Detection for chemical hazards and public health – surveillance, analysis and poisons information

African Society for Laboratory Medicine, 6th July 2023

Lydia Izon-Cooper, Principal Environmental Public Health Scientist, Radiation Chemical and Environmental Hazards, UKHSA
This session will present some introductory level content around:

- Introduction to detection
- methods for detection (including analysis) for chemicals
- common surveillance methods for identification of chemical issues of potential public health concern
- introduce the role of poison centres
Introduction to detection
Chemical Exposure Pathways

- Emissions, waste, accidental release,
- Consumer goods, pharmaceuticals
- Air
- Soil
- Surface Water
- Groundwater
- Crops
- Animals
- Fish
- Drinking water
- Humans
What are the exposure pathways of particular concern in your country? Are there any missing?
Chemical Exposure Pathways

- Air
- Soil
- Surface Water
- Groundwater
- Crops
- Animals
- Fish
- Drinking water
- Humans

Emissions, waste, accidental release
Consumer goods, pharmaceuticals
It is important to understand that chemicals can behave very differently to one another, due to their differing properties.

Examples of physicochemical properties which determine the behaviour of a chemical:

- Physical state
- Density
- Water solubility
- Vapour pressure
- Volatility
- Toxicity

E.g. if a chemical involved in an incident is liquid BUT has a high vapour pressure, it is more likely to form vapours which can spread more easily and may lead to the exposure of more people.
Detection and Alert Scenarios

<table>
<thead>
<tr>
<th>1. Environmental contamination</th>
<th>2. Health effects following known exposure</th>
<th>3. Health effects of unknown aetiology</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="#">Image</a></td>
<td><a href="#">Image</a></td>
<td><a href="#">Image</a></td>
</tr>
</tbody>
</table>

- **1. Environmental contamination**
- **2. Health effects following known exposure**
- **3. Health effects of unknown aetiology**
Methods of Detection
Field and mobile laboratory analysis

Mobile field techniques

- Immediate indication of chemicals in the field
- Chemical test kits, organic vapour analysers and other portable monitoring devices
- Quick turnaround
- Leak detection, confined space entry, HazMat response, personal exposure level etc.

Static laboratory techniques

- Sample collection followed by analysis in laboratory
- Compliance with government regulations in accredited laboratories
- More precise and high quality results, measurement of highly toxic compounds etc.
Laboratory analysis

- The types of laboratories: diagnostic, clinical, toxicological, environmental, forensic, food safety and research laboratories
- Quality assurance
- Pre-analytical considerations
- Analytical considerations
- Post-analytical considerations
Biomonitoring

• The measurement of the body burden of toxic chemical compounds, elements, or their metabolites or by-products, in the body

• **Blood, urine**, hair, serum, saliva, exhaled air, breast milk, feces – specimens of choice

• Detection window:
  • Blood – hours & urine – days

• Potential to correlate internal dose with observed health effects
Role of routine environmental monitoring

- provide data on **background levels** of chemicals in environmental media;
- demonstrate any **normal variation** in those levels;
- act as **a warning** when a sudden increase in chemical concentration is detected;
- enable comparison with levels following a chemical incident; and
- determine restoration to background levels.
Portable survey detectors

Colorimetric technologies
• Detector tubes available for measurement of over 200 gases/vapours

Ion mobility spectroscopy (IMS)
• The most commonly deployed detectors, predominately used for the field detection of explosives, illicit drugs and chemical agents

Photo ionisation detection (PID)
• Commonly used instrument for field detection of total VOCs (ppm)

Infra-red spectroscopy (IR)
• Detection of vapours, liquids and solid hazardous materials

Raman spectroscopy
• A distinct chemical fingerprint - can be used to very quickly identify the material, or distinguish it from others
• Solids, powders, liquids, gels, slurries and gases
Personal monitors

- Carbon Monoxide / Hydrogen Sulphide etc.
- Commonly used by emergency services to clear an area as safe before entering and for worker safety
- High level alarms
- Dust / particulate matter
- Often used in worker safety but can also be used in epidemiology
- Sample collection – laboratory analysis required
What chemical analysis is undertaken in your country? And who is responsible for this?
Surveillance
What is Surveillance

Information to Action

• to guide immediate public health actions
• planning and implementation of rational intervention programs to prevent and control disease.
• monitor changes or trends in health factors
• burden of disease and inform service delivery
What is Surveillance

**Prevention** – risks understood, assessment and mitigation measures implemented. SOPs.

**Recovery** – health monitoring, health and wellbeing recovery, physical recovery. After action review to feed into prevention and preparedness.

**Preparedness** – data capture put in place to test risk mitigation measures e.g. monitoring and action to be taken by who.

**Response** – Action to be taken on surveillance to protect health if immediate risks or mitigate if chronic risk

**Detection & Alert** – mechanisms in place for detection and alerting to employer, public health, poison centre etc. Surveillance stage.
Why do it?

- International Health Regulations (IHR)
- Sustainable Development Goals (SDGs)
- WHO Chemical Road Map
- Strategic Approach to International Chemicals Management (SAICM)
Outside of the remit of the UK Health Security Agency as worker safety falls under our health and safety authority – the Health and Safety Executive…however, HSE define worker health surveillance as:

*Health surveillance is a scheme of repeated health checks which are used to identify ill health caused by work. Health and safety law requires health surveillance when your workers remain exposed to health risks even after you have put controls in place. This is because control measures may not always be reliable, despite appropriate checking, training and maintenance. Health risks which require health surveillance include noise, vibration and substances hazardous to health.*
Case of potential or actual public health exposure to chemicals

- Reports from the public. Reports from private sector. Site inspections and observations. Incident response and monitoring.
- Reports from the public. Reports from the private sector. Reports from hospitals and healthcare. Incident response and monitoring.
- Associated with poisoning enquiries. Reports from hospitals and healthcare settings.
- Observations during incident response.
- Cases of unknown etiology. Results of biomonitoring. Patient presentations (possibly reported via poisons centre)

Environmental protection agency
Regional health agency / local authority
Poison Centre
First Responders
Healthcare Settings

Public Health Agency
Integrating Surveillance

- Event Based Surveillance
- Poisoning surveillance
- Indicator Based Surveillance
- Syndromic Surveillance

*Integration into existing surveillance / data collection roles may be most effective.*
<table>
<thead>
<tr>
<th>Toxidrome</th>
<th>Mechanism of action</th>
<th>Syndrome*</th>
<th>Poisons and environmental chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anticholinergic</td>
<td>Muscarinic receptor antagonism</td>
<td>Agitation, confusion, dry mouth, dry skin, hyperthermia, mydriasis, paralytic ileus, tachycardia and urinary retention</td>
<td>Antihistamines, antimuscarinics, antipsychotics, atropine, <em>Inocybe</em> mushrooms, Jimson weed (<em>Datura stramonium</em>), tricyclic antidepressants</td>
</tr>
<tr>
<td>Antimitotic</td>
<td>Cytotoxic to dividing cells</td>
<td>Alopecia, bone marrow suppression, diarrhoea, mucositis, vomiting</td>
<td>Arsenic, colchicine, chemotherapy agents, immunosuppressants, ionizing radiation, podophylline, thallium</td>
</tr>
<tr>
<td>Cardiac glycosides</td>
<td>Inhibition of Na⁺/K⁺-ATPase pump</td>
<td>Arrhythmia, confusion, hypotension, nausea, vomiting, xanthopsia</td>
<td>Digoxin, foxglove (<em>Digitalis</em> spp), lily of the valley (<em>Convallaria majalis</em>), oleander, ouabain, red squill</td>
</tr>
<tr>
<td>Cholinergic</td>
<td>Muscarinic and/or nicotinic receptor agonist</td>
<td>Bradycardia, diaphoresis, dyspnoea, lachrymation, loss of sphincter control, miosis, muscle fasciculation, muscle paralysis, vomiting and wheeze</td>
<td>Carbamates, chemical warfare nerve agents (sarin, soman, taban, VX, fourth-generation novichoks), hemlock, <em>Inocybe</em> mushrooms, laburnum, nicotine, organophosphates</td>
</tr>
<tr>
<td>Corrosives</td>
<td>Direct chemical irritation or reaction with tissues</td>
<td>Drooling, dysphagia, dyspnoea, haematemesis, melena, localized pain, vomiting, blisters, skin burns</td>
<td>Acids, alkalis, copper sulfate, hydrofluoric acid, iron salts, paraquat</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>Central nervous toxicity (volatile hydrocarbons) or aspiration pneumonitis</td>
<td>Arrhythmia, coma, confusion, cough, dyspnoea, gastrointestinal upset</td>
<td>Benzene, diesel, gasoline, kerosene, toluene</td>
</tr>
<tr>
<td>Toxic metals and metalloids</td>
<td>Oxidation–reduction reactions</td>
<td>Arrhythmia, confusion, hypotension, gastrointestinal disturbance, metal fume fever, peripheral neuropathy</td>
<td>Arsenic, chromium, iron, cobalt, lead, thallium</td>
</tr>
</tbody>
</table>
What chemical surveillance are you aware of in your country?
Role of Poison Centres

Poison Centre

- Clinical Care
- Public Health
- Chemicals Management
Poison Centre Models

Toxicology laboratory
Poisons information service
Clinical treatment unit
WHO global perspective on poisoning

- Unintentional poisoning
- Intentional poisoning
- Snakebite

https://www.who.int/publications/i/item/9789240009523
What Poisons Centres get called about?

Substances - Use Category %: Jan-Apr 2020

<table>
<thead>
<tr>
<th>Substance</th>
<th>Use Category %</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNKNOWN</td>
<td></td>
</tr>
<tr>
<td>PLANTS AND FUNGI</td>
<td></td>
</tr>
<tr>
<td>PESTICIDES</td>
<td></td>
</tr>
<tr>
<td>INDUSTRIAL</td>
<td></td>
</tr>
<tr>
<td>HOUSEHOLD</td>
<td></td>
</tr>
<tr>
<td>HANDYMAN</td>
<td></td>
</tr>
<tr>
<td>FOOD</td>
<td></td>
</tr>
<tr>
<td>COSMETICS</td>
<td></td>
</tr>
<tr>
<td>ANTISEPTICS &amp; DISINFECTANTS</td>
<td></td>
</tr>
<tr>
<td>ANIMALS BITES, STINGS</td>
<td></td>
</tr>
</tbody>
</table>

0.0 20.0 40.0 60.0 80.0 100.0 120.0 140.0 160.0 180.0 200.0
In 2019: “Only 47% of WHO Member States had a poison centre”
Health and economic benefits

- Reduces hospital admissions / emergency department attendances
- Reduces time patients spend in hospitals
- Reduces unnecessary treatments
- Has benefits in the prevention of poisoning, not just treatment
- Saves the healthcare system (i.e. Ministries of Health) money overall
  - US: In 2012, report on cost–effectiveness of US poison centres, which found a near 1:14 benefit for each US$ spent, equivalent to $1.8 billion per year
  - Brazil: Patients where poison centre was consulted stayed an average of 3.42 days fewer than those not discussed with the poison centre
Analytical toxicology labs

- Emergency qualitative and/or quantitative assays for common poisons, especially when may influence treatment

<table>
<thead>
<tr>
<th>URGENT</th>
<th>LESS URGENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carboxyhaemoglobin</td>
<td>Cholinesterase</td>
</tr>
<tr>
<td>Methaemoglobin</td>
<td>Lead</td>
</tr>
<tr>
<td>Iron</td>
<td>Mercury</td>
</tr>
<tr>
<td>Lithium</td>
<td>Methotrexate</td>
</tr>
<tr>
<td>Toxic alcohols (methanol, ethanol, ethylene glycol)</td>
<td>Thalium</td>
</tr>
<tr>
<td>Paracetamol</td>
<td>General toxicology screen</td>
</tr>
<tr>
<td>Salicylate</td>
<td></td>
</tr>
<tr>
<td>Paraquat</td>
<td></td>
</tr>
</tbody>
</table>
Poisons and toxicology

Do you have access to a poison centre or clinical toxicology in your country?
Thank You!
Any questions?