TRAINING FOR HEALTH CARE PROVIDERS

MERCURY

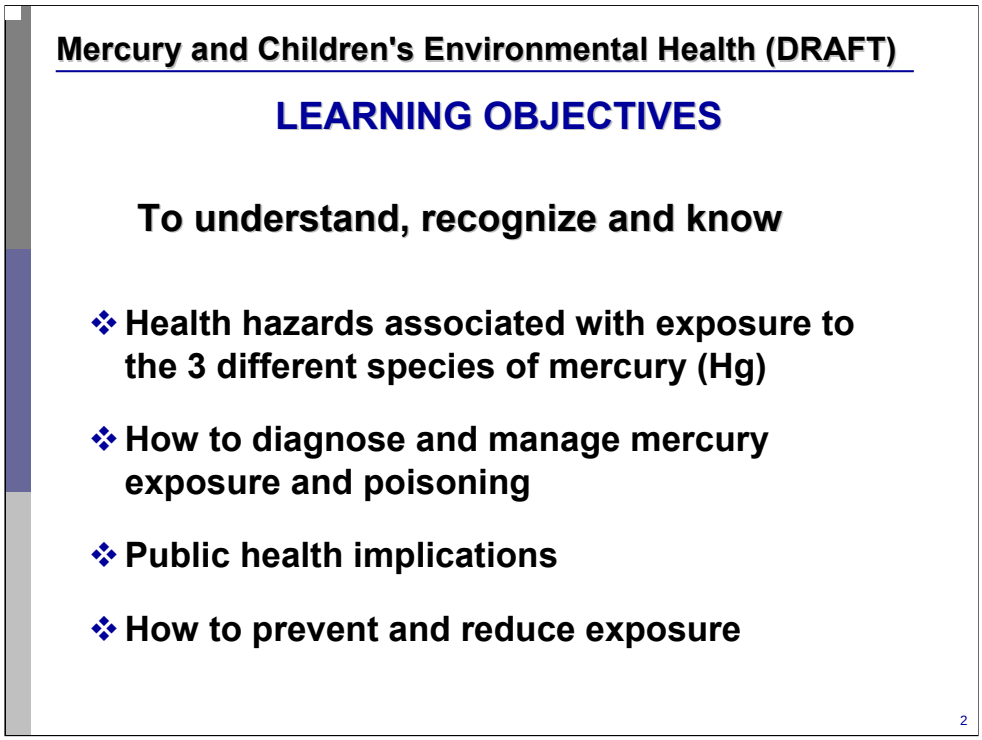
Children's Health and the Environment

CHEST Training Package for the Health Sector

1

<<NOTE TO USER: Please add details of the date, time, place and sponsorship of the meeting for which you are using this presentation.>>

<<NOTE TO USER: This presentation is long and covers all forms of mercury, their sources and toxicities. It may be helpful to emphasize those slides which apply most directly to the situation in your local region.>>

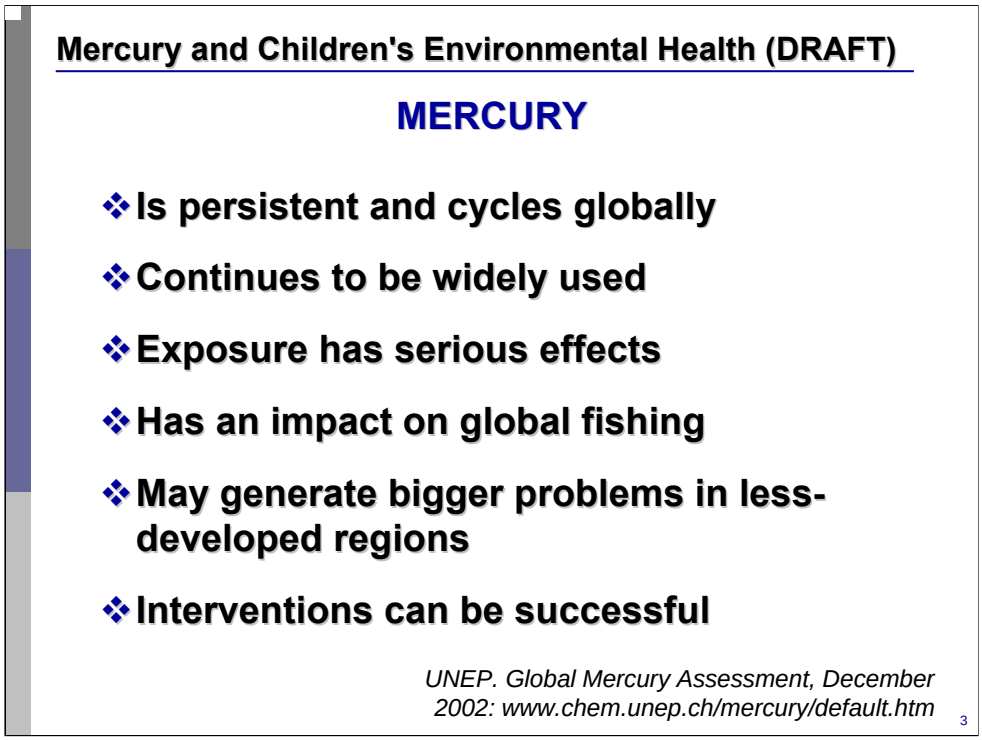


After this presentation, viewers should understand, recognize and know:

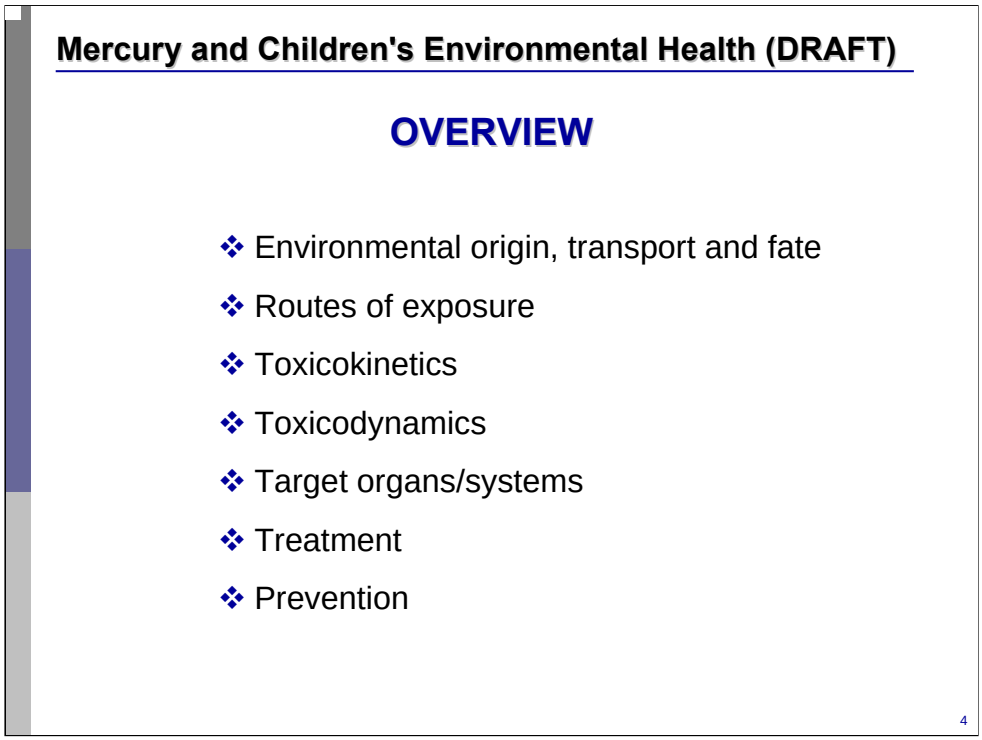
<<READ SLIDE>>

Mercury is a developmental toxicant whose effects have been known for many decades, but concern has increased in the last few years among the medical and environmental communities due to the recognition of its environmental ubiquity and persistence and the developmental effects observed at relatively low levels of exposure.

In December 2002, the United Nations Environment Program (UNEP) published a Global Mercury Assessment, calling for immediate actions to reduce pollution. In May 2005, the first Conference of the Parties (COP 1) proposed the inclusion of mercury into the group of the Persistent Toxic Pollutants (PTPs).



This slide states the main principles listed at the UNEP – Global Mercury Assessment, a 260-page document that responds to the specific requests made by UNEP's Governing Council (GC) and that will be the basis for considering the possibility of an international action.



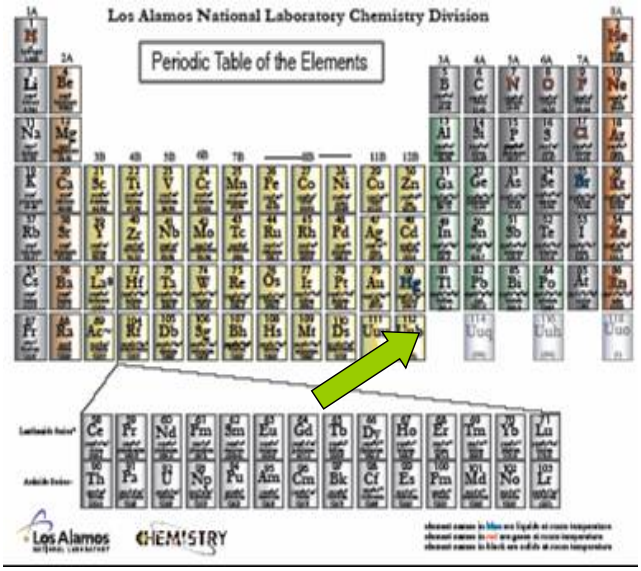
This presentation will cover the following topics:

<<READ SLIDE>>

Mercury and Children's Environmental Health (DRAFT)

ORIGIN

- One element
- 3 species
  - Elemental
  - Inorganic
  - Organic
- Different toxicity profiles!



pearl1.lanl.gov/periodic/default.htm

5

Mercury is a heavy metal, an element, and therefore cannot be created or destroyed. Natural sources of environmental emissions are volcanic eruptions, rock weathering and natural combustion. As most metals, it can exist in different forms. Each of its three forms: elemental (or metallic), inorganic (e.g. mercuric chloride) and organic (e.g. methyl- and ethyl-mercury), have different toxicity profiles with different implications for children's health and development.

Picture: pearl1.lanl.gov/periodic/default.htm

Mercury and Children's Environmental Health (DRAFT)

ENVIRONMENTAL SOURCES OF EXPOSURE

- Chloralkali production
- Artisanal gold and silver mining
- Mercury mining, smelting and use
- Burning fossil fuels
- Waste incinerators
- Volcanoes

Goldman, Pediatrics (2001) 108:197

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Mercury has many uses, including manufacture of chlorine and caustic soda, gold and silver mining, mirror production, dental amalgams, manometers. It is released from mercury-mining and production sources, from burning fossil fuels (especially rich in sulphur), from waste incineration (e.g. medical waste) incineration of corpses (with amalgams) and it may also be released form volcanoes.

According to the UNEP report sources are grouped as:

•Natural sources releases due to natural mobilisation of naturally occurring mercury from the Earth's crust (e.g. volcanic activity and weathering of rocks).

•Current anthropogenic (human activity-related) releases from the mobilisation of mercury impurities in raw materials (fossil fuels: specially coal but also gas and oil).

•Current anthropogenic releases from mercury intentionally used in products and processes (releases during manufacturing, leaks, disposal or spent products incineration).

•Re-mobilisation of historic anthropogenic releases previously deposited in soils, sediments, waters, landfills, waste piles.

Picture: Ball mill in Rwamagasa in Tanzania to grind the ore to extract gold from ore with mercury (© Stephan Boese-O´Reilly 2003)

Refs:

•Goldman, Committee on Environmental Health of the American Academy of Pediatrics: Technical Report: Mercury in the environment: Implications for Pediatricians, Pediatrics (2001) 108:197
Mercury is a ubiquitous environmental toxin that causes a wide range of adverse health effects in humans. Three forms of mercury (elemental, inorganic, and organic) exist, and each has its own profile of toxicity. Exposure to mercury typically occurs by inhalation or ingestion. Readily absorbed after its inhalation, mercury can be an indoor air pollutant, for example, after spills of elemental mercury in the home; however, industry emissions with resulting ambient air pollution remain the most important source of inhaled mercury. Because fresh-water and ocean fish may contain large amounts of mercury, children and pregnant women can have significant exposure if they consume excessive amounts of fish. The developing fetus and young children are thought to be disproportionately affected by mercury exposure, because many aspects of development, particularly brain maturation, can be disturbed by the presence of mercury. Minimizing mercury exposure is, therefore, essential to optimal child health. This review provides pediatricians with current information on mercury, including environmental sources, toxicity, and treatment and prevention of mercury exposure.

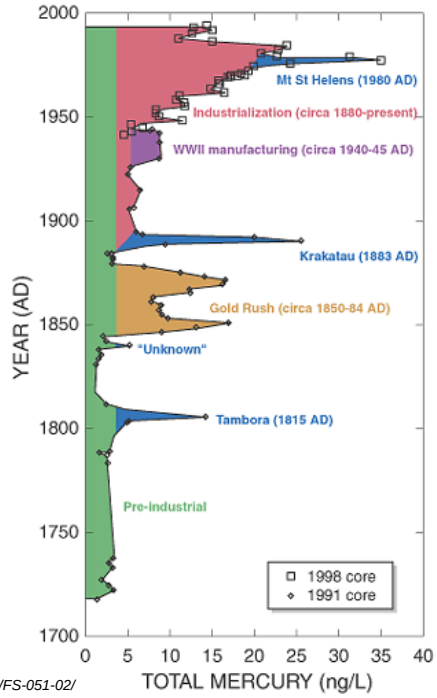
Mercury and Children's Environmental Health (DRAFT)

A man made problem

Major atmospheric releases detected in the ice core

- Natural background
- Volcanic
- Gold rush
- World War II
- Industrialization

Hg released in the last 100 years: 70% man made



http://toxics.usgs.gov/pubs/FS-051-02/

Explanation of the chart:

"Atmospheric mercury deposition corresponds to volcanic and anthropogenic events over the past 270 years. Preindustrial deposition rates can be conservatively extrapolated to present time (4 ng/L; in green) to illustrate the increase during the past 100 years (in red) and significant decreases in the past 15-20 years." (USGS)

Most mercury in the modern environment comes from human activities and heavy industry. Here is dramatic evidence that this problem of methylmercury contamination of our food is of our own making. This composite ice core record from Wyoming, USA shows the dramatic increase from baseline mercury levels (shown here in green) that have occurred due to human activity. In fact, 70% of the mercury released in the last 100 years has been anthropogenic.

Ref:

•*http://toxics.usgs.gov/pubs/FS-051-02/*

Mercury and Children's Environmental Health (DRAFT)

A LARGE ENVIRONMENTAL PROBLEM

- In small scale gold mining areas Hg is used to extract gold from ore (amalgamation process)
- 1 to 2 kg of Hg are used to process 1 kg of gold
- Most Hg is released into the environment (soil, air, water)
- More than 50% workers have high levels
- …and their children?

© Stephan Boese-O´Reilly 2003

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In Brazil, Guiana and in some other countries, gold-mining that requires large amounts of mercury is having tremendous consequences on the environment and the local community.

<<READ SLIDE>>

Ref: Agence France Presse, 26 October 2004.

"In the past two years, police have launched some 60 "Anaconda operations" -- named after the giant boa constrictors that inhabit this tropical French overseas department -- but they have not succeeded in squeezing the life out of the illegal gold trade that threatens the environment here.

Instead, an estimated 12,000 workers, for the most part illegal workers from across the border in Brazil, roam the rivers in search of the precious metal, poisoning the rivers with the quicksilver they use to extract the gold. Their method could not be more simple, or more brutal. From barges moored in the water, they pulverize the river banks with high-pressure hoses, pump out the resulting slurry and amalgamate the tiny specks of gold with quicksilver, or mercury.

Once the gold is extracted from the mercury, the highly toxic metal is dumped directly into the river along with the slurry. "It is an ecological disaster,"… that brings in *…the deforestation and environmental devastation left in the wake of the gold-washers… poisoning of the fish stocks, and consequently of the indigenous Indian population that depends on the fish as a dietary staple.*

The gold trade has brought with it some other curses of development, including malaria, AIDS and various kinds of illegal trafficking…

… supplies needed by the gold-extracting business,… include *… mercury. With the primitive methods in use, it can take 1.3 kilos of quicksilver to process every kilo of gold, and it is estimated that at least 10 tonnes of mercury are released into the environment every year.*

The impoverished Brazilian panhandlers, many living in conditions of virtual slavery, are the first victims of mercury vapor, which causes serious neurological defects. And according to a study carried out as long ago as 1997, more than half the Indians living along the river have excessive amounts of mercury in their organisms.

Picture: Liquid mercury used by miners to extract gold from ore in Tanzania (© Stephan Boese-O´Reilly 2003)

Mercury and Children's Environmental Health (DRAFT)

Continent	Stationary Combustion	Pig iron & steel production	Cement production	Waste disposal	Non-ferrous metal production	Artisanal gold mining	Sum quantified sources
Europe	**186**	**10**	**26**	**12**	**15**		**250**
Africa	**197**	**0.5**	**5.2**		**7.9**		**210**
Asia	**860**	**12**	**82**	**33**	**87**		**1075**
North America	**105**	**4.6**	**13**	**66**	**25**		**210**
South America	**27**	**1.4**	**5.5**		**25**		**60**
Australia &Oceania	**100**	**0.3**	**0.8**	**0.1**	**4.4**		**105**
Sum, quantified sources 1995	**1470**	**30**	**130**	**110**	**170**		**~1900**
Worldwide						**300-100**	

Drasch , Wiley VHC, Verlag, 2004, all data in metric tons

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<<READ SLIDE>>

Anthropogenic Sources

Estimates of global atmospheric releases of mercury from anthropogenic sources in 1995

Explanation of the chart:

“According to the recent estimates, about 50 to 75% of total yearly input to the atmosphere is due to anthropogenic activities (Munthe, 2001). Some estimates of global atmospheric releases of mercury from a number of major anthropogenic sources in 1995 are given in the table.

Mercury is naturally present in coal and other fossil fuels and minerals such as lime for cement production and metal ores. About 70 % of global mercury emission to the atmosphere is due to fossil fuel combustion, in particular coal (Pacyna, 2000) and incineration of wastes.

Emissions from artisanal gold mining are not included in the estimation of Pirrone, 2001.

Refs:Drasch, Mercury in: Merian E, Anke M, Ihnat M, Stoeppler M (eds) Elements and their compounds in the environment Vol 2, Wiley VHC Verlag, Weinheim, Germany, 2004.

•Lacerda, Global Mercury Emissions from Gold and Silver Mining. Water, Air and Soil Pollution (1997) 97 (3-4): 209.

•Munthe, Mercury species over Europe (MOE). Relative importance of depositional methylmercury fluxes to various ecosystems. Final report for the European Commission, Directorate General XII, 2001

•Pacyna, Assessment of emissions/discharges of mercury reaching the Arctic environment. The Norwegian Institute for Air Research, NILU Report OR 7/2000, Kjeller, Norway, 2000

•Pirrone, Regional differences in worldwide emissions of mercury to the atmosphere. Atmos Environ (1996) 30:2981.

•Pirrone Ambient Air Pollution by Mercury (Hg) – Position Paper. Office for Official Publications of the EC, 2001. (available on europa.eu.int/comm/environment/air/background.htm#mercury).

Mercury and Children's Environmental Health (DRAFT)

TRANSPORT: GLOBAL CYCLE OF MERCURY

Hg is emitted into the atmosphere and circulated globally

EPA

EPA 10

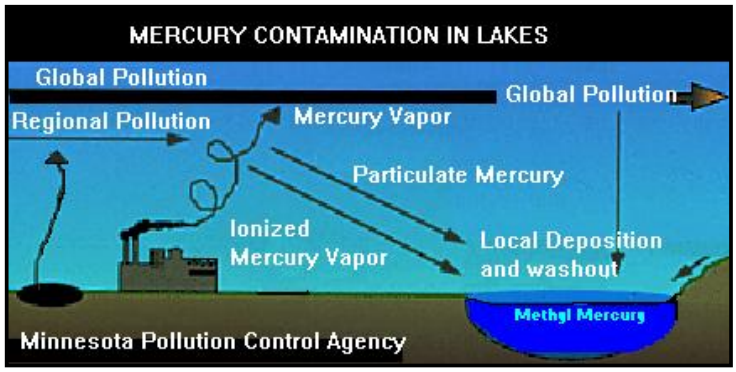
When mercury is emitted into the atmosphere, it may deposit close to the source, or be transported long distances, as shown in this diagram.

Picture: www.epa.gov/grtlakes/seahome/mercury/src/presmerc.htm

The Environmental Protection Agency, Purdue University, and the Agricultural & Biological Engineering Department.

Mercury and Children's Environmental Health (DRAFT)

TRANSPORT: GLOBAL CYCLE OF MERCURY



EPA

Ultimately enters water bodies and deposits

- Close to source
- Long distance from source → global pollution

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Eventually, atmospheric mercury from mercury emissions ends up in water bodies where it is methylated and bioconcentrated up the food chain. The major source of methylmercury for most people is from eating contaminated fish.

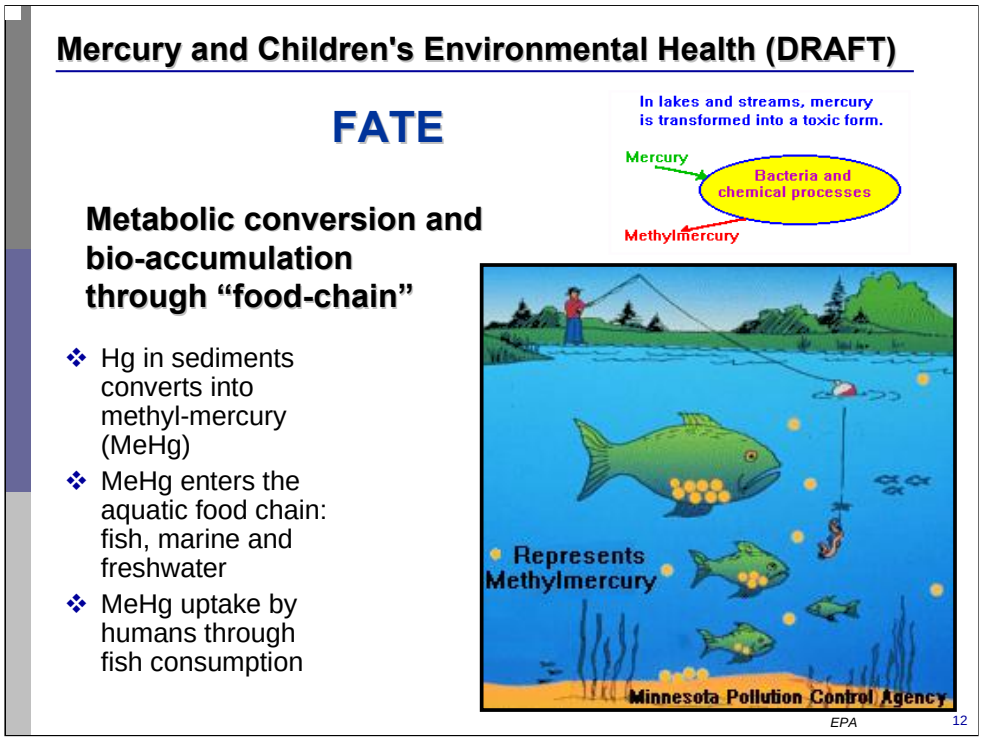
High risk groups are the fetus and small children whose nervous systems are developing, and women of child bearing age because of the exposure to the fetus.

•Main source: industrial emission

•Media: air and water

•Vector: fish

Picture: www.epa.gov/grtlakes/seahome/mercury/src/chemistr.htm



For most people who are not occupationally exposed, fish is the major source of mercury exposure.

❖Hg attached to aquatic sediments is subject to microbial conversion to methyl-mercury (MeHg).

❖MeHg enters the aquatic food chain, reaching highest concentration in "fish eating fish" (e.g.tuna, sharks).

- Ocean fish high in MeHg include mackerel, shark, swordfish, tile fish, large tuna, grouper.

- Freshwater fish contamination depends more on local conditions but also is highest in long-lived, predatory fish such as pike.

<<NOTE TO USER: Insert the list of local fish which are high in mercury>>

❖MeHg uptake by humans through fish consumption.

Ref:

•*Clarkson, The toxicology of mercury – current exposures and clinical manifestations, N Engl J Med, 2003, 349: 1731*

Picture: www.epa.gov/grtlakes/seahome/mercury/src/aquatic.htm

The Environmental Protection Agency, Purdue University, and the Agricultural & Biological Engineering Department.

ELEMENTAL (METALLIC) MERCURY – "QUICKSILVER"

Sources of exposure

- **Environmental:**
  - Volcanic explosions, rock weathering, degassing
- **Anthropogenic inadvertent**:
  - Combustion: fossil fuels (coal), waste incineration
  - Industrial: gold/silver mining, chloralkali plants, batteries, switches, fluorescent lights, thermometers, sphyngomanometers
- **Anthropogenic intentional:**
  - Dental amalgams
  - Ritual and folk-medicine use

Because of the complexity of mercury chemistry, it is often easier to discuss each species separately. The following series of 6 slides recaps sources by species and briefly outlines the common routes of human exposure, toxicokinetics and major systems damaged by excess exposure.

<<READ SLIDE>>

Ref:

•*Clarkson, The toxicology of mercury – current exposures and clinical manifestations, N Engl J Med (2003) 349: 1731*

ELEMENTAL MERCURY - QUICKSILVER

Routes of exposure

- Inhalation (volatile at room temp): 75-85% absorption
- Ingestion and skin: almost no absorption

Elimination

- Urine and Feces

Toxicity

- Lungs, eyes, gingival, skin
- Also: Central nervous system, kidneys, immune system

<<READ SLIDE>>

Ref:

•*Casarett and Doull, Toxicology – The basic science of poisons. 5th Ed..Ed: Klaassen., Mc-Graw-Hill, 1996.*

INORGANIC MERCURY

Sources of Exposure

- **Environmental**
  - None
- **Industrial products**
  - Vapor lamps, embalming,
  - Photography
  - Latex paint (pre 1990s)
  - Disinfectants, antimicrobials
  - Alternative medicines, cosmetics

<<READ SLIDE>>

Refs:

•*Drasch, Mercury in: Merian E, Anke M, Ihnat M, Stoeppler M (eds) Elements and their compounds in the environment Vol 2., Wiley VHC Verlag, Weinheim, Germany, 2004*

•*Global Mercury Assessment. UNEP chemicals report Geneva 2002. www.chem.unep.ch*

INORGANIC MERCURY

Routes of Exposure

- Ingestion - 10% absorbed
- Skin - can be high and deadly

Elimination

- Renal

Toxicity

- Primary: kidneys, gastrointestinal tract
- Secondary: Central nervous system

<<READ SLIDE>>

Refs:

•*Clarkson, The toxicology of mercury – current exposures and clinical manifestations, N Engl J Med (2003) 349:1731*

•*Drasch, Mercury in: Merian E, Anke M, Ihnat M, Stoeppler M (eds) Elements and their compounds in the environment Vol 2., Wiley VHC Verlag, Weinheim, Germany, 2004*

•*Global Mercury Assessment. UNEP chemicals report Geneva 2002. www.chem.unep.ch*

ORGANIC MERCURY

Sources of Exposure

- Environmental conversion:
  - Fish and shellfish (methyl-mercury)
- Industrial production:
  - Fungicides, bactericides (phenylmercury)
  - Vaccine preservatives (thimerosal)

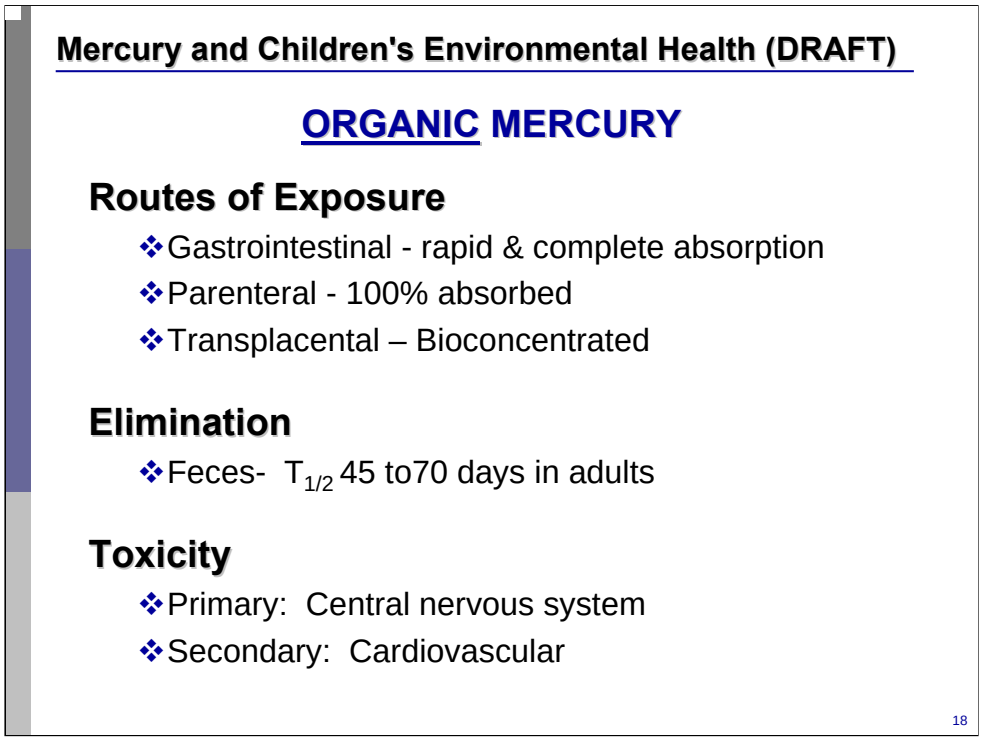
<<READ SLIDE>>

Refs:

•*Clarkson, The toxicology of mercury – current exposures and clinical manifestations, N Engl J Med (2003) 349: 1731*

•*Drasch, Mercury in: Merian E, Anke M, Ihnat M, Stoeppler M (eds) Elements and their compounds in the environment Vol 2., Wiley VHC Verlag, Weinheim, Germany, 2004*

•*Global Mercury Assessment. UNEP chemicals report Geneva 2002. www.chem.unep.ch*



Over 95% is absorbed from the GI (gastrointestinal) tract

Widely distributed to all tissues

•It crosses the placenta.

- Cord blood : Maternal blood – 1.7 *(Mahaffey, 2004).*

•It crosses the blood brain barrier.

- Active transport on L-methionine carrier.

-It is secreted in breast milk – but in very small amounts since most is bound to red blood cells.

-It is degraded slowly by the human body.

-Half-life in adults is 45-70 days—Therefore, prospective mothers can significantly reduce mercury body burden by avoiding exposure for 6-12 months prior to pregnancy.

- Excreted in feces.

-Builds up in the brain – duration many years.

Ref:

•*Mahaffey, Blood organic mercury and dietary mercury intake: national health and nutrition examination survey, 1999 and 2000, Environ Health Perspect. (2004) 112 (5): 562*

Mercury and Children's Environmental Health (DRAFT)

Mercury	Sources	Routes of exposure	Elimination	Toxicity
Elemental (metallic)	Volcanoes Combustion Waste incineration Thermometers Amalgams Folk remedies	Inhalation	Urine and faeces	CNS Kidney Lungs Skin (Acrodynia in children)
Inorganic (mercuric chloride)	Lamps Photography Disinfectants Cosmetics Folk medicine	Ingestion Dermal	Urine	CNS Kidney GI tract Skin (Acrodynia in children)
Organic (methyl; ethyl)	Fish Fungicides Preservatives	Ingestion Parenteral Transplacental	Faeces	CNS Cardiovascular

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This table summarizes the different sources of mercury, routes of exposure and elimination and main effects.

<<NOTE TO USER: The relative importance of sources and particular species will vary regionally. Please highlight what is most important in your population of children.>>

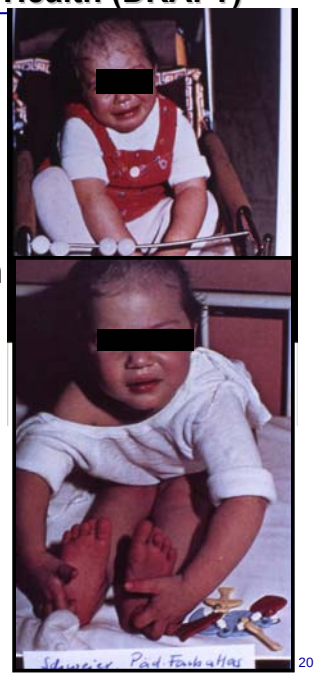
MERCURY: ACRODYNIA

Uncommon syndrome "Pink disease":

- Pain in the extremities
- Pinkish discoloration and desquamation
- Hypertension
- Sweating
- Insomnia, irritability, apathy

Considered as idiosyncratic reaction.

Schwarz,



Acrodynia is a rare idiopathic chronic toxic reaction to elemental or inorganic mercury exposure, which occurs mainly in young children. It is characterized by pain in the extremities and pink discoloration with desquamation of the skin.

<<READ SLIDE>>

Ref:

•California Poison Control System, Poisoning and drug overdose, 3rd edition, ed: Olson, Appleton and Lange, Connecticut, 1999

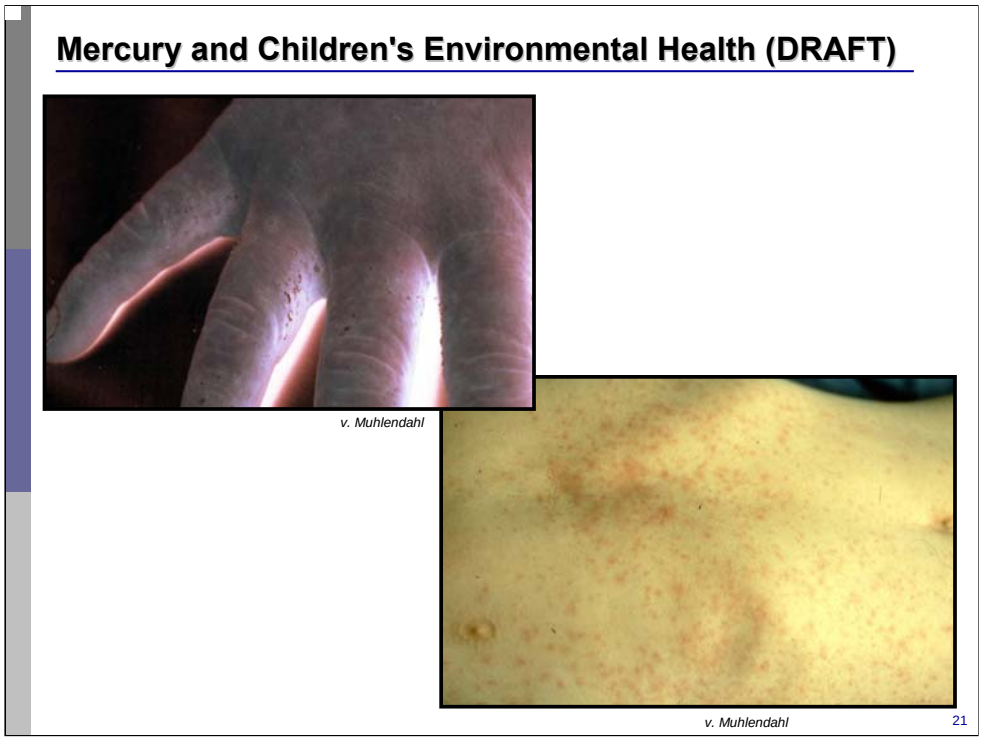
Picture above:

Pictures from:

Schwarz, Feersche Erkrankung (kindliche Akrodynie), Pädiatrische Praxis (1979) 21: 85 – 89. Used with permission (copyright: Hans Marseille Verlag GmbH).

Picture above: Frequently crying, unhappy, unwilling to walk, hence sitting in the buggy (acrodynia).

Picture below: 2 ½ year old girl. Hypotonia, constant scratching, with red fingers, foot soles, lips (acrodynia).



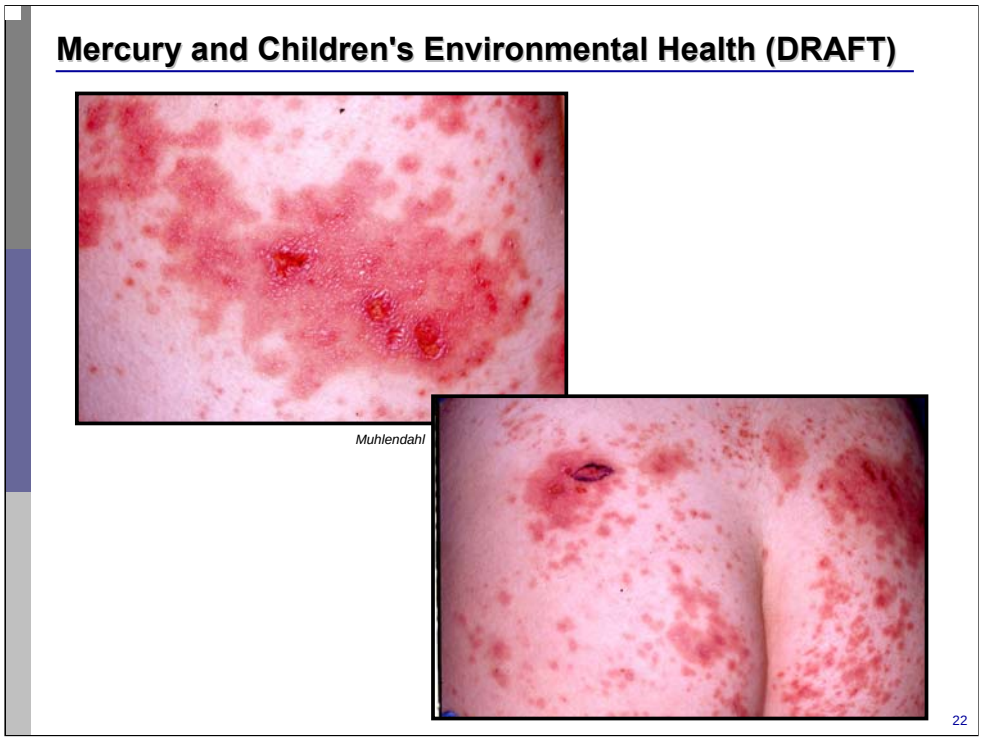
Miliarial rash is typical of acrodynia.

Picture above: v.Mühlendahl, Schulte-Wissermann, Grips, Hautveränderungen bei Feer'scher Krankheit. Pädiatrische Praxis (1995) 49, 647. Used with permission (copyright: Hans Marseille Verlag GmbH).

Feer's Disease (acrodynia), scaling of the skin between the fingers.

Picture below: V.Mühlendahl, Schulte-Wissermann, Grips, Hautveränderungen bei Feer'scher Krankheit. Pädiatrische Praxis (1995) 49, 647. Used with permission (copyright: Hans Marseille Verlag GmbH).

Feer's Disease. Exanthema due to Hg intoxication from a mercury thermometer broken in the children's room four months previously.

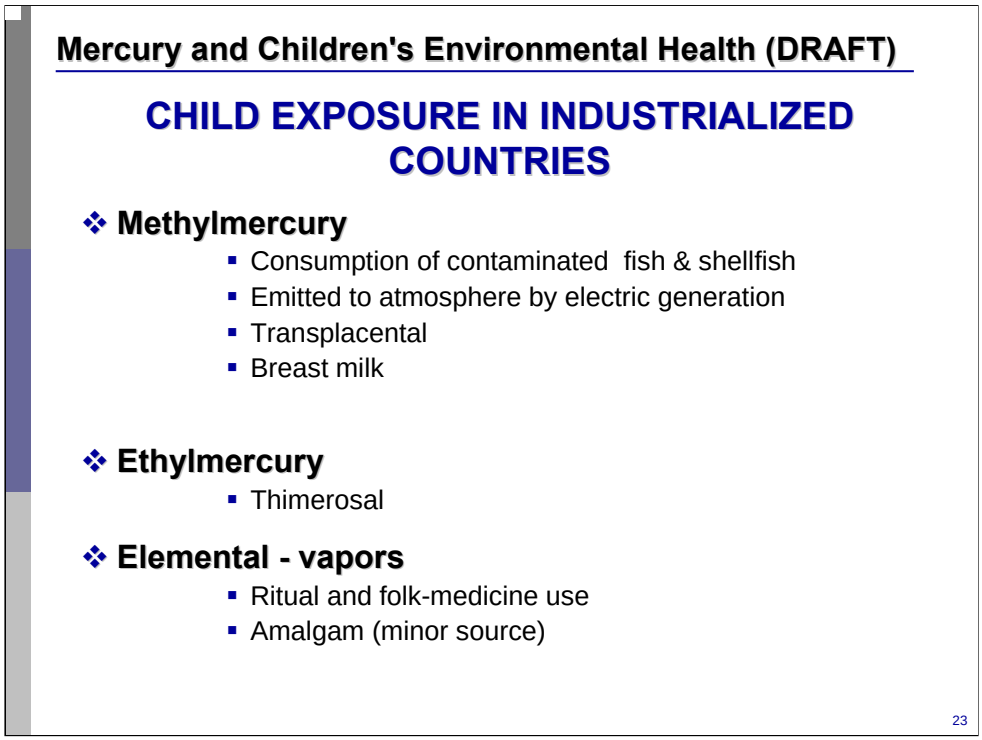


Picture above: v.Mühlendahl, Schulte-Wissermann, Grips, Hautveränderungen bei Feer'scher Krankheit. Pädiatrische Praxis (1995) 49, 647. Used with permission (copyright: Hans Marseille Verlag GmbH).

Feer's Disease (acrodynia). Exanthema due to Hg intoxication from a mercury thermometer broken in the children's room four months previously. Photo taken 3 weeks after the first pictures.

Picture below: v.Mühlendahl, Schulte-Wissermann, Grips, Hautveränderungen bei Feer'scher Krankheit. Pädiatrische Praxis (1995) 49, 647. Used with permission (copyright: Hans Marseille Verlag GmbH).

Feer's Disease. Exanthema due to Hg intoxication from a mercury thermometer broken in the children's room four months previously.



The relative importance of sources of mercury exposure vary according to the country, region, type of economic activity and level of development.

In the industrialized world, organic mercury exposure predominates in the form of methylmercury from fish consumption. Additional exposures from vaccine preservatives have substantially ceased since the late 1990s (this topic is covered in supplemental slide sets).

In some population groups, ritual use of quicksilver can lead to substantial exposures.

Amalgams probably represent a minor source (this topic is covered in supplemental slide sets).

The most critical period of vulnerability is prenatal. Small amounts of methylmercury can be transmitted by breast milk, however, this is not sufficient in quantity as to outweigh the benefits of breast-feeding (WHO strongly supports breast-feeding).

Once children are eating solid foods, dietary exposure from fish remains potentially dangerous throughout postnatal neurodevelopment.

A recent analysis on public health and the economic consequences of methylmercury toxicity to the developing brain concluded that "exposure to methylmercury emitted to the atmosphere by American electric generation facilities causes lifelong loss of intelligence in hundreds of thousands of American babies born each year and that this loss of intelligence exacts a significant economic cost to American society, a cost that amounts to at least hundreds of million dollars each year." (*Trasande, 2005*)

Refs:

•*www.chem.unep.ch/mercury/Report/GMA-report-TOC.htm*

•*Trasande, Public health and the economic consequences of methylmercury toxicity to the developing brain, EHP (2005) 113 (5): 590 (Available at ehp.niehs.nih.gov/members/2005/7743/7743.html).*

Mercury and Children's Environmental Health (DRAFT)

CHILD EXPOSURE IN DEVELOPING COUNTRIES

- "Occupational" exposures from gold/silver mining
- Regional cultural uses
- Eating contaminated fish

High exposure may cause overt symptoms

Sources of exposure for children in the developing world may be quite different.

❖"Occupational" exposures from gold/silver mining are usually high and may be acutely toxic. They may be seen in the context of child labour.

❖Regional uses of mercury are seen in different situations:

- Traditional rituals and folk remedies

- Preparation of cosmetics ("skin whiteners", creams, lotions and soaps)

❖Eating contaminated fish

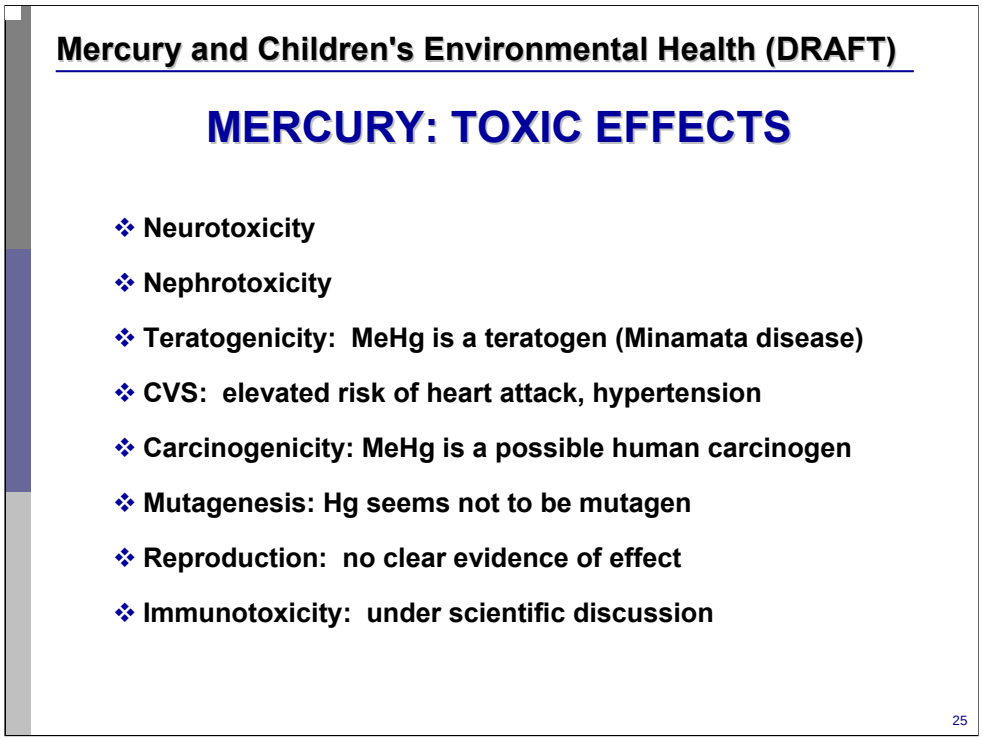
<<READ SLIDE>>

<<NOTE TO USERS: Insert information specific to your region or locality on the most important sources and pediatric exposures>>

Ref:

•*www.chem.unep.ch/mercury/Report/GMA-report-TOC.htm*

Picture: Stephan Boese-O´Reilly ©. Children in Amberose / Kadoma in Zimbabwe, where gold is extracted from ore with mercury, 2004.



All forms of mercury are more or less toxic to humans, because it is widely distributed in the body and many systems are affected. The toxic effects of mercury vary according to:

•Form: elemental, inorganic or organic.

•Dose: high dose acute poisonings vs low dose chronic effects.

•Timing: prenatal, infancy, childhood or adult.

In children, the central nervous system is the most vulnerable one.

The IARC (International Agency for Registry of Cancer) has classified MeHg as being group 2B: the agent (mixture) is possibly carcinogenic to humans. The exposure circumstance entails exposures that are possibly carcinogenic to humans.

<<READ SLIDE>>

Refs:

•Clarkson, The three modern faces of mercury, Environ Health Perspect. (2002) 110 (1):11

The three modern "faces" of mercury are our perceptions of risk from the exposure of billions of people to methyl mercury in fish, mercury vapor from amalgam tooth fillings, and ethyl mercury in the form of thimerosal added as an antiseptic to widely used vaccines. In this article I review human exposure to and the toxicology of each of these three species of mercury. Mechanisms of action are discussed where possible. Key gaps in our current knowledge are identified from the points of view both of risk assessment and of mechanisms of action.

Mercury and Children's Environmental Health (DRAFT)

PEDIATRIC EXPOSURE - FISH

- **Major source of mercury burden for children in most countries**
- **Fish may contain methyl-mercury**
- **Children exposed**
  - By eating fish
  - Transplacentally
  - Via breast milk

Rice field in the Philippines, irrigated with tailing sediments containing mercury

Long lived, predatory fish can contain high levels of methyl mercury. It is incorporated into the muscle when fish live in polluted marine or fresh waters, such as those in the paddy field shown on this slide.

Cooking does not eliminate mercury from fish muscle.

Methylmercury is the major source of body burden in children worldwide. Not only are they exposed directly by eating contaminated fish, but they can also be exposed most importantly, transplacentally from mothers with high methylmercury blood levels. Methylmercury also passes into breast milk but at very low levels. Most methylmercury in blood is lightly bound to red blood cells and not available for transport into breast milk.

Of the three routes, transplacental exposure is potentially the most dangerous one.

Picture: Stephan Boese-O´Reilly ©. Rice field near Monkayo in Mindanao (Philippines), irrigated with tailing sediments, containing mercury from a small scale mining operation area in Diwalwal, 1999.

Ref: Dorea, Mercury and lead during breast-feeding, Br J Nutr. (2004) 92(1):21

Hg and Pb are of public health concern due to their toxic effects on vulnerable fetuses, persistence in pregnant and breast-feeding mothers, and widespread occurrence in the environment. To diminish maternal and infant exposure to Hg and Pb, it is necessary to establish guidelines based on an understanding of the environmental occurrence of these metals and the manner in which they reach the developing human organism. In the present review, environmental exposure, acquisition and storage of these metals via maternal-infant interaction are systematically presented. Though Hg and Pb are dispersed throughout the environment, the risk of exposure to infants is primarily influenced by maternal dietary habits, metal speciation and interaction with nutritional status. Hg and Pb possess similar adverse effects on the central nervous system, but they have environmental and metabolic differences that modulate their toxicity and neurobehavioural outcome in infant exposure during fetal development. Hg is mainly found in protein matrices of animal flesh (especially fish and shellfish), whereas Pb is mainly found in osseous structures. The potential of maternal acquisition is higher and lasts longer for Pb than for Hg. Pb stored in bone has a longer half-life than monomethyl-mercury acquired from fish. Both metals appear in breast milk as a fraction of the levels found in maternal blood supplied to the fetus during gestation. Habitual diets consumed by lactating mothers pose no health hazard to breast-fed infants. Instead, cows' milk-based formulas pose a greater risk of infant exposure to neurotoxic substances.

Mercury and Children's Environmental Health (DRAFT)

METHYLMERCURY LEVELS IN FISH

Ocean Fish with high levels of mercury

Species	Mercury concentration (PPM)				N° of samples
	Mean	Median	Min	Max	
Mackerel King	0.73	NA	0.23	1.67	213
Shark	0.99	0.83	ND	4.54	351
Swordfish	0.97	0.86	0.10	3.22	605
Tilefish	1.45	NA	0.65	3.73	60

www.cfsan.fda.gov/~frf/sea-mehg.html

27

All levels of fish contamination vary with region, so it is difficult to judge risks in a particular location without local testing. The four fish usually listed as “do not eat” for all individuals are shown above. They tend to have very high methylmercury levels which are dangerous for all consumers.

Refs:

- *www.cfsan.fda.gov/~frf/sea-mehg.html*

Mercury and Children's Environmental Health (DRAFT)

METHYLMERCURY LEVELS IN FISH

Typical average mercury concentration in marine fish

Species	mg Hg/kg	Species	mg Hg/kg
Herring	0.013	Sea Bass	0.145
Salmon	0.035	Tuna	0.206
Mackerel	0.081	Halibut	0.250
Perch	0.116	Snapper	0.250
Cod	0.121	Shark	1.327

Drasch,, Wiley VHC Verlag, 2004: Adapted from US EPA (1997)

28

Surveys of mercury in fish are scant, but here are some data on a variety of marine fish. Note that shark contains well over 1ppm (considered unsafe for any age) as can tuna (though fresh and albacore tuna are often 3 times higher than chunk light tuna found in cans). These highly contaminated marine fish have counterparts in freshwater fish such as pike and large mouth bass. All levels of fish contamination vary with region, so it is difficult to judge risks in a particular location without local testing. Other fish are quite low in methylmercury and can be eaten safely.

Refs:

•*Drasch, Mercury in: Merian E, Anke M, Ihnat M, Stoeppler M (eds) Elements and their compounds in the environment Vol 2., Wiley VHC Verlag, Weinheim, Germany, 2004*

•*US EPA, Mercury study report to congress, US EPA, Washington, D.C, 1997. Downloaded from www.epa.gov/airprogm/oar/mercury.html*

METHYLMERCURY: POWERFUL NEURODEVELOPMENTAL TOXICANT

- Impedes nerve cell division and migration
- Binds with microtubules required for neuronal development
- Binds to and distorts DNA & RNA

EHP

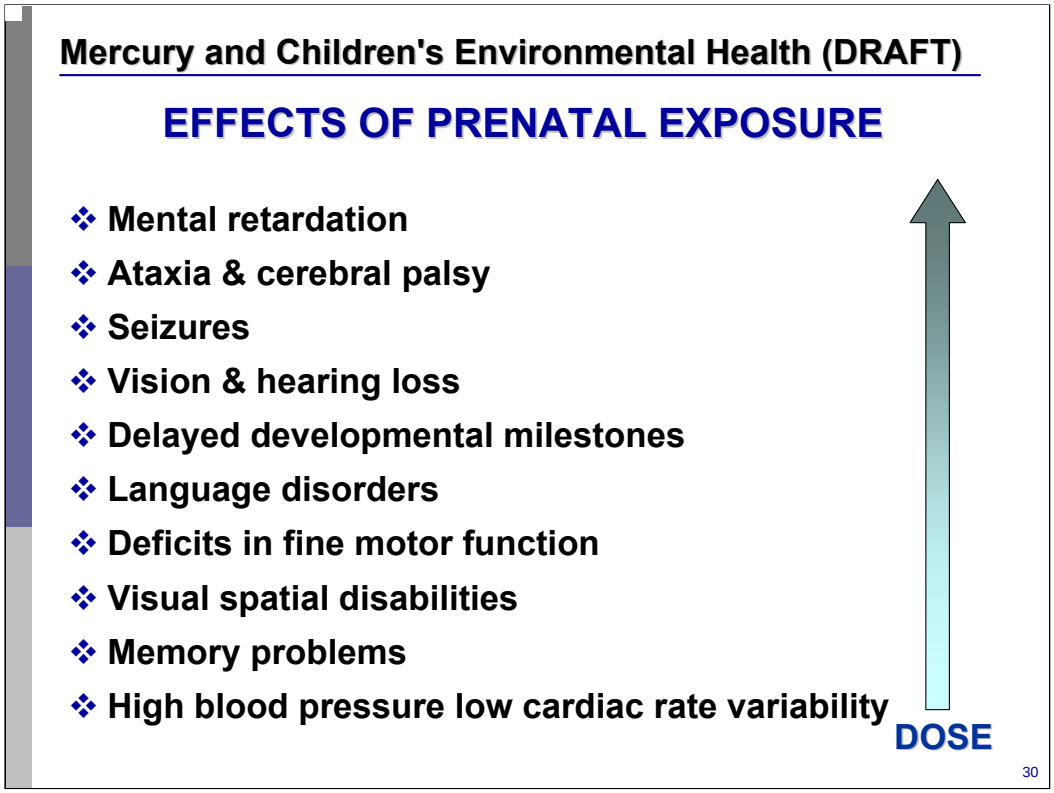
Toxicodynamics refers to the type of injury done to tissues.

The fetal brain is the most sensitive human tissue to damage from this powerful neurodevelopmental toxicant. In order for the brain to develop properly, an orderly process of cell differentiation and migration must occur to produce a specific and highly ordered brain architecture. Methylmercury interferes with this process by binding to critical structures such as microtubules which are crucial to normal cell division and migration. It also binds to and distorts important molecules like DNA and RNA.

Ref:

•*Casarett and Doull, Toxicology – The basic science of poisons. 5th Ed..Ed: Klaassen., Mc-Graw-Hill, 1996.*

Picture: EHP (2002) 110 (6)



Depending on the dose and timing of exposure during gestation, the effects may be severe and immediately obvious, or subtle and delayed.

Neurological symptoms include mental retardation, ataxia and cerebral palsy, seizures, vision and hearing loss, delayed developmental milestones, language disorders, and problems with motor function, visual spatial abilities, and memory.

The newest publications from long-term cohort studies suggest that the cardiovascular system is also at risk—with increased incidence of HBP and decreased heart rate variability as MeHg exposure increases.

Again, the full expression of these health effects of methlymercury can be delayed and deficits are often irreversible.

Ref: Casarett and Doull, Toxicology – The basic science of poisons. 5th Ed..Ed: Klaassen., Mc-Graw-Hill, 1996.

•Grandjean, Cardiac autonomic activity in methylmercury neurotoxicity: 14-year follow-up of a Faroese birth cohort.
J Pediatr. (2004) 144(2):169.

To determine whether heart function in childhood is affected by exposure to methylmercury (MeHg) from seafood. Prospective study of a Faroese birth cohort (N=1022). Examinations at ages 7 and 14 years included blood pressure, heart rate variability (HRV) and its frequency components of autonomic origin, and brainstem auditory evoked potentials (BAEPs). Mercury concentrations were determined in cord blood and in the child's hair. Results: Both low-frequency (LF) and high-frequency (HF) activities decreased by about 25% from 7 to 14 years; they correlated well with the blood pressures. A doubling of prenatal MeHg exposure was associated with a decrease in LF and HF powers of about 6.7% (P=.04) and in the coefficient of variation of the electrocardiographic R-R interval of 2.7% (P=.04) at age 14 years. No discernible effect on blood pressure was apparent. Decreased LF variability was associated with increased latency of BAEP peak III, but adjustment for MeHg exposure substantially attenuated this correlation. Conclusions: Methylmercury exposure was associated with decreased sympathetic (LF) and parasympathetic (HF) modulation of the HRV. Parallel MeHg-related delays of BAEP latencies may be

Mercury and Children's Environmental Health (DRAFT)

CONGENITAL MINAMATA DISEASE: METHYLMERCURY EXPOSURE IN PREGNANCY

- Mothers often asymptomatic!
- Microcephaly
- Cerebral palsy/spasticity
- Mental deficits
- Malformation of ears, heart, skeleton, eyes

Minamata Bay, Japan

Knowledge about the extreme vulnerability of the fetus to methylmercury began with the Minamata Bay, Japan experience. The bay was heavily contaminated with methylmercury from industrial discharge. Fish bioconcentrated the toxicant and mothers acquired high blood levels from eating fish from the bay. While the mothers were usually without symptoms of mercury poisoning, their babies were born severely damaged with microcephaly, cerebral palsy, severe mental retardation, seizure disorders, blindness, deafness and other malformations.

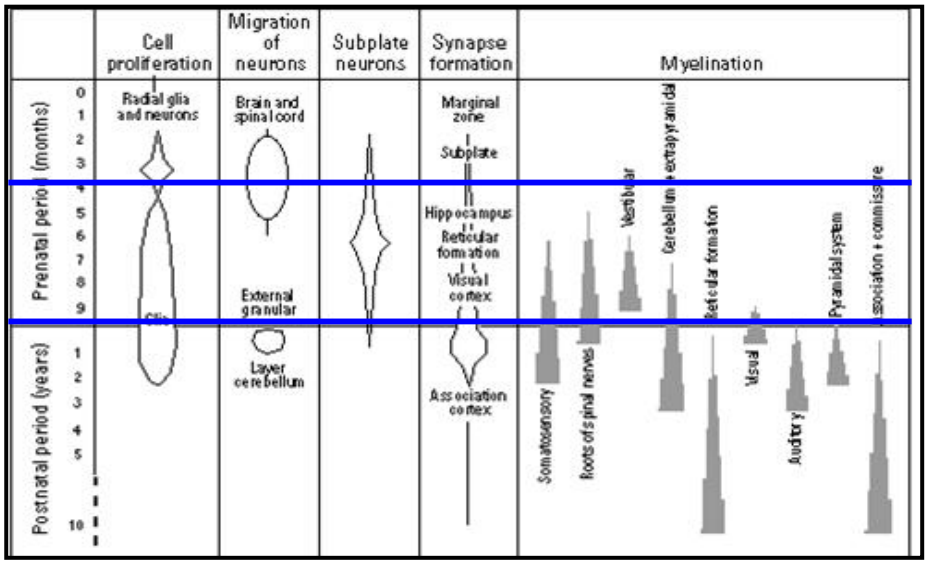
It is interesting to know that for many years, cats eating the fish in Minamata Bay area suffered a "strange" neurological disease…

Information on the Japanese Institute on Minamata Disease can be found at www.nimd.go.jp/english/index.htm

Picture: Stephan Boese-O´Reilly ©. Minamata Bay Japan, 2001.

Mercury and Children's Environmental Health (DRAFT)

NEURODEVELOPMENT



Rice, EHP, 2000 108 (3): 511

32

Recalling that mercury inhibits cell division and migration during development, it is easy to see from this schematic why the fetus and young children are particularly at risk when exposed. Note how much cell proliferation and migration occurs during the second and third trimester. Note also how much continues to occur in the first 2-3 years postnatally. Clearly, exposure to neurodevelopmental toxicants like methylmercury during these periods of rapid maturation and change can have profound consequences.

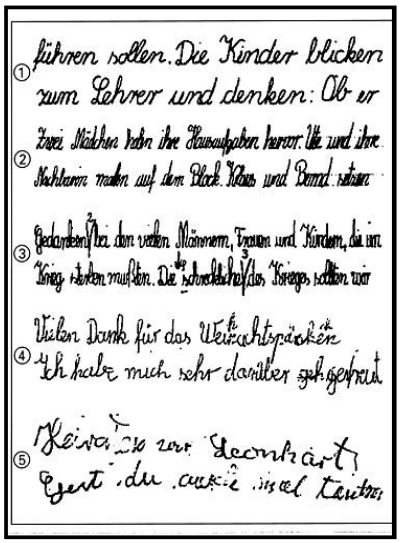
Ref: Rice, Critical periods of vulnerability for the developing nervous system: evidence from humans and animal models, Environ Health Perspect. (2000)108 (3):511.

Vulnerable periods during the development of the nervous system are sensitive to environmental insults because they are dependent on the temporal and regional emergence of critical developmental processes (i.e., proliferation, migration, differentiation, synaptogenesis, myelination, and apoptosis). Evidence from numerous sources demonstrates that neural development extends from the embryonic period through adolescence. In general, the sequence of events is comparable among species, although the time scales are considerably different. Developmental exposure of animals or humans to numerous agents (e.g., X-ray irradiation, methylazoxymethanol, ethanol, lead, methyl mercury, or chlorpyrifos) demonstrates that interference with one or more of these developmental processes can lead to developmental neurotoxicity. Different behavioral domains (e.g., sensory, motor, and various cognitive functions) are subserved by different brain areas. Although there are important differences between the rodent and human brain, analogous structures can be identified. Moreover, the ontogeny of specific behaviors can be used to draw inferences regarding the maturation of specific brain structures or neural circuits in rodents and primates, including humans. Furthermore, various clinical disorders in humans (e.g., schizophrenia, dyslexia, epilepsy, and autism) may also be the result of interference with normal ontogeny of developmental processes in the nervous system. Of critical concern is the possibility that developmental exposure to neurotoxicants may result in an acceleration of age-related decline in function. This concern is compounded by the fact that developmental neurotoxicity that results in small effects can have a profound societal impact when amortized across the entire population and across the life span of humans.

Mercury and Children's Environmental Health (DRAFT)

EXAMPLE OF *"TREMOR MERCURIALIS"*

Hand-writing of a 9 year old girl in monthly intervals after an accidental intake of mercury containing seed preservatives

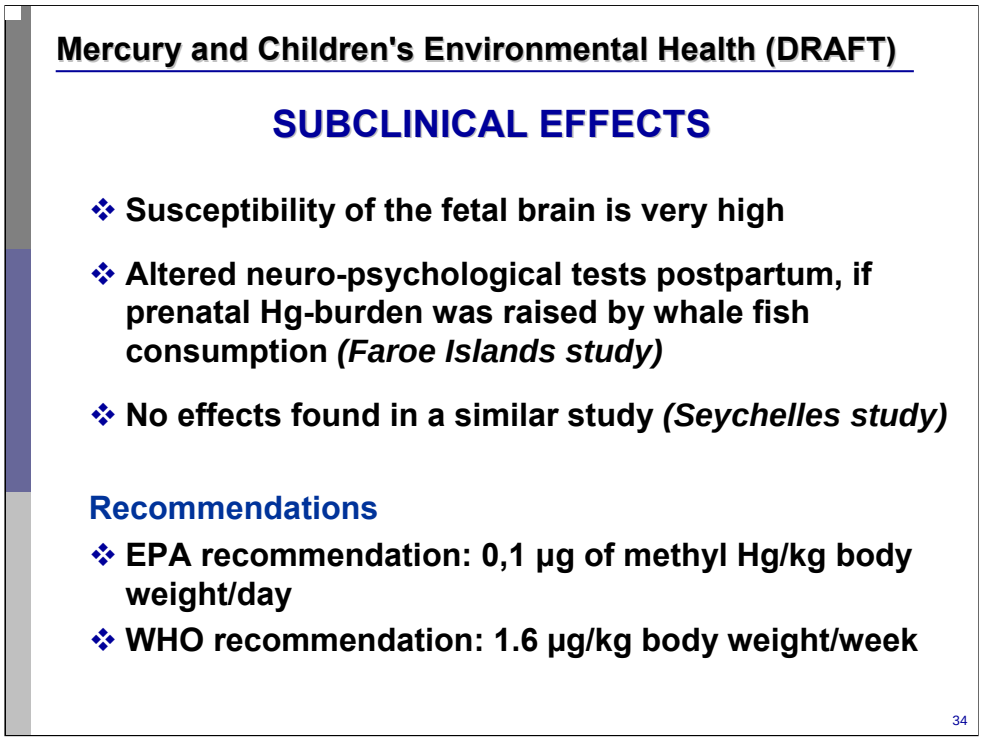

führen sollen. Die Kinder blicken
① zum Lehrer und denken: Ob er
Zwei Mädchen holen ihre Hausaufgaben hervor. Ute und ihre
② Nachbarin malen auf dem Block. Klaus und Bernd sehen
Gedanken bei den vielen Männern, Frauen und Kindern, die im
③ Krieg sterben mußten. Die Schrecklichkeit des Krieges, sollten wir
Vielen Dank für das Weihnachtspäckchen
④ Ich habe mich sehr darüber gefreut
⑤

Boese, Paediat Prax (1993) 45: 183

Hand-writing of a 9 year old girl in monthly intervals after an accidental intake of mercury containing seed preservatives. This exposure was due to contaminated grain, and demonstrates that exposures well after infancy can also have serious consequences.

Picture: Stephan Boese-O´Reilly ©. 9 year old girl, hand writing example, 1989.

Boese, Chronische Metallintoxikationen als Ursache neuropaediatrischer Erkrankungen. Paediat Prax (1993) 45: 183



Two important studies on Hg exposure in children rendered different results as it will be seen in the next slides.

In view of mounting evidence about the adverse effects of Hg, in 2003 the Joint Expert Committee for Food Additives and Contaminants (JECFA) revised the Provisional Tolerable Weekly Intake (PTWI) and reduced it to 1.6 µg/kg body weight/week in order to protect de developing fetus (it was 3.3 µg/kg body weight/week before)

Refs: Clarkson, The toxicology of mercury – current exposures and clinical manifestations, N Engl J Med (2003) 349: 1731

•FAO/WHO. Evaluation of certain food additives and contaminants. Sixty first report of the Joint FAO/WHO Expert Committee on Food Additives. WHO, Geneva, 2004.

•Myers GJ, Davidson PW: Does Methylmercury Have a Role in Causing Developmental Disabilities in Children? Environmental Health Perspectives (2000) 108 (3): 413

Methylmercury (MeHg) is a potent neurotoxin that in high exposures can cause mental retardation, cerebral palsy, and seizures. The developing brain appears particularly sensitive to MeHg. Exposure levels in pregnant experimental animals that do not result in detectable signs or symptoms in the mother can adversely affect the offspring's development. Studies of human poisonings suggest this may also occur in humans. Human exposure to MeHg is primarily dietary through the consumption of fish: MeHg is present in all fresh and saltwater fish. Populations that depend on fish as a major source of dietary protein may achieve MeHg exposure levels hypothesized to adversely affect brain development. Increasing mercury levels in the environment have heightened concerns about dietary exposure and a possible role for MeHg in developmental disabilities. Follow-up studies of an outbreak of MeHg poisoning in Iraq revealed a dose-response relationship for prenatal MeHg exposure. That relationship suggested that prenatal exposure as low as 10 ppm (measured in maternal hair growing during pregnancy) could adversely affect fetal brain development. However, using the same end points as were used in the Iraq study, no associations have been reported in fish-eating populations. Using a more extensive range of developmental end points, some studies of populations consuming seafood have reported associations with prenatal MeHg exposure, whereas others have found none.

Mercury and Children's Environmental Health (DRAFT)

FAROE STUDY

- **Cohort of 1022 children born 1986-1987**
- **Exposure to methyl-mercury from:**
  - Pilot whale meat - episodic, and potentially high
  - Fish consumption - continuous, but low
- **At age 7: neuropsychological tests**
- **At age 14: neurophysiologic tests**
- **Neuropsychological dysfunctions**
  - Language
  - Attention
  - Memory
- **Neurophysiologic tests**
  - Delayed brainstem auditory evoked potentials
  - Decreased autonomic heart rate variability
- **Attributed to pre-natal exposure**

35

Refs: Grandjean, Cardiac autonomic activity in methylmercury neurotoxicity: 14-year follow-up of a Faroese birth cohort,J Pediatr. (2004) 144(2):169.

Grandjean, Cognitive deficit in 7 year old children with prenatal exposure to methylmercury, Neurotoxicology and teratology (1997) 19: 417

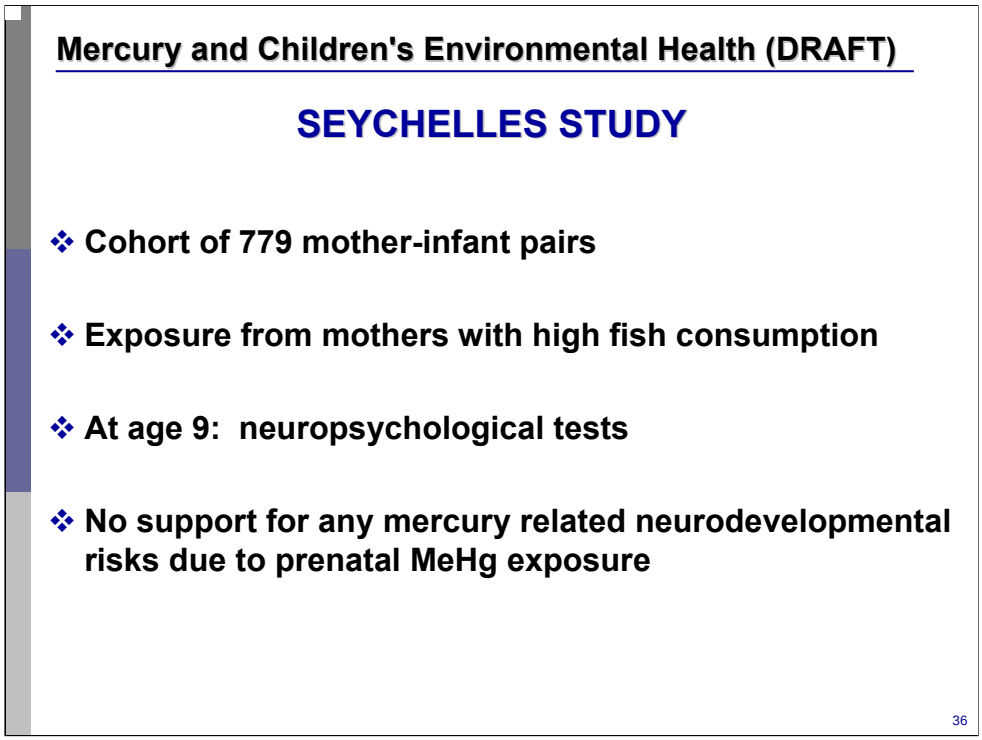
A cohort of 1022 consecutive singleton births was generated during 1986-1987 in the Faroe Islands. Increased methylmercury exposure from maternal consumption of pilot whale meat was indicated by mercury concentrations in cord blood and maternal hair. At approximately 7 years of age, 917 of the children underwent detailed neurobehavioral examination. Neuropsychological tests included Finger Tapping; Hand-Eye Coordination; reaction time on a Continuous Performance Test; Wechsler Intelligence Scale for Children-Revised Digit Spans, Similarities, and Block Designs; Bender Visual Motor Gestalt Test; Boston Naming Test; and California Verbal Learning Test (Children). Clinical examination and neurophysiological testing did not reveal any clear-cut mercury-related abnormalities. However, mercury-related neuropsychological dysfunctions were most pronounced in the domains of language, attention, and memory, and to a lesser extent in visuospatial and motor functions. These associations remained after adjustment for covariates and after exclusion of children with maternal hair mercury concentrations above 10 microgram(s) (50 nmol/g). The effects on brain function associated with prenatal methylmercury exposure therefore appear widespread, and early dysfunction is detectable at exposure levels currently considered safe.

•Grandjean: Neurodevelopmental disorders. In: Tamburlini G, von Ehrenstein O, Bertollini R. (eds): Children´s health and the environment: A review of evidence. WHO, Rome, 2002.

"At intake levels widely encountered in fisheating populations, new evidence of developmental effects at low exposure levels is emerging. In a cohort of 1 000 births on the Faroe Islands, methylmercury exposure was determined from the mercury concentration in the umbilical cord blood. Most of the dietary mercury intake there comes from pilot whalemeat, which has been a traditional food item for centuries. More than 90 % of these children were examined at the age of seven years. While clinical examination did not reveal any clear-cut mercury-related abnormalities, mercury related neuropsychological deficits were particularly pronounced in language, attention and memory, and to a lesser extent in visuospatial and motor functions. The associations could not be explained by other possible causes, and they remained after exclusion of highly exposed children with maternal hair-mercury concentrations above 10 µg/g (Grandjean et al., 1997)".

•Murata, Delayed brainstem auditory evoked potential latencies in 14-year-old children exposed to methylmercury, J Pediatr. (2004) 144(2):177.

To determine possible exposure-associated delays in auditory brainstem evoked potential latencies as an objective measure of neurobehavioral toxicity in 14-year-old children with developmental exposure to methylmercury (MeHg) from seafood. Prospective study of a birth cohort in the Faroe Islands, where 878 of eligible children (87%) were examined at age 14 years. Latencies of brainstem evoked potential peaks I, III, and V at 20 and 40 Hz constituted the outcome variables. Mercury concentrations were determined in cord blood and maternal hair, and in the child's hair at ages 7 and 14. Results: Latencies of peaks III and V increased by about 0.012 ms when the cord blood mercury concentration doubled. As seen at age 7 years, this effect appeared mainly within the I-III interpeak interval. Despite lower postnatal exposures, the child's hair mercury level at age 14 years was associated with prolonged III-V interpeak latencies. All benchmark dose results were similar to those obtained for dose-response relationships at age 7 years. Conclusions: The persistence of prolonged I-III interpeak intervals indicates that some neurotoxic effects from intrauterine MeHg exposure are irreversible. A change in vulnerability to MeHg toxicity is suggested by the apparent sensitivity of the peak III-V component to recent MeHg exposure.



Refs:

•Grandjean, Neurodevelopmental disorders. In: Tamburlini G, von Ehrenstein O, Bertollini R. (eds): Children´s health and the environment: A review of evidence. WHO, Rome, 2002.

"A large prospective study in the Seychelles has not revealed any clear adverse effects related to maternal hair mercury concentrations"

•Myers, Prenatal methylmercury exposure from ocean fish consumption in the Seychelles child development study, Lancet (2003) 361:1686

Exposure to methylmercury (MeHg) before birth can adversely affect children's neurodevelopment. The most common form of prenatal exposure is maternal fish consumption, but whether such exposure harms the fetus is unknown. We aimed to identify adverse neurodevelopmental effects in a fish-consuming population. We investigated 779 mother-infant pairs residing in the Republic of Seychelles. Mothers reported consuming fish on average 12 meals per week. Fish in Seychelles contain much the same concentrations of MeHg as commercial ocean fish elsewhere. Prenatal MeHg exposure was determined from maternal hair growing during pregnancy. We assessed neurocognitive, language, memory, motor, perceptual-motor, and behavioural functions in children at age 9 years. The association between prenatal MeHg exposure and the primary endpoints was investigated with multiple linear regression with adjustment for covariates that affect child development. Mean prenatal MeHg exposure was 6.9 parts per million (SD 4.5 ppm). Only two endpoints were associated with prenatal MeHg exposure. Increased exposure was associated with decreased performance in the grooved pegboard using the non-dominant hand in males and improved scores in the hyperactivity index of the Conner's teacher rating scale. Covariates affecting child development were appropriately associated with endpoints. Interpretation: These data do not support the hypothesis that there is a neurodevelopmental risk from prenatal MeHg exposure resulting solely from ocean fish consumption.

ANOTHER ORGANIC MERCURY: THIMEROSAL

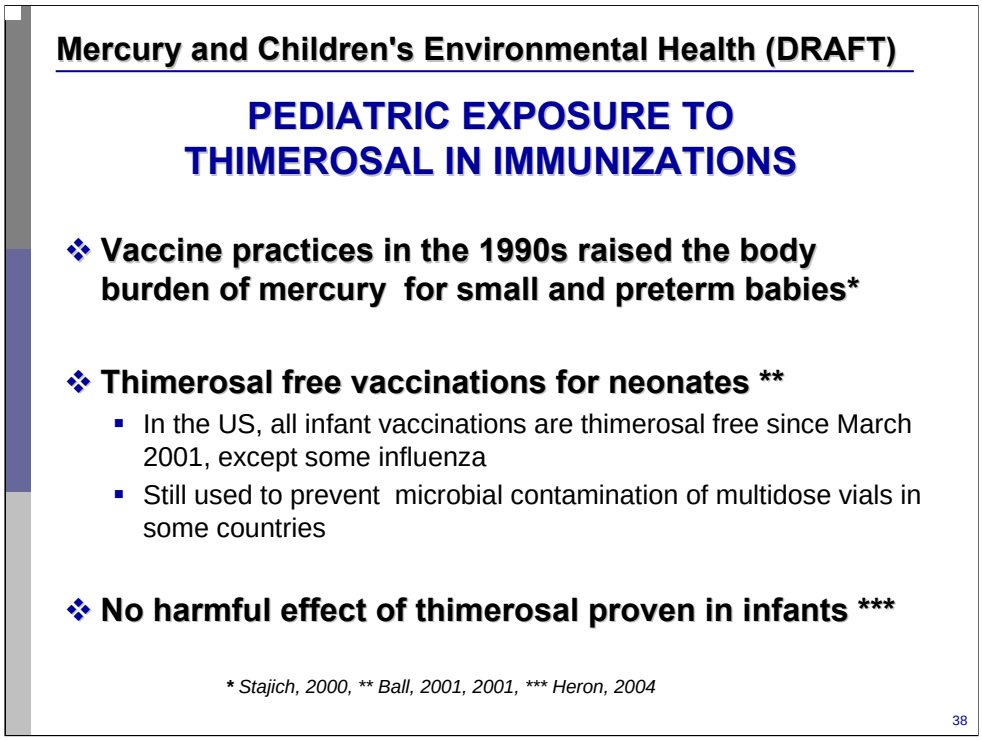
- **A mercury preservative used in**
  - Eye drops, antiseptics, other pharmaceuticals
  - Multidose vaccinations
- **It is metabolized to ethyl-mercury**
  - $T_{1/2}$ ~7 days in babies
  - Crosses blood brain barrier
  - Neurotoxic in high doses,
  - "Safe dose" unknown

Refs:

•*Pichichero, Mercury concentrations and metabolism in infants receiving vaccines containing thiomersal: a descriptive study, Lancet (2002) 360 (9347):1737.*

•*Stajich, Iatrogenic exposure to mercury after hepatitis B vaccination, J. Pediatr. (2000) 136: 679*

Thimerosal, a derivative of mercury, is used as a preservative in hepatitis B vaccines. We measured total mercury levels before and after the administration of this vaccine in 15 preterm and 5 term infants. Comparison of pre- and post-vaccination mercury levels showed a significant increase in both preterm and term infants after vaccination. Additionally, post-vaccination mercury levels were significantly higher in preterm infants as compared with term infants. Because mercury is known to be a potential neurotoxin to infants, further study of its pharmacodynamics is warranted.



It is unlikely that thimerosal causes overt disease, but studies are ongoing to evaluate more subtle symptoms from the highest exposures experienced by small infants during peak use in the 1990s. According to British studies, immunizing infants with vaccines containing thimerosal may be associated with improved behavior and cognitive outcomes *(Heron, 2004).*

Refs:

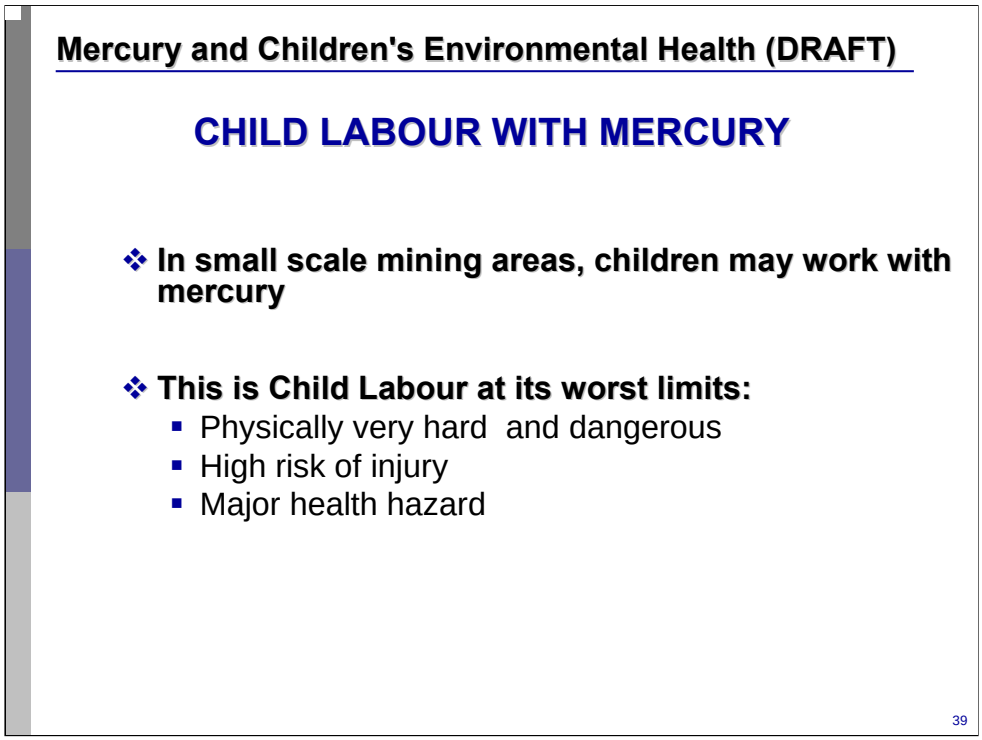
•Ball, An assessment of thimerosal use in childhood vaccines, Pediatrics (2001) 107: 1147.

•Clarkson, The toxicology of mercury – current exposures and clinical manifestations, N Engl J Med (2003) 349: 1731

•Heron, Thimerosal exposure in infants and developmental disorders: a prospective cohort study in the United kingdom does not support a causal association, Pediatrics (2004) 114(3):577.

There is an established link between exposure to mercury and impaired childhood cognitive development and early motor skills. Thimerosal (also known as thiomersal), a preservative used in a number of children's vaccines, contains ethylmercury (an organic compound of mercury), and there has been concern that this exposure to mercury may be of some detriment to young children. The aim of this research was to test in a large United Kingdom population-based cohort whether there is any evidence to justify such concerns. We used population data from a longitudinal study on childhood health and development. The study has been monitoring >14,000 children who are from the geographic area formerly known as Avon, United Kingdom, and were delivered in 1991-1992. The age at which doses of thimerosal-containing vaccines were administered was recorded, and measures of mercury exposure by 3, 4, and 6 months of age were calculated and compared with a number of measures of childhood cognitive and behavioral development covering the period from 6 to 91 months of age. Contrary to expectation, it was common for the unadjusted results to suggest a beneficial effect of thimerosal exposure. For example, exposure at 3 months was inversely associated with hyperactivity and conduct problems at 47 months; motor development at 6 months and at 30 months; difficulties with sounds at 81 months; and speech therapy, special needs, and "statementing" at 91 months. After adjustment for birth weight, gestation, gender, maternal education, parity, housing tenure, maternal smoking, breastfeeding, and ethnic origins, we found 1 result of 69 to be in the direction hypothesized-poor prosocial behavior at 47 months was associated with exposure by 3 months of age (odds ratio: 1.12; 95% confidence interval: 1.01-1.23) compared with 8 results that still supported a beneficial effect. We could find no convincing evidence that early exposure to thimerosal had any deleterious effect on neurologic or psychological outcome.

•Stajich, Iatrogenic exposure to mercury after hepatitis B vaccination, J. Pediatr. (2000) 136: 679

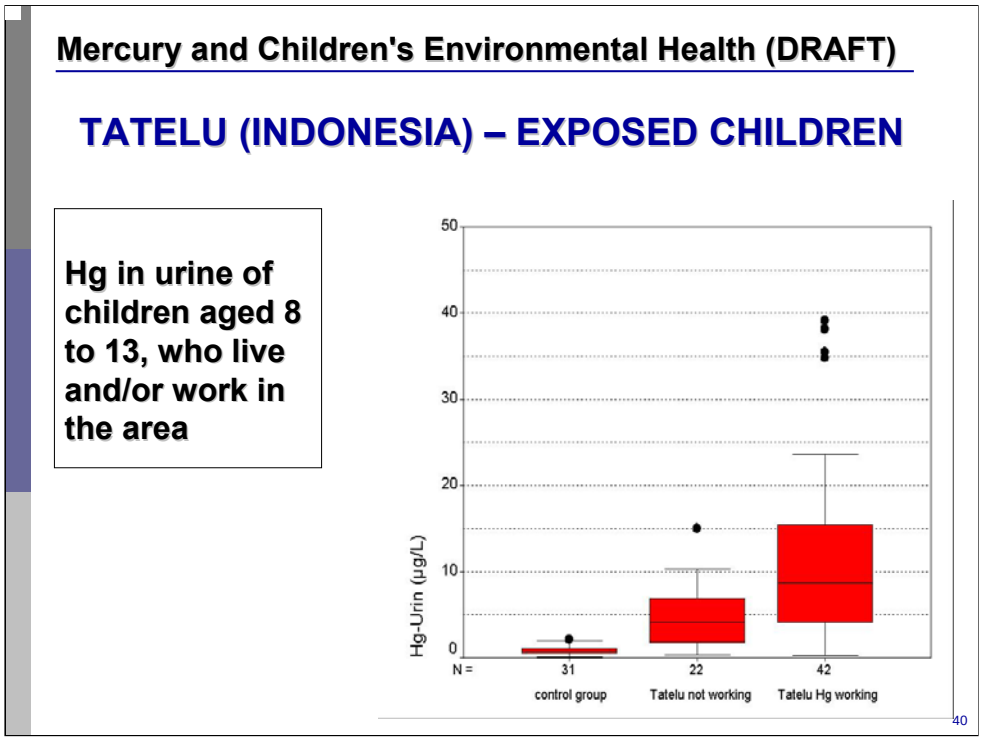


In numerous projects the United Nations Industrial Development Organization (UNIDO) has addressed the global issue of mercury as a health hazard caused by the release of the toxic metal from small-scale gold mining activities.

The UNIDO project “Removal of barriers to the Introduction of Cleaner Artisanal Gold Mining and Extraction Technologies” showed, as one of the results, a very high number of children working as miners with direct contact to mercury in Indonesia, Tanzania and Zimbabwe.

Worldwide, it is estimated by UNIDO that up to 10.000.000 people live in small scale mining areas, a major part of them children.

The following two slides are results from the UNIDO projects in Indonesia by Boese-O´Reilly S., Drasch G, Rodriquez S., Beinhoff C (unpublished by December 2004).



Tatelu is a village in Indonesia (Sulawesi). Children do work here as small scale miners with mercury. In a box plot the urine levels of mercury are shown. According to the exposure risk (control group in a different area with no specific mercury exposure, children living - but not working in the exposure area, children living and working in the exposure area) the mercury levels differ.

The colored box represents 25-75%, the line in side is the mean ,mercury level. The whiskers are the 95% confidence intervals and the dots are outliers.

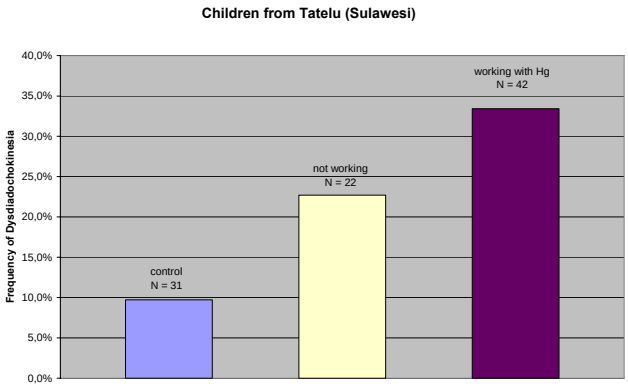
Ref:

•*Personal communication of Dr. S. Boese-O'Reilly (2004)*

Mercury and Children's Environmental Health (DRAFT)

TATELU (INDONESIA) – DYSDIADOCHOKINESIA

Cerebellar effects in children aged 8 to 13, who live or work and live in the area



Dysdiadochokinesia is a clinical symptom of cerebellar damage. According to the different exposure risks the children in the highest exposure group show the highest rate of symptoms.

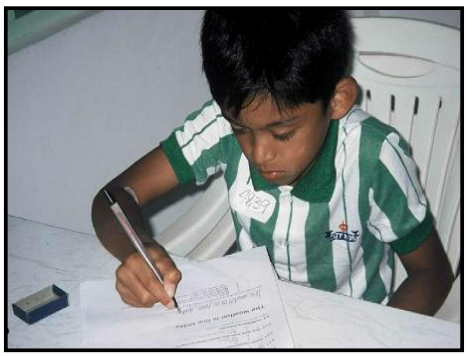
Ref:

•*Rodrigues Pereira Filho, Environmental and health assessment in two small-scale mining areas – Indonesia. Final report Sulawesi and Kalimantan. Technical Final Report to UNIDO, 2004.*

SYMPTOMS AND SIGNS OF HG EXPOSURE

Typical symptoms of chronic metallic mercury intoxication are:

- Tremor
- Ataxia
- Coordination problems
- Excessive salivation
- Metallic taste

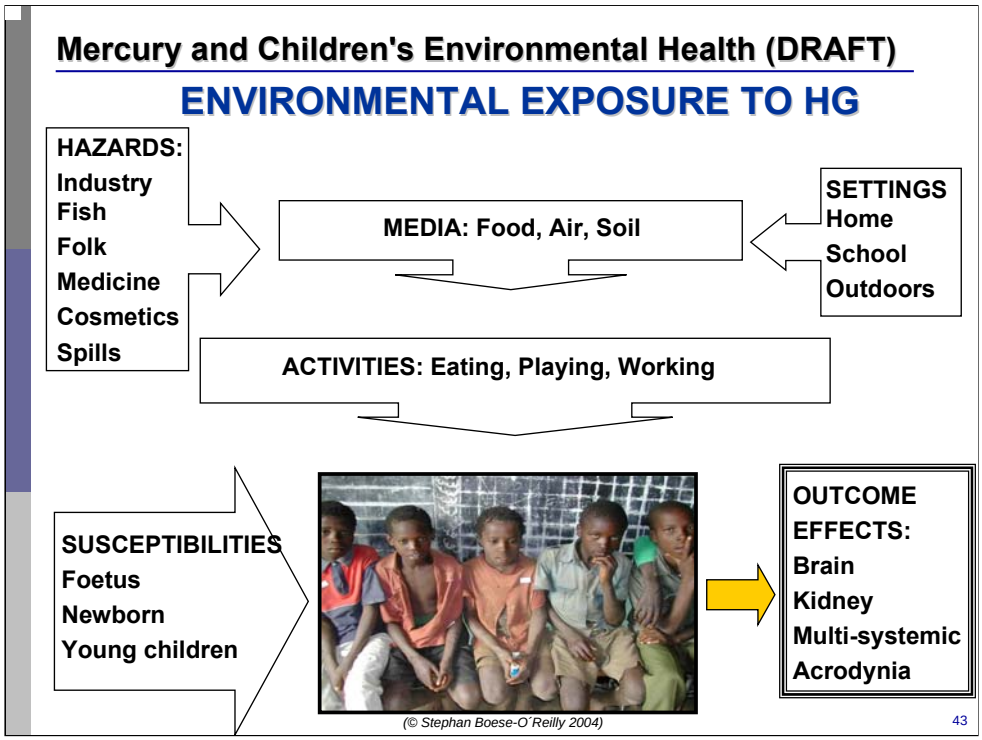


(© Stephan Boese-O´Reilly 1999)

Picture: Stephan Boese-O´Reilly ©. Boy from a small scale mining operation area near Monkayo in Mindanao (Philippines) being tested, 1999.

Ref:

•Drasch, The Mt. Diwata study on the Philippines 1999 – assessing mercury intoxication of a population by small scale gold mining, Sci Total Environ (2001) 267: 151



In this summary slide, we see the complexity of the issues related to children's environmental health and mercury exposure.

•Hazards may arise from different sources (industrial pollution, fish contamination, folk medicines, cosmetics – and spills at home)

•Mercury reaches the child through food, air, soil.

•At home, school or outdoors.

•Through activities, such as eating, playing, working.

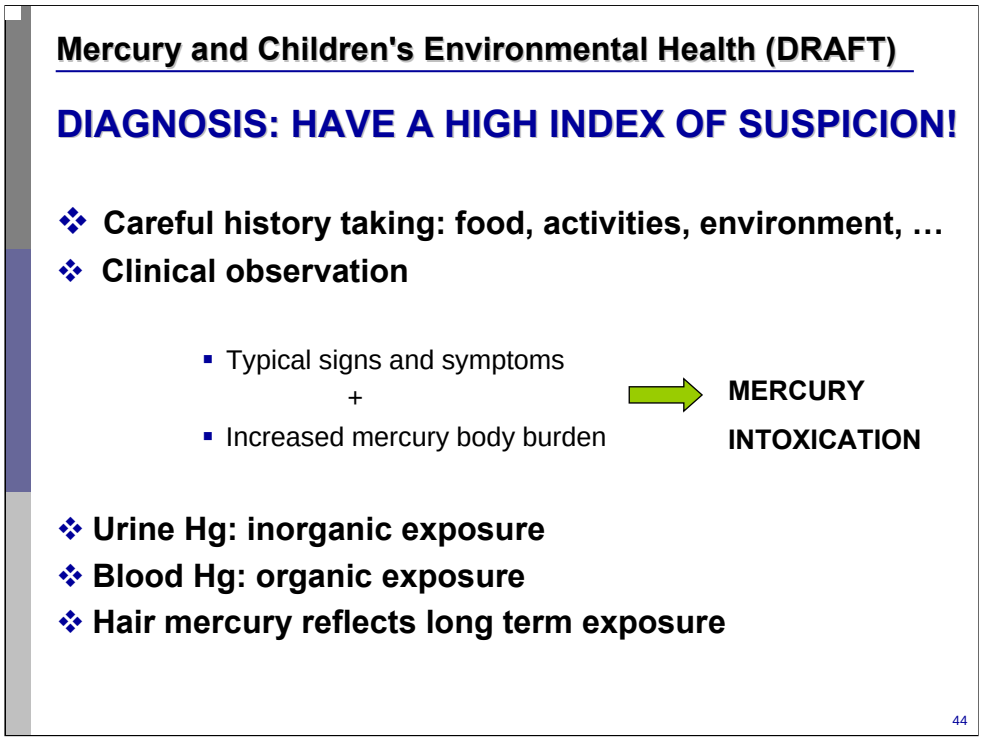
•The most susceptible ones are: foetus, newborn and young children.

•The outcomes depend on the form of Hg, dose and timing of exposure, but the main effects are on the central nervous system, kidney, mucosal and dermal, and also acrodynia.

<<READ SLIDE>>

Picture: Stephan Boese-O´Reilly (©).Children from Kadoma / Zimbabwe, 2004.

These children from Kadoma area, Zimbabwe work with mercury to extract gold from ore, thereby they are exposed to mercury vapor. Some of these children have raised levels of mercury in their urine, blood or hair, some of them already show symptoms of mercury intoxication.



Diagnosis of mercury intoxication, particularly if it is chronic and low dose requires a high index of suspicion.

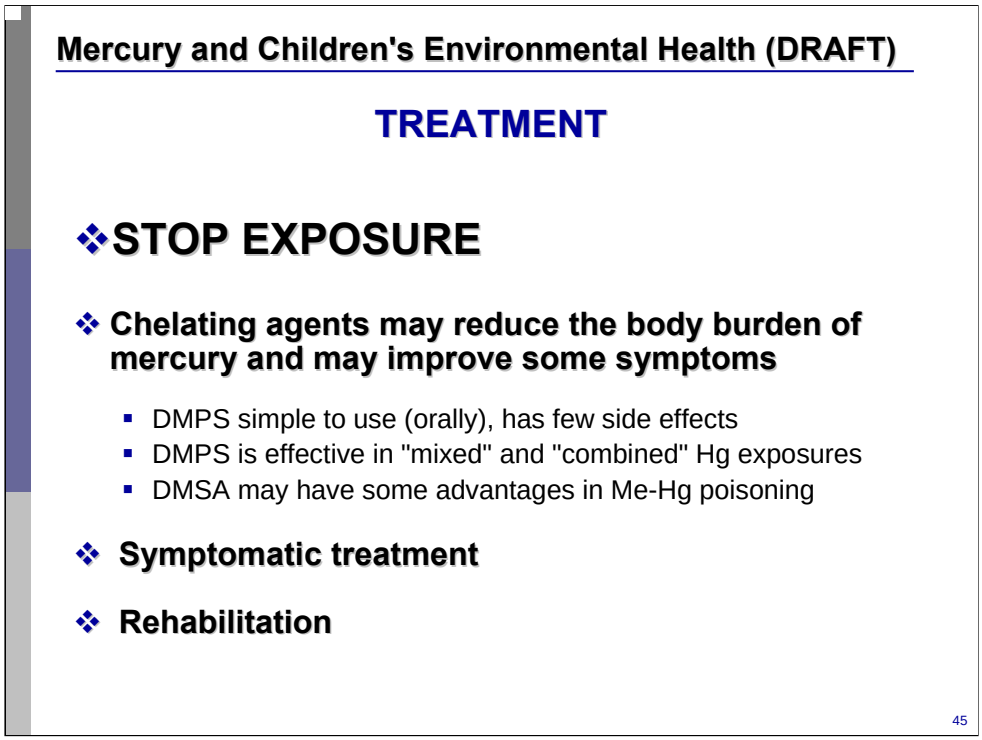
Careful history should be done to find potential sources of exposure.

If symptoms are found, the analysis of blood, urine or hair should be performed.

Urine mercury typically reflects inorganic exposure.

In most cases, total blood mercury reflects organic exposure. It is difficult to specify and to analyze MeHg, so total blood mercury can usually be used as a surrogate.

Hair analysis is most appropriate for research because there may problems due to possible contamination during collection and quantification by size of hair sample. It is, however, an excellent indicator of total body, long term exposure in sophisticated laboratories.



Treatment begins with the elimination of exposure. Permanent damage may have already occurred, but ongoing damage may be lessened through chelation in some cases of exposure. No medical therapy can replace the necessity for a reduction of the external burden, but it lowers the adverse effects of a mercury intoxication.

"Mixed" exposure: acute and chronic

"Combined" exposure: elemental, inorganic and organic (as seen in gold-mining areas).

With DMSA: Multiple courses of 3 week courses separated by 4-8 weeks are usually required (only approved for Pb).

DMPS (Unithiol): 2,3.dimercaptopropanesulphonic acid

DMSA (Succimer): meso-2,3-dimercaptosuccinic acid

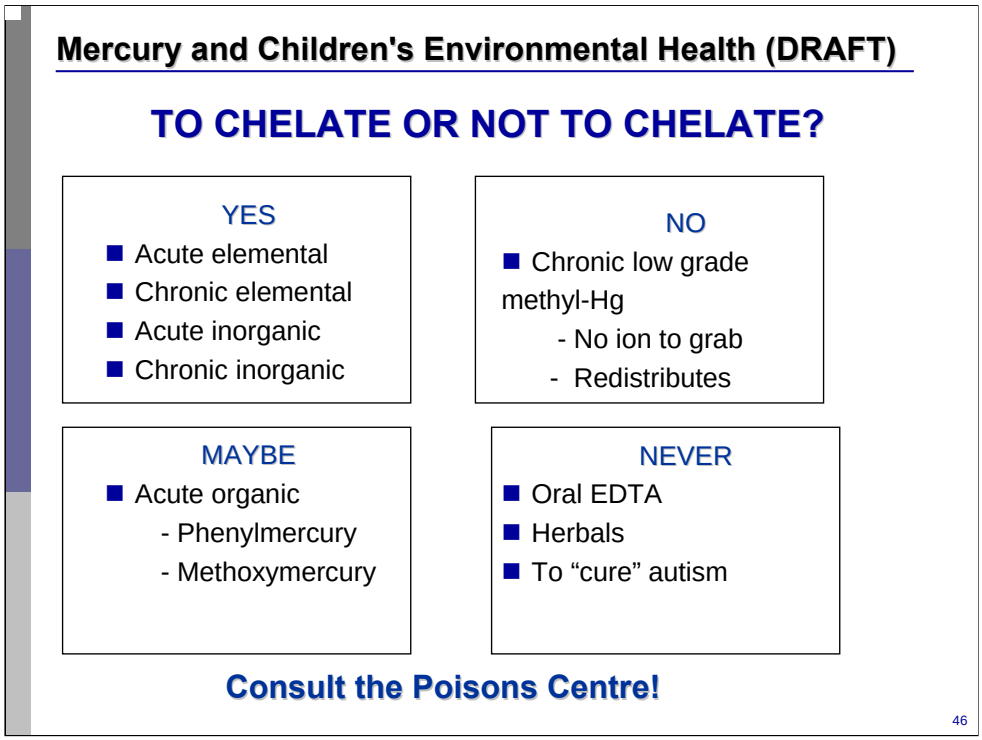
Always check the treatment indication and dosages with the local poison control centre!

Ref:

•Boese-O'Reilly, The Mt. Diwata Study on the Philippines 2000 - treatment of mercury intoxicated inhabitants of a gold mining area with DMPS (2,3-Dimercapto-1-propane-sulfonic acid, Dimaval®). Sci Total Environ (2003) 307: 71

Ninety-five inhabitants of the gold mining area of Mt. Diwata (on Mindanao, Philippines), who were diagnosed to be mercury (Hg) intoxicated, were orally treated with 2 x 200 mg of the chelating agent DMPS (Dimaval, Co. Heyl, Germany) for 14 days in the course of a UNIDO project focusing on mercury pollution abatement. Blood and urine samples before and after treatment, urine after the first application of DMPS and a hair sample were collected and analyzed for Hg. Before and after treatment extensive anamnestic data were collected, medical and neurological investigations and some neuro-psychological tests were performed. In spite of the short time of treatment most of the patients reported a marked improvement of the complaints which were stated by them before the therapy and which are characteristic for a chronic Hg intoxication, for example tremor, loss of memory, sleeplessness, metallic taste, etc. But even in some of the objective neurological parameters like hypo-mimia, Romberg test and tests for tremor/ataxia a statistical significant improvement could be found. Significant improvements could also be found in two neuro-psychological tests (pencil tapping and Frostig). In some cases an extreme high urinary Hg excretion was found under the chelating therapy with DMPS, and by this a distinct reduction of the Hg body burden. Nevertheless, in most cases Hg in blood and urine was not markedly decreased by the treatment. This shows that the duration of the treatment (14 days) was not sufficient for a permanent decrease in Hg. As DMPS excretes Hg mainly through the kidney, it can be concluded that in most cases even after 14 days of treatment there was an ongoing redistribution of Hg from other tissues to the kidney.

In conclusion, this study proves that a chelating therapy with DMPS is highly effective even in the case of a mixed chronic and acute intoxication with an unknown combination of Hg vapor, inorganic Hg and organic Hg=methylmercury (MeHg), as characteristic for gold mining areas in the third world. Adverse side effects were rarely reported. Only in one case the medication had to be terminated after the first application due to an allergic skin reaction.



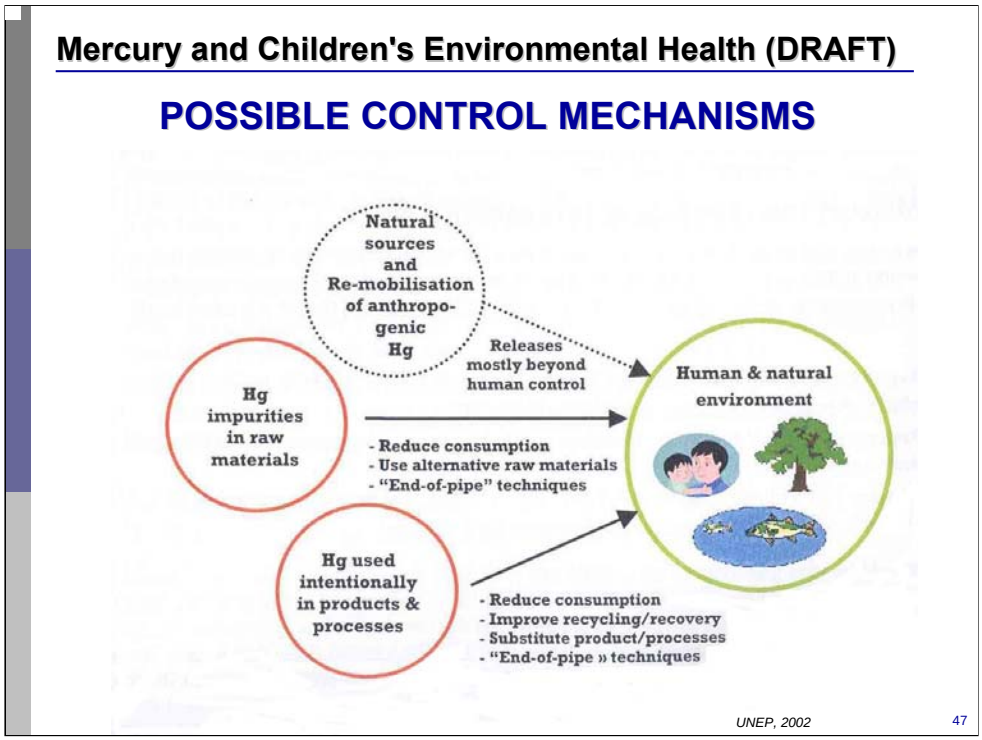
This slide summarizes the advise given to clinicians in a recent joint education meeting staged by US EPA and US DHHS.

There is no indication for chelation of low level, chronic methylmercury poisoning. Courses of oral EDTA which is not absorbed, herbal preparations and claims that chelation can cure autism have no foundation in science.

When confronted with a child who has suspected symptomatic mercury intoxication it is critical to **consult your local poison center** or clinical toxicologist before embarking on chelation treatments.

Ref:

•*Presentation at US EPA and US DHHS Conference: "Mercury: Medical and Public Health Issues." Tampa, Florida, 28-30 April 2004)*



This figure shows release categories of mercury to the biosphere with main types of possible control mechanisms.

Hg from natural sources is out of human control, but exposure to the Hg present in raw materials (e.g. fossil fuels, particularly coal and minerals) or used in products or released in processes may be controlled through:

-Reduction of use

-Use of alternative materials

-Improved recycling/recovery

-Technological improvements

-Good policies!

According to the UNEP report sources are grouped as:

•Natural sources releases due to natural mobilisation of naturally occurring mercury from the Earth's crust (e.g. volcanic activity and weathering of rocks).

•Current anthropogenic (human activity-related) releases from the mobilisation of mercury impurities in raw materials (fossil fuels: specially coal but also gas and oil).

•Current anthropogenic releases from mercury intentionally used in products and processes (releases during manufacturing, leaks, disposal or spent products incineration).

•Re-mobilisation of historic anthropogenic releases previously deposited in soils, sediments, waters, landfills, waste piles.

Ref: UNEP. Global Mercury Assessment, December 2002: www.chem.unep.ch/mercury/default.htm

Figure: UNEP Chemicals, Global mercury assessment. UNEP Chemicals, Geneva, Switzerland, 2002.

Mercury and Children's Environmental Health (DRAFT)

WHAT HEALTH CARE PROVIDERS CAN DO

NOAA Photo Gallery, Tuna

SECONDARY PREVENTION

- Fish consumption advice

PRIMARY PREVENTION

- Mercury free office and hospital
- Mercury free communities
  - Thermometer exchange
  - Hazardous waste education
  - Change high-risk behaviors
    Folk medicines, cottage industries, …
- Get politically active
  - Request emission controls on power plants, incinerators
  - Prevent childhood exposure to artisanal mining

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Prevention is pivotal because the brain has little or no ability to repair, particularly from prenatal damage to basic neuro-architecture. Since methylmercury from fish is the major world wide exposure, counseling mothers on safest fish consumption can help to protect the fetus and young children.

Primary prevention is crucial to prevent fish contamination at the source. Numerous programs are underway to reduce mercury use in medical equipment, batteries, switches and light bulbs. Regulations to control emissions and mining are also important, and health care providers have a powerful voice that can be used to influence politicians and regulators.

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EXAMPLE OF FISH CONSUMPTION GUIDELINES

For women and young children in the USA (USEPA/FDA)

1. Do not eat Shark, Swordfish, King Mackerel, or Tilefish

2. Eat up to 12 ounces (2 average meals) a week of a variety of fish and shellfish that are lower in mercury
   - Shrimp, canned light tuna, salmon, pollock, and catfish are examples
   - Albacore ("white") tuna has more mercury than canned light tuna, you may eat up to 6 ounces (one average meal) per week.

3. Check local advisories. If no advice is available, eat up to 6 ounces (one average meal) per week of fish you catch, but don't consume any other fish during that week.

   ...to your young child, serve smaller portions!

Here is the fish consumption advisory issued by EPA/FDA illustrates the complexity of the preventive messages. It only applies to women in the childbearing period and young children. Other individuals can safely eat more fish, even if it contains moderate amounts of mercury.

Ref:

•*www.epa.gov/waterscience/fishadvice/advice.html*

Mercury and Children's Environmental Health (DRAFT)

EXAMPLE OF FISH CONSUMPTION GUIDELINES

For women and young children in developing countries, where diets are based on fish that may have high levels of Hg

❖**Recognize neurodevelopmental problems in children**:

•Determine amount, type and frequency of fish consumption and provide advise

❖**Encourage consumption of fish low in methyl mercury, but:**

•Limit intake of larger, predatory fish.
•Greatly limit intake of marine mammals.
•Encourage consumption of "light" or "chunk light" tuna

WHO

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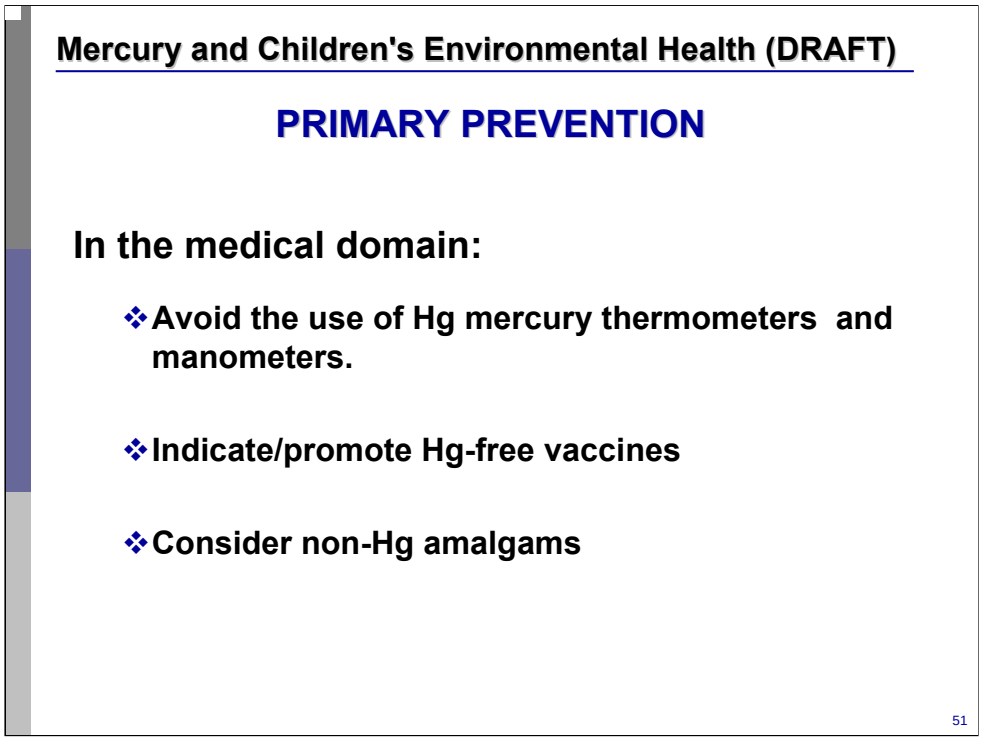
The advice to families in developing countries, especially those with diets based on fish, is quite different, When possible, limit intake of large fish who eat other fish. Smaller and younger fish are likely to have lower mercury levels. By eating a variety of fish, exposure is also likely to be reduced.

<<READ SLIDE>>

Ref:

•WHO/IPA Mercury leaflet (in preparation, 2004)

Picture: WHO, P. Virot. Air pollution, Ghana, Africa, 2003



Simple clinic-based strategies for primary prevention are listed in this slide.

In the medical domain:

Since electronic thermometers may be available, and are easier and safer to use, the unnecessary risk of mercury containing thermometers could be avoided.

Since mercury free vaccinations may be available, this source of contamination could be avoided

Non-mercury containing amalgams may be preferable when feasible.

<<READ SLIDE>>

PRIMARY PREVENTION

Primary prevention at home

- **Avoid ritual use of quicksilver**
- **Eliminate equipment with mercury**
- **Avoid having children play with "quicksilver"**
- **Dispose safely of mercury-containing products (old batteries and thermometers).**

The slide is self-explanatory. More detailed information for parents may be found at USEPA's website:
www.epa.gov/epaoswer/hazwaste/mercury

<<READ SLIDE>>

PRIMARY PREVENTION

In case of metallic mercury spill

- DO NOT clean yourself if amount is greater than that contained in a thermometer: Call local health or environmental agencies.
- NEVER VACUUM or use a broom
- NEVER put mercury down the drain
- NEVER wash mercury-contaminated items in a washing machine
- NEVER walk around if your shoes might be contaminated with mercury.
- Beware of contaminated clothes too.

www.epa.gov/epaoswer/hazwaste/mercury/spills.htm#cleanmercuryspills

<<READ SLIDE>>

When mercury, also known as "quicksilver," is exposed to air, it gives off vapors that, under some circumstances, can build up in indoor air at high enough concentrations to pose health risks to occupants. Air vapors from spilled mercury can also eventually settle onto water, increasing the mercury levels in fish. Therefore, it is important to clean up mercury spills properly and to report them to the proper authorities when necessary.

During a mercury spill, you will see that mercury breaks into tiny beads that roll, and can easily become trapped in small cracks in the surface. A mercury spill can be cleaned with minimal effort, if the proper instructions are followed.

What NEVER to do with a mercury spill:

Never use a vacuum cleaner to clean up mercury. The vacuum will put mercury into the air and increase exposure. The vacuum appliance will be contaminated and have to be thrown away.

Never use a broom to clean up mercury. It will break the mercury into smaller droplets and spread them.

Never pour mercury down a drain. It may lodge in the plumbing and cause future problems during plumbing repairs. If discharged, it can cause pollution of the septic tank or sewage treatment plant.

Never wash mercury-contaminated items in a washing machine. Mercury may contaminate the machine and/or pollute sewage.

Never walk around if your shoes might be contaminated with mercury. Contaminated clothing can also spread mercury around.

Spills: Less than or equal to the amount in a thermometer: tips.

Remove everyone from the area where cleanup will take place. Shut door of impacted area. Turn off ventilation system. DO NOT allow or gain assistance from children. Remember to remove all pets as well.

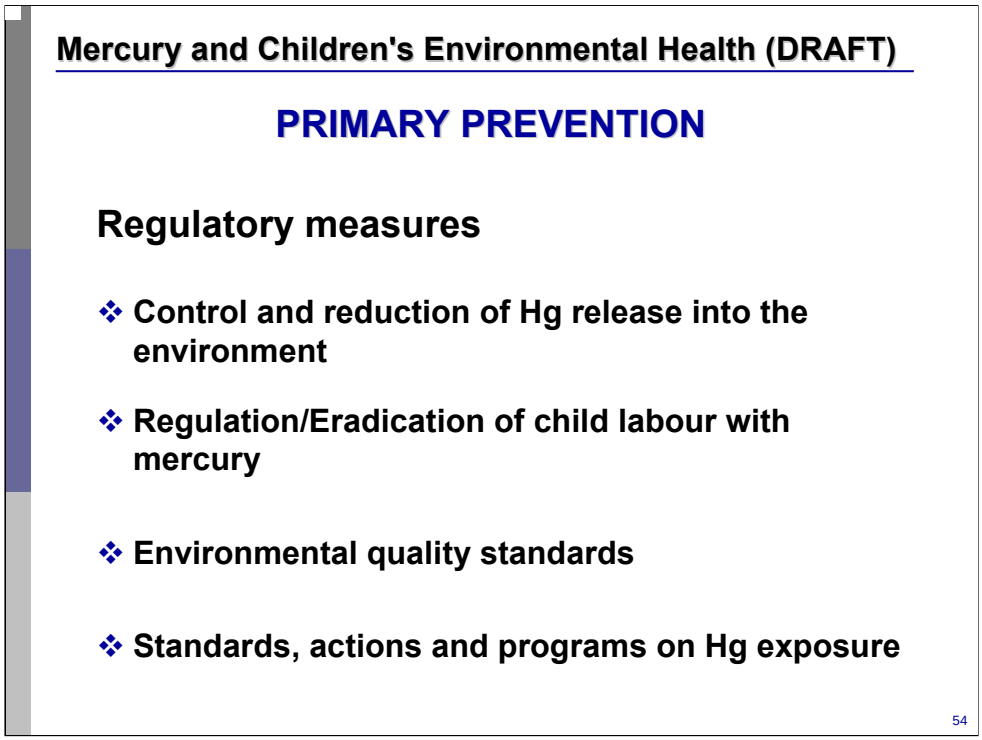
Mercury can be cleaned up easily from the following surfaces: wood, linoleum, tile and any other like surfaces.

If a spill occurs on carpet, curtains, upholstery or other like surfaces, these contaminated items should be thrown away in accordance with the disposal means outlined in EPA's website. Only cut and remove the affected portion of the contaminated carpet for disposal.

Spills: More than the amount in a thermometer. Caution:

The general public can clean up small mercury spills no greater than the amount contained in a thermometer from flat surfaces. If you estimate your mercury spill to be greater than the amount in a thermometer, isolate the contaminated area and call your local health or environmental agency.

These notes are taken from EPA's website. More detailed information on specific actions to be taken after spills may be found at EPA's website: *www.epa.gov/epaoswer/hazwaste/mercury/spills.htm#cleanmercuryspills*



<<READ SLIDE>>

❖Control and reduction of Hg release into the environment through actions on:

- Coal burning power plants
- Medical uses and waste
- Municipal and hazardous waste incineration
- Factory and mining discharges

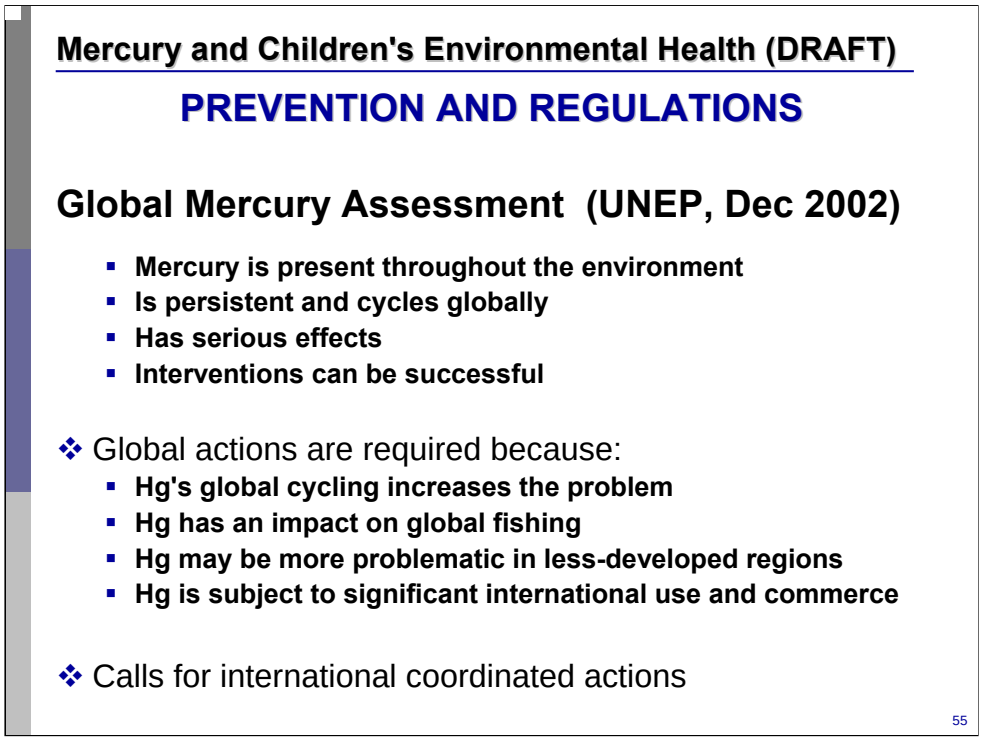
❖Regulation/eradication of child labour with mercury - In small scale mining areas and other occupations

❖Environmental quality standards – control of Hg levels in drinking water, surface waters, air, soil and foodstuff –fish

❖Standards, actions and programmes on Hg exposure - In the workplace, through fish consumption advisories and consumer safety measures.

These are more systemic approaches to prevention through regulatory measures.

<<NOTE TO USERS: If there are political strategies that are being proposed or developed in your local area, it would be ideal to insert them here.>>



As already seen, the United Nations Environmental Programme has prepared a Global Mercury Assessment publication with very comprehensive information on mercury as a global environmental and human health threat. It calls for local, regional and global actions, and for international coordination.

Available at: *www.chem.unep.ch*

<<READ SLIDE>>

<<NOTE TO USERS: If there are political strategies that are being proposed or developed in your local area, it would be ideal to insert them here.>>

Mercury and Children's Environmental Health (DRAFT)

HEALTH AND ENVIRONMENT PROFESSIONALS PLAY A CRITICAL ROLE:

WHO

- **Diagnose and treat**
- **Publish, do research**
  - Sentinel cases
  - Community-based interventions
- **Educate**
  - Patients and families
  - Colleagues and students
- **Advocate**
- **Role model**

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Health and environment professionals have a critical role to play in maintaining and stimulating changes that will restore and protect children's environmental health.

Our political and personal lives to support sustainable development, should include practices for ways to enhance the environmental health of our patients. All of us can do something to detect and avoid the effects of mercury in the environment.

Health care providers should include **Mercury Exposure** as a potential environmental etiology in differential diagnosis and preventive advice (avoiding the excess use of "idiopathic" as an etiology and looking in depth into environmental causes of disease and disability).

It is important to publish sentinel cases, detect other cases of exposure in the population and develop and write up community based interventions.

Patients, families, colleagues and students should be informed about mercury hazards and educated.

Health care providers and environmental officers should all become vigorous advocates for the environmental health of children and the future generations.

As professionals with understanding of both health and the environment, we are powerful role models. Our choices will be noticed and they should be thoughtful and sustainable.

Picture: WHO, C. Gaggero. Hospitals Maternity, Americas.

POINTS FOR DISCUSSION

<<NOTE TO USER: Add points for discussion according to the needs of your audience.>>