The Public Health Management of Chemical Incidents

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Background

Modern industrial society hugely dependant upon chemicals.

✓ Agriculture (pesticides, herbicides, fertilizers, growth accelerators etc).

✓ Housing and health (Household cleaners, detergents etc.).

✓ Pharmaceuticals

✓ Water quality

✓ Food preservation

✓ Consumer and cosmetic produce
Chemical Industry: Background

- Global turnover €1.87 trillion (excluding pharmaceuticals) in 2009.
- Industrialised countries account for 56% of world production.
- Asia-fastest growing market
- Global industry, reflecting world economic growth, reduction of tariffs and other boundaries, enhanced telecommunications and transportation.

Source: International Council of Chemical Associations
The Chemical Industry

• Third largest manufacturing industry in Europe; market value € 586 bn.

• Chemicals stored at 850,000 sites in USA.

• Dominant industry in South Africa.

• World chemical sales in 2004 €1736 bn.

• 200-300 new chemicals per year in the EU.

• Total global production in 2020 85% higher than in 1995 (OECD).
High Production Volume Chemicals (HPVs)

- Manufactured or imported in large quantities.
- >1 million pounds per annum by weight (USA).
- Produced or imported in volumes greater than 1000 tonnes per year (Europe)
## HPVs: Examples

<table>
<thead>
<tr>
<th>Alcohols</th>
<th>Acetonitrile</th>
<th>Benzene</th>
<th>Glucose</th>
<th>Nitric acid</th>
<th>Phenols</th>
<th>Styrene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium carbonate</td>
<td>Calcium carbonate</td>
<td>Hydrocarbons of varying chain length</td>
<td>Octane</td>
<td>Pyridine HCl</td>
<td>Tetraethyl lead</td>
<td></td>
</tr>
<tr>
<td>Alkenes</td>
<td>Chlorine</td>
<td>Lead oxide</td>
<td>Petroleum gases</td>
<td>Sulphuric acid</td>
<td>Titanium</td>
<td></td>
</tr>
<tr>
<td>Ammonium nitrate</td>
<td>Ethylene</td>
<td>Methane</td>
<td>Phosphoric acid</td>
<td>Sodium carbonate</td>
<td>Xylene</td>
<td></td>
</tr>
<tr>
<td>Boric acid</td>
<td>Ethylene dichloride</td>
<td>Propylene</td>
<td>Sodium hydroxide</td>
<td>Zinc Ores</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TOXIC INDUSTRIAL CHEMICALS

Manufactured, stored and utilised throughout world

- Gas, liquid or solid
- Highly toxic
- Large quantities
- Chemical hazards
- Physical hazards
## TICs: Examples

<table>
<thead>
<tr>
<th>Ammonia</th>
<th>Carbonyl sulphide</th>
<th>Methyl isocyanate</th>
<th>Cyanogen chloride</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorine</td>
<td>Arsenic trichloride</td>
<td>Parathion</td>
<td>Sulphuric acid</td>
</tr>
<tr>
<td>Hydrogen chloride</td>
<td>Nitric acid</td>
<td>Phosphine</td>
<td>Ethylene dibromide</td>
</tr>
<tr>
<td>Hydrogen fluoride</td>
<td>Phosgene</td>
<td>Hydrogen sulphide</td>
<td>Phosphorous trichloride</td>
</tr>
<tr>
<td>Hydrogen cyanide</td>
<td>Sulphur dioxide</td>
<td>acrolein</td>
<td>Fluorine</td>
</tr>
</tbody>
</table>
Chemicals are not without risk…

“Fears over impact of chemical plant”

“Tanker accident starts chemical alert”

“Five in hospital after chemical spill”

“Hospitals 'unready' for chemical alert”

Sandhurst, Oct 2000

Toulouse blast 2001

BBC

North Shields, April 2002
Case Study: Hungarian mud spill, October, 4 Oct 2010

- 9 people died and 150 affected from burns of skin and eye.
- Concern of transnational health and environmental impacts from trans-boundary movement of chemicals.
- 150 similar dams along the Danube.
Case Study: Toxic waste dumping, Cote d'Ivoire, 2006

- 500 tons of toxic waste dumped around the city.
- Several fatal cases reported.
- 100,000 persons sought medical attention.
- Health System overwhelmed.
- Panic and anxiety among the population.
Case Study: Heavy metal poisoning from mining, Zamfara, Nigeria.

- Event detected by international medical team (MSF).
- Extraction of gold from ore with high lead content.
- Over 1000 children poisoned, 207 deaths. In some villages, 10-30% of the children under 5 years old dead.
- Death + illness caused by lead exposure.
- In some villages, 70-100% of children needed emergency medical treatment.
- Long-term health consequences, in particular for children.
Case Study: Mass bromide poisoning, Angola, 2007

- Disease outbreak of unknown cause.
- More than 450 victims; mainly children.
- Symptoms suggested toxic origin.
- Industrial chemical confused with table salt.
Emergency planning & preparedness

- Research, surveillance
- Strategic Planning
- Professional development
- Alert and Response systems
- Training

Emergency Response

- Casualties
- Toxicological effects
- Psycho-social effects
- Reproductive effects
- Cancers

Chemical Incident

Acute - Chronic
Hazard

- Inherent property of an object, place or situation that makes it dangerous.
- Chemicals may be toxic, irritant, flammable corrosive or explosive.
- Such properties are not changeable and need to be managed
Risk and Impact

• Therefore risk of exposure from chemicals
• Accidents at installations, during transportation, conduit through pipelines.
• Deliberate release and chemical terrorism a possibility
• All environmental media may be contaminated
• Therefore number of scenarios is almost infinite
• Essential to risk assess, prioritise, mitigate and plan/prepare
Risk

Defined in many different ways

- “A likelihood that a hazard will cause its adverse effects” (HSE, UK)
- “The probability that an event will occur.”
- “The possibility of suffering harm or loss.”
- “The chance of harmful effects to humans health (or ecological systems)” (USEPA)
- “The probability of an adverse effect in an organism, system or (sub) population…” (IPCS)
- Risk = Probability \( \times \) Consequence (HPA, UK)
Vulnerability

- Susceptibility to exposure
- Proximity
- Other life-style determinants e.g. poverty, smoking.
- Prevalence of ill health
- Genetics
- Life-stage
Context of risk

- Chemicals produced, stored and transported in vast quantities.
- Many are hazardous.
- Public health impact potentially significant.
- Need to emergency plan and prepare in a risk-prioritised fashion.
- Requires prior risk assessment, prioritisation and mitigation.
Consideration: Maritime Transport

- Maritime transport of chemicals has increased significantly over the last 20 years.

- Many of these chemicals are classified as being “hazardous and noxious substances” (HNS).

- Risk to pollution of sea, wider environment and to human health.

- Need to prioritise risk according to toxicity, likely exposure, quantities and previous history.

[http://www.proactiveinvestors.co.uk/genera//img/companies/news/exportimport350_4964720e2d5d2.jpg]
## Risk Prioritisation

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Insignificant (no perceptible PH impact)</th>
<th>Minor (few/reversible transient health consequences)</th>
<th>Moderate (irreversible or long-lasting health effects)</th>
<th>Major (life-threatening)</th>
<th>Catastrophic (death, severe injury or debilitating effects)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almost certain (e.g. &gt;90% chance)</td>
<td>HIGH</td>
<td>HIGH</td>
<td>EXTREME</td>
<td>EXTREME</td>
<td>EXTREME</td>
</tr>
<tr>
<td>Likely (50-90%)</td>
<td>MODERATE</td>
<td>HIGH</td>
<td>HIGH</td>
<td>EXTREME</td>
<td>EXTREME</td>
</tr>
<tr>
<td>Moderate (10-50%)</td>
<td>LOW</td>
<td>MODERATE</td>
<td>HIGH</td>
<td>EXTREME</td>
<td>EXTREME</td>
</tr>
<tr>
<td>Unlikely (3-10%)</td>
<td>LOW</td>
<td>LOW</td>
<td>MODERATE</td>
<td>HIGH</td>
<td>EXTREME</td>
</tr>
<tr>
<td>Rare (&lt;3%)</td>
<td>LOW</td>
<td>LOW</td>
<td>MODERATE</td>
<td>HIGH</td>
<td>HIGH</td>
</tr>
</tbody>
</table>
Risk Mitigation

The process of risk reduction

Examples

• Clear labelling and inventories of hazardous chemicals
• Chemical substitution
• Isolation, bunding and reduced storage capacity
• Relocation of chemical industries from urban areas
• Diversion of chemical transportation away from urban developments
• Remediation of contaminated sites
Risk Mitigation: Layers of Protection

- Two types of LOP considered:
  - Preventative
    - prevent an incident from occurring
  - Responsive
    - reduce the impact of an incident

http://www.absconsulting.com/svc_opRisk_LOPA.html
Residual Risk

For chemicals:

- It is the risk that remains despite the best efforts to prevent and reduce the likelihood of its occurrence, some residual risk will remain which can materialize in a chemical incident.
Public health has a role in each phase of the emergency cycle.

Health sector plays an influencing, complementary and/or leadership role.

Multi-disciplinary approach.

Organizations responsible for those functions may differ for each nation.

Public Health Management of Chemical Incidents
Some typical public health questions

**Responders:**

- What are the chemicals involved? What is their identity? What are their toxicological properties?
- What Personal Protective Equipment is required? How to decontaminate?

**Public:**

- Am I at risk of developing adverse health effects? Are my children at risk?
- What are the health effects? Can I expect delayed effects?
- What should I do in order to reduce risk of chemical exposure or in case I/my family experience(s) effects?
Typical public health questions (cont'd)

Medical professionals:
- What are the typical signs and symptom from exposure to the chemical(s)? How do I treat? Where to get antidotes or other specific pharmaceuticals?
- Where to analyze human samples for diagnoses/treatment?
- What Personal Equipment and how and where to decontaminate?

Others:
- Evacuate or shelter in place? When can people return back home safely?
- What remediation or restoration measures?
- Where to build a hazardous installation?
Planning

• *Planning* is the process whereby plans for chemical incident management are constructed. A planned, prepared and practiced response to incidents contributes to preparedness and serves to protect the public.

• All major organisations should be involved in the planning process (*Integrated Emergency Management*), allowing respective roles and responsibilities to be clarified, defined and mutually understood.
The Plan - Should include:

- Requirements & Agreements
- Detection & Alert mechanisms
- Scaling up triggers
- Response process & structure
- Command and control
- Inventory of capabilities
- Coordination with stakeholders
- Communications
- Contact list
Role of public health - *Preparedness*

**Aim:** Build capacities and establish working systems for detection and alert, response, and recovery.

**Key elements:**

- Plans (usually multiple plans).
- Roles and responsibilities.
- Training.
- Exercises.
- Stockpiles, roster of experts, laboratories.
- Coordination and collaboration.
Role of public health - *Response*

**Aim:** Manage chemical incidents and emergencies effectively and efficiently once they have happened.

**Rapid assessment:**
- What are the risks?
- Who may be affected?
- What can be done to minimize harm?
- What are the existing capacities?

**Expanded assessment:**
- Gather health and environmental data.
- Model/measure transport and fate.
- Estimate risk.

**Risk and crisis communication**
Aims of Response

- Termination of release.
- Prevention of spread of contamination
- Limitation of exposure
1. Termination of release

- Public health role varies according to scenario.
- At a chemical plant, undertaken by fire service and company personnel.
- During an outbreak, PH officials play a key role in identifying source and limiting exposure.
2. Prevention of Spread

- Rapid risk assessment
- Incident zoning
- Command and control
Command and Control

- Incident command system.
- Utilises a standardised chain of command for all incidents.
- Allows consistent training of staff from diverse disciplinary backgrounds.
- Standardised on and off-scene model.
- Organised into modules—operational, tactical and strategic.
The most effective public health primary prevention measures are to:

- Avoid or restrict the intake or contact with contaminated food, water, air or other contact media.
- Require emergency responders to use personal protective equipment.
- Decontaminate contaminated individuals and materials.
- Shelter in Place or Evacuate

3. Limiting Exposure
**Triage**

- Process of determining priority of treatment based upon victim condition.
- Applies when insufficient resources to treat all at once.
- Prioritises removal from “hot” zone and subsequent treatment in “warm” zone.
- Dynamic process.
Decontamination serves to remove the hazardous substances from the victims, the responders and their PPE, and the equipment and vehicles at the site of a chemical incident.
Decontamination (continued)

The aims of decontamination procedures are:

- To prevent movement of hazardous substances from contaminated into clean areas.
- To protect the public and downstream responders from exposure by secondary contamination.
- To protect emergency responders by decreasing the chemical stress on their PPE.
Sheltering vs evacuation

• Exposure is a function of concentration and time.

• Therefore most appropriate option is usually to shelter.

• Close windows, doors; shut off air conditioning.

• Building structure *may* provide significant protection.

• Higher survival probability

• “Go in, stay and tune in”
Exceptions

- Prolonged incidents
- High pressure explosions
- Jet pool flames
- Boiling liquid expanding vapour explosions (BLEVEs)
Evacuation

• May be logistically difficult:
  ➢ Panic
  ➢ Reluctance
  ➢ Grid-locking
  ➢ Need to find accommodation
  • May increase exposure
  • Therefore, normal advice to shelter.
Role of public health - Recovery

Aim: Return to sustainable conditions.

- Support remediation or restoration activities.
- Study of intermediate and long-term risks (e.g. environmental epidemiological investigations).
- Ensure efforts are taken to prevent recurrence.
Long Term Monitoring

- Long term environmental contamination may occur.
- Requires on-going monitoring.
- Useful for ascertaining variation from baseline levels, characterisation of severity and extent of event.
- Complimentary to remediation strategy.
Epidemiological Investigation

Objectives:

- To identify potential *chronic* health effects
- To provide basis for *possible* link between contamination and health.
- To provide information regarding the probability of health effects.
- To delineate the exposure-dose/health relationship.
- To further understanding
International Training Centre

• Launch April 20, 2012 at Cardiff Metropolitan University.


• Basis for subsequent training
Public Health Management of Chemical Incidents

Prevention Emergency Planning Detection & Alert
Response Recovery Glossary

Welcome to Cardiff Metropolitan University’s Public Health Management of Chemical Incidents course site.
Materials (continued)
Target group:
Public health and environmental professionals and policy makers.

Purpose:
Introduce principles and functions of public health for the prevention and mitigation of chemical incidents.

Scope:
All types of chemical incidents that have the potential to affect the health of the public.

Further reading (continued)

• Assist its users with the performance of human health risk assessments.

• Promotes the use of information developed by international organizations.

• Designed for many risk assessment scenarios, including chemical incidents and emergencies.

http://www.who.int/ipcs/methods/harmonization/areas/ra_toolkit/en/
Key Points

- Modern society is hugely dependent upon chemicals which have an overall beneficial effect upon public health.
- Some chemicals are hazardous.
- Risk of chemical incidents which have the potential to have a major risk for public health, particularly susceptible groups.
- Need to identify hazards, assess, prioritise and mitigate risks.
- Subsequent planning and preparedness provide the basis for a co-ordinated, efficient and effective response.
- Timely response precedes recovery.