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# International Clearing House for Major Chemical Incidents

A WHO Collaborating Centre

**I P C S**  
International  
Programme on  
Chemical Safety



United Nations  
Environment  
Programme



International  
Labour  
Organisation



World Health  
Organization

## Public Health and Chemical Incidents

### Guidance for National and Regional Policy Makers in the Public/Environmental Health Roles

1999

**The International Programme on Chemical Safety (IPCS)**, established in 1980, is a joint venture of the United Nations Environment Programme (UNEP), the International Labour Organisation (ILO), and the World Health Organization (WHO). The overall objectives of the IPCS are to establish the scientific basis for assessing risk to human health and the environment from exposure to chemicals, through international peer-review processes, as a prerequisite for the promotion of chemical safety, and to provide technical assistance in strengthening national capacities for the sound management of chemicals.

**The Inter-Organization Programme for the Sound Management of Chemicals (IOMC)**, was established in 1995 by UNEP, ILO, the Food and Agriculture Organization of the United Nations, WHO, the United Nations Industrial Development Organization, and the Organisation for Economic Co-operation and Development (Participating Organizations), following recommendations made by the 1992 United Nations Conference on Environment and Development to strengthen co-operation and increase co-ordination in the field of chemical safety. The purpose of the IOMC is to promote co-ordination of the policies and activities pursued by the Participating Organizations, jointly or separately, to achieve the sound management of chemicals in relation to human health and the environment.

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# Preface

Chemical exposure has always been a feature of human society. Before human beings started making new chemical substances, they were exposed to poisonous plants, venomous animals, and chemicals of natural origin, such as produced by fire. With the onset of mining and smelting of minerals, workers were exposed to fumes and dusts. Poisoning occurred in early civilizations through the use of lead and mercury. However, the rapid industrialization of the last century, the increasing numbers and volume of chemicals produced in this century, and the growing global market in chemicals of the recent decades has accelerated dramatically the range of chemicals and types of exposure experienced by individuals and populations.

The public has become aware and increasingly concerned about exposure to chemicals, particularly through major chemical incidents, such as the Minimata mercury poisoning, the Itai-Itai disease caused by cadmium, the Seveso and Bhopal incidents involving dioxin and methyl isocyanate, respectively, and the Spanish toxic oil episode. Incidents such as these cause fear, and sometimes panic, in populations. They are frightening because they have the potential to cause large numbers of deaths and disabilities and because they raise questions about the fragility of technologies over which society, and the local community in particular, may lose control. Expressions of concern have also been increasing, not only by the public, but also by the scientific and medical community, that there may be long-term effects on human health, such as the development of cancers and congenital malformations, resulting from these chemical incidents. Furthermore, there is concern that exposure to chemicals may be giving rise to diseases, not hitherto recognized, or exacerbating diseases of another etiology.

Governmental authorities in many countries now recognize that these concerns need to be faced, both to allay unnecessary fears and to take timely, cost-effective action, where appropriate, to protect human health and the environment, and to mitigate deleterious effects of chemical incidents.

The International Programme on Chemical Safety (IPCS) was established in 1980 by the World Health Organization (WHO), the International Labour Organisation (ILO) and the United Nations Environment Programme (UNEP) to provide, through chemical risk assessment, an internationally-evaluated, scientific basis on which countries may develop their own chemical safety measures, and to strengthen national capabilities for prevention and treatment of harmful effects of chemicals and for managing the health aspects of chemical emergencies. Through an informal

IPCS Consultation of Experts, held in February 1992, a number of scenarios of concern to governments were identified where guidance was needed if health and environmental authorities were to meet their responsibilities for protection of human health and the environment. These scenarios included: chemical incidents involving human exposure with or without immediate health effects; where exposed persons needed to be followed-up for possible sequelae or delayed effects; and observation of health effects of unknown cause, but suspected chemical aetiology. As a result of this consultation, and in pursuance of its mandate in the field of chemical safety, the IPCS decided to prepare guidelines for governments as to the roles of health and environmental authorities in meeting their responsibilities in relation to these scenarios. Further, to support the work of the WHO in the area of chemical incidents, two WHO Collaborating Centres were established, one on the "Health Aspects of Chemical Accidents" at the Utrecht University Hospital, in the Netherlands, the other for an "International Clearing House for Major Chemical Incidents", at the University of Wales Institute, Cardiff, in the United Kingdom.

The United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro, Brazil, in June 1992, defined an international strategy for environmentally sound management of toxic chemicals within the principles of sustainable development and the improvement of quality of life for humankind. Promotion of effective international cooperation with respect to prevention of, preparedness for and response to emergencies and incidents involving chemicals, including management of poisoned patients, follow-up of sequelae, and incident site clean-up and rehabilitation, is one of the important aspects of sound management of chemicals identified by UNCED. Following UNCED, the IPCS has played a central role in establishing strengthened cooperation among international organisations through the Inter-Organization on Sound Management of Chemicals (IOMC), and in setting up an Intergovernmental Forum on Chemical Safety (IFCS). In relation to chemical incidents, the IPCS is dealing mainly with the health and medical aspects.

A number of important international initiatives have already been undertaken in relation to the health aspects of chemical incidents. In 1989, "Methods for Assessing and Reducing Injury from Chemical Accidents" was published jointly by the IPCS and the Scientific Committee on the Problems of the Environment (SCOPE) of the International Council of Scientific Unions (ICSU). In 1994, the IPCS, the Organisation for Economic Co-operation and Development (OECD), the United Nations Environment Programme Industry and Environment Programme Activity Centre

(UNEP-IE/PAC) and the WHO European Centre for Environment and Health (WHO-ECEH) published "Health Aspects of Chemical Accidents", giving guidance on chemical incident awareness, preparedness and response for health professionals and emergency responders. In 1996, OECD issued guidance concerning the "Health Aspects of Chemical Accidents", as a supplement to its "Guiding Principles for Chemical Accident Prevention, Preparedness and Response". In 1988, UNEP produced its APELL Handbook ("Awareness and Preparedness for Emergencies at Local Level") which gives a ten-step process of instituting or planning for, preparation of, and response to incidents at local level through cooperation between industry, local authorities and the public.

Following the consultation in 1992, the IPCS organised two international conferences (Cardiff, UK, 1-3 April 1993, and Sao Paulo, Brazil, 6-11 June 1994), at which a number of well-known chemical incidents were examined with a view to identifying the lessons to be learned by the health sector in dealing with such incidents. In consultation with an editorial panel (see Appendix A), guidance material on the public health sector role in chemical incident preparedness, response and follow-up was then drafted, based on the conclusions and recommendations of the two conferences. This draft material was examined at a number of IPCS workshops held in Wales, UK between 1995 and 1998 (see Appendices B and C) and subsequently assembled into a guideline document, which enabled the general principles for this policy document to be identified.

The IPCS gratefully acknowledges the financial support of the UK Department of Health, through its annual contributions to the Programme, throughout the period during which this activity was being undertaken. The lead role of the WHO Collaborating Centre for an International Clearing House for Major Chemical Incidents, UWIC, in the preparation of this document is also greatly appreciated.

**John Haines**

INTERNATIONAL PROGRAMME ON CHEMICAL SAFETY

# Structure of this document

This document describes how countries can improve the public health response to acute chemical incidents, and ensure a better outcome for the health of their populations.

**Part 1** is a succinct summary for the policy maker at government and regional level, and describes the major public health problems posed by chemical incidents and the actions that need to be taken by policy makers.

**Part 2** gives more details of the public health response to an incident. It has two purposes. Firstly, it is provided to give the interested policy maker **greater insight** into the technicalities of the public health approach. More importantly, though, this section is offered as a **template** for all the public health **functions** that will need to be introduced into every country to ensure an adequate public health response.

**Part 3** takes the functions as described in Part 2 and offers a **suggested model**, or structural framework, into which these functions can be built. It is intended purely as a model. There will be many possible ways of ensuring the provision of a comprehensive public health response - from wholly self-contained to wholly contracted in. There are some international structures already in place and these are described.

**Part 4** contains the appendices, covering for example individuals contributing to the document, examples of major chemical incidents, and a bibliography and the references.

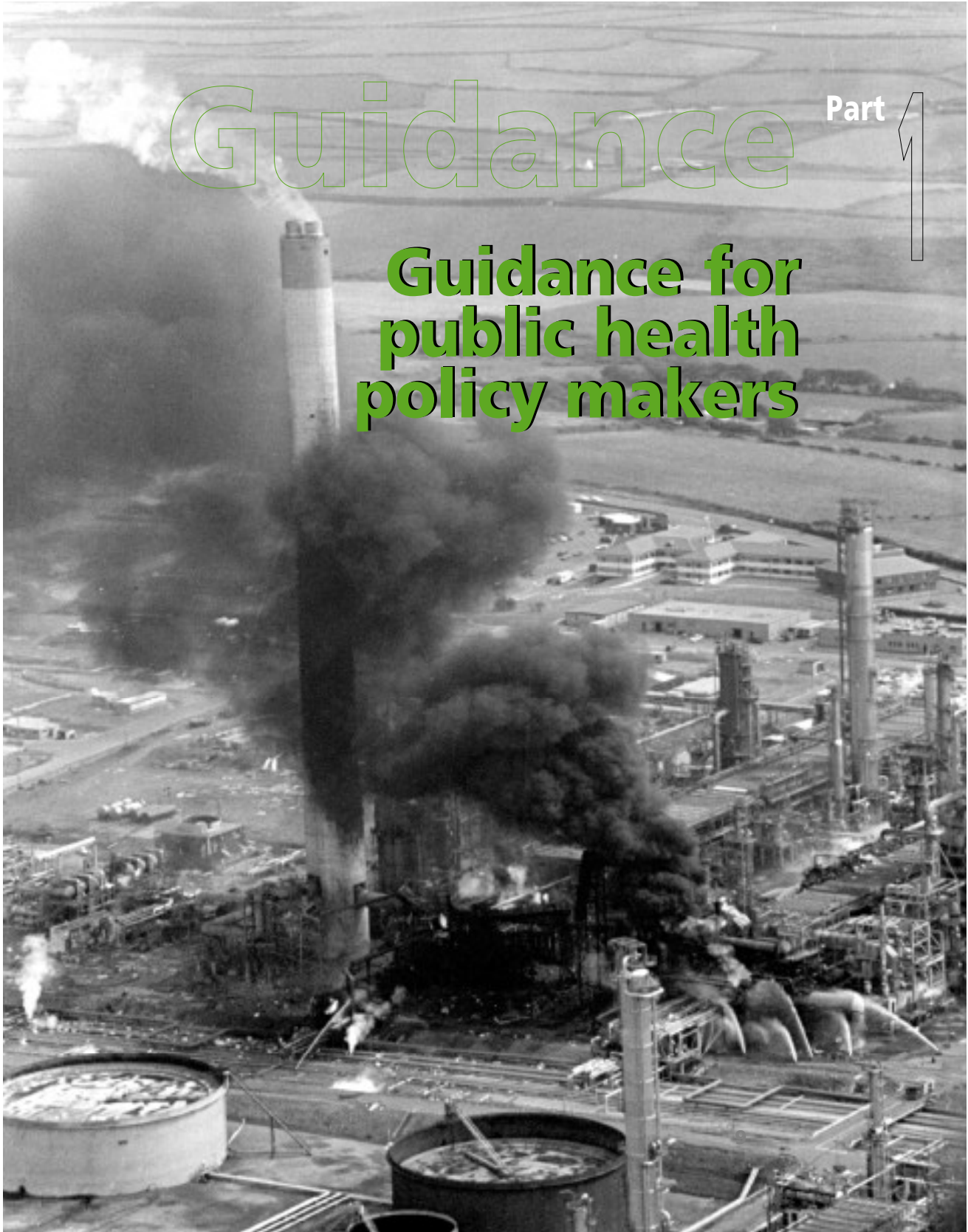


# Guidance

Part



## Guidance for public health policy makers



# Guidance for public health policy makers

## Introduction

*Emergency services deal with acute chemical incidents*

This policy document has been written primarily to give **policy makers** at national and regional level a **broad understanding** of the problems posed to the health of people and populations, as well as the environment, when a chemical incident occurs and chemicals are released into the environment. Often, the **release** will have occurred at a specific site - the incident **scene**. For this sort of release, the emergency services become involved and, by and large throughout the world, are well prepared, trained, and organised to cope with the release itself. They put out any fires, try to contain any liquid chemicals and rescue casualties. The chemicals, however, are often **dispersed**, into the air, onto the soil, or into the water etc.

In other sorts of incidents, the chemical is released into food or water. Occasionally, the release is silent and is only announced by an increase in symptoms or illness. In these cases, there is **no scene**, the emergency services are not involved, and it is other services, such as water authorities that become involved.

*the impact on the public's health is usually not considered*

What is rarely addressed, though, is the **impact** that the release of the chemical (and any containment or clean-up processes) has on the **health**- both the **short term** and the **long term** - of individuals and the public, and what difference there might have been to the health of the people if different courses of action had been taken by the emergency responders.

*public health professionals are trained to do this*

Addressing the impact on populations and advising on the best course of action to minimise the health impact is the **role of the public health services**. Public health is also concerned with the study of the distribution and determinants of diseases in populations. Public health / environmental health professionals are trained in epidemiological techniques and in the application of management skills to achieve change. These techniques and skills have typically been applied to the control of infectious diseases and food poisoning outbreaks. To be able to apply these techniques and skills to acute chemical incidents, some additional training will often be required. However, once this knowledge and expertise has been gained, it should be possible for public health / environmental health professionals, as **full members** of the emergency response team, to advise on the best course of action for the emergency responders to take.

The **public health response** in an acute chemical incident is therefore:

- **the assessment of the likely impact on the health of the first responders, exposed people and the population**

- **the provision of evidence-based advice on appropriate measures to be taken to minimise the loss of health, both mortality and morbidity; and**
- **the follow-up of exposed people.**

Generally throughout the world, this public health response is poorly developed. Often, it will require considerable **development** to provide sufficient public health / environmental health professionals with the proper training and experience at the national and regional level. This development can often usefully be conducted in parallel with the development of other public health functions, such as infectious disease control or food poisoning outbreak control. Once developed, a strong and vital public health response can only be achieved if public health/environmental health professionals are **full members** of the planning teams and emergency response teams.

*public health  
capability needs  
developing*



## The Public Health Problems of Chemical Incidents

Chemical incidents can happen any where, and at any time. This is true even if there are no chemical installations in the area. Lorries can spill their contents, rail tankers can overturn, and clouds of chemical vapour can drift over in the wind or be deposited in the rain. The vast majority of chemical incidents are not the media-grabbing type, such as Bhopal (see page 12). They are smaller, and involve less people; but they are none-the-less just as serious in terms of illness, death and anxiety to people, the public, the emergency services and employees.

*unpredictable nature  
of incidents*

Experience has shown that **preparedness** is the crucial factor for the successful management of chemical incidents. The most important areas for preparedness are incident combat (plugging the leak, extinguishing the fire etc), medical treatment, clean-up, and, most importantly from the point of view of the affected public and the emergency services, dealing with the questions and uncertainties about the health effects. Sadly, the sector with the expertise and knowledge to deal with this aspect - public health / environmental health specialists - is often left out of the planning and management of chemical incidents. Below are a couple of examples of chemical incidents that had a public health outcome, including one where public health involvement was lacking and where a different outcome might have been achieved if it had been present.

*problems if public  
health professionals  
are not involved  
in planning*

### Water-based contamination – Camelford UK

On 6th July 1988, a relief driver mistakenly emptied 20 tonnes of aluminium sulfate solution from his tanker into the contact chlorine reservoir of a small, unmanned drinking water treatment plant in the UK. Because there had been a technical problem at the site a few hours earlier, the resulting increase in levels of aluminium were not recognised until several days later. Aluminium levels of 620,000mg/l, sulfate levels of 4,500,000mg/l and pH values of 3.9 - 5.0 were recorded. Some 12,000 local residents and a further 8,000 holiday makers were put at risk.

*aluminium sulfate  
emptied into  
water supply*

Once a problem had been identified, the water authority installed bowsers, but did not reveal publicly the cause of the incident. Neither was an immediate rapid epidemiological assessment carried out. An inquiry was ordered in mid July, which reported in August, by which time much public anxiety and media interest about the long-term health consequences had been raised.

*considerable public  
anxiety could have  
been avoided*

Two further public inquiries and several epidemiological studies were initiated over the next two years, which found an increased incidence in a wide range of symptoms in the people who were exposed. However, the researchers were unable to exclude the possibility that the associations could have been due to anxiety and the publicity associated with the incident.

Considerable public anxiety and unrest continued for a number of years.

## **Air-borne contamination from a fixed site – Bhopal, India**

*poor land-use  
planning led to  
any people dying*

Union Carbide Corporation had a number of tanks storing methyl isocyanate (MIC) within its plant at Bhopal. On the night of 2nd/3rd December 1984, tank 610, containing 42 tonnes of MIC, started leaking following a rise in pressure. The gaseous cloud caused immediate lung and eye problems, and killed, ultimately, 2800 people, injured and debilitated between 50,000 and 150,000 people, hospitalised immediately 1400 people and caused widespread panic in the 5 million local residents. A second, neighbouring tank 611 threatened to leak, causing many people to leave the area until it was made safe. It is the worst chemical disaster in the world to date.

Considerable controversy surrounds the question of the chemical composition of the chemical cloud. The tank appears to have suffered a considerable rise in temperature, which would likely have given rise to a number of byproducts. These remain unknown.

Many clinical and epidemiological studies were started following the disaster, looking in particular at toxicological, immunological, neurological, psychological and genetic aspects. The principal long term effects have been on the lungs and the eyes.

### **Frequency of public health chemical incidents**

Public health chemical incidents are surprisingly common. There are a number of databases in the world that have collected comprehensive public health surveillance data about chemical incidents in their countries. The Agency for Toxic Substances and Disease Register (ATSDR), in the USA, has the largest current one - the Hazardous Substances Emergency Events Surveillance System (HSEES). The National Focus for Work on Response to Chemical Incidents (National Focus), in the UK, started a national surveillance system in 1998. A pilot surveillance system collected data from Wales during 1993 to 1995 - the All-Wales Environmental Health Surveillance Project (AWEHSP). Data from the HSEES and the AWEHSP are produced in Table 1.

**Table 1**  
**Frequency and outcome of all public health chemical incidents in the USA and Wales, UK**

Database	Period	Area / pop covered	Number of incidents	Died	Affected	Evacuated
HSEES	1993-7	Part of USA 80m. pop	24,573	111	9652	23,851
AWEHSP	1993-5	Wales 3m. pop	330	5	473	0



There is no international database that collects data on public health chemical incidents down to the level of these national databases. However, the United Nations Environment Programme (UNEP) does produce a list of all the large incidents that have involved a hazardous substance - large being where 25 or more people have been killed, or 125 or more people have been injured or 10,000 or more people have been evacuated.

*chemical incidents involving the public are common*

In the 28 years between 1970 and 1998, the data were as follows:

**Table 2**  
**Frequency and outcome of large scale public health chemical incidents, 1970 - 1998**

Geographical area	Number of large scale incidents	Died	Affected	Evacuated
USA	87	372	14,356	517,000
UK	9	167	489	133,000
Worldwide	350	13,000	100,000	3 million

It can be seen that, in the USA and UK, the ratio of the annual number of large scale incidents to all incidents (about 1:1600 and 1:400 respectively) is low. Thus, if the same ratios were applied to the worldwide number of large scale incidents, the estimated number of all incidents could range from 100,000 to 500,000 per year. (These figures are broadly indicative only, and must be taken with caution) A list of these large scale incidents is provided in Appendix E.

*incidents that threaten the public*

**What is a public health chemical incident?**

Many chemical incidents occur which do not threaten the safety of the public. This document is concerned with those incidents that do - that is, incidents that threaten to expose, or actually expose, two or more members of the public (ie: people who are not employees or first respondents) to a chemical hazard. These incidents are usually sudden and acute, although they can include chronic incidents where the public has just become aware of the release and the potential threat to health. Deciding that an incident is a threat to the public health, and who should make that decision, may not

always be easy matters to determine. Chemical incidents may be accidental or intentional (ie malicious or caused by terrorists).

### Outcomes of chemical incidents

*public concern is rising rapidly*

Analysis and experience of these has shown that the range of outcomes from incidents that affect the public health are:

**Public anxiety** The public's perception of the risk to their health from chemical incidents has changed dramatically over the last twenty years. Communities, pressure groups and the media are becoming increasingly interested in chemical incidents.

Governments are coming under rising pressure to demonstrate that there are policies, personnel and other resources in place to effectively deal with incidents, that the management of any incident will be in competent hands, and that the harm to the public is minimised.

- Public Health Outcomes of Chemical Incidents**
- Public anxiety
  - Deaths and illness
  - Delayed health effects
  - Damage to local economy
  - Opportunity costs
  - Legal costs
  - Rehabilitation costs

During an incident, this public anxiety leads to pressure on politicians and policy makers, as well as health professionals, to provide information about the short, medium and long term risks to the health of the people exposed. Because of the lack of public health involvement in the assessment of the health effects of chemical incidents, these questions are often difficult to answer. This has led in many countries to a loss of confidence by the public in the ability of national and local government, and particularly the public health services, to protect them.

**Deaths and illness** Large incidents, with extensive media coverage, are thankfully rare, but in all, the reported incidents, both large and small have caused in the order of 13,000 dead, 100,000 injured or ill and nearly 3 million people to be evacuated over the last 28 years worldwide (see Table 2). Evidence from ATSDR (the Agency for Toxic Substances and Disease Registry, USA (Jones *et al* 1993)) and from a survey in Wales, UK (The All-Wales Environmental Health Surveillance Project 1993 - 1995 (Bowen 1999)) has also shown that there are very many small chemical incidents that are unreported but which put the public at risk, raise considerable anxiety and often cause fatalities or injuries requiring hospital admission.

*large number of people have been affected*

**Delayed health effects** Chemicals do not necessarily produce an immediate effect. Depending on the level of chemicals taken into the body (the dose), there may be long term chronic effects, or effects that appear only years later. Examples of long term effects are skin scarring and disfigurement from burns, respiratory difficulties



from damage to the lining of the lungs, and so on. Delayed effects occur mainly as cancers, or teratogenic effects - problems appearing in the offspring during fetal development.

**Economy** The local and national economy can be affected. Livelihoods and productivity can be interrupted, often for long periods of time. Community anxiety can be raised, affecting inward investment.

**Opportunity costs** Whenever a chemical incident occurs, opportunity costs are encountered. Examples of these are the **closure** of contaminated health facilities, the costs of **monitoring** the pollution, and the costs of **decontaminating** the waterways, soil or food stuffs.

*environmental impacts are considerable*

**Litigation and compensation** When people have been injured or their livelihoods interrupted, they frequently look for compensation. The time taken to apportion blame and the legal processes all add considerably to the final costs of any incident.

**Costs of rehabilitation** The environment may have been extensively damaged by the incident, or may require extensive remediation to return it back to its previous state. Frequently, the clean-up operation of large spills requires large amounts of top soil or beach sand to be removed and disposed of safely. The costs of decontamination and the resulting effects on the environment and wildlife can be considerable.

**The polluter rarely pays** The evidence from around the world is that the polluter rarely pays. Often the polluter is unidentified, and considerable resources have to be expended to identify the chemical and the source. Even when the polluter has been identified and is clearly at fault, the legal process of bringing an action can take many years. It is usual, therefore, for **national** or **local governments** to **pay** for the majority of the costs of chemical incidents that affect the public and public areas.

## The problems caused by lack of involvement by public health professionals

The problem with many incidents is that there is no person or organisation present to take an objective, detached and holistic public health view of the incident. Each government agency is committed to fulfilling its own objectives and functions. There is often no person or organisation with the time or expertise to consider the impact of an action or decision on the health and well-being of the local population. This means that the best courses of action are not considered or researched, people are not registered to be followed up, and the long term health effects are not investigated.

*the population effect is not considered*

Public health personnel are specifically trained to take this view, to consider the long-

term effects, and to balance the different overall effects on the public. They are trained in appropriate research methods, in epidemiological approaches and in methods of multi-agency working and public relations.

## The roles at government level

The roles for government are:

*ensure  
high quality  
public health  
services*

**1.** At the LOCAL level, to ensure that the public health management of chemical incidents is comprehensively, effectively and efficiently conducted, so as to achieve the best outcome in terms of the health of the public whenever a chemical incident occurs. Additional national specialist support may be necessary for this.

*assume overall  
responsibility*

**2.** At the NATIONAL level, to take responsibility and to be accountable to the public for their protection and the overall management of public health chemical incidents.

## Recommended actions at government level

To ensure that these roles are met, government will need to carry out the following actions:

**Recommended Actions  
NATIONAL**

- 
- Identify responsible individual
- 
- Establish inter-departmental collaboration
- 
- Draw up national plan
- 
- Review legislation
- 
- Set up national surveillance systems
- 
- Ensure sufficient specialist health care facilities
- 
- Ensure sufficient resources for epidemiological surveillance and assessments

**1. Identify a responsible government individual or department** An individual or department needs to be identified who will be responsible for ensuring that the national public health plan for dealing with chemical incidents is implemented.

**2. Establish interdepartmental collaboration** There will be a number of separate departments within government each of which may have statutory responsibilities for areas covering chemical incidents. The public health response at a government level to a chemical incident is to balance the requirements and actions of the various departments to achieve the best public health outcome. This requires co-ordination and collaboration across the departments in advance of, and most particularly during any incident.

**3. Develop a national plan for dealing with chemical incidents** A national plan needs to be developed, which makes explicit the **policies** of the government, identifies the **gaps** in the service and any needed, sets **targets** and minimum **standards** at the national and local level, enacts the necessary

**legislation** and enables a political and administrative **response** in the event of a significant incident.

**4. Improve the legislative context** Legislation will usually be required for:

- the establishment of a hazardous sites register
- the control of hazardous sites
- building regulations
- land use planning
- the control of chemical transportation
- the control of waste disposal sites
- the control of contaminated crops, foodstuffs and drinking water
- formal command and control of the incident site and incident management.

**5. Fulfill other national requirements** The government will also need to establish:

- an efficient **public relations system**
- a **national surveillance** and data collection and collation system
- a system of **simulation exercises** at government level
- an **audit / evaluation system** of the effectiveness and efficiency of local exercises and responses,
- that there are sufficient specialist health service facilities and staff nationally.

The government should also be aware of, and plan for the fact that **terrorist attacks** are an increasing possibility. These attacks may use chemicals or biological agents, or may target chemical sites.

**6. Establish a comprehensive national public health function and structure.**

Chemical incident management is only one of a number of functions that can be performed by public health staff. These can include the control and management of outbreaks of infectious diseases, food poisoning, various aspects of major emergencies and disasters, the collection and interpretation of population health status data and various methods of controlling the demand, supply and effectiveness of the health care system.

A comprehensive public health function requires consideration of the recruitment, training and job market for the specialty; regulation and continuing professional education; the provision of epidemiological and other specialist skills; and the relationship with other health related agencies, such as housing, social services and education.

**7. Contribute to international collaboration.** Co-operation and collaboration at the international level are effective and efficient ways to ensure that:

- **research** is conducted that underpins the scientific basis of the public health response



- that **lessons are learned** about the public health responses to chemical incidents and that these lessons are **promulgated** to all countries of the world.

**Recommended Actions  
INTERNATIONAL**

- 
- Establish links with  
WHO Collaborating Centres
- 
- Contribute to the International Chemical  
Incident Register

To these ends, governments can help by **contributing** to the international development and standardisation of:

- guidelines for the public health management of chemical incidents
- chains of command: national - regional - local
- registration of chemical incidents
- data sets for the register
- training.

Many of these functions are conducted by the IPCS and the International Clearing House, UWIC, in Cardiff, which runs the International Chemical Incident Register.

## The roles at the local level

Governments will also need to ensure that, at the local level, there are **appropriate and efficient systems** to enable the following **functions** to be carried out to ensure the effective public health management of chemical incidents.

**1. Advice on the best actions to achieve the best public health outcome of a current incident.** During an incident, the **principle** public health **role** is to assess the **overall likely** impact of the incident on the health of the public, the first responders, the health care workers and the environment and to **advise** the first responders on the best actions. This assessment should take into account not only the **chemical** released during the incident, but also any consequences of the actions that might be taken by the emergency services to deal with it (**the emergency response options**), such as burning off, cleaning-up with other chemicals, flushing into the sewage system etc. Ideally, the assessment should consider the **short, medium and long term health effects** of the possible options. The principle role breaks down into the following sub-roles:

**Recommended Actions  
LOCAL**

- 
- Review the public health structures and  
links with emergency services  
and health services
- 
- Ensure sufficient training
- 
- Ensure high quality audits

- **Hazard identification** - identifying the nature and quantity of the chemical and its potential effects on health as it disperses into the environment
- **Risk assessment** - assessing whether the release of the pollutant actually poses a health risk to the emergency personnel, employees and the public
- **Advice** to the first responders - on their own protection, and on matters such as **personal protective equipment, casualty and personnel decontamination, evacuation and safe return**

- Assessing the (likely) **impact** of the emergency response and any environmental decontamination or clean-up on the health of the public
- Recommending the **courses of action** that produce the **best public health outcome**.

**2. Advising the public, the media and the politicians.** Information and advice about the health consequences of a chemical incident are usually required rapidly and in an authoritative and credible way. In particular, public health professionals are often asked to provide information about the short, medium and long term health effects of the current contamination. They may also be called upon to be the focal point for the issuing of such statements, or to bear responsibility for health-related sections of the general communication with the public.

**3. Measuring the actual health impact of the incident.** Pollutants can have an immediate effect, a long term effect or a delayed effect. Public health professionals need to organise for the **immediate measurement** of the health of exposed and potentially exposed people, and to organise to have them followed-up as part of a proper **epidemiological study**.

**4. Contributing to the rehabilitation of the community.** Once the incident is over, the local community may need to rebuild the economy and lifestyle, and to regain its confidence in the chemical industry and public services. Public health professionals can contribute to this process.

## Recommended actions at the local level

To ensure that these roles can be fulfilled, government will need to **ensure** that:

**1. Competent public health services are comprehensively established at the local level.** This may be achieved by extending the range of current services (such as the control of infectious disease outbreaks) or by developing new services. It may require a plan and resources to be identified. Where services are poorly developed, the less frequent but more dramatic nature of chemical incidents can be a useful incentive to the establishment of the full range of public health functions.

**2. Local public health professionals have access to skills, expertise, and resources** in the following areas:

- chemical and medical toxicology
- poisons information – on a 24 hour per day, 365 day per year, service
- environmental toxicology
- environmental epidemiology
- environmental risk assessment
- environmental sampling
- environmental monitoring and modelling

**1. Competent public local level.** This may be the control of infectious disease outbreaks require a plan and resources to be identified. Where services are poorly developed, the less frequent but more dramatic nature of chemical incidents can be a useful incentive to the establishment of the full range of public health functions.

- biological monitoring
- medical epidemiology
- surveillance
- risk assessment and hazard analysis
- risk perception and risk communication
- risk management
- media skills
- rehabilitation
- accident and emergency services
- audit

**3. There is a comprehensive training, simulation and exercise function** working at the local level and reporting to the national, central level.

**4. Public health services are fully involved in the planning processes and part of the off-site command team during an incident.**

# Functions

**The public health  
environmental health  
functions  
in the management  
of an acute  
chemical incident**

Part

2

## Part 2 The chronological flow of functions

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# Background information

## Chemicals worldwide

Chemicals have played a **major role** in the development of human societies - in agriculture and food; in industry and transport; in housing, and in health. Extraordinary advances in chemical technology have been made throughout the world in the last fifty years (United Nations Environment Programme 1992). Manufacturing has become far more complex and on a larger scale, and an ever increasing number of new chemicals is entering the market each year. Over **11 million chemical substances** are known and some **60,000 to 70,000** are in **regular use**. Between **200 and 1000** chemicals are produced in excess of **one tonne annually**. Currently **new** chemicals are entering the market at the rate of about 600 each month (or over **7000** per year) (Lillibridge 1997).

Dealing with chemicals involves manufacturing, processing, transportation, storage, distribution, use and waste disposal. More than **4 billion tonnes** of hazardous chemicals are **moved** each year around the world by motorway, rail, and pipeline systems. Fertilisers, weedkillers and insecticides are spread in huge quantities on agricultural land. Thus, even if a community does not have any fixed chemical sites, hazards may be passing through, or being used locally, putting that population at risk.

*there is a large and ever-increasing number of chemicals worldwide*

Given the increases in the production and use of chemicals, it is therefore not surprising that the potential for inadvertent chemical releases has increased, giving rise to a greater risk to human health and the environment.

## Types of chemical incident

Essentially, and for the purposes of this document, a chemical incident is an **unexpected, uncontrolled release** of a chemical from its containment. A **public health chemical incident** is one where **two or more members of the public** are exposed (or threatened to be exposed) to a chemical.

In the majority of cases, this is an **acute** release. An acute release is a release where the exposure dose is rising, or is likely to rise to rapidly.

Sometimes, however, the release is **chronic**. This is where the exposure dose is not rising rapidly and public health measures do not have to be taken so rapidly. It may be, however, that the public health concern emerges suddenly and acutely. This document is concerned with the acute releases.

*chemicals are released...*

*...and travel  
through media...*

Chemicals in all their states can be involved in incidents, from **gases** - heavier or lighter than air; **liquids** - volatile and non-volatile; **solids** - powders, dusts, the effluent from volcanic eruptions; **natural toxins**, such as from algal blooms; and increasingly important these days, **biological** toxins and chemicals used in **terrorist** attacks. They may or may not be **visible** or **odourous**. What are not included in this document are releases of **radio-active** materials such as leaks from power stations, or the detonation of nuclear warheads.

*...to the  
human body*

The released chemical usually enters an environmental medium (the **contaminated medium**) - air, water, soil, sediment or food. In the **air**, it may form a gas or vapour cloud or plume, and may rise up and drift away. It may disperse completely or it may fall to earth some distance away, contaminating whatever it lands on. Releases into **water** may seep into the soil and then into the aquifer, into rivers or reservoirs and thus into drinking water. Releases onto the **soil** may be washed by rain or containment water into the aquifer or rivers, or be taken up by crops, grazing animals or passing people. The chemical may also be released onto ready-to-eat food, or onto crops. Sometimes the chemical releases directly onto an object - such as a piece of equipment, or the floor. Very occasionally, the chemical is released directly onto the person or animal. Indeed, it is when the chemical comes into contact with humans or animals, or threatens to do so, that the incident becomes a public health matter. The route that the chemical takes from its release to the human body is known as the **pathway of exposure** (see Appendix G). It enters the body through a **portal of entry**, for example, skin, lungs or digestive tract.

*the chemicals,  
often unknown,  
cause considerable  
public anxiety*

At the time of the release or during the control procedures, chemicals may react to produce thermal or aqueous degradation or reaction **products** which may themselves present greater hazards than the original chemicals. There is often considerable **difficulty in identifying** the chemicals or the toxic products. There is also limited scientific knowledge of the acute and long-term health effects of these products. These uncertainties can become significant psychological and social **stressors** to the exposed and the general public over a substantial period of time. Experience has shown that these stressors may then emerge as problems that are more difficult to manage than the original potential danger from the chemical.

Chemical incidents can occur in **fixed sites**, such as chemical manufacturing sites, storage tanks or laboratories. They may also occur during **transportation**, on roads, rail, pipeline, waterways, sea or air.

*there are many  
types of releases...*

The **release** itself may be **caused by** a leak or spill from a container, the container may break or explode<sup>1</sup>, or the chemical may catch fire. Chemicals may also be released naturally from volcanoes. The factors leading up to the incident, the **contributory**

<sup>1</sup> a particularly dangerous example is the BLEVE (Boiling-Liquid Expanding-Vapour Explosion), when a sealed liquid canister is heated, ruptures and then explodes.

**factors**, include such things as poor maintenance of manufacturing and storage equipment, road traffic accidents, human error, poor weather conditions or terrorism.

The release itself may be **detected** or **silent**. Even if the release is known about, the identity of the **chemical** may be **known** or **unknown**. Different release states and identities have profound effects on the planning and management of incidents. Chemical incidents range from **small releases**, for example a chemical drum being washed ashore to **full-scale major emergencies**, (see Appendix H for examples).

*...affecting a few,  
to thousands of  
people*

From 1993 to 1997, more than **24,000 chemical incidents** were reported to the surveillance system in the United States (ATSDR - which covers 14 of the 54 states of the country). Eighty-five percent involved a single chemical agent, most often a volatile hydrocarbon. In addition, evidence from the UK surveillance system showed that the majority of **these incidents actually presented a threat to the public health** (National Focus Annual Report - 1999).

## Toxic versus physical effects of a chemical incident

Chemical incidents, by the very nature of the way many of them occur, will affect people in a number of ways.

- Effects of explosion. People may be subjected to blast injuries, mechanical trauma, the effects from building and structural damage and collapse, and from loss of housing and shelter.
- Effects of fire. People may be burnt or exposed to smoke and heat inhalation, or suffer from the longer term sequelae.
- Effects of natural disasters. People may be subjected to the suffocating effects of ash, to mudslides and loss of housing and amenities.

These physical effects are often seen in major trauma incidents; and other emergency planning systems have usually already been developed to cope with these. However, it should not be forgotten that during a chemical incident these effects may in fact present more of a health problem than the chemical itself.

- Socio/psychological effects.
- Effects of the toxic nature of chemicals.

This document is concerned with these two aspects.

## What happens at the scene of a typical chemical incident site

When an incident occurs, site employees and some or all of the emergency services usually attend the scene (**the first responders**). If formal co-ordination is required, an **on-site (operational)** command is initiated; this is usually controlled by the fire brigade. If the incident gets larger, or there is threat to life or property or public order, additional **levels of command** are initiated, usually with the police (or military) taking overall control of the management of the incident, at the **off-site**

*there will usually be  
a command and  
control structure*

**tactical** or **strategic** command centre. As many services and agencies as are necessary should be present in the off-site command centre.

*the site is usually divided into areas of increasing risk*

Chemical incidents will present the first responders with **health risks**. These risks may be toxic (from the chemical or its by-products) or physical (such as explosion or building collapse). When the risk of contamination or physical injury is sufficient, **protective equipment** (personal protective equipment (**PPE**) and shields etc.) is used. Depending on the level of risk, risk zones are usually established around the incident. The **hot zone**, bounded by a **hot line**, is the area where first responders must use protective equipment to prevent primary contamination or physical injury. The **warm zone**, which surrounds the hot zone, is the area where appropriate personal protective equipment must be worn to prevent secondary contamination. The **decontamination line** separates the warm zone from the cold zone. Decontamination should be performed across this line. Treatment, support and command facilities are located in the cold zone. (see Appendix F for a diagram)

It may also be necessary to **control access** to the scene of the incident. Public, press, sightseers and residents may try to gain access, putting themselves and others at risk. The first access control line is usually the outer boundary of the cold zone, the **cold line**. Various degrees of access may be imposed the nearer one gets to the incident site.

Some other terms used to describe the various zones are:

- hot zone: exclusion zone, red zone
- warm zone: contamination reduction zone, yellow zone
- cold zone: support zone, green zone.

*Primary and secondary contamination are important problems*

**Casualties** in the hot zone are usually collected by the fire service personnel and transferred across the hot line, through designated **access control points**, to ambulance personnel in the warm zone. Care must be taken to avoid contaminating the ambulance personnel during the transfer. Contaminated casualties should be decontaminated before removal from the warm zone, ideally in specially-designed decontamination units. There should be two decontamination sites, one for casualties, and one for first responders in protective suits. Casualties are often "triaged" before transfer to health care facilities, to identify those casualties that have the most serious injuries and who would benefit most from rapid transfer and treatment.

A **vulnerable zone** (in effect a potential hot zone) can be declared, which is the area likely to be contaminated if the emergency response actions are not successful.

## IPCS definition

The IPCS, following an international meeting of experts, has agreed a definition of an acute chemical incident requiring public health involvement, and four levels. These are:

Chemical Incident	An occurrence of public health concern caused by an acute release of a toxic or potentially toxic agent
Level 1	An acute release with no human exposure
Level 2	An acute release with suspected or actual exposure
Level 3	An acute release where the suspected / actual release is related to ill-health
Level 4	An acute release giving rise to a civil defence or equivalent major emergency.

## Effects on the health of the individual

The effect that a chemical can have on the human body and on the health of the person (the **morbidity**), is determined by a number of factors. These factors are described below, starting with the actual release and working forward to the human body. A brief description of the actual effects is then given.

### Factors affecting toxic outcome

**Pathway of exposure** Once a chemical has been released from its containment, it has to reach the body to have an effect. The route to the body can be varied, and will depend upon the nature of the release, the nature of the chemical, the types of media that are contaminated and their movement, and any preventive or protective measures that might be taken. These factors may well determine the portal of entry. (See Appendix G for a diagram)

*a chemical can be affected by many factors on its journey from the release to the tissues of the body*

**At the portal of entry** The actual route into the body will affect the dose. Chemicals will enter the body through the **skin, eyes, lungs or digestive tract**. The **rate of absorption** through each of these barriers will be different for different chemicals. Absorption will also be affected by the **concentration** of the chemical at the portal of entry, which may change over time, and the **exposure duration** - the length of time that the chemical is in contact with the body, and **air temperature, humidity** and the **person's age** (particularly children).

**In the body** Within the body itself, the effect will depend upon the actual **toxicity** of the chemical and the **biologically effective dose** - the quantity of chemical taken into the target tissue. The way the dose is accumulated in the **target tissue** can make a difference to its impact. Even if the exposure is short, the **peak level** might be high enough to cause toxic effects. Where the exposure is prolonged and

the dose rate low, it may be the total **cumulative dose** that causes toxicity. **Other factors** that may have a bearing on the effect of the chemical are age, gender, immune state, concomitant exposures and general fitness of the person.

### **Toxicological effects**

**Presentation of the effects** When a chemical has a toxic effect on the body, the signs and symptoms may present themselves differently. Every chemical has a particular pattern of injury, with adverse effects concentrated in certain **target organs** or tissues. Effects can be **local**, for example burning or blistering of the skin, eyes or respiratory tract. The effects can also be **systemic**, once the chemical has got into the body fluids. All organs and fluids in the body can be affected.

The **time elapsing** between exposure and the onset of the signs and symptoms can vary. Some effects, for example eye and respiratory irritation or central nervous system depression, can occur rapidly, within minutes or hours of the exposure (**acute effects**). Other effects, for example congenital malformations or cancers, may take months or years to appear (**delayed effects**).

The **duration** of the symptoms can also vary, from **short term**, to long term or **chronic**.

## **Effects on the health of the public**

**Stress and anxiety** The occurrence of major chemical incidents has shaped the way members of the public perceive exposure to chemical substances. Reports of incidents elsewhere, such as those listed in Appendix E, may cause fear and anxiety in populations living close to chemical industries. Such incidents are fear-inducing because they have the potential to cause large numbers of deaths and illness and because they raise questions about the fragilities of technologies over which society and the local community, let alone the individual, have little or no control. Concern is also increasingly being expressed not only by the public, but also by the scientific and medical community, and by pressure groups, that chemical incidents may lead to long-term effects on human health, such as cancers and congenital malformations, and that exposure to chemicals may be giving rise to diseases not hitherto recognised, or exacerbate diseases of another aetiology.

*Chemical incidents  
cause considerable  
public anxiety,*

As a result of these concerns, the public are becoming increasingly aware of all potential environmental hazards. With the inability of the chemical industry or the public health authorities to provide adequate information, the media are starting to quickly and loudly articulate those concerns. Public health authorities are increasingly being faced with problematic assessments of the risk to health and, in the absence of appropriate advice and expertise, are frequently being criticised for their inability to address community concerns.

In most countries, no surveillance systems exist for gathering data on these incidents or for bringing their effects to the attention of governments and thus to policy decision makers. Only a few reports on the management of minor incidents have been published (the selection mechanism often being the amount of media exposure). These have shown that during a chemical incident, the emergency personnel and the public are commonly exposed to chemicals because they are inadequately trained, equipped, or informed.

During an incident, lack of information because of the wish for secrecy, or differing professional opinions may raise public anxiety levels. Occasionally, public anxiety may lead to the mimicking of symptoms.

... morbidity  
and death

**Deaths and illness** Data gathered so far around the world have indicated that chemical incidents exact a high price in terms of deaths and illness. Large incidents are thankfully rare, but they have caused considerable numbers of deaths. Evidence from ATSDR (Jones et al 1993) and from the Welsh survey (Bowen 1999) has also shown that there are very many small chemical incidents that will remain unreported unless a specifically designed and targeted reporting system is in place. The particular concern here is that whilst many people assume that there are little or no public health concerns with these small incidents, the evidence is very much to the contrary. The public is often put at risk from these events, with injuries and deaths occurring, and considerable anxieties raised.

## The costs to society and the economy

There may be significant other effects of the incident upon society. These relate to the:

- Economy - livelihoods, and inward investments
- Opportunity costs - e.g., closures of health care facilities, schools, factories, etc
- Litigation and compensation - the costs of pursuing settlements
- Costs of rehabilitation - return the affected components of the community back to their original states.

# Planning and preparedness

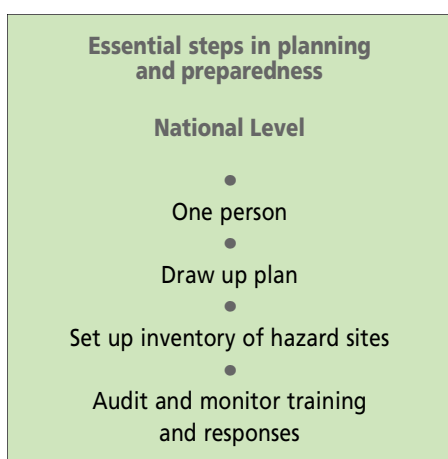
*Having plans ready and rehearsed has been shown to make a major difference to the management and the outcome*

Careful planning and thorough preparedness are prerequisites for an effective response to a chemical incident. At the national level, government needs to set up the procedures and organisations necessary to ensure the effective and comprehensive public health management of any chemical incident. A national plan should be produced, circulated and discussed widely until general agreement has been reached. Resources will need to be found to correct deficits in the national provision. At the local level, public health authorities need to identify the potential situations where chemical incidents could occur, and to assess the likely health risks to exposed people, property and the environment if such incidents were to occur. The public health sector needs to be fully involved in the planning and preparedness process, including emergency plan development and implementation.

## Planning and preparedness at the National Level

The following steps are required to ensure a comprehensive response to any chemical incident:

- Identify a **person** / government department to **take responsibility** for the national co-ordination of the public health management of chemical incidents.
- Identify all the government departments, national bodies and experts with a responsibility and/or **interest** in chemical incidents.
- Make an assessment of the impact of previous chemical incidents on the health of the public and the environment.
- Assess the **risk** of, and likely public health impact of new chemical incidents
- Draw up a **national plan** that
  - sets out the national structures required to ensure an effective local public health response
  - lays down national policies for the public health management of chemical incidents
  - ensures government inter-departmental collaboration and co-ordination
  - ensures cross-border liaison, collaboration and co-ordination with neighbouring countries
  - links to international bodies such as the WHO.
- Establish a national major hazard site **inventory** and enact the legislation required.
- Conduct **exercises** at the national level.
- Allocate the **resources** necessary.
- Set up systems to **monitor**
  - the production of local plans and the efficiency of local exercises
  - the effectiveness of the local response to actual incidents.



# Planning and preparedness at the Local Level

There are a number of procedures and activities that need to be actioned and pursued by local public health / environmental health officials, and these are described below:

1. set up multi-disciplinary public health working arrangements
2. start networking with all interested parties
3. conduct a community risk assessment
4. conduct a baseline health assessment
5. if necessary, conduct a baseline environmental assessment
6. start liaising with the local community
7. draw up a public health chemical incident plan
8. establish access to the variety of information sources, databases and people with expertise
9. assess the comprehensiveness of the local health care facilities
10. pursue measures to reduce the probability of incidents
11. pursue measures to reduce the health effects of incidents.

## 1. Set up multi-disciplinary public health working arrangements

The public health response to a chemical incident should be a multi-disciplinary one, as a wide range of skills and expertise is required (see Table 3). A multi-disciplinary **team** is usually the best way of achieving the various tasks that are necessary, both in the planning phase and during an incident. In addition, if the team has been meeting during the planning phase, then the resulting teamwork during an incident is likely to be greatly enhanced. A team therefore needs to be set up, taking into account the available staff and their skills and training. The team will fulfill all of the functions described below.

The team, and preferably a coordinating **centre**, should be established and if possible **resourced**. The geographical area covered by the team will need to be decided upon, and will depend on the terrain, the population, the types and distribution of chemical industries, the extent of chemical risk, the availability of expertise and resources and the arrangement of other public health chemical incident teams.

Public health services will also be required to respond to other types of incidents, such as infectious disease outbreaks and major disasters such as train crashes. Usually a team structure, with resources, is employed in these circumstances. Where existing structures are in place, it may be efficient to combine or link the several functions. Where these structures are not in place, the need to set up public health chemical incident teams can be a useful spur to the formation of these other structures.

## 2. Start networking

Many people and organisations will be involved in the planning and management phases of chemical incidents (see Table 3). Some will be local, but many will be further

*multidisciplinary team working (and practice) are essential for good public health management*

## 2. Start networking (continued)

afield, and usually only contactable by phone, fax or e-mail. The public health team will need knowledge of these people and organisations, and to have built up good relationships with them, so that during an incident, the maximum help and assistance is speedily obtained. The public health team will therefore need to establish a network of necessary **contacts**. These contacts will need to cover all aspects of chemical incidents, from planning and preparedness, through incident management and long-term follow-up, to audit and evaluation.

**Table 3**  
**People and groups in the public health chemical incident network**

other public health / environmental health 'departments and institutes	central government
medical and environmental toxicologists	major local chemical industries
poisons centres	environmental groups, pressure groups and watchdogs
toxicology laboratories	public and community groups
clinical medical specialists	emergency services
local hospitals	• fire
specialist hospitals	• police
occupational health services	• ambulance
environmental investigation and control	• transport
environmental monitoring and modelling	• emergency medical responders
biological monitoring	specialist environment agencies
health surveillance	• rivers
medical and environmental' epidemiologists	• wildlife
risk assessment, perception and communication	• transport
food safety organisations	• ocean / sea
health planners	• agricultural
emergency planners	• air quality
local government	pollution control agencies
	• factories inspectorates
	weather services

## 3. Conduct a community risk assessment

A community risk assessment is an **assessment of the severity** of the potential effects of a chemical incident in the local area. It is comprised of **four steps**:

- the identification of hazardous chemical sites, pipelines and transport routes
- the identification of possible incident scenarios and their exposure pathways
- the identification of vulnerable populations, facilities and environments, and
- an estimation of the health impact of potential chemical incidents and the requirements for health care facilities.

It is an important early task for the public health multi-disciplinary team.

The community risk assessment is conducted by the public health / environmental health specialists. It is a complex process, and involves a wide range of expertise and agencies. As much of the data required by each agency will overlap with others, a co-ordinated approach to data requests and collection will produce more valid and complete data returns. In addition, the process can be greatly improved by involving members of the public. They will help not only by providing local knowledge, but will also increase understanding and allay anxiety by relaying the methods and findings back to the community. Conducting a community risk assessment develops and strengthens the relationships between the emergency services, the chemical industry, the general public and the public health services. It will also help to identify training requirements.

**Hazardous Sites Assessments** The identification of hazardous sites in the local community is an important means of recognising possible emergency situations. Once identified, it may be possible to check the availability of appropriate expertise, site emergency plans, materials, decontamination equipment, antidotes, and site evacuation procedures. There are however, no generally accepted guidelines for doing this, and it will be best to pool ideas and experience from all members of the team.

*identify high risk sites*

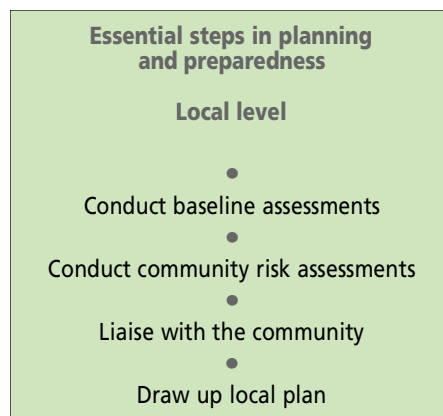


Ideally a local inventory should be collated. However, this will need to be kept up-to-date, and mechanisms need to be introduced to enable reporting of changes and to administer the register. Chemicals may change quite frequently, for example seasonal chemicals such as fertilizers, swimming pool disinfectants and fireworks.

There are a number of ways in which hazardous sites can be **identified**:

- **National hazard inventory.** If a national hazard inventory already exists (such as that based on the European Seveso II Directive), it should be searched for hazardous chemicals or hazardous sites in the local community. Depending upon the number of hazardous sites, the team may wish to prioritise the local list in order to cope rationally with the workload.

- **Direct local enquiry.** The people with the greatest amount of information about the types of chemicals present are the site operators themselves; and it would seem perfectly reasonable to request information about stored chemicals from them. Experience in many countries is that this is regarded as commercially confidential information, and is not given out. However, it is to hoped that a more



### 3. Conduct a community risk assessment (continued)

ethical and community sensitive attitude may develop which would enable the release of this information.

- **Planning enquiries.** Typically, local planning regulations in many countries will require companies to draw up plans for buildings and sites that describe their use. Frequently they are put into the public domain, and are sometimes presented for formal public consultation. Depending on local arrangements, it may be possible for the local authority to search their records to provide details of chemical sites, or even of the chemicals to be manufactured.
- **Local incident surveillance and environmental monitoring.** Monitoring systems set up to detect the occurrence of incidents or changes in the background environmental level of chemicals may indicate the types of chemicals being stored or used at sites.

It should also be remembered that sites include not only **fixed sites** but also **transport** routes including pipelines, and **waste disposal sites**. Chemical sites may be in danger from **terrorist attack** on the site itself, as well as from being near to other terrorist strategic sites, such as armed forces bases or significant civil buildings.

**Develop likely / possible incident scenarios** For each site identified, it will be necessary to identify the chemicals present (current and planned) and to develop scenarios of possible releases for each one.

**Map out the exposure pathways** For each site and substance, the vulnerable zone - the area to which the contaminants might be transported through air or water - is estimated. This can often be done using computer models. It requires a thorough knowledge of the topography of the area, the waterways, reservoirs and prevailing climate. A map can then be produced of the vulnerable zones.

*predict where released chemicals might travel to, and identify vulnerable sites*

**Community vulnerability assessments** The populations within the vulnerable zone that could be affected are then identified, with an emphasis on any especially **vulnerable groups** (children in schools, the elderly in residential facilities, hospital patients etc). It should be remembered that the population includes the **resident** population as well as the **working** population (in the plant and in the area), and other populations in the area at certain times, such as motorists, **tourists** and visitors to entertainment facilities. Factors that affect the vulnerability include the amount and quality of shelter, the access into and out of the site and the amount of training provided.

Facilities and **structures** in and around the vulnerable zone that provide essential services (e.g. hospitals) and which could be disabled by an incident are also identified. Areas where contamination would have **significant effects** such as farmland, water for leisure activities or wildlife support, areas for special conservation or with

### 3. Conduct a community risk assessment (continued)

endangered species should be considered.

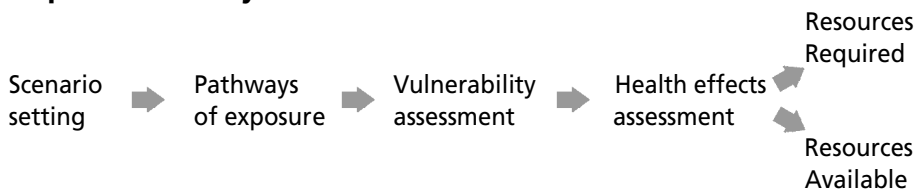
Assessing the vulnerability around chemical transport routes will present greater difficulties. However, it should be remembered that highly toxic chemicals are often transported by rail, which by its nature, passes through densely populated areas, and by inland waterways.

**Health impact assessment** This brings together the evidence from the exposure pathway and vulnerability stages to calculate the **casualties** - the number and distribution, the type and severity of the injuries; any **evacuation** and **sheltering** required, the **delayed effects** of acute exposure: the effects of **secondary contamination**. Air dispersion modelling programmes may be used during this process (e.g. the ALOHA programme).

*determine the ability of the local health care facilities to cope*

**Resource requirements** Given the quantity and quality of the health effects, it will then be necessary to translate these health effects into health care resources required. These requirements are then compared against the health care resources available. The team evaluates the capabilities of the health care sector, the emergency services and the public to respond to (or prevent) potential incidents based on current resources, legal safeguards, and existing plans, training, and procedures.

#### Steps in community risk assessment



An important point to determine is the 'saturation point' of the local health care facilities, so as to determine when to call in additional help, or refer patients to facilities out of the area. There are two ways of doing this: calculate the type and number of casualties that the local health care services could cope with, and apply this to the various scenarios to ascertain those that would breach them and those that would not. The second way is to work forwards from each scenario, and calculate the exact numbers of casualties. Total requirements can then be estimated, and links established with services in other areas. These estimates are by their nature imprecise.

The health impact assessment brings all these assessments together to make a final estimate of the impact of a release of the chemical on the health of the population, wildlife, environment and facilities. More quantitative methods can be used if resources are available (Risk Analysis, Emergency Management Institute, National Emergency Training Centre Student Manual SM 305.3, Washington DC USA, September 1990).

Initiatives to reduce both the risk of an incident occurring, and the vulnerability of the population are then undertaken.

## 4. Conduct baseline health assessment

To measure the impact on health (morbidity and mortality) that a chemical release has caused, it is necessary to know the background levels of illness in the community before the release. Of course, levels of morbidity and mortality can change over time. The purpose of the baseline measure is to **set up the systems**, and to **check** whether the levels are **normal** or indicate that there are already **chemical-related health effects**. There are two sorts of background levels that can be measured.

**General health statistics** With the huge number of chemicals being produced, the range of potential symptoms that could be produced is very wide. Therefore as wide a range of **morbidity and mortality statistics** should be accessed and reproduced as possible. The data should include process data, such as general practitioner visits and hospital admissions, morbidity data such as condition specific hospital admission rates, congenital malformation rates, and cancer registration rates, and mortality data.

In most countries, the health statistics will cover populations greater than that likely to be affected by a chemical incident, or with different geographical boundaries. This can make it more difficult to identify any changes in the health of the affected population. To increase the power of any epidemiological study to detect changes in the health of affected people, routine data should ideally be collected from **populations around the chemical sites**. However, this can be very expensive, and is usually impractical. Nevertheless, for very high risk sites, it may be worthwhile.

*It is very helpful if the background levels of illness are measured regularly*

If routine statistics are not available to produce a baseline measure, consideration should be given to conducting a one-off **survey**. Again, the resources required to do this will need to be found.

*Changes following a chemical incident are more easily identified*

In addition, it would be very valuable if **baseline** measurements of chemical **biomarkers** can be taken from the first responders. This is because they are the group of people at most long-term risk of exposure. Ideally, these measures should be conducted by the occupational health services. It is reasonable to freeze the samples and only analyse them after an incident, together with a post-incident sample. This improves the accuracy.

**Sentinel health events** A sentinel health event is a preventable disease, disability, or untimely death whose occurrence serves as a warning signal that a hazardous environmental exposure may have occurred.

A sentinel health event system uses many of the same datasets as the more general surveillance systems described above, but focuses more specifically on a limited

number of priority diseases and conditions.

All these diseases and conditions are sufficiently rare and sufficiently specific that they suggest exposure to hazardous levels of a contaminant and a need for control or further study. Because they are based on the International Classification of Diseases (ICD) codes, the conditions can be monitored using death certificates or hospital discharge data.

Sentinel health events include both acute conditions reported for individuals (**Type 1**), and unusual health patterns seen in populations (**Type 2**). For the second category, individual case reports are not considered to be sentinel events because the conditions are insufficiently specific. However, statistically significant excesses of cases in populations over defined periods of time, or space-time clusters, suggest the possibility of an environmental aetiology. In addition, unusual patterns in particular populations, such as the young, population unexposed to other known risks, or genetically unrelated individuals living in the same place, may suggest a need for further examination of the data.

*it can be helpful to collect data about certain chemical-related illnesses*



#### **Type 1** sentinel health events: conditions reported for **individual patients**

- poisoning with metals, pesticides, lead, and carbon monoxide. Clinical poisoning reports, and biomarkers of exposure (bone or blood leads above certain levels) or effect (cholinesterase inhibition)
- cancers specific to physical or chemical agents, such as mesothelioma, clear cell cancer of the vagina, and angiosarcoma of the liver
- precocious puberty - a rare event warranting inquiring into oestrogen exposure possibly associated with pesticides, industrial chemicals, or food additives
- certain blood disorders - methaemaglobinaemia
- certain neurological disorders - toxic neuropathies.

#### **Type 2** sentinel health events: unusual health patterns in a **population**

- Bladder cancer in the young, in non-smokers, in humans and their pets, in a spatial cluster
- Lung cancer in non-smokers
- Primary liver cancer in non-drinkers without known exposure to hepatitis B
- Multiple, excess occurrences of other rare cancers (rhabdomyosarcoma, myelogenous leukaemia, acute leukaemia in children, acute granulocytic leukaemia in adults)
- New asthma in low-risk, non-allergic children in non-smoking households (but specificity is low)
- New diseases.

## 5. Conduct baseline environmental assessment

*collecting regular samples from targeted areas for background measurement can be very helpful*

It is just as important to know the baseline levels of chemicals in the environment before an incident occurs. Air, water, soil, sediment and food in the vicinity of chemical plants should be sampled for the full range of chemicals, or their by-products, being manufactured, used or stored. Priority areas may need to be selected from the community risk assessment, and those areas targeted. It may be helpful, for a complete environmental assessment, to predict the levels of environmental contamination from a variety of likely release scenarios. There are various computer dispersion models available for this purpose; although many of the models are unable to adequately to take account of all the relevant variables.

## 6. Start liaising with the local community

*involving the public and local community into the planning systems has many benefits*

The local community is comprised of people who live and work in the area that could be affected by a chemical release. It is for their protection that all these measures are being taken. It is proper therefore that the local community is not only informed about the preparations, but is also involved in drawing them up. Community members who do help with these preparations must be seen to be truly representing their local community. Once an incident has occurred, there need to be robust public warning systems for informing the public of the incident and any protective measures that they should be taking.

Liaison itself should not be seen as a one-way process into the local community. It should be seen as a **three-way exchange**, - between the local community, the public services and the local chemical industry.

Some of the **methods** used to liaise with the public are described below. It will be appropriate for some of these meetings with the public to be with the chemical industry alone, with the public services alone, or with both parties.

*there are many ways of doing this*

**Large public meetings** These are the commonest and most familiar way of initiating face-to-face discussions with the public. Whilst this may be one of the most expedient ways of interacting with the largest possible number of concerned people at one time, it is often one of the least effective ways to institute a dialogue. However, public meetings can be beneficial if the hosting officials are skilled in risk communication and work to avoid negative outcomes.

**Public availability sessions** Informal, one-on-one communication has been shown to be perhaps the most effective way to discuss health risk issues. Although very time consuming and resource intensive, a personal and confidential discussion between a concerned individual or family and a public health / environmental health professional seems to reduce many of the barriers to communication described above.

One way to facilitate such one-on-one communications is through public availability

sessions. These sessions are hosted by public health agencies in the local community; experts are available to talk with all interested individuals either by appointment or on a first-come, first-served basis. The sessions need to be well publicised in advance and staffed by health professionals skilled in risk communication and knowledgeable about the local risks. The health professional should be conversant with the health effects of the chemical(s) and able to assess the potential harm.

**Community Advisory Panels** There is a growing recognition in many countries that to achieve an effective, long-term solution to the public health impact of chemical incidents, residents must be an integral part of the decision-making. Experience has shown that a good compromise between one-on-one communication and large public meetings is the establishment of Community Advisory Panels (CAPs). These panels provide the opportunity for an effective **dialogue** between community representatives and environmental / health officials and chemical industry representatives. The panels also help ensure continuity over a period of months or years, and the opportunity for mutual education.



In the United States, CAPs have proved to be an effective mechanism for government agencies to:

- obtain information about the health concerns of the community
- establish open and ongoing communication
- convey information about government-sponsored health activities as they occur
- educate the community about the scientific process and educate government health officials about the site in question
- reach agreement on the measures to be implemented.

CAPs typically **comprise** 12 to 15 community representatives, chosen either by self nomination or by community organisations. The panels, whose members represent the widest possible spectrum of community interests, usually meet every 3 months in a public forum. Rules regarding the conduct of meetings and issues to be covered are agreed upon at the outset and enforced throughout the process.

**Public Warning Systems** Some countries and towns have set up a public warning system where, for example, a siren is sounded and the public listen in to the radio for information and instructions. The public will need training and updating in the process. However, it can be very effective in high priority areas.

**Other Mechanisms for Public Interaction** There is a variety of other ways for government officials and the chemical industry to interact with people living in

environmentally threatened communities threatened by chemical incidents.

Site visits can help the community to appreciate the measures taken by the industry to protect the workers and the public. This can help reduce anxiety and build trust and confidence.

Mass **mailings** are an efficient way to notify residents of a concerned community about new scientific findings, planned activities, or upcoming meetings. Mailings are most effective when they are done in a one-page, "fact sheet" format with bulleted information. Information sheets will also be helpful in providing information about the priority sites and their chemicals, warning formats and protective actions to be taken.

**Other mechanisms** These include telephone help-lines, drop-in centres, and public training sessions. Radio and television can be very important and effective mechanisms, depending on local availability. However, it is essential that before any incident occurs, a policy is developed and followed, and that relationships with the media are developed and well maintained; and that during an incident, appearances on radio and television are restricted to a few, trained and experienced people.

## 7. Draw up a public health chemical incident plan

The management of a major incident is a complex affair which requires the input from a wide variety of organisations and agencies. These inputs should be timely and correct. If not, the outcome can become considerably worse. Planning (and rehearsals) help to ensure that people have developed, understood and learned their roles before any incident. **Plans** are an up-dateable record of those roles - a 'living' document.

*a well developed plan needs all the relevant parties to come together*

The planning for major incidents and disasters has been comprehensively developed throughout much of the world. In most places, there will be a general plan covering major incidents and disasters. In addition, there will often be a general plan covering the roles of the emergency services in chemical incidents. There will also usually be major incident plans in the hospitals, covering most types of incidents. However, public health plans to deal with chemical incidents are usually non-existent or poorly developed.

Before starting the process of producing a public health chemical incident plan, a decision needs to be taken as to where the plan will 'sit':

- stand alone
- integrated into a public health outbreak plan, covering food poisoning and infectious diseases
- integrated into the emergency services chemical incident plan
- integrated into the emergency services major incident plan.

Whichever is chosen, care must be taken to ensure that the plan is co-ordinated with the other relevant but un-integrated plans.

The public health chemical incident plan will need to cope with **four different scenarios**:

- a **detected** release of a **known** chemical from a **fixed** site - this will usually be from a registered hazardous site
- a detected release of a known chemical from a **non-fixed** site - such as from a well-labelled road tanker
- a detected release of an **unknown** chemical - typically, this will occur in releases from sites not on the hazardous site inventory, or with unknown combustion products from a chemical fire
- a **silent** release, where the release is unknown or was thought to be harmless, but is now suspected from other routes.

The four planning scenarios	
<b>1</b>	Detected release, known chemical, fixed site
<b>2</b>	Detected release, known chemical, moving site
<b>3</b>	Detected release, unknown chemical
<b>4</b>	Silent release, but suspected.

Plans should be developed in close co-operation with and with input from all the agencies, specialists, communities, commercial sectors and other authorities that the public health / environmental health professionals will need to interact with during an incident. The plans will also be significantly improved if relevant members of the local community are involve throughout the process. Templates of plans which have been developed and tested are readily available via the Internet. Extensive evaluation of the plan and its implementation should be carried out after every incident or training exercise.

## 8. Establish access to information, databases and expertise

At the time of an incident, it is vital to have rapid access to data about the chemical. It is important therefore that the **chemical databases** are purchased and installed, or 24 hour electronic access established well before. The data needed will include information about:

- the physical characteristics of the chemical (this influences the way it disperses in the environment and how it enters the body)
- the biological tests available to detect exposure and/or adverse health effects
- environmental sampling techniques and equipment needed
- lists of antidotes and decontamination procedures
- medical signs and symptoms and methods of treatment.

*ways of getting hold of information need to be set up*

People with expertise in these aspects may well be needed to supplement the information from the databases. Poisons centres are an excellent source of information. Contact is much better made before the incident, and this has been described above.

## 9. Assess the comprehensiveness of health care facilities

The availability of **adequate local health care facilities**, including toxicological laboratories, and adequately trained health care staff are very important for the successful care and treatment of casualties following an incident. Facilities need to be assessed for their numbers, medical equipment, decontamination equipment, drugs and antidotes, and training.

*the adequacy of the local health care facilities needs checking* Where the injuries involve burns or severe toxic symptoms, the local health care facilities can rapidly be overwhelmed by even a small number of casualties. Access to facilities in **neighbouring districts** or further afield will then be necessary. Identifying where those facilities are is an important step in the planning and preparedness phase.

An alerting mechanism (to the occurrence of an incident) needs to be developed and regularly tested.

## 10. Pursue measures to reduce the probability of incidents

The community risk assessment may have identified sites and procedures where improvements might lessen the probability of an incident occurring. Often, some of these improvements can only be done by the company producing, storing or transporting the chemical, and it may require a multi-agency team to negotiate these changes.

*preventive and protective measures should be put in place* Examples of common improvements are:

- an onsite chemical emergency plan coordinated with the local chemical incident plans
- clear procedures for off-site personnel making deliveries to a site
- additional training for workers in on-site hazards and routine safety procedures
- backup systems for evenings / weekends / holidays
- regular monitoring of contaminant levels from planned processing or releases
- regular surveillance and standardised reporting of incidents
- improved procedures for product or waste release, or waste product containment
- improved specifications for vehicles carrying hazardous substances.

## 11. Pursue measures to reduce the health effects of incidents

As well as measures to reduce the probability of an incident occurring, there are other preventive measures that can be put in place that will reduce the impact of the chemical on the people and the environment, should a chemical actually be released.

Examples of common improvements are:

- locating chemical sites away from centres of population
- registration of all chemicals in commercial establishments with the hazard inventory to ensure rapid identification of the released chemical

- regular evaluation of plans and their implementation
- storage of lesser amounts of chemicals
- smaller batch processing
- good quality labelling of all chemicals in transit
- rapid notification of the chemical incident emergency services in the event of an incident
- regular surveillance and standardised reporting of incidents, including the small “routine” ones
- measures to decontaminate land or water already contaminated by waste disposal, and to protect the public by education and other means
- measures to prevent or contain fire-water run-off
- introduction of separate drainage ditches or holding tanks to contain leaked liquid chemicals.

## Routine activities

Once the plans and assessments have been completed and put in place, there are certain routine procedures that need to be gone through on a regular or continuous basis.

These are:

- Recognising chemical incidents
- Conducting population health surveillance
- Conducting environmental monitoring
- Conducting exercises and training
- Conducting national incident surveillance and contributing to international incident surveillance

### Recognising chemical incidents

Although a few chemical incidents are major ones, and the event is self-evident, most acute chemical incidents are small-to-medium events, that only the polluter, and anyone directly involved, initially knows about. The polluter may not inform the emergency or public health services. This will most likely be because the polluter feels that the incident can be handled without outside assistance, and that the incident is not believed to pose any (appreciable) risks outside the facility (on the basis of a rapid initial assessment). Other reasons may include the polluter’s wish not to be identified, or because they do not appreciate (or care about) the personal or public health implications. Indeed, the emergency services do not always appreciate the possible public health implications.

*releases occur in different ways and can be difficult to detect*

Therefore, and in order for the public health / environmental health professionals to be able to help reduce the public health consequences of all acute chemical incidents, they need to set up **systems** that will **detect** the release of the chemicals. Once detected, the public health / environmental health professionals will need to rapidly

*various alerting mechanisms need to be set up*

assess, judge or estimate whether there is then a risk to the public's health.

Detection can occur in seven ways -

1. the polluter **informs** the emergency services who inform the public health services. In some cities, a mandatory notification system (of all releases) has been established
2. **observation** of a release itself - often as a major event, such as an explosion or oil tanker disaster
3. **information** from the public about an **environmental change** eg colour, smell, eye irritation
4. **ad hoc** observation of a **rise** in an environmental **contaminant**
5. observation of a rise in an environmental contaminant using routine monitoring environmental data
6. **hunches** from clinicians and others (e.g. poisons information centres) who are presented with a sudden rise in an unusual health problem
7. observation of a rise in a sentinel health event or other health measure, using **routine monitoring health** data

#### Seven detection methods

- 1  
polluter informs
  - 2  
direct observation
  - 3  
\*non-specific changes -colour, smell
  - 4  
\*rise in environmental pollutant level
  - 5  
\*rise in routine environmental monitoring levels
  - 6  
\*clinical hunches
  - 7  
\*rise in routine health monitoring levels
- \*requires public health activity to set up alerting systems

#### Toxicovigilance

Most of these methods require members of the community to become more aware of the possibility of a chemical incident and then to know what to do if their suspicions are raised. This 'toxicovigilance' has to be developed and encouraged in a wide variety of people and organisations, such as accident and emergency staff, primary care doctors and nurses, infectious diseases doctors and community investigators (because chemical incidents can mimic outbreaks of infectious diseases), poisons information centres, epidemiologists and public health / environmental health institutions, and other groups receiving reports of potentially toxic events. Members of the chemical industry need to be encouraged to report all acute chemical incidents, however small.

Once a suspicion has been raised, the person needs a quick and easy route to alert the emergency services and the public health chemical incident

management team. A toxicovigilance programme therefore requires:

- The public, local institutions and organisations, and all members of the emergency, environmental and health services to be regularly encouraged to **be alert** to the possibility of chemical incidents, and to be educated on the means of communicating rapidly with the emergency services and the public health

- chemical incident management team
- A well-publicised, twenty four hour incident **telephone line**, and a network co-ordinator always available
- A **surveillance and monitoring system**.

## Conducting population health surveillance

Once the baseline health assessment has been completed, routine surveillance needs to be established. Routine population health surveillance is the ongoing and systematic collection, analysis and interpretation of health data in order to:

- **identify a health event** that may be related to an unknown, acute release of a chemical
- monitor **trends** in the different types of health status
- **stimulate** epidemiological **research** likely to lead to control or prevention
- permit **assessment** of the effects of **control measures**

The same set-up for health surveillance will be required as for the baseline health assessment, that is access to regularly updated general health statistics and to regularly updated sentinel health events. There are certain **attributes** that any surveillance system should fulfill:

- Simplicity
- Flexibility
- Acceptability
- Sensitivity
- Predictive Positive Value
- Representativeness
- Timeliness.

The essential features of each system are described below.

### General health statistics

Data from a wide variety of routine sources need to be collected, collated and presented in a way that allows trends and comparisons to be made. This implies that the data are reasonably accurate, comprehensive, up-to-date and easily accessible. The common sources of data are:

**Censuses** Definition of the population is essential for calculating incidence rates and exposure rates. National censuses are carried out at regular intervals in most countries, but rapid population movements, and variable birth and death rates will seriously affect the accuracy of population estimates.

**Mortality Statistics** Most countries will have systems for registering deaths, usually with information about cause of death. Coding deaths using the International

*routine collection of health data helps in identifying trends and incidents, stimulating research, and auditing control measures*



Classification of Diseases (ICD) will allow standardisation of the data, better training of the coders, and may allow international comparison. However, inaccuracies in the data sets may occur at any step in the chain of procedures leading to the production of mortality statistics. These steps range from the making of a clinical diagnosis and the completion of a death certificate, through the transcription of this information on to the death notification together with its classification and coding, to the processing, analysis, and interpretation of the statistics produced.

**Hospital Admission Data** In many countries, this will be the main source of information about illness and disability. Usually, however, the data about patients are not related to geographical areas. For conditions of particular concern, the population admission rates will need to be calculated by searching the records of all the hospitals that the patients might have been admitted to.

**Data from outpatient services**, private practice, accident and emergency care and other primary care facilities. The data available from these sources will be variable between countries and may well be variable within countries. It will be important to set up links with these facilities, such that in the event of a chemical incident, rapid contact can be made to ascertain numbers attending for primary care.

*there are a standard set of data-bases that can help provide our data*

**Cancer Registration** Cancer registries have been useful in identifying spatial and temporal clusters of cancers and sometimes in allaying public fears about the existence of clusters surrounding chemical plants.

However, there are significant problems in using cancer as a potential end point for environmental health assessments. There is a long latency between exposure and disease onset, and this is usually compounded by the lack of accurate information on exposures of cancer cases. Exposed cohorts may be difficult to follow up for 30 years or more. Some countries have 'flagged' other total population registers, to keep track of deaths and illness. Cancer data have been useful for assessing chronic exposures but their usefulness in identifying acute exposures has yet to be proved. Methodologies for handling enquiries about possible clusters have been developed by cancer registries.

**Congenital Malformations** Population based registries have been set up in some countries both for research into the cause of congenital malformations and to detect changes in the frequency of different classes of disorder. Experience in the use of these registries however has shown that recognition and registration of the malformations is quite a slow process, and it is not feasible to use them to identify chemical incidents. Congenital malformations registers however may be more useful for prospective assessment of the population health effects after known incidents of exposure. It will be necessary to link new entries onto the congenital malformation register with the cohort of exposed people.

## Sentinel health events

A sentinel health event is a preventable disease, disability, or untimely death whose occurrence serves as a warning signal that a hazardous environmental exposure may have occurred. In health surveillance, the main purpose of monitoring sentinel health events is to identify chemical releases that have gone unreported or unnoticed, or where releases have been thought to be harmless. Once identified, the sentinel health event is useful for showing the need for (1) further epidemiological or environmental studies, (2) engineering or other control measures to eliminate a hazardous environmental pathway, (3) preventive measures to reduce the potential of a particular class of incident, and (4) preventive care and treatment for the sentinel individuals and others.

Public health chemical incident management teams can work with communities to identify diseases associated with priority chemicals in the area and to examine the feasibility and importance of setting up such sentinel systems before an incident has occurred. Once the incident has occurred, specific clinical reporting systems for sentinel health events can be set up around sites of contamination or at regional or national level using routine reporting systems such as death certificates or cancer registers.

However, there are problems in running a population health surveillance system, depending on the country in question, such as too little data, inaccurate data, uncollated data, insufficient resources, confidentiality and the diverse and often conflicting interests of the different reporting agencies.

## Conducting environmental monitoring

Monitoring of environmental chemicals is important for a number of reasons:

- to provide data on background levels of environmental chemicals
- to demonstrate any normal variation in those levels
- to act as a warning when a sudden rise is detected
- to enable comparison with levels after any chemical incident, and
- to determine when restoration to previous levels is complete.

Air, water and soil in the vicinity of chemical plants should be monitored for the range of chemicals being manufactured, used or stored.

The **general principle** underlying routine environmental monitoring is to ensure that, at the time of an incident, any available background **levels** of contaminants are **valid**. To enable this to happen, the samples will need to be **refreshed** on a regular basis.

The refreshment rate depends on the anticipated fluctuations of the contaminant in the local environment.

*regular  
environmental  
sampling is also  
very helpful*

*collection and analysis is more expensive than collection and storage*

**Analysis strategy.** Two strategies are possible in analysing samples to ensure that they are valid at the time of an incident.

1. Analyse all the samples at the time of each refreshment for the full range of contaminants that might be encountered in a local incident. Costs will be high, but data will be available for other purposes.
2. Store samples, and only analyse them at the time of an incident for those contaminants that are of interest. Practical problems of storage will need to be sorted out, but costs should be lower.

## Conducting exercises and training

Training and education play an important part in preparedness and response to chemical incidents. The emergency services, as well as other health professionals and employees at local chemical plants, etc. need to train their own personnel to properly manage occurrences that might grow to become chemical incidents, as well as the chemical incident itself, to understand the responsibilities of other professionals and to minimise the risks to the workers and members of the public. The separate agencies also need to contribute to the training of others. **Shared training** experiences can help to facilitate communication between various agencies during an emergency.

*regular exercises and training are essential in developing good working relationships and in testing the validity of the plans*

It is important that all those with specific responsibilities in chemical emergency response should receive joint theoretical and practical training in the use and implementation of jointly agreed emergency response plans. This will enable them to become familiar with taking part in a broad co-operative effort to respond to a chemical incident. It is of great importance that those with responsibilities in the event of a chemical incident are **familiar** with one another's **remits**, accept the necessity of the other parties as a part of the emergency management team, appreciate the other parties' roles and responsibilities and the difficulties in executing them, and are thus used to working effectively with one another. Training and simulation exercises can facilitate this process.

Other public health tasks can also provide an opportunity for working together, for becoming familiar with the background information and for practising assessment skills in a non-crisis situation. Community risk assessment should be an opportunity for those with little experience in epidemiology, toxicology, and environmental assessment to assist expert colleagues, helping them to understand aspects of chemical work with which they are unfamiliar. Other public health functions, such as the setting up of a surveillance system, should also provide training opportunities.

### Core training

Core training for the response team is an important mechanism for all the agencies' staff to get a good understanding of their own and others' needs. Public health elements that should be included in the core training are:

- Risk and exposure assessment
- Epidemiology and toxicology
- Emergency actions and procedures to reduce risk to responders and public
- The use of protective equipment
- Shelter and protective measures and procedures
- Biological and environmental sampling
- The key components of a major chemical hazard control system
- Risk communication techniques
- Regular exercises.

Agency staff will require specialist training to a higher level in the relevant core areas. Countries will need to review how to establish access to comprehensive training for all relevant public health / environmental health professionals. This could be organised through public health training centres, the poisons information centres, the national information and advisory centres or the local response units (see Part 3).

It has been clearly demonstrated that the effectiveness of theoretical training can be maximised by the use of exercises. **Exercises** are generally classified in three major categories: tabletop, functional, and full-scale simulations. Individual agencies may also consider holding preliminary orientation exercises to introduce participants to their responsibilities under the chemical incident plan, and to prepare them for the exercise process.

#### **Orientation Exercises** (single discipline)

An orientation exercise **acquaints staff** with policies and procedures in the chemical incident plan, providing a general overview of its provisions. It is especially effective in ensuring that personnel understand their roles and responsibilities and how to access background information and specialist advice. It also helps to clarify any complex or sensitive plan elements. The orientation exercise does not generally involve any direct simulation, but is used to review plan procedures and informally apply them to potential emergency situations, preferably those involving local priority sites and priority chemicals. The plan can also be applied to past events known to the team.

#### **Tabletop exercises**

A tabletop exercise is a more formally structured learning situation, and often involves more than one sector with responsibilities under the chemical incident plan. Prepared situations and problems are combined with role-playing to generate discussion of the plan, its procedures, the resources that can be called on, and the policies to be adhered to when making decisions. Tabletop exercises are a good method of familiarising individuals and groups with their roles and demonstrating proper coordination. They provide a good environment to reinforce the logic and content of the plan and to integrate new principles into the decision making process. Participants are encouraged to act out critical steps, recognise difficulties, use the

*there are a number of proven multi-disciplinary training methods available*

expertise of the other sectors represented, and resolve problems. Tabletop exercises usually last two to four hours and require specially trained facilitators.

### Functional Exercises

A functional exercise is an emergency simulation designed to provide training and evaluation of integrated emergency operations and management. More complex than a tabletop exercise, it focuses on **full scale interaction of decision-making** and agency coordination involving a typical incident coordinating centre. All field operations are simulated; information about activity is transmitted using actual communications equipment, including radio and telephone. It permits decision makers, off-site incident coordinators, onsite incident managers, coordination and operations personnel to practise emergency response management in a realistic situation with time constraints and stress. It generally includes several organisations and agencies practising interaction of a series of emergency functions, such as initial information gathering from the incident hotline, deciding the make-up of the core team, direction

and control off-site and communications to be made to those on-site, and access to and mobilisation of databases and specialists to provide advice, public warnings, and decisions on evacuation.

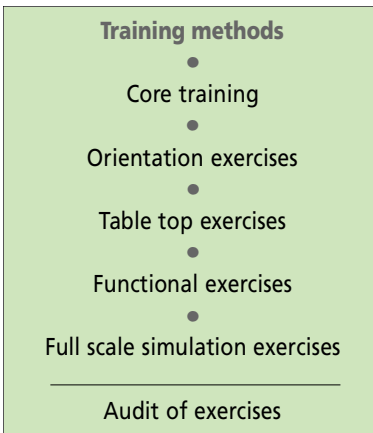
### Full-scale Simulation Exercises

A simulation exercise focuses on several components of an incident response and management system simultaneously. It exercises the interactive elements of a community emergency programme in a similar fashion to the functional exercise, but with a **field component added**. A detailed scenario and simulation are used to approximate an emergency which provides onsite direction and operations, and also includes coordination and policy making roles at the off-site incident coordinating centre. Direction and control, mobilisation of resources, communications, assessment, decontamination, treatment and triage, and other special functions are commonly exercised.

### Outcome of exercises

An **audit** of the various exercises will enable the chemical incident plan to be updated and improved, and for training requirements to be identified. Any audit should cover the following three areas at least:

- Plans - did the plans work, and are there any improvements to be made?
- Teamwork - how did the individual team members act in the group, and interact with each other?
- Decisions - did the team reach the right conclusions and make the right recommendations in the light of the available data?



*further  
exercise  
and  
training  
methods*

## Conducting national chemical incident surveillance and contributing to international chemical incident surveillance

Important public health lessons can be learned from an analysis of an actual incident and any epidemiological study conducted following it. In the same way, important lessons can be learned from accumulating data about the range of incidents that occur within a country and around the world.

These data should make it possible to:

- **detect trends** in the occurrence of different types of chemicals commonly involved in incidents
- provide **estimates** of the **magnitude** of morbidity and mortality related to the chemical incidents under surveillance
- **stimulate** epidemiological **research** likely to lead to control or prevention
- **identify risk factors** associated with the occurrence of chemical incidents
- permit **assessment** of the effects of **control measures**
- lead to improvements in practice by the health and environment officials who are the constituents of the surveillance system
- perform analyses to pinpoint additional expertise, training, resources, and facilities needed to deal with incidents in the area
- at the international level, stimulate governments to initiate proper incident control mechanisms.

*surveillance should also be conducted at the national level*



## Helping to deal with incidents

In any chemical incident, there are a number of essential steps that public health / environmental health professionals have to go through as part of the chemical incident / major incident plan. These are described below, in an approximate chronological order.

### Activating the public health management and control team

Once informed of the incident, it is important to get the control team together as soon as possible. The team needs to gather as much information as possible in the early stages so as to make a decision that the public have been put at risk.

*activate the team*

### Advising and alerting the health care services

Public health / environmental health professionals are in a good position to be able to assess the extent of the casualties and to alert and activate the local and further-afield health care facilities. This will involve providing **accident and emergency departments** with information about the nature of the chemical(s), any precautions

*alert the  
healthcare services*

to be taken, and information about secondary contamination and how to decontaminate casualties, staff and equipment if necessary. If the number of casualties is likely to prove too great for the receiving hospital, secondary and tertiary care facilities **further afield** will need to be alerted and given the same information. Procedures will need to be set up to give public health professionals this type of information.

## Best outcome assessment / estimation

Once a chemical incident has occurred, there are a number of courses of action (**management options**) that can be taken at different points in the sequence of events. A management option can be any choice available to the emergency responders or the public health / environmental health professionals. These might include options such as extinguishing a fire or letting it burn out, whether to use a chemical dispersant, and what type, in an oil spill, or whether to evacuate the people from an area or recommend sheltering.

*work out the  
best option  
to achieve  
the best  
public health  
outcome*

Each of these management options may end up with a different outcome on the health of the public, the responders, and the environment. First responders will be primarily concerned with saving lives and dealing with the incident, whilst hospital doctors will be dealing with the casualties, and neither will be able to view the incident from a distance or in the long term. The function of the public health team is to try to work out the management option that arrives at the **best outcome** for the health of the public, and the environment.

The accuracy with which the public health team can do this will depend on the amount of information and data that arrives from the incident site, and the amount of time available before a decision is required. However attempting to determine the best outcome should always be the principle focus of public health thinking.

A **simple schema** has been drawn up to help achieve this (Table 4). The schema needs to be kept '**live**' throughout the management of the incident, as more data and options arrive. The schema will also prove helpful in the audit process, in attempting to ascertain whether the best decisions and advice were arrived at and given.

For each option, it is necessary to describe the:

- hazard
- exposure pathway (including air dispersion modelling results)
- portal of entry
- actual/likely exposure dose - primary and secondary
- actual/likely effect - numbers of people, type and severity of effects, acute and delayed on the population and the environment.

In particular, data will be needed from local environmental sampling, weather

forecasters and environmental modellers to predict the likely distribution of the chemical in the area to calculate the exposure pathways. At an appropriate point, the options are compared, a decision taken and the action required passed on to the first responders.

**Table 4**  
**Best outcome assessment**  
**Schema to plot the outcome of various options**

Containment option		Hazard	Exposure pathway	Portal of entry	Actual / likely exposure dose	Actual likely effect-type, severity, & numbers affected	Assessment of risk
No 1	Population						
	Environment						
No 2	Population						
	Environment						
No 3	Population						
	Environment						

**Note:** This schema follows standard public health approaches to outcome assessments. The International Clearing House will be organising trials of the schema to ascertain its effectiveness.



## Advice to responders, public and media

### Information and public warnings - communication skills

The public will often need information about:

- the incident
- measures being taken to contain the release
- who is currently under threat
- what the health effects might be from exposure
- what the public can **actually do** to protect themselves
- how to get further information; when, where and how it will be made available.

Public warnings and directives, if required, must be **clear**, and **repeated**. Often this is done through the media, but may also be conducted through **public address systems**. All public information emanating from the control teams must be consistent. Communication skills are very important; and are best left to one or two **nominated** people with training.

*offer advice*

### Advice on protection

Proper assessment during the incident will determine whether individuals or a population are likely to be exposed, and what the possible health effects resulting from short-term, acute, and chronic exposure might be. This assessment may be done by the emergency services for populations near the incident site, or by the command

and control teams or the public health team for more distant populations. If it is decided that a population is at risk, there are two options available:

- Sheltering or
- Evacuation / Removal.

**Sheltering** For the public, the most feasible protective measure is in-place sheltering - ie staying indoors, closing all the windows and doors, and shutting down any ventilation or air-conditioning systems, until the chemical (usually in a cloud) has passed. This procedure will usually protect the population for a couple of hours, which is more than enough for the majority of incidents.

*offer advice  
to the public,  
responders  
and the media...*

There may be risks in the protection option. These will occur if the chemical does not disperse as quickly as was anticipated. People in houses will then either need to be evacuated, through the chemical hazard and at greater risk than before, or provided with additional protection, food, water and care.

*...on protection  
and restrictions*

**Evacuation / Removal** Evacuation is the removal of people away from the area of (likely) contamination to a place of safety. It will often involve **complex arrangements**, ranging from the provision of transport, and shelter, food, water, and appropriate medical care (for pre-existing conditions as well as the health effects of the exposure) in the area of safety. It may also require ensuring the security of the properties left uninhabited.

Evacuation is the better option when:

- the area is not yet exposed, but will be after some time (this time being longer than the time required for the evacuation), and
- the likely duration of exposure is such that the protection offered by in-place sheltering will become insufficient.

*the risks of  
sheltering and  
evacuation  
and return  
must be weighed*

Evacuation may also be the better option if:

- the chemicals are **widely dispersed** and contamination is **extensive**, or
- where toxic chemicals are suspected but cannot be identified readily, or
- where the chemical is highly hazardous, or
- where the air will be hazardous for a prolonged period.

If the exposure is highly hazardous and evacuation is the best method to minimise health effects, then it must take place as **rapidly** as possible. There are risks to this option, as well. These relate mainly to the attendant risks of moving numbers of people, such as falls and road traffic accidents, and disturbing the health of frail, elderly and disabled people.

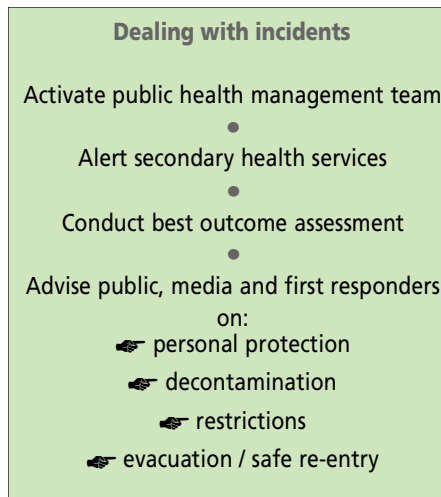
**Protection v evacuation** The decision must be based on a balance of the risks of the two options. The primary consideration is the risk of exposure (both level and duration). The secondary consideration arises from the attendant problems of moving

people about. A particular problem is when there is a threat of a release.

**Return** The decision to authorise **return** is dependent upon monitoring data adequate to be able to assert that the area is safe and the ability to provide adequate services.

#### Advice on other restrictions

When water or food supplies are contaminated, the **supply of uncontaminated products** may be preferable to evacuation. If soil is contaminated, it may be possible to **restrict movement** through the contaminated area, keeping people upwind of an air-contamination site, or away from any plume of smoke or dispersion cloud. Modelling and monitoring should be carried out to ensure that groundwater movement has not dispersed the contamination over a wider area or contaminated previously safe water supplies. Other measures include controlled distribution of, or restricted use of, contaminated **crops** or **livestock**, **drinking water supplies** from contaminated land or sources. Alternative supplies will need to be identified and provided.



*restricting access to contaminated products may be necessary*



## Ensuring a co-ordinated and integrated public health response

It is important to ensure that the public health response to the incident is **consistent**. With many people and agencies involved in the public health assessment, it is vital for advice to be channelled through one spokesperson.

## Organising registers and samples

From the public health point of view, it is very important to be able to link pollutants in the environment with ill-health in the population. In ideal circumstances, this is done by measuring the levels of pollutants over time - in the environment; at the portal of entry into the bodies of all the people exposed; within the bodies of the exposed people - and by measuring and comparing the levels of ill-health in the people exposed and not exposed. These measurements will also enable the effectiveness of the control measures to be evaluated, and to help plan any remediation. In the long term, it may also be possible to use these data and data from other events to make predictions in the early stages of an incident about the consequences of containment actions and thus to choose the best option.

There are **three important steps** that have to be taken:

- enter all the exposed people onto a register
- take samples from the people on the register

- take samples from the contact medium they were exposed to.

Registers of exposed people and biological and environmental samples are necessary for assessing any harm done by exposure to the chemical

Environmental modelling or rapid environmental sampling may enable the public health team to ascertain the media that have been contaminated and their geographical distribution. It may also be necessary to use this data to ascertain the populations likely to have been exposed.

Collection of these data will:

- ascertain when the risk of exposure in certain areas falls below the protective action threshold
- ascertain the populations and individuals requiring further follow-up and treatment
- supply baseline data for long term follow-up studies
- assess the success of mitigation efforts
- add to the understanding of the incident and exposure effects
- uncover continuing problems
- provide estimates for planning and resource allocation from the distribution and severity of health effects, and the environmental effects
- support environmental and community remediation efforts
- develop reference background material for future similar incidents and add to toxicological databases
- refine the theoretical models of assessment
- provide information for litigation and compensation.

there are many other benefits as well

### Registers of exposed populations

Exposed people are those where the chemical has arrived at the portal of entry. The objective of the register is to identify all those people for whom this is true - because these are the people who are at risk of toxicological health effects. Identifying accurately these people may be difficult, and it may be necessary to register people at other points in the exposure pathway, such as those who were in the area, or those who noticed a certain smell.

speed is probably the most important aspect of registers

It is important to set up the registers as soon as possible. The **speed** is necessary for a number of reasons. People's **recollection** of their symptoms and whereabouts can become confused over time partly through memory loss, and partly through publicity of the incident. **Volunteers** often turn up to help in certain pollution incidents, particularly where wildlife has been affected, and may become more heavily contaminated than the rest of the population. They often return to distant homes without any record of their names being taken. They are important groups to follow-up, partly for their own health and partly because the dose gradient can add significantly to any epidemiological studies.

Ideally, all named registers should contain details of the person, exposure time, exposure route, portal of entry, symptoms and biomarkers. Named registers require a

## Organising registers and samples (continued)

set of agreed definitions, permission from the individuals, confidentiality assurance, an updating mechanism and a commitment to the time and resources, which can be considerable.

### Collection of samples - biomarkers (BM) of chemicals and their effects

The nature of an unknown chemical contamination may in some cases be deduced from the health effects noted. Clinical signs and symptoms can in some cases point with a high degree of suspicion to a specific chemical or chemical class exposure. The most common signs and symptoms are nausea, vomiting, skin irritation, respiratory problems and central nervous symptoms. However, they can also be caused by a myriad of other infectious and non-infectious factors. In a few cases, specific diseases are associated with specific chemical exposures but take many years to develop. In other cases, biological measurements, if sampled correctly at the appropriate time and processed by a specialist toxicological laboratory, may confirm hypotheses about the nature of contaminants.

*exposure to the chemical can be demonstrated by identifying the chemical in the body, or by measuring physiological changes in the body*

Biological measurements, both of exposure and of the effects of exposure, can be an important tool. Unfortunately, and contrary to widespread misconceptions, no single blood test exists which will ascertain to which of the thousands of chemicals in the world an individual has been exposed. Testing for biomarkers of exposure and biomarkers of effect requires specific sampling and handling techniques depending on the chemical or class of chemicals presumed, and many of the tests can only be carried out in specialist toxicology laboratories.

**Biomarkers of Exposure (Exposure BMs)** These are measurable levels of the **parent chemical** or its metabolites **found in** one or more **body fluids or tissues** in an exposed population. Sensitive, replicable assays of human body burden for many contaminants are possible, but often must be performed within a short period after exposure.

*a raised level may not necessarily have been caused by the chemical incident*

If elevated levels could be caused by factors other than exposure to the agent of concern, it is important that information be gathered on hobbies, secondary occupations, source of water supplies, and any other determinants of elevated levels. It may be possible to compare the target population to a reference population (resembling the exposed population except with regard to this exposure). Reference levels exist for many tests.

Some degree of exposure to a variety of contaminants, is common in most countries. Some countries conduct population-based sampling to measure **background biological levels** of some contaminants, and databases such as that maintained by the U.S. National Centre for Health Statistics based on its National Health and Nutrition Examination surveys can be used as one source of reference levels for studies. Currently included are biological samples evaluated for evidence of exposure to lead, cadmium, and 36 volatile organic compounds.

*other causes need checking out*

**Organise sampling**

- Biomarkers of exposure
- Biomarkers of effect
- environmental media

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Collect other markers:

- animal sentinels
- immediate symptoms
- attack rate

Biomarkers of exposure are particularly valuable where contamination may have occurred through more than one portal of entry.

A preliminary **exposure survey** should test samples from the subgroup most likely to be highly exposed (exposure BM), or most vulnerable to exposure (effect BM); if samples from this group do not show measurable levels, further investigation of others is unlikely to be fruitful.

**Biomarkers of Effect (Effect BMs)** For many contaminants or situations, it is not possible to study biomarkers of exposure. In some cases, this is because the half-life within the human body is short and too much time has passed, in other cases, it is because appropriate laboratory tests are not available, and in

further cases, it may be that the chemical does not enter the body but has a local effect only.

any physiological changes have more than one cause

In these circumstances, it may be possible to measure **intermediate health effects** of exposure by using **physiological measurements** known to change with exposure. Many of these measurements are frequently tested in routine health care to diagnose a wide variety of conditions (most of which are not associated with environmental contaminants). The changes they measure, such as the changes in the appearance of red blood cells associated with lead poisoning, are also associated with other conditions, and care must be taken to examine all possible causes. Using more than one measurement affected by exposure to the contaminant can be helpful. A reference group chosen using an appropriate sampling strategy can also help to ascertain whether abnormalities in a measurement are associated with the exposure of concern.

looking at several different attributes can help

Publications detailing test batteries of immune function tests, adult neuro-behavioural tests, and respiratory tests which have been widely used and validated in environmental investigations have been published by ATSDR. It may be necessary to carry out **pilot studies** to ascertain which biomarkers of effect, and at what levels, are associated with known doses of agents to which a population has been exposed, in order to validate the biomarkers used in studies or clinical situations examining the current incident. Here also, the study may need to be conducted rapidly, if the adverse effects are to be reversed.

There is often a **conflict** between the need to **contain** the acute incident as an emergency, and the need for carefully documented **exposure and effect information** on individuals. Therefore, procedures will need to be agreed with the

### Organising registers and samples (continued)

emergency services as to how these epidemiological studies can be initiated as rapidly as possible, and certainly during the acute phase. These procedures should be included in the chemical incident plan. If measurable chemical levels in the body decline quickly, specimens taken days after the incident will not reflect accurately the exposure of individuals.

*deciding who should take the samples should be part of the planning process*

**Other markers** Where biomarkers have not, or could not have, been taken, levels may need to be **inferred** from:

- occupation, specific place and type of work
- special features of exposure such as working in a confined space, level of ventilation (e.g. doors open)
- whether indoors or outdoors at the time
- level of physical activity
- volume of chemical used in process (e.g. volume of paint containing mercury used in a home)
- immediate symptoms such as burning, itching which may signify high exposure
- attack rate in those exposed which may reflect dose
- time from exposure to onset of symptoms - short duration may indicate high dose
- special features which may affect absorption within the body (e.g. smoking, exercise, abrasions, pica)
- measures taken to reduce contamination of the individual (e.g. washing skin and clothes immediately)
- scorching of vegetation
- animal sentinels.

*sometimes, exposure has to be inferred*



### Categories of exposed people

Exposure levels will in general be quite different for the three main categories of people involved in an incident. These different levels may well have an effect on the type of biomonitoring that can be done, and may well affect the management of the incident and the content of the plans.

The three main categories and their exposure experiences are:

- employees and other on-site persons (contractors, truck drivers etc) - usually more than one exposure pathway, often inhalation of vapour and skin contact from splashing and clean-up. Accessibility for monitoring - good during an emergency. May already be occupationally contaminated
- emergency services - close to the emergency, drenched clothing of fire officers, secondary contamination of ambulance officers and medical staff from incomplete decontamination of casualties. Accessibility for monitoring - good during an emergency as long as the equipment does not interfere with their operations (so use passive samplers)
- public - exposure via air, water, soil etc. Accessibility for monitoring - poor.

### Collection of samples - environmental media

*environmental sampling is a technical matter and needs planning for*

Environmental measurements are critically important, but require **well-equipped** and **skilled** personnel to carry them out. It is important that a **systematic plan** is developed on the areas to be sampled - including the time, duration, frequency, sampling methodology, and comparisons to be made - so as to gain an accurate picture. The team must be backed up by **laboratory facilities** which carry out appropriate tests, are quality controlled, and use the correct measurement scales.

There is only one opportunity to obtain environmental samples to determine exposure levels during the emergency, and that is during the emergency itself. Arrangements may be needed to nominate a number of well-protected fire personnel or environmental officers for the purpose of sampling in the plume; these people need special training in advance to accomplish this task effectively and without endangering themselves.

Monitoring at the **source** of contamination should continue well beyond the moment at which the release is thought to have been controlled, to ensure that the release has indeed been controlled. The **likely contaminated media** should be monitored; and **personal monitoring**, reflecting the concentrations to which populations are actually being exposed as they go about ordinary activities, should be considered.

*monitoring (continued sampling) of the source, contaminated media (and sometimes of the public) may be necessary*

It may be that some modelling has been done of the likely distribution of the chemical. If so, it may be useful to check the accuracy by sampling outside the predicted contaminated zone. This is particularly so if there are reports of health effects in these areas.

If the source and nature of contamination remain uncertain but adverse health effects continue, environmental epidemiological detective work may be able to identify likely types or sources of chemicals. Factors associated with the affected population but not the unaffected population, such as geographical residence, water supply, occupation or leisure pursuits, or use of a particular food or product, can be used to generate hypotheses to be tested by environmental measurements.

It is important also to assess the **concerns of the community** about the possible contamination of their environment and their own exposure. These may point to areas for further study or remediation, and may also guide the presentation of the results of the investigation to demonstrate that their concerns have been addressed.

# Assessing the impact on the health of the public

## Objectives

All the decisions made and advice given by public health / environmental health professionals about chemical incidents are ultimately concerned with improving the health experience of people exposed, or at risk of being exposed, to chemicals. These decisions should be evidence-based; and the evidence comes from previous studies of human exposure and on animal toxicological studies.

There are thus two objectives in assessing the health effects:


- to offer advice throughout the incident, primarily on protection and treatment
- to contribute to the public health toxicological information base

To offer advice about protection, public health / environmental health professionals will need information from the incident on the source and type of chemical, and on the likely exposure pathways: and information from the databases about the type, frequency and severity of the health effects of the chemical - ideally at different concentrations of environmental contamination. To offer advice about treatment, public health / environmental health professionals will need to identify all those exposed, or suffering from acute health effects and follow them up for as long as is necessary.

To contribute to the public health toxicological information base, public health / environmental health professionals will need to set up epidemiological studies. This is especially important, as the data on the health effects of concentrations seen in acute exposure are very limited.

These then are the detailed objectives of the health assessment process in any incident:

- to give information about the probability of health effects.
- to follow-up exposed people and to offer treatment where necessary
- to find out if the particular chemical *does* affect health at acute exposure levels
- to delineate the exposure-dose / health-effect relationship
- to evaluate the effectiveness of the response actions.



*public health's role is to measure the actual health effects of the incident, and to contribute that knowledge to the public health information base*

## Assessment methods

The methods used to assess the impact on the health of the public will vary depending on the **stage** of the incident.

**Stage 1. Preparedness.** During the planning and preparation stages, public health / environmental health professionals will need to become familiar with the sources that give data on exposure and health risk and effect.

**Stage 2. Rapid Health Risk Assessment.** During the acute stage of an incident, a rapid health risk assessment must be conducted. Initially this can be done by using **predictive** health effects **models**, based on information gathered from other exposures. The models include **ERPGs**, the Emergency Response Planning Guidelines that predict health effects at 1 hour at various distances from the source, and **AEGLs**, Acute Exposure Guideline levels (see Appendix H). Once the model has been run, advice can be given on protective measures.

*there are various stages in the assessment process, from immediate, short term assessments to the epidemiological studies*

**Stage 3. Exposure Assessment.** The next method is to start assessing / measuring the exposure levels. This involves four principle methods:

- monitoring - environmental, and personal / biological
- questionnaires - of activity and movement in relation to the contaminant
- modelling - usually run on computers and cover the source, the dispersion, and the exposure. Good data are needed and may well require questionnaires. There are many computer models available for rapid air dispersion estimations.
- markers - there may be other indicators that can be used as surrogates, such as animal sentinels.

**Stage 4. Acute Health Effects Assessment.** The next stage is to start assessing / measuring the acute health effects. This involves gaining data on the **toxic** as well as the **stress** related effects. Data should be collected on the **functional, physical, morbidity and mortality** outcomes of the toxic and stress components. Advice can be given on protection, treatment and follow-up.

**Stage 5. Longer-term Health Effects Assessment.** Similar data on the longer-term health effects can be collected, although this demands considerable commitment and resources from both the agencies and the public.

**Stage 6. Epidemiological studies.** The **health effects** from **short to long term** can be identified using epidemiological studies and **correlated** to the **causes**.

## Reasons for doing epidemiological studies

Little is known about the health effects of chemicals in non-occupational settings where the exposure may be acute and the levels range from low to high. Ideally, the health effects should also be **correlated** with the **dose**, and this requires data on the levels of exposure and the severity of the health effects. Once the dose effect is known, it should be possible to offer good public health advice on the likely outcome of any incident and the preventative and protective measures that should be taken.

It is obviously not possible to collect data by conducting experimental trials. Chemical incidents, where the population is put at risk, therefore **represent unfortunate but genuine research opportunities**. All chemical incidents should be positively assessed for their research possibilities.

Large-scale analytical epidemiological studies are expensive in time and resources, and require a determination on the part of the public health / environmental health professionals as well as the public. They are described below. Studies requiring fewer resources than analytical epidemiological studies can be used to assess the feasibility of a major study, address the concerns of the public, and generate hypotheses for further studies. These include many of the descriptive studies described below.

Communities sometimes wish for studies to be conducted because risk communication efforts (or communications about a relative lack of risk) have not been successful and concern remains. They may also be demanded because of a simple desire to know that "someone is doing something" in a community where remediation efforts are perceived to be incomplete.

**Reasons for researching**

- Experimental trials are not possible
- Very little is known about the public health consequences of chemical incidents
- All incidents represent unfortunate but genuine research opportunities

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Investigate and publish everything



### Types of studies<sup>1</sup>

The type of studies can conveniently be categorised into two groups, the **descriptive** studies and the analytical studies. The distinction is not absolute and a descriptive study can form the basis for an **analytical** study. Essentially, a descriptive study is one that shows a change in either the exposure, or the health effect. It may also be able to show that the two are associated. Or it may be able to show that there is a time sequence, with the exposure coming before the effect.

*the major types of epidemiological studies are descriptive, or analytical*

Analytical studies are intended to go further and to show causality, that the exposure came before the effect and that it caused the effect. The studies are usually larger and more expensive, and are supported by statistical probability tests.

The choice of study to set up will depend greatly on the number of people at risk, on the social and political drive to find answers, and the available resources. It is extremely important to decide on a study structure and protocol before any work is started, and to get this agreed to by the major parties concerned with the incident.

<sup>1</sup> this is a condensed version from the 'WHO Assessing the Health Consequences 1997'

## Descriptive Studies

**Disease and symptom prevalence studies.** It is very tempting to quickly collect data on people with symptoms and signs. However, unless a control or reference group is included, this may well produce more problems than it solves. This is because a range of health disturbances may be identified, whose frequency is unknown and whose relationship to the exposure is difficult to assess. This will be difficult to explain to the public.

The other main types are shown in Table 5.

**Table 5**  
Linking health and exposure data through descriptive studies

Health data	Exposure data	Study design	Analysis	Results
Symptoms and signs in the population	Individual, qualitative	Survey / cross-sectional	Comparison of different exposure groups	Frequency of symptoms (including annoyance / anxiety) in different groups
Biological measurements	Individual, qualitative and/or quantitative	Cross-sectional (random sample or cluster sample)	comparison of different exposure groups	Correlation between markers of health effects and markers of exposure
Disease occurrence	Population- wide	Temporal aggregation	Time-series	Change in rates
		Spatial aggregation	Spatial comparisons	Difference between areas exposed and not exposed
Mortality, birth weight, etc	Population- wide	Temporal aggregation	Time-series	Short-term changes in mortality, birth weight etc
		Spatial aggregation	Spatial comparisons	Difference between exposure groups

**Cross-sectional studies** attempt to **compare diseased and non-diseased populations** with regard to current **exposure**, or exposed / non-exposed populations with regard to current health status, at a point in time or over a short period. Cross-sectional studies resemble disease and symptom prevalence studies but they are more formally structured, with precise definitions for disease and health outcomes of interest and with well-defined measurements or surrogate factors representing exposure levels or providing surrogates for exposure levels.

*descriptive studies attempt to show a change in exposure and/or health effect*

Generally an entire population is studied, or a sample selected for study, in which it is likely the investigators will find both exposed and non-exposed individuals and individuals with and without disease. Particular attention has to be paid to the sampling strategy in order to ensure that both groups are comparable except for their exposure. If the groups turn out not to be well matched, there are statistical techniques that can be used to adjust for these factors during analysis.

**Ecological studies** are studies where the unit of observation is the **population or community**. Disease rates and exposure rates are examined in each of a series of populations and their relationship examined. The question being investigated is usually whether a population has a sufficient dose of that contaminant to raise the **rate** of those effects above that of similar populations in other areas. Data collected for other purposes, such as routine statistical analyses on trends in the overall health of a population, are generally used, although case definitions, diagnostic techniques, and reporting reliability may vary from area to area, making comparisons difficult.

There are two important ways of comparing these populations - using geographical comparisons; or time trends.

**Cluster investigations** resemble ecological studies in that presence in an area during a specific time period is often used as a surrogate for suspected exposure. However, cluster analysis uses special statistical techniques to deal with small areas and small populations, and health effects information may involve active case finding and more precise case definitions. Statistical methods can be used in a small area with a small population and a low (<10/100,000) expected incidence of a health event. Cluster analysis looks at **patterns of cases in space and time** to evaluate if there are more occurrences than expected to occur by chance.

Cluster investigations **often** result from a **community's anxiety** that a perceived increased in disease frequency is linked to an environmental hazard. Reports of clusters may also come to an investigator's notice because a clinician has listed individuals with new or unusual disease(s). Lists have sometimes provided the basis for identifying a new hazard ; sometimes, instead, they represent a 'false cluster' of unrelated or misreported diseases, or a listing of diseases occurring within the range expected.

## Analytical studies

These are studies that attempt to **show an association** between the exposure and subsequent illness, or to identify a possible causative agent in a group of people with a particular illness. They do so by **comparing two groups** and their experience.

Analytical studies provide statistical evidence of causation by estimating the strength of an association between exposure and disease. The measures of association used are the odds ratio (OR) and the relative risk (RR). Additional evidence of causation is provided if a dose-response relationship can be identified. Dose-response is of crucial importance to risk assessment.

The usual classification of analytical studies in environmental epidemiology is into panel, cohort and case-control studies (see table 6).

*analytical studies  
attempts to show  
an association*

**Panel studies** are used for the **short term follow-up** of a group of people whose health events ( a few times a day, daily or weekly) or physiological changes (measured by, for example, self-reported symptoms in a diary or respiratory function tests) are correlated with the exposure measurements made at the same time. Each person acts as their own control, although a reference panel should be investigated at the same time to adjust for the possible confounding effects of time-dependant factors not related to the exposure (such as weather or reports by the mass media on the incident).

*there are  
various types*

They are **relatively simple** to carry out - a matter of days to weeks rather than months to years - and can form the basis for, or assess the utility and feasibility of, more formal studies. The population to be studied may be all those who are given tags representing a certain exposure level in an incident, or all those known to be resident near an event or working in its vicinity, or all those who reported to medical facilities during and immediately after an event, or all those assessed as exposed in some more formal way.

**Cohort studies** compare **groups** of **exposed** individuals with groups of **non-exposed** individuals, and follow them up to identify **episodes** of **symptoms or disease** in order to ascertain the association of disease to exposure. These studies may be prospective (beginning just before the exposure) or retrospective (beginning after the diseases have become apparent), or both (beginning after the time of exposure and continuing until the diseases become apparent).

In acute chemical incidents, such studies will have to be partly retrospective since the exposure will have taken place before the study commences. Thus documentation of exposure may be poor and recall variable. And it is essential for this type of study that groups with different levels of exposure are identified. However, if the study begins soon after the incident, better exposure information may be available than in a study which begins years after exposure. The control group is often difficult to

define or produce comparable exposure data from.

**Table 6**  
Linking health and exposure data through analytical studies

Study design	Exposure data	Health data	Analysis	Results
Panel	Individual	Biological markers, symptoms, signs, disease occurrence	Correlation between exposure, exposure indicators and changes in health indicators	Short term health effect
Cohort	Group exposure or individual	Mortality, disease incidence reproductive outcomes	Comparison between different exposure groups	Incidence of long-term effect, relative risk in various exposure groups
Case-control	Individual	Rare disease outcomes (such as cancer, malformations)	Comparison of exposure history between cases and referents	Confirmation of association between specific outcomes and exposure



**Case control studies** compare the **exposure history** of a group of people with a disease (the **cases**), with that of people without the disease (the **controls**). The study is by definition **retrospective** since it deals with people who already have a disease and looks at their history of exposure in the past. The method is useful for assessing the association of specific health outcomes with certain exposures; for verifying the effectiveness of the protective measures and the treatment; and for investigating the factors that give rise to susceptibility.

*the type of study chosen will depend on the question to be answered, the resources available and the political will to see it through*

The major limitations are that exposures are often not recorded precisely and patient recall of exposure details may be faulty and that health effects may be diffuse and poorly defined. However in investigation of acute incidents, such as outbreaks of infectious disease, the method has been a great success in identifying the probable causes of environmental exposures, and case control studies are now used routinely.

**Other problems encountered in epidemiological studies**

Unfortunately, verifying or refuting the effects of the incident is often problematic because:

- the (presumed long) latency period from exposure to effect is unknown
- the population moves about over a long time, so that following-up people is difficult to sustain
- many illnesses, such as cancer, are probably multi-factorial. Separation of the effect of a single exposure will require a large number of participants in any study

- the numbers of people exposed to chemicals during incidents is rarely of the order of magnitude necessary to provide sufficient statistical power to detect moderate increases in risk.

## Assessing the effects of long-term environmental contamination

Once an incident is over, the environment may continue to be contaminated. This contamination may continue to effect people. The state of contamination may need to be monitored regularly and over a long period of time, and the possible effects on people's health assessed regularly.

# Remediation, restitution and rehabilitation

Rehabilitation following an environmental incident is a mixture of remediation and restitution of the environment, action to prevent a further occurrence, and work to improve the community's health.

## Remediation

Remediation is the process of making the environment **safe and clean**. It may occur naturally, as with a volatile gas, or where the chemicals involved dissipate or break down quickly. However, where this does not occur, it may involve the physical **collection** of the contaminated medium and its **safe removal**, cleaning and **disposal**, or it may require other measures to reduce the toxicity of the chemical.

A range of expertise is needed to assess the extent of residual contamination of plant, soil, air and water, to devise appropriate decontamination measures where needed, and to ensure that it is safe for evacuated populations to return or for protection recommendations to be rescinded. The extent to which contamination has reached agricultural soil or land used by humans, and the contamination of crops and livestock, with subsequent risks to the food chain, must also be appraised and preventive or protective measures put into place.

*remediation is the process of making the environment clean and safe*

**Cleaning up** contaminated sites or land may entail standard **soil** stabilisation / disposal technologies or biological methods of decontamination. Material such as topsoil, beach sand, equipment or crops may need to be removed for cleaning or disposal, (without endangering the new site). Rehabilitation of large bodies of **water** may be costly and time-consuming, especially when the chemical has become bound to the sediment. Individual decontamination of affected wildlife may also be thought necessary. Significant contamination of the **food chain** is likely to require destruction of crops, products, and animals grown for food. Air decontamination may occur

*it may occur naturally or require cleaning up*

naturally within a few weeks, but occasionally ash or toxic pollutant levels persist for months or years because of interaction with local conditions. Decontamination of the drinking water or source water may not be possible and the system may have to be flushed out, causing potential for further contamination of soil, groundwater, or seawater. Alternative sources of **drinking water** may be difficult to supply and restoration of services may again be resource-heavy and time consuming.

*cleaning up includes decontamination, destruction and removal*

Sometimes, the removal of the chemical may not be possible. This can be because it would be too difficult, or too hazardous; it may cause further pollution or it may be too expensive. **Remedial actions** that reduce the volume, toxicity, or mobility of hazardous substances may then have to be put in place. If full remediation cannot be accomplished, it may necessary to declare the area as 'no-go, no-use', 'limited entry' or 'limited use'. These declarations may have to be in force for many years and may seriously disrupt the life of the community.

Any and all of these measures may leave the environment significantly changed.

## Restitution

Restitution is the process of **returning** the environment to its **original state** before the chemical incident. In some incidents, remediation will have left the environment unchanged. In other incidents, extensive remediation work may have occurred. Restoring the environment back to its original state may involve **landscaping** and **rebuilding**, replacing equipment and buildings, **replanting** of crops, and replacing animals and wildlife. It may again be considerably expensive. Finding the resources for this area of activity may be problematic, as it may need to occur after a considerable period of time has elapsed, it is not seen as urgent, and there may be difficulty in finding any organisation prepared to pay - the 'polluter pays' principle is rarely achieved.

*this is about returning the environment to its original state*

## Community rehabilitation

Rehabilitation of exposed persons or populations is the restoration of normal functioning and includes:

- health
- housing
- quality of life
- services
- economic livelihood
- feeling of security.

Responding to community concerns is vital for the rehabilitation of a community. Great psychological **stress** may be caused by incidents which pose no physical hazard and require few or no protective actions. Often stress can be resolved by good

communication of measures taken to prevent exposure; sometimes additional investigations to confirm a lack of health effects and environmental contamination is helpful. **Involving the community** in plans to reduce the risk of further incidents, and to quickly alert the public health team and the public if further incidents occur are both reassuring and protective of the public's health.

community  
rehabilitation  
includes health,  
housing,  
quality of life,  
services,  
economic livelihood  
and  
feelings of security

The effects of chronic exposure on health may be alleviated by removing the population at risk from a source of continuing contamination, by preventing exposure through cutting off the exposure pathway, or by setting a course of remedial action. The course of action chosen will depend on the available technology and resources. Methods used need to be relatively simple and easily deployed.

**Acute health effects** should be assessed and treated. Where hazardous concentrations of chemicals remain in the human body, measures such as chelation or treatment to aid the body in metabolising or expelling the chemicals should be given and monitored. Where exposure was uncertain and potential long-term health effects of an exposure are a concern, long-term monitoring should be considered as a part of community rehabilitation. **Registers** of contaminated and exposed people can be set up, but they require resources to remain current in order to ensure comprehensive medical follow-up and information dissemination.

If measures to restrict the use of land or facilities or livelihoods have been put in place, resources should be sought to maintain the quality of life. Local and sometimes national authorities should be involved in negotiating this, if appropriate. If important sites, such as play areas for children, or conservation areas are declared 'no-go' areas, provision of alternatives should be a high priority.

**Alternative accommodation** for residents and key facilities should be made available if clean-up is impossible. If exposure levels are considered acceptable but there is uncertainty about long term effects, or if intermittent unacceptable levels are likely, every effort should be made to reduce the levels and protect the population, especially vulnerable individuals. If this can not be done, monitoring the population to determine any adverse health effects or future expression of disease is essential.

After the first urgent communications, the public should continue to be provided with specific and timely information on appropriate behaviour and **safety measures**, and should have access to other **information** to understand the nature of the effects of the incident. Channels for the community to express their concerns are also vital. Consideration needs to be given to maintaining ( or establishing ) a **hot-line** or public information channel. This is best organised through a community spokesperson.

The community needs to be aware of the measures to prevent the incident occurring again. These measures include actions to reduce the probability of another incident,

actions to reduce the toxic effects of the incident, and any lessons that have been learned in the management and control of the incident.

**Rehabilitation** thus aims to:

- effect remediation of and restoration to the environment
- restore the health of the population at least to its state before the incident, or minimise the ill effects
- answer unanswered questions
- restore health care and community services prevailing before the incident and, whenever possible, improve these services
- provide evaluation and feedback on incident response and effect indicated changes
- monitor for unexpected effects or for potential effects when risk is uncertain
- continue risk reduction and prevention activities.

## 'Wash-ups', evaluations and audit

It is possible to conduct three types of review of the performance of the public health response to the incident. The time, effort and resources allocated to any or all of these will depend upon the nature of the incident, the complexity of the response, the time since and the lessons learned from the last review, and the resources available.

**Wash-ups** These are perhaps the simplest of the reviews, and involve a quick **rerun** of the events of the incident and the response of the public health / environmental health professionals. Obvious errors, deviations from the plan and problems in communications are highlighted in a non-threatening way so that participants can learn as much as possible from the actual incident and the rerun. The wash-up is conducted as soon as possible after the incident, while the events are still fresh, and is usually an '**in-house**' affair.

**Evaluations** An evaluation sets out, in a **methodological** way, to **analyse** the events of the incident and to assess what impact the response made on the outcome. In particular, questions are asked and judgements made as to the difference in outcomes if there had been no public health response, or if different responses had been given. It is a 'what if' exercise. Ideally, outside experts are brought in to add their expertise and a level of objectivity.

**Audit** An audit is a similar exercise to the wash-up, but the actual performance is measured **against standards**. Standards are stated, explicit levels of expected performance, covering qualities such as the speed of response, the presence or absence of minimum levels of equipment, the achievement of minimum or maximum levels of performance. The setting of standards is a complex issue in its own right, and may require data from previous incidents to be compiled. All of the steps and

*reviews of the conduct of the management of the public health aspects of the incident are important ways of learning lessons, correcting plans and developing public health management techniques*

procedures and processes that are ideally gone through in the public health management of a chemical incident are mapped out, and where a standard can be fixed for any given point, this is spelled out. Ideally the standards are set before any incident has taken place, but often this does not proved possible.

If an audit is going to be conducted, retrospective standards can be set. However, it is important that these standards are set before the audit and without an eye on the results. Nevertheless, it is far from ideal.

Data from the incident are collected and collated, and compared to the standards. Judgements are made as to how well the standards were met, and any areas for improvement noted. It can be seen, therefore that if the standards have been set before the incident, data necessary to measure the performance against the standard can be collected as the incident progresses. The data are much more likely to be accurate as a result.

## Publication

Whenever possible, the incident should be written up and published. Reports can be simple descriptions of the incident, epidemiological studies or lesson learned. Reports should be published in referenced journals, and/or sent to the WHO Collaborating Centre for an International Clearing House for Major Chemical Incidents.

# Guidelines and legislation required

### General governmental policies

*some powers are appropriate at the national level, some are better at local level*

The government needs to **motivate** all sections of society to recognise the need for accident prevention and preparedness and response. It needs to establish **safety objectives** and ensure that these are met. To do this it needs to establish a clear and coherent **control framework**. The framework should set binding requirements, define which installations and other possibly dangerous situations (such as transport routes) are covered, establish notification and information requirements and provide for enforcement action to cover non-compliance with requirements. **Guidance** will also be needed by industry and others to help them understand how to fulfil legislative standards. A **co-ordinating mechanism** should be established where more than one competent authority exists.

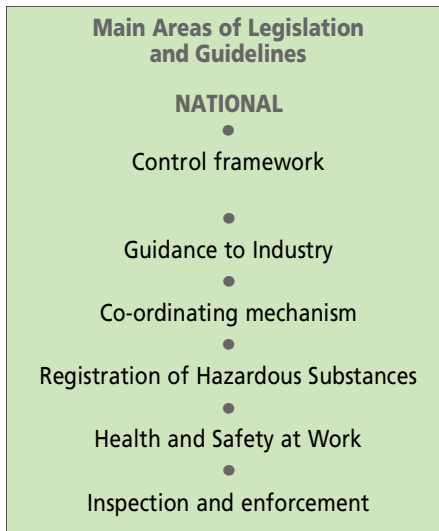
Most countries already have laws and statutory regulations that either include chemicals in their general application (such as health and safety regulations), or are specifically designed to cover particular aspects of the chemical industry or when

chemical incidents occur. The **specific statutes** usually **require** organisations or individuals to perform various tasks, such as register a chemical site, or **give powers** to agencies or public bodies. These powers include the setting up of bodies or groups; rights of visitation and inspection; control, restriction or closure; and enforcement .

Below are described some of the more useful statutes and regulations that countries may find helpful to enact in order to ensure the comprehensive prevention, control and management of chemicals and chemical incidents.

### Planning and building regulations

Many countries have introduced planning and building regulations at the local level that require commercial (and residential) enterprises to **notify the local authority** of the planned use of any building or site, and to **obtain permission** to carry out that function. Granting permission will ideally take into account the presence of any hazards and the possibility of any risk to the local community. Often, the local community's views are taken into account before permission is granted. If a system of incident notification is to be introduced, the requirement can be applied at the time of granting the planning permission.



It is just as important to ensure that any **buildings** and facilities are constructed and operated in a **safe** way. This requires standards to be set, and the site visited to ensure compliance with these standards. Setting standards in the operation of chemical processes can be a highly complex business, and may require a more specialised agency than can be provided by the local authorities.

Powers will be needed to ensure **compliance** with the planning and building regulations, and to exact penalties for non-compliance.

### Land use

In addition to laws concerning the individual site and its use, it is helpful for governments to have a broader policy on the overall use of land. It is frequently found around the world that the industries with the most hazardous chemicals are sited in areas where the population density is very high, the per-capita income is very low and the people live in poor quality housing that offers little in the way of protection in the event of an incident.

Proper land use planning would ensure that hazardous chemical sites are **located**

*they help in control, setting standards and definitions, hazard identification and response co-ordination*

**away** from resident populations (taking into account the likely flow of any chemicals into the environmental media in the event of an incident). Planning would need to ensure good transport for the workforce from the residential areas to the chemical site.

### **Hazardous sites registration and control**

In an ideal world, all chemical sites would be registered, the facility's workforce and management would ensure absolute safe operation and the activities would be regularly inspected and controlled. However, the number of sites and the available public authority staff make this impossible. A feasible option is to identify the **most hazardous chemicals** in the country and to require the **sites processing or storing a minimum quantity** of them to notify the national **register**. There are available internationally recognised lists of the most hazardous chemicals, and these are available from IPCS / ATSDR. In addition to registration, companies would be required to meet higher safety standards and to have in place an on-site chemical incident plan that co-ordinates with the local public authority plans. Vice versa, local authorities with such a site on their land should be obligated to plan for any foreseeable emergency in that facility, have access to trained emergency response staff and resources, and regularly inform the potentially affected population about risks, measures taken to reduce the likelihood of an event and the consequences if one happens, and the protective actions available.

*typically, powers are used to determine which chemicals can be manufactured, and where; how they get transported; the safe running of the sites; and what should happen if anything goes wrong*

### **Waste disposal sites registration and control**

The types of substances that may be disposed of at each site is usually regulated, to ensure that hazardous materials, ranging from asbestos to toxic chemicals to radioactive material, are only deposited in designated sites. Extra precautions need to be taken at these sites to ensure that the materials **do not escape** into the environment. At any site, however, hazardous materials may be deposited inappropriately, or different materials and chemicals may react together to produce unexpected chemical by-products. The regulations, covering registration, inspection, control, surveillance and penalties should also bear these problems in mind.

### **Control of transportation**

Various systems are in place for labelling containers to show the chemicals contained, the nature of any hazard, and the action that should be taken in the event of a chemical incident.

In some countries, there are strict controls of labelling, which may be backed up by legislation.

### **Control of contaminated land, water (drinking and other), crops and foodstuffs**

Following a chemical incident, any or all of the environmental media may be contaminated. It may be necessary from the public health point of view that people are **excluded from**, or have limited access to land, waterways or coastlines, and

much of this may be in private hands. Crops, foodstuffs and drinking water may also be contaminated, and it may be necessary to prevent access to, and to impound and **dispose of or destroy** them. Unless adequate compensation is offered, full notification will not be achieved, and this can often present a greater public health threat than the original incident. All these actions will require statutory powers of access, inspection, sampling, impounding, disposal, compensation and penalty imposition.

### Data collection and collation

- e.g. IPCS WHOCC surveillance, ATSDR, National Focus.

A local, or ideally, national **reporting centre** will be required, and this will enable the country to assess the safety record of the industry, the public and environmental harm done and any lessons that can be learned. Full and open disclosure of each chemical incident should be encouraged (or required).

**Contributing** to the international chemical incident register at the International Clearing House will also help to identify and disseminate lessons to be learned. Internationally agreed data sets are available, and countries may find it very helpful to use these as a basis for their own reporting mechanism.

Following major chemical incidents, it may be helpful to conduct a **public enquiry**. Powers may be necessary to compel witnesses to give evidence. Ideally, the enquiry should be in public and the report and its conclusions put into the public domain.

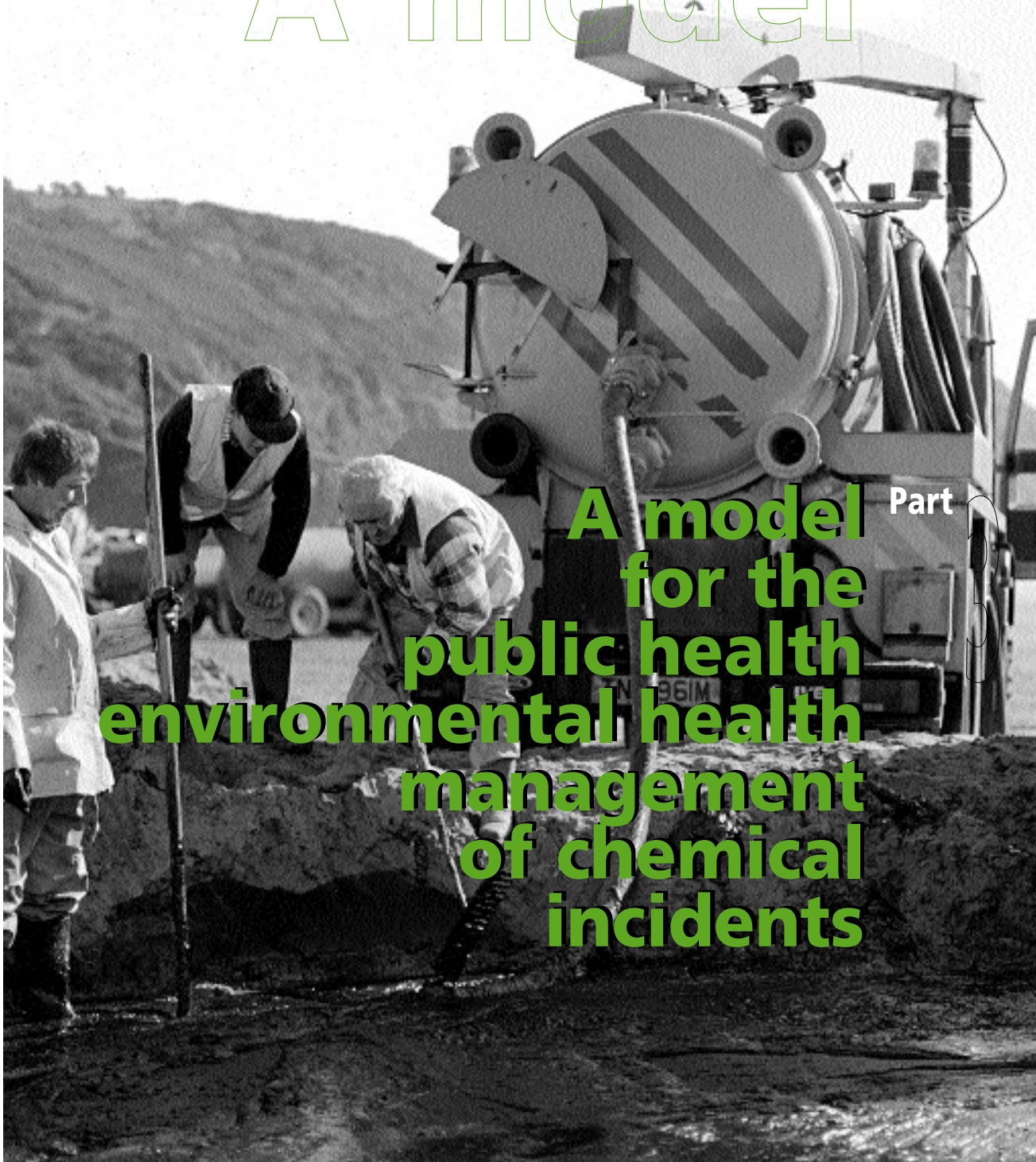




# A model

**A model  
for the  
public health  
environmental health  
management  
of chemical  
incidents**

Part



# A model for the public health management of chemical incidents

This chapter details the functions that are available or could be available to a country. The functions range from international to local ones.

## International functions

### WHO Collaborating Centre for an International Clearing House for Major Chemical Incidents

In 1996, the WHO established the WHO Collaborating Centre for an International Clearing House for Major Chemical Incidents at UWIC, in Cardiff, Wales in the United Kingdom.

The **functions** of the centre are:

- to investigate the possibilities of inter-country collaboration and co-operation
- to investigate methodologies for the establishment of national surveillance programmes for major chemical incidents
- to develop guidance materials and standardise documentation for the reporting of major chemical incidents. This will include what to report, when to report, to whom and by what mechanisms
- to collate and analyse the data received from such incidents and prepare reports in a form that will be useful to member states when planning their response to such incidents in the future
- to disseminate such information to the Regional Offices of the World Health Organisation for onward transmission to member states
- to make such information available to other WHO Collaborating Centres
- to develop an international database of the problems encountered in dealing with major chemical incidents
- in collaboration with the WHO Regional Offices and the other Collaborating Centres, to develop training materials and methods, to hold training courses, workshops and seminars and to participate in manpower development programmes for the management of major chemical incidents.

In effect, this means setting up a register and database of chemical incidents from around the world, including the lessons learned, and making these lessons

available to all. The International Clearing House is now established in the University of Wales Institute, Cardiff. The register of chemical incidents has been set up and an internationally approved data set designed and made available in a paper format and on the Internet.

## WHO Collaborating Centre for the Health Aspects of Chemical Accidents

In 1996, the WHO established the WHO Collaborating Centre for the Health Aspects of Chemical Accidents in Utrecht, the Netherlands.

This Centre is connected to the National Centre for Medical Toxicology and Emergency Medicine, a collaboration between the University Medical Centre Utrecht, the Central Military Hospital and the National Poisons Information Centre. The centre is situated in the Emergency Hospital of the Central Military Hospital. The Emergency Hospital is organised as a civilian military collaboration and is ready to receive civilian as well as military victims.

The **functions** of the centre are:

- the medical management of victims of acute chemical exposure
- the establishment of protocols for the approach, clinical evaluation and additional investigations of possible patients
- analysis and verification of complaints and symptoms attributed to chemical exposure
- risk analysis concerning acute and chronic health risks of chemical exposure
- organisation of courses in medical management of chemical emergencies
- organisation of simulation exercises on a national and international level
- investigation of the relation between exposure, body burden and effects of chemical emergencies
- in collaboration with the WHO Regional Offices and the other Collaborating Centres, to develop training materials and methods, to hold training courses, workshops and seminars and to participate in programmes for the medical management of chemical incidents.

A web-site for the Emergency Hospital is being prepared which will include details of the Collaborating Centre.

## National functions

### National public health co-ordination

National governments are increasingly becoming aware that it is vital to be fully informed about the risks to their populations of chemical incidents, and what steps are being taken when a chemical incident occurs to manage and reduce those risks. A number of countries have each set up a national centre to **monitor** chemical

incidents throughout their country, and to **advise the government** and ministers rapidly in the event of an incident. Examples of these are National Focus and ATSDR.

Public health expertise is often unevenly spread across the country. A further function therefore of the centre can be to **plan and co-ordinate** the development of public health chemical incident services throughout the country.

*It can be very helpful to government to have a body collecting data on incidents, and co-ordinating action*

The centre will require expertise in setting up and running databases, and should have access to expertise in:

- chemical and medical toxicology
- poisons information
- environmental toxicology
- environmental epidemiology
- environmental risk assessment
- environmental sampling
- environmental monitoring and modelling
- biological monitoring
- medical epidemiology
- surveillance
- risk assessment and hazard analysis
- risk perception and risk communication
- risk management
- media skills
- rehabilitation
- accident and emergency services.

## National / regional response and support

Skill, expertise and experience in the public health management of chemical incidents are usually limited at the local level. This is usually due a lack of training (public health training concentrates on infectious diseases rather than environmental health and chemical incidents) and the rarity of major events.

Experience has also shown that in many countries, public health / environmental health experts are not involved in planning and preparedness, responding or training.

*local public and environmental health professionals may require support-at-hand as well as over the telephone*

In these circumstances, there may be an advantage in concentrating skills and expertise in a team at regional or national level. This **team** would be able to provide the local public health / environmental health services with **advice** and **support** in the management of incidents. The response team can either take over the handling of the public health input into the incident, or it can remain in a supportive role, helping the local public health / environmental health professionals to deal with the incident.

The response teams will need permanent staff who are prepared to travel and live away from home. The number of response teams required in a country will depend on the size of the country, the number and severity of incidents, the number of skilled and experienced staff, the local public health / environmental health infrastructure and the means of transport and communication of the response team with the local public health team.

## Poisons information service

A poisons information service should provide 24 hour expert toxicological advice on the likely health effects of exposures to chemicals and the specialist treatments required. The service should be nationally recognised and have access to medical toxicologists and occupational toxicologists.

The poisons information service is usually located in a Poisons Control Centre (PCC). The principle functions of PCCs are concerned with persons exposed to the toxic effects of drugs (therapeutic and non-therapeutic), chemical substances and naturally-occurring substances. The functions of a PCC are:

- to provide telephone advice and support to medical professionals in the case of poisoning
- to provide education to medical professionals in the prevention and management of poisoning.

In addition, a number of PCCs offer:

- treatment of patients suffering from poisoning

## Other sources of data, information and expertise

There is a wide range of data, information and expertise available, either as hard copy, electronically or via personal contract. Routine, easy access to these sources is vital if the incident team is to be able to give public health advice to the emergency services quickly.

### Environmental chemical databases

Chemical databases are also available which describe in detail the **behaviour** of chemicals in various vehicles such as water, during various physical processes such as explosions and changes in temperature, their incompatibilities and predilections for combining with other chemicals, their gas densities and vapour pressures at various temperatures, their warning properties including odour, visual cues, and irritant activity, and other relevant information. Data about **sampling methods, personal protective equipment** and equipment needed for measuring chemical contamination should be included, as well as threshold levels in various situations which represent hazards. Laboratory equipment and training needed to process specific environmental specimens should be noted.

The WHO has for example, published two databases that are available as hard copy or CD ROM:

- INCHEM
- INTOX.

Another source of information is Tomes+ (Micromedex), IUCLIC, which is available as a CD ROM (See appendix H)

### **Expertise and skills**

The local public health / environmental health professionals will need to be able to access a wide range of expertises and skills, often at short notice. The sorts of expertises and skills needed will include poisons centres, the response unit, the national monitoring centre, the WHOCCs, toxicology laboratories, environmental and medical epidemiologists, chemical and medical toxicologists, environmental and biological monitoring, risk assessment specialists and media skills.

## **Chemical analysis of media**

Each country should have available at least one internationally recognised laboratory service that can undertake chemical analyses of environmental samples - air, water, soil, sediment and food, and biological samples - blood, urine and sputum. These laboratories should work to internationally agreed procedures and standards, inter-laboratory quality control programs and standard expression of results.

## **Other specialist chemical incident advice**

In many countries, units have been set up by the chemical industry that specialise in specific areas of chemical incidents, such as chemical data, transportation of hazardous substances and storage of hazardous substances. These units will usually provide telephone assistance and fax / e-mail data, and in some cases will actually assist or take the lead in clean-up operations. Some are listed in Appendix I.

## **Other related specialised services**

Within a country, there will usually be a wide variety of government departments, authorities, bodies, agencies, centres and units that statutorily or voluntarily will be involved with chemical incidents, amongst their other function. These various bodies will deal with:

- health
- agriculture
- fisheries
- external safety
- the environment - water quality  
- air quality
- trade and industry
- transport

and the functions that will be followed are:

- health care
- health and safety at work
- pollution control
- planning
- monitoring and inspection
- enforcement.

Typical examples of these bodies include marine pollution units, river authorities, air pollution units, environment agencies, industrial and factory planning, monitoring and inspection units, local authorities and health authorities.

The national centre and the response units will need to keep in regular touch with these bodies, to ensure the smooth exchange of information during an incident.

## Hazardous site inventory / register

In the disaster at Seveso, (Italy, 1976) where a chemical plant exploded, releasing dioxin, the local authorities were unaware of the presence of the chemical before the incident, and this greatly impeded the management of the incident. Since the incident, many countries have enacted legislation that requires all companies who manufacture, store, or use potentially hazardous chemicals in **certain quantities** to report into a **register**. Each company has to submit data on the types and quantities of each chemical present locally, and to produce, and lodge with the register **datasets** for each chemical. Some existing systems also require companies to report all 'releases' of each chemical at or above a set quantity.

*notification of high risk sites, transport routes and priority chemicals is increasingly being required*

Chemicals **transported** through the area, and chemicals **disposed of** in the local area but generated elsewhere, may be registered in other systems, and efforts can be made to have access to these as well. In addition, the establishment of a chemical incident surveillance system may identify the chemicals most often involved in local transportation-related incidents.

Internationally or nationally agreed lists of '**priority chemicals**' and classes of chemicals associated with significant health effects are available for help in prioritising chemicals. In addition to the basic information, the register should also include the chemical's potential interactions with the environment, adverse long- and short-term health effects, by-products or changes in form produced by combination with other chemicals or physical processes such as fire, dispersal or containment measures, and measures necessary to protect, decontaminate, and treat humans potentially exposed.

## Local functions

### Emergency response teams

Most countries now have well established structures, teams and plans for dealing with major emergencies and disasters. There is usually an on-site incident team, a receiving health care facility and a command structure. The police, fire and ambulance services are usually involved at both levels, with emergency planners sometimes being involved in the command structures.

*public health needs strong links with emergency response teams during an incident*

Public health / environmental health involvement is vital, both during the planning stages, and throughout an actual incident. During the planning phase, it is usually best if public health / environmental health is actually part of any planning team. During an incident, the public health / environmental health professionals will need

quick access to the secondary health care services and to all the sources of advice and information. The relationship with any command structure is therefore more complex. Depending on where the incident is, and the facilities available in the command site, a decision will need to be made as to whether the public health team joins the command team or sets up in its own offices and establishes links (via telephone or through a liaison officer) with the command structure and on-site teams. The purpose is to enable the public health advice to be given quickly and directly. However, by far and away the most effective input is to be in the same room as the emergency response teams, both tactical (silver) and strategic (gold), and to be part of the teams.

## Public health chemical incident control/management team

Forming a public health team for the control and management of the public health aspects of chemical incidents is the ideal approach. This team should operate in similar ways to the **outbreak control teams** often established during an infectious disease or food poisoning outbreak. Membership of the team needs to be established in advance of any incidents. The core members involved in most incidents will be personnel from the local public health / environmental health department (including specialists in epidemiology).

*a local  
public health /  
environmental  
health presence  
is necessary*

Depending on the incident itself and their proximity to the public health / environmental health department, other specialists, such as clinical toxicologists, medical practitioners and meteorologists should either join the team or be in easy telephone and e-mail contact. A matrix designating urgency and levels of response needed on one axis, and types of response / mix of skills needed on the other axis, can be used to establish the make-up of the team in planning scenarios involving local priority chemicals. These teams will be subject to review at the time of an actual incident, but may provide a framework for decision making and rapid alert.

Whenever an incident occurs, it is vital that relevant public health / environmental health professionals rapidly get together to manage the public health aspects of the incident and establish a rapid information flow between themselves and the command structure. This can be achieved by placing a liaison officer in the tactical or strategic command. This will ensure that first responders and any command structures receive appropriate advice without undue delay. Provisions should be made to recognise when an incident has escalated from one response level to a more severe level and who has the authority to declare a higher response level.

Local structures that contain public health and environmental health staff will be required across the country, at a level that enables them to have personal contact with all those involved in dealing with chemical incidents. These staff require sufficient **resources** for ongoing **training**, for conducting **epidemiological investigations** and for conducting the routine health surveillance necessary to

measure the impact of chemical incidents on the health of the public.

## Health care facilities

Health care workers need to be adequately informed, resourced with equipment (e.g. PPE), drugs and antidotes, and trained in the care of and decontamination of casualties likely to arise from incidents involving local chemicals. They also need access to adequate facilities (beds etc), to decontamination equipment and to have good liaison with first responders and information sources. All countries should have access to a specialist unit.

*health care facilities need preparation, and early warning*

## Decontamination facilities

Experience from many incidents has shown that secondary contamination of responders and health care workers and facilities, including ambulance, occurs often and has serious consequences. Secondary contamination occurs when a contaminated person is taken from the incident to another place, usually a hospital, before being decontaminated. Vehicles (ambulances), health care workers (ambulances officers, doctors, nurses and porters) and facilities can be secondarily contaminated by the fumes from or direct contact with the patient or their clothes. This can seriously disrupt the work of the secondary health care workers, causing the hospital to be closed and requiring decontamination, and can cause ill-health in those people secondarily contaminated.

The most serious risks of secondary contamination come from:

- highly toxic liquids, solids and finely divided solids such as organophosphate pesticides
- vapours which condense to liquids on clothing or skin
- radioactive liquids or dust
- biological agents including harmful viruses and bacteria.

Secondary contamination is highly unlikely if the patients have been exposed only to inhalation of gases or volatile liquids.

**Decontamination of casualties** and the public can be the responsibility of responders as diverse as the ambulance or medical or nursing staff, or the fire brigade. Decontamination equipment of casualties and the public is complex because the skin and or the clothes may be contaminated. Clothing needs to be removed without further contamination of the person or the operator and stored. The skin needs to be showered gently with large quantities of water. Depending on the local climate, warm or cold water should be used. Casualties may be either standing or stretchered. People should be decontaminated from head to foot. Great care will be needed with open wounds.

*decontamination of casualties, emergency responders and equipment, and the secondary contamination of health care staff and facilities needs to be planned for and resourced*

Sufficient decontamination equipment is needed to provide decontamination at the site of the incident of the casualties and the public. Various **mobile and portable** pieces of equipment are now available which can accommodate **standing** and **stretcher** cases, and provide **hot or cold water**. There will inevitably be occasions when contaminated patients arrive at the hospital. They may have been brought there rapidly for life saving procedures or by mistake. Often, ambulant patients make their own way to the hospital. For these eventualities, receiving hospitals need to have decontamination equipment installed or available to erect outside the accident and emergency department, with running water connected.

Decontamination of the emergency providers is the responsibility of the emergency services and will usually require less complex equipment.

# Appendices

- A - Drafting / editorial group**
- B - Working groups and conferences**
- C - Individuals contributing to the working groups**
- D - Conclusions from the IPCS working groups**
- E - Examples of major chemical incidents**
- F - Diagram of typical incident site risk zones**
- G - Diagram of pathways of exposure**
- H - Data sources**
- I - List of acronyms and contact addresses**
- J - Glossary**
- K - Bibliography and references**

**Part**

**4**

## Appendix A

# Policy document Drafting / editorial group

Dr Jeremy Queenborough - Consultant Public Health Physician, WHO Collaborating Centre for an International Clearing House for Major Chemical Incidents, UWIC, UK.  
Professor Gary Coleman - Professor of Environmental Health, and Director, WHO Collaborating Centre for an International Clearing House for Major Chemical Incidents, UWIC, UK.  
Professor Stephen Palmer - Medical Epidemiologist, and Chair of the Division of Public Health, University of Wales College of Medicine, UK.

With particular thanks to:

Dr Huw Bowen - Environmental Scientist, UK National FOCUS, UK.,  
Dr Diane Bennett - Researcher, USA.,  
for early working papers.

With particular thanks to:

Dr Marc Ruijten - Toxicologist, Environmental Health Unit, Rotterdam Municipal Health Services, Netherlands,  
for his significant individual contribution.

## Appendix B

# Working groups and conferences

1<sup>st</sup> International Toxicovigilance Conference. The Health Aspects of Chemical Accidents and their Follow-up. Cardiff, UK. 1 - 3 April 1993.

2<sup>nd</sup> International Toxicovigilance Conference. The Health Aspects of Chemical Accidents and their Follow-up. São Paulo, Brazil. 10 - 11 June 1994.

IPCS Workshop on International Toxicovigilance. The Health Aspects of Chemical Accidents and their Follow-up. Llangoed Hall, UK. 13 - 15 March 1995.

IPCS INTOX Working Group. Chemical Incident Response and Reporting. Llangoed Hall, UK. 25 - 29 March 1996.

IPCS INTOX Working Group. Harmonising Data Collection Formats, Data Reporting and Exchange. St Melons, Wales, UK. 10 - 14 March 1997.

IPCS INTOX Working Group. Chemical Incident Response and Reporting. Llangoed Hall, UK. 11 -13 March 1998.

The first conference and the workshops were funded by the Department of Health, UK, and organised by the WHO Collaborating Centre for an International Clearing House for Major Chemical Incidents, UWIC, Cardiff, Wales, UK, on behalf of the International Programme on Chemical Safety (IPCS). The second conference was hosted by CETESB (Brazilian State of São Paulo Environmental Sanitation Agency), and organised, on behalf of the IPCS, by the Toxicology Centre of the São Paulo Children's University Hospital.



## Appendix C

# Individuals contributing to the working groups

Mr Chris Aguirre - Firefighter, Miami Dade Fire Department, USA.  
Ms Gloria Alldridge - Information Scientist, National Poisons Unit, UK.  
Mr Ronnie Alexander - Welsh Chief Environmental Health Advisor, UK.  
Dr Lilia Albert - Associated Environmental Consultants, Mexico.  
Dr Christina Alonzo - Consultant Toxicologist, Ministry of Public Health, Uruguay.  
Mr Hubert Baratin - Ministry of Environment, France.  
Dr Nida Besbelli - Toxicologist, Toxicology Department and Poisons Centre, Turkey.  
Dr Huw Bowen - Environmental Scientist, UK National FOCUS, UK.  
Mr David Brophy - Canadian Centre for Occupational Health and Safety, Canada.  
Dr Donald Campbell - Consultant Public Health Physician, New Zealand.  
Mr Michel Cloutier - Transport of Dangerous Goods, CANUTEC, Canada.  
Professor Gary Coleman - Professor of Environmental Health, WHO Collaborating Centre for an International Clearing House for Major Chemical Incidents, UK.  
Professor Gareth Crompton - Professor of Public Health Medicine, UK.  
Professor Ralph Edwards - Medical Toxicologist, WHO Collaborating Centre for International Drug Monitoring, Sweden.  
Mr R Edwards - Assistant Chief Constable, Welsh Police Service, UK.  
Dr Ravindra Fernando - Toxicologist, National Poisons Information Centre, Sri Lanka.  
Dr Anthony Fletcher - Environmental Epidemiologist, UK.  
Dr George Forbes - Director of Environmental Health Unit, UK.  
Mr Stephen Fosh - Emergency Planning Officer, UK.  
Dr John Fountain - Medical Toxicologist, National Poisons Centre, New Zealand.  
Dr Mike George - Deputy Chief Medical Officer for Wales, UK.  
Mr Diego Gotelli - Toxicologist, CIQUIME, Argentina.  
Dr John Haines - International Programme on Chemical Safety, WHO, Switzerland.  
Mr Martin Hall - Environmental Scientist, UK National FOCUS, UK.  
Dr Kenneth Hartigan-Go - Medical Toxicologist, UP College of Medicine, Phillipines.  
Ms Georgie Jones - Director of External Affairs, ATSDR, USA.  
Dr Dana Kovalchick - Researcher, Washington Poisons Centre, USA.  
Dr Alexander Kuckuk - Medical Toxicologist, WHO European Centre for Environmental Health, Netherlands.  
Dr Lyse Lefèbrve - Toxicologist, Toxicology Centre for Quebec, Canada.  
Ms Marie Lindqvist - WHO Collaborating Centre for International Drug Monitoring, Sweden.  
Professor Timothy Meredith - Professor of Clinical Toxicology, Vanderbilt University, USA.  
Dr Jan Meulenbelt - Medical Toxicologist, WHO European Centre for Environmental Health, Netherlands.  
Dr Virginia Murray - Medical Toxicologist, Guy's and St. Thomas' NHS Trust, UK.

Dr Albert Nantel - Medical Toxicologist, Director of Toxicology Centre of Quebec, Canada.  
Dr Kim Noack - Toxicologist, Germany.  
Professor Stephen Palmer - Medical Epidemiologist, University College of Medicine, UK.  
Dr Sandra Payne - Consultant Public Health Physician, UK.  
Dr Jenny Pronczuk - Medical Officer, International Programme on Chemical Safety, WHO, Switzerland.  
Dr Harvey Prosser - Environmental Science Adviser, UK.  
Dr Corinne Pulce - Toxicologist, Lyons Poisons Centre, France.  
Dr Jeremy Queenborough - Consultant Public Health Physician, WHO Collaborating Centre for an International Clearing House for Major Chemical Incidents, UK.  
Mr Harley Quilliam - Computer Scientist, University of Surrey, UK.  
Dr Furtado Rahde, Toxicologist, Brazil.  
Dr Ir Marc Ruijten - Toxicologist, Environmental Health Unit, Rotterdam Municipal Health Services, Netherlands.  
Professor Phillip Routledge - Medical Toxicologist, Welsh National Poisons Unit, UK.  
Dr S Sans - Environmental Epidemiologist, UK.  
Mr Hank Sauer - Chemical Manufacturers Association, CHEMTREC, USA.  
Dr Jean Savelkoul - Medical Toxicologist, WHO Collaborating Centre on the Health Aspects of Chemical Incidents, Netherlands.  
Mr David Seal - Chief Environmental Health Officer, UK.  
Mr Peter Siberry - Fireman, Durham Fire and Rescue Service, UK.  
Dr Alan Spence - Director of Public Health Medicine, UK.  
Dr Wayne Temple - Toxicologist, National Poisons Centre, New Zealand.  
Ms Joanna Tempowski - Toxicologist, Medical Toxicology Unit, UK.  
Dr F van Leenwen - WHO Regional Office for Europe, Denmark.  
Dr Martin Wilks - Zeneca, UK.  
Ms Sandy Whitehead - Department of Health, UK.  
Dr Anthony Wong - Paediatrician and Medical Toxicologist, University of São Paulo, Brazil.



## Appendix D

# Conclusions from the IPCS working groups

### Current public health involvement

While the emergency services response to chemical incidents has continued to improve with the establishment of major incident plans and training and exercises, public health / environmental health professionals are **rarely involved**. This is due partly to a **lack of training and knowledge** on the part of public health / environmental health professionals, and partly a **lack of awareness** by the emergency services of the importance of considering the public health outcomes of their actions. Public health / environmental health professionals need their own specially designed specialist training, and joint training with the emergency services, and to be involved in the planning stages and part of the off-site command team during an incident.

### Baseline data and surveillance systems

There is a general **paucity of data** on both the short and long term **effects on human health** of a single short-term exposure such as those encountered in a typical chemical incident. Reports on incidents have rarely been published. This means that data about the relationship of the levels of the chemical (in the community, at the body and within the body) and the levels of mortality and morbidity (the dose-related health effects) are usually unavailable or unreliable. Therefore, it is usually not possible to predict the health outcome in any particular chemical incident.

When acute incidents are investigated environmental sampling may yield data on levels of contamination, but interpretation of the incident's contribution to the overall level is hampered by a general **lack of data on background levels of the chemical** in the environment. It is therefore often difficult to conclude that the level of the chemical found in a current incident represents a true additional exposure and consequently an additional health risk; and it is often difficult to define areas of land which may be considered high risk warranting the evacuation of residents.

Chemicals may react under certain conditions to produce substances which may themselves present greater hazards than the original chemicals. There is a need to identify possible **toxic products** which may be produced in chemical fires or explosions and to make this information available to public health / environmental health authorities for use at the scene of the incident and for the treatment of casualties.

Public health / environmental health authorities should review past incidents to identify reasons for successes and failure in detection, investigation and control of incidents. **Lessons learned** should be made available to policy makers and public health / environmental health officials. An important component of this process would be the establishment of **chemical incident surveillance systems**.

Countries should review the **legislative basis** for detection, control and follow-up of incidents. This should include the planning controls on chemical factories and the access to such information both for environmental risk assessment and for management of acute incidents.

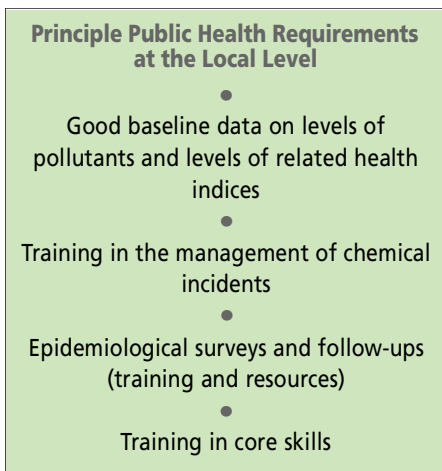
### Management of acute incidents

The management of chemical incidents is essentially a **multi-disciplinary process**. The services involved will be the emergency services whose primary task is to control the incident, the primary and secondary health care services dealing with the casualties and the public health / environmental health services whose task is to advise on the most appropriate control measures to achieve the best health outcomes for the population and the environment.

All countries need **24 hour** emergency access to expert **toxicological advice** in order to identify the likely health effects of exposure to chemicals; and to **secondary care services** to provide treatment. All counties should have access to **specialist clinical services**.

**Specialist public health / environmental health expertise** in investigation and control should also be provided by regional or federal units in support of **local public health / environmental health** authorities. It would be advantageous to link the surveillance responsibilities to these centres. The precise expertise and minimum resources required should be defined, including facilities for specialist environmental monitoring. The significant inputs of public health / environmental health professionals are in **best outcome assessment and assessing the short, medium and long term health impacts**.

At national, regional and local levels **plans** for the management of incidents should be developed and regularly evaluated by review of actual incidents and training and simulation exercises. The plans should identify roles and responsibilities of different tiers of administration and of key personnel, and the channels of communication within and between the agencies.



Two of the major problems faced in management of incidents are **communicating** appropriate information **to the public** and **responding** to public concerns. Failure to allay public concern during the incident may have serious long term consequences, for example a loss of confidence in the competency of officials, and an economic decline due to loss of confidence in the area by industry and commerce. Media and other reports may exaggerate or underestimate the scientific risks, sometimes leading to incorrect actions. There is a need to develop policies for working with the media so that balanced information is disseminated to the public.

The availability of on-site expert medical services and appropriate after-care for emergency personnel is a key aspect of appropriate management.

### **Uses of epidemiological methods**

Chemical incidents should be considered as 'natural experiments' from which we should advance our scientific understanding. In order to build up knowledge, incidents should be documented carefully in a way which will allow experiences to be compared. Reporting of incidents is to be encouraged and any reports should be made available to public health / environmental health authorities. IPCS / WHO have developed **standard guidelines and datasets** for the investigation and documentation of incidents including case definitions, recording and sampling criteria. Countries can use these to set up their own standardised information databases, and to contribute to the international database from which lessons for all countries can be learned.

**Follow-up studies and analytical epidemiological studies** will be necessary to measure the effects of exposure and to help identify the sources of contamination, the routes of exposure and the risk factors for contamination. Analytical epidemiological studies have proved to be vital tools in the investigation of infectious disease incidents, and are likely to be equally useful in chemical incidents. These standard methods of investigation and control should be adopted in all countries. Criteria for initiating follow-up studies should be developed. These criteria should include a consideration of the type of chemical, the number of casualties and deaths, and the number of people evacuated. The length of time for follow-up will need to be decided.

Pressure to conduct follow-up studies may arise from public concern or from the desire of those exposed to claim compensation. These issues should be distinguished and separated from the scientific criteria of collecting information about the incident and thence for future control.

Attention needs to be focussed on the **standardisation of exposure data** which will allow the valid comparison of follow-up health studies. Such exposure data usually need to be collected urgently and may have to be collected before a decision has been made to conduct a follow-up study and certainly during the acute phase of the incident. Currently, exposure

assessment during chemical emergencies is usually exclusively targeted at obtaining operational information. Risk assessment, and epidemiological studies, require a different measurement strategy. Plans for the management of incidents should take this requirement into account.

### **Training needs**

Analysis of previous incidents has shown that the specialist training needs for public health / environmental health professionals are:

- emergency planning
- emergency and crisis management
- hazard analysis
- risk assessment
- environmental epidemiology
- surveillance
- risk communication
- principle of basic toxicology
- clinical management of exposed patients
- biological / human monitoring
- environmental monitoring and modelling
- understanding the roles of the emergency services

for emergency responders are:

- the contribution of the public health / environmental professional to the prevention, control and management of chemical incidents

Most of this training should be done as joint training. The IPCS is developing a training package for public health / environmental health professionals and emergency responders.



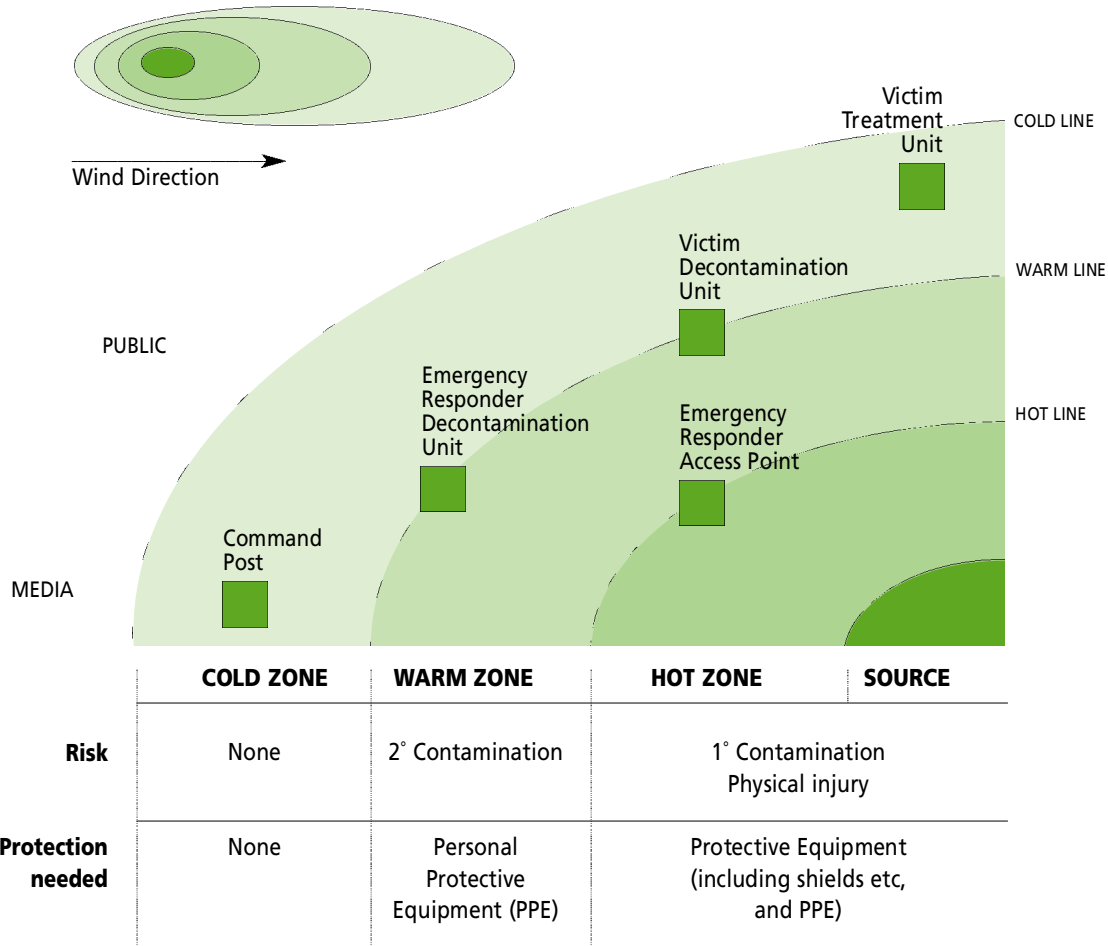
## Appendix E

# Examples of major chemical incidents<sup>1</sup>

Year	Location	Type of incident	Chemical(s) involved	Deaths	Injured	Evacuated
1970	Java, Indonesia	Tank fire	Kerosene	50		
1972	Duque de Brazil Caxias,	Process failure	Gas (LPG)	39	51	
1974	Flixborough, UK	Chemical plant (explosion)	Cyclohexane	28	104	3,000
1976	Seveso, Italy	Chemical plant (explosion)	Dioxin		193	226,000
1979	Novosibirsk, USSR	Plant	Chemicals	300		
1979	Toronto, Canada	Rail accident	Chlorine			730
1981	Madrid, Spain	Foodstuff contamination (oil)	as yet un-characterised	430	20,000	220,000
1982	Tacoa, Venezuela	Tank explosion	Fuel oil	153	20,000	40,000
1984	River Dee, UK	Drinking water contamination	Phenol		250 (2 million exposed)	
1984	San Juanico, Mexico	Tank explosion	Gas (LPG)	452	4248	200,000
1984	Bhopal, India	Chemical plant (leak)	Methyl isocyanate	2,800	50,000	200,000
1987	China	Misuse	Fertilisers		1,500	30,000
1992	Kwangju, Korea	Explosion at a gas store	Gas (LPG)		163	20,000
1993	Bangkok, Thailand	Fire in a toy factory	Plastics	240	547	
1993	Remeios, Columbia	Release	Crude Oil	430		
1996	Haiti	Poisoned medicine	Diethylene glycol	>60		
1998	Yaoundi, Cameroon	Transport accident	Petroleum products	220	130	
<b>Total of all incidents 24+ deaths or 125+ injured or 10,000+ evacuated 1970 - 1998</b>			<b>Incidents 350</b>	<b>Deaths 13,000</b>	<b>Injured 100,000</b>	<b>Evacuated 3,000,000</b>

1. taken from UNEP - LIST OF SELECTED ACCIDENTS INVOLVING HAZARDOUS SUBSTANCES 1998.  
A major incident is defined here as 25+ deaths or 125+ injured or 10,000 evacuated

# Appendix F Diagram of typical incident site risk zones



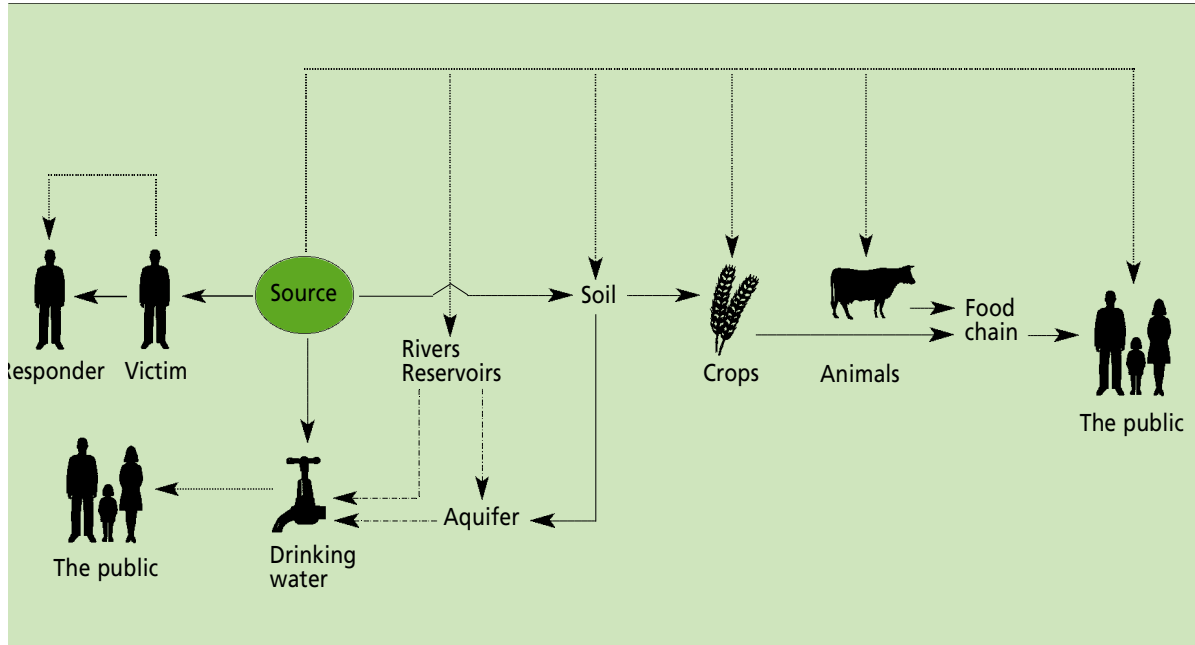
## Notes

1. Countries may use different terms or different layouts
2. Countries may use different layouts.
3. Risk may vary with the type of chemicals.
4. The layout should be determined locally and incorporated into the chemical incident plan.



# Appendix G

## Diagram of the pathways of exposure



### Pathways key

- > airborne
- - - - -> waterborne
- > other

# Appendix H

## Data sources

### Exposure guidelines

#### ERPGs - Emergency Response Planning Guidelines

These are airborne concentrations at which one might reasonably anticipate observing adverse effects from exposure to specific substances. The three ERPG levels vary with the health effects expected with exposure - transient symptoms, ability impairment, and life threatening. Guidelines for 77 chemicals have been published. The three bands are defined as:

ERPG-1: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odour.

ERPG-2 The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects of symptoms that could impair their abilities to take protective action.

ERPG-3: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.

They are published by the American Industrial Hygiene Association, tel:+1 703 207 3561.

#### AEGLs - Acute Exposure Guideline Levels

AEGLs concern acutely toxic airborne chemicals and are the threshold concentration levels at, or above, which specifically defined health effects are predicted to occur in humans. AEGLs are developed on a chemical-by-chemical basis. The three health effects for determining the threshold concentrations are: 1) death; 2) serious irreversible health effects or impaired ability to escape; and 3) detectability of the chemical and/or mild sensory effects. AEGL values for the three threshold concentrations are being developed for each of four exposure periods (30 minutes, 1 hour, 4 hours and 8 hours) to cover a wide range of applications.

AEGL-1: is the airborne concentration (expressed as ppm or mg/m<sup>3</sup>) of a substance at which it is predicted that the general population, including "susceptible" but excluding "hypersusceptible" individuals, could experience notable discomfort. Airborne concentrations below AEGL-1 represent exposure levels that could produce mild odour, taste, or other sensory irritation.



AEGL-2 is the airborne concentration (expressed as ppm or mg/m<sup>3</sup>) of a substance at which it is predicted that the general population, including “susceptible” but excluding “hypersusceptible” individuals, could experience irreversible or other serious, long lasting effects or impaired ability to escape. Airborne concentrations below AEGL-2 but at or above AEGL-1 represent exposure levels that may cause notable discomfort.

AEGL-3 is the airborne concentration (expressed as ppm or mg/m<sup>3</sup>) of a substance at which it is predicted that the general population, including “susceptible” but excluding “hypersusceptible” individuals, could experience life-threatening effects or death. Airborne concentrations below AEGL-3 but at or above AEGL-2 represent exposure levels that may cause irreversible or other serious, long lasting effects or impaired ability to escape.

Published by the National Advisory Committee, USA.

#### **Air Dispersion Models**

There are many computer air dispersion models available, and these can be used in scenario planning to predict likely dispersion patterns, and during an incident to estimate actual dispersion. See '[www.wrc.noaa.gov/sites/hazmat/cameo/aloha.html](http://www.wrc.noaa.gov/sites/hazmat/cameo/aloha.html)' for a list of some of them.

## **Human health and the environment**

#### **Environmental Health Criteria**

Descriptions of the risks posed by 120 chemicals on the environment and the health of humans are published as Environmental Health Criteria documents by the IPCS, and are helpful for authorities in establishing policies for the safe use of these chemicals.

#### **Federal Register**

Toxicological profiles of the 275 hazardous substances on the Federal Register are available from:

ATSDR  
Division of Toxicology / Toxicology Information Branch  
1600 Clifton Road NE, E - 29  
Atlanta, Georgia 30333.

## **CHEMET**

CHEMET is a subscription service to the Police and Fire Brigades of the UK. It provides rapid advice on current local meteorological patterns in the event of an incident, and dispersion risk advice.

## **Inventories**

### **Inventory of Information Sources on Chemicals:**

Available from Intergovernmental Organisations, Geneva, 1996.  
(<http://irptc.unep.ch/irptc/invent/igo.html>)

## **Medical management**

### **Antidote Series**

Describes the antidotes available to a wide variety of chemicals. Available from IPCS.

### **Guidelines**

Guidelines for the medical management of acute chemical exposure to about 30 chemicals are available from ATSDR. <http://atsdr1.atsdr.cdc.gov:8080>

### **Toxline**

Electronic database of the medical effects of chemicals. Produced by the US National Library of Medicine. <http://igm.nlm.nih.gov>

### **Exposure Register**

The ATSDR has created an exposure register to monitor the long term health effects in people exposed to hazardous substances from toxic waste sites investigated by the Agency.

## **Occupational health and safety**

### **ICSCs - International Chemical Safety Cards**

Summaries of essential product identity data and health and safety information on chemicals, and designed for the shop floor level, are available from IPCS.

### **ILO -CIS International Occupational Health and Safety Information Centre**

This centre, assisted by 70 national centres, provides information about:

- Laws, regulations and directives,



- Chemical safety information sheets
- Training materials.

Information is available from ILO-CIS, CH - 1211 Geneva 22, Switzerland.

#### **HSGs - Health and Safety Guides.**

Short documents summarising the toxicity information in nontechnical language, and providing advice on safe storage, handling and disposal of chemicals, through to the treatment of exposed cases. Designed for administrators, managers and decision-makers in government and industry. IPCS: Geneva.

#### **Material Safety Data Sheets**

Produced by the chemical manufacturers in a wide variety of formats and data quality, and aimed primarily at employers of people handling chemicals.

#### **Occupational exposure limits**

Summaries are available from the Health and Safety Executive, Broad Lane, Sheffield, S3 7HQ, UK Tel: +44 114 289 2345.

#### **Pesticide Data Sheets**

Sheets for some 80 pesticides are available from IPCS.

#### **TOMES - Toxicological Occupational Medicine and Environmental Series**

This is a proprietary collection of databases including:

MEDITEXT

HAZARDTEXT

SARATEXT

INFOTEXT

RIPROTEXT

CHRIS - Chemical Hazard Response Information Service (US Coastguard)

HSDB - Hazard Substances Database, US Library of Medicine (available on subscription).

#### **TREMCARDS - Transport Emergency Cards**

These are some 800 cards, intended to be carried in the vehicle cab, giving basic information about the chemical and emergency instructions.

Available from the European Chemical Industry Council (CEFIC).

<http://cefic.be/activities/logistics/>

## Poisons information

### IPCS INTOX Package

This is a software and CD-ROM data source to assist Poisons Information Centres. It is produced by over 100 experts and is updated regularly. The software system contains five classification schemes:

- a classification of chemical and pharmaceutical substances
- a classification of poisonous plants
- a classification of animals
- a use or function classification
- a classification of clinical features of poisoning.

It is available from IPCS.

### UKPID - United Kingdom Poisons Information Database.

Accessed via UK poisons units. Other countries may well have their own internal database.

## Priority chemicals

### Federal Register, April 29 1996. (61 FR 18744)

List of 275 hazardous substances most commonly found ( at facilities on the CERCLA\* National Priorities List) and that pose the most significant potential threat to human health, as determined by ATSDR and the EPA.

(\* Comprehensive Environmental Response, Compensation, and Liability Act 1980)

### IRPTC - International Register of Potentially Toxic Chemicals

This was established in 1976 by UNEP, the United Nations Environment Programme.

Further information on the chemicals can be obtained from:

IRPTC / UNEP, Palais des Nations,  
1211 Geneva 10, Switzerland.

Tel: +41 22 798 8400



## Appendix I

# List of acronyms and contact addresses

### **APELL**

#### **AWARENESS AND PREPAREDNESS FOR EMERGENCIES AT LOCAL LEVEL**

This is part of the United Nations Environment Programme and is a programme aimed at preventing technological accidents and their impacts by assisting decision makers and their technical personnel to improve community awareness of hazardous installations, and in preparing response plans.

Tour Mirabeau  
39 - 43 Quai André Citroën  
75739 Paris Cedex 15  
France.  
e-mail: Unepie@unep.fr  
website: <http://www.unepie.org>

### **ATSDR**

#### **AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY**

is a federal Public Health Services agency and part of the US Department of Health and Human Services. Its stated mission is to prevent exposure and adverse human health effects and diminished quality of life associated with exposure to hazardous substances from waste sites, unplanned releases and other sources of pollution present in the environment. Further information is available from:

1600 Clifton Road  
Atlanta  
GA 30333  
USA.  
website: <http://atsdr1.atsdr.cdc.gov>

### **AWEHSP**

#### **THE ALL-WALES ENVIRONMENTAL HEALTH SURVEILLANCE PROJECT**

A database of chemical incidents in Wales notified by a number of agencies over a 3 year period 1993 - 1995.

### **HSEES**

#### **THE HAZARDOUS SUBSTANCES EMERGENCY EVENTS SURVEILLANCE SYSTEM**

A chemical incident surveillance system run by ATSDR and covering 14 states and a population of 80 million. See Bibliography.

## ICE NETWORK

### INTERNATIONAL CHEMICAL ENVIRONMENT NETWORK

This is a network set up by the international chemical industry to provide information, advice and resources to the emergency authorities. Further information is available from:

Austria	FCIO	+ 43 1 50105
Czech Republic	SCHP	+ 420 2 671 54131
Denmark	FDKI	+ 45 33 151748
Finland	KT ry	+ 358 9 172841
France	UIC	+ 33 1 465 31100
Germany	VCI	+ 49 69 25560
Hungary	MAVESZ	+ 36 1 343 8920
Italy	Federchimica	+ 39 2 268101
Netherlands	VNCI	+ 31 70 337 8787
Spain	FEIQUE	+ 34 91 431 7964
Sweden	Kemikontoret	+ 46 8 783 8000
Switzerland	SGCI/SSCI	+ 41 1 368 1711
United Kingdom	CIA	+ 41 171 834 3399.

## ILO

### INTERNATIONAL LABOUR ORGANISATION

The ILO, as a collaborating organization in the IPCS, contributes to the IPCS its technical work in the field of chemical incident prevention, preparedness and response. Following major industrial incidents such as those of Bhopal, Seveso and Mexico City, the ILO accelerated its activities in the field of the prevention of major industrial incidents and the mitigation of their consequences, including work on emergency preparedness. The ILO has since published a manual on major industrial incidents and executed a number of technical co-operation projects on the organisation of major hazard control systems in developing countries. For more information, contact:

4, route des Morillons  
CH -1211 GENEVA 22  
Switzerland.  
Tel: +41 22 799 6111  
Fax: +41 22 798 8685



**INTOX**

Poisons Information Package for Developing Countries

For more information, see Data Sources Appendix H.

**IOMC**

INTER-ORGANIZATION PROGRAMME FOR THE SOUND MANAGEMENT OF CHEMICALS

was established in 1995 by UNEP, ILO, the Food and Agriculture Organization of the United Nations, WHO, the United Nations Industrial Development Organization, and the Organisation For Economic Co-operation and Development (Participating Organizations), following recommendations made by the 1992 United Nations Conference on Environment and Development to strengthen cooperation and increase coordination in the field of chemical safety. The purpose of the IOMC is to promote coordination of the policies and activities pursued by the Participating Organizations, jointly or separately, to achieve the sound management of chemicals in relation to human health and the environment.

**IPCS**

INTERNATIONAL PROGRAMME ON CHEMICAL SAFETY

During the 1970's, international concern about the dangers of chemicals for humanity and the natural environment led to the establishment in 1980 of the International Programme on Chemical Safety (IPCS) by the World Health Organisation (WHO), the United Nations Environment Programme (UNEP) and the International Labour Organisation (ILO).

The IPCS, located at WHO headquarters in Geneva, was set up to provide an internationally-evaluated scientific basis on which countries could develop their own chemical safety measures, and to strengthen national capabilities for the prevention and treatment of the harmful effects of chemicals and for managing the health effects of chemical emergencies.

In fulfilling its mandate, the IPCS works with other international, intergovernmental and non-governmental organisations, associations and professional bodies which have important activities in the field of chemical safety. Since its establishment, the IPCS has disseminated international evaluations of some 120 chemicals and groups of chemicals, 1205 food additives, 655 residues of pesticides and 30 residues of veterinary drugs in food. These evaluations are published in different types of documents adapted to the needs of the user, ranging from the scientist and technical expert, the administrator and decision maker to the person at the shop floor. Some 14 volumes have been published on the methodology of risk assessment, including validation of test methods. A series of major

activities to support the national poisons control programmes has been established, including preparation of the INTOX poisons information package and evaluation of the efficacy of antidotes and other substances used to treat the harmful effects of chemicals. Some 500 training courses have been organised throughout the world.

For more information, contact:

IPCS/WHO  
20 avenue Appia  
CH -1211 GENEVA 27  
Switzerland.  
Tel: +41 22 791 3588  
Fax: +41 22 791 4848  
<http://www.who.int/pcs>

### **IUPAC**

INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY

The main international governing body for the naming of chemicals and analytical techniques. For more information, contact:

PO Box 13757  
Research Triangle Park  
North Carolina  
27709-3757  
USA.  
Tel: +00 1 919 485 8700  
email: [secretariat@iupac.org](mailto:secretariat@iupac.org)

### **NATIONAL FOCUS**

NATIONAL FOCUS FOR WORK ON RESPONSE TO CHEMICAL INCIDENTS AND SURVEILLANCE OF THE HEALTH EFFECTS OF ENVIRONMENT CHEMICALS

For more information, contact:

University of Wales Institute, Cardiff  
Western Avenue  
Cardiff  
CF5 2YB  
UK.  
Tel: +44 1222 506381  
Fax: +44 1222 506387  
e-mail: [nfocus@uwic.ac.uk](mailto:nfocus@uwic.ac.uk)



**OECD****ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT**

The OECD is an inter-governmental organisation grouping of 24 industrialised countries. It provides a forum where member countries discuss issues of common interest, and where they co-ordinate and, as appropriate, harmonise their national policies. In particular, the OECD has published the Guiding Principles (see above), two User Guides, on chemical databanks and information systems, and a directory of Emergency Response Centres.

For more information, contact:

2, rue André-Pascal  
F-75775 Paris Cédex 16  
France.  
Tel: +33 1 45 248200  
Fax: +33 1 45 248500  
<http://www.oecd.org/>

**UNCED****THE UNITED NATIONS CONFERENCE ON ENVIRONMENT AND DEVELOPMENT**

The promotion of effective international co-operation with respect to the prevention of, preparedness for, response to and rehabilitation of emergencies and incidents involving chemicals is one of the important aspects of environmentally sound management of chemicals identified by UNCED, the United Nations Conference on Environment and Development held in 1992. The IPCS provides the health and medical aspects of this area of international co-operation.

**UNEP****UNITED NATIONS ENVIRONMENT PROGRAMME**

For more information, contact:

PO Box 30552  
Nairobi  
Kenya.  
Tel: +254 2 26 1234  
Fax: +254 2 22 6886  
<http://www.unep.ch/>

**WHO****WORLD HEALTH ORGANISATION**

For more information, contact:

WHO  
20 avenue Appia  
CH -1211 GENEVA 27  
Switzerland.  
Tel: +41 22 791 2111  
Fax: +41 22 791 0746  
<http://www.who.ch/>

**WHO CCs****WHO COLLABORATING CENTRE FOR AN INTERNATIONAL CLEARING HOUSE FOR MAJOR CHEMICAL INCIDENTS**

See page 78 and 79 for further details.

For more information, contact:

University of Wales Institute, Cardiff  
Western Avenue  
Cardiff  
CF5 2YB  
UK.  
Tel: +44 02920 416852  
Fax: +44 02920 416803  
e-mail: [healthchem@uwic.ac.uk](mailto:healthchem@uwic.ac.uk)  
<http://www.healthchem.uwic.ac.uk>

**WHO COLLABORATING CENTRE ON THE HEALTH ASPECTS OF CHEMICAL ACCIDENTS**

See page 79 for further details.

For more information, contact:

National Institute of Public Health and Environmental Protection  
Utrecht University Hospital  
PO Box 85500  
3508 GA Utrecht  
The Netherlands.



## Appendix J

# Glossary

The following glossary is provided only to assist the reader of this document. It is important to recognise that, for many terms, there are no internationally agreed definitions. Therefore countries should only use these definitions after careful review.

- acute effects effects that occur rapidly following exposure and are of short duration (WHO 1989)
- acute exposure chemical exposure of less than 14 days
- acute public health chemical incident a public health chemical incident where the exposure dose is rising, or is likely to rise rapidly and where rapid public health measures may limit the exposure
- aetiology assignment of a cause, philosophy of causation
- at risk where an individual or population is threatened by a chemical release
- bio-availability the extent to which a chemical substance to which the body is exposed (by ingestion inhalation, injection or skin contact) reaches the systemic circulation and the rate at which this occurs (WHO 1989)
- bio-accumulation the process by which the amount of a substance in a living organism (or its parts) increases with time (WHO 1989)
- chemical incident an uncontrolled release of a chemical from its containment
- chronic effects effects that develop slowly and have a long duration. They are often, but not always, irreversible. Some irreversible effects may appear a long time after the chemical substance was present in the sensitive tissue. In such cases, the latent period (or time to occurrence of an observable effect) may be very long, particularly if the level of the exposure is low (WHO 1989)
- contaminated the presence of a substance in or on an environmental medium or surface, that has the potential to pollute. It usually applies to situations where there is a danger of secondary exposure to people or animals.

- emergency an incident that has passed the control capability of one emergency service
- emergency responders all the services that come together, off-site and on-site, to deal with an incident - fire, police, ambulance, water, food, port, public health / environmental health
- emergency services fire, police and ambulance services. Sometime search-and-rescue
- epidemiology the study of the distribution and determinants of health -related states or events in populations and the application of this study to control health problems (WHO 1989)
- exposure where the released chemical has reached the portal of entry of a person
- exposure limit a general term implying the level of exposure that should not be exceeded (WHO 1989)
- first responders the people from the services that attend the scene of an incident - fire, police, ambulance, site employees
- hazard the latent property of a substance which makes it capable of causing adverse effects to people or the environment under conditions of exposure and contamination
- latent period time from contamination to occurrence of an observable effect
- odds ratio the ratio of the odds of exposure among cases to the odds of exposure among controls
- pathway of exposure the route that a chemical takes through environmental media from its release to the portal of entry at the human body
- pollution the presence in a medium of a pollutant(s) in concentrations great enough to interfere, directly or indirectly, with man's comfort, safety, health or enjoyment of his property
- portal of entry the point at which a chemical enters the body - skin, eyes, lungs or digestive tract



- prevalence the number of cases in a defined population at a specific point in time
- primary contamination direct contact of the person with the chemical contaminant
- public health chemical incident an incident where two or more members of the public are (threatened to be) exposed to a chemical
- rehabilitation the restoration of normal functioning of people and communities
- relative risk same as risk ratio (see below)
- remediation the process of making the environment clean and safe
- restitution the process of returning the environment to its original state
- risk assessment the identification of environmental health hazards, their adverse effects, target populations and conditions of exposure. A combination of hazard identification, risk estimation, exposure and risk characterisation
- risk communication the process of sharing information and perceptions about risk. It should be a two-way interaction in which experts and non-experts exchange and negotiate perceptions relating to both scientific and community values and preferences
- risk estimation the quantification of dose-effect and dose response relationships for a given environmental agent, showing the probability and nature of the health and environmental effects of the agent
- risk management the managerial, decision-making and control processes to deal with those environmental agents for which risk assessment has indicated that the risk is too high (WHO 1989)
- risk of the probability of the occurrence of an adverse event. A term that should be avoided in preference to 'probability of'
- risk ratio the ratio of the incidence of a disease among exposed people to the incidence of the disease among unexposed people

- **risk to** the probability of the occurrence of an adverse effect from a substance on people or the environment combined with magnitude of the consequences of that adverse effect
- **secondary contamination** the transfer of chemical from a contaminated person (usually from their clothing, skin, hair or vomitus) to personnel or equipment, directly or as off-gassing
- **toxicity** the capacity of a substance to cause injury to a living organism. A highly toxic substance will cause damage in small quantities, whilst a substance of low toxicity will need large quantities to produce an effect. Toxicity is also dependant on the portal of entry, the time frame of exposure and the latent period. (WHO 1989)
- **triage** the assessment of the clinical condition of exposed individuals with designations of priorities for decontamination, treatment and transportation.



## Appendix K

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