The World Health Organization is a specialized agency of the United Nations with primary responsibility for international health matters and public health. Through this Organization, which was created in 1948, the health professions of over 190 countries exchange their knowledge and experience with the aim of making possible the attainment by all citizens of the world of a level of health that will permit them to lead a socially and economically productive life.

The WHO Regional Office for Europe is one of six regional offices throughout the world, each with its own programme geared to the particular health problems of the countries it serves. The European Region embraces some 860 million people living in an area stretching from Greenland in the north and the Mediterranean in the south to the Pacific shores of the Russian Federation. The European programme of WHO therefore concentrates both on the problems associated with industrial and post-industrial society and on those faced by the emerging democracies of central and eastern Europe and the former USSR. In its strategy for attaining the goal of health for all the Regional Office is arranging its activities in three main areas: lifestyles conducive to health, a healthy environment, and appropriate services for prevention, treatment and care.

The European Region is characterized by the large number of languages spoken by its peoples, and the resulting difficulties in disseminating information to all who may need it. Applications for rights of translation of Regional Office books are therefore most welcome.

Assessing the health consequences of major chemical incidents – epidemiological approaches

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Contents

Foreword

Chemical incidents can have serious and widespread effects on health. Epidemiology is an important tool for evaluating these effects and thus supplying information on which to base action to deal with a current incident and to help prepare for future ones. Such action helps to create environments conducive to health, which is one of the primary goals of the WHO European strategy for health for all.

Epidemiologists can make a valuable contribution to each phase of a chemical incident: preparedness, response and follow-up. Recognizing this, the WHO European Centre for Environment and Health convened a working group to discuss and set out some of the most effective epidemiological approaches to chemical incidents. This book is the result of the group's work.

This publication aims to promote awareness of the role of epidemiology in the management of chemical incidents. It identifies the special part that epidemiology can play in a coordinated multidisciplinary response to a chemical incident, the tools to use in health risk assessment and roles in supportive activities such as training and the dissemination of information. The book supports and illustrates its arguments with examples showing the contributions of epidemiology to the management of four major incidents in Europe: the fire at Schweizerhalle, the Seveso accident, the grounding of an oil tanker in Scotland and the toxic oil syndrome in Spain.

Realizing the potential contribution of epidemiology to the management of chemical incidents is an important step in creating an effective multidisciplinary response. Such a response could help to protect health by offering better assistance to people exposed to current incidents and improving preparedness for future events.

J.E. Asvall
WHO Regional Director for Europe

Preface

The rapid industrialization of the last two centuries has often caused environmental contamination far beyond the confines of the industrial sector. Further, as the size and scale of industrial activities have increased, a number of dramatic industrial accidents, such as those at Seveso and Bhopal, have heightened public awareness of the potential risks of such activities to the health of the surrounding population and to the environment. Public concern is more acute when the nature and toxicity of the chemicals discharged are uncertain, the extent of environmental contamination is unknown, and the health consequences are poorly understood. Exposure to chemicals may cause new, previously observed diseases or exacerbate diseases of another etiology.

Epidemiology is an important tool for evaluating the health consequences for populations exposed to chemicals as a result of chemical incidents or environmental contamination. Many parallels can be drawn with the use of classical epidemiology in the investigation of infectious diseases. Further, epidemiological methods may be used to evaluate the effectiveness of activities to reduce the health effects of exposure to chemicals.

The participants in the United Nations Conference on Environment and Development, held in Rio de Janeiro in June 1992, noted that gross chemical contamination of the environment with grave damage to human health, genetic material and reproductive outcomes has arisen in recent times in some of the world's most important industrial areas. They defined an international strategy for the environmentally sound management of chemicals within the principles of sustainable development and improved quality of life for humankind. The participants recognized, however, that both national and international efforts need significant strengthening to carry out this strategy. They identified the promotion of international cooperation in the prevention of and response to chemical accidents as an important aspect of the process.

Over the past 15 years, both the WHO Regional Office for Europe and the International Programme on Chemical Safety (IPCS) (a joint venture of WHO, the International Labour Organisation (ILO) and the United Nations Environment Programme (UNEP)) have taken a number of important initiatives in the prevention of and response to chemical accidents. *Planning emergency response systems for chemical accidents*[1] was issued in 1981. In 1987, jointly with the International Council of Scientific Unions (ICSU) Scientific Committee on Problems of the Environment (SCOPE), IPCS published *Methods for assessing and reducing injury from chemical accidents*.[2] In 1994, IPCS and the WHO European Centre for Environment and Health collaborated with the Organisation for Economic Co-operation and Development (OECD) and UNEP on *Health aspects of chemical accidents*,[3] giving guidance on chemical accident awareness, preparedness and response for health professionals and emergency response personnel. At present, IPCS is developing guidelines on the role of the public health sector in chemical incident preparedness, response and follow-up, directed specifically at public health policy-makers to help them establish the necessary administrative infrastructure and measures. These guidelines do not deal with the technical aspects and the tools involved, but recognize the need for specific publications on these topics, such as epidemiological methods.

This publication complements those already cited and is directed specifically at the public health official or epidemiologist who may need to plan or undertake an epidemiological study of populations exposed to chemicals through major accidents or environmental contamination. It is meant to promote awareness of the role of epidemiology among public health professionals managing chemical incidents and to describe some tools for

[1] *Planning emergency response systems for chemical accidents. Administrative guidelines*. Copenhagen, WHO Regional Office for Europe, 1981 (document).

[2] *Methods for assessing and reducing injury from chemical accidents*. Geneva, World Health Organization, 1987.

[3] *Health aspects of chemical accidents*. Paris, Organisation for Economic Co-operation and Development, 1994 (OECD Environmental Publication, OECD/GD (94)1).

designing and implementing studies, but not to be a detailed technical manual.

After an initial consultation in 1994 and discussion on the need for such a publication at the forum of the European Concerted Action "Air Pollution Epidemiology", the WHO European Centre for Environment and Health set up the Working Group on Epidemiological Approaches to Assessment of Health Consequences of Accidents and Disasters. At its first meeting in Basle on 12–13 January 1995, the Group examined the epidemiological investigations that had followed a number of well known chemical accidents, to identify the key elements of these investigations as the basis for a guideline document. The Group drew up the outline of the present publication and assigned the sections to be drafted to various experts. The Working Group examined the first draft of the document at a meeting in Bilthoven on 4–5 May 1995. The Editorial Group edited the draft and circulated it for peer review. A summary was presented for discussion at the annual Meeting of the International Society for Environmental Epidemiology in August 1995. As a result of this discussion, and using comments on the draft from the Working Group members and the invited reviewers, the Editorial Group prepared a final version that was reviewed again by the members of the Working Group.

This work was made possible through the financial support of the Government of Switzerland, which is gratefully acknowledged.

I believe that the Working Group has created a good basis for the application of environmental epidemiology to the management of chemical incidents, and that its work will contribute to a reduction of associated health effects.

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Introduction: definition and health effects of chemical incidents

Definition

For the purposes of this publication, the terms "chemical accident" or "chemical incident" refer to an event resulting in the release of a substance or substances hazardous to human health and/or the environment in the short or long term. Such events include fires, explosions, leakages or releases of toxic substances that can cause people illness, injury, disability or death.

The terms accident and incident tend to be used interchangeably. Accident is used most widely to refer to technological failure in a chemical plant or spillage during the transport of a chemical load. The term incident is preferred, because it embraces unanticipated failures in the integrity of a storage container, as well as events involving human error, sabotage, or social and organizational factors.

Chemical incidents may manifest their presence in one of two ways: a failure in the containment of chemicals, with or without exposure of workers or the population, or an outbreak of illness.

This publication focuses on incidents with a known release of chemicals into the environment. The methodology applied in the investigation of the second type of incident is the subject of an earlier WHO report *(1)*.

Routes of Exposure

Human exposure to chemical releases can occur through air, food and drink, water or direct dermal contact with the chemical. Chemical fires and releases into the air due to failures of production, storage containers, road and rail tankers or pipelines are the most common incidents involving human exposure. This book therefore focuses on these as the most important public health risks.

Incidents involving drinking-water supplies have not been very important worldwide because most chemical contaminants are readily detectable by smell or taste, and thus people usually avoid drinking water containing them. Foodborne incidents, on the other hand, have given rise to major outbreaks of chemical-induced disease, such as toxic oil syndrome (see Annex) and organic mercury poisoning. Epidemiologists need to be aware that apparently inexplicable disease outbreaks may be the first evidence of a toxic release into the community.

Health Outcomes of Chemical Disasters

Although chemicals have specific modes of action and adverse effects, in most instances the mechanisms and health outcomes of exposure are unknown. In general, the adverse responses to toxic exposures may be:

- effects that are local or arise at the site of contact with the chemical, such as bronchoconstriction from respiratory irritants or irritation of the skin and eyes by irritant gases;
- effects that are systemic or affect organ systems remote from the site of absorption, such as depression of the central nervous system from absorption of solvents through the skin, or necrosis of the liver from the inhalation of carbon tetrachloride; and
- effects on mental health arising from real or perceived releases, which depend on the psychological stress associated with an incident.

Mental effects can arise from disturbing experiences such as traumatic death, or fears of chronic impairment or stigmatization from chemical contamination. Post-traumatic stress disorder, chronic anxiety and depression may be prominent and lead to measurable outcomes. Acute anxiety from the fear of chemical contamination alone can induce physical states that mimic acute, toxic reactions and may lead to diagnostic confusion.

The timing of the adverse health effects after exposure may vary. Acute effects appear within seconds or minutes, and include eye irritation, bronchoconstriction or pulmonary oedema. Subchronic effects appear within hours or days, and include delayed pulmonary oedema from phosgene, or renal failure in arsenic poisoning. Chronic effects appear weeks to years after exposure. These may be of the greatest concern in an incident, even in the absence of any casualties with acute or subchronic effects, and may include cancer and reproductive abnormalities.

Chemical-induced disorders can manifest themselves in any organ system. Because the body has only a limited repertoire of disease responses, the signs and symptoms may resemble diseases arising from other causes. Unless the disorder is highly specific to the particular agent, epidemiological studies may be necessary to determine whether the occurrence of a disease in a population has increased as a result of chemical exposure.

Factors Determining and Modifying Health Impairment

In investigations of chemical incidents, the main factors to be considered are the toxicity of the chemical and factors influencing exposure and dose, such as exposure routes, physical characteristics of the chemical(s) involved and the presence of other potentiating particles and substances in the release. These may lead to heterogeneous effects within the exposed population; another important factor is differences in susceptibility between individuals.

Toxic effects can depend on the peak levels and the duration of exposure, as well as the dose of the chemical. The behaviour of individuals following the incident determines exposure and dose. For example, extreme fear and lack of preparedness may increase exposure to gases by making people flee into the path of a gas cloud, hyperventilate, or fail to take the appropriate protective measures. In the Bhopal disaster, those who ran in response to the chaos inhaled larger quantities of methyl isocyanate, which caused pulmonary oedema and instant death. The availability of emergency care should be considered when assessing outcomes. For example, the time taken to reach decontamination or medical facilities may be important. Finally, an inappropriate or poorly managed emergency response can become a kind of disaster in itself, with psychological and socially disruptive consequences.

Responses in target organs may vary widely in different individuals exposed to the same doses. There are three main mechanisms for differences in susceptibility:

- increased absorption
- increased effects with equally absorbed doses
- lower threshold of effects.

For example, chemicals may be absorbed more readily through the gastrointestinal tract than through the skin, and by children than by adults. Children absorb lead faster through the intestines than through the skin. The newborn have a much higher capacity than adults for percutaneous absorption of lindane from applications of scabicidal agents. In the contamination of food and drink, dietary constituents may alter the bioavailability of the chemical.

As to increased effects from equally absorbed doses, people with a slow acetylator phenotype may have a higher probability than others of contracting bladder tumours from carcinogenic aromatic amines. They metabolize a larger proportion of these amines to reactive compounds that induce such tumours.

As to a lower threshold of effects, a pre-existing health condition may reduce the body's reserve capacity. Well known examples include the sensitivity of asthmatics to exposure to low levels of sulfur dioxide, and that of patients with coronary heart disease to exposure to carbon monoxide. In addition, nutritional deficiencies may increase the risk of toxic reactions.

More examples could be drawn from experience with chemical exposures in occupational settings, but little information is available on individual susceptibility to brief exposures in chemical incidents. For example, human or experimental data are insufficient to allow dogmatism about the likely heterogeneity of effects of single, brief exposures to chemical carcinogens or teratogens. In general, the most susceptible to chemical insults are people at the extreme ends of the age range and those with physiological variants. Such people comprise up to 25% of the total population.

Community vulnerability may be reduced by minimizing the degree of exposure in a chemical incident and influencing individual susceptibility. Socioeconomic or political factors, as well as housing conditions and nutritional habits common to all communities, should be considered in all phases of chemical incident management.

Need for Systematic Health Risk Assessment

In major chemical incidents, the emergency services function as they would in major accidents or fires. The obvious priority is to rescue people, to put an end to the fire or the release of chemicals, and to avoid further casualties, damage and confusion. Firefighters, police officers and ambulance crews all have their assigned tasks and might – in the case of a chemical incident – be exposed while fulfilling their duties. In addition to these activities, however, there is a need to investigate the health impact, pool available data, search the literature, contact outside experts, propose necessary further investigations and advise on preventive measures. An epidemiological team, working within the framework of the emergency response group, can fulfil these tasks.

Structure of this Publication

This monograph is arranged in three parts. Chapter 1 addresses the role of epidemiologists in the immediate and longer-term aftermath of a major chemical incident. A rationale and context for employing an epidemiological approach is provided, as well as several recommendations for the proper placement of epidemiological activities vis-à-vis the other vital medical activities that may be required. Chapter 1 also presents important ethical considerations that need to be considered as part of the epidemiological response. Recommended epidemiological activities are described within the three phases of the health assessment: planning and preparedness, acute response and follow-up.

Chapter 2 is intended for epidemiologists and related health professionals participating in the health assessment following a chemical incident. This chapter provides a comprehensive set of practical measures to be taken during the three phases of the health assessment. While a basic familiarity with the terminology, concepts and methods of epidemiology is assumed, the references cited can provide additional study or support for people who will be involved in these health assessments and need further information.

Chapter 3 discusses the need for collaboration between epidemiologists and other professionals participating in a health assessment. It recommends a collaborative, interdisciplinary approach, but does not suggest that epidemiology is any more important than other areas involved in the response. In fact, it is as part of a broad, multidisciplinary approach that epidemiology's tangible benefits will be observed. Chapter 3 also covers issues related to the communication and dissemination of information resulting from health assessments, and training needs.

Examples illustrating the principles presented in the text are offered wherever possible. Additionally, an Annex is provided, containing several case studies of health assessments following significant chemical incidents. These can only be considered as illustrative, however, since all chemical incidents present unique problems requiring specially tailored responses. In addition, cultural, economical and political circumstances usually influence eventual health assessment strategies.

1

Role of epidemiology in assessing health effects following a major chemical incident

Why to Employ the Epidemiological Approach

Epidemiology is a "science studying distribution and determinants of diseases in human populations, and applying this study to control of health problems" *(2)*. It is an essential tool for evaluating the health consequences of environmental exposure. The practice of studying populations at risk, monitoring changes in exposure or health status, recording and interpreting data, and following up communities at risk has been adopted by numerous groups, including environmental and health policy-makers. The past decades have seen rapid advances in methods of exposure assessment, health data collection, information management and statistical analysis. These perspectives and methods can be of great practical value when assessing a community's health after an accidental exposure to one or more potentially toxic substances.

Management of a chemical incident involves decisions on relocation, medical treatment or other actions. These decisions must be based on reliable and timely information. In the event of a major chemical incident, epidemiology has a central role in gathering the information needed to undertake the health risk assessment and providing accurate and timely advice to emergency officials and to the population at risk.

The vast majority of chemicals in use today have not been adequately investigated for their impact on human health at doses that can be received following an accidental release. Chemical incidents may be complicated by fires or chemical reactions producing mixtures of chemicals, and these may have effects over and above those anticipated by exposure to the individual substances alone. The toxicology of the products of the reactions is often not well understood. Thus, without appropriate expert guidance, public health officials will rarely be able quickly and accurately to determine the range of potential short-term and long-term adverse health effects, the expected severity of these effects, and their frequency (the proportion of the exposed population estimated to be affected). For these reasons, the full participation of an epidemiologist, from the beginning of the work of the emergency response team and including the preparedness for the incident, should result in a more accurate and comprehensive health risk assessment.

Epidemiology has an essential public health role in devising and evaluating intervention measures taken to prevent the worst consequences of an incident. This role is best accomplished by a team that includes toxicologists, exposure assessment specialists and public health officials or managers.

When a Health Risk Assessment is Needed

A rapid health risk assessment is needed in all incidents, so specialists with experience in doing such appraisal should always be available as members of the emergency team. Health risk assessments are essential to ensure that the health needs of the population are met, even in minor incidents that do not seem to jeopardize physical health. In some incidents, psychological stress may far outweigh physical risk from chemical exposure; reducing the level of anxiety in the community may be the main justification for an assessment.

In the event of an outbreak of illness or a severe incident involving fatalities, there may be little doubt about the need to establish the chemical agents and their effects. Other incidents may result in few, if any, immediate casualties, but medical and public concern may focus on the potential for long-term effects, such as carcinogenicity or teratogenicity. In-depth follow-up studies will be needed to confirm or allay these anxieties.

Epidemiological and clinical studies after chemical incidents will have two main purposes:

- scientific (to measure the morbidity and mortality associated with the chemical exposure as part of the health risk assessment); and
- case finding (to detect treatable disorders associated with the chemical exposure or to provide reassurance).

Unfortunately, no formula can be provided for determining whether an in-depth assessment involving special resources should be undertaken. The following need to be taken into account:

- uncertainty about the extent and severity of the exposure
- uncertainty about the toxic hazard and likely health effects
- the community's perception of health risk
- ethical considerations
- liability issues.

Accidental chemical exposures have sometimes been ignored, from the health standpoint, for months or years after the event (see Box 1). The problems associated with the management of the example given illustrate the importance of contacting and registering exposed people as soon as possible, and obtaining immediate objective exposure data as well as environmental samples. Retrospective health assessments have proved to have a very limited ability to provide a comprehensive and accurate picture of an accident's impact on human health.

Box 1. The northern Cornwall incident

In an incident involving water contamination by aluminium sulfate in northern Cornwall, United Kingdom in 1988, failure to carry out rapid epidemiological assessment contributed significantly to psychological stress among the population. A retrospective investigation found an increased incidence of a wide range of symptoms in people who were exposed, but researchers could not exclude the possibility that these associations were due to anxiety and the publicity associated with the incident. Further, the overall response rate was low. This was attributed to "confusion about planned long-term studies and other studies set up by local interest groups", and delay in conducting the survey *(3,4)*.

Ideally, the decision about whether to initiate a health assessment should be heavily influenced by a team of scientists, including one or more epidemiologists. Depending on the incident, the team should include one or more public health physicians, toxicologists, environmental engineers (such as hydrogeologists) and government officials. Additional technical support may be required from such diverse professionals as microbiologists, occupational hygienists, agricultural scientists and veterinarians. The active participation of representatives of the affected community and of interest groups may facilitate decision-making. Such people, however, may over- or underestimate the significance of the episode and be biased in their opinions on the need for further studies.

Finally, whether it is decided to go forward with a detailed health assessment or not, the reasons for the decision must be set down in writing and kept for future use. The document should be shared with individuals and organizations wanting to know the rationale for the decision.

Whether to Conduct a Study – Ethical Issues

Considering the technical issues in planning the study related to the incident, as described above, an epidemiologist must remember the basic ethical principles of beneficence, non-maleficence, justice and autonomy governing the conduct of any health-related investigation. Important issues to consider include informed consent, the guarding of privacy, peer review and the dissemination of results. In the case of environmental incidents, conflicts of interest might arise among various interest groups (such as industry, the local community, the local administration and researchers) and individuals within the community. Some conflicts may influence the results of an investigation assessing the health consequences of the incident. When strict diagnostic criteria are not applied, people may either expect a return (such as compensation) or be disturbed by the idea of being labelled as contaminated. Further, bias in reporting symptoms is common, and pressure from individuals and scientific uncertainties may modify physicians' sensitivity and specificity in identifying victims of the accident, particularly in borderline cases.

Epidemiologists are often pressed to quantify the consequences of an incident quickly. The zeal of John Snow, who produced his report on the Broad Street pump in little over three months, should be in the forefront of the epidemiologist's mind *(5)*. Nevertheless, before launching any study, consideration should be given to a number of critical questions, such as those given in Box 2. Local or national committees on research ethics may help answer such questions.

Box 2. Ethical considerations in a decision to undertake a study

1. Might the desire for a more scientifically complete study unduly delay the implementation of preventive measures?
2. Has the proposed research programme been thought through sufficiently to be put down on paper?
3. Could the retrieval of information on exposure and/or outcome compromise people's privacy? If so, how should the investigators interrelate with those investigated?
4. Is it possible to predict whether the results will lead to excessive use of medication and medical services?
5. Will the survey uncover conditions not amenable to treatment? If so, will the community still agree to participate in the study?
6. Could the study itself or its predictable findings lead to undue discrimination, for example, following the registration for clinical purposes of all those exposed?
7. Have potential conflicts of interest between sponsors, investigators and study subjects been disclosed?
8. Will the study subjects receive an explanation adequate to ensure that their consent to participate will actually be informed?
9. Will the study create anxiety disproportional to the foreseeable benefits?

Roles of Epidemiology in the Phases of Incident Evaluation

The three chronological stages of the evaluation and management of a chemical accident are called the planning and preparedness phase, the response phase and the follow-up phase.

Planning and preparedness

The preparedness phase takes place during the period before a chemical release. In practice, it is a continuous activity, with periodic updates and revisions. This is the time to prepare an efficient and effective system for emergency response (incident management), rehabilitation and follow-up.

Activities in this phase include:

1. establishing and maintaining an inventory of potential risk sources, such as hazardous installations and transport routes;
2. establishing a chain of command and a network of cooperating emergency response services and expert consultants;
3. drafting emergency response guidelines and medical treatment protocols;
4. running collaborative (interagency) training sessions with every party involved in the emergency response;
5. obtaining all necessary equipment and supplies, or making arrangements to obtain them at short notice in case of an emergency; and
6. planning for an emergency under existing legislation with industry and local authorities.

Role of epidemiology

During this phase, an efficient and effective system should be prepared for initiating an emergency response and planning rehabilitation and follow-up. Adequate resources should be dedicated to this task. In this period the decisions can be made by consensus. Any activity that can be performed in the response stage should be included in the contingency plans developed in the preparedness phase.

Important stimuli for adjustment of the contingency plans in this phase are the experiences from previous emergency responses and/or training sessions. Specific activities include:

1. identifying the epidemiologist's role in the planning team;
2. identifying population and health data sources;
3. identifying existing environmental monitoring networks;
4. identifying poison centres active in the area;
5. preparing for the planning and conduct of epidemiological studies;
6. specifying and preparing methods for rapid assessment of potential health effects, including facilities for collection, storage and analysis of biological samples; and

7. testing the methods for investigating disease outbreaks and performing other small surveys of acute incidents.

Response

The response phase starts when it is recognized that an incident has occurred, and lasts as long as rapid interventions are conducted. As quickly as possible and under pressure of time, decisions are made according to the prearranged chain of command, and emergency response personnel attempt to comply with prepared contingency plans.

Activities in this phase include:

1. verifying the incident, and identifying the source and nature of chemical(s) and/or the nature of immediate health consequences;
2. terminating the incident and/or the associated chemical release;
3. preventing exposure to employees, emergency response personnel and the general population;
4. assessing the exposure and health outcomes;
5. assessing health risk to exposed individuals and to the population;
6. preventing and/or mitigating adverse health effects due to exposure, by advising the public and the authorities;
7. providing medical treatment of casualties; and
8. identifying the casualties.

Role of epidemiology

During the response phase, the epidemiologist undertakes health risk assessment, defines the populations at risk of different types of exposure, rapidly collects valid data on health status and exposures, and relates exposure data to information on health status. The epidemiologist should also be involved in evaluating the impact of the incident and, in this way, provide the background for the advice on preventive intervention measures given to the public and public health officials.

Carrying out epidemiological functions during the response phase is often difficult, because many emergency response personnel do not perceive the relevance of field epidemiology at that time. All public health professionals and emergency personnel must therefore understand the role of epidemiology and the need for data collection during the acute crisis. Epidemiological input in the planning and preparedness phase is essential to achieve this.

Several illustrations of epidemiological activities in the response phase of health assessments exist. For example, during the 1986 incident in Basle (see Annex), epidemiologists analysed daily mortality, inpatient and outpatient attendance and symptoms in different population groups *(6)*. In the Shetland oil spillage in 1993, epidemiologists determined the immediate effects and collected baseline health data and biological measurements *(7)*. The Annex provides some details of these incidents and describes the involvement of epidemiologists in their evaluation.

Follow-up

The follow-up phase encompasses the time after the termination of the rapid response activities. It lasts as long as effects of the incident can be expected to occur.

Once the acute phase is over, the general public tends to return to its usual activities, and becomes less interested in the incident or its consequences. In contrast, the people affected by the incident start the process of coping with the consequences. While more time is usually available to make decisions than in the response phase, public and political pressure may place time constraints on studies of health consequences.

Activities in this phase include:

1. rehabilitation, that is, restoring the affected area, its occupants, workforce and emergency response system to a state equivalent to or better than the original;
2. follow-up of exposed employees, emergency response personnel and the general population, including:
   - the provision of medical, social, economic and psychological care;
   - epidemiological follow-up of the incident;
3. risk assessment of the health consequences of the incident;
4. follow-up and/or clean-up on the environmental consequences of the incident, which (from a public health perspective) may cause secondary exposure through, for

example, contamination of the food chain and/or drinking-water; and
5. appraisal of the emergency response phase.

Evaluation of an incident should lead to recommendations to prevent repetition and to adjust emergency response plans where they did not perform perfectly.

Role of epidemiology

In the follow-up phase, health risk assessment should be continued whenever there are reasons to suspect medium- or long-term effects. Such effects may include disturbances of lung function, neurological and behavioural disorders, allergy, adverse pregnancy outcome and cancer. A decision as to whether such adverse effects may be expected must be made promptly, with the collection of baseline data on both exposure and earlier health status commencing as soon as possible. Urgent toxicological expert consultations are usually necessary and should be carried out without delay, for example, by contacting poison information centres. Advice from an occupational health specialist may also be valuable.

Epidemiological follow-up should include the activities listed in Box 3. They may be undertaken:

- to respond to public concern and to alleviate the worries of people exposed in the incident and those living in the vicinity of chemical plants;
- for the purposes of current or future litigation or compensation;
- owing to political pressure to do something;
- to expand knowledge on health effects in exposed populations; or
- to develop evidence of a causal connection between exposures and health effects.

A considerable part of the information needed in the follow-up phase must be collected during the response phase. This should be anticipated during the planning and preparedness phase. Further, in the longer-term aftermath of an incident, official and public interest is likely to wane. It is therefore important for public health authorities at all levels to accept the need to support and fund follow-up studies, and to build this consideration into the planning and preparedness phase.

Box 3. Epidemiological activities in the follow-up phase

These activities include:

- following up cases or the exposed population;
- establishing a study to evaluate long-term health effects;
- evaluating the effectiveness of response action and making recommendations to improve the response; and
- making recommendations to improve existing databases and other sources of information.

Follow-up studies should be carefully designed and implemented in order to overcome particular problems. These problems are related to:

- population:
  - size (and its effect on study statistical power); and
  - mobility and cooperation (maintaining high response rate during follow-up);
- health outcomes:
  - the unknown (but often long) latent period from exposure to effect;
  - the changing background morbidity of the population over a long time;
  - the need to separate the effects of exposures in multifactorial diseases;
  - the availability of valid and comprehensive data; and
  - possible bias in subjective assessment of health status related to special interests (such as political issues or the prospect of financial compensation);
- availability of reliable quantitative data on exposure;
- technical and feasibility issues:
  - focus on long-term studies during the acute phase;
  - the need for resources to obtain and store samples and to set up registers in acute situations; and

- the lack of standard definitions, and of measurement tools to use and to permit comparison of studies.

Properly implemented follow-up studies provide unique opportunities to obtain information on the long-term results of exposure to chemical substances. Thus, they should be seriously considered as part of the response to all chemical incidents.