[Korea]

Food Safety; How to Assess Chemical Risk? —With a Case Study of Mercury in Fish*1

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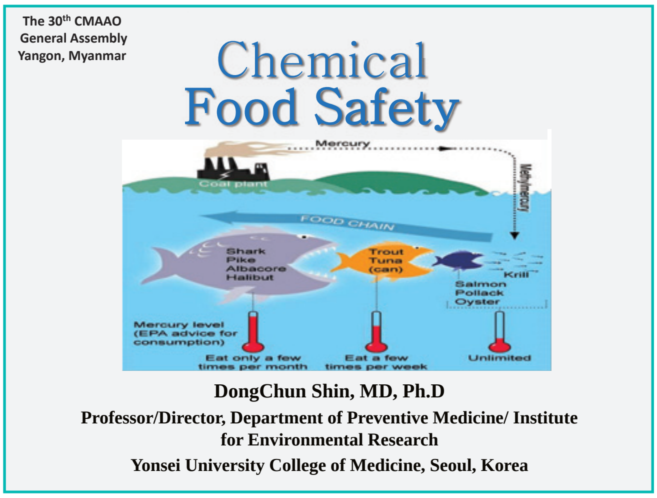
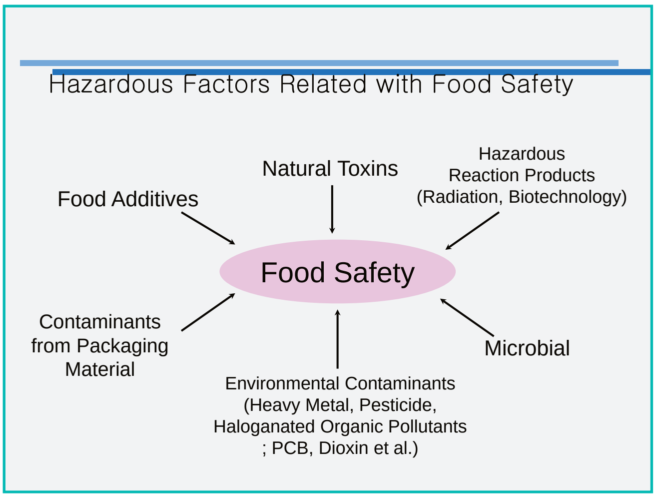
With the development of modern society, the issue of food safety has also become more complex and sophisticated from traditional microbial food poisoning to contamination from chemicals and food additives.

The chemical industry has developed in line with the development of human civilization from the second half of the 20th century, and as a result, chemicals have become ubiquitous to human life globally and are entering the human body through marine life food chain, and via air and water. The increase in trans-border export and import of food has also increased opportunities for exposure to contaminated food.

The chemical contaminants found in food that are most harmful would be heavy metals and endocrine disruptors, which may cause chronic toxicity in various organs as well as cancer and hormone disruptions through long-term exposure. However, in today's modern society, people are exposed to chemicals even from the fetal period, and cannot be free of chemicals throughout their lifetimes. Therefore, the question posed to medical science is what would be the acceptable level of contamination for human-beings. To answer this question, an understanding of the relationship between exposure to contaminants and health effect would be necessary as well as a quantitative assessment based on a dose-response relations.

Unfortunately, it is rare to have enough data to conduct a quantitative assessment regarding the various chemicals we are exposed to. Given this reality, this paper introduces a case study on an assessment process using mercury, with the aim of discussing the role of medicine in the area of food safety and control, which is critical to public health. Also, this paper explores what are necessary for the government and society to develop and implement effective policies.





*1 This article is based on a presentation made at the Symposium "Ensuring Food Safety: An Important Challenge Today" held at the 30th CMAAO General Assembly and 51st Council Meeting, Yangon, Myanmar, on September 23-25, 2015.

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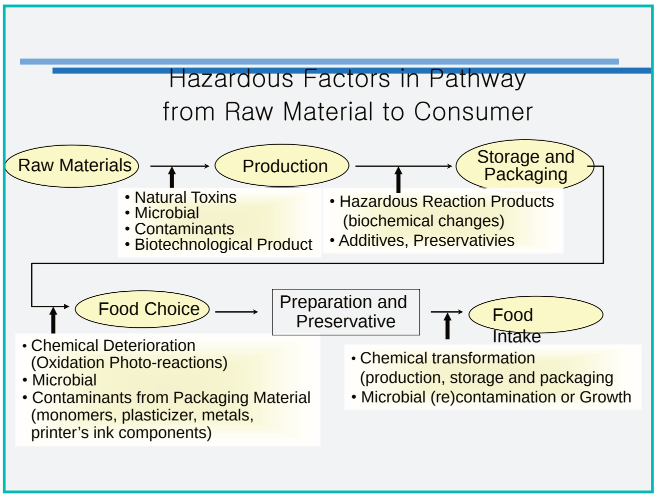
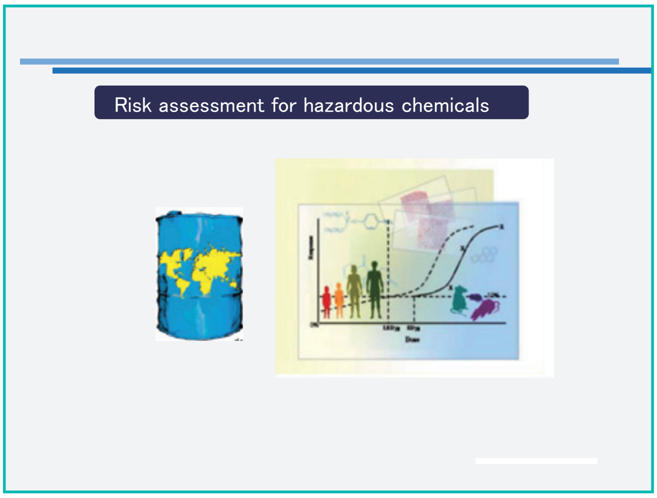
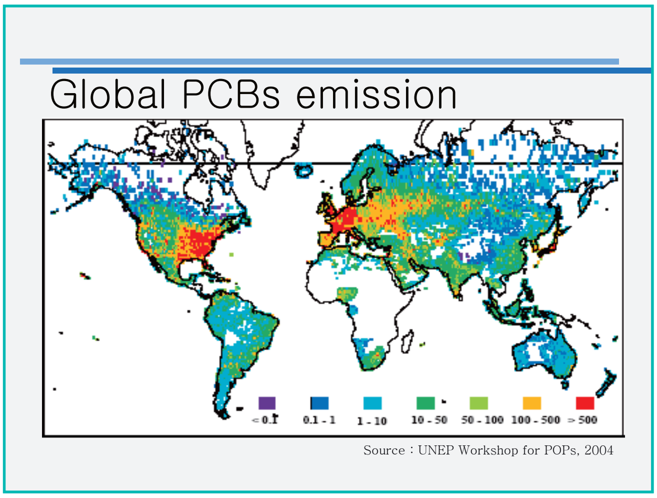
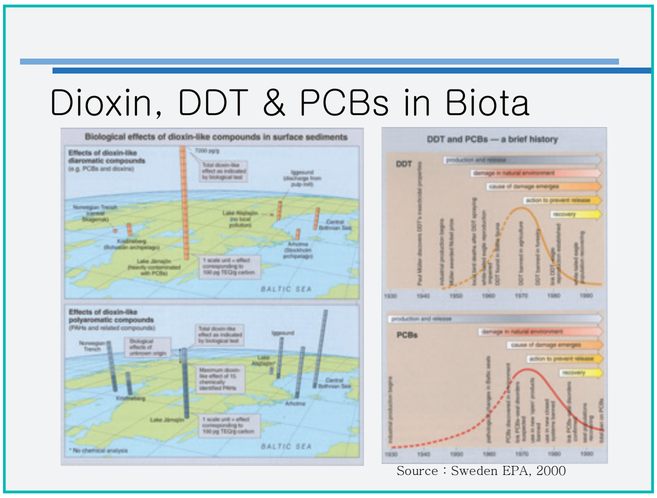


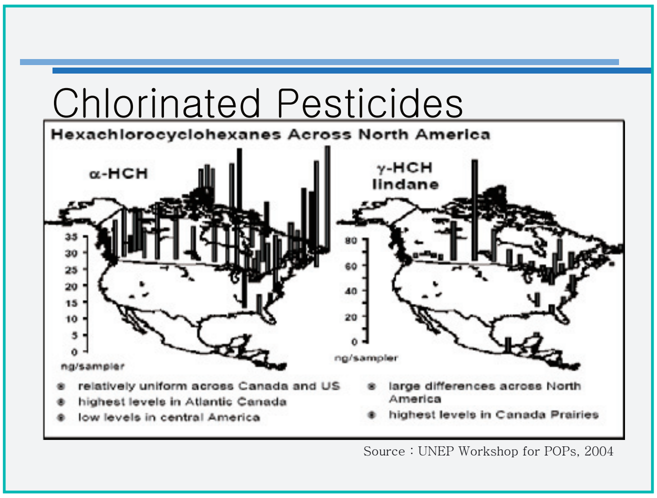




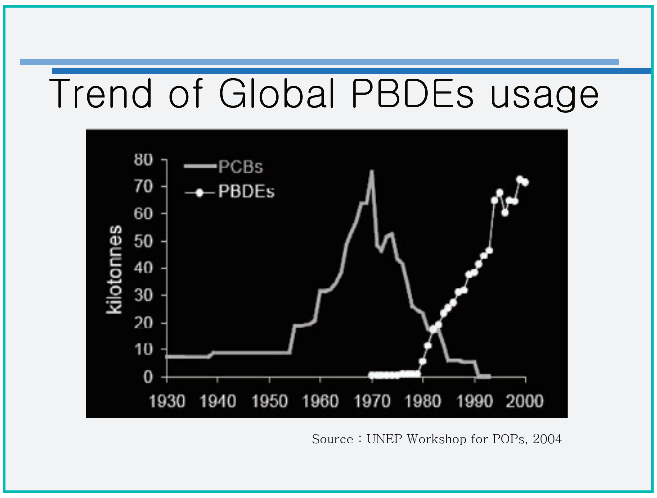
Source : UNEP Workshop for POPs, 2004



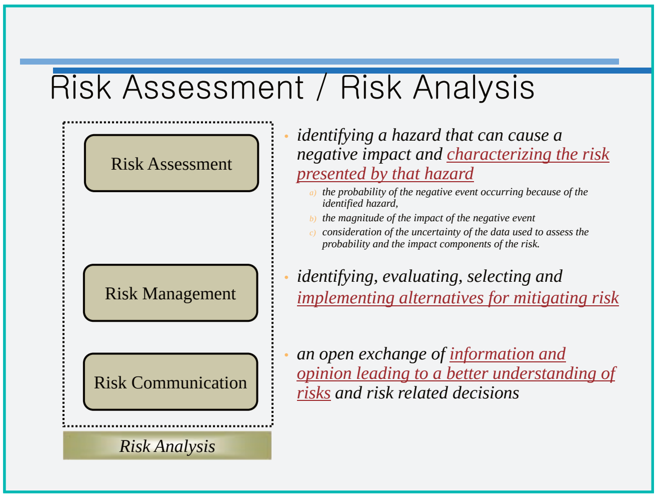
Source : Sweden EPA, 2000

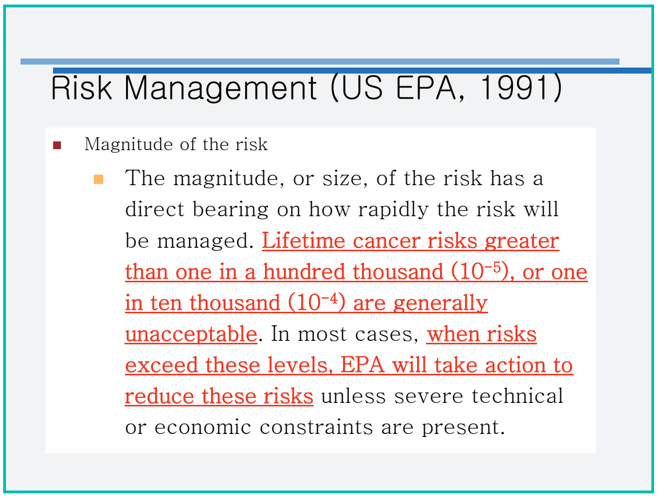


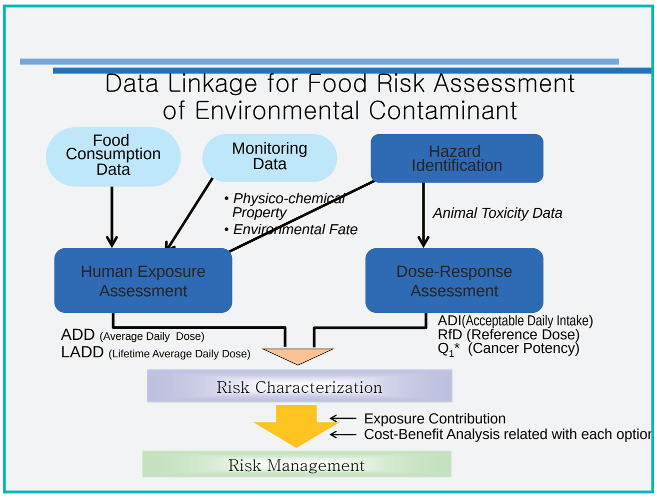
Source : UNEP Workshop for POPs, 2004

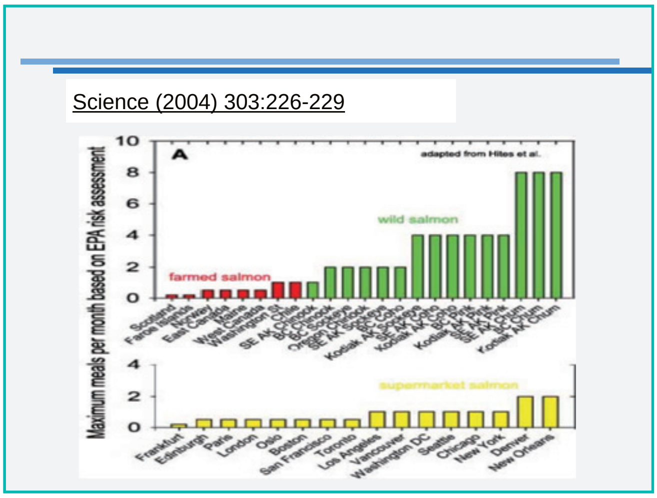


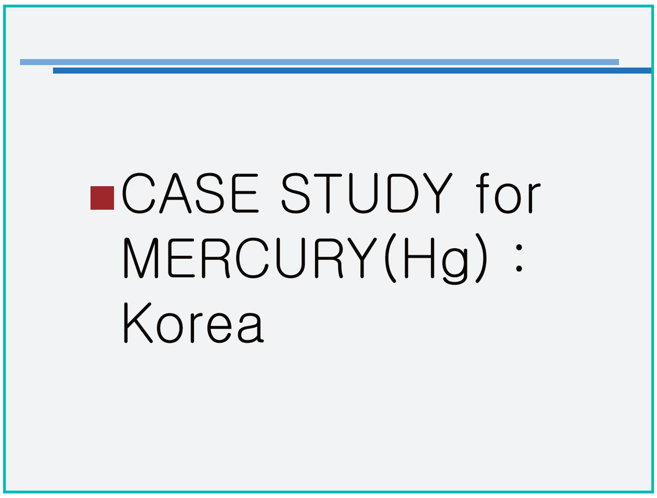
Source : UNEP Workshop for POPs, 2004

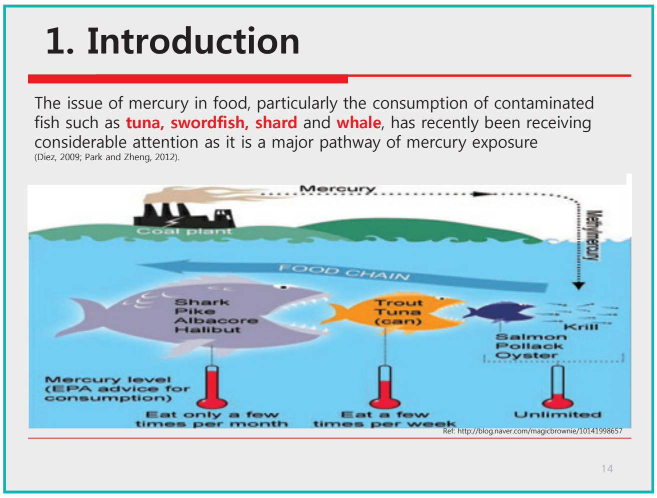

Risk Assessment / Risk Analysis
Risk Assessment
Risk Management
Risk Communication
Risk Analysis
identifying a hazard that can cause a negative impact and characterizing the risk presented by that hazard
a) the probability of the negative event occurring because of the identified hazard,
b) the magnitude of the impact of the negative event
c) consideration of the uncertainty of the data used to assess the probability and the impact components of the risk.
identifying, evaluating, selecting and implementing alternatives for mitigating risk
an open exchange of information and opinion leading to a better understanding of risks and risk related decisions


Risk Management (US EPA, 1991)
Magnitude of the risk
The magnitude, or size, of the risk has a direct bearing on how rapidly the risk will be managed. Lifetime cancer risks greater than one in a hundred thousand (10⁻⁵), or one in ten thousand (10⁻⁴) are generally unacceptable. In most cases, when risks exceed these levels, EPA will take action to reduce these risks unless severe technical or economic constraints are present.


Data Linkage for Food Risk Assessment of Environmental Contaminant
Food Consumption Data
Monitoring Data
Hazard Identification
• Physico-chemical Property
• Environmental Fate
Animal Toxicity Data
Human Exposure Assessment
Dose-Response Assessment
ADD (Average Daily Dose)
LADD (Lifetime Average Daily Dose)
ADI(Acceptable Daily Intake)
RfD (Reference Dose)
Q1* (Cancer Potency)
Risk Characterization
Exposure Contribution
Cost-Benefit Analysis related with each option
Risk Management


Science (2004) 303:226-229
Maximum meals per month based on EPA risk assessment
A
adapted from Hites et al.
farmed salmon
wild salmon
supermarket salmon
Scotland
Faroe Islands
Norway
East Canada
Maine
West Canada
Washington St
Chile
Frankfurt
Edinburgh
Paris
London
Oslo
Boston
San Francisco
Toronto
Los Angeles
Vancouver
Washington DC
Seattle
Chicago
New York
Denver
New Orleans


CASE STUDY for MERCURY(Hg) : Korea


1. Introduction
The issue of mercury in food, particularly the consumption of contaminated fish such as tuna, swordfish, shard and whale, has recently been receiving considerable attention as it is a major pathway of mercury exposure
(Diez, 2009; Park and Zheng, 2012).
Mercury
Coal plant
Methylmercury
FOOD CHAIN
Shark
Pike
Albacore
Halibut
Trout
Tuna
(can)
Krill
Salmon
Pollack
Oyster
Mercury level
(EPA advice for consumption)
Eat only a few times per month
Eat a few times per week
Unlimited
Ref: http://blog.naver.com/magicbrownie/10141998657
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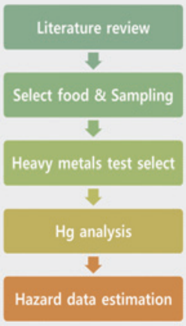
2. Materials & Method

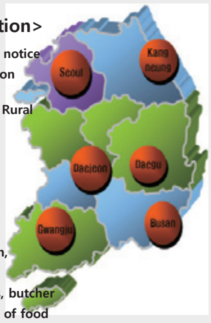


<Standard of food selection>

- Ministry of Food and Drug Safety notice
- Korea National Health and Nutrition Examination Survey
- Ministry of Agriculture, Food and Rural Affairs notice

<Purchasing criteria>

- Purchase in prime locations
- Seoul, Gyeonggi, Gangwon (Gangneung and Wonju), Daejeon, Daegu, Gwangju and Busan
- Supermarkets, traditional markets, butcher
- Purchase the appropriate amount of food collected with standards



2. Materials & Method

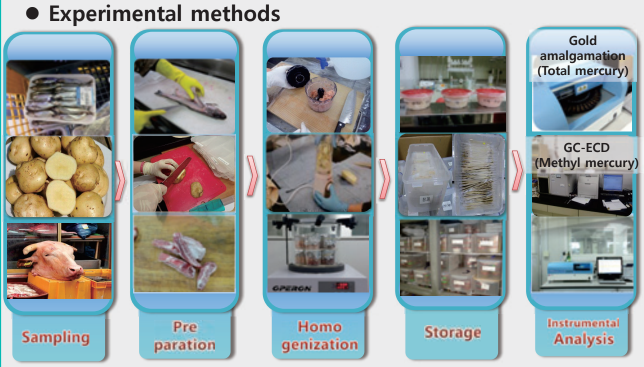
- Select food & surveyed period

Fishery products (Mar. ~ Oct. 2012) | Agricultural products (Jan. ~ Oct. 2013) | Livestock products (Jan. ~ Oct. 2014)

	2012	2013	2014
	Fishery	Agricultural products	Livestock
type	115	136	93
cases	11,192	12,951	10,140
total		34,283	

2. Materials & Method

- Experimental methods



2. Materials & Method

- Risk Assessment of Mercury & Methyl mercury
  - The risks of Hg and MeHg were evaluated by calculating chronic daily intake of Hg and MeHg, and then comparing it with the PTWI values set by JECFA
  - The PTWI values of Hg and MeHg established by JECFA are 0.005 and 0.0016 mg/kg-body weight per week, respectively (PTDI = 0.7 (Hg) and 0.23 (MeHg) ug/kg-day)
  - Food intake rate and body weight were derived from National Nutrition Survey report, 2008 - 2010 in Korea (MHWK, 2011)

$$\text{Chronic daily intake of Hg} = \sum_{i=1}^{n} \sum_{j=1}^{n} \frac{(c_i \times FIR_{i,j})}{BW_j}$$

$$\text{Risk ratio of Hg (\%)} = \frac{\text{Chronic daily intake of Hg}}{\text{PTWI of Hg / 7}} \times 100$$

C_i : Concentration (mean value) of mercury in food (ug/g)
$FIR_{i,j}$: Food intake rate of i food and i age group (g/day)
BW_j : Average body weight of j age group (kg)
PTWI : The provisional tolerable weekly intake (ug/kg-day)

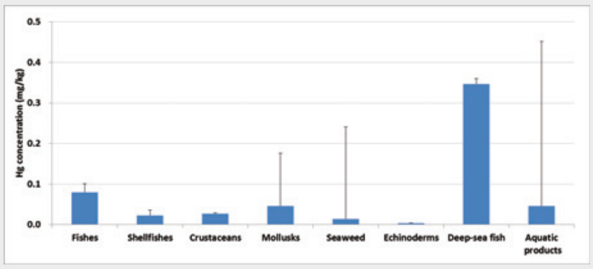
3. Concentrations in food

- **Mercury and methyl mercury levels in raw food**
  - The average concentration of mercury and methyl mercury were 0.015 ppm and 0.199 ppm (only deep-fish), respectively in all food
  - Hg levels in the aquatic products such as fish, shellfish and seaweed was the highest

Food groups	Samples (type/cases)	Hg levels (mg/kg)	Methyl-Hg levels (mg/kg)
Total Food	344/34,283	0.015±0.074 (≤0.0001 ~ 6.339)	-
Aquatic products	115/11,192	0.046±0.130 (≤0.002 ~ 6.339)	0.199±0.424 (≤0.005 ~ 5.932)
Agricultural products	136/12,951	0.001±0.003 (≤0.0001 ~ 0.072)	-
Livestock products	93/10,140	0.002±0.003 (≤0.0001 ~ 0.045)	-

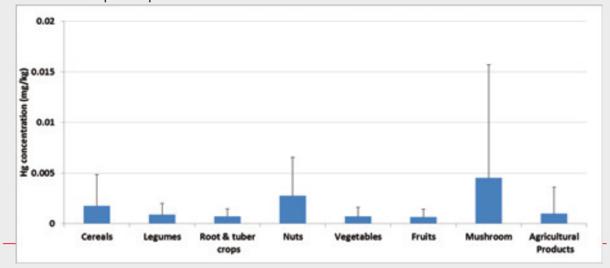
3. Concentrations in food

- **Aquatic products**
  - The mercury levels in the deep-sea fish was highest, followed by fish, mollusks, and crustaceans



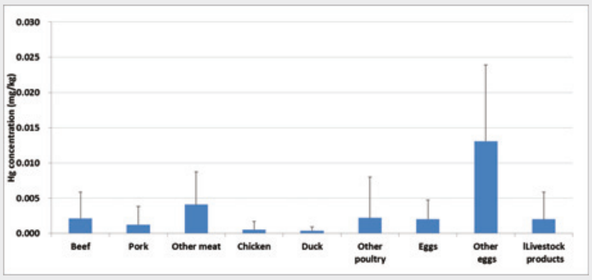
3. Concentrations in food

- **Agricultural products**
  - The mercury levels in agricultural products was as follow; mushroom, nuts, cereals, and legumes
  - But, Hg level in the mushroom was 10 times lower than the levels in the aquatic products



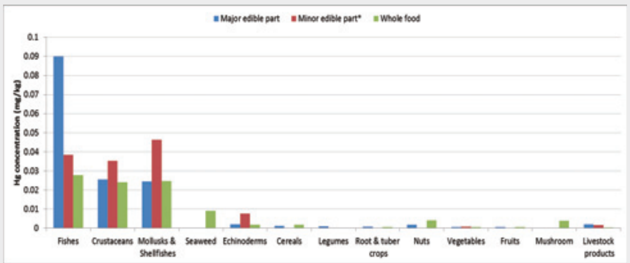
3. Concentrations in food

- **Livestock products**
  - The mercury levels in the eggs of poultry except hen was highest and levels in the meat was less than 0.005 ppm
  - But, Hg level in the poultry's egg was 100 times lower than the levels in the aquatic products



3. Concentrations in food

- **Food segmental concentration**
  - The mercury levels of the minor edible parts (guts, ink sac and skin) in the crustaceans, mollusks, shellfish, and echinoderms were higher than those of the major edible parts and whole food



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4. Risk Assessment

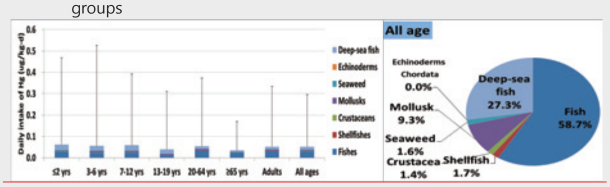
- Daily food intake rates

  Food intake rates based on National Nutrition Survey report during the survey period, 2008 - 2010

Food groups	Surveyed Subjects (persons)	Daily intake rate (g/day)	Daily intake rate of target food (g/day)
Total Food	26,041	1423.7	747.5 (53%)
Aquatic products	26,041	76.9	76.7 (99%)
Agricultural products	26,041	837.9	574.0 (67%)
Livestock products	26,041	100.6	96.8 (96%)

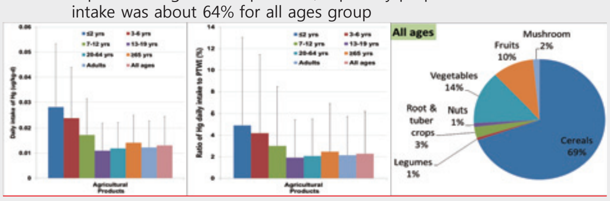
4. Risk Assessment

- Risk Assessment consumed by aquatic products (1)
  - The daily intake of Hg in aquatic products was 0.05 ug/kg-day, corresponding to about 10% of Hg PTDI (0.7 ug/kg-day)
  - Risk population who intake more than PTWI was estimated as low as 1.5%
  - Fish (more than 55%) and deep-sea fish (more than 25%) constituted the major contribution to total aquatic dietary exposure for all age groups



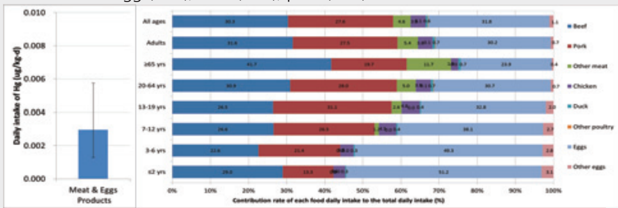
4. Risk Assessment

- Risk Assessment consumed by agricultural products
  - The daily intake of Hg in agricultural products was 0.02 ug/kg-day, corresponding to about 3% of Hg PTDI (0.7 ug/kg-day)
  - There was not estimated the risk population via agricultural food intake
  - Cereals (more than 65%) was the major source to Hg dietary exposure in agricultural products, especially proportion of milled rice intake was about 64% for all ages group



4. Risk Assessment

- Risk Assessment consumed by livestock products
  - The daily intake of Hg in meat and eggs products was 0.003 ug/kg-day, corresponding to about 0.5% of Hg PTDI (0.7 ug/kg-day)
  - The order of contributed food to the meat and eggs dietary exposure was beef (32%), hen's egg (30%), pork (28%) for adults and hen's egg (50%), beef (25%), pork (15%) for infant and child



4. Risk Assessment

- Risk Assessment consumed by all food products
  - In all aquatic, agricultural, meat and eggs products, Hg total daily intake and relative risk to the PTWI were less than 0.1 ug/kg-day and 14%, respectively. Thus Korean foods are believed to be safe from Hg
  - Aquatic products (76%) were major contribution to total dietary exposure of Hg

	Age group	Chronic daily intake (ug/kg-day)				Ratio of Hg daily intake to PTWI (%)			
		All food	Aquatic products	Agricultural products	Livestock products	All food	Aquatic products	Agricultural products	Livestock products
Food daily intake	All ages	1251.2	52.8	572.8	625.6	-	-	-	-
Chromic daily intake of Hg	≤2 yrs	0.096	0.062	0.028	0.006	13.7	8.9	4.0	0.8
	3-6 yrs	0.085	0.056	0.024	0.006	12.2	8.0	3.4	0.8
	7-12 yrs	0.080	0.058	0.017	0.004	11.4	8.3	2.5	0.6
	13-19 yrs	0.054	0.040	0.011	0.003	7.7	5.7	1.6	0.5
	20-64 yrs	0.070	0.055	0.012	0.003	10.0	7.9	1.7	0.4
	≥65 yrs	0.050	0.035	0.014	0.001	7.1	4.9	2.0	0.2
	Adults	0.066	0.051	0.012	0.003	9.5	7.3	1.7	0.4
	All ages	**0.067 (100%)**	**0.051 (76.2%)**	**0.013 (19.4%)**	**0.003 (4.4%)**	**9.6**	**7.3**	**1.9**	**0.4**