International Labour Organization

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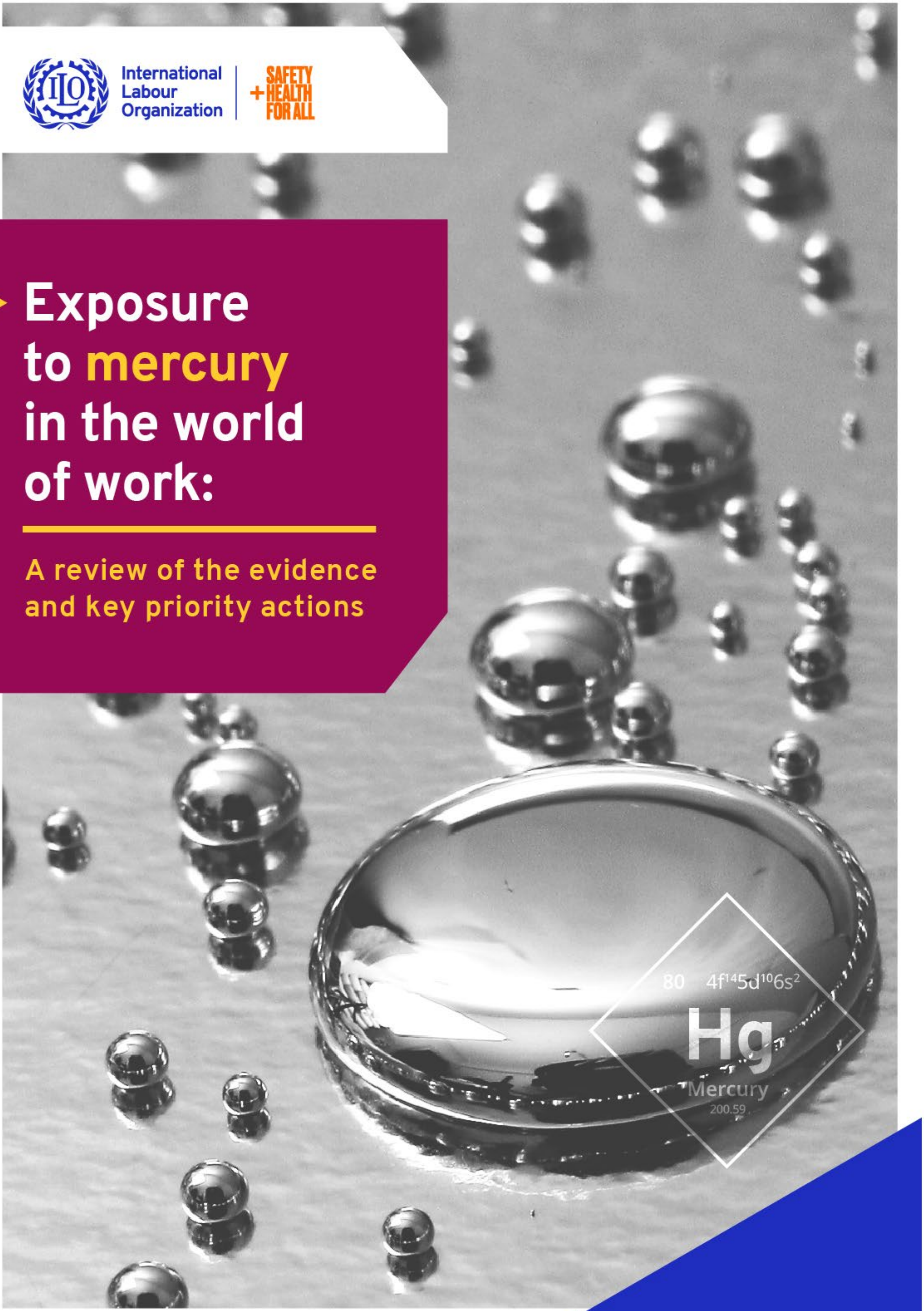
Exposure to mercury in the world of work:

A review of the evidence and key priority actions



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Foreword

Every year, millions of workers around the world are exposed to mercury – a toxic heavy metal. Workers in artisanal and small-scale gold mining are particularly at risk, however numerous other sectors have been identified as areas of concern, including vinyl chloride monomer production, manufacturing, healthcare, waste-picking and recycling. Exposure to this hazardous metal can severely damage body systems and organs, leading to disability, life-long illness and even death. Given the scale of exposure and potential severity of health impacts, occupational mercury exposure has been identified as a global health concern.

Since its founding in 1919, one of the core objectives of the International Labour Organization (ILO) has been to promote safe and healthy working environments for workers globally. The ILO has long recognized the occupational risks posed by mercury exposure, and in fact, mercury poisoning was identified as one of the very first occupational diseases, listed in the ILO list of occupational diseases already in 1925. Since then, the ILO has developed and promoted numerous International Labour Standards relevant to occupational safety and health, chemical hazards and mining.

In 2013, the Minamata Convention was adopted, with an aim to reduce global mercury emissions and to protect human health and the environment from hazardous mercury exposures. The ILO continues to actively support the implementation of the Convention at international, regional and national levels, by promoting ratification of relevant international labour standards, supporting project activities in high-risk sectors, and developing awareness raising and capacity development materials relevant to chemicals in the world of work. Tackling hazardous mercury exposures through enhanced occupational safety and health is an important step to achieving the 2030 Sustainable Development Goal 8 on Decent Work and Economic Growth. This report provides a review of the current evidence on occupational mercury exposures and health impacts, as well as highlighting priority areas for action.

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Chief

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Executive Summary

Occupational mercury exposures present a serious threat to the health of workers in many industries 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. Serious health effects can result, including chronic metallic mercury vapour intoxication (CMMVI), heart palpitations, kidney abnormalities, cognitive dysfunction, respiratory failure and death. Even low levels of chronic exposure can result in severe disability and debilitating chronic conditions, impacting long-term health and well-being. This significant burden for workers, and society as a whole, is entirely preventable.

The International Labour Organization (ILO) Centenary Declaration for the Future of Work (2019) states that "safe and healthy working conditions are fundamental to decent work". The ILO has long recognized that protecting workers from hazardous chemicals, such as mercury, is essential to ensuring healthy populations, as well as sustainable environments. Whilst mercury use is decreasing across some industries, for example in chlor-alkali production, its numerous applications and lack of regulation in many sectors, contributes to a high potential for increased occupational exposure. There is therefore an urgent need to take action and implement a range of effective measures to prevent harm to workers, their families and wider communities.

Following the conclusion of the negotiations at the fifth session of the intergovernmental negotiating committee, the Minamata Convention on Mercury was adopted in October 2013 and entered into force in August 2017. The Convention was developed to help protect human health and the environment from releases of mercury and mercury compounds, and 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[1], the Convention has the potential to assist tripartite constituents of the ILO and 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.

Although progress has been made, workers around the world continue to be exposed in numerous settings. Greater attention is needed on mercury as an occupational hazard and the specific risks it poses to workers worldwide, many of whom are working in informal conditions and lacking adequate social protection. 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, in particular Goal 8: "Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all". This is a complex issue, however, as mercury use is essential for economic survival in many poorer communities, and it cannot just be removed overnight. Despite this, world of work stakeholders must ultimately prioritize the elimination of this extremely hazardous chemical.

This report was undertaken in order to provide a sound evidence base for mercury as a world of work concern. It aims to provide governments and policy makers, as well as social partners, with an educational and planning tool, to assist with the following actions:

- Identify the types of industries and sectors where workers may be exposed in their regions and the populations at risk.
- Understand the potential scale of the problem in terms of occupational health impacts.
- Implement key priority actions at both national and workplace levels to better protect exposed workers.

1 As of 5 July 2021.

Main findings

A number of sectors of exposure were identified as priorities:

- Artisanal and small-scale gold mining (ASGM)
- Primary mercury mining, and other non-ferrous ore mining (e.g. zinc, lead, copper)
- Chlor-alkali production
- Vinyl chloride monomer (VCM) production
- Acetaldehyde production
- Coal-fired power plants
- Oil and natural gas processing
- Manufacture of mercuric compounds, including organomercury compounds (e.g. antiseptics, fungicides)
- Manufacture of mercury-containing devices (e.g. mirrors, paint, fluorescent lights, batteries, barometers)
- Healthcare (where mercury-containing products are used)
- Healthcare waste processing
- Dentistry
- E-waste scavenging and recycling
- Recycling of mercury-containing devices
- Cosmetics (e.g. skin lightening products, eye make-up)
- Gilded crafts and religious idol production
- Biocide/pesticide agriculture
- Chemical laboratory processes
- Construction

The major mercury uses 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.

- The ASGM sector alone has over 19 million workers in 70 countries. Approximately 4.5 million of these workers are women and 600,000 are children.
- Around 30 per cent of ASGM miners are estimated to suffer from CMMVI, for which symptoms include ataxia, dysdiadochokinesia, tremor and neurobehavioural deficits. The resulting global burden of disease is estimated to range from 1.22 to 2.39 million disability-adjusted life years (DALYs), with the highest burden in the World Health Organization (WHO) African Region.

Workers may be exposed during industrial processes or when handling mercury-containing products. Those involved in plant shutdowns or factory closures are also at risk.

For the great majority of industries, exposure data does not exist, and the total number of mercury exposed workers cannot be estimated.

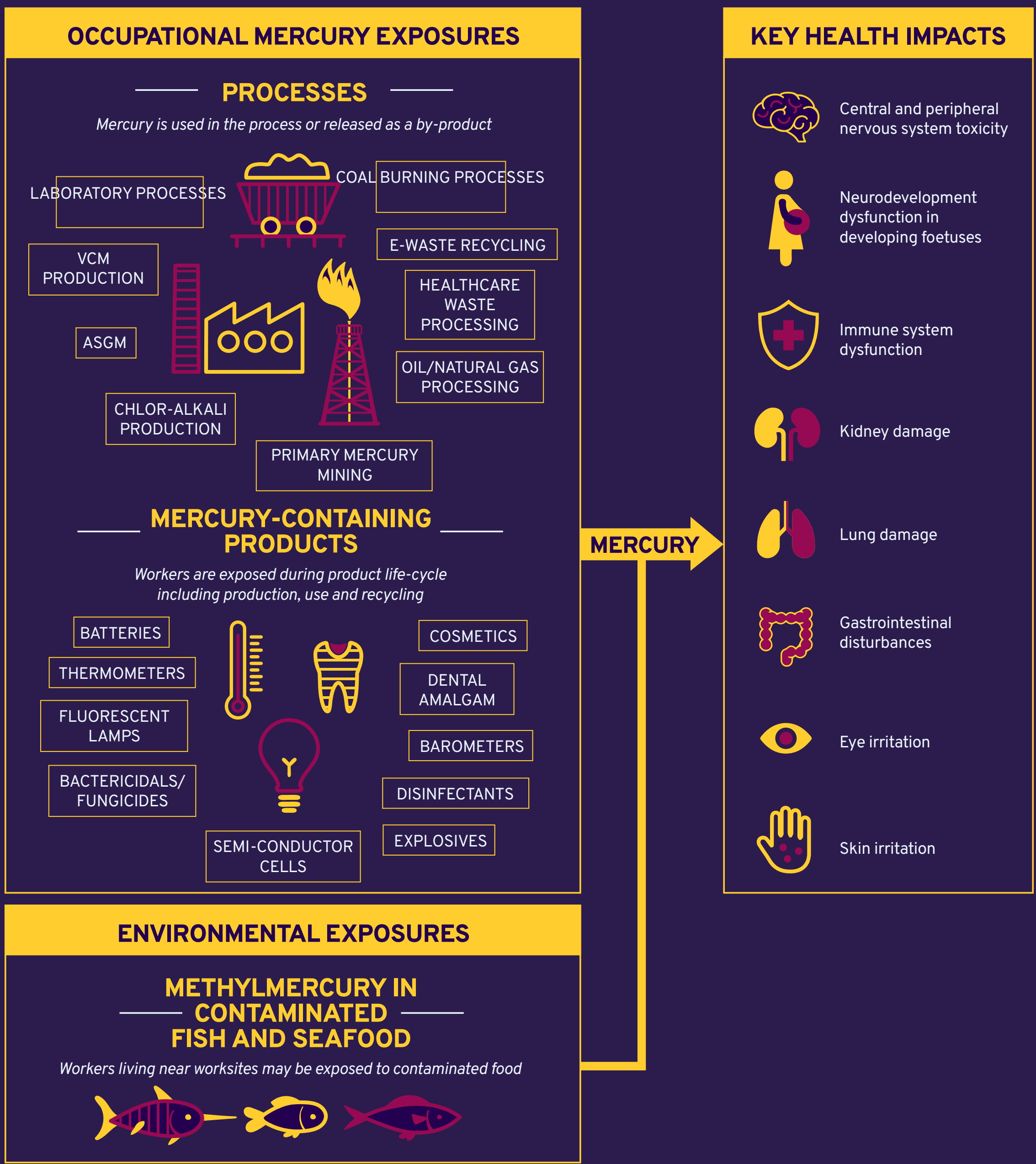
Occupational exposure to mercury may occur through inhalation, ingestion or dermal contact, however, most occupational exposure to mercury occurs through inhalation of elemental mercury vapours in the workplace.

- 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 (Figure 1).

- The nervous system is the most sensitive target for mercury exposure. Studies of workers in fluorescent tube manufacturing, wood processing, chlor-alkali, and thermometer plants have demonstrated subtle central nervous system toxicity at mercury vapour concentrations in air as low as 20 µg/m³.

- Workers may face a double burden of exposure due to occupational, as well as environmental exposures.

Figure 1. Overview of occupational and environmental mercury exposures and key health impacts



Priority actions

Given that occupational mercury exposure is a global concern, prompt action is needed to protect workers. Key actions to ensure worker protection and prevention efforts should be taken at both the national policy level and at the workplace level. These include:

- 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. Following elimination, additional preventative measures should be implemented, following the Hierarchy of Controls.
- 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). Other relevant conventions for a strong OSH system include:
  - The Occupational Safety and Health Convention, 1981 (No. 155) and its accompanying Recommendation (No. 164), which call for the adoption of a coherent national OSH policy, as well as action to be taken both at the national and enterprise level to promote safety and health and to improve working conditions.
  - The Occupational Health Services Convention, 1985 (No. 161) and its accompanying Recommendation (No. 171), which provide for the establishment of occupational health services which are entrusted with essentially preventive functions and are responsible for advising employers, workers and their representatives at the enterprise level on maintaining a safe and healthy working environment.
  - In addition to OSH Conventions, key ILO conventions pertaining to the safe management of mercury, include ILO Convention No. 170, ILO Safety and Health in Mines Convention 1995 (No. 176), ILO Employment Injury Benefits Convention, 1964 (No. 121) and their accompanying Recommendations, as well as the List of Occupational Diseases Recommendation, 2002 (No. 194) (revised 2010), amongst others.
- Establish a preventative safety and health culture at national and workplace levels, with diverse stakeholders engaged at all levels.
- Implement the Globally Harmonized System of Classification and Labelling of Chemicals (GHS).
- Ensure national occupational exposure limits (OELs) for mercury are implemented and monitored across all sectors.
- Strengthen Global Burden of Disease (GBD) estimates for occupational exposures and outcomes. Data from the ASGM sector provides a snapshot into the scale of the problem, however statistics from other industries using mercury is currently scarce.
- Mainstream gender into OSH policy and practice. Recognize, respect and address gender diversity at work, and develop inclusive and responsive gender-sensitive OSH policies and practice.
- Assess the possibility of formalization in ASGM and promote decent work for miners worldwide. In ASGM specifically, numerous mercury-free processes are available, but these are not widely used, least of all by ASGM operators in the informal sector. By supporting a transition from informal to formal ASGM that considers the needs and vulnerabilities of both women and men, it should in principle become easier to identify, reach out to and provide ASGM mining operators with the knowledge and assistance needed to apply mercury-free processes and to improve working conditions.

- Follow a workplace programme approach for the sound management of mercury and instigate a workplace strategy involving chemical identification, comprehensive risk assessment and implementation of control measures.
- Develop health surveillance programmes for workers in high exposure industries and train workers effectively to make sure that guidance is followed.
- Adhere to relevant guidance on mercury handling from national and international level authorities, including for the disposal of healthcare waste, recycling of fluorescent light bulbs and the safe clear-up of spillages.
- Develop and support campaigns to increase stakeholder capacity and worker participation on mercury issues and broader chemical exposures in the world of work.
- Participate in social dialogue to promote transparent and active communication at all levels, particularly between governments and social partners.

- The health effects 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.

Acronyms

ASGM	Artisanal and small-scale gold mining
CMMVI	Chronic metallic mercury vapour intoxication
CFLs	Compact fluorescent lamps
DALY	Disability-adjusted life year
DWCPs	Decent Work Country Programmes
GBD	Global Burden of Disease
GHS	Globally Harmonized System of Classification and Labelling of Chemicals
ILO	International Labour Organization
LMICs	Low- and middle-income countries
NAP	National Action Plan
OSH	Occupational safety and health
UNEP	United Nations Environment Programme
USEPA	United States Environmental Protection Agency
TLV	Threshold limit value
TWA	Time weighted average
VCM	Vinyl chloride monomer
WOA	Whole ore amalgamation
WHO	World Health Organization
YLD	Years lived with disability

Background

Introduction

Occupational exposure to mercury poses a significant risk to the health of workers around the world. Workers in many different industries are exposed, however often have little protection against the harmful effects of this toxic heavy metal. Workers who may be exposed include artisanal and small-scale gold miners, chemical laboratory workers, chlor-alkali workers, dentists, healthcare workers, waste recyclers and factory workers manufacturing mercury-containing products, such as batteries, thermostats and thermometers, among many others.

The harmful effects of mercury exposure to human health are widely recognized. The 1950s Minamata Bay disaster, where mercury contaminated waste was discharged from a chemical plant, caused thousands of deaths and resulted in many more incapacitating disabilities. Widespread mercury poisoning also occurred in rural Iraq in 1971, when methylmercury contaminated grain was consumed. Mercury-containing teething powders were withdrawn from the market in the 1950s, after they were linked to acrodynia or 'pink disease' in infants.

The adverse health impacts caused by occupational exposure to mercury have also been evidenced throughout history. In the 18th and 19th centuries, mercury-based compounds were used to manufacture felt hats, leading to mercury poisoning among milliners, often called 'mad hatter disease'. The harmful health impacts of mercury use in the felt hat industry was well documented by the United States Public Health Service in the 1930s, as were those experienced by chlor-alkali workers in the 1970s (Mahaffey 2005). The ILO has long recognized the health risks of occupational mercury exposure, and moreover, mercury poisoning was recognized as one of the very first occupational diseases, alongside anthrax and lead poisoning, in the 1925 ILO list of occupational diseases.

Mercury continues to be a serious issue globally, with the World Health Organization (WHO) identifying mercury as one of the top ten chemicals of major public health concern (WHO 2017). The Minamata Convention was developed to protect human health and the environment from releases of mercury and mercury compounds, and obliges governments to take a range of actions, including to address mercury emissions and to phase-out certain mercury-containing products (UNEP 2013). Clear synergies exist between the Minamata Convention and ILO Chemicals Convention, 1990 (No. 170) and the ILO has supported the implementation of Minamata through the promotion of ILO international instruments, project work at the country level, and production of global codes of practice and working documents (UNEP 2019b).

Whilst progress has been made, a greater focus is needed on mercury as an occupational hazard and the specific risk posed to workers worldwide. Urgent action is needed to protect the millions of workers exposed on a daily basis, many of whom may be working in uncontrolled environments (from artisanal mining to waste and demolition activities), with effects undiagnosed or misattributed, unrecorded and unaddressed. In line with the Minamata Convention, the elimination of mercury use globally must be prioritized. A 'toxics use reduction' approach is key, whilst simultaneously addressing the need for alternative sources of income for many poorer communities, who rely on mercury use for their livelihoods. This report aims to provide a sound evidence base for mercury as a world of work concern and to highlight key priority actions for stakeholders at both the policy and workplace levels.

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What is mercury?

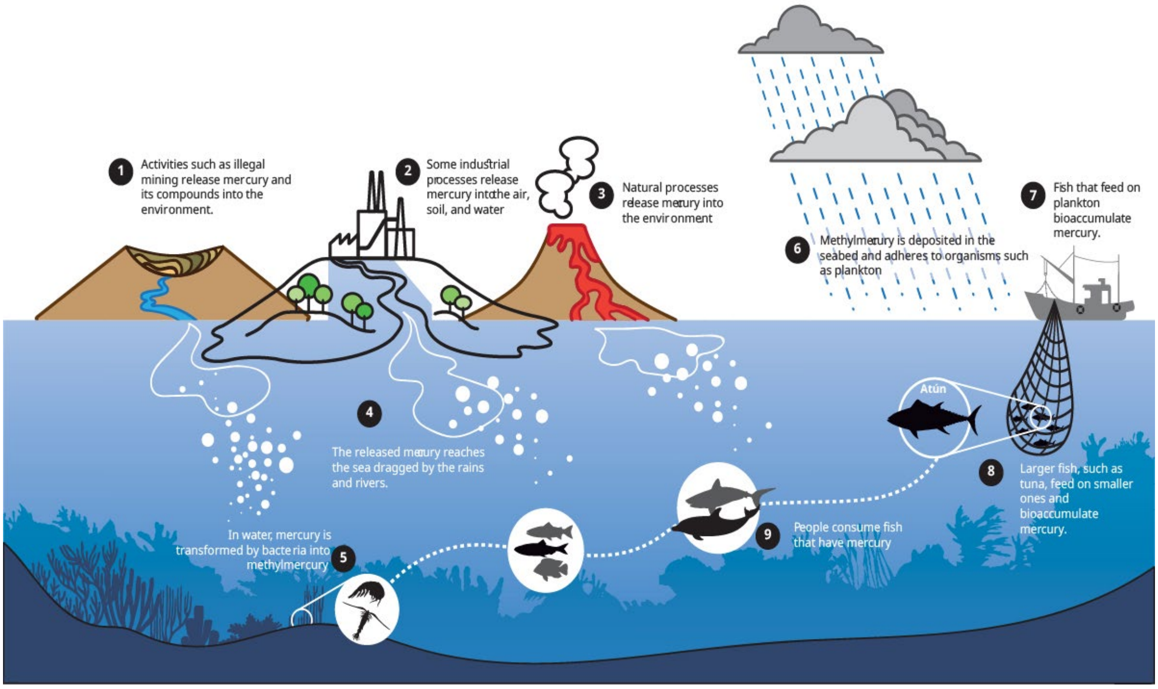
Mercury (Hg) can be released into the environment from both natural and anthropogenic sources and is considered a persistent toxic substance, which cannot be broken down or degraded once it enters the environment. Mercury can stay up to a year in the atmosphere, where it can be transported and deposited globally. Global emissions to air from anthropogenic sources accounts for about 30 per cent of mercury emissions (UNEP 2018). This was about 2220 tonnes in 2015, an approximate increase of 20 per cent from 2010 (UNEP 2018). Emissions associated with artisanal and small-scale gold mining (ASGM) account for almost 38 per cent of this total, with non-ferrous metal production, cement production and waste, that includes mercury-added products, accounting for 15 per cent, 11 per cent and 7 per cent respectively (UNEP 2018).

Due to its physical and chemicals properties, including water insolubility, electrical conductivity and ability to form alloys, mercury is used in a wide variety of industrial processes and is contained in a large number of products. Mercury can be elemental (metallic), inorganic and organic, and its form influences its distribution in the body and corresponding health impacts.

Elemental mercury

Elemental mercury is a silver-white liquid (quicksilver) primarily obtained from the refining of mercuric sulphide in cinnabar ore. It is used in electrical equipment, for example thermostats and switches, fluorescent light bulbs, thermometers, sphygmomanometers, barometers and in artisanal mining (ATSDR 1999). 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.

▶ **Figure 2. Bioaccumulation of mercury from anthropogenic and natural sources (Martinez 2020)**



Inorganic mercury

Inorganic mercury compounds (mercury salts) are formed when mercury combines with other elements such as chlorine, sulphur or oxygen. They are 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

Organic mercury compounds are 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. Bioaccumulation occurs as large fish eat smaller, methylmercury-containing fish, increasing organic mercury concentrations as it moves up the food chain (Figure 2). 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.

Mercury in the workplace

Working environments presenting potential sources of mercury exposure include facilities where production processes are carried out, for example, in chlor-alkali production and ASGM, and those where mercury is released as a by-product, for example during coal-burning. Workers may also be exposed when handling mercury-containing products. This may occur during all stages of the product's life cycle, including production, useful product life and during disposal, for example recycling, incineration or waste picking. Examples of these processes and products are shown in Table 1.

Table 1. Common sources of occupational mercury exposures

Production processes (Mercury is either used in the process or is released as a by-product)	ASGM Primary mercury mining Other non-ferrous ore mining 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

Global mercury trade

Box 1. Provisions for global trade, as set out by the ILO Chemicals Convention, 1990 (No. 170)

Article 19 of Convention No. 170 states: “When in an exporting member State all or some uses of hazardous chemicals are prohibited for reasons of safety and health at work, this fact and the reasons for it shall be communicated by the exporting member State to any importing country.”

Mercury supply

According to UNEP (2017), the five main mercury supply sources are:

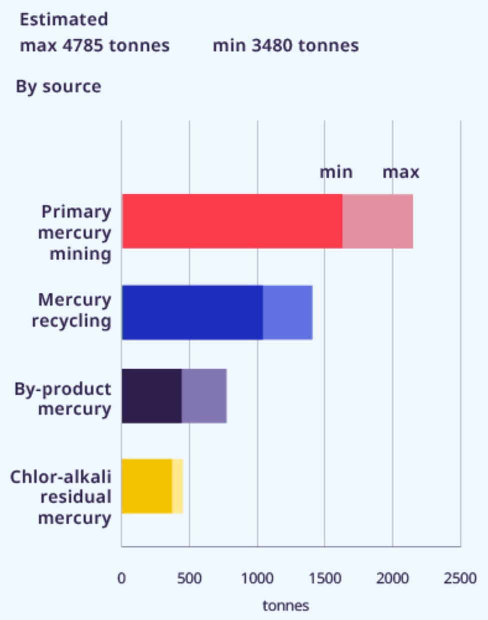
1. Primary mercury mining of cinnabar ore
2. By-product mercury recovery from non-ferrous metal mining or oil and gas processing
3. Decommissioning of mercury-cell chlor-alkali facilities
4. Recycling of mercury-added products
5. Net change in government or private stocks of mercury

Whilst the quantity of mercury available on the open market from the chlor-alkali industry has declined in recent years, primary mercury mining has increased overall in response to strong demand. Estimated mercury supply in 2015 is shown in Figure 3.

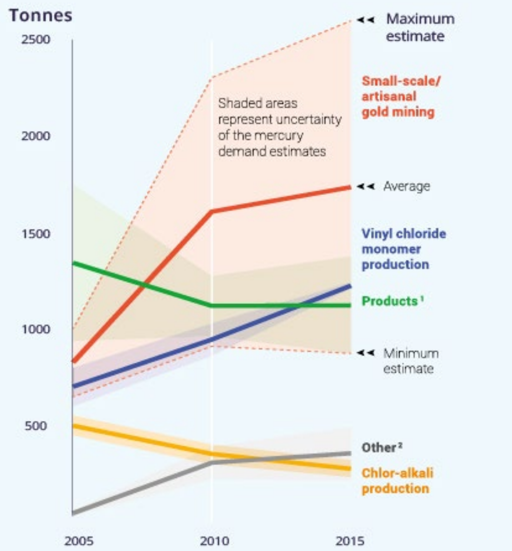
Mercury demand and consumption

The major mercury uses 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). Figure 4 and Table 2 show changes in mercury demand by sector between 2005 and 2015. Due to the high price of gold, the extent of ASGM has steadily increased since 2000, corresponding to a high mercury consumption in this area. Whilst VCM production using mercury has also increased, the use of mercury in the chlor-alkali industry has declined significantly. Mercury use in most product categories has similarly decreased, as a result of regulation, increased knowledge of environmental impacts and the provision of mercury-free alternatives, however significant differences do exist between regions. In addition, the use of some mercury-containing products continues to rise, including measuring and control devices and lamps.

▶ Figure 3. Global mercury supply in 2015 (UNEP 2018)



▶ Figure 4. Mercury demand by sector (with uncertainties) (UNEP 2017)



1. Batteries, dental applications, measuring and control devices, lamps, electrical and electronic devices
2. Paints, laboratory, pharmaceutical, cultural/traditional uses, etc.

In terms of geographic region, East and Southeast Asia regions predominate in overall mercury consumption, particularly in ASGM, VCM production, batteries and measuring and control devices (Tables 3 and 4). 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).

▶ Table 2. Global mercury consumption by sector (UNEP 2017)

Sector mercury consumption (tonnes)	2015	2010	2015
Small-scale/artisanal gold mining	650-1,000	912-2,305	872-2,598
Vinyl chloride monomer (VCM) production	600-800	860-1,030	1,210-1,241
Chlor-alkali production	450-550	300-400	233-320
Batteries	300-600	230-350	159-304
Dental applications	240-300	270-341	226-322
Measuring and control devices	150-350	219-280	287-392
Lamps	100-150	105-135	112-173
Electrical and electronic devices	150-350	140-170	109-185
Other (paints, laboratory, pharmaceutical, cultural/traditional uses etc.)	30-60	222-389	215-492
Total	**3,000-3,900**	**3,258-5,400**	**3,404-6,027**

Table 3. Global mercury consumption by geographic region (UNEP 2017)

Regional mercury consumption (tonnes)	2005	2010	2015
East and Southeast Asia	1,600-1,900	1,697-2,638	1,931-2,882
South Asia	300-500	124-182	192-334
European Union	400-480	314-470	194-304
CIS and other European countries	150-230	115-189	113-230
Middle Eastern States	50-100	77-106	79-136
North Africa	30-50	22-29	29-52
Sub-Saharan Africa	50-120	216-506	234-660
North America	200-240	191-275	107-167
Central America and the Caribbean	40-80	54-88	51-104
South America	140-200	433-897	458-1,130
Australia, New Zealand and Oceania	20-40	15-20	16-27
Total	**3,000-3,900**	**3,258-5,400**	**3,404-6,027**

Note for Table 2 and Table 3 (from UNEP 2017): Rather than "demand," the term "consumption" is used here to indicate the mercury content of all mercury-added products used in a given country or region during a given year, as well as the gross mercury inputs of any industrial process. For example, although most energy-efficient lamps (such as compact fluorescent lamps) are produced in China and therefore represent basic Chinese "demand" for mercury, many of them are exported, used and disposed of in another country, which is the actual place of "consumption." If mercury-added products consumed in a country are also produced in the same country, then all of the mercury that goes into their production (and related production waste) is also included in the calculation of consumption. Likewise, all mercury used in dental practices should be included in the calculation of a country's mercury consumption. If mercury happens to be consumed, recycled and consumed again in the same year, it would be counted two times as consumption, consistent with the overall level of activity.


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Table 4. Mean mercury consumption by region and by major application (UNEP 2017)

Region	ASGM	VCM production	Chlor-alkali production	Batteries	Dental applications	Measuring and control devices	Lamps	Electrical and electronic devices	Hg compound and other applications[2]	Regional totals
	Mean[3]	Mean[3]	Mean[3]	Mean[3]	Mean[3]	Mean[3]	Mean[3]	Mean[3]	Mean[3]	Mean[3]
East and Southeast Asia	645	1,215	8	95	52	208	69	52	62	2,407
South Asia	4	5	27	33	72	39	12	12	59	263
European Union (28 countries)	0	0	85	8	56	3	13	1	84	249
CIS and other European countries	24	6	45	13	19	12	7	7	37	171
Middle Eastern States	0	0	38	13	13	18	7	9	9	107
North Africa	0	0	11	8	4	6	4	2	4	41
Sub-Saharan Africa	366	0	1	24	7	11	5	19	15	447
North America	0	0	8	9	32	2	8	19	61	137
Central America and the Caribbean	16	0	19	9	6	9	4	6	8	78
Australia, New Zealand and Oceania	0	0	0	**1**	**3**	**1**	**3**	**13**	**1**	**22**
Total per application	**1,735**	**1,226**	**277**	**231**	**274**	**330**	**142**	**147**	**354**	**4,715**

Note 1 – The term “consumption” is defined here in terms of the end-use of mercury-added products, as opposed to overall regional “demand” for mercury. For example, although most energy-efficient lamps (such as CFLs) are produced in China and therefore represent basis Chinese “demand” for mercury, many of them are exported, used and disposed of in other countries, representing the actual place of “consumption.”

Note 2 - “Mercury compounds and other applications” include uses of mercury in cosmetics, pesticides, fungicides, catalysts, chemical intermediates, porosimeters, pycnometers, pharmaceuticals, traditional medicine, cultural and ritual uses, etc.

Note 3 – The values presented here are the means of wider ranges of estimates representing various levels of uncertainty, depending on the application.

Sectors where mercury is used

Artisanal and small-scale gold mining (ASGM)

Whilst the ILO does not provide a standard definition of ASGM, it acknowledges that the operations often share specific characteristics, such as a low level of mechanization, physically demanding work, modest productivity, poorly qualified employees and minimal levels of safety, health, environment and social security awareness (ILO 2016a). United National Environment Programme (UNEP) defines ASGM as "gold mining conducted by individual miners or small enterprises with limited capital investment and production" (UNEP 2013).

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 2019a). ASGM largely occurs in low- and middle-income countries (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).

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Gold extraction with mercury is the most commonly used extraction method in ASGM, because it is cheap, quick and easy and can done by one person independently (UNEP 2012a). Whole-ore amalgamation (WOA), where mercury is added directly to the gold ore during the grinding or crushing process, is a major source of pollution and has been identified as worst practice, to be eliminated under Annex C of the Minamata Convention. This process is most common in Bolivia, China, Colombia, Ecuador, Indonesia, Peru, the Philippines, Suriname and Venezuela (UNEP 2017).

ASGM workers are exposed to dangerous levels of mercury vapour

ASGM workers were identified as one of four populations of concern for mercury exposures, above general population levels (Basu et al. 2018). Mercury use in ASGM is particularly hazardous and workers are at high risk of toxic exposures specifically due to the way mercury is handled and used. The most direct route of exposure is via inhalation of mercury vapour from heated amalgam, for example during the open burning process or smelting (WHO 2016a). 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 2012a). This means that all workers in the area may be exposed to hazardous mercury levels, even those not directly handling mercury (Gibb and O'Leary 2014). Workers can also be exposed to elemental mercury vapour if liquid mercury is not properly stored, if surfaces are contaminated or they are in contact with contaminated waste material (WHO 2016a).

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, a urinary concentration where renal tubular effects are believed to occur, and 100 μg mercury/g-creatinine a urinary concentration where the probability of developing the classical neurological signs of mercury intoxication is "high" (WHO 2013).

Case study:
Exposure in 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).

Work tasks and exposure risk vary by gender and age

Millions of people in the developing world depend on ASGM for their livelihoods. It is associated with a host of labour and social issues, including poor working conditions, hazardous child labour, mercury emissions and environmental destruction (ILO 2019b). Workers often have limited training and low literacy rates, placing them more at risk (WHO 2016a). The work is frequently informal, and mining authorities may lack funding and the resources to effectively supervise and monitor ASGM. Techniques are often inefficient, product quantities are small and profits are low (Barry 1996). Despite the risks 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). For example, a recent study of the socio-economic benefits of ASGM in Malawi, found that ASGM has helped alleviate poverty in places and situations where other industries could not (Haundi et al. 2021).

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). Tasks carried out by females vary according to region. For example, in Bolivia, women mainly gather and process ore, often using sledgehammers, whilst in Africa they are involved in all aspects of mining including digging, crushing, transporting, sorting, processing and trading (WHO 2016a). In Africa, 40 to 50 per cent of the ASGM workforce are women (IGF 2017).

Almost all work performed by children in ASGM is hazardous and has characteristics that fit the definition of a "worst form of child labour" under the ILO Worst Forms of Child Labour Convention, 1999 (No. 182) (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 2016a). Girls often participate in wet and dry panning, extraction and amalgamation, whilst boys are involved in extraction and processing (ILO 2005).

▶ Box 2. Other mining activities involving mercury

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

- **Primary mercury mining:** Mercury is currently only mined in China, Mexico, Indonesia and the Kyrgyz Republic (UNEP 2017). In 2019, the world production of mercury from mining was 4,000 metric tonnes and the leading global producer was China (3,500 metric tons) (USGS 2020). Both China and Mexico have ratified the Minamata Convention, so all existing mines are to be phased out within 15 years of that date.
- **Non-ferrous ores:** Mercury may appear as a trace contaminant in other non-ferrous ores, including zinc, gold, lead and copper ores. By-product mercury is generated from non-ferrous mining operations, which is a preferable source of mercury to primary mining. Most of 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. In some locations, quantities are high enough to cause serious equipment problems during processing if the mercury is not removed (UNEP 2006).

Healthcare

Healthcare workers may be exposed to mercury when handling broken mercury-containing devices, such as thermometers, during the disposal of medical waste and when performing certain procedures, for example during dental treatments. The healthcare sector employs a sizeable number of workers in many regions, particularly in developing countries.

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. Of all mercury instruments used in healthcare, the largest amount of mercury is used in mercury sphygmomanometers (80 to 100g/unit), and their widespread use make them one of the largest mercury reservoirs in the healthcare setting (WHO 2005). Although suppliers now offer mercury-free alternatives, production of mercury-containing devices in some countries continues, for example China. Global mercury use in measuring devices in 2015 is estimated to range from 267-392 tonnes, although not all of this can be attributed to healthcare directly (UNEP 2017).

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. 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). 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, making the mercury difficult to remove. 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).

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 in the world, 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 therefore be at risk of mercury exposure when placing mercury fillings, removing teeth containing filling and disposing of mercury waste (Al-Zubaidi and Rabee 2017).

There is evidence in the scientific literature of elevated mercury levels in the body fluids and tissues of dental workers, compared to control groups (Nagpal et al. 2016), with one study reporting that dentists had urinary mercury concentrations over four times that of control subjects (Ritchie et al. 2002). Another study of occupational exposure of dental workers to amalgam in four dental clinics in Baghdad, found that mercury vapour concentrations in the indoor air of some dental clinics exceeded OSHA short-term exposure limits (Al-Zubaidi and Rabee 2017). Additionally, increased blood mercury levels were associated with lower standards of safety and hygiene, for example with poor ventilation systems and improperly cleaned amalgam spills (Nagpal et al. 2016).

Industrial production

Industrial use of mercury in production processes, such as chlor-alkali production and VCM production, can result in occupational mercury exposure for workers, as well as exposure for populations living near industrial sites.

Vinyl chloride monomer (VCM)

VCM is mainly used to produce PVC, the global demand for which has grown rapidly, particularly in developing countries. Indeed, the VCM industry is the second largest mercury user after ASGM (UNEP 2017). This carbide-based process to produce VCM involves using mercury-dichloride as a catalyst. It is of particular concern, as it is not known how much mercury is released and in what form (Hui et al. 2017). Workers in VCM production may be exposed to elemental mercury and therefore toxic mercury vapours, however research in this area is scarce. Concerns also exist regarding the management of mercury waste streams, including the spent catalyst and activated carbon filters. It is likely that workers working with this type of mercury waste may also be exposed to unhealthy levels of the toxin. Whilst VCM production has been phased out in most countries, production in China, mainly in Inner Mongolia, Xinjiang, Shangdong, Henan and Tianjin, is at an all-time high (UNEP 2017). Limited production also occurs in India and Russia (UNEP 2017).

Chlor-alkali sector

The mercury-cell process, using mercury as a catalyst, is one of three manufacturing processes used by the chlor-alkali sector to produce chlorine and caustic soda. Mercury waste is generated during this process, which is released into the environment or recycled. There are significant variations between companies in the amount of mercury released during production, with some plants consuming 10-20 times more mercury per unit capacity than the best performing plants. This process is on the decline however, as facilities have been converted to mercury-free processes or replaced by new mercury-free facilities. In 2005 there were about 9 million tonnes of global chlorine capacity using mercury cell technology, however in 2015 this had declined to 4.8-5.0 million tonnes (UNEP 2017). 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). The European Union, which historically has relied quite heavily on mercury cell technology, has placed its member states under increasing regulatory pressure to develop plans to close or convert all 27 plants that were still operating at the end of 2015 (UNEP 2017).

Chlor-alkali workers are mostly exposed through breathing air polluted with mercury vapours released from chlor-alkali electrochemical reactors 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).

Acetaldehyde sector

Acetaldehyde production using mercury-sulphate as a catalyst has almost entirely been abandonned, following the famous mercury pollution tragedy that occurred in Minamata Bay, Japan in 1950s and 60s. A limited number of companies in the world still use the technology, however alternative, non-mercury processes are now common globally.

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). Although coal contains only low concentrations of mercury, it is burnt in very large volumes. There is therefore the potential for occupational exposure when coal is burnt in coal-fired power plants, industrial broilers and stoves, however extremely limited evidence exists regarding the scale of these exposures. Despite a growing number of countries moving away from coal, global demand is expected to remain steady over the next 5 years (IEA 2018) and while some power plants already control their emissions of mercury, many do not have advanced pollution control equipment (USEPA n.d.).

Oil and natural gas processing

Most oil and natural gas contain mercury in trace quantities. Although there is potential for worker exposure to toxic mercury at plants that process gas and liquids that contain mercury, the concentrations of mercury found in oil and natural gas are generally too low for any serious health risk to be generated from exposure. In addition, due to the harmful effects of oil and natural gas on humans, normally there will be controls in place to prevent workers coming into contact with these fluids, and hence the mercury. The biggest potential risk to workers arises during plant shutdowns or during maintenance work when mercury that has accumulated onto the internal surface of processing equipment via adsorption can be released to the atmosphere (UNEP, n.d.). This process of releasing mercury is accelerated if any hot work is carried out (e.g. cutting or welding) and can be particularly problematic in confined spaces where the mercury concentration could potentially rise above the occupational exposure limit (OEL) (UNEP, n.d.). If not monitored and controlled correctly, a plant processing oil and gas containing mercury can lead to worker exposure during maintenance and plant shutdowns (UNEP, n.d.).

Manufacturing

Workers in many different manufacturing industries may be exposed to mercury during the course of their work. Those at risk include workers involved in the manufacture of mercury-containing products, such as mirrors, thermometers, fluorescent lights, batteries and paint, workers in electrical equipment manufacturing and the automotive industry and employees at chemical processing plants. Organic mercury poisoning can also occur among exposed workers in the paper and pulp industries.

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

Construction

Workers in the construction industry may be exposed to mercury when doing building and remedial work at contaminated sites, as well as during the installation, removal and disposal of mercury-containing devices, such as fluorescent lights (ATSDR 1999).


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Other mercury-containing products

E-waste

Mercury use in electrical and electronic devices in 2015 was estimated at 109-185 tonnes globally (UNEP 2017). 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). Mercury is also found in switches and relays, which are used in a variety of consumer, commercial and industrial products, including appliances, space heaters, ovens, air handling units, telecommunication circuit boards, commercial and industrial electric ranges security systems, levelling devices and pumps (NEWMOA n.d.).

Use of these devices as been reduced in many countries, for example, the EU, Canada, Japan and China, due to the availability of mercury-free alternatives and legislation prohibiting the sale of new mercury-containing products (UNEP 2017).

Nonetheless, mercury use remains significant, and it is likely that mercury switches and relays will be present in waste for years to come due to a very long service life of these items.

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). Evidence suggests that solid waste management and recycling provide employment for 19 to 24 million women and men worldwide, of which only four million work in the formal waste and recycling sector (ILO 2013b). It has been estimated that informal and formal e-waste workers are over 690,000 in China (Wang et al. 2013), 500,000 in India (Joon and Shahrawat 2017), 100,0000 in Nigeria (Ogungbuyi et al. 2012) and 34,000 in Argentina (ILO 2020a). High-volume informal recycling of e-waste has also been reported in Ghana, the Philippines, Thailand, and Vietnam (Orisakwe et al. 2020).

Box 3: What is e-waste?

Electronic and electrical waste (e-waste) is defined as any end-of-life "equipment which is dependent on electrical currents or electromagnetic fields in order to work properly" This includes: small and large household appliances; information technology and telecommunications equipment; lighting equipment; electrical and electronic tools, toys, and leisure and sports equipment; medical devices; monitoring and control instruments; and automatic dispensers, components and parts of electrical and electronic equipment (batteries, circuit boards, plastic casings, cathode-ray tubes, activated glass, lead capacitors etc). In 2016, Asia was the region that generated by far the largest amount of e-waste (18.2 million tonnes - Mt), followed by Europe (12.3 Mt), the Americas (11.3 Mt), Africa (2.2 Mt), and Oceania (0.7 Mt) (ILO 2021).

LMICs generally have less e-waste management infrastructure than higher income countries and workers at these sites are often exposed to a cocktail of toxic and harmful chemicals, including mercury (Balde et al. 2017). Waste scavenging is frequently informal, with limited access to health surveillance, medical monitoring or personal protective equipment (PPE). Informal recycling activity may consist of manual disassembly or the use of instruments such as hammers, thermal heating to melt plastics and separate components from printed circuit boards and cables, and acid baths for the recovery of gold and other metals (Gouveia et al. 2019). In an informal e-waste recycling site in China, the levels of inorganic mercury in worker hair samples were much higher than in reference samples, showing correlation with working time (Tang et al. 2015). Even in formal recycling companies in Sweden, despite the adoption of safety measures, e-waste recycling workers had 20 times the mercury concentration in air samples compared to administrative staff and there was a significant correlation between urine mercury concentrations and air concentrations (Julander et al. 2014).

In many countries, women and children play dominant occupational roles in e-waste, increasing their risk for potential mercury exposure. For example, the electronics industry in Vietnam employed 634,440 people in 2016, where around 70 per cent of the workforce was female. Over 85 per cent of those workers were under the age of 35 (UNIDO 2019). In some countries, the work tasks are segregated by gender, with men collecting the waste and women and children conducting manual processing, which may carry a higher exposure risk (UNEP 2020a). A systematic review showed that pregnancy outcomes were negatively affected in workers exposed to e-waste, including increases in spontaneous abortions, stillbirths, premature births and reduced birth weights (Grant et al. 2013).

Compact fluorescent lamps (CFLs)

Whilst the move to sustainable energy sources undoubtedly provides numerous benefits to human health and the environment, the use of energy-efficient mercury-containing products has risen as a result in many regions. The risks to workers who handle these products regularly must be considered.

The use of compact fluorescent lamps (CFLs) has increased dramatically over the past years, as they are 75 per cent more energy efficient than incandescent light bulbs and have a greater useable lifespan (Bose-O'Reilly et al. 2010). China remains the world leader in production and consumption of mercury-added lamps and incentives for reduced energy demand have increased the use of CFLs in many countries (UNEP 2017). Whilst energy-efficient, but mercury-free alternatives do exist, such as light-emitting diodes, these are expensive and availability may be limited in some locations.

CFLs often contain substantial mercury concentrations, and 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). As an illustration of the effects of CFL breakage, the release of only 1 mg of mercury vapour (approximately 20 per cent of the mercury inventory in a single CFL) into a 500 m^3 room yields 2.0 $\mu g/m^3$ or ten times the ATSDR-recommended level of 0.2 $\mu g/m^3$, in the absence of ventilation (Johnson et al. 2008). Exposures could therefore be substantial in places where breakages occur frequently, for example during production, or in recycling facilities where lamps are purposefully broken.

A study of occupational exposure to mercury vapour carried out at a CFL factory in Iran found that lamp breakage was the main source of mercury vapour in the CFL factory, with vapour quantities dependent on the amount of mercury in the lamp and lamp age (Darvishi et al. 2019). In addition, workers in different areas of the factory had different urinary mercury levels. The production line supervisor had the highest levels because she was responsible for the removal of broken lamps and was exposed to greater than 29 mg/m^3 of mercury vapour for 8 hours per day, 6 days per week. Another study of mercury exposure during the demolition of a CFL factory reported cases of acute mercury poisoning in workers (Do et al. 2017).

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, while still considerable, is in decline.

Mercury has mainly been used in non-rechargeable batteries. It is used in particularly high concentrations in mercury oxide batteries, although exists in other batteries too. Button-cell shaped batteries of alkaline, silver oxide, and zinc/air types normally still contain mercury in most cases, though mercury-free alternatives are now available. 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).

Limits on the mercury content of some batteries have been incorporated into the Minamata Convention. For the main battery type affected by the Minamata Convention (alkaline manganese button cells), China is the major producer (UNEP 2017). Other large exporters include Belgium, Indonesia, Singapore and the United States (UNEP 2017).

Niche exposures

Cosmetics

Inorganic mercury is used in various 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 2019a). 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). Mercury-containing skin lightening products are manufactured in many countries and areas, including Bangladesh, China, Dominican Republic, Jamaica, Lebanon, Malaysia, Mexico, Pakistan, Philippines, Republic of Korea, Thailand and the United States (WHO 2019a). Various studies have found that mercury content of skin-lightening creams can be at levels which are hazardous to human health (EEB 2018). Whilst the danger to consumers is clear, evidence regarding the impact of workers in production facilities is minimal. It is possible that workers in cosmetics factories around the world are at risk, and more research is needed on this subsector.

Textiles

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

Gilded crafts and religious idols

Mercury can be used in gold plating in a process called "mercury gilding" or "fire gilding", practiced in the manufacturing of gilded crafts and religious idols. This involves mixing metallic mercury and gold particles to form a paste which is applied to the idols. The mercury is then burned off, leaving a gold coating and exposing the workers to the mercury vapours (IPEN 2014).

Other light sources

Aside from CFLs, workers using other light sources may also be at risk of mercury exposures. Other light sources containing mercury include high-pressure mercury vapour lamps, high-pressure sodium lamps, UV light for tanning, metal halide lamps, specialty lamps for chemical analysis, and backlights for computer and TV flat-screens (Martinez 2020).

Agricultural workers using biocides and pesticides

Mercury pesticides and fungicides were banned in most countries in the 1970s and 80s and have been classified as highly hazardous pesticides by the WHO, the United Nations and the Food and Agriculture Organization (Broussard et al. 2002). Most countries no longer allow these pesticides to be manufactured or marketed for crop protection due to their toxicity (UTZ 2015). Despite this, stockpiles of mercury-containing pesticides are likely to exist and controlling usage is problematic. Additionally, Australia is yet to ratify the Minamata Convention and only banned the use of mercury-containing pesticides in 2020. Until recently many sugar cane farmers used Shirtan, a fungicide containing mercury, the long-term health impacts of which are unknown (Schneider 2021).

Nanotechnology

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. These compounds were used to extend shelf-life by controlling bacterial fermentation in the can and to retard fungus attacks upon painted surfaces under damp conditions (fungicides).

Case study:
High levels of mercury exposure in gold plating in Nepal

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.

The lengthy process of amalgam-making involves mixing mercury and gold together by hand using a pestle and mortar to make amalgam, applying amalgam paste to the metal statues and then heating off the mercury to leave a gold coating. Workers are exposed during all stages of the gold plating process, including mixing the amalgam, applying amalgam to the statues, heating to evaporate the mercury, and finally washing and shining. Exposure is through mercury vapour inhalation and dermal absorption.

The Government of Nepal signed the Minamata Convention on 10th of October 2013. According to the 2019 Minamata Initial Assessment (MIA) for Nepal, gold plating is the highest source of mercury emissions in Nepal. Total annual emissions are estimated to be 19,615kg of mercury, with gold plating accounting for over 65 per cent of this (MOFE, Government of Nepal 2019).

Biomonitoring of 20 female metal plating workers revealed hair mercury concentrations similar to those of ASGM workers using mercury amalgam (IPEN 2017). The average level of mercury in women's hair, reflecting mercury exposure and subsequent body burden was 3.62 ppm, with levels ranging from 0.35 to 28.46 ppm. 75 per cent of samples exceeded 1 ppm, which equates approximately to the United States Environmental Protection Agency's (USEPA) reference dose for mercury in human hair (USEPA 2001).

Aside from direct exposures from their tasks, workers and nearby communities are also subject to high levels of environmental exposures from contaminated air, water and soil in the workplace. A 2020 report by the Center for Public Health and Environmental Development (CEPHED), a national level NGO in Nepal working on chemical safety, occupational safety and health (OSH) and workers' rights, demonstrated that untreated wastewater from metal plating workshops contained very high levels of mercury (ANROEV 2021). The mercury content of water sourced from five workshops ranged from 0.627 mg/L to 11478 mg/L, which is 62.7 to 1,147,800 times more than the Nepal Generic Standard of Wastewater Effluent for Waterways.

Workplace protections such as PPE are negligible, and the vulnerability of workers is further amplified by a lack of information and limited awareness of the toxic effects of mercury. Research findings indicate that workers are at high risk of adverse health impacts from hazardous mercury exposures. Swift ratification of the Minamata Convention by the Government of Nepal is essential and metal plating processes using mercury should be included in the Convention. Urgent measures are needed to improve safety at the workplace level, for example, through the introduction of sound mercury recovery technologies or completely shifting to alternative metal plating processes, such as electroplating. Medical surveillance systems are also vital, combined with treatments for those already exposed and suffering from mercury-related disease.

Source of text and photos: Ram Charita Sah, CEPHED, Nepal

Main health outcomes

Exposure pathways

Mercury is highly toxic and can adversely impact the health of workers of all ages. Occupational exposure to mercury can cause serious injury or illness, resulting in long-term disability and chronic conditions. Mercury exposure may occur through inhalation, ingestion or dermal contact (Table 5).

Table 5. Mercury absorption – key facts

Inhalation	▶ Inhalation of elemental mercury vapour is the main source of occupational exposure (WHO 2017). For example, in the chlor-alkali industry, inhalation accounts for over 90 per cent of all mercury absorbed into the body (Euro Chlor 2010). ▶ Another common exposure to metallic mercury occurs when mercury is released from a mercury-containing product that breaks. A harmful contamination of the air can be reached very quickly on evaporation of mercury at 20°C (ILO 2019c). ▶ 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. Whilst this is form of mercury is not associated with occupational exposures specifically, contamination of food sources may be a problem for those workers and their families living near their worksites. ▶ Ingestion of mercury in the workplace may occur when hygiene standards are limited, for example from unwashed hands.

Exposures may be acute, for example due to an industrial accident, or chronic, where workers may be exposed to lower concentrations over a long period of time. The toxic effects and severity of health impacts are determined by factors such as: (i) type of mercury; (ii) dose of exposure; (iii) age or developmental stage of the exposed individual; (iv) duration of exposure; and (v) route of exposure, either via inhalation, ingestion or dermal contact (WHO 2017; Martinez 2020). Pathways through the body of the different forms of mercury are shown in Table 6.

Table 6. Mercury pathways – key facts

	Absorption	Pathways through body
Elemental mercury	Inhalation is the main route of exposure. Approximately 80 per cent of inhaled mercury vapour is absorbed in the lungs. **Dermal absorption** is limited. **Oral ingestion** results only in a very limited absorption (<0.01 per cent of dose).	Due to the high lipid solubility, elemental mercury rapidly penetrates alveolar membranes and is then distributed to all tissues of the body. The primary target organs of elemental mercury are the brain and nervous system, as well as the kidneys. It can cross the blood-brain barrier and blood-placenta barrier.
Inorganic mercury	**Ingestion** is the main exposure route, with approximately 7 per cent to 15 per cent of doses absorbed in the gastrointestinal tract. Mercury intoxication symptoms have been reported for **dermal absorption**.	The highest concentration of inorganic mercury is found in the kidney, which is a major target organ of inorganic mercury. It is not lipid soluble, so is unable to cross the blood-brain barrier.
Organic mercury	Organomercury compounds 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. The central nervous system is the major target organ following exposure to methylmercury and most other organic mercury compounds.

Sources: WHO 1991, WHO 2021a, Park and Zheng 2012, Risher et al. 2002

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 2021a). The Global Burden of Disease for mercury is shown in Table 7.

Elemental mercury

Inhalation of elemental mercury vapour can produce harmful effects on the nervous, digestive and immune systems, lungs and kidneys (WHO 2017). High inhalational exposures can also lead to respiratory failure and death (Landrigan and Etzel 2013).

The central nervous system is the most sensitive target for elemental mercury exposure, with chronic and acute exposures eliciting similar neurological effects. Neurotoxic symptoms may include tremors, insomnia, memory loss, neuromuscular effects, headaches and cognitive and motor dysfunction (WHO 2021a). Studies of workers in fluorescent tube manufacturing, wood processing, chlor-alkali, and thermometer plants have demonstrated subtle central nervous system toxicity at mercury vapour concentrations in the air as low as 20 μg/m^3 (Poulin and Gibb 2008). The peripheral nervous system may also be affected resulting in slowed sensory and motor nerve conduction velocities.

Respiratory tract infection and renal damage may occur at higher mercury exposures (Poulin and Gibb 2008). Acute and chronic exposures have also been associated with cardiac effects, including hypertension, heart palpitations and increased heart rate, specifically in studies of chlor-alkali workers and mercury miners (Barregard et al. 1990; Boffetta et al. 2001; Kobal et al. 2004).

Inorganic mercury

The kidney is the critical target organ following ingestion of inorganic mercury, with chronic oral exposure resulting in renal damage. Other health impacts include gastrointestinal disturbances, skin rashes, eye irritation and muscle weakness. Acute high-dose oral exposure can induce severe gastrointestinal effects (WHO 2000).

In contrast to elemental and organic mercury, the inorganic form does not readily cross the blood-brain barrier and, therefore, does not have similar central nervous system effects. However, inorganic mercury may damage the peripheral nervous system (ATSDR 1999).

Organic mercury

The main route of exposure to organic mercury, specifically methylmercury, is through eating contaminated fish and seafood. Although not an occupational exposure, workers at some sites may face a double burden of exposure, from polluted food sources as well as occupational exposures. Workers handling organomercury compounds may also be exposed.

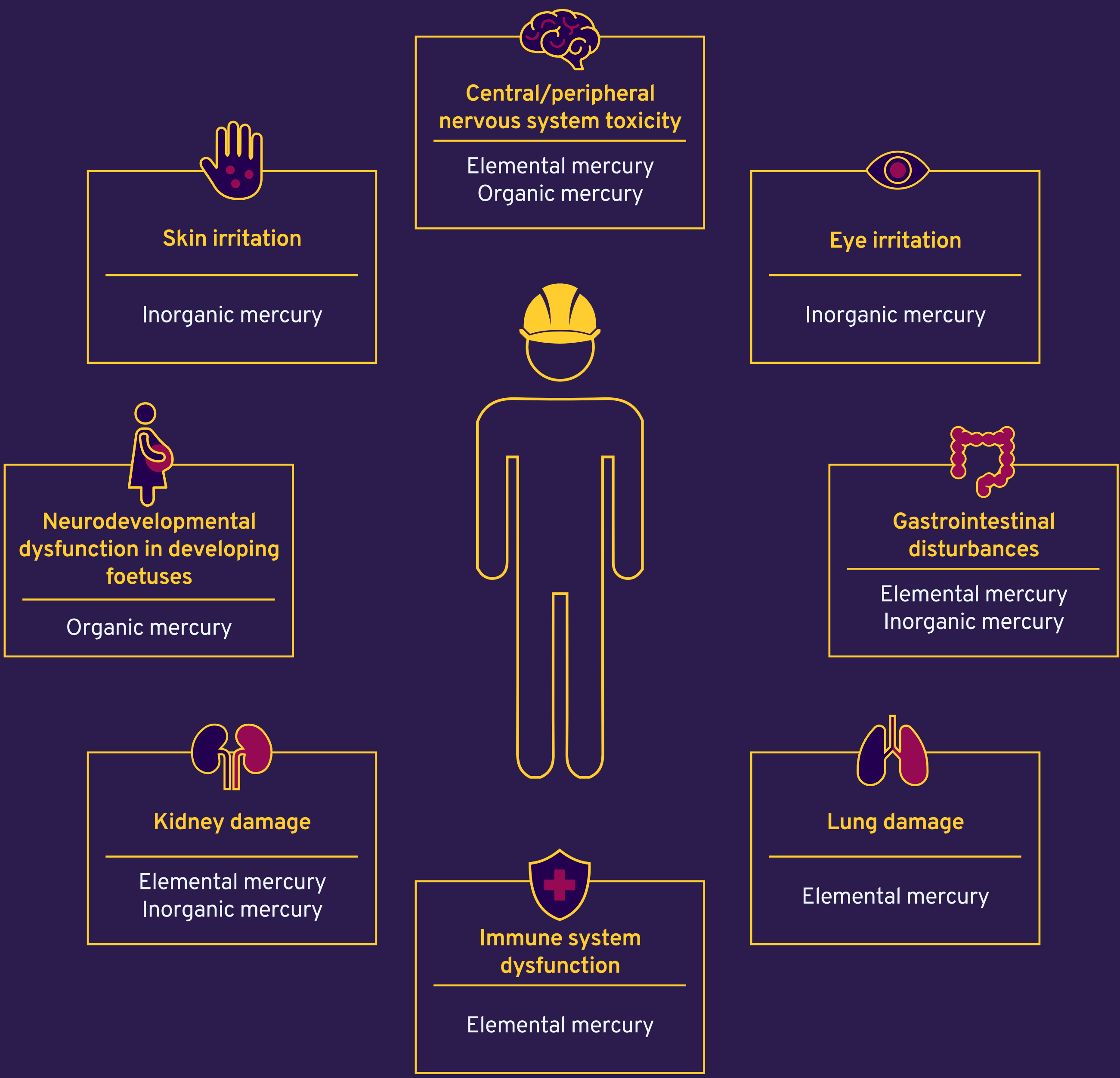
The central nervous system is the major target organ following exposure to methylmercury and most other organic mercury compounds. Neurological symptoms similar to those observed following elemental mercury exposure may be observed, including tremors, emotional changes, headaches, weight loss and insomnia. Pregnant women and their foetuses are particularly at risk and transplacental exposure may result in neurodevelopmental problems in the developing foetus (WHO 2021a).

An overview of the main health impacts of the different mercury forms are shown in Figure 5.

▶ **Table 7. Global Burden of Disease for mercury**

Primary health impacts	Global burden of occupational exposures	Work-related health impact
Neurotoxicity Nephrotoxicity Immune toxicity Reproductive toxicity	19,000,000 (Limited data for ASGM only) (Steckling et al. 2017)	Limited Data (>2,000,000 disability-adjusted life years (DALYs) attributable to chronic metallic mercury vapour intoxication) (Steckling et al. 2017)

Figure 5. Summary of the main health impacts of different mercury forms



Vulnerable worker groups

The specific health impacts of mercury on different vulnerable worker groups must be considered, including females, child labourers, migrant workers, and those with disabilities.

Gender and mercury

Recognising both social and biological gender differences is critical for protecting the health and safety of workers exposed to mercury. Men and women have different occupational roles, which will impact the type, magnitude and duration of mercury exposure. For example, in ASGM, men often participate in tasks requiring physical strength, such as digging and crushing, while women and children engage in amalgamation activities, increasing their risk of mercury exposure. Some women even burn amalgam in their homes, which contaminates their living environments (Diaz et al. 2020). Women are less frequently engaged in managerial positions and therefore lack decision-making power regarding hazardous exposures. They are also less likely than men to be organized in professional bodies and less likely to participate in OSH (ILO 2013a).

With regard to health effects, it is well evidenced that biological differences (physiological, chromosomal and hormonal) create diverse susceptibilities to the effects of toxic chemicals. Female workers are at particularly high-risk during child-bearing years and pregnancy, when even low doses of mercury can elicit dramatic and irreversible effects. Females are more likely to have more adipose tissue and to store chemicals that bioaccumulate, including heavy metals like mercury. Female workers exposed to mercury in ASGM, in the dismantling of e-waste, or other sectors, may face severe consequences to their reproductive health and exposure during pregnancy may result in spontaneous abortion, neurobehavioural consequences or birth defects. The fact that mercury can bioaccumulate means that occupational exposures even years before pregnancy can still negatively impact the developing foetus.

▶ Case Study:
Harmful levels of body mercury in indigenous Latin American women of childbearing age

An IPEN report entitled ‘Mercury Exposure of Women in four Latin American Gold Mining Countries’ analysed the mercury levels in 1631 indigenous women of childbearing age from Bolivia, Brazil, Colombia and Venezuela (Bell and Evers 2021). 58.8 per cent of the women exceeded the 1 ppm USEPA threshold level at which harmful effects may be detected in the foetus and 66.8 per cent exceeded the 0.58 ppm level, the lowest concentration in which there are recognizable negative impacts on the foetus. The highest mercury levels were found in the Bolivian indigenous Eyiyo Quibo and Portachuelo people, whose diet consisted mainly of fish obtained from rivers near gold mines. Communities evaluated in Brazil and Venezuela also had mercury in their bodies. The lowest mercury levels were found in the Colombian indigenous groups who did not live near mines and had non-fish-based diets. The report demonstrates that despite bans on mercury use in gold extraction, the practice likely continues in many regions, with dietary exposure to mercury-contaminated fish resulting in elevated mercury levels for those living nearby.

Children and mercury

The adverse impact of mercury exposure on children’s health is unique due to their developing physiology, anatomy, metabolism, and health behaviours. Developing children are especially vulnerable and may have different susceptibilities during different life stages, especially during “critical windows of development” (Landrigan et al. 2004). Children may inhale larger doses of mercury vapour than adults, as their lungs have a greater surface area relative to their body weight and they breathe faster. In addition, mercury vapour is heavier than air and higher concentrations may accumulate at lower heights near a child’s breathing zone (Besser 2009).

“

children working with mercury

showed symptoms of mercury intoxication,

including **ataxia and dysdiadochokinesia**, as well, as **high levels of urinary mercury** compared to non-exposed children

Exposure to very high mercury levels can cause irreversible neurodevelopmental damage to children's brain function, causing problems with attention span, language, visual-spatial skills, and coordination. Acrodynia (or 'pink disease), characterized by red and painful extremities, insomnia, irritability and light sensitivity, has been reported in young children as a result of chronic mercury exposure (WHO 2021a). Other mercury-induced health effects observed in children are like those seen in adults. Beyond the physical health impacts that children face, child labour can affect social, mental and psychological development. The effective abolition of child labour has been included as one of the four fundamental principles and rights at work[2].

Other vulnerable workers

Other groups of workers may face higher risks of being exposed to or affected by dangerous levels of mercury. Migrant workers, for example, may not speak the local language or dialect, making it difficult for them to understand chemical labels, safe handling procedures and training materials. Migrants and seasonal workers also frequently work in the informal economy, with many unable to negotiate safe and healthy working conditions, making them more susceptible to exploitation. The lack of regulation in these informal workplaces leaves many workers at risk, as they lack information and education of health hazards and may not have adequate or effective protective equipment. Disabled people have been shown to have generally poorer health outcomes (WHO 2011) and disabled workers may also face unique risks depending on their particular disability, making them vulnerable to mercury exposure and its effects.

Evidence from ASGM

A large systematic review of over 60 studies by Gibb and O'Leary (2014) looked at the health impacts of workers in ASGM. It found that workers, including many children, were exposed to dangerously high levels of elemental mercury vapour, as evidenced by urinary mercury concentrations. The most common adverse health impacts reported among workers were neurological effects, including tremor, ataxia, memory problems and vision disorders. Another study found that between 25 per cent and 33 per cent of miners were estimated to suffer from chronic metallic mercury vapour intoxication (CMMVI) (Steckling et al. 2017). Symptoms of CMMVI include ataxia, dysdiadochokinesia, tremor and restricted performance in neuropsychological testing (Steckling et al. 2017). The resulting Global Burden of Disease (GBD) was estimated to range from 1.22 to 2.39 million disability-adjusted life years (DALYs), with the highest burden in the WHO African Region (Steckling et al. 2017) (Figures 6 and 7). All figures are likely to be underestimated however, as data is limited and often low quality.

2 The fundamental principles and rights at work include: the effective abolition of child labour, elimination of discrimination in respect of employment and occupation, elimination of all forms of forced or compulsory labour and freedom of association and the effective recognition of the right to collective bargaining. For further information, consult the ILO's website here: https://www.ilo.org/global/about-the-ilo/how-the-ilo-works/departments-and-offices/governance/fprw/lang--en/index.htm

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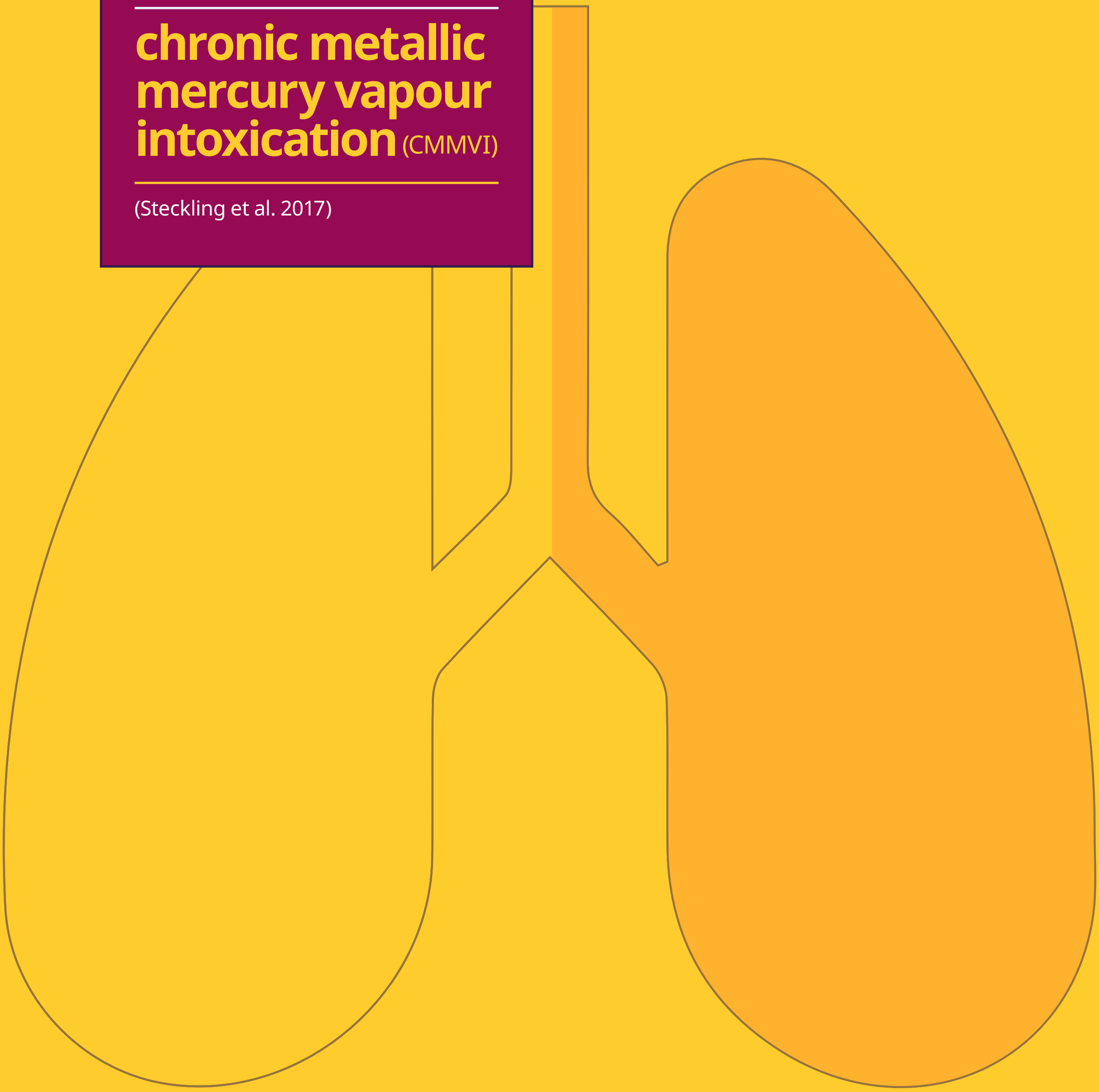
between

25% and 33%

of miners were estimated to suffer from

chronic metallic mercury vapour intoxication (CMMVI)

(Steckling et al. 2017)



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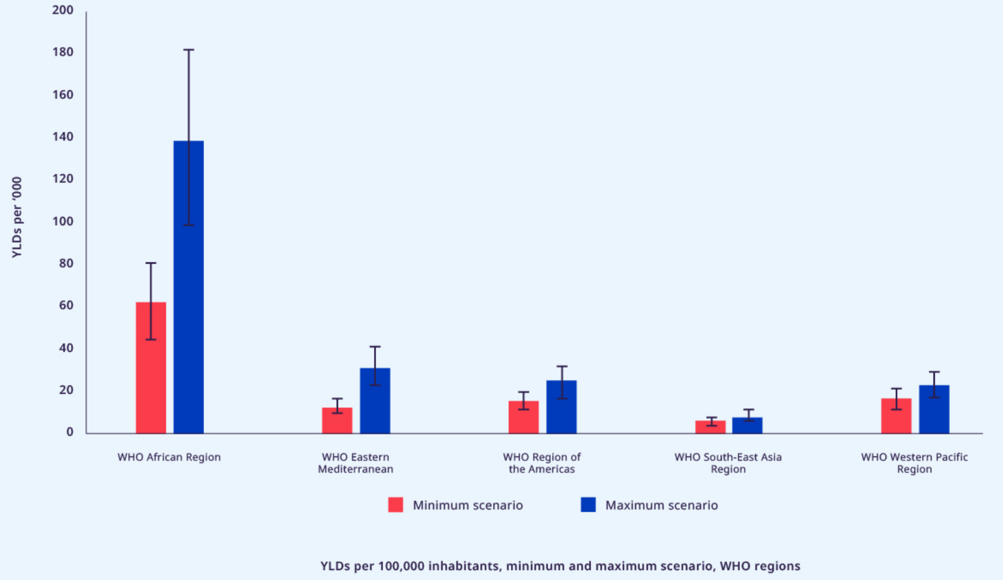
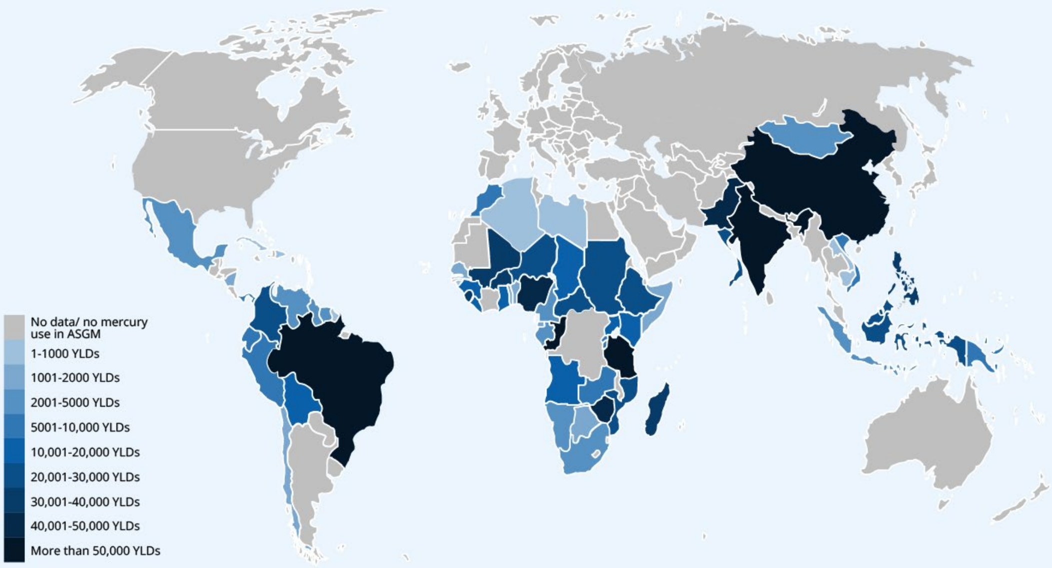
(Steckling et al. 2017)

▶ **Figure 6. Years lived with disability (YLDs) per 100,000 inhabitants by WHO regions (Steckling et al. 2017)**



▶ **Figure 7. Number of total years lived with disability (YLDs) corresponding to total DALYS (Steckling et al. 2017)**



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, and another in Venezuela, where 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).

A study carried out in Indonesia and Zimbabwe by Bose-O'Reilly, looking at mercury exposure in 80 children aged between 9 and 17 working in ASGM. It reported that children working with mercury showed symptoms of mercury intoxication, including ataxia and dysdiadochokinesia, as well, as high levels of urinary mercury compared to non-exposed children (Bose-O'Reilly et al. 2008). When considering the numbers of children involved in ASGM, the potential burden of disease in adulthood for former ASGM child labours is likely to be considerable.

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as the threshold beyond which there is a high probability of developing

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Evidence from chlor-alkali production facilities

A number of studies have investigated the impacts of mercury exposure on workers in the chlor-alkali industry. A study of mercury vapour exposure on workers over a 40-year period reported high urinary mercury concentrations for cell-room workers and mechanics, in particular (Nordhagen et al. 1994). It also found that the introduction of new cells and stabilizing the volume of production may have been important for reducing exposure, however other changes in production processes had little effect. Two other studies showed increased urinary mercury concentration in exposed workers, as well as increased incidence of neurophysiological problems such as fatigue, memory loss, blurred vision, depression and tremor (Hosseinabadi et al. 2020; Neghab et al. 2012).

Case study:
Mercury Exposures and Symptoms in Smelting Workers of Artisanal Mercury Mines in China

Mercury exposures to smelting workers of artisanal mercury mines in Wuchuan, China were evaluated by urine and hair mercury levels (Li et al. 2008). The mean urinary mercury (U-Hg), hair total mercury (T-Hg), and hair methyl mercury (Me-Hg) for smelting workers was 1060 µg/g creatinine (µg/g Cr), 69.3 and 2.32 µg/g, respectively. The results were significantly higher than that of control group, which is 1.30 µg/g Cr, 0.78 and 0.65 µg/g, correspondingly. The average urinary beta2-microglobulin (beta2-MG) was 248 µg/g Cr for the exposed group, compared to 73.5 µg/g Cr for the control group. The results showed a serious adverse effect on the renal system for the smelting workers. The workers were exposed to mercury vapour through inhalation and the exposure route of Me-Hg may be through intake of polluted diet. Clinical symptoms including finger and eyelid tremor, gingivitis, and typical dark-line on gums were observed in six workers. This study revealed that smelting workers in Wuchuan had higher levels of mercury in their urine and hair, and also exhibited higher levels of preliminary health impacts, evidenced by increased beta2-MG and clinical symptoms.

Case study:
Mercury exposures in ASGM

There are more than 850 ASGM hotspots identified in 27 provinces of Indonesia, most of which use mercury to extract gold (Yuyun Ismawati 2014). These provide livelihood to more than 1 million people. In 2015, a study was conducted in a small village (Pangkal Jaya) where all inhabitants either worked in the gold mining industry or were engaged in some way. Ore processing took place close to homes within residential areas. Samples were taken to assess mercury vapour in the air as well as within rice collected in the area. The average concentration of mercury vapour in the air was 4.154 nanogram/m^3, notably higher than recommended levels. The average mercury content in the rice samples was 143 ppb, almost three times higher than the safe level recommended by the government of Indonesia. Several community members and children showed severe symptoms of mercury poisoning such as mental retardation, cerebral palsy, muscular dystrophy and seizures.

Priority actions

This review demonstrates the need for prompt action to protect workers from the harmful effects of mercury across various economic sectors worldwide. Based on the priorities that emerged in this review, various actions have been identified that can help promote the safer management of mercury within the world of work and beyond. Priority actions should be implemented at both the policy level and the workplace level, with a strong foundation of social dialogue throughout.

Policy level actions

Implement a national OSH system for the sound management of chemicals

A strong national OSH system is critical for the effective implementation of policies and programmes on OSH and the sound management of mercury, and all hazardous substances in the workplace. Policies and programmes should follow a 'toxics use reduction' approach that prioritizes elimination. Policies for the sound management of chemicals should follow a systems approach, as outlined in the Promotional Framework for Occupational Safety and Health Convention, 2006 (No. 187) and Recommendation (No. 197). This should include:

- Laws and regulation, collective agreements where appropriate and any other relevant instruments on OSH pertaining to the sound management of chemicals.
- An authority or body, or authorities or bodies, responsible for OSH of chemicals, designated in accordance with national law and practice.
- Mechanisms for ensuring compliance with national laws and regulations regarding chemical management, including systems of inspection.
- Arrangements to promote, at the level of undertaking, cooperation between management, workers and their representatives, as an essential element of workplace-related prevention measures for the sound management of chemicals.

Box 4. Follow a 'toxics use reduction' approach

In line with the Minamata Convention, mercury use in products and processes should be phased out and replaced with mercury-free alternatives where possible. A 'toxics use reduction' approach is essential to prioritize the identification and use of safer alternatives to mercury. Economically viable alternatives to mercury are crucial and where necessary alternative sources of income must be identified. A 'one size fits all' approach will not be effective considering the many different populations and industries currently using mercury.

Ratify and implement key ILO instruments

The following are key ILO instruments that can be applied for protecting workers from OSH risks of exposure to mercury through an integrated approach. The provisions outlined in the instruments allow countries to develop or adapt their own legislative and regulatory frameworks on the safe handling of chemicals, and specifically mercury, in the workplace.

- **Promotional Framework for Occupational Safety and Health Convention (No. 187) and Recommendation (No. 197), 2006**

This Convention aims to promote a preventive safety and health culture and to progressively achieve a safe and healthy working environment. It emphasizes the need to ensure that higher priority is given to OSH in national agendas and to foster political commitments in a tripartite context for the improvement of OSH. It is a promotional rather than prescriptive Convention and is based on the application at the national level of a systems management approach to OSH. The Convention also defines the elements and function of the national policy, the national system and the national programme and discusses monitoring, evaluation and improvement of the national OSH system. Further operational details and mechanisms are provided in the Recommendation (No. 197).

- **ILO Occupational Health Services Convention (No. 161) and Recommendation (No. 171), 1985**

The Convention deals comprehensively with the provision of occupational health services and commits ratifying States to progressively develop occupational health services for all workers. The Convention provides for the status, organization and conditions of operation for health services. The functions of these services are to include surveillance of the working environment and of workers' health, information, education, training and advice, and first aid, treatment and health programmes. Further guidance is given in the supplementing Recommendation (No. 171).

- **ILO Occupational Safety and Health Convention (No. 155) and Recommendation (No. 164), 1981, and its Protocol of 2002**

The Convention lays down fundamental objectives and defines the basic principles of a coherent national OSH policy. It covers workers in all branches of activity and is the most comprehensive of the current standards. The key provisions require Member States, in consultation with the most representative employers' and workers' organizations, to formulate, implement and periodically review a coherent national policy on OSH and the working environment, the aim being the prevention of occupational accidents and injuries by eliminating or minimizing the causes of hazards. The Convention is supplemented by a Recommendation (No. 164) which provides further details and additional practical guidance on several of the provisions in Convention No. 155. The Protocol of 2002 to Convention No. 155 calls for the establishment and the periodic review of requirements and procedures for the recording and notification of occupational accidents and diseases, and for the publication of related annual statistics.

- **ILO Labour Inspection Convention (No. 81) and Recommendation (No. 81), 1947, and its Protocol of 1995**

The Convention lays down the main rules governing the establishment, organization, means, powers and obligations, functions, and competence of the labour inspectorate as an enforcement institution for protecting workers and for promoting legislation adapted to the changing needs of the world of work. The establishment of a labour inspection system is obligatory for industrial establishments and optional for commercial establishments. Pursuant to the Protocol to Convention No. 81, member States should extend the application of the Convention to activities in the non-commercial services sector. Convention No. 81 is supplemented by a Recommendation (No. 81), which provides further details on the preventive duties of labour inspectorates and the collaboration of employers and workers in regard to safety and health and annual reporting on inspection.

▶ ILO Chemicals Convention (No. 170) and Recommendation (No. 177), 1990

The Convention is general in scope and concerns all chemicals classified as hazardous that are used or produced in the workplace. It provides for a comprehensive national framework for the sound management of chemicals, including the formulation, implementation and periodic review of a coherent policy, in consultation with employers' and workers' organizations. A very important feature of the Convention are its provisions on chemical hazard communication designed to ensure that information on hazards and related preventive and protective measures flows from manufacturers and importers to the users. This includes requirements for the classification and labelling of chemicals, as well as regulating the production, handling, storage and transport of chemicals, the disposal and treatment of chemical wastes, the release of chemicals and the maintenance, repair and cleaning of equipment and containers for chemicals. At the workplace, the employer is required to ensure that all chemicals are identified, and that adequate information is available through labelling and safety data sheets, as well as to take all the necessary measures to eliminate, minimize or control exposure.

▶ ILO Prevention of Major Industrial Accidents Convention (No. 174) and Recommendation (No. 181), 1993

This Convention provides for precautionary measures to avoid or minimize the consequences of industrial disasters due to chemicals and other hazardous substances. The purpose of C174 is twofold: prevention of major accidents involving hazardous substances, and limitation of the consequences of such accidents. The Convention provides for the development of a "coherent national policy concerning the protection of workers, the public and the environment" and measures involving central and local government, employers and workers and bodies such as the police, fire and medical authorities concerned with emergency planning.

▶ ILO Employment Injury Benefits Convention (No. 121) and Recommendation (No. 121), 1964

This Convention notes that member states shall prescribe a list of diseases, comprising at least the diseases enumerated in Schedule I (Diseases caused by mercury or its toxic compounds).

▶ ILO Safety and Health in Mines Convention (No. 176) and Recommendation (No. 183), 1995

This convention includes provisions for protecting the safety and health of workers in the mining sector, including risks posed by chemical hazards including mercury. The main provision in Convention No. 176 addressing chemicals is Art. 9, which mandates that employers must inform workers of existing chemical hazards and all relevant preventative and protective measures for these hazards; take appropriate measures to eliminate or minimize those hazards; provide free protective equipment in the event that safety cannot otherwise be ensured; and ensure provision of first aid, transportation and appropriate access to medical facilities for workers suffering from injury or illness due to chemical hazards.

▶ ILO Safety and Health in Construction Convention (No. 167), 1988

The Convention includes provisions for protecting the health of workers from chemical hazards through the implementation of appropriate preventative measures in the construction sector.

▶ ILO Safety and Health in Agriculture Convention (No. 184), 2001

This Convention prescribes standards on the safe use of chemicals used in agriculture, including pesticides.

▶ ILO Maternity Protection Convention (No. 183) and Recommendation (No. 191), 2000

The Convention sets out that pregnant women should not be obliged to carry out work that is a significant risk to her health and safety or that of her child. It outlines the need for the elimination of any workplace risk, additional paid leave to avoid exposure if the risk cannot be eliminated, and the right to return to her job or an equivalent job as soon as it is safe for her to do so. The accompanying Recommendation provides for specific risk assessment and management of risks concerning pregnant women, including exposure to chemical agents which represent a reproductive hazard.

- **ILO List of Occupational Diseases (revised 2010) in the annex of ILO Recommendation No.194**

The List of Occupational Diseases and the recording and Notification of Occupational Accidents and Diseases [List of Occupational Diseases Recommendation, 2002], includes diseases caused by mercury or its compounds (para.1.1.7). It represents the latest worldwide consensus on diseases which are internationally accepted as caused by work. It was designed to assist stakeholders in the identification and recognition of occupational diseases, including those caused by mercury.

- **ILO Guidelines on occupational safety and health management systems (ILO-OSH 2001)**

The ILO-OSH 2001 provides a unique international model, compatible with other management system standards and guides. It reflects ILO values such as tripartism and relevant international standards, including Convention No. 187 and Convention No. 155. It provides guidance on the systematic management of OSH at the national and organization levels. The ILO Guidelines encourage the integration of occupational safety and health management systems (OSH-MS) with other management systems and state that OSH should be an integral part of business management. At the national level, they provide for the establishment of a national framework for OSH-MS, preferably supported by national laws and regulations. At the organization level, the ILO-OSH 2001 encourages the integration of OSH–MS elements into overall policy and management arrangements, as well as stressing the importance that, at the organization level, OSH should be a line management responsibility, and should not be seen as a task for OSH departments and/or specialists. The establishment of an effective system to manage safety and health at work is an essential aspect for safety and health in all fields, including the sound management of mercury.

The Minamata Convention on Mercury

The Minamata Convention, a global UN treaty to protect human health and the environment from the adverse effects of mercury, entered into force on 16th August 2017. It now has 128 signatories and 131 ratifications[3], who are legally bound to fulfil a range of mandatory measures. The Convention's core objective is "to protect human health and environment from anthropogenic emissions and releases of mercury and mercury compounds."

The main features of the Convention impacting workers are:

- The ban on new mercury mines and phase-out of existing ones, and controls on international trade in mercury (Article 3 – Mercury supply sources and trade).
- The phase-out and phase-down of mercury use in products. Provisions and phase out dates are provided for specific products, including batteries, fluorescent lamps, pesticides and dental amalgam (Article 4 and Annex A – Mercury-added products).
- The phase-out and phase-down of mercury use in processes. Provisions and phase out dates are provided for processes including chlor-alkali production and VCM production (Article 5 and Annex B - Manufacturing processes in which mercury or mercury compounds are used).
- Controls on ASGM and guidelines for National Action Plans (NAPs) (Article 7 and Annex C – Artisanal and small-scale gold mining).
- Development and implementation of education and preventative programmes on occupational exposure to mercury (Article 16 – Health aspects).
- Other relevant articles include: Article 11 – Mercury wastes, Article 12 – contaminated sites, Article 14 – capacity building technical assistance and technology transfer, Article 17 – Information exchange and Article 18 – Public information, awareness and education.

The Convention has the potential to assist world of work stakeholders and help reduce harmful global mercury exposures for the numerous workers exposed worldwide. In addition, it states that parties are encouraged to consult and collaborate with the ILO and the World Health Organization when

3 As of 5 July 2021.

considering health-related issues, as well as promoting cooperation and exchange of information with these organizations. Collaboration between the ILO, the Conference of the Parties to the Minamata Convention on Mercury and the secretariat of the Minamata Convention is based on the text of the Convention, in particular paragraph 2 of article 16. (A full description of all the Articles in the Convention can be found here).

The key areas for cooperation and collaboration with ILO include the development and implementation of educational and preventive programmes on occupational exposure to mercury and mercury compounds and the establishment and strengthening of institutional and health professional capacity for the prevention, diagnosis, treatment and monitoring of health risks related to exposure to mercury and mercury compounds. Since the adoption of the Minamata Convention, relevant ILO activities in support of the implementation of the Convention have included promotion of ILO international instruments, project work at the country level, and production of global codes of practice and working documents (UNEP 2019b). (A list of ILO work relevant to the Convention can be found in the Annex).

▶ Box 5. ILO Conventions and the Minamata Convention

Synergies exist between the Minamata Convention and the ILO chemicals and OSH instruments. Mercury is covered by the general chemicals Conventions (Nos. 170, 174 and also 155), which cover all chemical risks. The obligations in the Minamata Convention with the most overlap with ILO Conventions is Art. 5 on manufacturing processes involving mercury. As mercury is a hazardous chemical, it is covered by the general provisions in ILO Conventions No. 170 and 174, which protect workers against exposure to mercury in all manufacturing processes involving this substance.

▶ Box 6. ILO Convention No. 176 and the Minamata Convention

A highlight of Convention No. 176 is its synergies with the Minamata Convention on Mercury. Use of mercury in mining, especially in gold mining, continues to constitute a major health and environmental hazard. While Convention No. 176 does not mention mercury directly, the open provisions on chemicals in Art. 9 cover this substance and therefore mandate the elimination or at least minimization of hazards relating to mercury as well as other hazardous chemicals used in gold mining. Mercury in mining is also addressed by the Minamata Convention, which contains provisions on the dangers relating to ASGM. C176 and the Minamata Convention therefore complement each other, as C176 closes the gaps when it comes to chemical exposures, for example, regarding other hazardous chemicals used in mines.

The Minamata Convention and National Action Plans (NAPs)

The Convention obliges governments to take a range of actions, including to address mercury emissions to air, the phase-out of certain mercury-containing products and processes, and its disposal and storage. It covers intentional use, for example in ASGM, and unintentional emissions, such as the burning of coal. The convention outlines the importance of financial, technical, technological, and capacity-building support, particularly for developing countries, and countries with economies in transition, to strengthen national capabilities for the management of mercury and to promote the effective implementation of the Convention. It also recognizes that the Convention and other international agreements in the field of the environment and trade are mutually supportive. Given the multisectoral nature of the Convention,

Figure 8. Content of the national action plan according to the Minamata Convention (WHO 2021b)

- Strategies to eliminate worst practice and promote mercury-free methods
- Steps to facilitate the formalization or regulation
- Baseline estimates of the quantities of mercury used and the practices employed
- Strategies for managing trade and preventing the diversion of mercury
- Strategies for providing information to ASGM affected communities
- A public health strategy on the exposure of miners and their communities to mercury
- Strategies to prevent the exposure of vulnerable populations
- FAIRTRADE Strategies for mercury-free ASGM and market-based mechanisms or marketing tools

it is essential that all stakeholders collaborate effectively to realize the Convention's full potential (WHO 2014b). The Convention states that the Conference of the Parties, in considering health-related activities, should consult, collaborate, and promote cooperation and exchange of information with ILO, WHO, and other relevant intergovernmental organizations, as appropriate.

Countries that have ratified the Minamata Convention are obliged to develop a NAP, which describes its approach to reduce, and if possible, eliminate, the use of mercury in ASGM (Figure 8). The ILO advises that NAPs should align with ILO Decent Work Country Programmes (DWCPs), the main vehicle for delivery of ILO support to countries. DWCPs set forth the priorities of the ILO in a specific country, with the aim to promote decent work as a key component of national development strategies, as well as organising ILO knowledge, instruments, advocacy and cooperation to advance the Decent Work Agenda. In addition, effective multi-sectoral collaboration is needed for NAPs at both national and local levels, especially with labour sector stakeholders. 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.

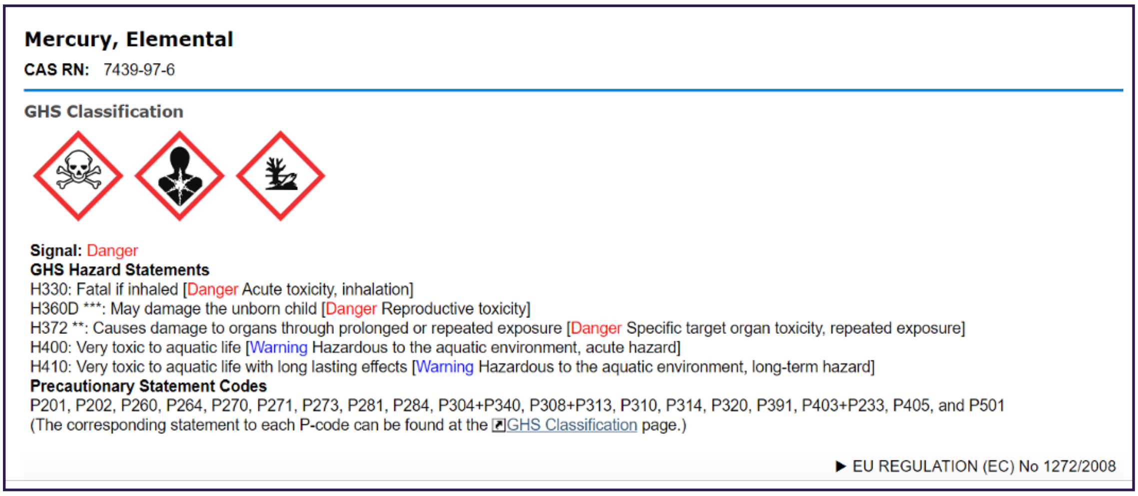
Other policy level recommendations

▶ Increase stakeholder capacity and worker participation as a matter of priority

Develop and support campaigns to increase stakeholder capacity and worker participation on mercury issues and broader chemical exposures in the world of work.

▶ Implement the Globally Harmonized System of Classification and Labelling of Chemicals (GHS)

The GHS is an internationally agreed upon system to standardize hazard information of chemicals through labels and safety data sheets. Correct classification and labelling, as well as comprehensive worker training, can help improve OSH and workplace safety systems. Appropriate handling, use and storage of hazardous substances, such as mercury can in turn contribute to preventing hazardous exposures, as well as major industrial accidents.



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

▶ Implement and enforce Occupational Exposure Limits (OELs) for Mercury

Evidence-based national occupational exposure limits for mercury in all sectors should be implemented and adopted, including in sectors where mercury is present as a contaminant. To ensure accurate measurement of workplace exposure levels, appropriate facilities and equipment must be used, as well as a skilled workforce. OELs may vary according to country or region and exposures should not exceed the national legal OEL.

Some workplace exposure limits for mercury include:

- ACGIH: TLV (threshold limit value) 0.025 mg/m^3 as 8-hour time-weighted average (TWA)
- EU-OEL: 0.02 mg/m^3 as TWA
- OSHA: Permissible exposure limit (PEL) for mercury is a ceiling limit of 0.1 mg/m^3 as TWA
- NIOSH: Exposures to mercury metal be limited to an average of 0.05 mg/m^3 over a 10-hour workday, in addition to a ceiling limit of 0.1 mg/m^3.

▶ Box 7. Mercury and central nervous system toxicity

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

▶ Mainstream gender considerations into OSH policy and practice

It is essential that inclusive and responsive gender-sensitive OSH policies are developed. The ILO Maternity Protection Convention (No. 183) and accompanying Recommendation (No.191) set out that pregnant women should not be obliged to carry out work that is a risk to her or her child and provides for specific risk assessment concerning pregnant women, including chemicals such as mercury, which represent a reproductive hazard.

Furthermore, the ILO has developed Guidelines for Gender Mainstreaming in Occupational Safety and Health to assist policy-makers and practitioners in taking a gender-sensitive approach for the development and implementation of OSH policy and practice. In taking a gender sensitive approach, one recognizes that because of different jobs that men and women participate in, and the different societal roles, expectations and responsibilities they have, they may face unique chemical exposure scenarios, thus requiring appropriately designed control measures. This approach improves the understanding that gender-based division of labour, biological differences, employment patterns, social roles and structures all contribute to gender-specific patterns of hazardous exposures.

▶ Strengthen Global Burden of Disease (GBD) estimates for exposures and outcomes

Whilst global and country-based estimates of the disease burden caused by mercury in ASGM do exist, data for other industries is limited. Even for ASGM, the total disease burden is likely undercounted due to poor data availability and quality. National assessments of mercury usage and disposal should be conducted. This will allow countries to develop an effective and targeted response to dealing with the mercury problem.

Workplace level actions

Although the phase out of mercury is a priority, workplace prevention efforts must also be implemented as complementary actions. Targeted strategies are needed at both the national and workplace levels, particularly in LMICs and in the informal economy.

Implement a workplace programme for the sound management of mercury

In line with ILO Convention No. 170, the priority should always be to conduct risk assessment to identify possible safer alternatives for the elimination or substitution of mercury. In situations where this is not currently viable, the ILO recommends that the following components are used as a general blueprint for the sound management of chemicals in the workplace (Table 8). As always, national guidelines should be considered in the first instance.

Table 8. Components of a workplace programme for the sound management of mercury

Elements of the programme	Components included
General obligations, responsibilities and duties	Role of the competent authority; responsibilities and duties of employers, workers, and suppliers Rights of workers
Classification and Labelling following the GHS	Criteria for classification of hazards Methods for classification Type of labelling on containers of hazardous chemicals
Chemical Safety Data Sheets	Provision of information and training Content of safety data sheet
Operational Control Measures	Assessment of control needs and elimination of hazards Control measures for: health hazards; flammable, dangerously reactive or explosive chemicals; disposal and treatment of chemicals
Design and Installation	Enclosed systems where feasible Separate areas for hazardous processes to limit exposures Practices and equipment that minimize releases Local exhaust ventilation and general ventilation
Work Systems and Practices	Administrative controls Cleaning and maintenance of control equipment Provision of safe storage for hazardous chemicals
Personal Protection	Personal protective equipment Welfare facilities and personal hygiene Practices to maintain equipment and clothing as necessary Training on personal protection

Information and Training	Workers should be provided information (labels and safety data sheets), and be trained how to handle them safely, what to do in an emergency, and how to obtain additional information
Maintenance of Engineering Controls	Practices and procedures to keep engineering controls in good working order
Exposure Monitoring	Measuring methods Monitoring strategy Recordkeeping Interpretation and application of data
Medical and Health Surveillance	Medical exams as necessary Recordkeeping Use of results to evaluate programme Paid time off for affected workers, including paid sick leave Employment protection for those harmed by mercury Transfer to alternative employment for pregnant/breast feeding workers
Emergency Procedures and First Aid	Planning should be done to anticipate possible emergencies, and have procedures to deal with them First aid should be available on-site
Investigation, Recording and Reporting of Accidents, Occupational Diseases and Other Incidents	All incidents should be investigated to determine why they occurred, what failed in the workplace or in the emergency plan The accident and dangerous incident book should be reviewed regularly to identify risky jobs and processes Authorities should be notified as required by national laws

Health surveillance of high exposure industries

Regular health surveillance and biomonitoring of workers, together with recognition of OELs, help in the early detection of exposure and related biological effects (WHO 2015). Recent exposure to metallic mercury can be assessed by blood sampling within 24 hours after exposure, whilst urinary mercury provides an indicator of long-term inhalation (Romilda et al. 2017). Challenges exist however with regard to monitoring and surveillance, as many countries do not have the technical capacity and laboratory capacity to establish baseline conditions and subsequently to conduct monitoring (WHO 2019b). Human biomonitoring is seen as an effective approach to identify and monitor vulnerable populations, but there is a need for assistance to implement it in many countries.

Training of workers, employers and labour inspectors is key

A number of workers were poisoned during the dismantling of a chlor-alkali unit in Poland in 2015. This occurred despite organizational and technical measures being undertaken, including the use of PPE, regular biomonitoring and control of the quality of the working environment. Analysis of cases shows that a lack of awareness among young workers who disregarded the rules for safety and health. Lessons from this poisoning case have now led to the strengthening of protective measures. Repeated training for employees, supervisors, occupational medicine physicians and safety staff appears to be of particular importance (WHO 2016b). The ILO also emphasizes the value of labour inspector training, in order to develop competences of labour inspectorates and enhance inspection effectiveness. This is essential for enforcing legal provisions relating to work conditions and the protection of workers and for identifying defects of existing legal provisions.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Other challenges exist

Many other challenges exist in delivering preventive strategies to protect workers' health, for example: difficulties in access to workplaces in the informal sector, the lack of a mandate to enter private enterprises, rapidly changing work practices, the lack of an occupational health training programme for primary healthcare personnel, shortages in the health workforce and a lack of knowledge of occupational health hazards among providers (WHO 2016b).

▶ Box 8. Five Steps for eliminating mercury from the healthcare setting (Health Care Without Harm n.d.)

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:

1. Replace mercury devices and products with safe, accurate, affordable alternatives and adopt a mercury-free purchasing policy.
2. Establish a mercury waste management and storage programme. A policy and programme to manage, segregate and store mercury waste should be developed and implemented as mercury-based medical devices are being substituted in the hospital.
3. Training and education of staff to broaden knowledge about the toxicity of mercury, its impact on health and the environment, the correct way to handle small spills, segregation and transitional storage of mercury waste.

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.

▶ Box 9. Strategies for the disposal of hazardous healthcare waste

Hazardous waste containing mercury must be disposed of appropriately by healthcare facilities to prevent workers being exposed. The following recommendations were made by WHO (2014):

- Waste containing mercury must be segregated and collected separately.
- Waste must be clearly labelled and should include hazard labels.
- Mercury waste must not be flushed down the drain, but should be stored in leak-proof containers.
- Low-energy light bulbs and batteries should be segregated and treated by recycling processes.
- Mercury spillages must be clearly up promptly using spill kits.
- Mercury waste should not be treated in an autoclave, to avoid releases into the air.
- Mercury waste should not be treated using microwave technologies.
- Reduce the use or mercury-containing equipment and replace with mercury-free alternatives.

More detailed technical guidelines for the sound management of mercury waste are provided by UNDP (UNDP 2010) and The Secretariat of the Basel Convention and UNEP (UNEP 2012b).

Implement a workplace level strategy

The overall strategy to achieve the sound management of mercury in the workplace and in protecting the general environment can be described in three steps:

STEP 1

Identification of chemicals

Classification of hazards/labels and safety data sheets

STEP 2

Determination of potential exposures in the workplace

Risk assessment

STEP 3

Identification of control measures based on risk assessment

Implementation of controls; evaluation of effectiveness; and maintenance of level of protection

- The first step is to identify what chemicals are present; ensure that they are classified as to their health, physical, and environmental hazards; and that labels and safety data sheets are used to convey the hazards and associated protective measures. Without such information on chemicals in the workplace, or released to the environment, it is not possible to go farther in terms of an evaluation of impact, and determination of appropriate preventive measures and controls. Information provides the underlying structure needed to achieve the sound management of chemicals.
- The second step is to evaluate how the identified and classified chemicals are used in the workplace, and what exposures can result from this use. This may be accomplished through exposure monitoring, or through application of tools that allow for estimation of exposures based on factors regarding the quantity used, the potential for release given the conditions in the workplace or facility, and physical characteristics of the chemical.
- Once the hazards have been identified, classified, communicated, and their risk has been assessed, the third step is to use this information to design an appropriate preventive and protective programme for the workplace, using the Hierarchy of Controls (Figure 9). Other provisions of a thorough programme that support and enhance these controls are exposure monitoring; information and training for exposed workers; recordkeeping; medical surveillance; emergency planning; and disposal procedures.

Box 10. Protecting workers from mercury exposure while crushing and recycling fluorescent bulbs

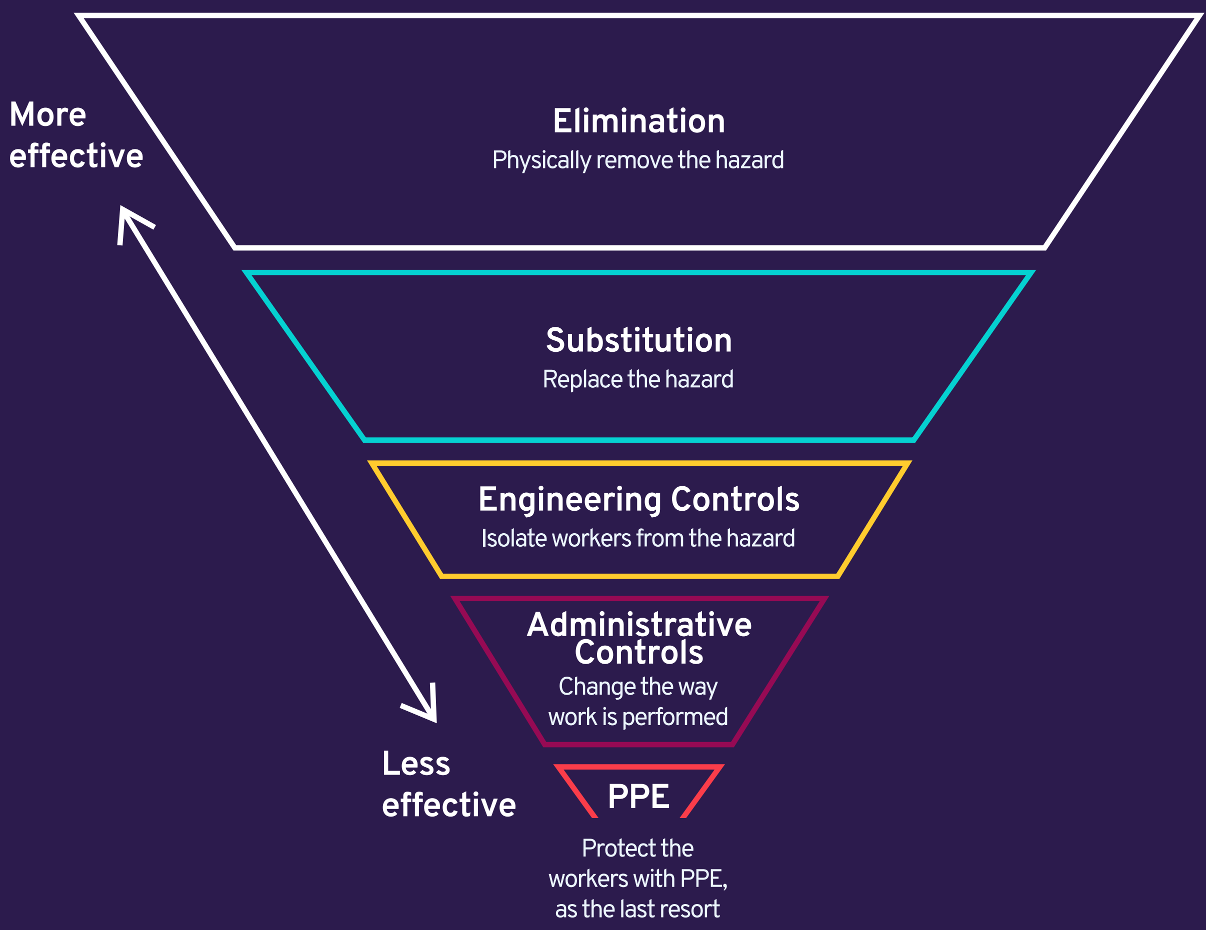
OSHA recommendations include the following work practices (OSHA, n.d.):

- A clean-up plan to informs workers how to safely clean up incidental mercury releases from broken bulbs.
- Training to educate works about mercury exposes and safe practices.
- Process isolation so that areas where bulbs are broken or recycled are physically separated from areas where workers are not involved with bulb processing.
- Floor materials that are easy to clean.
- Well-ventilated work areas.
- Evaluation and maintenance programmes for equipment.
- Air monitoring to measure the amount of mercury present in the air.
- 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 biological 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.

Apply the Hierarchy of Controls

The Hierarchy of Controls (Figure 9) is a system used to eliminate or minimize exposure to occupational hazards, such as mercury. There are five categories in the hierarchy, with control methods at the top of the hierarchy potentially more effective than those at the bottom

Figure 9: The Hierarchy of Controls



In keeping with the main goal of the Minamata Convention, elimination and substitution of mercury should be considered priority actions where possible. Some examples of alternatives to mercury-containing equipment are shown in Table 9.

Table 9. Alternatives to mercury-containing equipment

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

Sources: UNEP 2019, ATSDR n.d.

In situations where mercury use is absolutely necessary, engineering and administrative controls should be prioritized. PPE should only be used as a last resort. If necessary, employers should make available, free of charge, a range of appropriate PPE that is designed to effectively protect workers of all body types, including physiological differences between genders, with training on its correct use. When clothing is contaminated, it should be changed promptly to avoid absorption through the skin. An example of the Hierarchy of Controls when applied to mercury use in ASGM is shown in Table 10.

Table 10: Example of the Hierarchy of Controls for mercury use in ASGM

Most effective ↑	**Elimination**	Physically remove the chemical	e.g. Eliminate the use of mercury and use a zero-mercury approach instead, for example, panning, sluicing or spiral concentrators
	Substitution	Replace the chemical	e.g. Use an alternative chemical for the process, for example cyanide
	Engineering Controls	Isolate workers from the chemical	e.g. Use retorts or fume hoods to remove the mercury fumes
	Administrative Controls	Change the way work is performed	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
↓ Least effective	**Personal Protective Equipment (PPE)**	Protect the worker with PPE	e.g. Workers should wear appropriate PPE, for example gloves, overalls, masks with filters, and safety glasses, as deemed relevant by risk assessment

▶ Box 11. Protecting workers from mercury spillages

Mercury may be spilled when mercury-containing instruments, such as thermometers, break. If spillages are not promptly cleaned, mercury may accumulate on surfaces and then vaporize. OSHA and NIOSH recommend the following good work practices in the case of mercury spillages (adapated from OSHA n.d.):

- Do not allow workers who are not trained in proper procedures to clean up spills.
- Establish procedures to isolate the contaminated area and be aware that mercury can unknowingly be carried home on clothing, skin, or hair.
- Increase ventilation in the area where the spillage occurred.
- Spills can be cleared up with special mercury vacuum cleaners and water-soluble mercury decontaminant.
- Use mercury spill kits to help clean up small spills of 25ml or less. Kits should contain gloves, protective glasses, Hg absorb powder, mercury sponges, and a disposal bag.
- If deemed necessary, use a Mercury Vapor Analyzer (e.g. Jerome) to verify that the area is safe to re-enter.
- Avoid using mercury on carpets or porous surfaces where clear-up may be difficult.
- Prevent spills by replacing outdated mercury-containing products with mercury-free devices.

Special focus on the ASGM sector

Multiple programmes are in place to help miners shift to mercury-free mining processes, but the challenges are vast (UNEP 2017). Whilst national and international initiatives seek to reduce mercury use in ASGM and to improve the safety and health of workers in the sector, the extent and informal nature of ASGM activities make implantation challenging.

UNEP has recommended the cessation of a number of common practices in ASGM, including WOA, open burning of amalgam without vapour capture systems or retorts, and reprocessing of mercury-contaminated tailings with cyanide. For artisanal workers who practice amalgamation, the burning of amalgam and gold sponge should no longer be done in the absence of personal protective equipment. Alternatives, such as "gravity only" separation, direct smelting and chemical leaching in keeping with good health and safety practices could be employed in the ASGM industry to reduce or eliminate mercury exposure and emissions.

Box 12. Whole ore amalgamation (WOA)

Whole ore amalgamation (WOA) is a major source of pollution globally, however, is a cheap, quick and easy way for miners to extract gold. WOA is considered poor practice because:

- Mercury use ranges from high (4 parts mercury for each part gold recovered) to very high (20 parts mercury for every part gold or higher). In extreme cases, for example where ore is rich in silver, the ratio can be 50:1.
- WOA is inefficient - it rarely captures more than 30 per cent of the gold and results in major losses of mercury to tailings (waste material).
- Large amounts of mercury are lost to the tailings because the mechanical process produces tiny mercury droplets ("floured mercury") that are too dispersed to capture. The result is mercury contaminated sites that are very difficult to clean up.

Reduced mercury and mercury-free technologies

- **Concentrate amalgamation:** Uses less mercury than WOA, as mercury is used only on the concentrate which contains the heaviest minerals and gold. In concentrate amalgamation, the ratio of mercury used to gold produced is much lower than WOA (generally 1:1 to 1.3:1), and little or no mercury goes into the tailings. This method can still result in significant human exposure however, when safety equipment such as retorts or fume hoods are not used.
- **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. Recycling mercury lowers costs for miners and gold shops by reducing mercury consumption. Capturing and recycling mercury can be an effective first step in moving towards mercury-free processing.
- **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. Miners are turning increasingly to cyanide, especially for the reprocessing of tailings, but improper cyanide use and management is leading to catastrophic levels of local pollution. It must be used with care given the considerable hazards it entails to human health and the environment.

- **Manual concentration:** Panning is widely used at many ASGM sites. Panning with water causes lighter particles to flow over the edge of the pan while heavier particles, including gold, remain in the bottom – gold is 19 times heavier than water; mercury is 13 times heavier; average rock is only 3 times heavier.

- **Gravity:** Gravity-based methods are the ones most widely used to concentrate gold in ASGM. Using gravity is effective because gold is heavy: approximately 7 times heavier than an average rock of the same size. 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. Efficient concentration is a key requirement for direct smelting. This is not a direct replacement for mercury, as it is not applied at the same stage of processing. Mercury is commonly applied to large masses of concentrate - for example, 20 kg coming from the carpets of a sluice - whereas direct smelting is performed on small masses of high grade concentrate usually no larger than 100g.

Box 13. Case study of mercury-free processing in Mongolia

An example of zero-mercury processing as carried out in Mongolia shows that with the right equipment and suitable ore, high gold recovery rates are possible with gravity-only methods. The project and plant design were developed by the Sustainable Artisanal Mining Project (SAM), a collaboration between the Mongolian Government and the Swiss Development Cooperation (SDC), Mongolia. The system involves a combination of zero-mercury methods, including rock crushing, Chilean mills, sluice carpets and shaking tables. The gold concentrate is smelted (with borax) and poured into iron moulds. It recovers around 70 per cent of the gold present in ore, a relatively high percentage for an ASGM operation. Tailings from this process are properly managed. As they still contain about 30 per cent of the gold, they are accumulated on site for future reprocessing, perhaps by a flotation and leaching method.

Further considerations for implanting mercury-free technologies in ASGM

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. This can help pave the way for mercury-free practices to be integrated into processed over the course of time.

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 2012a). This can be achieved by methods such as more efficient processing and better yields of gold to improving extraction techniques. In addition, miners may get a premium for good practices through a fair-trade mechanism, such as the Fairtrade-Fairmined Standard developed by the Alliance for Responsible Mining (ARM) and the Fair Trade Labelling Organisation (FLO) (UNEP 2012a).

Assess the potential for the formalization of ASGM activities

By supporting the transition from informal to formal ASGM in line with the ILO Transition from the Informal to the Formal Economy Recommendation, 2015 (No. 204), it should in principle become easier to identify, reach out to and provide ASGM mining operators with the knowledge and assistance needed to apply mercury-free processes and to improve working conditions and safety and health at work. A successful example of ASGM formalization was the 'Contribution Toward the Elimination of Mercury in the Artisanal and Small-Scale Gold Mining Sector: From Miners To Refiners' initiative launched in Mongolia in 2019. The initiative involved formalising ASGM activities and supporting miners' access to markets for responsible gold, as well as moving to mercury-free mining and processing. This reduced mercury emissions, alleviated poverty and promoted local development. Other initiatives exist, such as the Fairmined Initiative, an assurance label that certifies gold from empowered ASGMs, and Impact's Just Gold project in the DRC, a traceability and due diligence system for artisanal gold.

Nonetheless, it has become increasingly clear that the transition to the formal economy must be managed in ways that address specific risks as well as vulnerabilities of women in the sector. Women, for instance, will not be able to benefit from formalization in countries where they are prohibited from owning land or mineral rights. Hence, the transition to a formal mining economy should be accompanied by complementary and supportive policies for women and other marginalized groups – be it land rights, education and fundamental principles and rights at work – to ensure that formalization brings about equal opportunities and contributes to the advancement of decent work for all.

Worker training and awareness raising

Miners and other ASGM workers often have limited knowledge of the harmful health impacts of mercury exposure. Awareness raising through health promotion campaigns is essential for those working with mercury. Miners should be educated about the dangers of mercury vapour, for example released during WOA methods, as well as the detrimental environmental impacts. Various existing training tools could be used or adapted to address the specific concerns of the ASGM sector, including WISE, WISH, SCORE and WIND.

▶ Box 14. The ILO-Caring Gold Mining Project

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 2019b). 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.

Implement integrated OSH management systems

Effective data gathering is essential to inform the design and effective implementation of national OSH programmes for artisanal mines. It should be made mandatory for all dangerous events to be reported and registered, including those causing no injury or disease. Governments should endeavour to redress the shortcomings of labour

inspection systems and ensure that international OSH standards are being met in ASGM. The training of new inspectors would help ensure wider coverage and hence encourage greater compliance on the part of mining companies.

Where mercury use is essential, basic measures and practices should be introduced to improve working conditions, and this should go hand-in-hand with appropriate training and information programmes. This should include the use of wheelbarrows or hand carts to transport sacks of ore, the wearing of solid gloves when handling mercury, especially when reprocessing tailings and during whole ore amalgamation. Gloves should normally be used for all wet work, and mercury should always be stored in durable containers clearly labelled “mercury” and “toxic” and should be covered with a layer of water to prevent the mercury from evaporating. Disposable dust masks and respirators for mercury vapour and gases should be used and safety goggles worn when grinding dry rock ore. Safety helmets should always be worn on the site.

▶ Box 15. Summary of key actions

- Use mercury exposure reduction methods to concentrate gold more effectively (to reduce the quantity of mercury used in the amalgamation process).
- Avoid open air burning of amalgam. Operate mercury capture devices such as retorts or fume hoods to capture mercury vapour emitted when the mercury/gold amalgam is burned.
- Utilize mercury-free processes in ASGM, for example, gravity-only concentration methods, such as panning, sluicing, centrifuges, spiral concentrators, vortex concentrators and shaking tables.
- Mainstream gender-sensitive policies into OSH policy and practice in ASGM.

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Social dialogue

Promote social dialogue at all levels: towards effective ratification of ILS and implementation of the Minamata Convention

Social dialogue is defined by the ILO to include all types of negotiation, consultation or simply exchange of information between, or among, representatives of governments, employers and workers, on issues of common interest relating to economic and social policy. It can exist as a tripartite process, with the government as an official party to the dialogue or it may consist of bipartite relations only between labour and management (or trade unions and employers› organizations), with or without indirect government involvement. Social dialogue processes can be informal or institutionalized, and often it is a combination of the two. It can take place at the national, regional or at enterprise level. It can be inter-professional, sectoral or a combination of these. The main goal of social dialogue itself is to promote consensus building and democratic involvement among the main stakeholders in the world of work. Successful social dialogue structures and processes have the potential to resolve important economic and social issues, encourage good governance, advance social and industrial peace and stability and boost economic progress.

If laws and regulations are essential in determining the legal framework regulating the administration of national OSH infrastructures, the successful application of laws and regulations within the workplace rests to a large extent with employers, workers and the organizations representing them. Often, the subject of OSH, including all aspects of chemical safety at work, has been the starting point for developing wider bipartite dialogue. Both employers and workers, and particularly employers’ and workers’ organizations, give OSH an important place in their collaborative or separate actions. The inclusion of the subject of OSH has long been a standard feature of collective bargaining agreements. Although the legal basis for the application of collective bargaining may differ significantly from country to country, the legislation of most industrialized and developing countries include a system for regulating collective bargaining. National legal frameworks also affect how collective bargaining applies to OSH. Mandatory joint safety committees are the main mechanism for bipartite management of OSH within the enterprise. The traditional vision of collective bargaining is that of a formal periodic process of negotiation, but it is also a flexible continuous mechanism for solving problems as they arise. OSH is frequently seen as an ideal subject for mutual gains bargaining since both sides are interested in avoiding occupational accidents and diseases.

The promotion of OSH and improvement of working conditions has certainly benefited greatly from such dialogue. This principle is embedded in the Chemicals Convention, 1990 (No. 170), which requires the formulation, implementation and review of a coherent policy on safety in the use of chemicals at work to be undertaken on a tripartite basis, as well as requiring the cooperation between employers and workers with respect to safety in the use of chemicals at work.

To support sound social dialogue practices, systems for coordination and cooperation between the different authorities and bodies involved in the administration of the national OSH system are necessary to ensure coherence of action at all levels and to facilitate the flow of and access to information. The assignment of this function to a central body is an effective way to enhance the performance of such systems. Mechanisms for the consultation of organizations of employers and workers as well as other stakeholders and their participation in policy and legislation development and review are also needed in order to take their views and concerns into account and ensure their support in implementation.

In this context, the Minamata Convention promotes coordination, cooperation and consultation among different actors at the global level. The Minamata Convention anticipates that “coordinated implementation of the obligations of the Convention will lead to an overall reduction of mercury levels in the environment over time.” What is clear is that the Convention requires multispectral coordination and action. Given that mercury is used in numerous countries around the world and in many different industries, cooperation and collaboration at global, regional and national level will be key to achieving Convention objectives

(WHO 2016b). In conclusions, to achieve the effective implementation of the Minamata Convection at all levels, it is highly suggested to promote it together with the ILO instruments on OSH particularly Convention No. 170. Social dialogue between all stakeholders, particularly governments and social partners, will be essential part of this global collaboration.

Enhance sound governance frameworks

The sound management of chemicals requires effective governance through transparency, public participation, and accountability among the world of work stakeholders and specifically governments, employers› organizations and workers› organizations. Making better use of social dialogue is important to improve legislation and its implementation. This includes effective labour inspection provided for with adequate means and conducted by suitably qualified and trained inspectors. The active participation of employers' and workers' organizations is essential for the development of national policies and programmes for the management of chemicals as well as its governance.

Employers have a duty to take preventive and protective measures, through assessment and control of the risks at work, including to those related to chemical exposures. They also can promote sound governance frameworks at the national and workplace levels. Workers and their representatives have a right to be involved at all levels in formulating, supervising and implementing prevention policies and workplace programmes. They have a right to be protected from workplace risks and to take an active role in governance both at the national and workplace level.

Policy makers, managers, supervisors, OSH professionals, and workers all have important roles to play, through effective social dialogue and participation in risk-management systems as well as the promotion of sound governance frameworks at all levels.

▶ Box 16. Increase engagement of governments and social partners in international policy efforts

There are a number of international policies, agreements and conventions in the field of chemical safety. SAICM in particular represents a global policy framework that can harmonize and integrate important elements needed for a universal approach to the sound management of chemicals worldwide. One of the key objectives of a revitalized strategy for SAICM Beyond 2020 is increased multi-sectoral and multi-stakeholder engagement to ensure that the new platform will be of interest to, and useful for, the work of the different ministries as well as a variety of stakeholders.

While social partners, including employers from the chemical industries and workers organizations, have demonstrated their commitment to SAICM and its processes, there is a continued need for enhanced participation and engagement of key world of work stakeholders in ongoing policy negotiations. Occupational exposure considerations should be at the core of SAICM Beyond 2020 and measures are needed in this new framework to protect workers from chemical exposures. As such, enhanced social dialogue will be critical during the intersessional process leading up to Fifth session of the International Conference for Chemicals Management (ICCM5), and beyond.

The ILO and social dialogue in the chemicals sector in the context of corporate structural changes

Many sectors using chemicals are of strategic importance to the sustainable development of national economies. The ILO has noted the importance of the chemical sector since the early stages of the Organization's activities and has actively promoted social dialogue in the sector for many years. Conclusions on the Tripartite Meeting on Promoting Social Dialogue on Restructuring and its Effects on Employment in the Chemical and Pharmaceutical Industries (Geneva, 24-27 October 2011) notes social dialogue can promote an atmosphere conducive to better industrial relations during restructuring in the chemical and pharmaceutical industries. The Conclusions state: "Social dialogue plays an essential role in making restructuring processes successful in the chemical and pharmaceutical industries. To be effective in this respect, such dialogue should:

- be timely, meaning at the earliest possible stage;
- be based on a relationship of mutual respect in the context of good industrial relations between employers and workers as well as their respective organizations and be carried out in a spirit of cooperation and good faith;
- consider and address the possible restructuring scenarios and their respective implications for management and the workforce;
- be based on a full and meaningful exchange of views;
- be based on all relevant information shared at the earliest possible stage by management with workers and their representatives; and
- involve employers' and workers' representatives and, where appropriate, the relevant government entities.

Good social dialogue practice in the context of restructuring also requires that the agenda and content of the process be clearly defined in consultation between employers, workers and their representatives. Dialogue, to be effective, must be in accordance with the national law and practice and the relevant ILO principles and standards. Good social dialogue practices which exist in some countries provide valuable models that could be documented and disseminated for the information of sectoral social partners in other countries. Among other aims, restructuring-related social dialogue should seek to expand employment opportunities with decent work conditions and worker employability through greater investments in education, vocational training and lifelong learning for all workers, while at the same time seeking to increase the competitiveness of companies in the industries." Sustainable industrial policies underpinned by meaningful and effective social dialogue are key to managing the opportunities and challenges arising from digitalization and other technological advances in the chemical and pharmaceutical industries. In 2018, the ILO Global Dialogue Forum on Initiatives to Promote Decent and Productive Work in the Chemical Industry adopted Points of Consensus to guide governments, employers and workers in shaping a future that works for all in the chemical and pharmaceutical industries.

Annex

Work of the ILO relevant to the Minamata Convention on Mercury (as of 2021)

1. Collaboration between the ILO and the Conference of the Parties to the Minamata Convention on Mercury and the secretariat of the Minamata Convention is based on the text of the Convention, in particular paragraph 2 of article 16. ILO and its constituents have focused their technical support in line with article 7 of and annex C, covering ASGM and have expanded the scope of its initiatives to other sectors. The ILO has increased its research efforts in order to develop a strong knowledge base on mercury in the world of work to promote the development of evidence-based policies.

2. Since the adoption of the Minamata Convention, relevant ILO activities in support of the Convention have included promotion of ILO international instruments, extensive project work at the country level, production of codes of practice, working documents, and technical research reports, as described below.

Promotion of ILO international instruments for the prevention of mercury exposure

3. ILO has been promoting the ratification and the implementation of ILO international instruments relevant to mercury exposure. This includes the Chemicals Convention, 1990 (No. 170); the Prevention of Major Industrial Accidents Convention, 1993 (No. 174); the Safety and Health in Mines Convention, 1995 (No.176) and the Safety and Health in Agriculture Convention, 2001 (No. 184). The Promotional Framework for Occupational Safety and Health Convention, 2006 (No. 187) aims to strengthen national occupational safety and health (OSH) systems within which to anchor the implementation of the other conventions. The ILO List of Occupational Diseases in the annex of ILO Recommendation No. 194 concerning the List of Occupational Diseases and the Recording and Notification of Occupational Accidents and Diseases, includes diseases caused by mercury or its compounds.

4. ILO is currently developing diagnostic criteria guidance notes to provide assistance to countries that lack the specific knowledge for diagnosis, recognition, reporting, and prevention of the occupational diseases listed in ILO Recommendation No. 194, including diseases caused by mercury or its toxic compounds, which will also be instrumental towards SDG Indicator 8.8.1.

5. ILO has provided continued support to the Philippines in the implementation of the ILO Safety and Health in Mines Convention, 1995 (No. 176). The Philippines is currently revising its list of occupational diseases in line with R194, as are Ethiopia, Indonesia, the Lao People's Democratic Republic, Myanmar and Namibia.

Projects in the artisanal and small-scale gold mining (ASGM) sector

6. The ILO "Caring Gold Mining Project" has been described in previous reporting periods (the project ended March 2020). A project evaluation highlighted critical achievements and remaining challenges to addressing child labour, including prevention of mercury exposure. Highlights of project activities and evaluation findings are presented below for Ghana and the Philippines.

7. In Ghana, the ILO participated in the drafting, validation and launch of the MIA, which was completed and deposited with the Minamata Convention secretariat. ILO was also a member of the technical working group developing a national action plan on the elimination of mercury and the National Steering Committee overseeing the implementation of the complaint regime for the Minamata Convention. A project evaluation found that the project was most successful at linking ASGM communities to the National Health Insurance Scheme and getting large numbers of persons registered for health insurance. In addition, community child protection committees and school clubs were effective in addressing child labour and hazardous exposures in ASGM. The mining ban on ASGM is underway and appears poised to achieve nearly all its indicator targets. Continued challenges identified included the lack of an acceptable alternative to mercury and limited technical and financial support to help small-scale miners comply with stringent contract requirements, so they are able to operate legally.

8. In the Philippines, the ILO participated in baseline data collection on mercury use in ASGM and the drafting of the MIA. The project lobbied for the expansion of membership of the MIA technical working group to include the Department of Labour and the Department of Social Welfare as an important step in increasing the multi-stakeholder nature of Minamata Convention engagement and implementation. The ILO promoted the use of the gravity concentration method as a mercury-free gold processing technology in the project's pilot sites and implemented mercury-free technology training/coaching sessions in mining communities. The ILO organized the first Inter-Regional Knowledge-Sharing Forum on Child Labour and Working Conditions in ASGM (ILO 2019d) which included sessions on the Minamata Convention and mercury-free technologies. The project evaluation found that Strategic Helpdesks for Information, Education, Livelihood and other Developmental Interventions against Child Labor in the Philippines were highly effective interventions. The project successfully linked project communities to the Department of Labor and Department of Social Welfare to receive a range of livelihood and social protection services. Challenges still remain when it comes to lack of acceptable alternatives to mercury and limited support to help miners comply with stringent contract requirements, so they are able to operate legally.

9. In the Philippines, as a follow up to the Caring Gold Mining Project, the ILO is implementing a new project on "Improving Workers' Rights in the Rural Sectors of the Indo Pacific, with a Focus on Women". Since one of the target sectors of the Project is mining, it will ensure that its work on OSH will contribute to the National Action Plan on the Phase Out of Mercury, through working with social partners to integrate relevant initiatives for the mining industry in the national OSH programme, providing support for education and awareness and social dialogue within the industry, and elimination of its use in the workplace and community.

10. In Guyana, ILO supported the Guyana School of Mining in the finalization of the OSH inspection manual for small and artisanal open-cast mines. The manual, which makes reference to the Minamata Convention and its principles, was motivated by a recent incident in the Guyana Gold Board related to mercury contamination (DPI 2018).

11. In Suriname, ILO is in the process of finalizing a draft manual similar to the Guyanese manual. Within the process, ILO will reflect the provisions of the Minamata Convention and explore synergies with the ASGM project being carried out by UNDP (GEF 2017). In addition, an ILO decent work country programme agreement (2019-2021) was signed in 2019, which will enhance activities related to this process.

12. In Mauritania, ILO is developing initiatives to address the concerns raised by exponentially growing mining activity. L'Union Nationale du Patronat de Mauritanie (UNPM), the national employers' organization, and the "Office National de Médecine du Travail (ONMT)", the OSH national institute, has expressed an interest in taking action with ILO to inform artisanal and industrial prospectors of the risks associated with the industry. ILO held discussions with UNPM and ONMT to conduct an assessment of OSH risks and a capacity-development programme for safety officers in gold mines. Discussions are ongoing with ONMT to support capacity building on assessment and management of OSH in ASGM including exposure to mercury. This includes mercury exposure risk assessment and OSH risk prevention efforts.

13. In Democratic Republic of Congo, ILO is developing a project to promote OSH in artisanal mines. This will include an assessment of exposure to occupational risks (including exposure to mercury) and capacity building of workers, employers and OSH professionals in managing OSH. The project will also include an assessment of strengths and challenges on the application of international standards on OSH, as well as the Minamata convention.

14. In Bolivia, the project "Desarrollo regional productivo, sostenible y con mejores condiciones de seguridad y salud en el trabajo en la minería y manufactura de Bolivia" has been leading a number of activities related to the prevention of mercury exposure. With the support of «Cumbre del Sajama» and in coordination with the Vice-Ministry of Mining Cooperatives of the Bolivian Ministry of Mining, a virtual training programme on OSH for miners was carried out, with the objective of reinforcing knowledge for the prevention of accidents and occupational diseases, including those related to mercury exposure. The programme incorporated 17 sessions that addressed OSH topics and the ninth session was oriented to diseases caused by mercury and the main causes of intoxication in artisanal mining. In addition, a booklet was prepared on OSH and addressed aspects of mercury-related diseases.

15. In Africa, the ILO project «Accelerating Action for the Elimination of Child Labour in Supply Chains in Africa (ACCEL AFRICA)» has the overarching goal of eliminating child labour in selected supply chains in Uganda, Malawi, Egypt, Mali, Nigeria and Côte d›Ivoire, and will include targeted actions for the mining sector. For example, in Mali, activities aimed at raising awareness on the dangers of using mercury among artisanal miners through training sessions and communication support are planned for future months. Similarly, in Nigeria and Côte d'Ivoire the project plans to carry out capacity building programme in mining communities on mercury exposure and safety and health risk prevention efforts including the use of mercury-free technologies, with a particular reference to the impact on children. The application of the CRAFT Code is also planned to be rolled out in the three target countries.

Projects in the automobile dismantling and e-waste sector

16. In Fiji, as a follow-up to the "Promoting decent work and a just transition in automobile dismantling sector in Fiji" (2017-2018; described in the last ILO report), which assisted in the prevention of occupational exposure to mercury and its safe disposal in the automobile dismantling sector, a number of follow-up activities are planned. Future work is foreseen to develop and promote the application of OSH and environmentally friendly waste disposal guidelines on e-waste, chemicals and car battery disposal, including those components that contain mercury. These guidelines will provide the basis for capacity development efforts and widespread training which is envisioned to target policymakers, sector stakeholders and society in general.

17. In Latin America, the ILO is implementing the project "Strengthening of national initiatives and enhancement of regional Cooperation for the environmentally sound management of POPs in Waste of Electronic or Electrical Equipment (WEEE) in Latin-American countries". The objective of the project is to mobilize governments, employers› and workers› organizations and other private sector and academia to better manage electronic waste, including the hazardous chemicals and heavy metals it contains (including mercury), and promote decent work in the sector in Latin America, starting with Argentina and Peru. The project contributes to a UNIDO Regional Programme funded by the GEF.

Global codes of practice, research papers and working documents

18. The ILO published the Code of Practice on safety and health in shipbuilding and ship repair (revised edition). The revised code promotes a preventative safety and health culture in which the right to a safe and healthy working environment is respected at all levels. Specifically, the Code of Practice has the following provision:

19. "9.4.1. Spray painting: Spray painting should not be carried out using any toxic material, such as mercury, antimony, arsenic, arsenic compounds or methanol, or a mixture containing more than 1 per cent of benzene, unless the workers wear adequate airline breathing apparatus."

20. The ILO published an issues paper entitled Decent work in the management of electrical and electronic waste (e-waste) (ILO 2019a). The paper notes the role played by the Minamata Convention in protecting human health and the environment from mercury emissions and releases, and thus in the management of e-waste, much of which contains mercury. In addition, the ILO published country level case studies on e-waste management in India and Nigeria (ILO 2019e).

21. ILO has published a study entitled Sectoral Studies on Decent Work in Global Supply Chains: Comparative Analysis of Opportunities and Challenges for Social and Economic Upgrading, which it is currently promoting among constituents (ILO 2016b). The study includes a case study on "Promoting Decent Work in Global Supply Chains: The Gold Industry" (pages 49-88) that refers to OSH concerns related to mercury use in the gold mining sector.

22. In May 2021, the ILO published a technical report: Exposure to hazardous chemicals at work and resulting health impacts: A global review (ILO 2021). This review presents data on occupational chemical exposures, including a section on heavy metals and mercury. The review also looks at the health effects of these chemicals on exposed workers and examines trends in mercury exposure, including regional trends, the role of gender and main sectors of exposure. The publication includes examples of priority actions that can be taken at the national policy level, as well as examples of enterprise level interventions.

23. The ILO has developed a technical report titled Exposure to mercury in the world of work: A review of the evidence and key priority actions which is expected to be released in July 2021. The report explores ways to reduce ASGM workers' exposure to mercury, support ILO technical assistance, promote a sustainable culture for accident and disease prevention and improve OSH. It discusses the potential health outcomes on workers who are exposed and outlines several priority actions including policy level, enterprise level and a special focus on the Minamata Convention. The report describes the provisions of the Minamata Convention and discusses how the Convention can assist stakeholders in the world of work and enhance collaboration with the labour sector.

ILO continued support and future initiatives

24. In the ASGM sector, formalizing artisanal mining is a crucial step towards resolving the problem of mercury use and ensuring that gold is produced responsibly and in keeping with social and environmental standards. ILO interventions will consist of conducting targeted studies and proposing sustainable mining approaches and projects to Governments through a tripartite arrangement involving the authorities responsible for mining resources, miners' organizations and employers' organizations, with the goal of finding alternatives to mercury-based ore processing methods and enhancing OSH practices. Governments will be encouraged to implement binding action plans for reducing mercury use in ASGM.

25. At the global level, the ILO has increased its efforts to enhance the knowledge base on hazardous exposures in the world of work, specifically on the topic of mercury exposures, in order to support the development of evidence-based policies at both the national and enterprise level. The ILO looks forward to enhancing multi-lateral collaboration specifically when it comes to the global implementation of the Minamata Convention and enhancing the labour and decent work component in these efforts.

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