

Managing Occupational Health

Lecture Title: Toxicology & Exposure to Chemicals & Control Strategies

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Undergraduate Diploma in
Occupational Health and Safety

Link

- <https://www.youtube.com/watch?v=-W8BByS6gLs>



What Is Exposure?

- Exposure is contact between a worker and a hazardous agent over a period of time.

Exposure depends on:

- **Intensity** (how strong the hazard is)
- **Duration** (how long the worker is exposed)
- **Frequency** (how often exposure occurs)
- **Route** (inhalation, skin contact, ingestion, injection)



Exposure vs Dose

- Dose is the amount of a hazardous agent that actually enters the body.

Exposure	Dose
Contact between a worker and a hazardous agent Depends on concentration/intensity, duration, and frequency Describes what the worker is exposed to	The amount of the hazardous agent that actually enters the body Depends on exposure and the body's ability to absorb it Describes what the body receives

Routes of Exposure

Routes of exposure are the ways a hazardous agent enters the body.

Main routes

- **Inhalation** – breathing in dusts, fumes, vapours, gases
- **Skin absorption** – chemicals passing through the skin
- **Ingestion** – swallowing contaminants (hands, food, drink)
- **Injection** – puncture wounds, sharps, high-pressure equipment



Inhalation Exposure

Inhalation exposure occurs when hazardous substances are breathed into the lungs.

- Common inhalation hazards:
- Dusts (silica, asbestos, wood dust)
- Fumes (welding fumes)
- Vapours (solvents)
- Gases (carbon monoxide)



Dermal Exposure

- Dermal exposure occurs when hazardous substances come into contact with and pass through the skin.

Common dermal hazards:

- Chemicals (solvents, acids, oils)
- Pesticides
- Wet cement
- Contaminated surfaces



Ingestion Exposure

- Ingestion exposure occurs when hazardous substances enter the body through swallowing.

Common causes:

- Contaminated hands touching the mouth
- Eating or drinking in contaminated areas
- Poor personal hygiene
- Accidental swallowing of chemicals or dust



Injection Exposure

Injection exposure occurs when a hazardous substance enters the body through puncture of the skin.

Common causes:

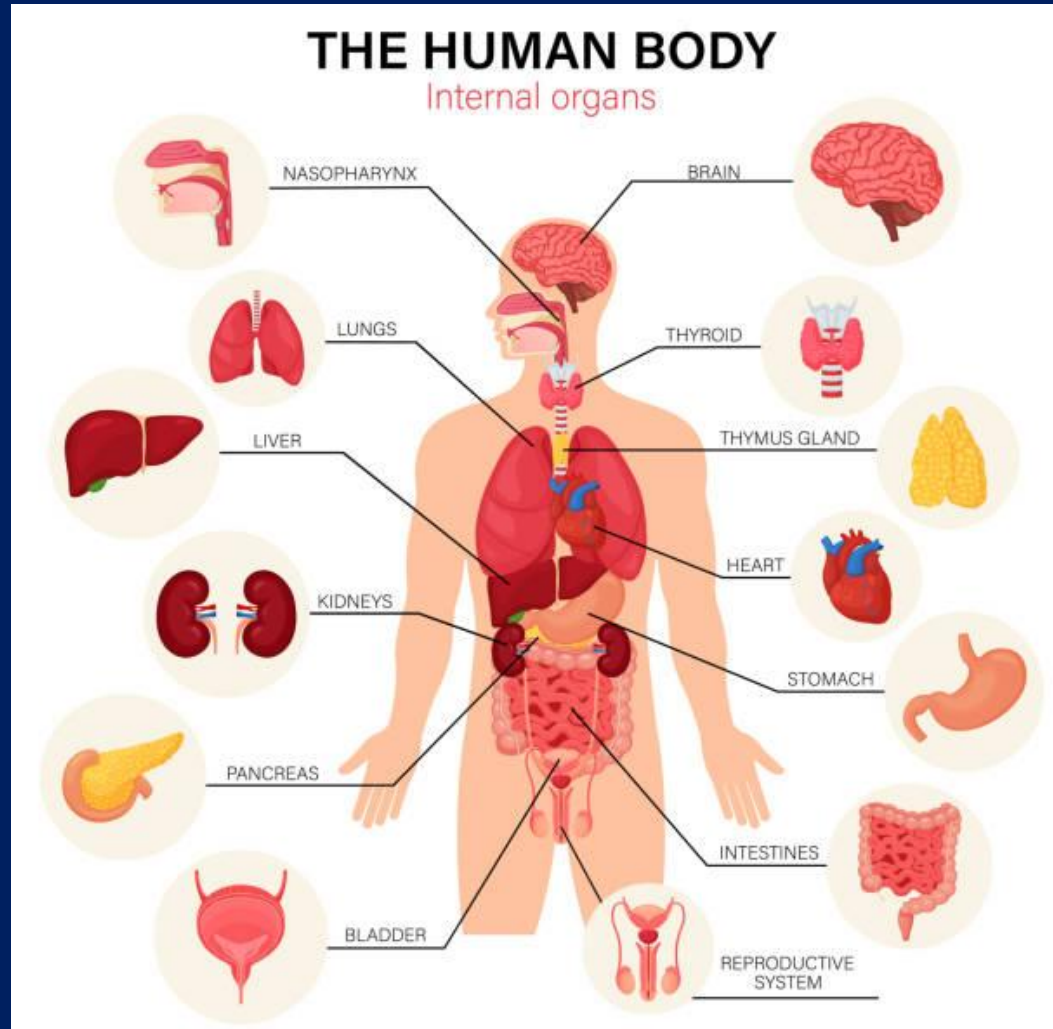
- Needle-stick injuries
- Cuts from contaminated sharp objects
- High-pressure equipment (e.g. grease guns)
- Animal or insect bites

Introduction to Toxicology

- Toxicology is the study of how substances cause harm to the body.



Organs of the body



Major organs and systems:

Brain – controls thoughts, movement, senses

Heart – pumps blood

Lungs – breathing and oxygen exchange

Liver – detoxification and metabolism

Kidneys – filter blood and remove waste

Stomach – digestion

Intestines – nutrient absorption and waste removal

Skin – protection and temperature control

Eyes – vision

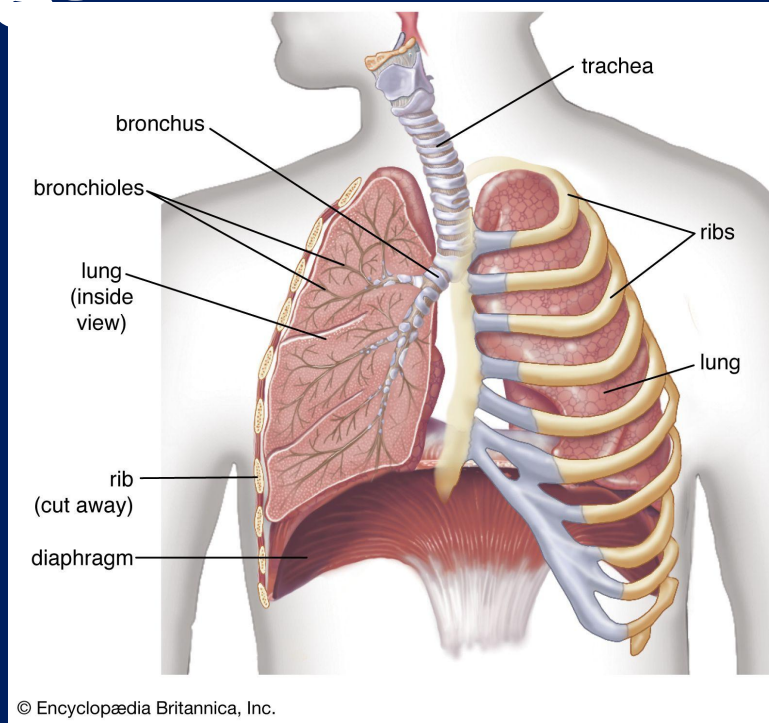
Ears – hearing and balance

Blood – transports oxygen and nutrients

Nervous system – communication and control

Reproductive organs – reproduction

Lungs



Function:

- Enable **breathing** and **oxygen exchange**
- Remove **carbon dioxide** from the body

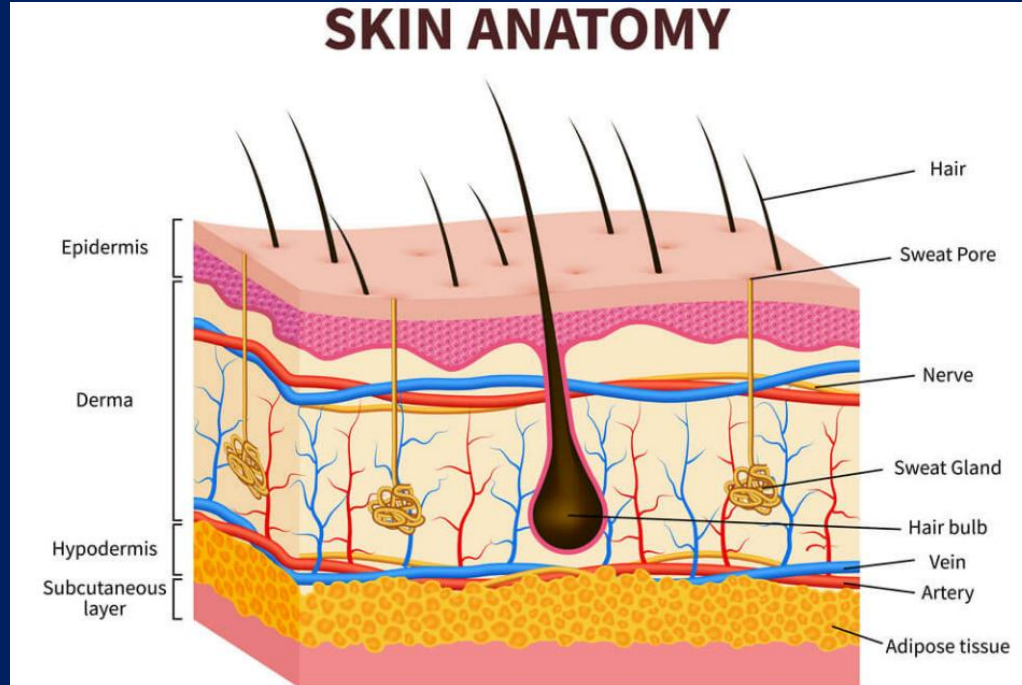
OHS relevance:

- Primary target organ for **inhalation exposure**
- Easily affected by **dusts, fumes, vapours, and gases**

Common work-related lung diseases:

- Asthma
- Silicosis
- Asbestosis
- Chronic bronchitis

Skin



Function:

- Acts as the body's **protective barrier**
- Regulates **temperature** and prevents infection

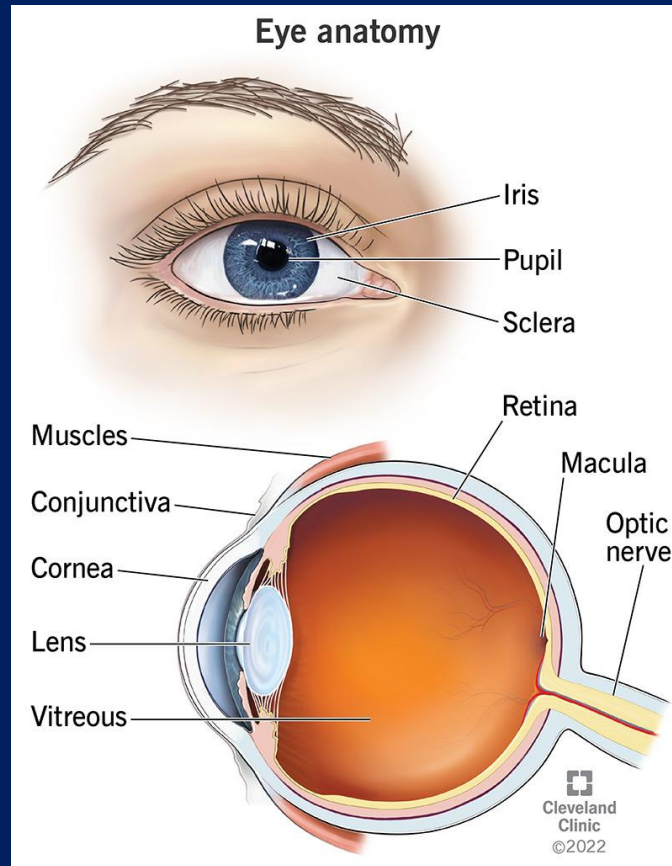
OHS relevance:

- Main target organ for **dermal exposure**
- Can absorb **certain chemicals** into the body

Common work-related skin conditions:

- Contact dermatitis
- Chemical burns
- Allergic reactions
- Skin infections

Eyes



Function:

- Provide **vision**
- Detect **light, colour, and movement**

OHS relevance:

- Highly vulnerable to **splashes, dusts, fumes, and radiation**
- Damage can occur **very quickly**

Common work-related eye injuries/conditions:

- Chemical burns
- Eye irritation and inflammation
- Foreign bodies (dust, metal)
- Vision loss

Heart

Function: Pumps blood to supply oxygen and nutrients to the body and remove waste products.

OHS relevance:

Work conditions can directly affect cardiovascular health, especially in physically demanding or high-stress jobs.

Work-related risk factors:

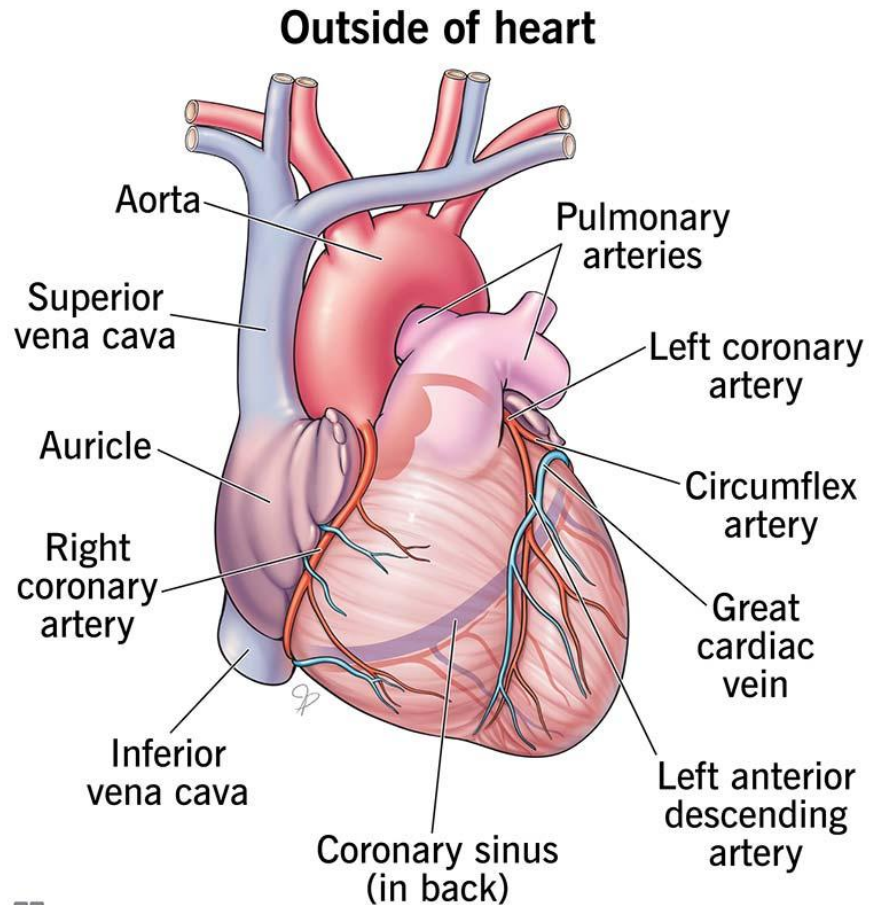
Heavy physical work and overexertion

Heat stress and dehydration
Long working hours and shift work

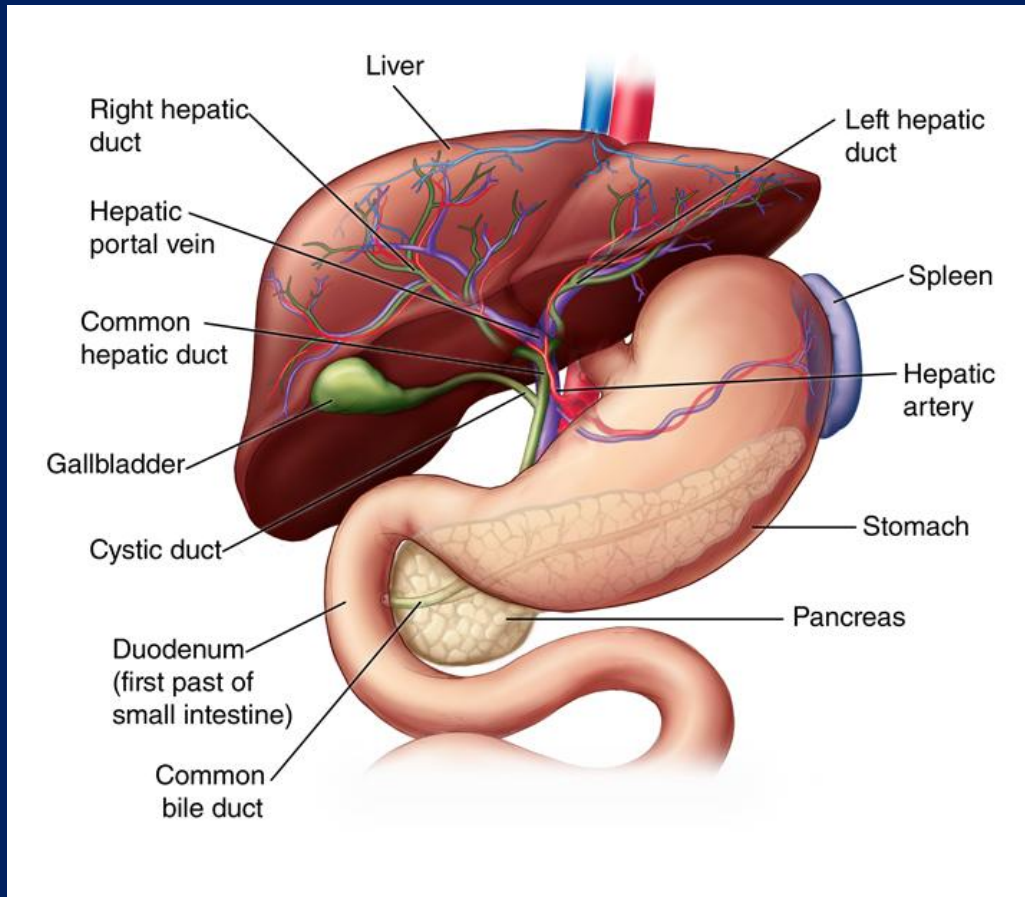
Psychosocial stress (high workload, low control)
Sedentary work and poor work–rest balance

Possible health effects: High blood pressure, increased heart rate, fatigue, and increased risk of cardiovascular disease.

Prevention measures: Manage workload, provide adequate rest breaks, control heat exposure, promote stress management, and encourage healthy work practices



Liver



- Function:** The liver **detoxifies harmful substances**, metabolises chemicals and drugs, and processes nutrients essential for energy and repair.

- OHS relevance:** Many workplace substances are processed by the liver, making it a **primary target organ** for occupational exposure.

- Work-related risk factors:**

Exposure to **organic solvents**, pesticides, and heavy metals

- Prolonged or repeated **chemical exposure** at low levels

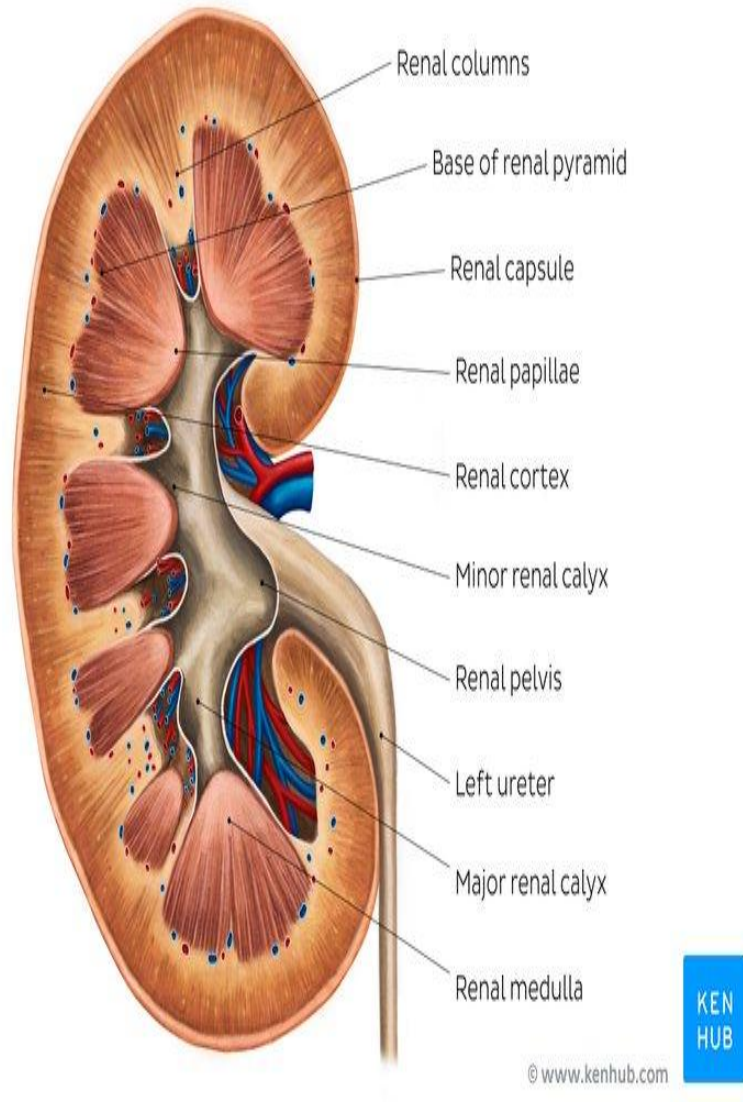
- Combined exposure from multiple substances

- Poor use of control measures and PPE

- Possible health effects:** Liver inflammation, reduced liver function, chronic liver disease, and in severe cases liver failure.

- Prevention measures:** Effective chemical risk assessment, substitution where possible, engineering controls (e.g. ventilation), proper use of PPE, and health surveillance where required

Kidney



- Function:** The kidneys **filter waste and toxins** from the blood, regulate fluid balance, and maintain electrolyte and blood pressure control.

- OHS relevance:** Many workplace chemicals are **excreted through the kidneys**, making them vulnerable to occupational exposure.

- Work-related risk factors:**

- Exposure to **heavy metals** (e.g. lead, cadmium, mercury)

- Solvents and other nephrotoxic substances

- Dehydration** due to heat stress or inadequate access to water

- Long working hours in hot or physically demanding environments

- Possible health effects:** Reduced kidney function, kidney damage, chronic kidney disease, and electrolyte imbalance.

- Prevention measures:** Control chemical exposure, ensure adequate hydration, manage heat stress, provide health surveillance, and promote early reporting of symptoms.

Dose–Response Relationship

The dose–response relationship describes how the **severity or likelihood of a health effect changes with the amount of exposure (dose) to a hazard.**

- **Higher dose → greater health effect**
- **Some substances have a threshold (no effect below a certain dose)**
- **Others (e.g. carcinogens) may have no safe level**
- **Basis for exposure limits and standards**

Acute and Chronic Effects

Acute	Chronic
Occur immediately or shortly after exposure	Develop slowly over long periods
Usually from high-dose or short-term exposure	Usually from repeated or long-term exposure
Examples: irritation, burns, dizziness, poisoning	Examples: occupational asthma, hearing loss, cancer

Target Organs

Target organs are the specific organs or body systems most affected by a hazardous substance.

Common target organs

Lungs – dusts, fumes, gases

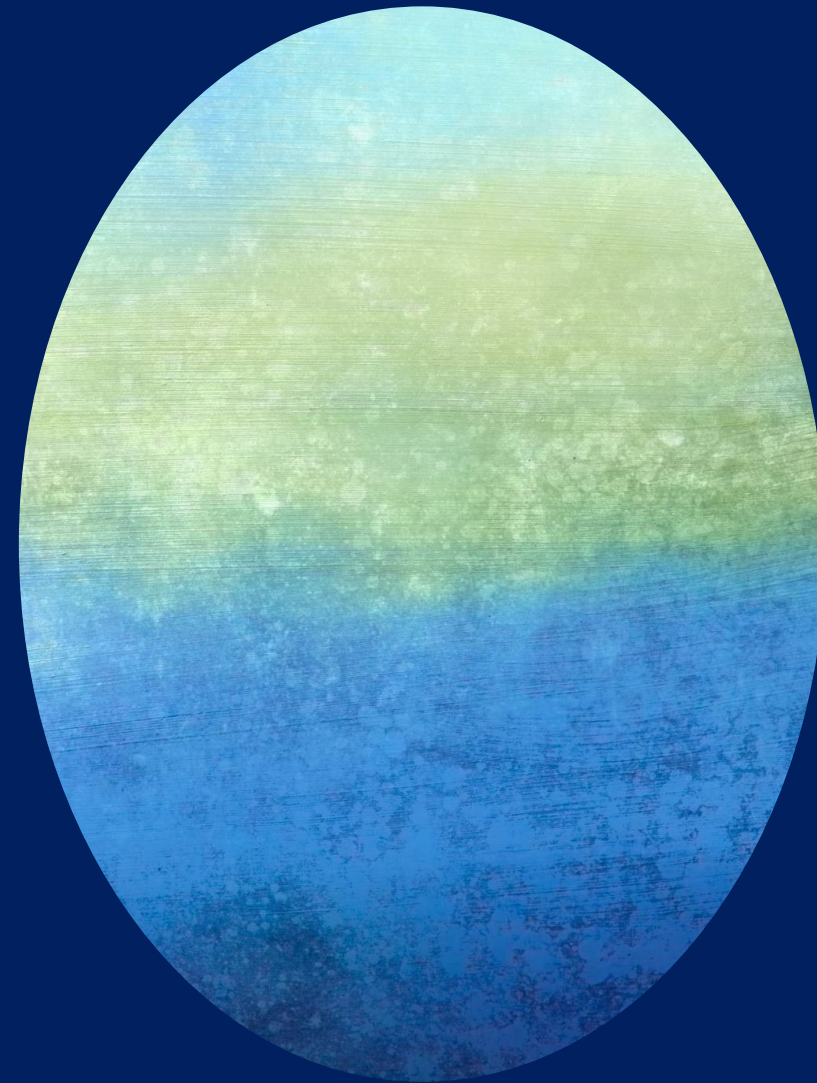
Skin – chemicals, solvents

Liver – solvents, toxic chemicals

Kidneys – heavy metals

Nervous system – solvents, pesticides

Blood – carbon monoxide, benzene



Occupational Exposure Limits

Occupational Exposure Limits are legal or recommended maximum levels of exposure to hazardous substances in the workplace.

- Set to protect workers' health
- Based on dose–response data
- Usually expressed as:
 - Time-Weighted Average (TWA) – average over a workday
 - Short-Term Exposure Limit (STEL) – short peak exposure
 - Ceiling Limit – must never be exceeded



Types of Exposure Limits

- **Common types of occupational exposure limits**
- **Time-Weighted Average (TWA)**
Average exposure over a normal workday (e.g. 8 hours)
- **Short-Term Exposure Limit (STEL)**
Maximum exposure for a short period (typically 15 minutes)
- **Ceiling Limit (C)**
Exposure level that must never be exceeded
- **Biological Exposure Index (BEI)**
Measures hazard levels in the body (blood, urine, breath)



Limitations of Exposure Limits

- Exposure limits have important limitations:
- Do not protect all workers (individual sensitivity varies)
- Usually based on single substances, not mixtures
- Do not account for peak or accidental exposures
- Often based on healthy adult workers only
- May not prevent long-term or chronic effects
- Outdated limits may still be in use



Limitations of Exposure Limits



Meeting an exposure limit
does not guarantee zero risk



Exposure limits reduce risk
but do not eliminate it

Exposure Monitoring

- Exposure monitoring is the measurement and assessment of workers' exposure to hazardous agents in the workplace.
- Key points
 - Identifies who is exposed and to what level
 - Compares results with exposure limits
 - Helps evaluate effectiveness of control measures
 - Can be personal, area, or biological monitoring

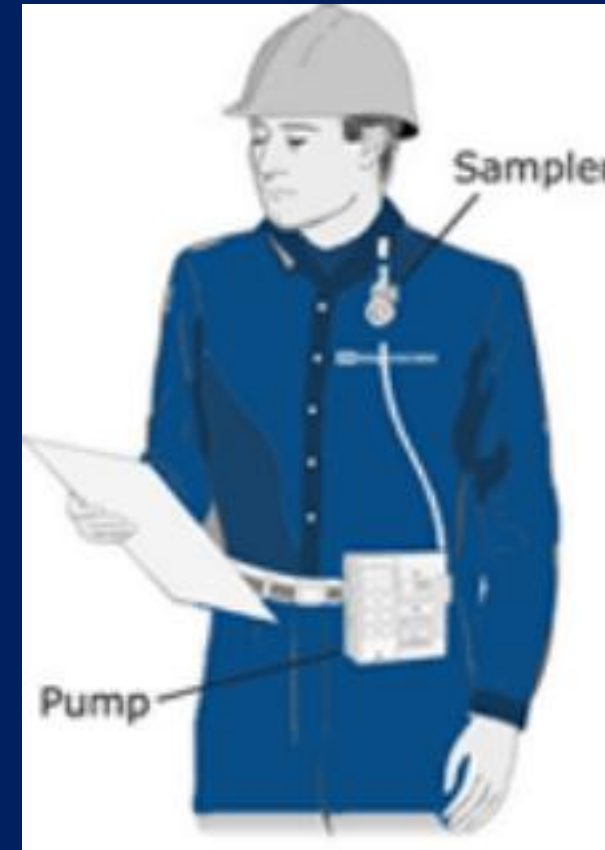


Air Sampling

- Air sampling is the collection and measurement of airborne contaminants to assess inhalation exposure.
- Measures dusts, fumes, vapours, and gases
- Used to compare results with OELs
- Can be:
 - Personal sampling (worker breathing zone)
 - Area sampling (general workplace air)
- Essential for risk assessment and control

Personal Sampling

- **Personal sampling** is a method of **air sampling** that measures a **worker's actual exposure**.
- Sampling device worn by the **worker**
- Measures air in the **breathing zone**
- Provides the **most accurate exposure data**
- Used to assess **compliance with OELs**



Area Sampling

Area sampling is a method of air sampling that measures contaminant levels in a fixed workplace location.

- Sampling equipment placed in a **specific area**
- Measures **general air quality**, not individual exposure
- Useful for identifying **sources of contamination**
- Supports **control effectiveness** checks

Area sampling = measures airborne contaminants in a workplace area.



Biological Monitoring

- Biological monitoring is the measurement of hazardous substances or their metabolites in the body.
- Uses blood, urine, or breath samples
- Measures the dose actually absorbed
- Accounts for all routes of exposure
- Compared with Biological Exposure Indices (BEIs)



Using Exposure Data in Risk Assessment

Exposure data is used to evaluate risk and guide control measures.

- Identify who is exposed and to what extent
- Compare exposure levels with OELs and BEIs
- Assess likelihood and severity of health effects
- Prioritise risk control actions
- Review effectiveness of existing controls
- Support legal compliance



GHS Pictograms

GHS pictograms are standardized symbols used to communicate chemical hazards. They are part of the Globally Harmonized System (GHS) of Classification and Labelling of Chemicals. Each pictogram is a black symbol on a white background with a red diamond border. GHS pictograms help workers quickly identify hazards at a glance.



Purpose of GHS Pictograms

- Improve hazard communication
- Reduce chemical-related injuries and illnesses
- Ensure consistent understanding across countries and industries



Types of GHS Pictograms and Their Meanings



- **Health Hazard** – Carcinogens, respiratory sensitizers, organ toxicity
- **Flame** – Flammable gases, liquids, aerosols, self-reactive substances
- **Skull and Crossbones** – Acute toxicity (fatal or toxic)
- **Corrosion** – Skin burns, eye damage, corrosive to metals
- **Exclamation Mark** – Irritation, skin sensitization, harmful effects
- **Gas Cylinder** – Gases under pressure
- **Exploding Bomb** – Explosives, self-reactive chemicals
- **Environment** – Hazardous to aquatic life

Importance of GHS Pictograms in the Workplace

- Enable **quick hazard recognition** during handling and storage
- Support **risk assessment and control selection**
- Guide correct **PPE usage**
- Improve emergency response during spills or exposure
- Mandatory under chemical safety regulations in many countries

Workplace Examples:

- Laboratories
- Manufacturing plants
- Construction sites
- Healthcare and cleaning services



Control Strategies for Occupational Health Risks



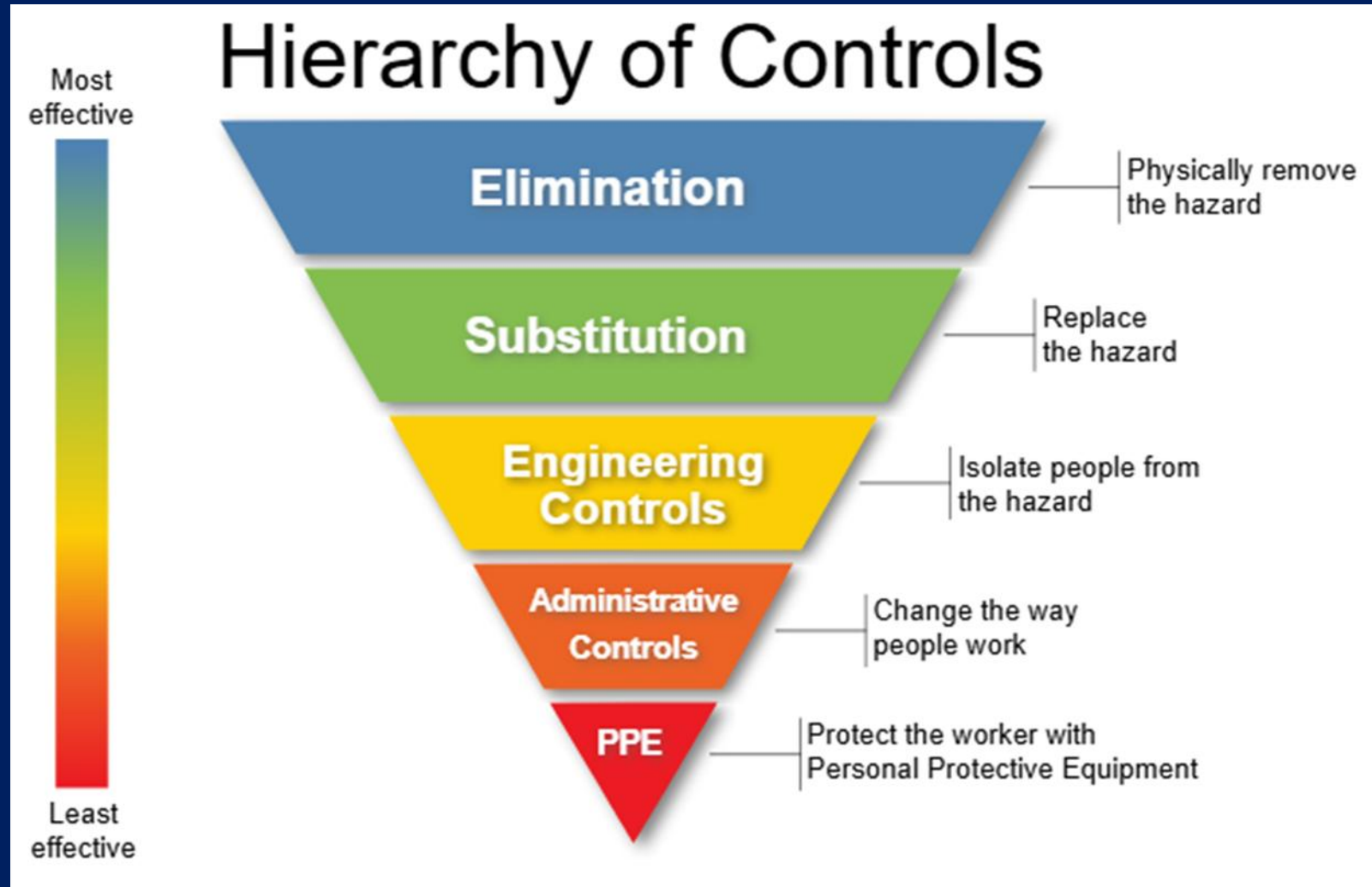
The Hierarchy of Controls

The Hierarchy of Controls is a system used to minimise or eliminate exposure to hazards, ranked from most effective to least effective.

Levels

1. Elimination – remove the hazard completely
2. Substitution – replace with a safer alternative
3. Engineering controls – isolate people from the hazard
4. Administrative controls – change how work is done
5. Personal Protective Equipment (PPE) – protect the worker





Elimination

- **Elimination** is the most effective control in the hierarchy and involves completely removing the hazard from the workplace.
- Hazard no longer exists
- Removes the risk entirely
- No reliance on worker behaviour or PPE
- **Examples:**
 - Designing out a hazardous process
 - Removing a dangerous chemical entirely
 - Automating a task to remove human exposure



Substitution

Substitution involves replacing a hazardous substance, process, or equipment with a safer alternative.

- Reduces the **level of risk**, but does not remove it completely
- Must ensure the substitute is **genuinely safer**
- More effective than administrative controls or PPE

Examples:

- Using a **less toxic chemical**
- Replacing solvent-based paints with **water-based paints**
- Using quieter machinery to reduce **noise exposure**

Engineering Control

Engineering controls reduce exposure by isolating people from the hazard through physical or mechanical means.

- Do not rely on worker behaviour
- Provide continuous protection
- More effective than administrative controls and PPE

Examples:

- Local exhaust ventilation (LEV)
- Machine guards and enclosures
- Soundproofing and noise barriers
- Automation of hazardous tasks

Administrative Controls

Administrative controls reduce risk by changing how work is organised and performed.

- Rely on procedures and worker behaviour
- Do not remove the hazard
- Less effective than elimination, substitution, and engineering controls

Examples:

- Safe work procedures and permits
- Training and supervision
- Job rotation and work/rest schedules
- Warning signs and labels



Combining Control Measures

Combining control measures means using more than one level of the hierarchy of controls to reduce risk effectively.

- No single control is usually sufficient
- Higher-level controls should be used **first**
- Lower-level controls support and **reinforce** higher ones
- Provides **layered protection**

Example:

- Substitute a hazardous chemical
- Install local exhaust ventilation
- Apply safe work procedures
- Provide appropriate PPE

Link

- <https://www.youtube.com/watch?v=ijXc7-XU4Eg>



Case Study: Applying the Hierarchy of Controls

- Workers in a metal fabrication workshop are exposed to welding fumes, which can cause respiratory irritation and long-term lung disease

Applying the Hierarchy of Control

1. Elimination

- Redesign the product so **welding is no longer required**
- Use prefabricated components instead
Result: Hazard removed completely (best option)

2. Substitution

- Replace traditional welding rods with **low-fume welding consumables**
- Use **MIG welding** instead of manual arc welding
Result: Reduced fume generation



Applying the Hierarchy of Control Cont.

3. Engineering Controls

- Install **local exhaust ventilation (LEV)** at welding stations
- Enclose welding areas or use **fume extraction arms**
Result: Fumes removed at source

4. Administrative Controls

- Limit time spent welding (job rotation)
- Provide training on correct welding techniques
- Implement maintenance schedules for ventilation systems
Result: Reduced exposure duration

5. Personal Protective Equipment (PPE)

- Provide **appropriate respirators**
- Use welding helmets and protective clothing
Result: Final layer of protection



Case Study



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A manufacturing workshop uses solvent-based degreasers to clean metal parts before assembly. The chemicals are stored in unlabelled containers near the workstations. Workers report headaches, dizziness, and skin irritation, particularly towards the end of their shifts. Although PPE such as gloves is available, workers are unclear about the specific hazards of the chemicals. GHS pictograms are not displayed, and Safety Data Sheets are stored in an office that workers rarely access.



- Identify the chemical health hazards present
- Explain which GHS pictograms should be displayed
- Apply the hierarchy of controls to reduce exposure
- Discuss why PPE alone is insufficient





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