



## Health surveillance – Arsenic (inorganic)

**Medical practitioners undertaking health surveillance are required to have an understanding of the potential adverse health effects of inorganic arsenic and to use their clinical knowledge to advise on health surveillance for workers in the workplace.**

### Source

Arsenic is widely distributed in rocks and soil. Arsenic is highly toxic in its inorganic form.

Occupational exposure to arsenic occurs in mining and refining processes including roasting arsenopyrite ore and smelting minerals such as gold, lead, zinc and copper. Arsenic is present in mining waste. Arsenic exposure also occurs in industries such as waste disposal, some manufacturing and laboratories. It is used, or has historically been used, in metal alloys, pigments, ceramic enamels, anti-fouling paints, pesticides, rat poison, and leather hide and wood preservation.

Fish, shellfish and seaweed contain arsenobetaine and arsenosugars. These sources of organic arsenic are referred to as dietary arsenic and are not considered toxic.

### Toxicokinetics

Inorganic arsenic enters the body by inhalation or ingestion. The respiratory tract is the major portal of entry in occupational exposure. Arsenic compounds such as arsenic trioxide are soluble in bodily fluids and cleared rapidly from the lungs. Less soluble arsenic compounds (calcium arsenate, lead arsenate, arsenic sulphide) are retained in the lungs and 80-90% of arsenic trioxide is absorbed by the gastrointestinal tract. Dermal absorption is likely to be low.

Inorganic arsenic binds to red blood cells and is deposited in liver, kidneys, muscle, bone, hair, skin and nails. Arsenic readily crosses the placental barrier with potential for adverse effect on the foetus.

Arsenic is metabolised by the reduction of pentavalent arsenic (As(V)) to trivalent arsenic (As(III)), and methylation to metabolites (monomethylarsonic acid (MMA) and dimethylarsinic acid (DMA)). Trivalent arsenic is more toxic than pentavalent arsenic. Methylation is triggered after about eight hours.

Inorganic arsenic is rapidly excreted via the kidneys, of which 10-20% is excreted unchanged, 10-20% as MMA and 60-80% as DMA.

Excretion commences within the first few hours after exposure. Most of the arsenic is excreted in the urine within three days (half-life of one to two days). However, it may take weeks to completely eliminate a single dose.

### Health effects

Symptoms from exposure vary depending on the dose, chemical form, mode and duration of exposure, individual characteristics and health status.

Acute poisoning results in acute abdominal pain, nausea, vomiting, diarrhoea, cramps in the extremities, restlessness and spasms. There may be cardiac arrhythmias, liver toxicity, kidney failure and peripheral neuropathy, convulsions, dehydration, shock and death at very high doses.

Arsenic is a local irritant to mucous membranes resulting in eye irritation, nose irritation, epistaxis and even nasal septum perforation. Skin folds (nose, mouth, axillae, scrotum) where surfaces are moist, are susceptible to local irritation, vesiculitis, folliculitis and ulcers. Arsenic also causes skin hyperpigmentation, hyperkeratosis and sensitisation. The skin changes are the most specific obvious signs of chronic inorganic arsenic toxicity.

Chronic poisoning may cause peripheral neuropathy, cardiomyopathy and arrhythmias, and non-malignant pulmonary changes.

Inorganic arsenic is classified as a carcinogen (Group 1, IARC) in humans. The metabolites, MMA and DMA, are classified as possible carcinogens (Group 2B, IARC). Chronic arsenic exposure is associated with skin, lung and bladder cancer. Skin cancers include basal cell carcinoma and squamous cell carcinoma. Smoking has been shown to increase the risk of lung cancer in exposed workers.

### **Health surveillance**

Health surveillance should include medical and work history, smoking history and clinical examination of the skin, respiratory and peripheral nervous system. Health surveillance including biological monitoring for new employees is recommended, followed by periodic health surveillance.

### **Health counselling**

The medical practitioner has an important role in educating and reinforcing good personal hygiene and safe work practices.

- Check for other sources of arsenic (e.g. seafood, arsenical products, etc.).
- Inform workers of potential adverse health effects from arsenic dust or fumes.
- Counsel all workers to stop smoking.
- Be clean shaven for effective respiratory protection when using respiratory protective equipment (RPE).
- Understand safety controls in the work environment.
- Reinforce safe work practice, particularly the use of appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE).
- Reinforce personal hygiene and cleanliness, including:
  - washing face and hands before eating, drinking or smoking
  - no eating, drinking or smoking in the workshop or room where arsenic is present
  - showering and changing into clean clothes and footwear before leaving the work area.

### **Biological monitoring**

Arsenic levels in urine are indicative of exposure over the previous two to three days. Measurement of inorganic As(III), As(V) and the metabolites (DMA and MMA) is the preferred method for biological monitoring.

If the biological method used is total urinary arsenic (non-specified) and the levels exceed 35 µg/L, the pathology laboratory should be instructed to automatically perform speciation.

Avoidance of seafood and seaweed for three days prior to urine sampling is essential because dietary arsenic compounds may be substantial. Seafood and seaweed contain organic arsenic compounds including arsenobetaine and arsenosugars. Arsenobetaine is excreted rapidly unchanged in urine. However, DMA is a major metabolite of arsenosugars (found in seaweed).

Tobacco smokers may have slightly higher urinary arsenic levels due to the presence of arsenic in cigarettes and a potentially reduced capacity for elimination of arsenic.

Blood testing is not recommended as arsenic is cleared from the blood rapidly and may have poor correlation with recent exposure.

### **Biological exposure standard for inorganic arsenic**

Urinary inorganic arsenic by speciation (As(III) plus As(V) plus metabolites, MMA and DMA) should not exceed 35 µg/L.

### **Sample collection**

Urine samples should be collected and tested after four to five working days with exposure (at the end of the shift). The worker needs to shower prior to providing a sample to avoid contamination by skin or clothing. The worker should also abstain from consuming seafood and seaweed for at least three days prior to providing a sample.

### **Removal**

When there is a level of urinary inorganic arsenic (by speciation) of 35 µg/L or more:

- remove the worker from arsenic exposure
- conduct a medical review as soon as can be arranged with emphasis on skin, respiratory system and peripheral nervous system
- the workplace is to review safety controls and systems of work, personal hygiene and personal protective equipment
- the medical practitioner (overseeing health monitoring) determines the frequency of tests (between two to four weeks), taking into account the urinary arsenic level
- the medical practitioner may arrange prompt referral to an occupational physician or other relevant physician for assessment and advice as required
- the medical practitioner recommends a return to arsenic work when urinary arsenic is 20 µg/L or less and there are no other clinical concerns.

### **Notification requirements**

The medical practitioner:

- informs the employer of the outcome of the assessment including removal of the worker from arsenic-risk work (as appropriate) and advise on the need for remedial action (if any)
- informs the worker and explains the results of the assessment.

### **For mining operations (Mines Safety)**

The employer submits the biological monitoring results to Mines Safety via SRS.

### **For all other industries (WorkSafe)**

The appointed medical practitioner (AMP) has a duty to notify health surveillance results to the regulator. The AMP forwards the completed Health Surveillance Notification Form: Other [www.commerce.wa.gov.au/publications/health-surveillance-notification-form-other](http://www.commerce.wa.gov.au/publications/health-surveillance-notification-form-other) along with the pathology laboratory report, to [safety@dmirs.wa.gov.au](mailto:safety@dmirs.wa.gov.au).

### **Further information**

*Mines Safety and Inspection Act 1994*

Mines Safety and Inspection Regulations 1995

*Occupational Safety and Health Act 1984*

Occupational Safety and Health Regulations 1996

Safe Work Australia

Health Monitoring for Registered Medical Practitioners

<https://www.safeworkaustralia.gov.au/doc/health-monitoring-registered-medical-practitioners-guide>

Health Monitoring Guide for Arsenic (inorganic)

[www.safeworkaustralia.gov.au/system/files/documents/2002/health\\_monitoring\\_guidance\\_-\\_arsenic.pdf](http://www.safeworkaustralia.gov.au/system/files/documents/2002/health_monitoring_guidance_-_arsenic.pdf)