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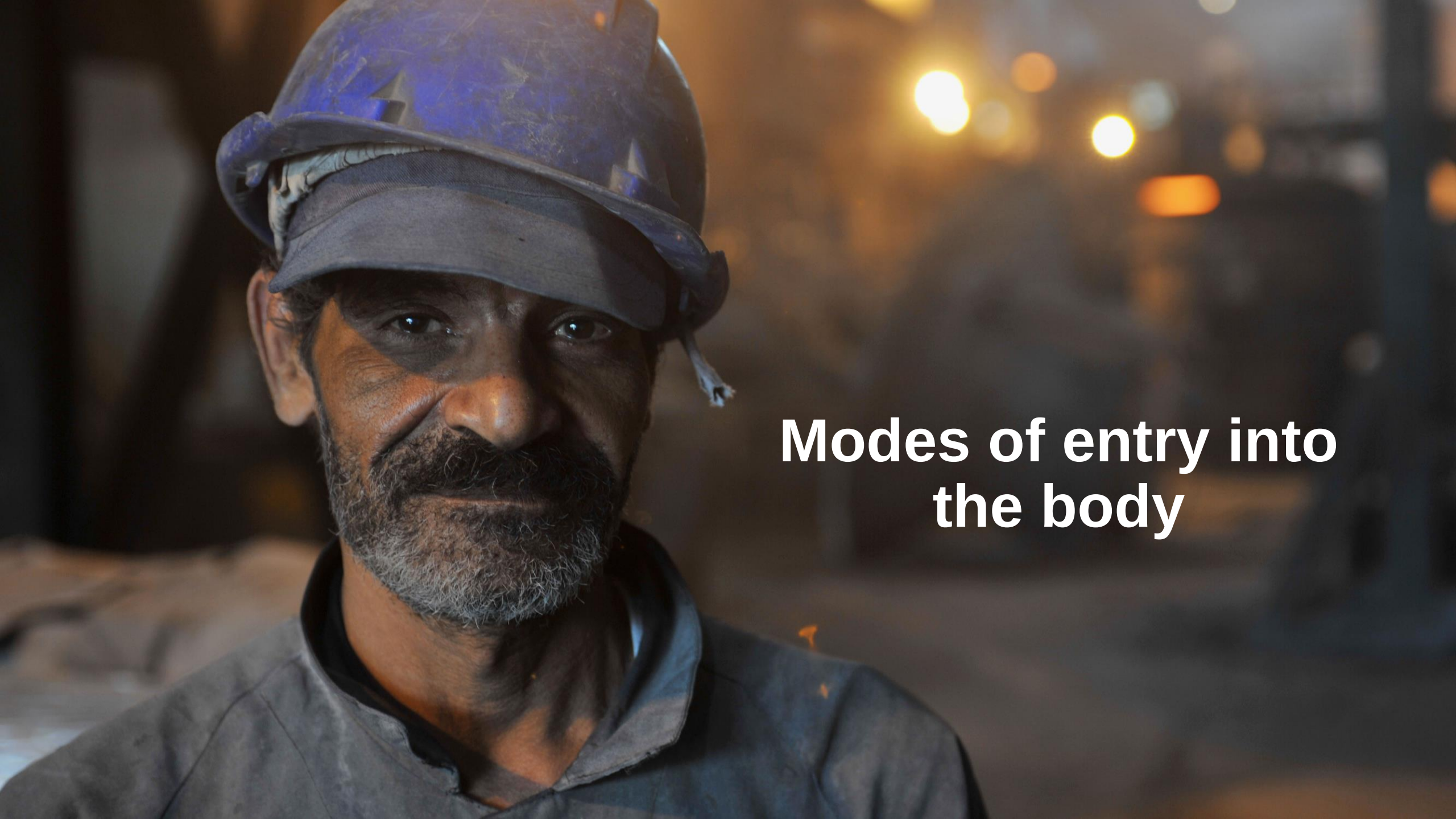
Routes of chemical exposure and health impacts

Objectives

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

1. Describe the modes if entry of chemicals into the human body.
2. Know the processes that occur when chemicals enter the body.
3. Name factors which impact the severity of health impacts.
4. Categorize the different types of harm chemicals can cause.
5. Understand the relationships between chemicals and various diseases.
6. Identify population groups that may be especially vulnerable to chemical exposures.



Modes of entry into the body

Modes of entry

- **Inhalation** (breathing in)
- **Absorption** (through skin or eyes)
- **Ingestion** (eating, swallowing)
- Transfer across **placenta** (of pregnant woman to the unborn child)
- Transfer across **breast milk** from mother to infant

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Inhalation

Chemicals can be dispersed in the form of dust, mist, fumes, gas or vapour, leading to inhalation risk.

- Even workers not directly handling chemicals can be affected.
- Once inhaled, chemicals are either exhaled or deposited in the respiratory tract.
- This can cause **irritation** and **respiratory tissue destruction**.
- Chemicals may enter the blood and are **distributed around the body**.

Dermal absorption

Handling chemicals without proper protection can lead to absorption through the skin or eyes.

- Usually occurs when chemical is in liquid form.
- Dust also if wetted (e.g. through sweat).
- Second most common route of exposure.
- Can cause **mild redness** or **destruction of the skin tissue**.
- Many chemicals can cross into the blood, causing **systemic damage**.
- The eyes are particularly sensitive to chemicals.

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Ingestion

Chemicals can enter the body through (accidental) ingestion.

- For example, when food is contaminated by dirty hands or when dust is swallowed.
- Do not usually harm the gastrointestinal tract itself, unless they are **irritating** or **corrosive**. Insoluble chemicals are **generally excreted**.
- Soluble chemicals are absorbed through the lining of the gastrointestinal tract.
- They are then transported by the blood to internal organs, where they can cause **damage**.

Placental

Even low doses of chemicals can elicit dramatic effects in the developing foetus.

- Particularly relevant for **endocrine-disrupting chemicals** (EDCs), which induce hormonal effects at **extremely low dosages**.
- The greater amount of adipose tissue in females can lead to **bioaccumulation of chemicals**, such as persistent organic pollutants (POPs) and mercury.
- These exposures can cause consequences to foetal health, including **spontaneous abortion**, **birth defects** and **neurobehavioral impairments**.

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Breast milk

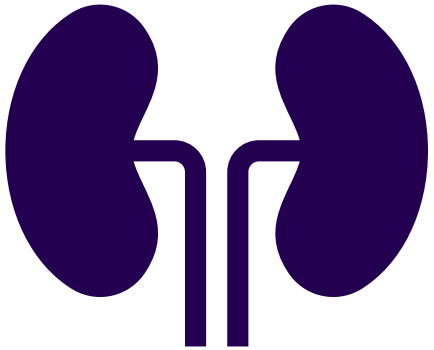
Babies are at risk of chemical exposures through their mother's breast milk.

- Women exposed to chemicals at work, may pass these chemicals to nursing children.
- PFAS, a **toxic chemical** found in fire-fighting foam and waterproof clothing, has been found in US mothers' breast milk. A study found all 50 samples tested at levels nearly **2,000 times what is considered safe in drinking water** *(Zheng at al 2021)* .
- Better-designed studies are needed to characterize infant exposures to chemicals in breast milk, particularly with respect to working mothers.

Health impacts of occupational chemical exposure

Three processes that occur when chemicals enter the body

1. **Metabolism** – Chemicals can be metabolized or transformed via chemical reactions in the body.
2. **Storage** – Chemicals can be distributed and stored in different organs.
3. **Excretion** - Chemicals can be eliminated from the body through exhaled breath, perspiration, urine, faeces or detoxification. Some are eliminated in days whilst others persist in the body for a lifetime.



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Question:

Name some factors which may impact the severity of health impacts

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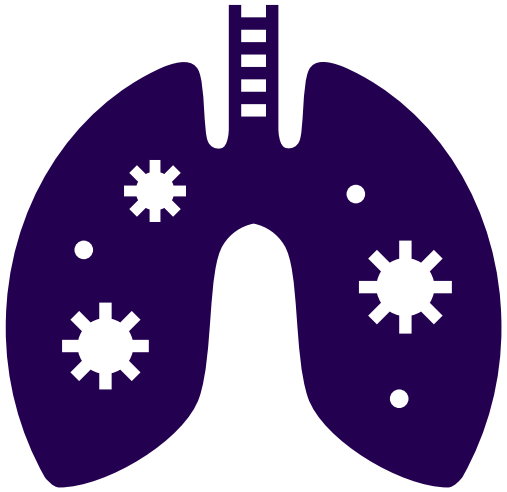
Answer:

- Type of chemical: Properties and toxicity
- Mode of entry: Route into the body
- Exposure: Dose, duration, frequency
- Individual: Age, sex, genetic susceptibility, developmental stage, health…

Acute vs chronic effects?

- **Acute effects:** A short exposure with an immediate effect.
- **Chronic effects:** Repeated exposure with a delay between first exposure and appearance of adverse health effects.
- Chemicals may cause both acute and chronic effects.
- Damage from exposure may be reversible or irreversible.

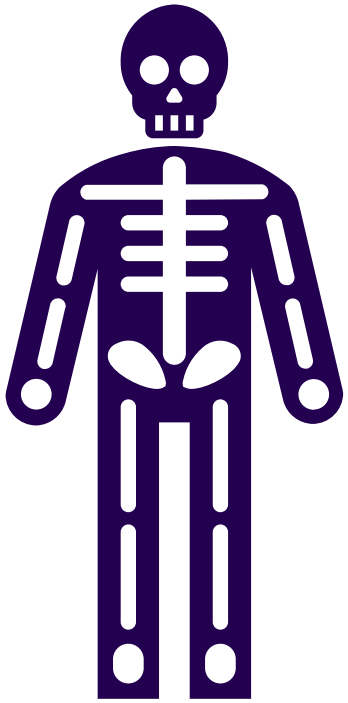


Pesticides – An example of acute vs chronic effects

- Agricultural workers using pesticides may have **both** acute and chronic health effects.
- Workers exposed to pesticide fumes may experience **nausea** or **vomiting** – this is reversible!
- However, chronic use of pesticides can **damage the nervous system** or even cause specific types of **cancer**.

Local vs systemic effects?

- **Local effects:**
  - An acute injury in one area of the body.
  - For example, corrosive damage to the skin from an accidental acid spill.
- **Systemic effects:**
  - Harm to the whole physiological system from chronic exposure to a substance.
  - For example, inhalation of mercury fumes can cause harm to the neurological system.



How chemicals affect us

Type of harm	Description	Example *(industry)*
Mutagen	• Substances that change the genetic information of an organism, mostly by changing DNA. • Usually also carcinogens.	Formaldehyde *(healthcare, manufacturing)*
Carcinogen	• Substances associated with causing or promoting cancer in humans and animals.	Asbestos *(construction)* Benzene *(petroleum industry)*
Teratogen	• Substances that cause harm to the foetus during pregnancy • Birth defects can occur even when the mother shows no/low signs of toxicity.	Mercury *(mining)* Lead compounds *(construction)*
Allergen	• Agents that cause abnormal immune response.	Latex *(manufacturing)*

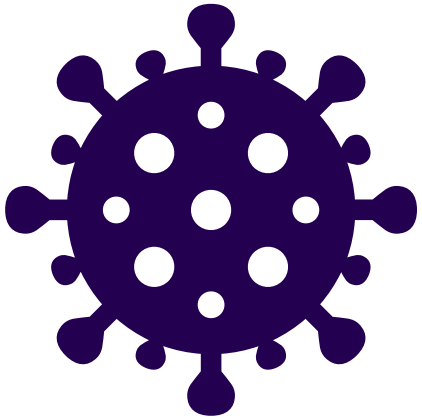
The relationship between chemicals and non-communicable diseases (NCDs)

- NCDs represent the vast majority of work-related diseases.
- Deaths from occupational cancer are increasing annually, for reasons such as the **emergence of new carcinogens** and **aging populations**.
- An increased risk of NCDs is often associated with occupational chemical exposures *(Budnik et al. 2018)*.
- Numerous NCDs have been linked with different chemical exposures, including **cancer**, **neurological disabilities**, **respiratory diseases** and **reproductive impairments**.
- For example, pesticides have been linked with various cancers, including thyroid cancers, lymphomas and leukaemia, as well as neurodegenerative disorders.

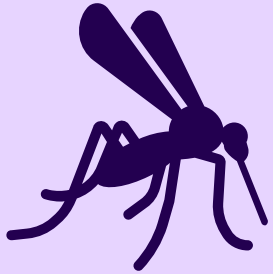
Occupational cancer accounted for 27% of the total number of work-related fatalities *(Takala et al. 2014; Takala 2015)*

The relationship between chemicals and infectious diseases

- Chemicals can increase the incidence and risks related to infectious diseases by **altering the immune response**.
- For example, **increased COVID-19 mortality** has been associated with air pollution.
- Chemicals can also affect pathogens, making them more **dangerous**, for example, the use of disinfectants has been linked to the growth of **antibiotic superbugs** *(Mc Cay et al. 2010)*.
- At the same time, infectious diseases can affect occupational chemical exposures.
- For example, PPE worn for infectious diseases can provide some protection against chemical exposure.



Case study: Mercury and malaria in ASGM



Malaria may influence mercury toxicity, and mercury can influence the immune response to malaria infection *(Eagles-Smith et al. 2018)*.

- A cross-sectional survey of 135 informal gold miners in Brazil found that mercury exposure interacts with the human immune system to **impair host resistance** to the parasite. Also, mercury exposure occurring after malaria infection induced **autoimmune dysfunction** *(Silbergeld et al. 2002)*.
- Biomarkers of autoimmune dysfunction were common in mercury-exposed populations with a history of malaria contraction, but not in mercury-exposed populations with limited malaria exposure *(Motts et al. 2014)*.
- In addition, areas of **stagnant water**, such as digging areas, may become **mosquito breeding grounds**, increasing mosquito density around mines.
- Malaria-endemic areas of the world exhibit a substantial geographic overlap with major regions of ASGM, **increasing potential interactions** between mercury and malaria.

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Covid-19 and chemicals

The early stages of the pandemic caused severe disruption to the chemicals sector worldwide.

- During that time, the overall burden of chemical exposure in workers declined, however **production of disinfectants and PPE grew**.
- Overall, the pandemic increased the use of disinfectants in many sectors, including transportation and supermarkets.
- Disinfectants have been linked to **COPD** *(Dumas et al. 2019)*, **infertility** *(Melin et al. 2014)* and **asthma** *(Fair 2020)*.
- Also, chemical accidents occurred when factories and plants were shutdown due to the pandemic.

Vulnerable workers

The role of gender and biological sex

Gender and biological sex are important aspects to consider in relation to occupational exposure to chemicals.

- Gender: **Socially constructed differences** between males and females, dependent on context and within societies and cultures *(ILO 2007)*.
- Biological sex: **Biological differences** between men and women, including differences in gonads and reproductive organs, hormonal cycles, fat distribution and immune response *(IPEN 2020)*.

Gender

Gender-related differences in occupational roles can influence level, frequency and source of chemical exposure.

- Men:
  - More exposed to **carcinogenic chemicals** and those causing **cardiorespiratory diseases**.
  - More male workers in some sectors using chemicals, including **construction**, **mining**, **agriculture** and **metal production**.
- Women
  - Chemical exposures are **dramatically increasing** and are **often underestimated**, particularly in informal sectors and in LMIC.
  - More exposed in sectors such as **health professions**, **textile production** and **cleaning** e.g. dyes and solvents in the garment sector.
  - Work tools and personal protective equipment (PPE), designed for men, may fit female workers poorly.

Biological sex

Leads to important differences in exposure and health effects when it comes to chemicals.

- Women:
  - **Reproductive cycles** and **life stage** impacts vulnerability e.g. pregnancy, lactation and menopause.
  - Even **low doses of chemicals** can elicit dramatic effects in the developing foetus.
  - EDCs can induce hormonal effects, affecting **fertility**, **fecundity** and **development**.
  - Bioaccumulation of chemicals may occur in adipose tissue, leading to **spontaneous abortion**, **birth defects** and **neurobehavioral consequences**.
- Men:
  - Male **fertility and development** may be affected, including development of the reproductive organs.

Migrant workers

- May not speak the local language, therefore **unable to understand chemical labels, safe handling procedures and training materials**.
- Not allowed to organise and bargain for their rights.
- Unable to negotiate safe and healthy working conditions.
- Victims of **forced labour** and discrimination may be more affected by chemical exposure.
- **Lack of regulation** in informal workplaces.
- Workers have **limited information and education** on health hazards.
- Limited access to effective protective equipment

Disabled workers

- Disabled people have been shown to have generally **poorer health outcomes** *(WHO 2011)*.
- They may be **more susceptible** to hazardous chemicals and face **unique risks** from chemical exposures depending on their particular disabilities.
- For example, a disabled worker with a respiratory impairment may be more vulnerable to toxic fumes and gases.
- Also, in a chemical accident, some disabled workers may face significant challenges for evacuation.

Youth workers (16-24 age range)

Significantly higher rates of occupational injury than adults.

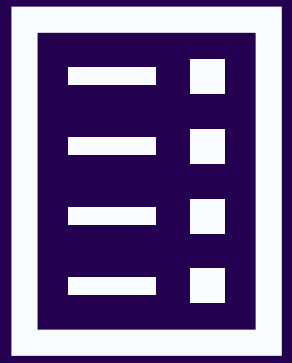
- Exposed to chemicals in numerous industries e.g. manufacturing, health and social care workers, mining and domestic work.
- Still developing, both physically and mentally, therefore **more susceptible to harm** from hazardous chemicals.
- Impacts often only seen later in adulthood.
- **Greater costs to society** when young workers are injured.
- Often **unaware of their rights** as employees and of their occupational safety and health (OSH) responsibilities.
- **Reluctant to speak out** about OSH risks.

Incidence of non-fatal injury at work was more than 40 per cent higher among young workers between the ages of 18 and 24 than among adult workers
(EU-OSHA, 2007)

Child labourers

- The adverse impact of chemical exposure on children's health is unique due to their **developing physiology, anatomy, metabolism and health behaviours**.
- Exposures to even low doses can cause **devastating and lifelong functional impairments**.
- Children may **inhale larger doses** of chemical vapour than adults, as their lungs have a greater surface area relative to their body weight and they breathe faster.
- Higher concentrations of chemical vapours may accumulate at lower heights near a child's breathing zone *(Besser 2009)*.
- Exposure to very high chemical levels can cause **irreversible neurodevelopmental damage**.

End of session activity



Quiz

Quiz

1. Name the different modes of entry used by chemicals to enter the human body.
2. What are they three processes that occur when chemicals enter the body.
3. Give and example of an acute and a chronic health impact.
4. Define what a teratogen is and give an example.
5. Describe how infectious diseases can impact chemical exposures and visa versa, using COVID-19 as an example.
6. Why could migrant worker groups be more vulnerable to chemical exposures?

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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).
- Prevention of major industrial accidents: code of practice (1991).
- ILO indicators of progress in implementing SAICM (2021).