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# State of the evidence:

# Results from the ILO Global Chemicals Review (2021)

# Session objectives

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

1. Suggest why the ILO Global Chemicals review was conducted.
2. Pinpoint the main findings of the review.
3. List the ten key chemical types identified as priorities.
4. Describe how workers are exposed to each of the chemical types.
5. Identify prevalent health impacts for workers.
6. Illustrate health impacts using examples from case studies.

# Introduction to the review

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# Why was the review conducted?

- The ILO Global Chemicals Review was a **scoping review** undertaken in 2021.
- It is a **comprehensive analysis of recent trends and priorities** when it comes to protecting the health and safety of workers from occupational chemical exposures.
- Chemical exposures were considered for inclusion if they were well-known or **>1 million workers were exposed** worldwide. Global burden of disease (GBD) and mortality figures were also considered.
- It provides a sound evidence base towards policy efforts.

# Main findings

- Chemical exposure **data is inadequate** and the number of workers exposed can often not be estimated.
- Only a limited number of chemical exposures are considered, monitored and regulated in workplaces.
- Global burden of disease calculations are often **missing or are severely underestimated**.
- Whilst some hazardous chemicals have been phased out, **toxic substances are still used globally**, particularly in LMIC.
- **Cancer is the main cause of work-related death**, and more than 200 different substances have been identified as known or probable human carcinogens.
- Occupational chemical exposures have toxic effects on **different body systems**, as well as **specific organs.**

# Overview of health impacts


# The key chemical priorities

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# Key chemical priorities

- Asbestos
- Silica
- Heavy metals
- Solvents
- Dyes
- Manufactured nanomaterials (MNMs)
- Perfluorinated chemicals (PFAS)
- Endocrine disrupting chemicals (EDCs)
- Pesticides
- Workplace air pollution

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## Question:

Can you identify any uses of the key chemicals?


Asbestos

# Asbestos: Exposure

- A group of **naturally-occurring minerals**, including chrysotile, amosite, anthophyllite and crocidolite.
- Exposure occurs through **inhalation of fibres** from air contaminated with asbestos.
- More than 50 countries have **phased out asbestos**.
- However, major producers continue to produce and export asbestos, especially to LMIC, where **use has increased**.
- Over 2,030,000 tonnes of asbestos are consumed annually *(Furuya et al. 2018)*.
- High risk occupations are **male-dominated** and generally involve **physical labour**.
- The exception is the **textile industry**, which has a large proportion of females.

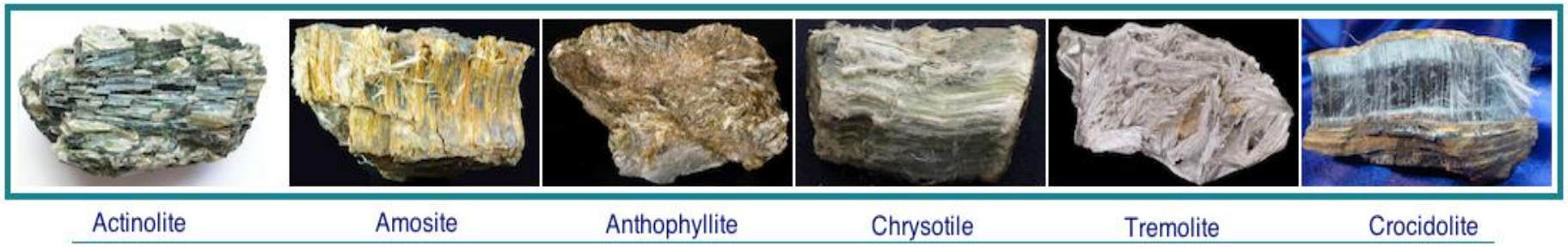
# Asbestos: Overview

| SECTORS OF EXPOSURE | PRIMARY HEALTH IMPACTS | GLOBAL BURDEN OF OCCUPATIONAL EXPOSURES | WORK-RELATED HEALTH IMPACT |
|---|---|---|---|
| **Mining**<br>**Construction**<br>**Agriculture; plantations; other rural sectors**<br>**Automotive industry**<br>**Protective textiles** | Cancer (mesothelioma, cancer of the lung, larynx, ovary)<br>Asbestosis and pleural disease | >125,000,000 (WHO 2018)* | >233,000 deaths annually (GBD 2019) |

**Based on estimates from 2018. A new WHO/ILO joint estimate is under development*

# Asbestos: Health impacts

- Asbestos is classified by the IARC as **carcinogenic to humans (Group 1)**.
- Asbestos causes **mesothelioma** and **lung, larynx and ovary cancer**. Associations have also been found for other types of cancer.
- **Asbestosis**, a type of pneumoconiosis, occurs primarily as a result of occupational exposure.
- Occupational exposure to asbestos causes an estimated **233,000 deaths each year** due to mesothelioma, lung cancer, larynx and ovary cancers, and asbestosis *(Furuya et al. 2018)*.



# Case study: An asbestos-cement factory in Colombia

- The asbestos industry began operations in Colombia in 1942, with an asbestos-cement facility located in the municipality of Sibaté.
- In recent years, residents have been complaining about an unusually large number of people diagnosed with **asbestos-related diseases**.
- A 2015 study of soil samples confirmed the existence of an underground layer of friable and non-friable asbestos **in close proximity to a school and residential dwellings.**
- The estimated age-adjusted incidence rate of **mesothelioma** in Sibaté was higher those reported in other cities, regions and countries of the world *(Ramos-Bonilla et al. 2019)*.


Silica

# Silica: Exposure

- Silica, or silicon dioxide (SiO2), is a **natural compound** of silicon and oxygen found mostly in sand.
- Silica exposure is most extensive in occupations involving **manual labour**, that typically are **predominately male**.
- **Workers in LMICs** are the most exposed, however exposed workers within all countries are more likely to be **migrant or ethnic minorities**.

# Silica: Overview

| SECTORS OF EXPOSURE | PRIMARY HEALTH IMPACTS | GLOBAL BURDEN OF OCCUPATIONAL EXPOSURES | WORK-RELATED HEALTH IMPACT |
|---|---|---|---|
| **Mining**<br>**Construction**<br>**Agriculture; plantations; other rural sectors**<br>**Oil and gas**<br>**Manufacturing (e.g. pottery, ceramics, bricks, stone cutting**<br>**Niche industries using abrasive sandblasting (e.g. textiles)** | Cancer (cancer of the lung)<br><br>Silicosis | >50,000,000 (Limited data covering 35 countries) (OSHA 2002; IOM 2011)* | >65,000 deaths annually (GBD 2019) |

**Based on estimates from 2018. A new WHO/ILO joint estimate is under development*

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# Silica: Health impacts

- **>65,000 deaths** occurred worldwide in 2019 due to occupational silica exposure *(GBD 2019)*.
- Crystalline silica (c-silica) is classified by IARC as **carcinogenic to humans (Group 1)**.
- There is also sufficient evidence that c-silica causes **lung cancer** *(IARC 2012)*.
- Exposure also can cause **silicosis**, a long-term progressive lung disease with no available treatment.

# Case study: Artificial stone workers in Australia

- Occupational lung disease after inhalation of respirable silica is variable and potentially **life-threatening**.
- As the artificial stone industry has grown over the last two decades, clinicians have described unique manifestations of silicosis with signs and symptoms different from classic chronic silicosis.
- For example, a number of masons working with artificial stone have been forced to undergo **lung transplantation** due to silicosis.
- These patients have both fibrotic/nodular silicosis and conspicuous alveolar proteinosis within the same lung parenchyma.
- Radiological and histopathological correlates of disease has been shown clearly in the literature *(Levin et al. 2019)*.


Heavy
metals

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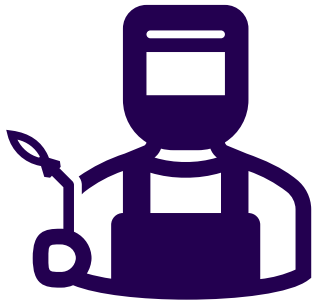
# Question:

Can you name any hazardous heavy metals?



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# Answer:

- Some examples are arsenic, cadmium, hexavalent chromium, lead, mercury and nickel.
- Can you think of any others?

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# Heavy metals: Exposure

**Hazardous high-density metals include arsenic, cadmium, hexavalent chromium, lead, mercury and nickel.**

- Usually enter the body as **dusts or fumes**.
- **LMICs** carry the largest burden of exposure for all heavy metals.
- Both genders are subject to heavy metal occupational exposure.

# Heavy metals: Arsenic, cadmium and chromium

- **Arsenic:** Used in industrial processes to produce antifungal wood preservatives, in the pharmaceutical and glass industries and in the manufacture of alloys, sheep dips, leather preservatives, arsenic-containing pigments, antifouling paints and poison baits. Waste pickers can also be exposed.
- **Cadmium:** The highest potential occupational exposures to cadmium occur in production and refining of cadmium, nickel-cadmium battery manufacture, cadmium pigment manufacture and formulation, cadmium alloy production, mechanical plating, zinc smelting, brazing with silver-cadmium-silver alloy solder and polyvinylchloride compounding.
- **Hexavalent chromium:** Large numbers of workers are exposed to high concentrations of chromium compounds in the electroplating, welding and painting industries.

# Heavy metals: Lead, mercury and nickel

- **Lead**: Occupational exposure to lead is one of the most prevalent overexposures. Industries with high potential exposures include construction work, e-waste recycling, smelting, radiator repair shops, lead crystal glassware and firing ranges. Lead is also used in the production of lead-acid batteries, plumbing materials and alloys, as well as in cable sheathing, paints, glazes and ammunition *(WHO 2017)*.
- **Mercury**: Occupational exposure occurs in many industries, including artisanal and small-scale gold mining (ASGM) and other mining, in vinyl chloride monomer production, oil and natural gas processing, paper-making, dentistry and the manufacturing of religious idols.
- **Nickel:** In occupational settings, exposure to nickel and nickel compounds occurs primarily during nickel refining, electroplating and welding.

| SECTORS OF EXPOSURE | SUBSTANCE | PRIMARY HEALTH IMPACTS | GLOBAL BURDEN OF OCCUPATIONAL EXPOSURES | WORK-RELATED HEALTH IMPACT |
|---|---|---|---|---|
| **Mining**<br>**Construction**<br>**Agriculture, plantations, other rural sectors**<br>**Manufacturing**<br>**Basic metal production**<br>**Shipping, ports, fisheries, inland waterways**<br>**Utilities (water, gas, electricity)**<br>**Textiles, clothing, leather, footwear**<br>**Mechanical and electrical engineering** | Overview | Various | >25,000,000 | Limited data |
| | Lead | Cancer (stomach)<br>Neurotoxicity<br>Cardiovascular disease | >1,800,000 (EU-OSHA 2014; CAREX-Canada 2020) | Limited data (>900,000 due to environmental lead exposure (GBD 2019)) |
| | Mercury | Neurotoxicity<br>Nephrotoxicity<br>Immune toxicity<br>Reproductive toxicity | >19,000,000 (Limited data for artisanal small-scale gold mining only) (Steckling et al. 2017) | Limited Data (>2,000,000 DALYs attributable to chronic metallic mercury vapour intoxication) (Steckling et al. 2017) |
| | Arsenic | Cancer (lung, skin, urinary and bladder)<br>Skin toxicity<br>Neurotoxicity<br>Nephrotoxicity | >3,000,000 (GBD 2019) | Limited data |
| | Cadmium | Cancer (lung)<br>Nephrotoxicity<br>Bone toxicity | >500,000 (GBD 2019) | Limited data |
| | Hexavalent chromium | Cancer (lung)<br>Nephrotoxicity<br>Lung toxicity<br>Skin toxicity<br>Liver toxicity | >1,000,000 (GBD 2019) | Limited data |

# Heavy metals: Cancer

**The IARC has classified arsenic, cadmium and hexavalent chromium as carcinogenic to humans (Group 1).**

- Arsenic causes **cancer of the lung, skin and bladder**. Also, positive associations have been observed for cancer of the prostate, kidney, liver and bile duct.
- Cadmium causes **cancer of the lung** and positive associations have been observed for prostate and kidney cancer.
- Hexavalent chromium compounds cause **cancer of the lung**. Positive associations have been observed for cancer of the nasal cavity and paranasal sinus, as well as stomach cancer *(IARC 2012; Welling et al. 2015)*.
- Lead is classified as **probably carcinogenic to humans (Group 2A)**.

# Arsenic exposure photos

# Heavy metals: Other health outcomes

**WHO has identified arsenic, cadmium, lead and mercury as four of the top ten chemicals of major public health concern.**

- **Heavy metal exposure can adversely impact many different body systems**, including the reproductive, neurological, immune and cardiovascular systems.
- Examples of health impacts:
  - **Acute arsenic poisoning** from accidental ingestion of insecticides or pesticides.
  - Hexavalent chromium exposure can induce **asthma, irritation, kidney damage, liver damage, pulmonary congestion and oedema.**
  - The **kidney** is the main target of cadmium.
  - Lead exposure is associated with **neurobehavioural deficits, kidney dysfunction and an increased risk of Amyotrophic Lateral Sclerosis.**
  - Mercury is toxic to the **central and peripheral nervous system**.
  - Both lead and mercury are transferred to the foetus in pregnancy and the child during breast-feeding, causing developmental harm to brain and nervous systems.

# Case study: Child labour in the cobalt mines of DRC

- **Children as young as six** are risking their lives in cobalt mines for the world's big electronic firms.
- The cobalt is used in **lithium-ion rechargeable batteries**, used in smartphones, laptops and tablets, as well as fashion superalloys, jet engines and gas turbines.
- It is also used in the **batteries of electric cars** and for **storing power from wind and solar plants**.
- 60% of the world's cobalt supply is mined in the 'copper belt' of the south-eastern provinces of the DRC.
- Large numbers of children work in the mines without PPE, breathing **cobalt-laden dust**.
- Water supplies are also **contaminated** with waste from processing plants.

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# Spotlight on e-waste: Hazardous substances within the life cycle of high tech electrical and electronic products

- **All stages of an electronic product's lifecycle can lead to hazardous chemical exposure**, including extraction, production, transport, use, recycling and waste management.
- **More than 60 chemical elements can be found in electronics**, including aluminium, gallium, arsenic, lead, cadmium, chromium, mercury, copper, manganese, nickel, iron, zinc, brominated flame retardants and polychlorinated biphenyls (PCBs).
- **The majority of the workforce in the electronics industry are young women.**

Exposure to the various chemicals, compounds and by-products present in e-waste have been identified **as carcinogenic to humans (Group 1)** by IARC. Other health effects include **neurotoxicity** and impacts to the reproductive system.


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# Solvents: Key info

- The term ‘solvent’ is generic and may include hundreds of different chemical compounds.
- Solvent exposure is **one of the most common chemical exposures in the workplace** *(Benke et al. 2017)*.
- Used **in large quantities globally** and found in many products, such as **cleaning materials**, **paints**, **adhesives**, **inks** and **toiletries**.
- Common examples are isopropanol, benzene, toluene, xylene and solvent mixtures, such as white spirits.

# Solvents: Exposure

- High solvent exposure occupations include **painters**, **lacquerers**, **printers**, **dry cleaners**, **footwear manufacturers**, **occupations in graphics and plastic product works**.
- Exposure is mainly through **vapour inhalation**, although dermal contact may be high in industries such as painting.
- The **1987 Montreal Protocol** has led to the restriction or phase out of many ozone-depleting solvents.
- Water-based paints have replaced traditional, solvent-based coatings *(Dick 2006)*.
- In some industries (e.g. dry cleaning), improvements to equipment and processes have lessened solvent use.

# Solvents: Overview

| SECTORS OF EXPOSURE | PRIMARY HEALTH IMPACTS | GLOBAL BURDEN OF OCCUPATIONAL EXPOSURES | WORK-RELATED HEALTH IMPACT |
|---|---|---|---|
| **Food; drink; tobacco**<br>**Mechanical and electrical engineering**<br>**Construction**<br>**Chemical industries**<br>**Printing**<br>**Plastics**<br>**Rubber**<br>**Textiles; clothing; leather; footwear**<br>**Manufacturing**<br>**Dry cleaning** | Cancer<br><br>Neurotoxic effects including 'chronic solvent-induced encephalopathy' (CSE)<br><br>Reproductive toxicity | Limited data | Limited data |

# Solvents: Health impacts

- IARC has classified **benzene** and **trichloroethylene** (TCE) as **carcinogenic to humans (Group 1)**. Some solvents e.g. methylene chloride and tetrachloroethylene, are probably carcinogenic (Group 2A).
- Benzene has been specifically linked with **leukaemia** *(WHO 2019)* and chlorinated hydrocarbons to **renal cancer** *(Brüning et al. 2003)*.
- Occupation as a **painter** has consistently been associated with a **40% increased risk of lung cancer**.
- Numerous other health effects have been associated with solvent exposure, including **chronic solvent induced encephalopathy (CSE)**, **kidney and liver damage**, **skin lesions and adverse reproductive impacts, such as sperm changes and infertility.**

# Case study: French CONSTANCES study

- Evaluated the association between occupational solvent exposure and cognitive performance in a cohort of over 40,000 participants, aged 45-69 years old.
- Cognitive function, episodic verbal memory, language ability and executive function were evaluated using a standardised battery of cognitive tests.
- Results showed that men occupationally exposed to gasoline, white spirits or cellulosic thinner were at **greater risk of cognitive impairment**, whilst women exposed to white spirits or exposed for more than 20 years had **poorer cognitive performance**.
- Cognitive performance decreased with the number of solvents to which individuals were occupationally exposed and with the cumulative exposure time *(Letellier et al 2020)*.

# Dyes

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# Dyes: Exposure

- Synthetic dyes are used to modify the colour of different substrates, such as textiles, paper and leather.
- There are around **800 dyes currently in use**, including **azo dyes**, the most common dyes *(Licina et al. 2019)*.
- The global demand of dyestuff corresponds to approximately 9 million tonnes *(Rawat et al. 2016)*.
- **Textiles make up a significant proportion of dye use**, with China, Bangladesh and Vietnam being three of the world's top five garment exporters *(ILO 2019)*.
- Dyes are also commonly used in pharmaceuticals, food and cosmetics.
- The manufacturing of benzidine and the use of azo dyes are specifically prohibited in some regions.

# Dyes: Overview

| SECTORS OF EXPOSURE | PRIMARY HEALTH IMPACTS | GLOBAL BURDEN OF OCCUPATIONAL EXPOSURES | WORK-RELATED HEALTH IMPACT |
|---|---|---|---|
| Textiles; clothing; leather; footwear<br>Chemical industries<br>Food; drink<br>Pharmaceuticals<br>Cosmetics | Cancer (bladder) | Limited data | Limited data |

# Dyes: Health impacts

- Some azo dyes degrade to release **carcinogenic aromatic amines**, such as benzidine *(Licina et al. 2019)*.
- Azo dyes and aromatic amines have been linked to cancer, for example, benzidine has been linked to bladder cancer (IARC 2010b).
- Can cause **respiratory problems**, **skin irritation** and other allergic symptoms *(Hassan & Nemr 2017)*.
- Women are more likely to use dyes at work and are at a **higher likelihood of adverse health outcomes**, especially during pregnancy.

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# Case study: Hairdresser dyes

- Hairdressers are frequently exposed to dyes.
- The major pathway for exposure is via skin contact, followed by dermal absorption.
- The IARC has identified **occupational dye exposures as a hairdresser are probably carcinogenic to humans *(IARC 2010)***.
- In particular, the risk of **bladder cancer** was considered to be increased, particularly for men.
- In 2007, the EU banned the use of **135 individual ingredients** in hair dyes.

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# Spotlight on textiles

- One of the **largest employers worldwide**
- **80 million garment workers are employed worldwide**, with the Asia-Pacific region accounting for 60% of global apparel exports *(ILO 2020)*.
- Thousands of dyes and solvents are used in textiles, many of which have **mutagenic** and **carcinogenic** properties *(Singh and Chadha 2016).*
- Commonly used chemicals include **crease-resistant agents** (e.g. formaldehyde), **flame retardant chemicals** (e.g. organophosphorus compounds) and **azo dyes**.

# Spotlight on textiles

- Women constitute more than 80% of the workforce in the textiles, clothing, leather and footwear industry *(ILO 2019)*.
- Many of these are **young women** and therefore concerns exist regarding the potential impact on current and future **pregnancies** *(ILO 2019)*.
- Work in textiles has been associated with bladder and lung cancer, dermatitis, COPD and increased mortality from diabetes and ischaemic heart disease.
- **Phasing out the most hazardous chemicals** is considered a priority action for the textile industry.
- The EU has restricted the use of 33 substances classified as carcinogenic, mutagenic or toxic for reproduction (CMR) in the textile/garment sector *(EU-Commission 2018)*.

# Case study: Garment factory workers in Bangladesh

- Health status of garment and textile factory workers in Bangladesh was reviewed using 1906 medical records.
- The mean age of the workers was 27.9±7.3 y, with 60 per cent female and 40 per cent male.
- **20% were found to be anaemic, 12% had elevated blood pressure and 8% had elevated fasting blood glucose**.
- Significant percentages of workers were identified as having **undiagnosed health conditions** which required **urgent medical attention**.
- The findings suggest that **annual health screening** would help improve health of garment workers *(Solinap et al. 2019)*.

# Manufactured nanomaterials (MNMs)

# Manufactured nanomaterials (MNMs): Key info

- One dimension (height, width or length) is **<100 nanometers**.
- Do not belong to any specific chemical group.
- Humans have long been exposed to **unintentionally produced nanoparticles**, e.g. from combustion processes
- The **recent increase of MNM production** in a wide variety of industries represents a novel exposure risk for workers.
- When particle size is decreased to the nanoscale range, **physical and chemical properties often change** with **consequent new product opportunities**.
- This also presents **new risks and uncertainties**.

# MNMs: Exposure

- Commonly found in sunscreen products, catalytic converters, thin film solar cells, nanolithographic tools and nanoscale electronic memories, nanosilver and pest-control products.
- The global nanotechnology market is expected to grow by a compound annual growth rate of 18 per cent from US$39.2 billion in 2016 to US$90.5 billion by 2021 *(BCC Research 2017)*.
- The United States, South Korea, China, and Japan are the largest producer of nanoproducts *(StatNano 2019)*.
- Brazil and South Africa have research laboratories that produce carbon nanotubes. LMICs produce nanosilver that is incorporated in milk packs, fabrics and clothes.

# MNMs: Overview

| SECTORS OF EXPOSURE | SUBSTANCE | PRIMARY HEALTH IMPACTS | GLOBAL BURDEN OF OCCUPATIONAL EXPOSURES | WORK-RELATED HEALTH IMPACT |
|---|---|---|---|---|
| Chemical industries<br>Food; drink; tobacco<br>Health services | Carbon Nanotubes (MWCNT) | Cancer (mesothelioma and lung cancer) | Limited data | Limited data |
| Mechanical and electrical engineering<br>Textiles; clothing; leather; footwear | Titanium Dioxide | Cancer (lung cancer) | Limited data | Limited data |

# MNMs: Health impacts

- Health hazards can result from inhalation, ingestion or skin absorption.
- Can reach the **deepest regions of the lungs** due to their tiny size.
- From the alveolar regions, the smallest nanoparticles can pass through the air-blood barrier and be **translocated to other organs** in the body.
- **Multi-walled carbon nanotubes and titanium dioxide have been classified by IARC as possible carcinogens (Group 2B)**.
- Other health impacts for a range of MNMs include **specific organ toxicity** after chronic exposure.
- Further research is needed on health impacts and gender concerns.

# Case study: Biomarkers in US workers

- An industry wide cross-sectional epidemiological study of 108 workers from 12 US worksites was conducted to evaluate associations between **occupational carbon nanotube and nanofiber (CNT/F) exposure** and sputum and blood biomarkers of early health effect.
- CNT/F exposure was assessed via personal breathing zone, filter-based air sampling.
- A number of **biomarkers of early health effect** were associated with CNT/F exposure.
- Inhalable, rather than respirable CNT/F, was more consistently associated with **fibrosis**, **inflammation**, **oxidative stress** and **cardiovascular biomarkers** *(Beard et al. 2018)*.


Perfluorinated chemicals (PFAS)

# Perfluorinated chemicals (PFAS): Key info

**Include 4,730 man-made chemicals that contain fluorine atoms bonded to a carbon chain.**

- **Perfluorooctanoic acid (PFOA)** and **perfluorooctane sulfonate (PFOS)** have been manufactured the longest and are the most  widespread in the environment.
- PFAS are oil and water repellent, stabile at high and low temperatures and effective for friction reduction.
- PFAS are used in **many products**, including textiles, paper, semiconductors, automotive and aerospace components, cookware, food packaging and firefighting foams.

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# PFAS: Exposure

- The highest levels of exposure tend to be observed near **PFAS producing facilities or disposal sites** *(Guelfo et al. 2018)*.
- Particularly high levels are often found in workers in **chemical industries**. **Firefighters** and **ski-wax technicians** are also particularly at risk.
- Different developed countries are starting to **phase out PFAS** and are imposing more **restrictive limits**, however this is not occurring in LMICs.
- PFOS and PFOA have been listed under the **Stockholm Convention for global elimination**, however there are **thousands of PFAS still in use**.

# PFAS: Overview

| SECTORS OF EXPOSURE | PRIMARY HEALTH IMPACTS | GLOBAL BURDEN OF OCCUPATIONAL EXPOSURES | WORK-RELATED HEALTH IMPACT |
|---|---|---|---|
| **Chemical industries**<br>**Food, drink, tobacco**<br>**Textiles, clothing, leather, footwear**<br>**Construction**<br>**Electronics manufacturing**<br>**Aerospace**<br>**Automotive**<br>**Emergency response** | Cancer (testicular, liver and kidney)<br>Immune toxicity<br>Liver Toxicity<br>Reproductive Toxicity | Limited data | Limited data |

# PFAS: Health impacts

**PFAS have been linked to a variety of cancers, with PFOA classified as possibly carcinogenic to humans (Group 2B) by the IARC.**

- Increases in **testicular, liver and kidney cancer** have been observed in workers and communities chronically exposed to high levels of PFAS.
- They are also known to interfere with **immune function**, **endocrine function** and **breast development**.
- Biological sex can influence effects resulting from PFAS exposure, as well as bioaccumulation and clearance.
- Studies have shown elevated levels of PFAS in the blood of both **male and female firefighters**.

# Case study: PFAS in firefighting foam

- Several studies have shown that firefighters have higher blood levels of PFAS compared to the general population.
- Exposure is from **PFAS-containing firefighting foam**, as well as **PFAS-treated protective gear**.
- Firefighting is generally a male-dominated occupation and most studies have been focussed on male worker cohorts.
- However, a recent study of an all-female cohort of firefighters showed that all the 86 female firefighters had at least four PFAS detected in their serum samples (PFHxS, PFOA, PFOS, and PFNA). Three additional PFAS were detected in 70 per cent of the firefighters

# Endocrine-disrupting chemicals (EDCs)

# Endocrine-disrupting chemicals (EDCs): Key info

- Substances that can **act at very low doses** to impact the functioning of the **endocrine system**. They act as exogenous hormones or alter the endogenous hormone balance.
- Belong to many different chemical groups and used in a wide range of occupations.
- UNEP has produced a list of **45 substances** identified as EDCs or potential EDCs belonging to **18 chemical groups**.
- The life cycles of EDCs are of particular concern, since many of them can **contaminate workers even decades after their use** has been discontinued.
- The life cycle of plastics containing EDCs represents a **global challenge**.

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# EDCs: Exposure

- The **construction and plastics industries employ millions of workers globally**, which use **large quantities** of known or suspected EDCs.
- Exposure to EDCs varies widely within and among countries.
- In the USA, most EDC health costs are due to **flame retardants**, while in Europe they are related to **organophosphate pesticides** *(Trasande et al. 2016; Attina et al. 2016)*.
- The **phasing out and ban** of the most toxic EDCs has been successfully implemented, in particular in HICs.



| SECTORS OF EXPOSURE | SUBSTANCE | PRIMARY HEALTH IMPACTS | GLOBAL BURDEN OF OCCUPATIONAL EXPOSURES | WORK-RELATED HEALTH IMPACT |
|---|---|---|---|---|
| **Chemical industries**<br>**Food; drink; tobacco**<br>**Health services**<br>**Mechanical and electrical engineering**<br>**Textiles; clothing; leather; footwear**<br>**Oil and gas production; oil refining**<br>**Agriculture; plantations; other rural sectors**<br>**Construction** | Overview | Various | Limited data | 800,000 cases of male infertility in the US and Europe |
| | Phthalates | Reproductive toxicity<br>Obesity<br>Diabetes | Limited data | Limited data |
| | Pesticides (Organophosphates, Triclosan) | Neurotoxicity | Limited data | Limited data |
| | Parabens | Reproductive toxicity | Limited data | Limited data |
| | Bisphenols | Cancer (breast, prostate)<br>Obesity<br>Reproductive toxicity | Limited data | Limited data |
| | Flame retardants | Neurotoxicity<br>Reproductive toxicity | Limited data | Limited data |

# EDCs: Health impacts

- EDCs have been implicated in **multiple reproductive disorders in men and women**, as well as **cancers**, **neurodevelopmental disorders** and **obesity**.
- In **women**, EDCs have been linked to early puberty, infertility, abnormal cyclicity, premature menopause, endometriosis, fibroids, and adverse pregnancy outcomes.
- In **men**, there have been birth defects of male reproductive organs, increased incidence of testicular germ cell carcinoma and poor semen quality *(Gore et al. 2015)*.
- This can lead to adverse health effects in an organism, its offspring or populations, such as **changes in the morphology, physiology, growth, development, reproduction or life span**.

Estimated costs due to health effects of EDCs:

- US$217 billion per year in the EU
- US$340 billion per year in the US

# Case study: Phthalate exposure in sales clerks

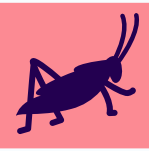
- High levels of phthalates in cosmetic products have raised concerns about **phthalate exposure** and the associated risk for cosmetics sales clerks in southern Taiwan.
- The exposure and risk of phthalates was analysed in 23 cosmetics, 4 perfume, and 9 clothing department store sales clerks.
- Urinary levels of phthalates were **higher post-shift** compared to pre-shift levels.
- 70 percent exceeded cumulative risk of phthalate exposure for **anti-androgenic effects**.
- Cosmetic and perfume workers had **increased risks of reproductive or hepatic effects** for diethyl phthalate (DEP) and DEHP exposure.
- The study also noted that **dermal exposure** represents an important route of phthalate exposure for cosmetics and perfume workers *(Huang et al. 2018)*.

# Pesticides

# Pesticides: Key info

**One of the major hazards in agriculture due to their toxicity.**

- Chemicals with **biologically active ingredients.**
- Used by agricultural workers and those in vector control.
- **Toxic by design** and **all present some level of risk**.
- **Kill pests**, including insects, rodents, fungi and unwanted plants.
- Most are designed to act on the **nervous system of animals**.

| Category (example) | |
|---|---|
|  | Insecticides (Carbamates, DDT) |
|  | Herbicides (Glyphosate “Roundup”) |
|  | Rodenticides (Warfarines) |
|  | Fungicides (Triazoles) |

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# Pesticides: Exposure

- Approximately **1.8 billion people are engaged in agricultural activities** worldwide and **most use pesticides** to protect food and commercial products that they produce *(Carvalho 2017)*.
- LMICs account for about **70% of worldwide Highly Hazardous Pesticides (HHP)** use, i.e. over 1.2 million tonnes in 2017 *(Public Eye 2020)*.
- Global pesticide use has continued to grow steadily to 4.1 million tonnes per year in 2017, **an increase of nearly 81% from 1990** *(FAOSTAT 2019)*.

# Pesticides: Exposure

- Occupational exposure occurs during **handling, dilution, mixing, application and disposal** of pesticides, as well as during **cleaning of containers** and **handling of crops**.
- Exposure is mainly by the **dermal route** for preparation of sprays and by the **dermal and inhalation routes** during application
- **Ingestion** might occur through consumption of contaminated food during or following work or through oral contact with contaminated hands.
- **Contaminated clothing** is a significant source of exposure.
- **Stocks of obsolete pesticides** still represent an exposure hazard in many countries, in particular if storage or disposal is inappropriate *(WHO 2019)*.

# Pesticides: Overview

| SECTORS OF EXPOSURE | PRIMARY HEALTH IMPACTS | GLOBAL BURDEN OF OCCUPATIONAL EXPOSURES | WORK-RELATED HEALTH IMPACT |
|---|---|---|---|
| **Agriculture, plantations, other rural sectors**<br><br>**Chemical industries** | Poisoning<br><br>Cancer<br><br>Neurotoxicity<br><br>Endocrine disruption | Limited Data (although presumably a majority of global agricultural workers (1.8 billion) exposed) (Carvalho 2017) | Limited Data (>300,000 deaths annually due to unintentional cute pesticide poisoning alone) (Boedecker 2020) |

# HHPs criteria table

| | |
|---|---|
| 1 | Pesticide formulations that meet the criteria of **Classes Ia or Ib** of the **WHO Recommended Classification** of Pesticides by Hazard |
| 2 | Pesticide active ingredients and their formulations that meet the criteria of **carcinogenicity Categories 1A and 1B** of the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) |
| 3 | Pesticide active ingredients and their formulations that meet the criteria of **mutagenicity Categories 1A and 1B** of the **GHS** |
| 4 | Pesticide active ingredients and their formulations that meet the criteria of **reproductive toxicity Categories 1A and 1B** of the **GHS** |
| 5 | Pesticide active ingredients listed by the **Stockholm Convention** in its **Annexes A and B**, and those meeting all the criteria in paragraph 1 of **annex D** of the Convention |
| 6 | Pesticide active ingredients and formulations listed by the **Rotterdam Convention** in its **Annex III** |
| 7 | Pesticides listed under the **Montreal Protocol** |
| 8 | Pesticide active ingredients and formulations that have shown a **high incidence of severe or irreversible adverse effects** on human health or the environment. |

# Pesticides: Health impacts

**WHO considers HHPs as a major public health concern *(WHO 2019)* and the introduction of regulations to phase out the use of HHPs has saved uncountable lives *(WHO/FAO 2019)*.**

- Health effects may be acute or chronic.
- **Acute effects** are related to **pesticide poisonings**, which occur commonly in developing economies where **pesticides are mislabelled**.
- Pesticide poisoning represents a **major occupational health crisis** with estimates indicating that **up to 44 per cent of farmers** are poisoned every year.
- A range of different pesticides have been classified by IARC as **carcinogenic to humans (Group 1)** and **probably carcinogenic to humans (Group 2A)**.
- Other health impacts include **neurotoxic effects e.g. Parkinson's disease**, **Alzheimer's disease** and **endocrine disruption**.

# Pesticides: IARC classification

| Carcinogenic to humans (Group 1) | Probably carcinogenic to humans (Group 2A) |
| --- | --- |
| ▸ Arsenic and arsenical compounds<br>▸ Pentachlorophenol (PCP)<br>▸ Lindane<br>▸ Ethylene oxide | ▸ Dichlorodiphenyltrichloroethane (DDT)<br>▸ Organophosphates (malathion, diazinon, glyphosate)<br>▸ Aldrin and dieldrin captafol<br>▸ Ethylene dibromide formaldehyde |

# Case study: Pesticide exposure in cotton farmers in Pakistan

- A study assessed exposure to pesticides and self-reported health problems in 318 randomly selected male cotton farmers.
- Based on WHO's classification, 23 per cent of pesticides were '**highly hazardous**' and 55 per cent were '**moderately hazardous**.'
- Common high exposure risks included: **pesticide spills** in the stage of spray solution preparation (76 per cent), the use of low-technology and **faulty sprayers** (68 per cent) and spraying in **inappropriate weather** (47 per cent).
- **>33% reported multiple symptoms** including skin and eye irritation, headache and dizziness.
- Most farmers thought these symptoms were nothing out of the ordinary and that few reported visiting the doctor *(Khan and Damalas 2015)*.


# Air pollution

# Air pollution: Key info

**Pollution of air at the workplace, either indoors in the work premises or during work outdoors, can cause a range of health impacts.**

- Worldwide at least **1.2 billion workers work outdoors** for a majority of their work time *(WHO 2018)*.
- Indoor air pollution, caused by gases, fumes, aerosols, particles and other substances, is also a major risk for workers.
- Indoor air pollution is common in sectors that include processes such as **burning**, **cleaning** or **internal combustion**. In the absence of good ventilation, indoor air pollutants can be more concentrated *(WHO 2018)*.
- The most common air pollutants are **fine (PM2.5) and course (PM10) particulate matter**, **ozone**, **nitrogen dioxide** and **sulphur dioxide**.
- Other air pollutants that can be important for specific health issues and that are less frequently considered in air pollution estimates include **benzene**, **formaldehyde** or **carbon monoxide**.

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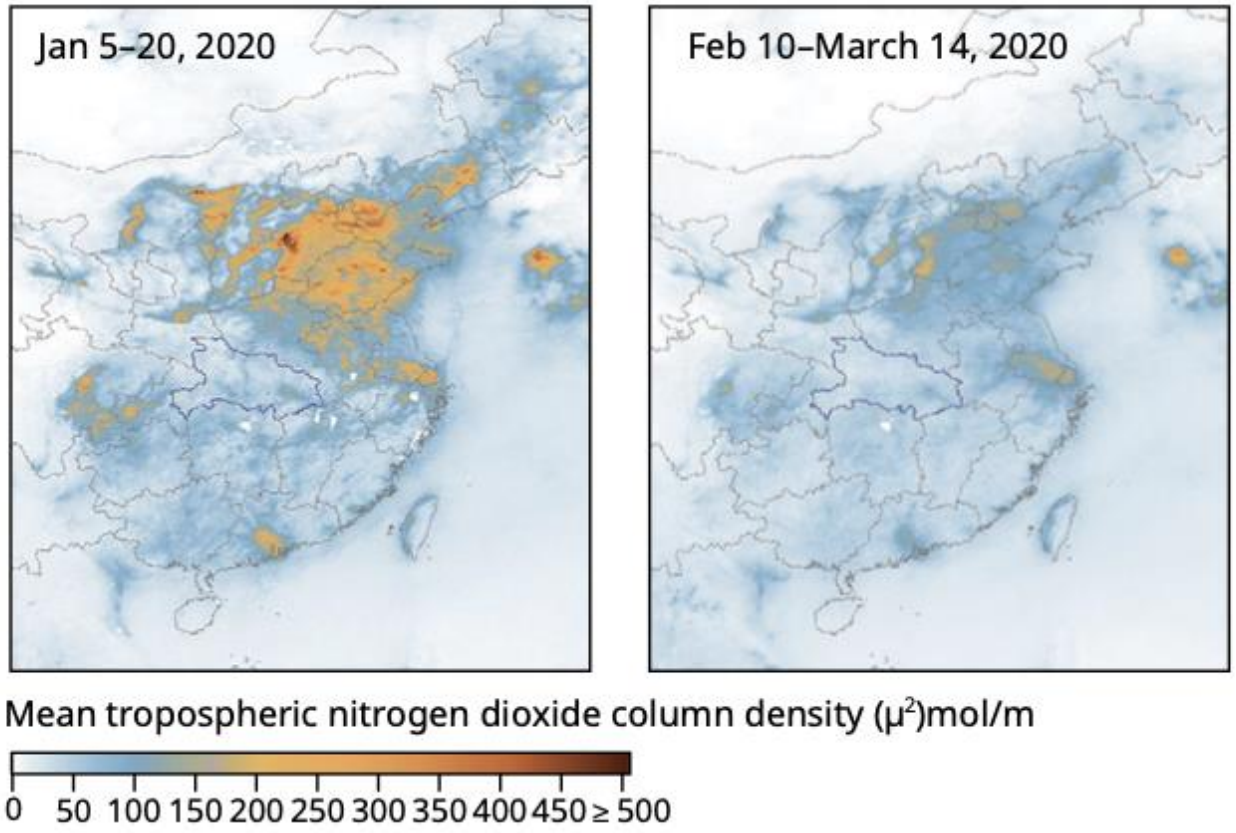
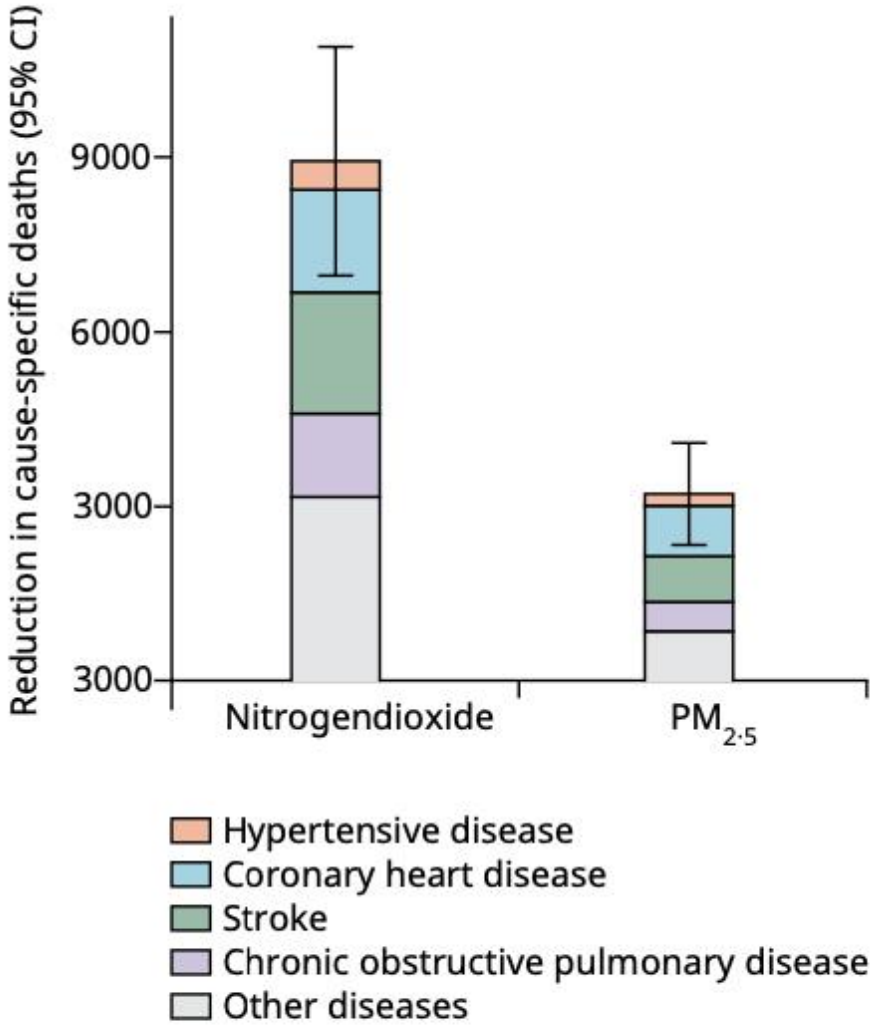
# Air pollution: Exposure

- In 2016, **91% of the world's population** was living and working in places where the WHO standards for air quality were not met *(WHO 2016)*. This equates to approximately **3 billion workers**.
- Higher exposures are observed for outdoor workers in areas with **high levels of air pollution** generated by heavy traffic or industries.
- Level of exposures are in general higher in **LMIC megacities** and **industrial areas** *(Chen 2020)*.
- **Targeted pollution control strategies** in some HICs have been successfully implemented.

# Air pollution levels and avoided cause-specific deaths during the Covid-19 outbreak in China




*Source (Chen 2020).*

# Air pollution: Overview

| SECTORS OF EXPOSURE | PRIMARY HEALTH IMPACTS | GLOBAL BURDEN OF OCCUPATIONAL EXPOSURES | WORK-RELATED HEALTH IMPACT |
|---|---|---|---|
| **All sectors** | Cancer (lung)<br><br>Respiratory disease<br><br>Cardiovascular disease | >1.2 billion (WHO 2018c) | >860,000 deaths annually (WHO 2018c) |

# Air pollution: Health impacts

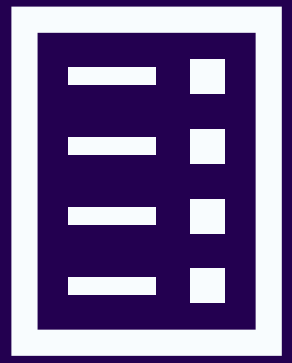
- Can cause a range of acute and chronic health impacts.
- The WHO estimates that **860,000 deaths a year can be attributed to occupational exposure to air pollutants**, although the real magnitude of the health impacts on workplace air pollution is **likely to be much higher**.
- **Air pollution**, **particulate matter** and **diesel exhaust** have been classified by IARC as **carcinogenic to humans (Group 1)**.
- For **lung cancer** alone, air pollution causes **223,000 deaths/year worldwide** *(IARC 2013a, 2015)*.
- Air pollution has also been linked to to a **wide range of diseases** in several organ systems, such as **cardiovascular** and **pulmonary** disease.

# Air pollution: Commuters in London

**Low-income workers often experience higher exposures to air pollutants.**

- Exposure to particulate matter (PM1, PM2.5 and PM10), black carbon (BC) and ultrafine particles for typical commutes (car, bus and underground) from four London areas with different levels of income deprivation was compared (G1 to G4, from most to least deprived).
- The highest BC and PM concentrations were found in G1 while the highest particulate number concentration was in G3.
- Workers from least deprived areas have a predominant use of cars, receiving the lowest doses during commute, but generating the largest emissions per commuter.
- Conversely, workers from most deprived areas have a major reliance on the bus, receiving higher exposures, while generating less emission per person.
- These findings suggest an aspect of environmental injustice and a need to incorporate the socioeconomic dimension in air pollution exposure assessments.

# End of session activity



Quiz

# Quiz

1. How are workers normally exposed to asbestos?
2. Name two potential health impacts of silica exposure.
3. Can you identify some industries where workers may be exposed to lead?
4. What is CSE and what symptoms does it cause?
5. Why are azo dyes specifically very dangerous?
6. Describe nanoparticles?
7. Name two professions where workers are particularly at risk of PFAS exposure.
8. How do EDCs impact the body?
9. What are HHPs?
10. Can you name some common air pollutants?

# Match the chemicals with the chemical types

| | |
|---|---|
| Aromatic amines | Air pollution |
| Benzene | PFAS |
| Dichlorodiphenyltrichloroethane (DDT) | Metal |
| Quartz | Dyes |
| Nitrogen dioxide | Asbestos |
| Phthalates | Manufactured nanomaterials |
| Perfluorooctanoic acid | Endocrine-disrupting chemicals |
| Nanosilver | Silica |
| Cobalt | Pesticide |
| Chrysotile | Solvent |

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# Key ILO resources

- Exposure to hazardous chemicals at work and resulting health impacts: A global review (2021).
- The GHS in the world of work: Mapping synergies between ILO Instruments and the Globally Harmonized System of Classification and Labelling of Chemicals (GHS).
- ILO Instruments on Chemical Safety – Analysis and synergies with other international frameworks on the sound management of chemicals (2020).
- The Sound Management of Chemicals and Waste in the World of Work (2019).
- All You Need to Know: Convention No. 170.
- Guidelines on occupational safety and health management systems (2001).
- Major hazard control: A practical manual (1993).
- Safety in the use of chemicals at work: code of practice (1991).
- EExposure to mercury in the world of work: A review of the evidence and key priority actions.
- ILO indicators of progress in implementing SAICM (2021).

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# Thank you

For further information please contact:

Halshka GRACZYK

LABADMIN/OSH, ILO

E-mail: graczyk@ilo.org