Spotlight on mercury in the world of work

Session objectives

At the end of the session, you will be able to:

1. Understand the history of human and environmental mercury exposures.
2. Describe the different forms of mercury.
3. Explain how workers may be exposed to mercury.
4. Identify the main sources of supply and demand of the global mercury trade.
5. Recognize the key sectors of exposure.
6. Know the exposure pathways for different mercury types.
7. Name the main health impacts of mercury exposure.
8. Provide priority actions for mercury at both policy and workplace levels.
9. Apply the knowledge you have gained to different workplace settings.

Introduction

Introduction

Occupational exposure to mercury poses a significant risk to the health of workers around the world.

- Mercury is **toxic** to the nervous, digestive and immune systems, as well as specific organs, such as the liver, heart, brain and skin.
- Even low levels of chronic exposure can result in **severe disability** and **debilitating chronic conditions**, impacting long-term health and well-being.
- Workers in many **different industries** are exposed.
- This **significant burden** for workers, and society as a whole, is entirely preventable.
- Urgent action is needed to **protect workers**, their families and wider communities.

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Question:

Can you think of any disasters in history involving mercury?

History

- ‘**Mad hatter disease**’ in the 18th and 19th centuries.
- Mercury poisoning was recognized as one of the **very first occupational diseases** in the 1925 ILO list of occupational diseases.
- United States Public Heath Service review of mercury use in the **felt hat industry** in the 1930s.
- 1950s **Minamata Bay disaster.**
- Mercury-containing teething powders were withdrawn from the market in the 1950s, after they were linked to acrodynia or ‘**pink disease**’ in infants.

History

- **Widespread mercury poisoning** also occurred in rural Iraq in 1971, when methylmercury contaminated grain was consumed.
- Health impacts of mercury exposure in **chlor-alkali workers** in the 1970s.
- The **Minamata Convention on Mercury** was adopted in October 2013 and entered into force in August 2017.
- The ILO has supported the implementation of the Convention through the promotion of ILO international instruments, including the **Chemicals Convention, 1990 (No. 170)**, project work at the country level, and production of global codes of practice, research reports and working papers.

Progress so far

- Use is **decreasing in some industries** (e.g. chlor-alkali production),
- However, workers continue to be exposed in **numerous settings**.
- Workers in **informal settings**, with minimal social protection, are particularly at risk.
- To achieve the goals of the Minamata Convention and ILO Convention No. 170, specifically the total elimination of mercury in the world of work, a '**toxics use reduction**' approach is crucial.
- Protecting workers and their communities from the risks of mercury will contribute towards achieving the **Sustainable Development Goals.**

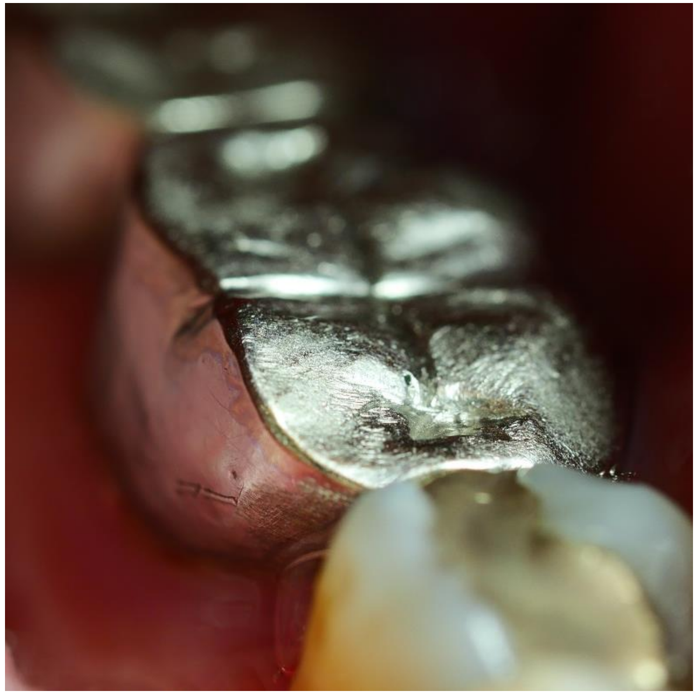
SDG 8:
"Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all."

What is mercury (Hg)?

- Mercury is a **naturally-occurring** chemical element
- Found in rock in the earth's crust, including in deposits of coal.
- Released from both **natural** and **anthropogenic sources**.
- Mercury can stay up to a year in the atmosphere, where it can be **transported and deposited globally**.
- A **persistent toxic substance**.
- **Widely used** due to its physical and chemical properties, including water insolubility, electrical conductivity and ability to form alloys.
- There are three types of mercury: **Elemental mercury**, **inorganic mercury** and **organic mercury.**

Elemental mercury

- A **silver-white liquid** (quicksilver), primarily obtained from the refining of mercuric sulphide in cinnabar ore.
- Used in many **products**, including electrical equipment, fluorescent light bulbs, thermometers, sphygmomanometers and barometers.
- It is also used in **industrial processes** and is released into the air when coal and other **fossil fuels are burnt**.
- Mercury is a liquid at room temperature and vaporizes readily into a **mercury vapour**, **an odourless toxic gas**.
- Vapours may be present in locations such as dental offices, smelting operations and locations where mercury is spilled or released as a by-product into the air.



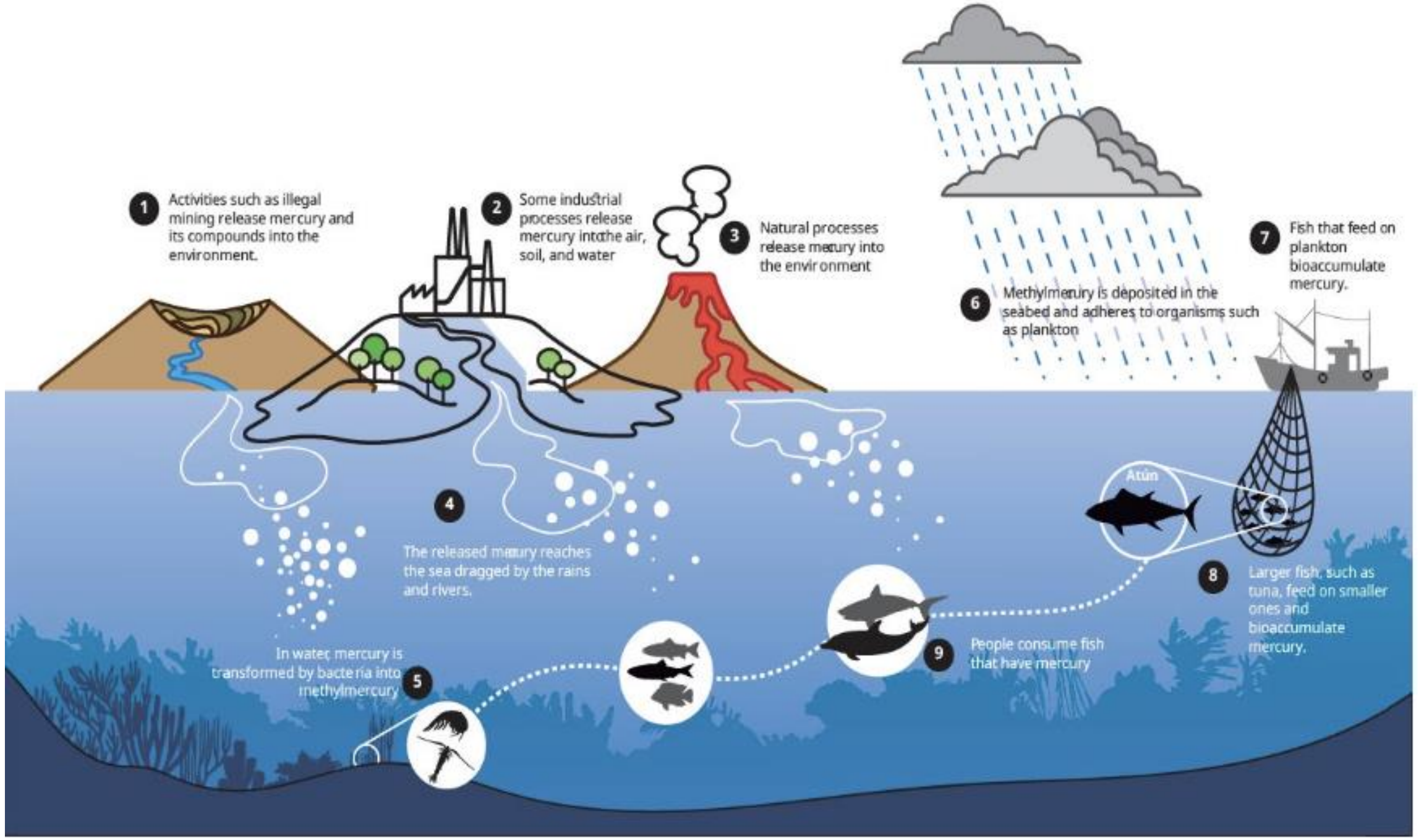
Inorganic mercury compounds

- Also known as **mercury salts**.
- Formed when mercury combines with other elements such as chlorine, sulphur or oxygen.
- Used in the production of **batteries**, **vinyl chloride monomer (VCM) production** and pigments, as well as **skin-lightening products** *(ATSDR 1999)*.
- Mercury salts are **highly toxic** and **corrosive**.
- Workers may be exposed if inorganic mercury compounds are used in their place of work.

Organic mercury compounds

- Created when **mercury combines with carbon**, either through the **action of bacteria** or via **manmade processes**.
- The most common, **methylmercury**, is formed when mercury settled in lakes and rivers is transformed by bacteria into methylmercury.
- This highly toxic compound **accumulates in living organisms**, such as phytoplankton, zooplankton and fish.
- People are mainly exposed through the consumption of **contaminated fish and shellfish**.
- Organic mercury compounds may also be manmade, for example, dimethylmercury, which is used in **fungicides and insecticides**, and phenylmercury, found in **paints and cosmetics**.

Bioaccumulation of mercury from anthropogenic and natural sources



(*Source: Martinez 2020*)

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The global mercury trade

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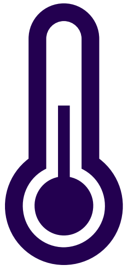
Question:

Can you think of any products which contain mercury? Or any industry which uses mercury in a process?



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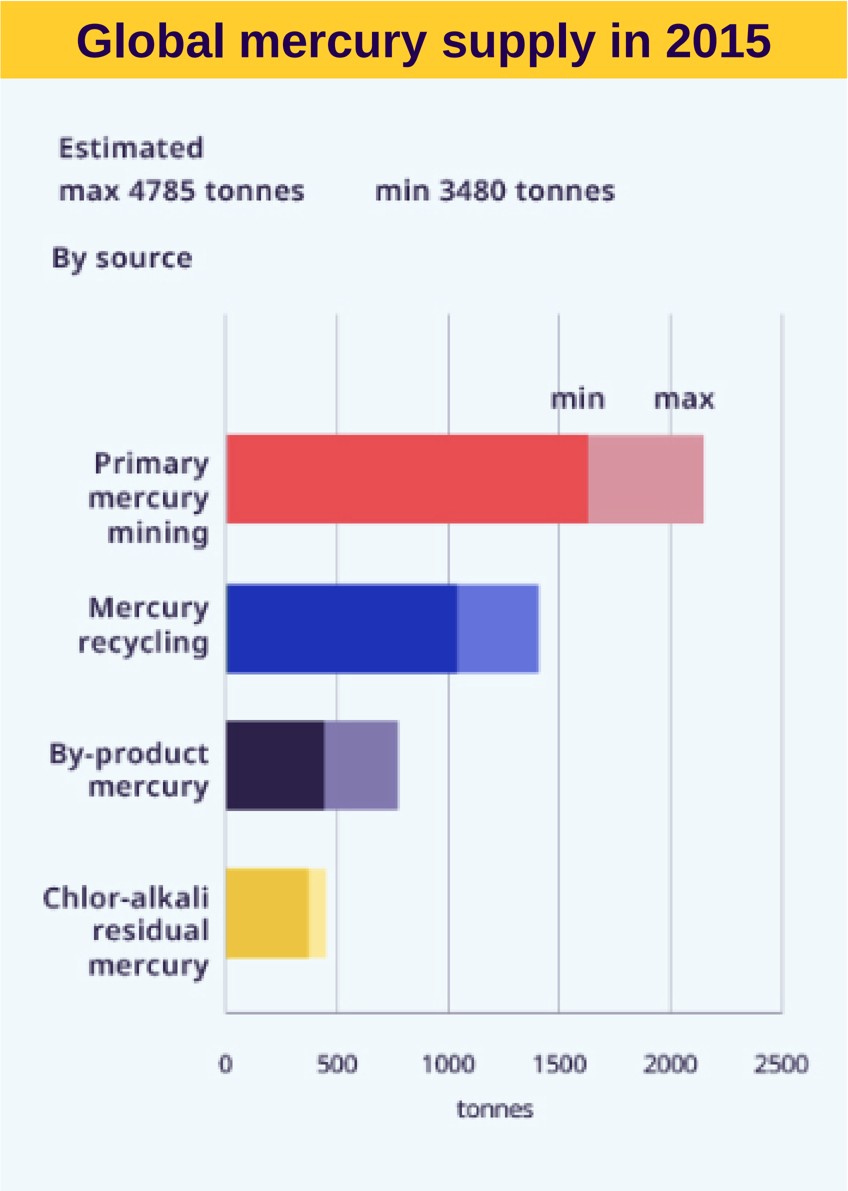
Mercury in the workplace

Production processes *(Mercury is either used in the process or released as a by-product)*	• ASGM • Primary mercury mining • Other non-ferrous ore mining • Vinyl chloride monomer (VCM) production • Chlor-alkali production	• Acetealdehyde production • Coal-fired power plants • Oil and natural gas processing • Electroplating Paper manufacturing	• Silver and gold production • Taxidermy • Chemical laboratory processes • Photography • Construction
Products *(Workers may be exposed when handling mercury-containing products during all stages of the product life cycle*	• Thermometers • Barometers • Batteries • Calibration instruments • Disinfectants • Semi-conductor cells Explosives	• Dental amalgams Fluorescent lamps • Neon lamps • Paints • E-waste • Mirrors	• Antiseptics • Bactericidals/ fungicides • Cosmetics (e.g. skin lightening creams, eye make-up) • Tattooing inks • Laundry products

The global mercury trade

Mercury supply

- Five main mercury supply sources *(UNEP 2017)*:
  - Primary mercury mining of cinnabar ore
  - Recycling of mercury-added products
  - By-product mercury recovery from non-ferrous metal mining or oil and gas processing
  - Decommissioning of mercury-cell chlor-alkali facilities
  - Net change in government or private
  - stocks of mercury



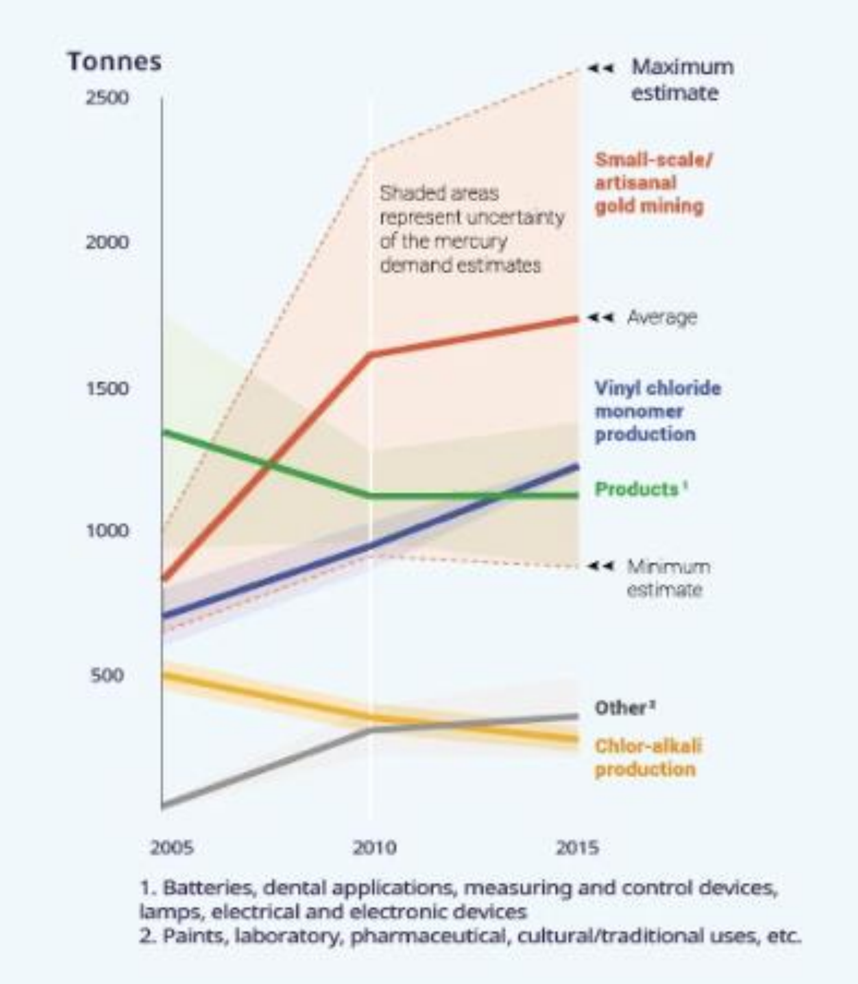
(Source: UNEP 2017)

The global mercury trade

Mercury demand and consumption

- The major mercury users continue to be in ASGM (mainly in Africa, Asia and Latin America) and for VCM production (primarily in China), accounting for over 60 per cent of global mercury consumption *(UNEP 2017)*.
- The use of mercury in the chlor-alkali industry has declined significantly.
- Mercury use in most product categories has similarly decreased, due to regulation, increased knowledge of environmental impacts and the provision of mercury-free alternatives.
- The use of some mercury-containing products continues to rise, including measuring and control devices and lamps.

Mercury demand by sector



(Source: UNEP 2017)

The global mercury trade

Mercury demand and consumption

- East and Southeast Asia regions predominate in overall mercury consumption, particularly in ASGM, VCM production, batteries and measuring and control devices.
- Consumption in Sub-Saharan Africa and South and Central America has also grown, although declines are seen in other global regions.
- Demand for mercury continues to be high in China, the main country using mercury for VCM production and also a major manufacturer of many mercury-containing products *(UNEP 2017)*.

Key sectors of exposure

An overview of the key sectors of exposure

- Artisanal and small-scale gold mining (ASGM).
- Other mining industries.
- Healthcare (mercury-containing products, medical waste and dental amalgam).
- Industrial production (VCM production, chlor-alkali sector and others).
- Products (e-waste, batteries, cosmetics, textiles and others).

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Mining

- Numerous mine workers around the world are exposed to harmful levels of mercury.
- The main sector of exposure is ASGM.
- Miners may also be exposed in:
  - Primary mercury mining
  - The mining of non-ferrous ores
  - Oil and gas processing

ASGM

ASGM continues to be the largest user of mercury globally, with an estimated 14-19 million people working in the industry, in 70 countries *(Steckling et al. 2017)*.

- Approximately **4.5 million of these workers are women** and **600,000 are children** *(UNEP 2019)*.
- ASGM largely occurs in **LMIC**, primarily in East and South-East Asia, Sub-Saharan Africa and South America, which account for the **great majority of the burden of occupational exposure to mercury** *(UNEP 2017)*.
- The extent of ASGM has **steadily increased** since the year 2000 and shows no sign of falling off, as long as the **price of gold remains high** *(UNEP 2017)*.

ASGM as a livelihood

Millions of people in the developing world depend on ASGM for their livelihoods.

- Associated with **poor working conditions**, **hazardous child labour**, **mercury emissions** and **environmental destruction** *(ILO 2019)*.
- Workers often have **limited training** and **low literacy rates** *(WHO 2016)*.
- The work is frequently informal, with conditions unsupervised by authorities.
- However, ASGM can represent an **economic opportunity** for communities where alternative livelihoods are scarce or where people are employed in seasonal work *(Haundi et al. 2021)*.
- Notably, the industry has the potential to **alleviate poverty** in rural populations and contribute to **economic development** *(Neumann et al. 2019)*.

Gold extraction with mercury in ASGM

Most commonly used extraction method in ASGM, because it is cheap, quick and easy and can done by one person independently *(UNEP 2012)*.

- One of four **populations of concern** for mercury exposures *(Basu et al. 2018)*.
- Most direct exposure route is via **inhalation of mercury vapour** from heated amalgam e.g during burning or smelting *(WHO 2016)*.
- Even workers not directly handling mercury can be exposed *(Gibb and O'Leary 2014)*.
- Workers can also be exposed to elemental mercury vapour if liquid mercury is **not properly stored**, **surfaces are soiled** or they are in contact with **contaminated waste material** *(WHO 2016)*.

Mercury vapours in the air around amalgam burning sites can be alarmingly high and usually exceed the WHO limit for public exposure of 1.0 µg/m^3 *(UNEP 2012)*

Work tasks and exposures vary by gender and age

ASGM demographics vary considerably, with people of all ages working on different mining tasks.

- Men work primarily in mines and are also involved in decisions regarding **mining exploration**, **prospecting** and **benefits distribution** *(Eftimie et al. 2012)*.
- Although often excluded from underground extraction, women participate in a variety of tasks, including amalgamation *(ILO 2007)*.
- Almost all work performed by children in ASGM is hazardous and has characteristics that fit the definition of a **"worst form of child labour"** *(ILO 2015)*.
- **Children are involved in all stages of ASGM**, including ore extraction, processing and burning, as well as running errands, carrying equipment and delivering food and water to miners *(WHO 2016)*.

Using biological matrices to measure mercury exposure

- **Biological matrices using urine, blood and hair** can be used to measure mercury exposure.
- Urinary mercury can be **hugely elevated** for those involved in both **amalgamation** and **heating/burning** processes.
- For example, studies report urinary mercury concentrations well above:
  - **50 µg mercury/g-creatinine**, where renal tubular effects are believed to occur, and
  - **100 µg mercury/g-creatinine**, where the probability of developing the classical neurological signs of mercury intoxication is "high" *(WHO 2013)*.

Case study: ASGM communities in Colombia

- A study of 238 ASGM miners in Colombia assessed total mercury in blood, urine and hair samples, as well as methylmercury in hair.
- Approximately 40 per cent of miners showed mercury concentrations in blood, urine and/or hair **above WHO thresholds**.
- Miners burning amalgams showed significantly higher concentrations than miners not involved in this process, with values 7-, 7- and 8-fold higher in blood, urine and hair respectively *(Calao-Ramos et al. 2021)*.

Other mining sectors involving mercury

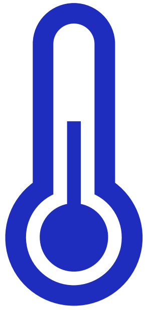
Aside from ASGM, workers in other mining industries may also be exposed to mercury. These include:

- **Primary mercury mining**:
  - Only mined in China, Mexico, Indonesia and the Kyrgyz Republic, with China being the largest producer *(UNEP 2017)*.
  - Both China and Mexico have ratified the Minamata Convention, so all existing mines are to be phased out.
- **Non-ferrous ores**:
  - Mercury may appear as a trace contaminant in other non-ferrous ores (e.g. zinc, gold, lead and copper) and is produced as a by-product in non-ferrous mining operations.
  - This mercury goes to disposal or is released into the environment *(AMAP/UNEP 2013)*.
- **Oil and natural gas**:
  - Crude oil and natural gas often contain trace quantities of mercury, which is released during extraction and refining.
  - The biggest risk to workers is during plant shutdowns or maintenance work.

Healthcare

The healthcare sector employs a sizeable number of workers in many regions, particularly in developing countries.

- Healthcare workers may be exposed to mercury when **handling broken mercury-containing devices**, such as thermometers.
- During the **disposal of medical waste**.
- When performing certain procedures, for example during **dental treatments**.



Measuring and control devices

Mercury is contained in many different measuring and control devices used in healthcare, including thermometers, oesophageal dilators, feeding tubes, sphygmomanometers and gastrointestinal tubes.

- Sphygmomanometers contain the most mercury (80 to 100g/ unit), and their widespread use make them one of the largest mercury reservoirs in the healthcare setting *(WHO 2005)*.
- Although mercury-free alternatives exist, production of mercury-containing devices continues, for example China.
- A variety of studies have shown that mercury-containing healthcare equipment will invariably break leading to mercury spills.
- Spills of even small amounts of elemental mercury, for example from breakage of thermometers, can contaminate air and lead to serious health consequences.

Measuring and control devices

- **Accidental spills** can also occur when **broken devices** are repaired or during sterilization and centrifugation in maintenance areas *(OSHA n.d.)*.
- Mercury may **accumulate on surfaces** and settle into cracks or cling to porous materials, like carpet and fabric.
- Spilled mercury can be **tracked on footwear**, exposing other healthcare staff.
- **Inadequate cleaning** may expose healthcare staff to potentially dangerous mercury vapours or dermal exposures *(OSHA n.d.)*.
- Non-mercury alternatives have been found to be as **cost-effective** and **accurate** as products containing mercury *(WHO 2005)*.

One survey in Buenos Aires found that more than 40,000 thermometers were lost per year in 33 hospitals and 38 clinics, mostly due to breakage, and in Mexico one hospital broke an average of 385 thermometers per month *(Karliner et al. 2008)*

Medical waste

- Aside from spillages, workers in the healthcare sector may also be exposed to mercury during the **disposal of hazardous waste**.
- This can include **broken clinical equipment**, **dentistry products** and also **batteries**, particularly small button batteries *(WHO 2014)*.
- Workers in **many different facilities** may be exposed, including hospitals, outpatient clinics, prisons, military medical centres, laboratories and research centres, mortuaries, blood banks and nursing homes *(WHO 2014)*.
- Many healthcare facilities have adopted a policy of **gradual replacement** with mercury-free alternatives, but in numerous places mercury-containing devices are still widely used.

Dental amalgam

Due to its low price and durability, dental fillings using mercury continue to be widely used globally, especially in developing countries.

- Dental amalgam is a potentially significant source of release, as it can contain up to **50 per cent elemental mercury**.
- Dental workers may be at risk of mercury exposure when **placing mercury fillings**, **removing teeth** containing filling and **disposing of mercury waste** *(Al-Zubaidi and Rabee 2017)*.
- Urinary mercury concentrations in dentists have been found to be **over four times** that of control subjects *(Ritchie et al. 2002)*.
- Mercury vapour concentrations in the indoor air of some dental clinics have **exceeded OSHA short-term exposure limits** *(Al-Zubaidi and Rabee 2017)*.

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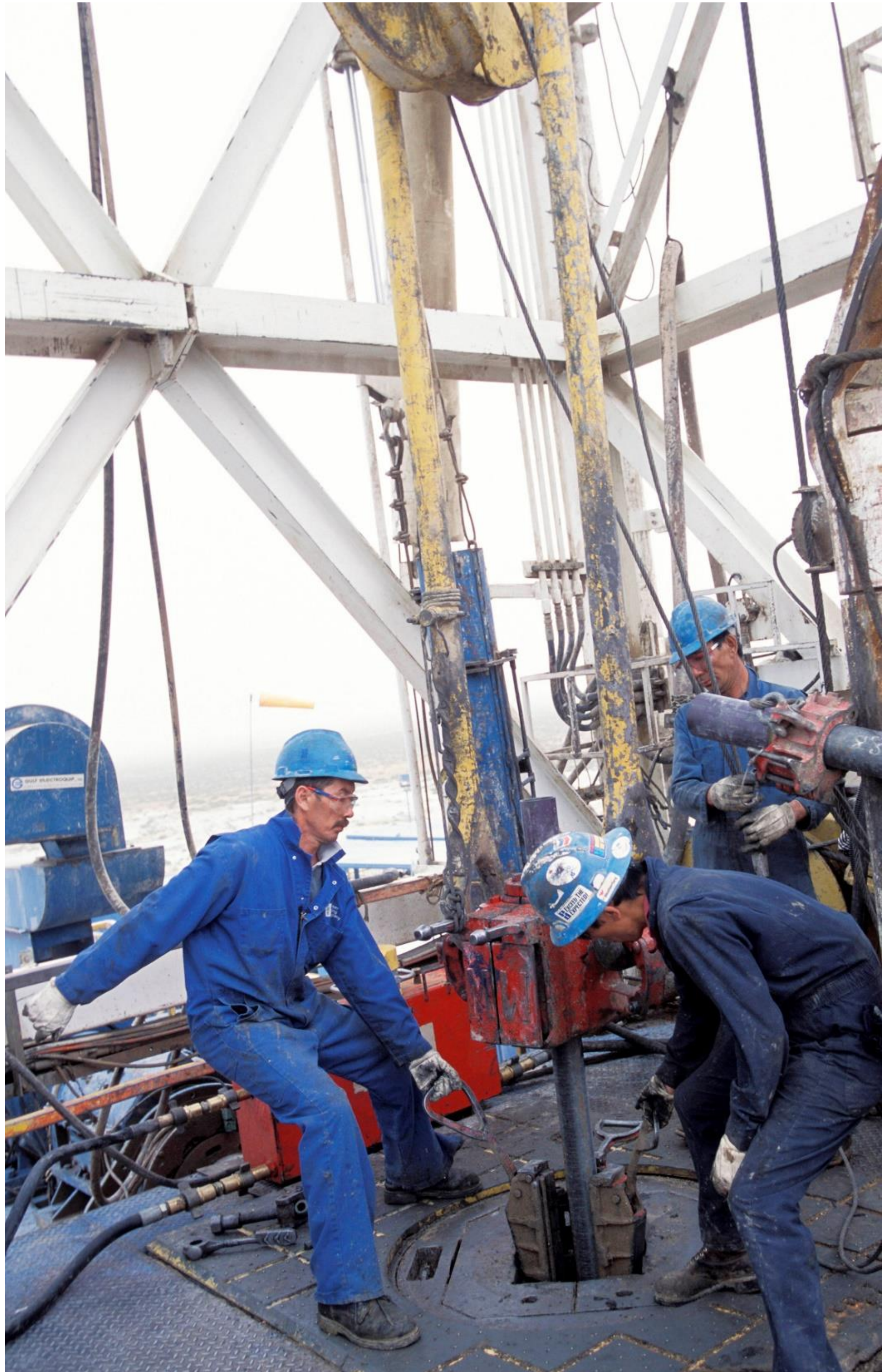
Industrial production

- Industrial use of mercury in production processes can result in occupational mercury exposure for workers.
- Populations living near industrial sites can also be exposed.
- Workers in different sectors are exposed to mercury, either when mercury is **used in the process** or when it is **released as a by-product**.
- Sectors include: VCM, chlor-alkali, acetaldehyde, coal-fired plants, manufacturing and construction.



Vinyl chloride monomer (VCM)

- Mainly used to **produce PVC**, the global demand for which has grown rapidly, particularly in developing countries.
- The **second largest mercury user after ASGM** *(UNEP 2017)*.
- It is of particular concern, as it is not known how much mercury is released and in what form *(Hui et al. 2017)*.
- Concerns also exist regarding the **management of mercury waste streams**, including the spent catalyst and activated carbon filters.
- Although production has been **phased out in most countries**, production in China is at an **all-time high**, with limited production also in India and Russia (*(UNEP 2017)*.

Chlor-alkali sector

- Manufacturing process to produce **chlorine** and **caustic soda**.
- **Mercury waste** generated during this process, is **released into the environment** or **recycled**.
- Many facilities have been converted to **mercury-free processes** or replaced by **new mercury-free facilities**.
- The intent of the Minamata Convention is for all chlor-alkali production to be **mercury-free** and at the end of 2015, **72 plants in 40 countries** remained *(UNEP 2017)*.
- Exposures are by breathing air **polluted with mercury vapours** or **direct skin contact** *(Shirkhanloo et al. 2014)*.
- One study of a chlor-alkali petrochemical industry in Iran found that chlor-alkali workers had considerably **higher concentrations of mercury in blood and urine samples** than unexposed controls *(Shirkhanloo et al. 2014)*.

Other industrial processes

- **Acetaldehyde production**
  - The process, using mercury-sulphate as a catalyst, has **almost entirely been abandonned**, following the Minamata Bay disaster.
  - A limited number of companies in the world still use the technology, however **alternative, non-mercury processes** are now common globally.
- **Construction**
  - Workers may be exposed at **contaminated sites** and during the installation, removal and disposal of mercury-containing devices.
- **Coal-fired power plants**
  - Mercury occurs naturally in the earth's crust, which leads to coal being contaminated by mercury and the potential for occupational exposure in coal-fired power plants *(IPEN 2014)*.

Case study: Ship industries in Pakistan

- Those in the shipbuilding, ship repair and ship recycling industries may face significant risks.
- For example, Pakistani workers were recently poisoned during the scrapping of a mercury-laden tanker.
- Hazardous chemicals were found in the ship's steel structures, ballast waters, oil slops and oil sludge *(Hellenic Shipping News 2021)*.

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Products

- **Numerous products** still contain mercury or are **manufactured** using mercury.
- Workers may be exposed during different stages of the **product life-cycle**, including production, handling and use, and recycling.
- Sectors of exposure include e-waste, lamps, batteries, cosmetics, textiles, gilded crafts and religious idols, pesticides, paints and nanotechnology.

E-waste

- Mercury is a **component of different types of e-waste**, including thermostats, sensors, monitors, cells, printed circuit boards and cold cathode fluorescent lamps *(Grant et al. 2013)*.
- The production and use of electronics is **rapidly expanding** and the amount of e-waste is expected to increase to 111 million tonnes by 2050 *(Parajuly et al. 2019)*.
- Waste management and recycling provides employment for **19 to 24 million women and men worldwide**, of which only four million work in the formal waste and recycling sector *(ILO 2013)*.
- Informal recycling activity may involve manual disassembly, the use of instruments, such as hammers, to separate components and **acid baths** for the recovery of gold and other metals.
- Workers have **limited access to health surveillance**, **medical monitoring** or **PPE**.
- In many countries, **women and children** play dominant occupational roles in e-waste.

Compact fluorescent lamps (CFLs)

- CFLs are **75 per cent more energy efficient** than incandescent light bulbs and have a **greater useable lifespan** *(Bose-O'Reilly et al. 2010)***.**
- However, they contain **substantial mercury concentrations**.
- Workers handling these products are at high risk of mercury exposure due to **product breakages** and subsequent **mercury vapour release** *(Bose-O'Reilly et al. 2010)***.**
- Lamps may be broken accidentally during production, shipping, retail sales or purposefully during recycling *(Raposo et al. 2003)*.
- It was reported that **33 per cent of mercury** is released from bulbs in the first 8 hours after breakage *(Johnson et al. 2008)*.
- Mercury-free alternatives are often **expensive** and **availability may be limited** in some locations.

Batteries

- The use of mercury in various types of batteries has been extensive and it has been **among the largest product uses of mercury**.
- Globally, however, the use of mercury in batteries is in **decline**.
- Mercury has mainly been used in **non-rechargeable batteries**.
- Workers in **battery production factories** and those involved in **recycling** are at risk of occupational mercury exposure.
- For instance, **high urinary mercury levels** has been reported in alkaline battery recycling workers *(Reh et al. 2001)*.
- China is the major producer. Other large exporters include Belgium, Indonesia, Singapore and the United States *(UNEP 2017)*.

Cosmetics

- Inorganic mercury is used in cosmetics products in **significant amounts**, including skin lightening creams, anti-aging products, acne treatments, soaps and eye make-up.
- Many countries have **banned mercury-containing skin-lightening products**, because they are hazardous to human health *(WHO 2019)*.
- However, the skin lightening industry is one of the **fastest growing beauty industries worldwide** and is estimated to be worth **US$ 31.2 billion by 2024** *(Shroff et al. 2018)*.
- Various studies have found that mercury content of skin-lightening creams can be at levels which are hazardous to human health *(EEB 2018)*.
- It is possible that workers in cosmetics factories around the world are at risk, however **minimal evidence exists for this sector**.

Textiles

- Workers in the textile industry may be exposed to hazardous levels of mercury, as many dyes contain mercury *(UNEP 2020)*.
- There are approximately **80 million garment workers globally**, 75 per cent of which are in the **Asia-Pacific region** *(ILO 2020)*.
- Women constitute more than **80 percent of the workforce** in the textiles, clothing, leather and footwear industry *(ILO 2019a)*.
- Many of these are young women, which raises concerns about their **reproductive health** and the impacts of mercury exposures on **future generations** *(ILO 2019b)*.
- The use of mercury in textiles has been restricted in some regions, for example in the EU, but remains a **global concern**.

Other products

- **Gilded crafts and religious idols**
  - Mercury is used in gold plating processes in the production of religious idols.
- **Agricultural workers using pesticides**
  - Although mercury-containing pesticides have been banned in most countries, stockpiles are likely to exist and controlling usage is problematic.
- **Nanoparticles**
  - Selected nanoparticles are used to initiate reactions or enable functions unachievable by the larger chemical form *(UNEP 2017)*. The effects of nanomercury specifically on health are unknown, due to its unique exposure potential, biological uptake and toxicity (*ECOS 2012*).
- **Paints and varnishes**
  - Phenyl mercuric acetate (PMA) and similar mercury compounds were formerly widely added as biocide to water-based paints and may still be used in some countries.

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Case study: Gold plating of metal statues

- The gold plating of metal statues, also known as **mercury gilding**, is a centuries old practice using gold-mercury amalgam.
- More than **4,000 people**, **primarily from one ethnic community in Nepal**, are involved in this work.
- Workers are exposed during all stages of the gold plating process.
- Gold plating is the **highest source of mercury emissions** in Nepal.
- Biomonitoring of 20 female metal plating workers revealed hair mercury concentrations **similar to those of ASGM workers** using mercury amalgam *(IPEN 2017)*.

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Exposure pathways and health impacts

Exposure pathways

Inhalation	▶ **Inhalation of elemental mercury vapour** is the main source of occupational exposure *(WHO 2017).* ▶ Another common exposure to metallic mercury occurs when mercury is released from a mercury-containing product that **breaks**. ▶ **Poorly ventilated, warm, indoor spaces** are of particular concern in cases of airborne mercury vapours.
Dermal absorption	▶ Dermal absorption may occur if mercury is **handled inappropriately** or if it is **spilled** and not cleaned properly.
Ingestion	▶ The primary source of exposure to organic mercury for most populations is the consumption of **methylmercury-contaminated fish** and shellfish. ▶ Ingestion of mercury in the workplace may occur when **hygiene standards are limited**, for example from **unwashed hands**.

Pathways through the body for different mercury types

	Absorption	Pathways through body
Elemental mercury	▸ Inhalation is the main route of exposure. Approximately 80% of inhaled mercury vapour is absorbed in the lungs. ▸ Dermal absorption is limited. ▸ Oral ingestion results only in a very limited absorption (<0.01% of dose).	▸ High lipid solubility, therefore rapidly penetrates alveolar membranes and is distributed around the body. ▸ Primary target organs are the kidneys, brain and nervous system. ▸ Can cross blood-brain barrier and blood-placenta barrier.
Inorganic mercury	▸ Ingestion is the main exposure route ▸ Approximately 7% to 15% of doses absorbed in the gastrointestinal tract. ▸ Mercury intoxication symptoms have been reported for dermal absorption.	▸ Highest concentration found in the kidney. ▸ Not lipid soluble, so is unable to cross the blood-brain barrier.
Organic mercury	▸ May be absorbed though dermal contact. ▸ Ingestion of methylmercury from fish consumption is the main exposure route. ▸ Most of an oral dose of methylmercury is absorbed from the gastrointestinal tract.	▸ Organic mercury is rapidly and evenly distributed throughout the body. ▸ Major target is the central nervous system.

Health impacts

- Exposure to mercury, even in small amounts, may adversely impact the nervous, digestive and immune systems, as well as specific organs, such as the liver, heart, brain, lungs, kidneys, skin and eyes *(WHO 2021)*.
- Exposure to different types of mercury will produce different adverse health impacts.

Health impacts

Elemental mercury

- Harms the nervous, digestive and immune systems, heart, lungs and kidneys *(WHO 2017)*. High inhalational exposures can lead to respiratory failure and death *(Landrigan and Etzel 2013)*.
- The central nervous system is the most sensitive target for elemental mercury exposure.

Inorganic mercury

- The kidney is the critical target organ, with chronic oral exposure resulting in renal damage.
- Also, gastrointestinal disturbances, skin rashes, eye irritation and muscle weakness.

Organic mercury

- Impacts the central nervous system the most.
- Pregnant women and their foetuses are particularly at risk and transplacental exposure may result in neurodevelopmental problems in the developing foetus *(WHO 2021)*.

Mercury: Vulnerable worker groups

- **Females** are at **high risk during child-bearing years** and **pregnancy**. Mercury can cross the placental barrier to cause **irreversible neurodevelopmental** damage to the foetus.
- **Children** are especially vulnerable due to their **developing physiology**, **anatomy**, **metabolism and health behaviours**. Exposure to very high mercury levels can cause **irreversible damage to children's brain function**, including attention span, language, visual-spatial skills, and coordination.
- **Migrants** may not speak the local language, making it difficult to understand chemical labels, safe handling procedures and training materials.
- **People with disabilities** face **unique risks** depending on their disability.

Evidence from ASGM

- Between **25 and 33 per cent of miners** are estimated to suffer from **chronic metallic mercury vapour intoxication (CMMVI)** *(Steckling et al. 2017)*.
- ASGM workers frequently have urinary mercury concentrations **above the WHO threshold**, beyond which there is a high probability of developing classic neurological signs of mercury poisoning.
- **Global burden of mercury exposure for ASGM alone was estimated to be over 19 million** *(Steckling et al. 2017)*.
- The Global Burden of Disease (GBD) from ASGM alone was estimated to be over **2 million disability-adjusted life years** (DALYs) *(Steckling et al. 2017)*.

Case studies: Urinary mercury concentrations

The WHO considers urinary mercury concentrations of 100 µg Hg/g creatinine as the threshold beyond which there is a high probability of developing classic neurological signs of mercury poisoning.

- Numerous studies have shown concentrations of well above 100 µg Hg/g creatinine, with concentrations particularly high for those making the mercury-ore mixture or heating amalgam *(Harari et al. 2012)*.
- Examples of high concentrations in urine observed in ASGM include a study conducted in Burkina Faso, which showed average urinary mercury among gold traders of 299.1 µg Hg/g creatinine.
- Another in Venezuela found the average urinary Hg concentration was 148 µg Hg/g creatinine, with the highest recorded at 912 µg Hg/g creatinine *(Drake et al. 2001)*.
- Gold dealers are also thought to be frequently exposed to mercury vapour *(Tomicic et al. 2011)*.


New Publication:
Diagnosis and exposure criteria for occupational diseases

Diagnostic and exposure criteria for occupational diseases

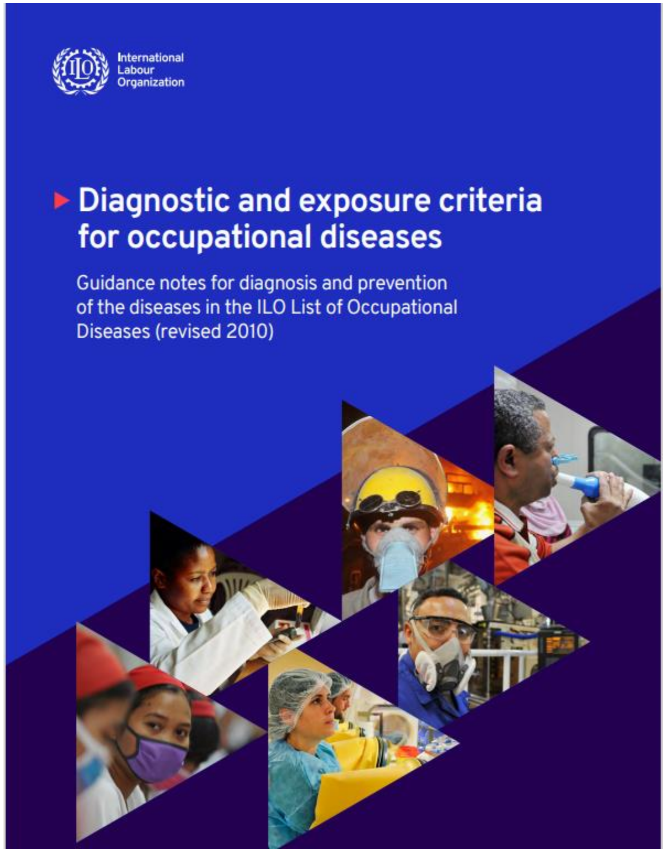
ILO List of Occupational Diseases (revised 2010)

- Covers exposure and diagnostic criteria for more than 40 chemical agents (e.g. mercury, lead and pesticides)

Guidance notes were prepared for each type or group of disease items specified in the 2010 ILO List, according to the following structure:

- General characteristics of the causal agent
- Occupational exposures
- Toxicological profile (for chemical agents) or biological mechanisms (for physical and biological agents), main health effects and diagnostic criteria
- Key actions for prevention

Full report available here.



Diseases caused by mercury or its compounds

1.1.7 Diseases caused by mercury or its compounds	ICD Code T56.1 +Z57
General characteristics of the causal agent	Mercury (Hg), CAS number 7439-97-6, is the chemical element with atomic number 80 in the periodic table of elements and is classified in Group 17 (II-B; Transition metals). Mercury is poly-isotopic with natural isotopes between ^{196}Hg and ^{204}Hg (the most abundant, at 30%, is ^{202}Hg), and its mean atomic mass is 200.56 Da. Under ambient temperature and pressure conditions, mercury is the only metallic element in liquid form with a high specific gravity (13.59 at 20°C); in addition, it vaporises slowly even at ambient temperature and boils at 356.73°C. Liquid mercury is silver-grey, shiny and mobile, has a high surface tension (which leads to the formation of tiny droplets) and a high expansion coefficient with temperature. In the elemental state, mercury is sparingly soluble in water and oily solvents, and forms inter-metallic alloys (*amalgams*) with other pure elements, among which several are of technological importance. Mercury has a positive electrochemical reduction potential in water and features oxidation numbers I (only as Hg_2^{2+}) and II, which is stable in aqueous solution over the entire range of acidity. Mercury (II) has a specific strong chemical affinity with sulphur, selenium and tellurium (*chalcogen*), a property that has important biological and environmental consequences. Mercury occurs in the natural environment in the form of the free liquid metal in cinnabar sands, although it also occurs as inorganic salts and as organic compounds of biogenic origin. The main industrial source of mercury is cinnabar ore (HgS), which is localized in exploitable quantity and concentration only in some regions, e.g. Spain, central Italy, some areas of China and of Andean South America. Recycled mercury is recovered from heating scrapped mercury-containing products and wastes. Inorganic compounds of mercury of practical relevance are mainly those of mercury (II) and include oxide, sulphate and nitrate. Of the two chlorides, that of mercury (I) (Hg_2Cl_2) is also known as calomel, is poorly soluble in water and historically was used as a bactericidal and purgative. Mercury (II) chloride ($HgCl_2$) is an easily sublimating white solid (corrosive sublimate) with a high solubility in water, where it forms very stable tetrahedral coordination complexes with chloride (e.g. $HgCl_4^{2-}$, which is one of the main chemical forms of mercury in extracellular biological fluids). Some organic compounds of mercury are found in the natural environment and are important in the bio-geochemical cycling of the element: these are the volatile di-methyl mercury, which is produced by some micro-organisms, and the water and lipid-soluble mono-methyl mercury, which is an important mercury species for its toxicological role. Biotransformation of inorganic mercury compounds to methyl mercury when in contact with water and soil explains why high concentrations of organic mercury can be found in fish and other sea organisms. Aryl-mercury compounds, such as phenyl-mercury, are of human synthetic origin.

Occupational exposures	Prehistoric man used mercury compounds as evidenced by the cinnabar red pigments present in cave paintings and in burials. Since ancient historical times, mercury has been extensively employed in the extraction of metallic gold from low-grade ores, in the process of amalgamation. The extensive use of this highly polluting technology in Andean South America, starting in the 16th century, has caused extensive pollution. An even larger release of mercury into the atmosphere started in the 19th century, with the use of mined coal, not only for combustion but increasingly as a starting material in the chemical industry. This is still the largest individual source of environmental mercury. Due to the health hazards presented by mercury, in recent years, many countries have banned the industrial and consumer uses of mercury, and the Minamata international convention was signed in 2013 to this effect. Historical industrial uses of mercury were in the felt-hat industry and in the treatment of animal furs. Organo-mercurials were previously used as fungicides, algicides, insecticides, antibacterial and disinfectant drugs. Mercury amalgams are still widely used in dentistry, although composite resins have superseded them in several countries. Occupational exposure to elemental mercury is still possible in the chemical industry, especially with old or outdated production methods. It is employed in the production of sodium hydroxide using the chloralkali (amalgam) process, as a catalyst in the production of vinyl acetate from acetylene, and in small amounts as a laboratory reagent. Other uses which are steadily decreasing are the residual manufacture, maintenance, repair and disposal of medical instruments (e.g. sphygmomanometers and thermometers), fluorescent lamps, and electric batteries for small devices. The artisan mining industry still uses mercury to amalgamate gold and silver in their extraction from very low-grade ores: this activity entails the exposure of informal workers and of their communities to health-threatening levels of mercury.

Toxicological profile and diseases caused by mercury

1.1.7 Diseases caused by mercury or its compounds	ICD Code T56.1 +Z57
Short toxicological profile	Elemental mercury is rapidly absorbed by inhalation, moderately absorbed through the skin. There is no significant absorption via the gastrointestinal tract. From the blood, it rapidly distributes to the central nervous system (grey matter especially) and other organs, such as kidneys, liver, intestinal mucosa, myocardium, skin, and respiratory system, all representing the main targets of mercury deposition. Inorganic mercury compounds vary in their absorption characteristics. They tend to be absorbed less rapidly through inhalation, probably because they usually occur in the form of dust particles that deposit in the higher respiratory tract and are eliminated through mucociliary clearance. Some are absorbed rapidly via the gastrointestinal tract and skin, depending on their specific chemical characteristics. Since inorganic compounds are less liposoluble, they mainly distribute in plasma, deposit in the kidneys and the liver, and are less likely to pass the blood-brain barrier. Alkyl (i.e., organic) mercury compounds pass through the blood-brain barrier and the placenta very rapidly. Methyl mercury is one of the most hazardous of the alkyl compounds because of its prolonged elimination (the half-life is 40 to 105 days), and because other forms of mercury in the environment are bio-transformed to methyl mercury. Methyl mercury in the blood is found mainly in red blood cells. From the blood, it distributes to the central nervous system, kidneys and liver, reaching a blood-tissue steady-state in about four days. Elemental mercury and its organic compounds are excreted mainly in urine and faeces, with small amounts in exhaled air, sweat and saliva. Organic compounds are mainly excreted through the bile, and 90% is eliminated with the faeces.

Name of the diseases and ICD code: **Acute diseases caused by mercury or its compounds**
(Specific disease code) **+T56.1 + Z57**

Acute conjunctivitis (H10.2), Burn of mouth and pharynx (T28), Irritant contact dermatitis (L24), Allergic contact dermatitis (L23), Acrodynia (T56.1), Upper respiratory inflammation (J68.2), Acute chemical bronchitis and pneumonitis (J68.0), Acute chemical bronchiolitis (J68.4), Chemical pulmonary oedema (J68.1), Acute gastrointestinal toxicity (K52.1), Acute toxic nephropathy (N14.3), Acute toxic encephalopathy (G92)

Short description of the disease

Exposure to mercury via inhalation, skin contact, or ingestion may lead to respiratory damage, renal dysfunction, involvement of the eyes, skin and mucosae, nervous system and gastrointestinal tract effects. Many inorganic and aryl compounds, including bichloride, nitrate, phenyl and butyl salts, are corrosive when swallowed. The compounds high solubility in acidic chloride-containing gastric juice show the highest levels of toxicity. However, inhalation rather than ingestion represents the most common route of exposure in occupational settings.

Diagnostic criteria

Clinical manifestations

- Inhalation of high mercury vapour concentrations for relatively short periods can cause weakness, chills, bronchitis, bronchiolitis, pneumonitis, chest pain, dyspnoea, cough, and general malaise: basal, late-inspiratory crackles on physical examination and patchy shadowing on chest radiograph may be present, in the most severe cases, pulmonary oedema, respiratory failure, and eventually death can occur.
- Effects following the direct contact of metal vapours with the skin or the ocular and gastrointestinal mucosae include irritant contact dermatitis, conjunctivitis, stomatitis, gingivitis, sialorrhoea, metallic taste, nausea, vomiting, abdominal pain, and diarrhoea.
- Soluble and insoluble inorganic and organic mercury compounds are absorbed through the skin, and allergic contact dermatitis may develop as a consequence of exposure to elemental mercury and its divalent inorganic compounds. For further details on clinical features of allergic and irritant contact dermatoses, refer to items 2.2.1 and 2.2.2, respectively.
- A particular form of mercury-related skin disease can develop, called acrodynia, also known as "pink disease" being characterized by erythema of the palms and soles with oedema of the hands and feet. This may be an idiosyncratic hypersensitivity response.
- Inorganic mercury has been associated with an immunologically mediated, rapidly presenting glomerulonephritis or nephrotic syndrome. Acute exposure to elemental mercury and inorganic compounds can cause transient proteinuria and oliguria, renal tubular dysfunction, whilst acute papillary necrosis and renal failure can also occur. Since occupational mercury exposure leads to a small reversible increase in urinary enzymes (such as urinary N-acetylglucosaminidase and gamma glutamyl-transpeptidase), these indicators are used in epidemiological studies as markers of exposure that might lead to toxicity.

Key actions for prevention of occupational mercury exposure

1.1.7 Diseases caused by mercury or its compounds	ICD Code T56.1 +Z57
Key actions for prevention	Mercury poisoning can be prevented by reducing or eliminating exposure to mercury and its compounds. Discontinuation of occupational exposure is the most effective measure to prevent further health damage. On October 10, 2013, the "Minamata Convention for Mercury" was signed to protect human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds. The Convention includes a ban on new mercury mines, the phasing-out of existing ones, control measures for air emissions, and the international regulation of the informal sector for artisanal and small-scale gold mining. The extraction and use of mercury have been already prohibited in many countries, and its use in devices such as medical thermometers and blood pressure measuring devices has been discontinued. In exceptional cases, where it is impossible to find alternatives, such as in laboratory analyses of mercury, it might become necessary (based on risk assessment) to provide closed-cycle equipment with full-time environmental control and warning systems. In industry, mercury should be handled in hermetically sealed systems, and extremely strict hygiene rules should be applied at the workplace. When mercury is spilled, it very easily infiltrates crevices, gaps in floors and workbenches. Due to its vapour pressure, a high atmospheric concentration may occur even following seemingly negligible contamination. It is therefore important to avoid the slightest soiling of work surfaces; these should be smooth, non-absorbent and slightly tilted towards a collector or, failing this, have a metal grill over a gutter filled with water to collect any drops of spilt mercury which fall through the grill. Working surfaces should be cleaned regularly, and, in the event of accidental contamination, any drops of mercury collected in a water trap should be drawn off as rapidly as possible. Where there is a danger of mercury volatilizing, local exhaust ventilation systems should be installed. Work arrangements should be planned in such a way as to minimize the number of persons exposed to mercury. Most exposure to organic mercury compounds involves mixed exposure to mercury vapour and the organic compound, as the organic mercury compounds decompose and release mercury vapour. Contamination of clothes and parts of the body should be avoided, as these may be dangerous sources of mercury vapour close to the breathing zone. Special protective work clothes should be used and changed after the work shift. Individuals planning to have children should keep their exposure to mercury as low as possible by using engineering controls, personal protective equipment for the skin and respiratory tract and good personal hygiene. Pregnant workers should avoid any exposure to the metal. Workers exposed to mercury should be cautious when breast-feeding, since breast-milk may contain significant amounts of inorganic as well organic mercury. The group of experts considered that the following limits of exposure of workplace atmospheric concentrations (estimated as 8hr TWA) have been observed to provide a reasonable level of protection for workers' health and have been used in a number of countries: • 0.1 mg/m³ for aryl mercury compounds. • 0.025 mg/m³ for elemental and inorganic mercury. • 0.01 mg/m³ for organometallic alkyl mercury compounds.

1.1.7 Diseases caused by mercury or its compounds — **ICD Code T56.1 +Z57**

Further reading

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7. U.S. Dept. of Health and Human Services - Public Health Service. Agency for Toxic Substances and Disease Registry: Toxicological Profile for Mercury (1999) at: http://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=115&tid=24. Last accessed: 26.01.2022.
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9. Hunter's Diseases of Occupations. Editors Baxter PJ, Aw T-C, Cockcroft A, Durrington P, Harrington JM. Tenth Edition, London: Hodder Arnold, 2010.
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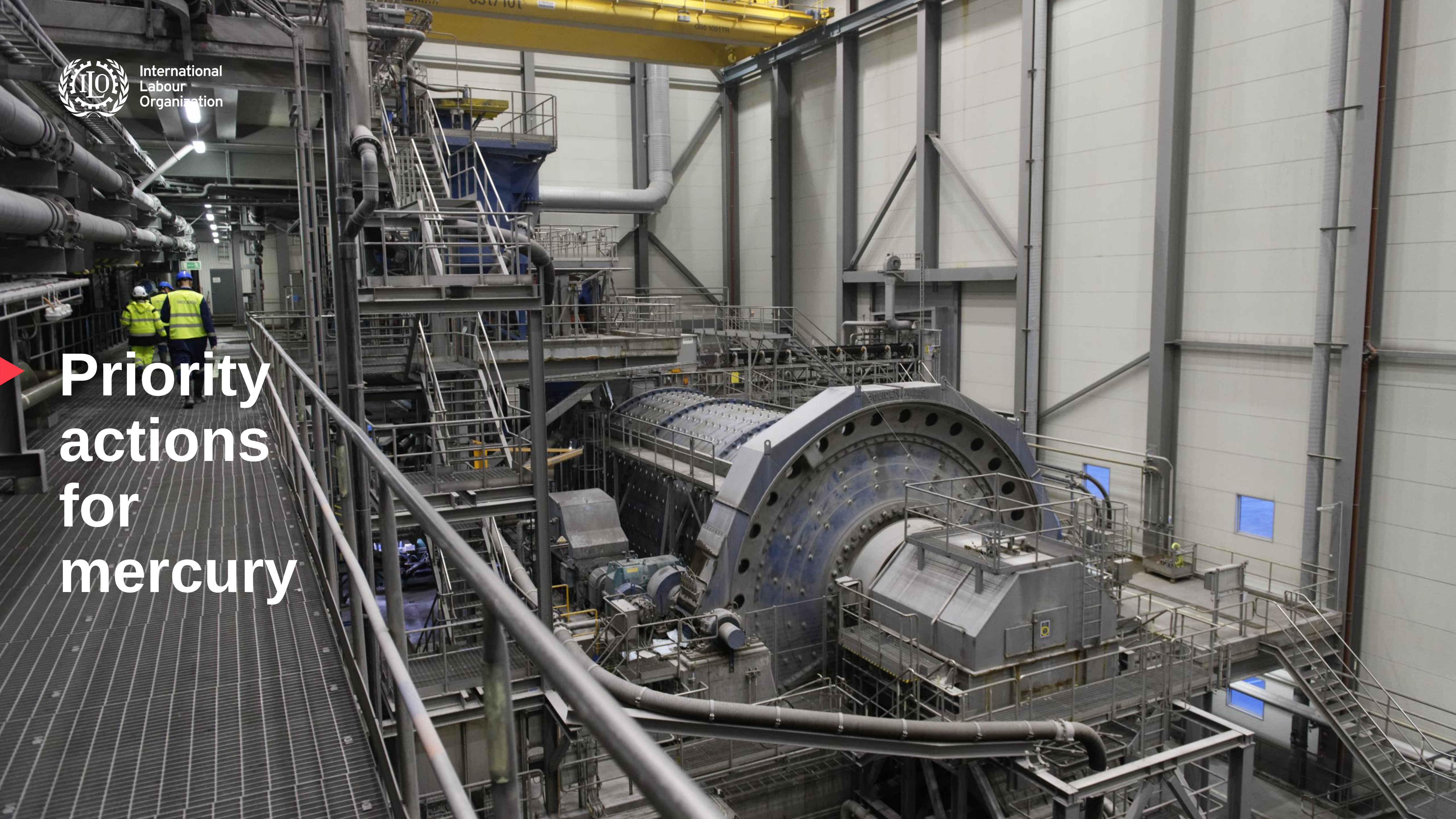
11. Harrison's Principles of Internal Medicine. 18th Edition. Chapter 384. Peripheral Neuropathy. Mercury.
12. Michael C. Byrns; Trevor M. Penning. Environmental Toxicology: Carcinogens and Heavy Metals. Chapter 67, in Goodman & Gilman's The Pharmacological Basis of Therapeutics, 12e.
13. CRC Handbook of Chemistry and Physics, 84th ed.; CRC Press: Boca Raton, FL., 2003.

Mercury entries in the collection of International Chemical Safety Cards (ICSC), hosted by the ILO

Name	Synonyms	ICSC
Mercury	Quicksilver; Liquid silver	0056
Phenyl mercuric acetate	Phenylmercury (II) acetate; Phenylmercury acetate; Acetoxyphenylmercury; PMA	0540
Mercuriphenyl nitrate	Mercuriphenyl nitrate; Merphenyl nitrate; Mercury, Nitratophenyl	0541
Mercuric acetate	Acetic acid, mercury (2+) salt; Mercury di(acetate)	0978
Mercuric chloride	Mercury dichloride; Mercury (II) chloride	0979
Mercuric nitrate	Mercury (II) nitrate; Mercury dinitrate	0980
Mercuric oxide	Mercury (II) oxide	0981
Mercuric sulfate	Mercury (II) sulphate; Mercuric bisulfate	0982
Mercurous chloride	Dimercury dichloride; Calomel	0984
Dimethyl mercury	Mercury, dimethyl	1304

Diseases and risk factors related to mercury with international classification of diseases (ICD) 10 or 11 codes

ILO	Disease name	ICD-10	ICD-11
1.1.7	Acute/chronic diseases caused by mercury or its compounds	T56.1	NE61 & XM1FG4
1.1.7	Gastrointestinal toxicity	K52.1	1A40.0
1.1.7	Toxic nephropathy	N14.3	GB55.1
1.1.7	Toxic encephalopathy	G92	8D43.0Z
1.1.7	Upper respiratory inflammation	J68.2	CA81.2
1.1.7	Acute chemical bronchitis and pneumonitis	J68.0	CA81.0
1.1.7	Acute chemical bronchiolitis	J68.4	CA81.Y
1.1.7	Chemical pulmonary oedema	J68.1	CA81.1
1.1.7	Irritant contact dermatitis	L24	EK02
1.1.7	Acute conjunctivitis	H10.2	9A60.Z
1.1.7	Allergic contact dermatitis	L23	EK00
1.1.7	Acrodynia	T56.1	NE61
1.1.7	Mercury pigmentation	L81.8	ED6Y
1.1.7	Chronic gingivitis	K05.1	DA0B.Y
1.1.7	Disturbances of taste and smell	R43.8	MB41.Z
1.1.7	Toxic polyneuropathy	G62.2	8D43.2Y
1.1.7	Chronic progressive renal failure	N14.3	GB61.Z
1.1.7	Chronic kidney dysfunction	N18.9	GB61.Z
	Exposure to occupational risk factors	Z57	QD84.Y



International Labour Organization

Priority actions for mercury

Policy level actions

Given that occupational mercury exposure is a global concern, prompt action is needed to protect workers.

- Mercury use in products and processes should be **phased out** and **replaced with mercury-free alternatives**, in line with the Minamata Convention and ILO Convention No. 170.
- A **'toxics use reduction'** approach is essential to identify safer alternatives to mercury where available and to find safer processes, substances and products where not.
- **Promote international labour standards (ILS)** on occupational safety and health (OSH) and on chemicals. These should contain specific guidance for **safeguarding decent work** and **protecting workers' safety and health**.
- Ensure that policies for the sound management of mercury follow an **integrated OSH management systems approach**, as outlined in the ILO Promotional Framework for Occupational Safety and Health Convention, 2006 (No. 187) and its accompanying Recommendation (No. 197).

Policy level actions

Other relevant conventions for a strong OSH system include:

- The Occupational Safety and Health Convention, 1981 (No. 155) and its accompanying Recommendation (No. 164).
- The Occupational Health Services Convention, 1985 (No. 161) and its accompanying Recommendation (No. 171).
- Other key ILO conventions (and their accompanying recommendations) include:
  - ILO Chemicals Convention, 1999 (No. 170)
  - ILO Safety and Health in Mines Convention 1995 (No. 176)
  - ILO Employment Injury Benefits Convention, 1964 (No. 121)
- List of Occupational Diseases Recommendation, 2002 (No. 194) (revised 2010), amongst others.

MINAMATA
CONVENTION
ON MERCURY

Minamata Convention on Mercury

- Adopted in October 2013 and entered into force in **August 2017**.
- Developed to help **protect human health** and the **environment** from releases of mercury and mercury compounds.
- Obliges governments to take a range of actions, including to **address mercury emissions** and to **phase-out certain mercury-containing products**.
- With over 128 signatories and 131 ratifications, the Convention has the potential to help **eliminate harmful global mercury** exposures for the numerous workers exposed worldwide.
- Since the adoption of the Convention, relevant ILO activities in support of the implementation of the Convention have included promotion of ILO international instruments, including the Chemicals Convention, 1990 (No. 170), project work at the country level, and production of global codes of practice, research reports and working papers.

Minamata Convention and National Action Plans (NAPs)

- Countries that have ratified the Minamata Convention are obliged to develop a NAP to describes its approach to reduce, and if possible, eliminate, the use of mercury in ASGM.
- The ILO advises that NAPs should align with ILO Decent Work Country Programmes (DWCPs).
- Effective multi-sectoral collaboration is needed at both national and local levels.
- Many countries have started developing a NAP, including collecting baseline data regarding ASGM activity in their regions *(UNEP 2018)*.
- The ILO recommends the integration of OSH into the public health strategy of the NAP, as well as identifying strategies to protect vulnerable populations, such as child labourers.

Other policy level actions

- Increase **stakeholder capacity** and **worker participation** as a matter of priority.
- Implement and enforce **Occupational Exposure Limits (OELs)** for Mercury.
- Implement the **Globally Harmonized System of Classification and Labelling of Chemicals (GHS)**.
- Mainstream **gender considerations** into OSH policy and practice.
- Strengthen **Global Burden of Disease (GBD)** estimates for exposures and outcomes.

Mild subclinical signs of central nervous system toxicity can be seen in workers exposed to an elemental mercury level in the air of 20 μg/m^3 or more for several years (WHO 2021a). There may therefore be a case for more stringent OELs than currently exist.


Mercury, Elemental
CAS RN: 7439-97-6

GHS Classification

Signal: Danger
GHS Hazard Statements
H330: Fatal if inhaled [Danger Acute toxicity, inhalation]
H360D ***: May damage the unborn child [Danger Reproductive toxicity]
H372 **: Causes damage to organs through prolonged or repeated exposure [Danger Specific target organ toxicity, repeated exposure]
H400: Very toxic to aquatic life [Warning Hazardous to the aquatic environment, acute hazard]
H410: Very toxic to aquatic life with long lasting effects [Warning Hazardous to the aquatic environment, long-term hazard]
Precautionary Statement Codes
P201, P202, P260, P264, P270, P271, P273, P281, P284, P304+P340, P308+P313, P310, P314, P320, P391, P403+P233, P405, and P501
(The corresponding statement to each P-code can be found at the GHS Classification page.)

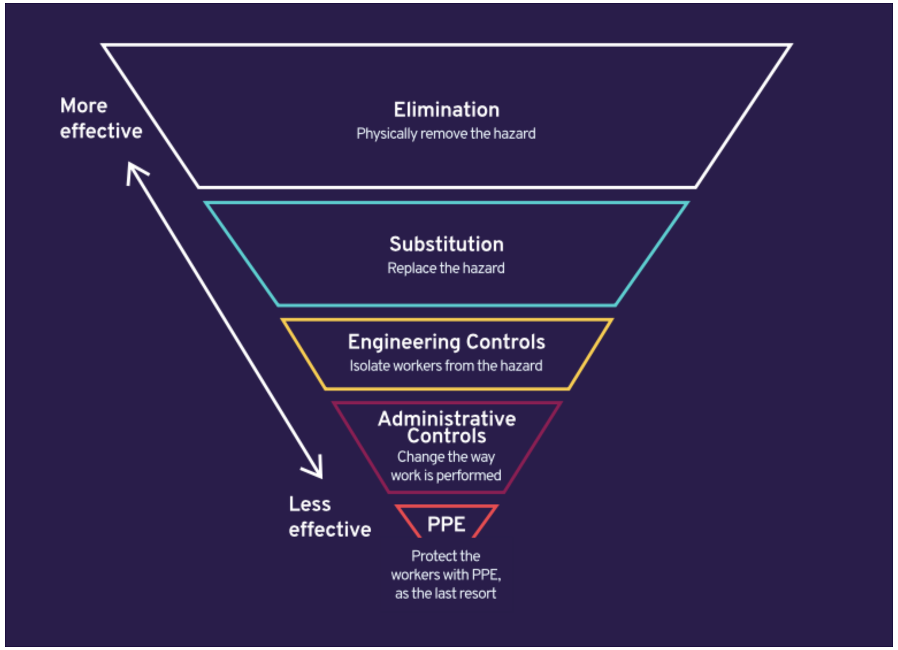
► EU REGULATION (EC) No 1272/2008

Workplace level actions

Although the phase out of mercury is a priority, workplace prevention efforts must also be implemented as complementary actions.

- Implement a workplace programme for the sound management of mercury.
- Implement a workplace level strategy:

Apply the Hierarchy of Controls



Elimination	e.g. Eliminate the use of mercury and use a zero-mercury approach instead, for example, panning, sluicing or spiral concentrators
Substitution	e.g. Use an alternative chemical for the process, for example cyanide
Engineering controls	e.g. Use retorts or fume hoods to remove the mercury fumes
Administrative controls	e.g. Adjust work tasks or schedules to limit the time workers are exposed to mercury and create written operating procedures on handling hazardous substances
PPE	e.g. Workers should wear appropriate PPE, for example gloves, overalls, masks with filters, and safety glasses, as deemed relevant by risk assessment

Alternatives to mercury-containing products

Mercury products	Alternatives
Thermometers	Digital, gallium-indium-tin thermometers, dot matrix thermometers or alcohol thermometers
Sphygmomanometers (blood pressure equipment)	Aneroid and electronic devices
Fluorescent lamps	Light-emitting diode (LED) lamps
Thermostats	Air-controlled, reed switch, vapor-filled diaphragm, snap-switch or programmable digital thermostats
Barometers	Aneroid, digital, or liquid barometers
Dental amalgam	Composite fillings, glass ionomer fillings, porcelain or gold inlays
Batteries	Lithium, silver and alkaline batteries

International Labour Organization

Priority actions in specific settings

Phasing out mercury use in ASGM

- Multiple programmes are in place to help miners shift to mercury-free mining processes, but the challenges are vast due to the extent and informal nature of ASGM *(UNEP 2017)*.
- **A two-step approach is recommended**: Whilst using completely mercury-free processing and refining may seem ideal, reducing mercury use may be a more realistic first step.
- **Miner income must be increased or maintained**: Reductions in mercury use is likely to be accepted by miners if income is at least maintained *(UNEP 2012)*.
- Assess the potential for the **formalization of ASGM activities**: Must be managed to address vulnerabilities of women in the sector.
- **Worker training** and awareness raising are essential.
- **Implement integrated OSH management systems**: Ensure that international OSH standards are being met in ASGM.

Reduced mercury and mercury-free technologies in ASGM

- **Concentrate amalgamation:** Uses less mercury than WOA, as mercury is used only on the concentrate which contains the heaviest minerals and gold.
- **Retorts/fume** hoods: An alternative to open air burning of amalgam is closed circuit burning, where mercury vapour is captured in a retort or under a fume hood. Simple and affordable models can reduce mercury emissions by 75 to 95 per cent.
- **Chemical leaching using cyanide:** Cyanidation is the most promising procedure for fully replacing mercury use in the treatment of gold ore, however, may be financially or technically beyond the reach of artisanal miners.
- **Gravity:** Gravity-based methods are the ones most widely used to concentrate gold in ASGM. Using gravity is effective because gold is heavy. There are a wide variety of approaches to gravity concentration, from basic such as panning and sluicing, to more complex such as centrifuges and shaker tables.
- **Direct smelting:** A small mass of high-grade concentrate is first produced (by panning or by using a shaking table for example), then it is melted to separate the gold from other minerals. This is not a direct replacement for mercury, as it is not applied at the same stage of processing.

Eliminating mercury from healthcare settings (Health Care Without Harm)

Health Care Without Harm recommends the following five steps for eliminating mercury in healthcare settings:

- **Step 1:** Create a mercury task force – Bring together the key stakeholders in the hospital community.
- **Step 2:** Establish hospital commitment – Have hospital management sign a pledge or letter of commitment to phase-out mercury.
- **Step 3:** Conduct a mercury inventory – Conduct a situation assessment and inventory of equipment, instruments and waste products that contain mercury.
- **Step 4:** Develop a mercury-substitution programme:
  - Replace mercury devices and products with safe, accurate, affordable alternatives and adopt a mercury-free purchasing policy.
  - Establish a mercury waste management and storage programme.
  - Training and education of staff.
- **Step 5:** Conduct a post-implementation evaluation – Re-evaluate hospital plans and document progress towards eliminating mercury, identifying obstacles and sharing experiences with other healthcare establishments.

Case study: ILO-Caring Gold Mining Project in Ghana and the Philippines

The CARING Gold Mining Project's overall goal is to address child labour and improve working conditions in ASGM globally, and in Ghana and the Philippines as pilot countries *(ILO 2019)*.

- It does so by pursuing four outcomes, the first three to be carried out in the pilot countries and the fourth one on a global scale. These are:
  - **Outcome 1:** Laws, policies and action plans to address child labour and/or working conditions in ASGM in are strengthened, enforced and/or implemented.
  - **Outcome 2:** Access of vulnerable households living in ASGM communities to relevant social protection and livelihoods programmes is improved.
  - **Outcome 3:** Mechanisms to increase monitoring of child labour and working conditions in gold mining supply chains, particularly ASGM, are developed and implemented.
  - **Outcome 4:** Global networks to reduce child labour and improve working conditions in ASGM are operational.

Summary

- The health impacts of mercury exposure are well-known, yet long-term implications of hazardous occupational exposure will only become evident in years to come.
- This is particularly true in newly identified sectors, such as e-waste recycling.
- Despite progress being made with respect to Minamata Convention goals, the informal nature of many sectors where workers are exposed creates an ongoing crisis which must be addressed.
- Effective and evidence-based systems for the sound management of mercury must be implemented at both the national and workplace level as a matter of urgency.
- Collecting exposure data from different industries is critical to provide a clearer picture of the true scale of the problem and to allow countries to develop an effective and targeted response to the global mercury problem within the world of work.

End of session activity

Group work and quiz

International Labour Organization

1. Group work

You and your group have been asked to provide advice regarding decreasing mercury exposures in ASGM.

1. Group work instructions

- Can you think of ways to reduce to reduce hazardous mercury exposures in ASGM at both policy and workplace levels.
- Give an example of how the Hierarchy of Controls can be used to protect mine workers.
- What are important points which must be considered?

2. Group work

You have been asked to advise a fluorescent bulb recycling plant about the best ways to protect workers from potential mercury exposures. Describe some practical measures which can be implemented at the workplace level.

2. Group work - OSHA recommendations for protecting workers from mercury exposure while crushing and recycling fluorescent bulbs

The environment

- Process isolation so that areas where bulbs are broken or recycled are physically separated from other areas.
- Well-ventilated work areas.
- A clean-up plan - Informs workers how to safely clean up incidental mercury releases from broken bulbs.
- Floor materials that are easy to clean.
- Evaluation and maintenance programmes for equipment.

Training

- Educate workers about mercury exposes and safe practices.

2. Group work - OSHA recommendations (continued)

- **PPE**
  - Respiratory protection is required if feasible engineering and administrative controls do not prevent concentrations of mercury from exceeding OELs.
  - PPE such as coveralls, booties, gloves, face shields and safety goggles should be provided and cleaned regularly.
  - For those involved in breaking or crushing bulbs, disposable or reusable protective clothing is needed.
- **Medical and workplace monitoring**
  - Monitoring of exposed workers, including medical examinations focusing on the eyes, skin, respiratory system, nervous system and kidneys, as well as measuring mercury levels in urine.
  - Air monitoring to measure the amount of mercury present in the air.

3. Quiz

1. Which industry was impacted by mercury poisoning in the 18th and 19th centuries?
2. Which year did the Minamata Convention come into force?
3. Name the 3 types of mercury and give an example of how they are used.
4. Describe what happens when mercury enters the environment.
5. Discuss how healthcare workers may be exposed to mercury.
6. Which is the second largest mercury user after ASGM?
7. What is e-waste and why is it a concern?
8. Identify some specific populations who may be especially vulnerable to mercury exposures..

International Labour Organization

Key ILO resources

- Exposure to mercury in the world of work: A review of the evidence and key priority actions.
- Exposure to hazardous chemicals at work and resulting health impacts: A global review (2021).
- Chemicals, wastes and climate change: Interlinkages and potential for coordinated action (2021), Minamata Convention on Mercury.
- Interlinkages between the chemicals and waste multilateral environmental agreements and biodiversity: Key insights (2021), Minamata Convention on Mercury.
- The Sound Management of Chemicals and Waste in the World of Work (2019).
- Diagnostic and exposure criteria for occupational diseases - Guidance notes for diagnosis and prevention of the diseases in the ILO List of Occupational Diseases (revised 2010).
- All You Need to Know: Convention No. 170.
- Safety and Health in Mines Convention, 1995 (No. 176).
- List of Occupational Diseases Recommendation, 2002 (No. 194).