Notes:

• Please add details of the date, time, place and sponsorship of the meeting for which you are using this presentation in the space indicated.

• This is a large set of slides from which the presenter should select the most relevant ones to use in a specific presentation. These slides cover many facets of the problem. Present only those slides that apply most directly to the local situation in the region.
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.

After this presentation, viewers should understand, recognize and know these learning objectives.

**Learning objectives**

- Recognize health hazards associated with exposure to the three different mercury (Hg) species
- Understand how to diagnose and manage mercury exposure and health disorders attributable to mercury
- Describe public health implications
- Explain how to prevent and reduce exposure

**References:**

Note:
When selecting the slides to include in your presentation, please choose only those of relevance to the region and/or interests of your audience.

- **Introduction & magnitude of the problem:**
  - One element with three species
- **Environmental origin, transport and fate:**
  - Routes of exposure, anthropogenic emissions, populations at risk
  - Artisanal small-scale gold mining, exposure from fish
- **Health effects of exposure**
  - Target organs and systems, neurodevelopmental effects
  - Metallic mercury, methylmercury, Minamata Disease
  - Diagnosis
- **Case studies**
- **Prevention and management of exposure**
  - At home, medical domain, regulatory measures
  - Minamata Convention, Sustainable Development Goals
This section introduces mercury, one element with three species, and its global distribution in the context of children’s environmental health.
Figure:

- © WHO
Figure:
- © WHO
**WHAT IS THE MINAMATA CONVENTION?**

It is an international agreement that aims to protect people and the environment from mercury.

The health sector is working to:

1. Phase out thermometers and blood pressure devices that contain mercury
2. Promote oral health and reduce dental amalgam use
3. Implement strategies to protect small-scale gold miners and other vulnerable groups
4. Monitor mercury exposure and provide health advice

Everyone can contribute:

- Dispose of mercury-containing products safely
- Choose mercury-free products when possible
- World Health Organization

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**Figure:**

- © WHO
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 with most metals, it can exist in different forms.

Because of the complexity of mercury chemistry, it is often easier to discuss each species separately. Each of its 3 forms: elemental (or metallic), inorganic (e.g. mercuric chloride) and organic (e.g. methyl- and ethylmercury), have different toxicity profiles with different implications for children’s health and development. This table summarizes the different sources of mercury, routes of exposure and elimination and main effects. Each type of mercury is toxic to the nervous system, but also a number of other organ systems are affected.

Notes:
- The relative importance of sources and particular species will vary, and so please highlight what is most important in your region.

References:
The populations around the world most at risk from mercury contamination are in South-East Asia, West Africa, and South America, however other parts of Asia, Africa, and Europe are also vulnerable due to mercury pollution from mining and ore processing.

**Figure:**
Hg 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.**

**References:**

Notes:
• Presenters should illustrate the numerous anthropogenic sources of mercury, and highlight the three major sources: ASGM (38%, yellow), fossil fuel and biomass consumption (24%, green), and industry (28%, blue) as 90% of total anthropogenic emissions.
• Presenter should draw attention to their local area and the level and kind of mercury consumption.

Figure:
Between 10 million and 15 million people in 70 countries, including 4 million – 5 million children, are involved in ASGM mining. As part of the gold mining process, elemental mercury is combined with gold in whole ore amalgamation. Large amounts of mercury are used, and most is released as waste. Following, the gold-mercury amalgam is burned to vaporize the mercury, exposing workers and communities to mercury inhalation. Mercury is furthermore released into the environment where it can bioaccumulate into organic mercury.

Mercury exposure in ASGM can be reduced, substituted and eliminated. Exposure reduction includes more effectively concentrating gold with less mercury, separating processing from residential areas, recapturing mercury emitted and using mercury-free processes such as gravity-only concentration.

References:
Notes:
• Presenters should illustrate that ASGM is occurring around the world but highlight their own region, including the extent of mercury releases as well as the number of miners.

Figure:
Eventually, atmospheric mercury from mercury emissions, such as ASGM, ends up in water bodies where it is methylated by bacteria and bioconcentrated up the food chain. Top predators can have concentrations of mercury 10 million times higher than levels in surrounding water. Fish, shellfish and marine mammal consumption is responsible for 75% of methylmercury exposure worldwide.

Cooking does not eliminate mercury from fish. In contrast, concentrations tend to increase with cooking, possibly due to water loss.

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.

Notes:
• Presenters should illustrate the numerous ways mercury enters the environment. Insert the list of local fish which are high in mercury.

Reference:

Figure:
Methylmercury (MeHg) is the major source of body burden in children worldwide, and most exposure is through fish that live in polluted marine or fresh waters, such as those in the paddy field shown on this slide. There are many benefits to eating fish for child neurodevelopment, so it is important to balance these benefits with the risk of mercury exposure.

Not only are children exposed directly by eating contaminated fish, but they can also be exposed 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.

Methylmercury has also been found to accumulate in rice, both from point and diffuse mercury sources. In many parts of Asia, rice is a staple food and can therefore be the major source of mercury exposure. Unlike fish, rice does not have specific micronutrients beneficial to health. This emerging issue requires greater attention so that mercury exposure through rice can be reduced.

References:

Photo:
- Dr. 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.
Notes:
• In addition to bioaccumulating in fish, mercury is present in a number of products that many people use, including thermometers, cosmetics, electronics, fluorescent lamps, and batteries.
• Presenters should include any local products or foodstuffs that may have mercury in them.

Figure:
Skin lightening products are commonly used in some African and Asian countries, as well as by some dark-skinned populations in Europe and North America. Mercury prevents melanin formation, resulting in a lighter skin tone. Mercury is also used in some soaps for antimicrobial and antifungal properties.

Inorganic mercury is used in soaps and creams, while organic mercury is used in eye making cleansers and mascara.

Many skin-lightening products contain mercury in high concentrations that are easily absorbed by the body. This can cause kidney damage, skin damage, anxiety, depression, psychosis and peripheral neuropathy. The mercury in these products also makes its way to wastewater and enters the environment and food chain.

Mercury in products have been banned in many countries but may still be permitted in small quantities or available over the internet. Regulation of mercury content reduces exposure, and product labelling allows consumers to make healthy choices.

References:

Figure:
Children have a special vulnerability to mercury for several reasons.

- They consume more food per unit of body weight relative to adults. Therefore, toxicants that are carried in food are delivered at 2–4 times higher rates in young children than in adults.
- Children metabolize toxicants differently from adults.
- Mercury has severe effects on multiple developing systems in the body, including cardiovascular, neurodevelopmental, and immune. Because children, especially young children, are still developing and growing, they are especially at risk to the effects of mercury.

The most critical period of vulnerability to mercury is prenatal, though vulnerability extends to adolescence.

Small amounts of methylmercury can be transmitted by breast milk, however, this is not sufficient in quantity as to outweigh the benefits of breastfeeding (WHO strongly supports breastfeeding). Once children are eating solid foods, exposure remains potentially dangerous throughout postnatal neurodevelopment.

**Notes:** Insert information specific to your region or locality on the most important sources and paediatric exposures.

**References:**
Mercury exposure in children can be divided into the four major developmental phases: prenatal, infancy, childhood and puberty/adolescence. Prenatal and infant exposures are mostly related to maternal exposures. Childhood exposures are influenced by many factors, including diet, consumer products and setting. When children are employed in child labour, they may be exposed to very high levels of mercury, as discussed on the following slide.

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

Notes: Insert information specific to your region or locality on the most important sources and paediatric exposures.

References:
Both boys and girls take part in ASGM. Most children are pressed into this worst form of child labour due to poverty. Children contribute to ASGM to earn money for their household and when other opportunities, such as school, are lacking. ASGM is often a family activity, with even young children accompanying parents to work. Children in ASGM are not only at physical risk, including to mercury exposure, but also at social risk.

Child labour in the ASGM sector has been reported in Niger, the Democratic Republic of the Congo, Burkina Faso, Sierra Leone, Ghana, Indonesia, Nepal, the Philippines, Mongolia, Tanzania and Zimbabwe.

Children involved in e-waste recycling are also exposed to mercury contained in electronic products. Scavenging, dismantling and burning these products puts the many children involved in e-waste at risk.

References:

Photo:
Thiomersal is a compound containing ethyl mercury, which is different from methyl mercury. Ethyl mercury is an organic form of mercury with a short half-life that is actively excreted via the gut, whereas methyl mercury accumulates in the body. Safe limits have been defined for use of thiomersal in vaccines.

The use of thiomersal in some vaccines prevents bacterial and fungal growth. This is necessary for inactivated vaccines in multi-dose vials, as contaminants may be introduced during repeated use. In many countries, such a preservative is a regulatory requirement. Thiomersal is only used in inactivated vaccines, in which the virus has been killed, and not in live vaccines, because it would kill the immunizing component. It is also used in vaccine production to inactivate certain organisms and toxins and to maintain sterility.

WHO has closely monitored scientific evidence relating to the use of thiomersal as a vaccine preservative for over 10 years, in particular through its independent expert advisory group, the Global Advisory Committee on Vaccine Safety. The Committee has consistently reached the same conclusion: there is no evidence to suggest that the amount of thiomersal used in vaccines poses a health risk. Other expert groups (the U.S. Institute of Medicine, the American Academy of Pediatrics, the United Kingdom Committee on Safety of Medicines, and the European Agency for the Evaluation of Medicinal Products), have reached similar conclusions.

WHO supports continued use of thiomersal as an inactivating agent and preservative for vaccines. The use of multi-dose vials remains the best option for routine immunization programmes in many countries because they are safe and effective, they limit the required storage capacity and waste, and help reduce vaccine costs.

References:


Image:
• © WHO / Heba Farid
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 versus low dose chronic effects.
- **Timing:** prenatal, infancy, childhood or adult.
This figure illustrates general and occupational exposures to Hg that are associated with effects on human health throughout the body. Of note, children and infants are more susceptible to central nervous system damage and to the effect of Hg on neurodevelopment, with early lifetime exposure leading to long-term morbidity.

- MeHg is neurotoxic: the central nervous system is the most sensitive target for elemental mercury vapour.
- Hg may be ototoxic, producing both peripheral and central auditory system damage with chronic Hg exposure able to cause irreversible damage to the auditory cortex.
- Hg may be mutagenic and genotoxic.
- Hg may have multiple cardiovascular effects.
- Hg, particularly organic Hg, is teratogenic, causing Minamata Disease (see slide 26).
- Hg may be nephrotoxic.
- Hg may be immunotoxic.
- Methylmercury has been classified by IARC as a Group 2B carcinogen: possibly carcinogenic to humans. Data linking MeHg to human cancer is limited.

References:

Figure:
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. Clinical features of acrodynia in children include hypertension, sweating, insomnia, hair loss, loose teeth, itching, irritability and apathy.

The top photo on the right side of the slide shows a child who is frequently crying, unhappy, unwilling to walk, hence sitting in the buggy. The bottom photo shows a girl, 2½ years of age, with hypotonia and constant scratching. Notice that she has red lips, fingers, and soles of the feet.

References:

Photos:
  Top: Frequently crying, unhappy, unwilling to walk, hence sitting in the buggy (acrodynia).
  Bottom: 2½ year old girl. Hypotonia, constant scratching, with red fingers, foot soles, lips (acrodynia).
Miliary rash is typical of acrodynia, as seen in these photos of children suffering mercury intoxication from a broken thermometer. Photos shown were taken four months after the incident (left side), and then three weeks later (right). Notice the scaling of the skin between the fingers and the exanthema.

Photos:
Metallic mercury exposure, usually through inhalation, causes several typical symptoms.

- **Airway symptoms**: cough, dyspnoea
- **Skin symptoms**: acrodynia
- **CNS problems**: tremor, ataxia, coordination issues, dysdiadochokinesia
- **PNS problems**: polyneuropathy with sensation difficulties, abnormal reflexes
- **Mercurial erethism**: excitability, memory loss, insomnia, extreme shyness
- **Kidney problems**: proteinuria

Inorganic mercury is nephrotoxic, damaging proximate tubules. Severe cases of inorganic mercury intoxication can overcome the regeneration capacity of tubular cells, leading to reduced kidney function and even acute kidney failure-related death.

**References:**


**Photo:**

- Dr. Stephan Boese-O’Reilly, 2013. Drum mill in Lombok, Indonesia to grind the ore to extract gold from ore with mercury
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 that are crucial to normal cell division and migration. It also binds to and distorts important molecules like DNA and RNA.

Reference:

Figure:
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. Exposure to neurodevelopmental toxicants like methylmercury during these periods of rapid maturation and change can have profound consequences.

References:

Figure:
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 with severe neurological symptoms and birth defects. These included: microcephaly, cerebral palsy, intellectual disability, seizure disorders, paraesthesia, neuralgia, dermatographism, blindness, deafness, and impairment of hearing. Children born with Minamata Disease experienced comas and even death due to prenatal methylmercury exposure.

Information on the Japanese National Institute on Minamata Disease can be found at [http://www.nimd.go.jp/](http://www.nimd.go.jp/).

References:

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

Results from long-term cohort studies suggest that the cardiovascular system is also at risk with decreased heart rate variability as methylmercury exposure increases. One study suggested diastolic blood pressure in boys may be associated with prenatal methylmercury exposure, but the association needs more study.

Health effects of methylmercury are often irreversible.

References:
A 2016 publication examined the economic implications of mercury exposure in 15 developing countries near mercury sources named in the Minamata Convention. There is a 0.18 loss in IQ for every part per million of additional hair mercury. Measuring mercury concentrations in human hair, researchers then calculated increases in intellectual disability, lost Disability-Adjusted Life Years (DALYs) and lost economic productivity in 2010 US dollars. Given that these estimates are only for selected countries, an even larger economic burden could be prevented through implementation of the Minamata Convention.

Moreover, the costs attributed to the neurotoxic effects of methylmercury are not limited to the developing world. A number of analyses conducted over 2005 and 2006 indicated that there are considerable health and financial benefits from restricting Hg exposure in the developed world. At cord blood mercury levels above 5.8 µg/dL, children experience lost IQ. Examining cohorts of hundreds of thousands of American babies, it was found that $8.7 billion in 2000 US dollars were lost every year due to mercury exposure. Removing mercury exposure from electricity generation facilities in the country would save $1.3 billion of that lost economic productivity.

References:
Case studies:
1. Siblings
2. Tatelu (Indonesia) exposed children
3. Tremor mercurialis
Case study 1: Siblings

**Patient 1 history:**
- PC: boy, 7 years of age, was referred for pain in legs, neck and abdomen
- HPC: 2-3kg weight loss, reduced appetite; nil fever, vomiting, diarrhoea
- PMHx: measles, charcoal poisoning
- FHx: sister (patient 2) has abdominal pain. Nil other notable FHx

**Patient 2 history:**
- PC: girl, 13 years of age, was referred with abdominal pain, extremity pain, dermal eruptions
- FHx: brother (patient 1)

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**References:**

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PC = presenting complaint
HPC = history of presenting complaint
PMHx = prior medical history
FHx = family history
HR = heart rate
RR = respiration rate
BP = arterial blood pressure
Temp = temperature
NAD = no abnormality discovered

References:
Investigations

- Full blood counts
- Urinary studies
- Liver and renal function tests
- CRP, ANA, LDH, TFT
- Blood Hg studies
  - Patient 1: 9.3ug/dL
  - Patient 2: 12.8ug/dL

Both patients have developed chronic mercury poisoning as a result of frequent play with mercury containing batteries in the home over a long period of time.

References:

This slide shows results from the UNIDO projects in Indonesia by Boese-O’Reilly S., Drasch G, Rodriguez S., Beinhoff C.

Tatelu is a village in Indonesia (Sulawesi) studied for its ASGM industry. Children worked here as small scale miners with mercury, and no separation was observed between working and housing areas. In the box plot of mercury levels in urine shown here, Tatelu children were divided into three exposure risk groups: control group from non-exposed area with a similar social structure; children living but not working in the exposure area; and children living in the area and working in ASGM. It is clear that mercury levels differed between each group, with the highest levels for child labourers but also significantly elevated levels for children living in the area and not working.

UNIDO: United Nations Industrial Development Organization

References:

Figure:
Dysdiadochokinesia is a clinical symptom of cerebellar damage. This slide shows cerebellar effects in children 8 to 13 years of age divided into the same groups from the previous slide: control group, living but not working in the area, and working in the area. The children in the highest exposure group showed the highest rate of symptoms.

References:
Tremor mercurialis, tremor caused by mercury exposure, is a typical symptom of acute and chronic mercury intoxication. The image shows writing samples from a young girl exposed to mercury developed a tremor, as seen by the progressive deterioration in her handwriting. This exposure was due to contaminated grain, and demonstrates that exposures well after infancy can also have serious consequences.

Figure:
- Dr. Stephan Boese-O’Reilly. 9 year old girl, handwriting example, 1989.

References:
Prevention and management of mercury exposure:
- At home, medical domain, regulatory measures
- Minamata Convention
- Sustainable Development Goals
When mercury is exposed to air, it gives off vapours that, under some circumstances, can build up in indoor air at high enough concentrations to pose health risks to occupants. Air vapours 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, mercury breaks into tiny beads that roll and can easily become trapped in small cracks in the surface. Proper precautions are necessary to protect the health of oneself and one’s family.

**General procedure for spillages:**
- Evacuate and secure the contaminated area. Do not allow children to assist.
- Decontaminate eyes and skin of exposed personnel immediately.
- Limit the spread of the spill (do not walk around in contaminated clothing or shoes)
- Collect all spilled or contaminated material. Ideally, spilt droplets of mercury should be recovered for safe disposal. Never brush or vacuum mercury, to avoid creating smaller droplets and dispersing mercury in air.
- Decontaminate the area. Smooth surfaces can be cleaned but absorbent materials cannot.
- Safely dispose of mercury waste; do not incinerate or pour down drains, to prevent atmospheric pollution and contamination of wastewater. Consult local health and safety authorities on how to safely dispose of mercury waste in your area.

**Reference:**
Immediate management of mercury exposure

- There are no global guidelines on chelation treatment or treatment of Hg toxicity, and so **always check with local treatment protocols**
- Remove person from exposure
- Chelating agents may reduce the body burden of Hg and may improve some symptoms
  - DMPS: simple to use (orally), has few side effects
  - DMPS: effective in ‘mixed’ and ‘combined’ Hg exposures
  - DMSA: may have some advantages in MeHg poisoning
- Symptomatic treatment
- Rehabilitation

Treatment begins with the elimination of exposure. Permanent damage may have already occurred, but ongoing damage may be reduced 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 (This is approved only 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 or health centre!

**References:**
In this summary slide, 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!

References:

Figure:
Examples of common products that may contain mercury include: antiques, electronics, lamps, thermometers, batteries, cosmetics.

Burning coal to produce electricity also releases mercury found in coal. Some households may be able to choose different sources other than coal-burning power plants. Alternative energy sources include: natural gas, nuclear power, wind and solar.

**Note:** These are not WHO guidelines. Further suggestions may be found on the U.S. EPA’s website, as referenced below.

**Reference:**
Prevention is pivotal because the brain has little or no ability to repair, particularly from prenatal damage to basic neuro-architecture. Primary prevention is crucial to prevent mercury releases at the source.

Mercury is used in health care settings in thermometers, sphygmomanometers, cantor tubes, dilators, mercury switches and some button-shaped batteries. Mercury may also be present in dental amalgams. Health care facilities are responsible for up to 5% of mercury contamination in water through wastewater disposal and 10% of historic mercury release in air through incineration.

In the health care settings, providers can:
- Develop safe mercury clean-up, handling and storage procedures. Keep mercury spill kits and train medical staff on how to use them where mercury is present in health care settings.
- Practice environmentally preferable purchasing by reducing unnecessary use of mercury equipment and replacing with mercury-free alternatives.

Health care providers can also encourage mercury-free communities, through thermometer exchange, hazardous waste education and change to high-risk behaviours, such as folk medicines and cottage industries.

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.

Since methylmercury from fish is the major worldwide exposure, counselling mothers on safer fish consumption can help to protect the fetus and young children as a form of secondary prevention.

**Reference:**
Diagnosis of mercury intoxication, particularly if it is chronic and low dose, requires a high index of suspicion. Careful history-taking is necessary to find potential sources of exposure.

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

- Urine mercury is a widely used biomarker for elemental and inorganic exposure.
- Total blood mercury indicates absorbed dose and amount systemically available, though interpretation depends on knowledge of exposure sources. By itself, blood mercury cannot establish magnitude or timing of exposures.
- Hair analysis reflects the cumulative exposure in the last months. Hair grows about 1.25 cm per month and takes three weeks to grow out of the skin. Segmental analysis can provide information about magnitude and timing of past exposure.

References:
Primary prevention - regulation

- Control/reduce Hg release into the environment
- Enforce environmental standards
- Implement standards, actions, and programmes on Hg exposure
- Eradicate child labour with Hg

• Control/reduce 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
• Enforce environmental standards – control of Hg levels in drinking water, surface waters, air, soil and foodstuff – fish
• Implement standards, actions and programmes on Hg exposure - In the workplace, through fish consumption advisories and consumer safety measures.
• Eradicate child labour with mercury - In small scale mining areas and other occupations

These are more systemic approaches to prevention through regulatory measures.

Notes:
• If there are political strategies that are being proposed or developed in your local area, it would be suitable to insert them here.
The Joint FAO/WHO Expert Committee on Food Additives (JECFA) established a provisional tolerable weekly intake for inorganic mercury of 4 μg/kg body weight, applicable to dietary exposure to total mercury from foods other than fish and shellfish. The provisional tolerable weekly intake for methyl mercury is 1.6 μg/kg body weight, applicable to dietary exposure from fish and shellfish.

The Joint FAO/WHO Expert Consultation on the Risks and Benefits of Fish Consumption (WHO risk/benefit analysis) found that neurodevelopmental risks of not eating fish exceed risks of eating fish

- for up to at least seven 100 gram servings per week for all fish containing less than 0.5 μg/g methylmercury; and
- for up to at least two 100 gram servings per week for fish with greater than 1 μg/g methylmercury.

Additionally, the Joint FAO/WHO Food Standards Programme Codex Committee on Contaminants in Food has proposed a maximum limit of 0.3 mg/kg for Albacore tuna and other (than Atlantic and Southern) Bluefin tuna, Bigeye tuna, Alfonsino, Dogfish, Marlin, Shark, and Swordfish.

FAO: Food and Agriculture Organization of the United Nations

References:
US EPA and FDA have made the above fish intake recommendations to balance the nutritional benefits of eating fish with the risks of mercury intake. They recommend eating more fish lower in mercury for women of childbearing age (about 16-49 years of age), pregnant and breastfeeding women, and young children.

Note: This is not a WHO guideline.

References:

Figure:
Levels of fish contamination vary by region, as illustrated by differences between recommendations in the USA and Australia and New Zealand. While USA advice focused on pregnant women and children and suggested avoiding high-mercury fish entirely, Australia and New Zealand advise that fish with higher levels of mercury can be consumed if done so less frequently and without other fish consumption. Australia and New Zealand also contrast recommendations for pregnancy and childhood with recommendations for the rest of the population.

**Note:** This is not a WHO guideline. Check fish consumption advice in your area.

**References:**

**Figure**
- © Food Standards Australia New Zealand.
In Minamata Bay, Japan during the 1950s and 1960s people began experiencing severe neurological symptoms, including seizures and convulsions leading often to coma then death. They were suffering from severe mercury poisoning, later termed Minamata disease, due to high mercury levels in the fish and shellfish they consumed from the bay. Unbeknownst to residents, a nearby factory had been releasing contaminated wastewater into the water.

The infamous disaster drew attention to the issue of environmental mercury exposure and spurred international action. Decades later, Minamata serves as the namesake of the 2013 treaty to protect human health and the environment from the adverse effects of mercury by reducing emissions and controlling releases.

Of note, Article 16 lays out actions that parties may take relating to health:
• Programmes to identify and protect populations at risk
• Guidelines for exposure, targets for exposure reduction
• Education to prevent occupational and public exposure
• Healthcare for prevention and treatment for affected populations
• Strengthen programmes to identify and protect populations at risk

The Minamata Convention on Mercury was adopted in October 2013 and entered into force in August 2017, the first global environmental agreement of the 21st century. As of April 2019, there are 107 parties and 128 signatories to the convention.

The World Health Assembly approved resolution WHA67.11 in 2014: Public health impacts of exposure to mercury and mercury compounds: the role of WHO and ministries of public health in the implementation of the Minamata Convention. The resolution commits WHO to support Member States in implementing the Minamata Convention, including by ratification of the convention, addressing health aspects of mercury exposure and ensuring the safe management of mercury compounds throughout their lifecycle.

References:
• Mori C, Todaka E (2011). Environmental contaminants and children's health: sustainable health science for future...

Image:
• © National Land Image Information (Color Aerial Photographs), Ministry of Land, Infrastructure, Transport and Tourism of Japan
An increased focus on the elimination of mercury as well as the implementation of the Minamata Convention will contribute to the achievement of several SDG Targets (excerpts above, full text below):

- **3.9**: By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution and contamination.
- **6.3**: By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.
- **12.4**: By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment.

**References:**
Acknowledgements for current version

Reviewers: Stephan Boese O’Reilly (Germany), Fiona Goldizen (Australia), Amalia Laborde (Uruguay), Irina Zastenskaya (WHO/EURO), Carolyn Vickers (WHO).

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