and specific chemical (MeHg and DLCs) contaminant levels in a range of fish species
- Review recent scientific literature covering the risks and benefits of fish consumption
- Consider risk-benefit assessments for specific end-points of benefits and risks

Intention

- Provide guidance to national food safety authorities and the Codex Alimentarius Commission on managing risks related to eating fish, taking into account the existing data on the benefits of eating fish

FAO/WHO Expert Consultation Terms of Reference:

- Assessment of the health risks associated with the consumption of fish and other seafood
- Assessment of the health benefits of fish and other seafood consumption
- Comparison of the health risks and health benefits of fish and other seafood consumption
- Develop a methodology for carrying out quantitative assessments of the risks and benefits related to seafood consumption

Experts

- 17 experts representing 11 countries and 5 continents
- Expertise in nutrition, toxicology, epidemiology, dietary exposure and risk-benefit assessments

There is convincing evidence that:

- LCn-3PUFA (DHA) is important for optimal brain development during gestation and infancy.
- Maternal fish consumption during gestation and nursing lowers the risk of suboptimal brain development in their children.
Maternal MeHg intake during gestation increases the risk of suboptimal brain development in their children.

Based on quantitative risk-benefit analysis of DHA and MeHg, the neurodevelopmental risks of not eating fish exceed the risks of eating fish under most circumstances evaluated.

MeHg and DHA/EPA

- Decided to conduct a comparison between the effects of prenatal exposure to LC n-3 PUFA and MeHg on child IQ
- Establish a dose-response relationship from multiple cohort studies

→ quantitative risk-benefit analysis

**MeHg Risks**

- Three meta-analyses studies
  - Faeroe Islands
  - Seychelles
  - New Zealand

- Assumptions:
  - Serving size 100g
  - Body weight 60 kg
  - Ratio Hg in hair and daily MeHg intake (µg/kg body weight/day) is 9.33

**PUFA Benefits**

- Four analyses considered
  - Cohen et al. 2005
  - FDA 2010
  - Oken et al. 2008
  - Oken et al. 2008

- Some assumptions:
  - 28 g fish gives 100 mg DHA (average)
  - DHA ratio of LC n-3 PUFA = 0.67

**IQ increase/decrease**

- 4 IQ points gain per 100mg/day DHA, maximum gain 5.8 IQ points

- 0.18 (central estimate) to 0.7 (upper limit) IQ points decrease per µg/g MeHg in maternal hair

**Estimated changes in child IQ**

<table>
<thead>
<tr>
<th>MeHg (µg/g)</th>
<th>2x 100g fish/week</th>
<th>EPA</th>
<th>DHA</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤0.1</td>
<td>-0.04, -0.2</td>
<td>+1.5</td>
<td>+4.2</td>
<td>+5.8</td>
</tr>
<tr>
<td>0.1-0.5</td>
<td>-0.2, -0.9</td>
<td>+1.5</td>
<td>+4.2</td>
<td>+5.8</td>
</tr>
<tr>
<td>0.5-1</td>
<td>-0.6, -2.3</td>
<td>+1.5</td>
<td>+4.2</td>
<td>+5.8</td>
</tr>
<tr>
<td>&gt;1</td>
<td>-1.2, -4.7</td>
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### Estimated changes in child IQ

**EPA + DHA by total mercury**

<table>
<thead>
<tr>
<th>Mercury level</th>
<th>EPA + DHA mg/g</th>
</tr>
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<tbody>
<tr>
<td>x≤0.1 µg/g</td>
<td>-0.08, -0.31</td>
</tr>
<tr>
<td>0.1&lt;x≤0.5 µg/g</td>
<td>-0.48, -1.9</td>
</tr>
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<td>-1.2, -4.7</td>
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<td>x &gt;1 µg/g</td>
<td>-2.4, -9.3</td>
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**Methyl mercury**

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### Estimated changes in mortality

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<td>x≤0.1 µg/g</td>
<td>+330</td>
</tr>
<tr>
<td>0.1&lt;x≤0.5 µg/g</td>
<td>+4200</td>
</tr>
<tr>
<td>0.5&lt;x≤1 µg/g</td>
<td>+10 000</td>
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### Dioxin-Like Compounds (DLC)

- Fish and EPA+DHA consumption lower the risk of CHD mortality.
- High DLC exposure increases the risk of cancer.
- Established CHD mortality benefits exceed theoretical upper estimate cancer risks for all frequencies and categories of fish consumption and DLC exposure evaluated.

### EPA + DHA dioxins

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Factors that might affect risks and benefits of consuming fish and sea mammals

- Position in the food chain
- Age of animal to be eaten
- Fatty acid composition
- Micronutrient content, such as selenium

SELENIUM IN THE MERCURY ISSUE

- Methylmercury toxicity does not appear to occur when selenium is present in molar excess of mercury in tissues.
- Methylmercury toxicity occurs because mercury is an irreversible inhibitor of selenoenzymes.
- Biochemical effects of mercury toxicity correspond with expected effects of diminished selenoenzyme activities.
- Selenium-dependent protection against mercury toxicity supports the hypothesis that selenium sequestration is the primary molecular mechanism of mercury toxicity.
- Consumption of selenium-rich ocean fish prevents mercury toxicity rather than contributes to it.
- Consumption of high-mercury, selenium-poor freshwater fish may be far more toxic than is currently expected.

Selenium Health Benefit Values

To minimize risks in target populations, the committee recommends that member states should:

- Acknowledge fish consumption as an importance food source of energy, protein, and a range of essential nutrients and part of the cultural traditions of many peoples.
- Emphasize the CHD mortality benefits of fish consumption (and CHD risks of not eating fish) for the general adult population.
- Emphasize the neurodevelopment benefits to offspring through women of childbearing age, pregnant women, and nursing mothers consuming fish and the associated neurodevelopment risks to offspring through such women not consuming fish.
- Develop, maintain, and improve existing databases on specific nutrients and contaminants in fish consumed in their region.
- Develop and evaluate risk management and communication strategies that both minimize risks and maximize benefits from eating fish.

Regional differences

- Nutrients including LCn-3PUFA and contaminants in fish including MeHg and especially DLCs can have large regional differences.
- It is critical that national and regional authorities have specific information on nutrients and contaminants in fish consumed in their region.
CONCLUSIONS

• Consumption of fish provides energy, protein, and a range of essential nutrients, including the long-chain n-3 poly unsaturated fatty acids (LC n-3 PUFA’s).

• Eating fish is part of the cultural traditions of many peoples and in some populations is a major source of food and essential nutrients.

• Among the general adult population, consumption of fish, particularly oily fish, lowers the risk of coronary heart disease (CHD) mortality. There is absence of probable or convincing evidence of CHD risks of MeHg. Potential cancer risks of DLCs are well below established CHD benefits.

• Among women of childbearing age, considering benefits of LC n-3 PUFA’s vs. risks of MeHg: fish consumption lowers the risk of suboptimal neurodevelopment in their offspring compared to not eating fish in most circumstances evaluated.

• At levels of maternal DLC intake (from fish and other dietary sources) that do not exceed the provisional tolerable monthly intake (PTMI) of 70 picograms/kg bodyweight/month established by JECFA, the neurodevelopmental risk is negligible. At levels of maternal DLC intake (from fish and other dietary sources) that exceed the PTMI, neurodevelopmental risk may no longer be negligible.

• Among infants, young children, and adolescents, the data available were insufficient to derive a quantitative framework of health risks and benefits of eating fish. However, healthy dietary patterns that include fish established early in life influence dietary habits and health during adult life.