Thirty-five Years of Disaster-Medicine Studies

Experience from KAMEDO's operations 1963–1998

We regret to inform you that 6 pictures are missing in this pdf-file (on page 56, 87, 105, 108, 121, 128)

Socialstyrelsen
THE NATIONAL BOARD OF HEALTH AND WELFARE

Cover picture: a selection of the reports published by KAMEDO.
Author: Henry Lorin

The Disaster Medicine Organisation Committee, KAMEDO, is part of the Department of Emergency and Disaster Planning of Sweden's National Board of Health and Welfare. The Committee's chief task is, using observers on the spot and through fact gathering, to study the medical, psychological and social effects of disasters and war and the associated relief and medical care activity.

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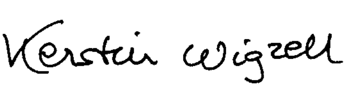
Foreword

The idea of creating an organisation for disaster-medicine studies was put forward in the then Defence Medical Research Advisory Committee in 1963. The next year, the disaster-medicine organisation committee, KAMEDO, was established. Its chief task was to gather medical information from countries afflicted by war or serious accidents. Observers were sent to disaster areas in order to summarise their experience in KAMEDO reports. KAMEDO was moved in 1974 to the Swedish National Defence Research Establishment in connection with the winding up of the Defence Medical Research Advisory Committee. The Department of Emergency and Disaster Planning of the National Board of Health and Welfare assumed responsibility for KAMEDO in 1989.

For thirty-five years KAMEDO has studied the medical effects of disasters and war. Experts from different fields have been sent at short notice to afflicted areas to collection information and gain their own experience of the disasters. At a relatively small cost Sweden has gained important knowledge of disaster medicine. Some seventy reports have been published.

Between 1977 and 1995 Dr *Henry Lorin* was scientific secretary of KAMEDO. Apart from being responsible for editorial work he also collaborated as an observer and as author of a large number of reports. In the present report he has gathered together experience of the work of KAMEDO over thirty-five years.

It is the Board's hope that this overview of KAMEDO's work will represent a valuable supplement to earlier published reports.



Kerstin Wigzell

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KAMEDO – An Organisation for Disaster-medicine Studies

History

In 1963 the then Defence Medical Research Advisory Committee noted that civilian medical services in Sweden were geared exclusively to a normal situation and that there was a great need for disaster medicine research. The very next year the Advisory Committee resolved to form a committee tasked with endeavouring to satisfy this need by sending observers to regions afflicted by war or by major disasters. The problems of disaster medicine had been highlighted by the devastating earthquakes occurring at that time in Agadir and Skopje. Sweden itself was not located in an earthquake-prone region, but ongoing urbanisation, high-speed, high-capacity transport, technical expansion and disturbances in the world at large were felt to have increased the likelihood of medical disasters in Sweden.

The committee came to be called "the Disaster Medicine Organising Committee" (Swedish acronym: KAMEDO). Through their own observations and by means of information-gathering, the observers dispatched were to analyse the course and effects of, and rescue measures associated with, violent occurrences in which large numbers of people were injured. To some extent KAMEDO was also to observe the subject field by monitoring publications and by contacting individuals with useful knowledge and experience of disaster medicine.

KAMEDO's task, then, was one of knowledge-gathering. Its organising committee included representatives of the Supreme Commander of the Swedish Armed Forces, the Red Cross, the National Board of Health and Welfare, the National Civil Defence Board, the Medical Board of the Swedish Armed Forces and the Defence Medical Research Advisory Committee. Activities were directed and supervised by this committee, which subsequently co-opted representatives of the Swedish Association of Local Authorities, the Federation of Swedish County Councils, the National Police Board and the then National Fire Safety Board.

As part of the reorganisation of defence research in 1974, KAMEDO was perpetuated as a project within the Defence Research Establishment (FOA). The official representatives formerly included in the organising committee were kept on as an advisory council. Studies of major accidents with medical effects continued in accordance with previous guidelines. The committee met twice annually and received reports on activities occurring since the previous meeting, as well as discussing the continuing direction of KAMEDO's work. Day-to-day work between these meetings was the responsibility of the Scientific Secretary, whose tasks included arranging, in consultation with the Chairman, observer visits to other countries and overseeing the compilation and publication of the observers' reports.

KAMEDO was taken over in 1989 by the Department of Emergency and Disaster Planning of the National Board of Health and Welfare. The Chairman, as previously, is recruited externally. Two Scientific Secretaries are responsible for observer recruitment and the editing of reports. Now that other authorities with duties of planning and response in the event of major accidents are in a position to dispatch their own observers, KAMEDO has been able to concentrate more and more on studying the medical problems involved.

Focus of activities

Disaster studies during KAMEDO's early decades were conducted by about 50 people, most of them physicians, who were vaccinated and otherwise ready at short notice to travel as observers to disaster areas and gather information. Many of the contacts established in the afflicted country were intra-professional, and as a rule the observers had no trouble in obtaining all the information they wanted. Stand-by agreements with observers no longer exist, and instead, when a disaster occurs, efforts are made to put together a group of between two and four persons with a good knowledge of the medical branch involved. At least one of these observers should have had previous experience of disaster medicine. Nowadays immediate arrival in the disaster area is not always considered as important as it used to be.

On their return home the observers, together with one of the Scientific Secretaries, prepare a report for publication, setting out their experience and presenting any proposals which may be of value. It has now been accepted that a year or more may pass before the report is completed, by which time more plentiful and reliable information about the occurrence can be collected. Sometimes observers publish articles in specialist journals.

Medical studies

Firm and efficient leadership at all levels, good co-ordination and good co-operation between the rescue organisations involved are essential to a successful rescue operation. The organisational problems are often formidable. Studies can teach us a great deal for avoiding the repetition of earlier mistakes.

Studies are made of alert and response procedures, care of persons in distress at the scene of the accident and the functioning of equipment. The scene of the accident may be difficult to reach and weather conditions may be adverse. Not infrequently, large numbers of people are injured and resources are inadequate. Which categories of injured should have top priority? How much medical care should be provided on the spot? What particular principles are applied to the rescue operation and how do the relief units protect themselves against toxic or radioactive substances?

In a country like Sweden, measuring 2,500 km from end to end and with its population heavily concentrated in certain regions, medical transport is also important. The organisation of ambulance services in the country concerned and requirements to be met by vehicles and equipment are of particular interest.

Injured persons, next-of-kin, personnel and media representatives converge on the receiving hospitals. Measures are needed to cope with these problems. How is this achieved? Is there a workable disaster plan? Which categories of injured are given top priority at the hospitals, and what measures and types of examination are judged deferrable? Are hospital resources sufficient as regards surgery, intensive care, laboratory tests and X-ray examinations?

The medical injury panorama varies according to the type of accident. A certain mapping of the physical injuries can be useful with a view to channelling the right resources into future medical responses. An understanding of the origin of injuries also has a useful bearing on the prevention of similar injuries in future.

Psychosocial studies

Not infrequently, the media speak of panic, meaning irrational escape reactions. But are such reactions common? Is it not so that people try to extricate themselves from a life-threatening situation in the best possible way by taking to flight? Sometimes spontaneous leaders appear among people in an emergency situation. Such persons can be of help, but they can also lead people astray. Who are the people who assume this role? How do others react to their advice and orders? Studies of individual and group behaviour in a constrained situation can furnish knowledge of human capacity to use escape routes, rescue aids and information in difficult emergencies.

A severe accident means an emotional trauma, not only for the people directly involved, but also for those indirectly affected by it, e.g.

rescue personnel. There may be a great need for mental first aid. Simple measures which the rescue personnel or friends are capable of taking may suffice. But how can people in danger of developing more persistent mental difficulties be identified at an early stage of things? Which people need to be quickly examined by a specialist? During the 1980s and 1990s, more and more attention has been on the need for mental support.

Psychological reactions in the disaster context can also assume many other forms. Not infrequently, people tend to look for scapegoats for what has happened and to speak critically of the rescue measures. Not infrequently, these reactions are rooted in dissatisfaction with one's own contribution. Onlookers, feeling themselves to be powerless, are also prone to criticise rescue operations. Media representatives too are readily disposed to voice criticism and to find one or more people who have acted wrongly. How can this be taken into account in a rescue operation, so as to alleviate such reactive tendencies? After a time, the relation between care personnel at a hospital and the next-of-kin of accident victims may turn into one of distrust or even conflict. Studies can improve our knowledge of these matters.

Severe accidents are attended by considerable social problems. There is a great need for support, be it economic or purely practical. Society includes groups of people with particular problems who are especially hard hit. In certain cases, studies are made of the care given to people with chronic illnesses and disabilities, language difficulties and economic problems. The need for crisis groups shows how people affected by severe accidents require more than just medical and economic assistance.

Identification

Identification of the dead and injured is a police responsibility. Major accidents often entail a large number of deaths. Not infrequently, physicians contribute facts to facilitate identification (signs of previous physical injuries, dental finds and genetic analysis). The dead are autopsied or otherwise examined to ascertain the cause of death. Even if only partial remains of the victims are recovered or their bodies are missing altogether, establishment of the cause of death is important, bearing in mind the psychological, social and economic consequences.

Experience in brief

Disaster planning

The KAMEDO studies confirm the need for ongoing disaster planning with efficient, rapid-response resources of both personnel and material. Many authorities and organisations may be affected when a severe accident occurs, and they must be able to co-operate accordingly. Their tasks and responsibilities need to be defined in advance. It is important that plans should be well known and thoroughly rehearsed. Implementation should be capable of proceeding by stages and should be adapted to the extent and character of the accident. Things are made easier by a certain automation of response.

Alerting procedures

In several disasters the personnel responsible for giving the alarm had difficulty in coping with their duties during the initial phase, due mainly to under-manning, deficiencies of routine and the overloading of inadequate radio and telecommunications. Control centres must have time to alert all the resource and medical organisations concerned, summon reinforcements, seek information and field incoming enquiries. In Sweden, the past few years have seen a reinforcement and enlargement of emergency services centres and air-sea rescue control centres.

Direction

In connection with certain severe accidents, the emergency services centres are allotted a medical disaster management team in which staff medical officers are included. This group takes charge of co-ordination between the hospital(s) concerned and rescue organisations and is intended to command a total picture of activities in progress, subscription of hospital capacity, traffic conditions etc. In the case of very extensive accidents it has been found necessary for an overarching authority or organisation (the County Administrative Board in Sweden's case) or somebody at government level to take general charge of rescue measures.

At the scene of the accident, strong operational leadership is needed which can control the timing, location and scale of rescue measures. The command post should be clearly marked. The person in charge of activities within the accident area is an Incident Commander, who in Sweden, where accidents on land are concerned, is always a senior officer of the rescue services. The Incident Commander's staff, if there is one, includes a police director on-scene and a medical director on-scene. Sometimes, e.g. when there are toxic or radioactive emissions involved, special experts are also included. In some other countries the rescue operation is always headed by a representative of the police, or else command is allotted *ad hoc*, according to the nature of the accident and the experience and specialist qualifications of the person in question.

Activities in the accident area

All personnel within the accident area should carry distinct markings denoting their category and position. Previously there have been many deficiencies in these respects. There have been instances of medical personnel being unaware of the presence on the scene of a medical team from another hospital. Supervised cordons are needed, to prevent unauthorised persons from blocking access routes or entering the accident area. Conditions permitting, the Incident Commander may allow media representatives to visit the scene of the accident for information purposes, together with a member of the rescue services. This was done, for example, in connection with the air and fire disaster in Amsterdam. Press conferences are also necessary. On many occasions, radio and television have kept up a continuous supply of information of value to hospitals and members of the general public affected by what has happened.

The KAMEDO studies have revealed the great extent to which people in the surroundings have had to provide first aid in the accident area. Accordingly, the importance of the general public being trained in clearing airways, artificial respiration, staunching life-threatening bleeding, "giving blood to the brain", performing cardiac compression and assisting the injured in cases where there is a danger of injury to the spinal cord cannot be overstated. In this way, loss of life while awaiting the arrival of professional assistance can be prevented.

Hospitals and certain health centres in Sweden have staff members who are trained to serve at the scene of an accident. They take medical equipment with them, and additional equipment can be conveyed to the scene as required. This equipment must be impervious to rain, snow, severe cold, darkness, high winds and other extreme conditions. The personnel need to be trained and equipped for this kind of activity. They are liable to be subjected to severe physical and mental stresses. The principle of deploying teams of this kind, with a physician included, has proved highly workable but is not applied in all countries. Some countries are instead committed to upgrading the medical skills of ambulance crews.

A casualty assembly point is usually established, where the injured can be comprehensively examined and resources of materiel and personnel are concentrated for advanced first aid and stabilisation of vital functions prior to evacuation. Other preparations are also made for the avoidance of deterioration or unnecessary suffering. It is often an advantage if the casualty assembly point can be sited in a building or tent, but in favourable weather conditions, and given rapid evacuation facilities, a segregated space outdoors may suffice.

Treatment and evacuation priorities are decided according to the nature and extent of injuries and the treatment required, the age and illnesses of the individuals concerned and the medical resources available. An effort is made to achieve optimum distribution of the patients between the available hospitals, on the basis of medical assessment and in consultation with the Incident Commander. In the event of resource constraints, priority should be given to casualties in urgent need of attention and with good survival prospects. It has been hard for people in the surroundings to perceive early on the poor prognosis for many casualties, especially where severe burns and injuries from ionising radiation are concerned. Pain relief and measures to prevent unnecessary suffering are also an important part of the medical response at the scene of the accident. Given the time and opportunity, certain personal and medical record particulars should be gathered prior to evacuation.

The length of time elapsing between the accident and qualified care in hospital is very important. In the accidents which have been studied, the aim as a rule has been to obtain emergency surgery in hospital at once and at most six hours after the occurrence of the injury (two hours where sever internal bleeding is involved). Quite often this calls for helicopter assistance. Opinions sometimes differ concerning the extent of medical care to be provided at the scene of the accident. The Americans have advocated little medical care and rapid evacuation to hospital – "load and go". Other countries, Sweden among them, have been prepared if necessary to devote more time to medical treatment at the scene of the accident – "stay and play". Needless to say, the distance to the hospital makes an important difference here. The general advice "Medical Preparedness for Disasters" (1992:5) published by the National Board of Health and Welfare state: "Following the decision of the doctor in command in consultation with the Incident Commander – if sufficient transport is readily available and the hospital is only a short distance away – the injured can in exceptional cases be conveyed to hospital without prior assessment and medical registration". Even in cases of this kind, however, a certain basic prioritisation and first aid are aimed for.

Activities at the hospital

When distributing casualties between hospitals, it is an advantage if their injuries and treatment requirements can be matched with the hospital's resources and competencies. If resources are constrained, no one should impose more of a burden on qualified medical care than his or her injuries require. KAMEDO's observers have quite often found hospitals to be very unevenly loaded, due partly to the lack of a comprehensive picture of the total medical situation. It is important that overloading of a single hospital should be avoided wherever possible, because this can prove detrimental to the quality of care. Casualties in Sweden are often distributed between several hospitals where possible, whereas Britain and several other countries often apply the principle of "designated hospitals' to severe accidents, delivering all casualties to *one* hospital as far as its capacity allows, before moving on to the next hospital. This avoids the disruption of activities at a large number of hospitals, makes it easier for families and different language groups to be kept together and facilitates an overview of what has happened to the people involved in the accident. On the other hand there is some risk of the designated hospitals finding themselves overloaded.

In Sweden the hospitals concerned are notified of a disaster by being alerted from the emergency services centre. The hospitals are called upon to dispatch a medical team, and if necessary a disaster alert can be given at the hospital itself. In many cases, hospitals have received their first intimation of an accident by other means, *viz* phone calls from helicopter crews, radio and television broadcasts or a sudden, massive influx of injured persons in the casualty department. This last mentioned has been a problem, because hospitals need time to augment their resources and to prepare for the reception of large numbers of casualties. Information may be needed concerning the anticipated number of injured and the nature of their injuries.

Hospitals in Sweden and several other countries have disaster plans which can be activated. A disaster management group is set up if necessary. Extra personnel may need to be called in, surgery schedules revised, inpatients discharged, spaces and resources re-allocated, traffic both outside the hospital and inside the buildings (use of lifts, for example) regulated, telephone lines reserved for external and internal communication, blood bank and hospital kitchen alerted, and so on. Resources also have to be created for taking care of next-of-kin and the media. Police or security personnel are needed for the maintenance of order. Psychosocial activities often come under heavy pressure for a relatively long time and often need to be reinforced. Information systems are needed. During the acute phase, responsibility for information should be vested in *one* person only, so as to avoid the risk of confusion. Overriding responsibility for the identification of the dead and injured in connection with disasters devolves on the police, who accordingly also assume a major responsibility for the supply of information. Co-operation between hospitals may need to be stepped up, e.g. for the transfer of patients and resources. For economic reasons, reserve supplies are often kept in small quantities, which can be a cause of vulnerability in the event of prolonged heavy loads or disruptions.

Hospital routines in a disaster situation should still adhere as closely as possible to the normal course of activities, so that personnel will be familiar with their duties. Hospitals too, however, can be severely damaged and disrupted, as has happened, for example, in connection with earthquakes, fires and storms. There have also been cases of hospitals being located within areas exposed to toxic substances. Patients may thus have to be evacuated to other hospitals. If so, it is important that their condition should not be impaired by lack of resources in connection with the transfer, and that next-of-kin should be informed of their new whereabouts.

If an exceptionally large number of people have been exposed, for example, to toxic gases, not all of then can be hospitalised. Temporary facilities for treatment and care may then have to be set up in gymnasiums or schools and staffed by medical personnel.

Natural disasters

Journeys of observation to areas afflicted by natural disasters were made chiefly during the 1960s. The world had opened up to the Swedes and solidarity with the peoples of the developing countries was felt to be great. There was considerable interest in international aid efforts. But the purpose of the studies was primarily to learn more about mass-injury care and large-scale rescue operations. Observers were sent by KAMEDO to areas afflicted by storms, floods, landslides, earthquakes and volcanic eruptions. On the other hand natural disasters with slow courses such as severe drought were not studied. Figures in brackets give the numbers of the KAMEDO reports to which reference is made.

Storms, hurricanes and floods

Cyclones occur in tropical areas and as a rule form in the Atlantic or the Pacific. A condition is that the air masses over an ocean surface long remain above 28 °C. The energy source is evaporation and condensation of the water. The strong winds thus arising exist commonly at a radius of 100 km from the centre of the cyclone. But if the cyclone has existed for a fairly long time and moves, devastation can affect areas at large distances from the place of origin (1, 4). Often, coastal areas and islands suffer the greatest damage not only because of wind strengths, but also in consequence of floods caused by violent cloudbursts and raised sea water levels in connection with the low atmospheric pressure at the centre of the storm. But even in cooler latitudes storms occur with winds that in gusts may reach hurricane strength and that can cause damage to vessels, buildings and electrical grid systems.

Floods are caused, apart from by tropical cyclones, by abundant rain (or heavy snow melts) within the drainage area of a river. Dams may burst and large land areas may be laid under water. Landslides may be triggered and buildings may collapse. An important factor is the drainage and absorption ability of the ground surface.

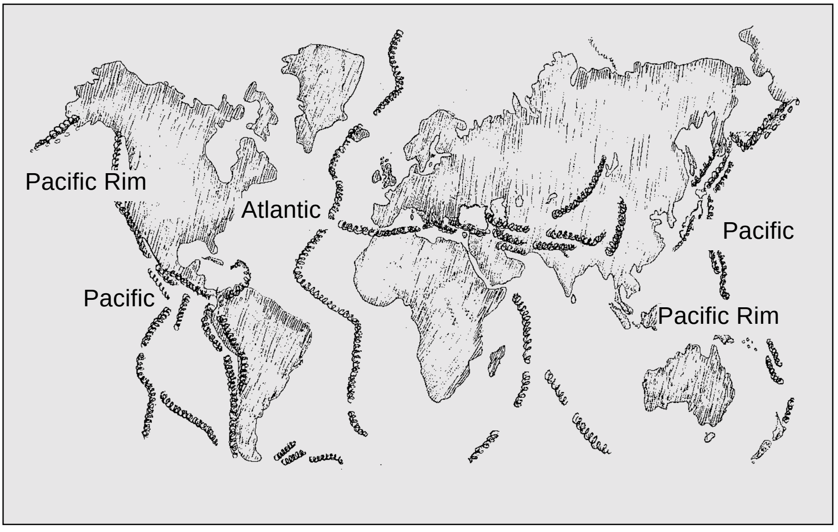
Even after the acute phase of the flooding, problems often remain great. When the water recedes from flooded areas rotting animal bodies are left behind and must be dealt with (1, 11). Surviving snakes and other animals may have sought shelter in buildings sticking up above the surface of the water. Hygienic conditions are poor. Watercourses and drains have been destroyed as have some food stores. Dangerous chemicals may have escaped (1).

The *Tsunami* is a seismic oceanic wave arising in sudden vertical movements of the sea bed, often correlating with earthquakes, volcanic eruptions or submarine avalanches. The wave moves over the sea at a speed that is proportional to the square of the ocean depths. In the Pacific, where tsunamis are most frequent, speeds of 750 km an hour may be reached. Coastally, the speed is reduced but the height of the wave increases as the depth of the water decreases and may reach 20 m. A tsunami can cause serious damage far from its place of origin. To lessen the effects of these waves, forests are planted along coastlines. In Japan breakwaters are built to protect built-up areas along the coast (4).

Landslides, earthquakes and volcanic eruptions

Landslides can also cause great damage. The upper layer of an area of land or snow cover can loosen from its sloping sub-stratum and move over large distances, burying and damaging people and buildings (37). If they land in lakes or if dams and barrages are breached, devastating floods can be caused.

Earthquakes are related to seismic activity. A particularly active area is "Circum Pacific" extending from New Zealand northwards via the Philippines, Japan and the Kuril Islands to Alaska. It then turns downwards along the Canadian and American west coast via Central America and along the Andes.



Map of the world showing the most important earthquake zones.

Another active area is the “Mediterranean and Alpine area”. This runs from Morocco via southern Europe and the Balkans down through the Middle East. There it divides into two. One arm goes south of the Himalayas, the other north of the Baikal.

Somewhat less active are two large fault systems, one along the east coast of Africa and the other stretching under the Atlantic from north to south.

In an earthquake there may be widespread destruction of buildings. Houses of brick and mortar withstand but poorly the lateral forces arising in the earthquake (3, 9). Wooden houses and buildings with elements of concrete manage better, but not even reinforced concrete always survives strong earthquakes. In Kobe (66) the steel reinforcement in the pillars carrying the “Hansin Expressway” were bent. The motorway which ran ten to twenty metres above the ground leaned over on its side or parted. The same had happened the year previously in an earthquake in California. Not even the wooden houses held in Japan. In line with Japanese building practice, the roofs were very heavy. The bearing timbers were too weak for the strong lateral forces and the buildings collapsed.

It is not uncommon for earthquakes to have serious secondary effects. Fires can arise when gas pipes, heating installations or electrical equipment are damaged. Power cuts and failures in the water supply hamper firefighting and medical care or render it impossible. Serious floods and landslides may bury communities when lakes or snow/soil in mountain areas is released by the earthquake. Further examples of secondary effects are infectious diseases caused by water pollution and cramped living conditions in emergency shelters.

With historical material, particularly maps, seismological measurements and other methods, researchers have attempted to find methods of predicting earthquakes, so far with little success. Attempts to erect buildings that can resist earthquakes have met with greater success. However, hardly any buildings are guaranteed “earthquake proof”.

Volcanic eruptions occur when different forms of material from the interior of the earth are pressed up by the gas pressure arising from chemical reactions further in towards the centre of the earth. The violence of the eruption depends largely on the physical properties of the material pressed out. If it is of low viscosity, i.e. flows easily, the eruption is mostly in the form of a lava flow. If the material is of high viscosity the eruption can be explosive with an outflow of exploded stone or dust and sometimes very hot clouds of gas or melted material. A further threat from volcanoes is the slow accumulation of dust and ash on the slopes. In rain this can start to flow downhill.

Studies conducted

Storms, hurricanes and floods

Five KAMEDO reports deal with disasters occurring in connection with heavy storms and floods (table 1). Two of these "The wreck of the accommodation platform Alexander L. Kielland 1980" (44) and "The loss of MS Estonia in the Baltic on 28 September 1994" (68) occurred during heavy storms but are discussed in the chapter on "Accidents at sea".

Table 1. *Studies of storms, hurricanes and floods.*

Report Number	Event	Number of Deaths	Injured Survivors	Material damage/ problems	Notes
1	Hurricane Betsy 1965				
a)	In Florida	4	No information	Relatively large	Population prepared
b)	In Louisiana	10	No information	Very serious floods	Population unaccustomed
11	East Pakistan Flooding Burma 1968	1,000	No information	60,000 homeless	Cyclone over Burma, with flooding
14	Storm Ada Göteborg 1969	10	More than 100	Roofs blown off, power cuts etc	Hospitals without electricity and water

Landslides, earthquakes and volcanic eruptions

Up to 1970 KAMEDO studied the effects of six earthquakes (3, 8, 9, 15, 17, 18) (Table 2). It was then decided to stop studying earthquakes since these represented no real threat to Sweden. In addition, the cultural, social, economic, technical and care situations in the countries affected differed from those in Sweden. Direct comparisons with Swedish conditions could seldom be made.

But on 17 January 1995 the city of Kobe and its surrounding area in Japan was afflicted by a severe earthquake which laid waste large areas of the region. This time there was almost total disruption of a modern, high-technological community with large numbers of casualties and deaths. War, terrorist attack or widespread accidents in certain industries could have similar consequences in Sweden. A journey of observation was therefore undertaken.

Table 2. Studies of landslides, earthquakes and volcanic eruptions.

Report Number	Event	Number of Deaths	Injured Survivors	Material damage/ problems	Notes
3	Earthquake in Varto, Turkey in 1966	2,500	4,000	Clay brick houses pulverised	Help arrived after 6 hours
8	Earthquake in Debar, Albania in 1967	Around 60	400	21,000 people affected	Inaccessible area
9	Earthquake in Sicily in 1968	1,000	No information	56 quakes between 14–30 January	Cold, fear
15	Earthquake in Banja Luka, Bosnia in 1969	10	No information	Many buildings collapsed	Initial tremors gave warning
17	Earthquake in Kutahya, Turkey in 1970	1,050	No information	Buildings collapsed; 130,000 homeless	Majority were sleeping
18	Earthquake in Peru in 1970	Approximately 40,000	Approximately 10,000	Buildings and roads destroyed	Landslides, avalanches
37	Landslide in Tuve, Sweden in 1977	9	About 60	Houses taken with the landslide	Fog, mud
66	Earthquake in Kobe, Japan in 1995	5,000	30,000	Houses and roads destroyed. Power and water cuts	Fires, medical care paralysed
12	Volcanic eruption in Merapis, Java in 1969	0	0	Living areas and plantations destroyed	Lava and mud down the mountain

Experience

Observer visits to the above areas have afforded possibilities of studying the many problems that arise when the normal functions of a community are suddenly destroyed and authorities and population attempt to limit the damage of a natural disaster through preparation and rescue work. In what follows some experience is reported.

In a serious natural disaster a city's or a region's vital functions can rapidly be rendered inoperable. Local rescue and medical resources are often insufficient.

The Kobe earthquake (66) showed how in a few seconds an earthquake can destroy most of the vital functions of a large city. Tumbled motorway sections, ruined railways and port areas, streets blocked by collapsed buildings, water electricity and gas supplies cut off, damaged telephone network, serious fires and more than 5,000 dead and 30,000 injured – these were the immediate effects of the earthquake. It is almost impossible to assist and save those in distress in a satisfactory manner where the rescue personnel themselves are affected by the accident, when vehicles cannot make their way to the damage scene, when there is no water to fight fires with and necessary information is unavailable. The care that can be offered does not correspond to acceptable medical care in the modern sense when there is no water, electricity or gas supply.

There arises an acute and great need of rescue services, medical care, humanitarian, psychological, police and economic assistance. Often it is countries with a large poor population that are worst afflicted (3, 4, 8, 9, 11, 12, 15, 17, 18), even though highly developed and industrialised countries are not free either (1, 14, 37, 66). Since the need of acute help is very great, local efforts remain insufficient. National and also, sometimes, international support is required. Even management resources may need supplementation from outside since those responsible on the spot may have been seriously afflicted themselves and therefore unable to perform their duties. There must be preparedness both locally and at a higher level to set in replacements in various positions with knowledge of local conditions.

Primary tasks in rescue operations are to,

- relieve those in distress,
- give first aid to casualties,
- transport serious casualties to care centres,
- clear and search for survivors,
- take care of the dead, register and identify,
- help the homeless with somewhere to live,
- obtain necessities for those affected,
- continue the search for survivors. Even if continued search in fallen masses gives poor results, this is important in view of popular reactions.

In earthquakes, clearance can be divided into several phases (9),

- Preparation of approach routes to reach to afflicted areas;
- Clearance in afflicted towns and villages to obtain viable routes so

that casualties and those in distress may be transported and so that help can reach the damage scenes;

- Clearance of dangerous parts of buildings;
- Widening of roads and removal of fallen rubble

Areas affected by a natural disaster have often been subjected to similar events earlier and the population have attempted to adapt.

In some parts of the world, the likelihood that a certain type of natural disaster will occur is greater than in others (1, 3, 4, 8, 9, 11, 12, 15, 17, 18, 37, 66). People living there attempt to limit the injurious effects in different ways. Contingency plans, special construction principles, surveillance and alarm systems, and stocks of foodstuffs, drugs and medical care materials are examples of this. Areas with recurring natural disasters that demand many human lives may be thought unsuitable for occupation. But in many cases the country has a large population of poor people economically unable to give up this land.

In East Pakistan (11) the authorities had attempted to reduce the damaging effects of storms and floods within low-lying areas by erecting barrages along the coast. A well-developed warning system was to make it possible to evacuate the population in time. Buildings were erected on concrete piles where a large number of people could seek shelter. Stationed along the coasts were “cyclone and flood rescue teams” with the job of alerting the population and assisting with evacuation. The managers of these teams had undergone thorough training arranged by the Red Cross in East Pakistan. Through such measures the loss of human life in floods had been reduced. On the other hand it was still hard to rescue livestock. There was a risk of bacteriological spread from rotting animal bodies, but with special methods of burying the bodies the situation was mastered.

In areas of high seismic activity earthquakes must always be born in mind when erecting dwellings, bridges, dams and other constructions. In technically highly-developed countries this is done through the building norms applied (66). One limitation here is building costs in relation to the expected strengths of earthquakes. In developing countries it is seldom possible to demand earthquake-resistant buildings. The population must more frequently fall back on the country’s own building materials and traditional construction principles.

Even in better-off states the population is sometimes poorly prepared when afflicted by violent natural forces (3, 8, 17, 18, 37, 66). The cyclone "Betsy" (1) which ravaged Florida in 1965 was an example of how the effects of cyclones may be minimised. The buildings were designed for recurrent heavy storms, the population was warned in advance and evacuated from the exposed areas, people followed given instructions and remained in shelter. Only a few people were injured.

When the same cyclone later reached the state of Louisiana, however, both material damage and personal injuries were extensive. Apart from the unfavourable geographical circumstances, what contributed to the devastating effects was that serious cyclones had not afflicted the area for the previous seventy years. Dwelling houses were thus not designed to resist the high wind strength and accompanying floods. The population, who did not take cyclone warning sufficiently seriously and who also feared plundering of their homes, did not follow the authorities' urges but to a large extent stayed at home. In addition, authority disaster planning was inadequate. The large military resources available were not used since Louisiana's governor, for reasons of prestige, did not request this assistance.

The population of areas particularly exposed to natural disasters need special training, but well organised professional relief is required at the earliest possible stage.

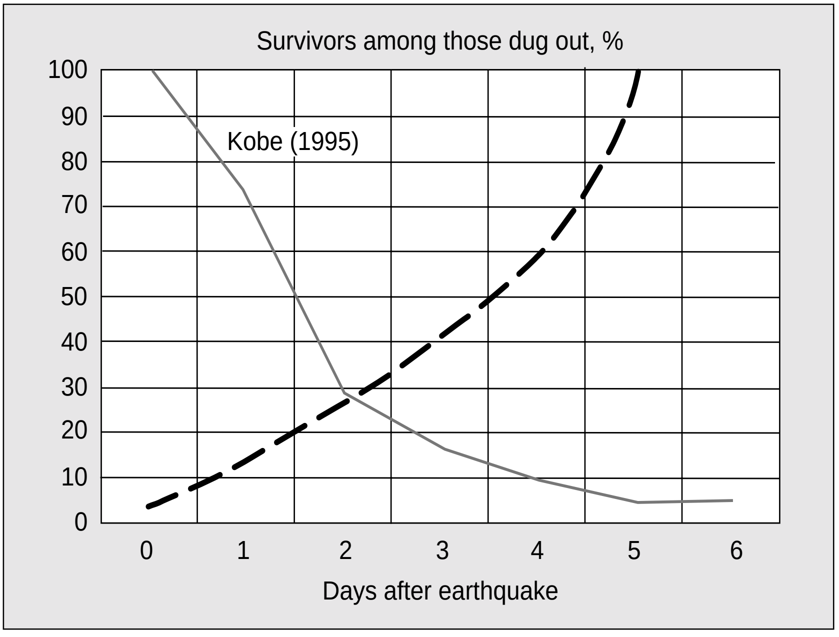
Through information to the population on how best to shelter, on simple health and medical measures (1) and on the resources available when help and support are needed, it is often possible to reduce fatality figures and the damage outcome. The ability to intervene to help oneself and those close to one in serious situations has been of the greatest importance in many natural disasters (3, 8, 18, 66). In Japan the population spends one day a year training in important measures to be taken in the case of earthquakes.

Even though local people through spontaneous help rescue many in distress, the measures taken are seldom co-ordinated and fully efficient (3, 8, 9, 15, 17, 18, 66), but improvisations where circumstances take over. People in the affected area have no possibility to survey the extent of the accident and have been afflicted with psychological traumata and personal losses which affects their action. They expect that organised help and large resources will rapidly come to their relief even though they realise that not all problems can be solved in this way (3, 5, 9, 66).

Rapid and correct information from the damage scene is of great help in disaster work, but early information from disaster areas is often in-complete and seldom fully reliable (1, 8, 18, 66). Communications equipment may have been destroyed. Persons in key positions have died or been injured or themselves found it difficult to obtain reliable information. Important information may have been misunderstood or suppressed to avoid criticism or unrest. It often turns out that the scope of the accident is greater than indicated at the first details.

Without immediate rescue and medical help, fatality increases. "The Golden 24 Hours".

In natural disasters there are a number of distressed and/or injured people who can be rescued if efficient relief and ABC measures are adopted in time, but who without early help will die or suffer permanent injury (3, 8, 9, 18, 37). It often takes a long time for relieving forces to make their way from surrounding cities and countries, and not infrequently in the first chaotic circumstances, they lack information on



Percentage of survivors among those taken from the ruins of Kobe during the first five days after the 1995 earthquake. The percentage of those dug out alive is clearly greater during the first twenty-four hours than later. The dotted line shows the estimated availability of rescue and medical resources in the most seriously affected areas. The graph is also similar for other earthquakes.

where the need for help is most acute. The directly life-saving help must then come from areas very close by and the helpers must have competence and the necessary materials. The availability of firefighting services and civil defence, medical teams, the Red Cross, volunteers etc is necessary and these must be able to function at very short notice, even though they themselves have been affected. In Kobe there was a fire station in each city district and also volunteer fire services which immediately started rescue and firefighting (66). There was a large number of fairly small hospitals over and above the large university and central hospitals.

Excessively centralised rescue services and medical care may have unworkable effects in natural disasters.

The expression “The Golden 24 Hours” is best described with a graph showing how survival decreases with time in people buried in fallen rubble. During the first few hours a not inconsiderable number are still alive. After twenty-four hours the survival curve starts to fall more steeply and after five days, all who are dug out are dead.

Another graph shows what possibilities there normally are of getting out people who have been buried in fallen rubble. Rescue resources are initially very small as a rule, and first grow slowly, increase and reach their maximum around the fifth day. But then it is too late. Great efforts must be made to mobilise considerable rescue and medical resources to help those in distress during the first twenty-four hours.

Resources are also required for rapid care in hospital. But hospitals may also be put out of service in natural disasters.

In the earthquake in Peru (18) one of the causes of the low proportion of injuries in relation to the number of deaths is that many of the seriously injured did not receive the timely hospital care needed for survival. Disaster medical plans should comprise a medical care chain in which casualties are given more definitive care in hospital within a few hours following their rescue and life-supporting measures at the accident scene (66). Field hospitals etc brought in from surrounding regions and countries often arrive so late that their task is limited to reconstructive surgery, continuing care of wounds and offering extra medical care resources for rescue crews and the remaining population.

Modern high-technological hospitals are entirely dependent on water, electricity and functioning tele- and radio communications. The water supply bowsers can give is insufficient for acceptable operation

(66). Water is needed for most activities such as dialysis, irrigation, cleansing, sterilising, developing and cooling.

Reserve electrical power aggregates are often water-cooled, also, and cannot be used without adequate water supplies. Electricity is needed for almost everything – lighting, lifts, medical apparatus, fans, sterilising etc. During recent decades much of the work has become computerised, which also makes demands upon efficient electricity supplies.

In the "Ada" storm in Göteborg in 1969 (14) some of the consequences of the power cut at the Sahlgrenska hospital were

- necessary operations had to be performed by torchlight,
- monitoring instruments in the cardiac intensive unit did not work,
- respirators did not work,
- X-ray examinations were very limited and at times could not be done at all.

Since the hospital is on high ground electrically driven pumps were needed to pump water to the buildings. In a power cut there was thus a cut in the water supply which meant that

- autoclaving of surgical instruments became impossible,
- the sterilisation centre did not function,
- the blood bank was threatened. The cold rooms required water,
- dialysis activity became critical,
- ward hygiene become unsatisfactory.

Not infrequently medical resources are unevenly loaded after natural disasters.

Casualties are often taken to the nearest hospital (9, 22, 62, 66). There is not always distribution to different hospitals with reference to the type and extent of injuries. There are many reasons for this. The number of people in the damage area requiring medical care may be too large. Access on the streets and roads may be poor, the management function weak and information on the capacities of the different hospitals poor. Rescuers may feel it is sufficient to get all those who are seriously injured off to a hospital somewhere.

If a hospital then becomes overloaded or lacks staff and material, prerequisites for optimal treatment and care, it is up to its staff to refer casualties further to other hospitals for more definitive treatment. In extensive accidents studied, communication between hospitals has in many cases been poor and the number of people referred therefore low during the first few days. Unfortunately, there has also been "territorial" thinking. Prestige and economic factors have been the reasons for patients not being sent on to hospitals with higher medical competence and larger material resources (9, 66).

It is important even in disaster situations, and perhaps particularly then, to consider the total medical resources of the region and its abilities to care for disaster victims.

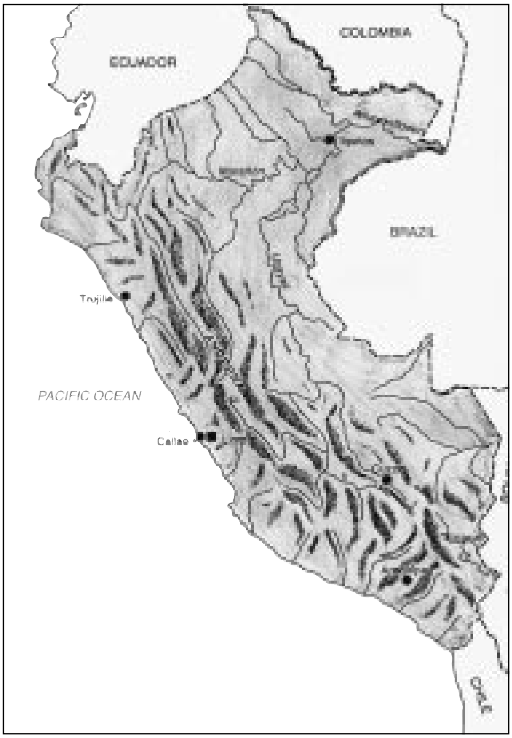
It is often hard to get material assistance to the afflicted area. Military co-operation is most frequently needed in disaster work. The helicopter is a "necessary evil".

Earthquakes often affect mountainous regions (3, 8, 15, 17, 18) and may have triggered landslides or avalanches (18) which reduce accessibility. Bridges may have collapsed. Those few roads that wind their way up to villages and towns may be been destroyed (18) or blocked by people fleeing from the disaster (8, 9). In all circumstances it may take several days before relief arrives (18).

Not infrequently the necessary materials and drugs are available in the afflicted country or are flown in from other countries. But it is hard to get the assistance out to the disaster areas. In, for example, the Peru earthquake in 1970 (18) large stocks of aid consignments stayed in warehouses in the capital, Lima, and at airfields along the Peruvian coast.

Not infrequently, military units assist in rescue and medical work (3, 8, 9, 17, 66). These normally represent rapidly mobilisable, trained and well-equipped resources. Since military units only obey commanders in a military hierarchy and follow military regulations, it is important that military and civil command meet "at a suitably high level" in a rescue operation so that it is possible to cooperate towards joint goals.

In natural disasters with roads and bridges destroyed, with the need for rapid rescue and medical care, with the demands on rapid medical transport, with the need for reconnaissance and surveillance, etc, the helicopter is an excellent and necessary vehicle. But the helicopter has certain negative aspects that must be considered. It is extremely noisy at low altitude and in a rescue it can render it difficult for people on the ground to hear each other and even to hear calls from people in distress. The noise also puts a strain on rescue personnel if it continues for any time. In addition, there is a powerful down-draught from the rotor blades which may both chill and blow away objects and equipment.



Peru consists of three geographical areas. The desert-like coastland with oases, the high land of the Andes and the lowlands of the East representing part of the Amazon tropical rainforest.

Since the lift of a rotor depends on the surrounding air, it decreases as the air becomes thinner at high altitudes. This limits rescue in high mountain regions.

Co-ordination is important in relief operations

National and international help constitutes an important part of relief following natural disasters. It is a matter of obtaining the most positive effect possible. The real value of a relief operation is not infrequently too small (8, 9, 18). On occasion, the "help" may even worsen the situation for those afflicted by, for example, taking up available scarce transport resources better needed for something else (18) or by competing with still-functioning economic activity in the area.

Nationally

In view of the need for rapid relief, local and regional resources are the most important in disaster work. Every nation needs a national disaster plan defining the responsibilities and tasks of its authorities and organisations in the case of disasters within the country. An authority, or a joint commission representing the authorities affected, is given overall responsibility for relief and co-ordination of help operations in the different types of natural disaster. It is important for the authority or the commission to be given powers to activate operations so as to avoid unnecessary delay. In Japan several days passed following the earthquake before centrally initiated help operations became effective. This was because the political system lacked a clear power centre. The endeavour to achieve a consensus between political and organisational units made rapid decisions hard (66).

Adapted to the disaster risks that may obtain, there should be "standing machinery" ready to function at short notice (4). Even though action plans cannot be entirely followed but need to be replaced by improvisation, the outlook for a well-organised rescue operation is greater if an organisation familiar with the problems is already in place (11).

Internationally

Each national should also in advance have surveyed the expected need of assistance in certain other countries at great risk of natural disasters (4). It is important that the recipient country only receives what is really needed and this in the right place and at the right time. Well established co-operation is required between donor countries and recipient countries. The Red Cross is an example of an organisation already established, with necessary knowledge in the area, certain stocks ready and geographically distributed and able to control the resources (1, 4). WHO organs may also assume responsibility for co-ordination of help operations.

Several organisations that run non-commercial activities hesitate before being incorporated in co-ordinated relief operations in which they risk not being able to direct the aid to their particular target groups. Nor in these cases do they have the same possibility of "being seen and doing PR for their work", which fosters generosity in the collections in their home countries (4).

Relieving units from distant places may find it difficult to win the confidence of afflicted people. People are often unwilling to depart from religious injunctions.

A population that has suffered a disaster and survived the acute phase through joint action experiences a great feeling of togetherness (9). When relief units arrive after a certain time from elsewhere they are experienced as outsiders, particularly if language, dialects, religion or behaviour differ from those of the afflicted population. This applies specially if a relatively long time has passed since the event.

People in the relieving units must accept that it may be difficult for those afflicted by a disaster to see outside persons giving orders and searching in what, before the disaster, were their homes. The helpers must attempt to win popular confidence, in which task understanding and respect are required for the cultural, religious and social circumstances obtaining in the recipient country.

Basic knowledge of the afflicted country and its language is required. Many volunteer foreign physicians waited for permits to give medical aid following the earthquake in Peru. The attitude of the authorities was that no help was needed from foreign physicians particularly from those who did not speak Spanish, unless they belonged to field hospitals (or equivalent) approved by the Peruvian government with the availability of interpreters and vehicles and their own supply organisations (18). In the Kobe disaster it was only exceptional for foreign physicians to help – and then only together with Japanese colleagues (66). Knowledge of the county's drugs, medical routines and social circumstances was needed.

In Varto (3) the population was Muslim with ritual prescriptions regarding handling of foodstuffs. A relieving English unit was obliged to employ a Turkish cook to have the food prepared and flavoured.

In the Debar earthquake (8) the Muslim Ramadan fast was in progress with its rigorous prescriptions regarding mealtimes and foodstuffs. The population refused all forms of joint eating. Instead the relieving personnel had to hand out milk, eggs and bread to each family. In Sicily, also, most families wished to prepare their meals themselves using the food that had been distributed.

Tents are invariably needed following natural disasters.

The use of tents as living quarters may seem primitive. But if they have efficient means of heating they may offer acceptable shelter against cold, wind and precipitation pending better housing (3,8,9,17).

If possible, tents should not be shared by several families. In Debar (8) the population could not accept the larger tents since several families were then assigned to share tents.

Kütahya (17) and Peru (18) received from Germany the materials for igloo-like buildings of polystyrene that were erected on site. They were then tethered so that they did not blow away. There were apparently warmer than tents and thus suitable for cold climates. It is uncertain whether they had other advantages over tents. Prefabricated barracks give better protection and comfort. But it takes a relatively long time to deliver them where needed and they cost more.

International support with field hospitals or other mobile medical units in the area affected is of limited value.

In many cases other countries have sent field hospitals (9,17,18) to help disaster victims. For the donor country the action has often represented a trial of the suitability of the medical equipment under primitive conditions. It has also given medical personnel useful experience, and achieved turnover of the materiel.

But despite careful planning it has taken several days for the personnel and equipment to arrive on site and for the work to be organised for current medical needs. Practical problems have proved greater than anticipated owing to e.g. social or political factors (20). The most acute phase has had time to pass and the need of life-saving assistance is no longer so great. As opposed to this it has been possible to use field hospitals for treatment of residual conditions or complications following injuries, and for general health and medical care.

Later analysis of operations has pointed out that for the recipient country the medical and social and social benefit of the operation would probably have been greater if corresponding economic investment had been made in other measures with the use of materiel and people from the afflicted country.

The question of what casualties in a natural disaster should be evacuated to regions outside the disaster area is a complicated one.

A community afflicted by an extensive natural disaster often has but scant means of giving casualties and the sick satisfactory treatment and care. Hospitals at the scene may have been put out of action through heavy material damage, inadequate electricity and water supplies (14, 66) or because staff have died or left the area (3).

The need to evacuate casualties to hospitals outside the region affected by the disaster must be judged in the light of available care resources both at the scene of the disaster and outside this, the number and extent of bodily injuries and social circumstances. A basic principle should be that if acceptable medical and social resources are still intact, care should be provided as near the casualties' homes, families and friends as possible.

For a well-conducted evacuation, functioning telephone and radio communications are needed both in the disaster region and outside. In the Kobe earthquake (66) the city's medical care system was put out of action. Undamaged hospitals were 50–100 km away but this were hardly used at all, the main reason being shortcomings in information and co-ordination.

The care of relatively uninjured persons may also be problematical. Where possible one should consider brief evacuation of that part of the population that cannot take part in rescue work or is not required for special functions (4). Handicapped persons and certain specially vulnerable groups may have a particularly bad time after a disaster.

The population fear that their homes will be plundered.

In Western countries, where houses are evacuated, rumours of plundering almost always spread (37). Sometimes the population dare not leave their homes because of the risk of plundering (1). Representatives of the media willingly follow up these rumours since theft from an accident

The landslide in Göteborg in 1977. An area of about 300,000 square metres was affected by a landslide which carried away 67 houses. Water mains and drainage conduits were damaged and water collected in the pit formed by the landslide. Fog and growing darkness hindered the rescue work. A rumour of plundering circulated during the next few days.

victim is considered of great news value. The police must anticipate that rumours of plundering will always appear and immediately arrange a guard (37). In Peru (18) the military had orders to shoot anyone suspected of plundering.

It can be assumed that the moral and religious values applying in a population under normal conditions also apply in a disaster.

In the Kobe earthquake (66) there was hardly any theft: the population could leave their belongings entirely unguarded.

It is also important for those whose homes have been destroyed to be able to return and, in an orderly manner, collect certain belongings – even of more modest character such as photographs and mementoes (37).

The need for medical care increases but serious epidemics after natural disasters are uncommon nowadays.

The hygienic situation during the Louisiana, USA, flood (1) was very serious. Among other things 15–20,000 people had been obliged to leave their homes and were gathered in large corrugated-iron sheds without water or toilet facilities. No real epidemics broke out in Louisiana but many elderly people and chronically ill people could not manage the long stay in the primitive shelters and had to be taken to hospital (1). After the Kobe earthquake, thirty years later, (66) the large gathering of homeless people in cold shelters with inadequate hygiene had as a consequence that colds, pneumonia and simple gastro-intestinal infections afflicted hundreds of thousands of people.

Studying the medical effects of the Sicily earthquake (9) one finds that the people who died as a direct consequence of injuries were relatively few in relation to those who died as a consequence of inadequate treatment and the upsets the disaster caused.

Deaths because of serious injuries in the disaster	280 people
Deaths because of shortcomings in the treatment of injuries	459 people
Deaths from other causes (illnesses)	401 people

It is clear that the consequences for the survivors of a natural disaster involve very serious strains that represent a grave risk, particularly for certain vulnerable groups. The endeavour must therefore be to improve, as soon as possible after the acute help efforts, the living conditions of those affected by the disaster.

Epidemics of cholera, typhus and other serious infectious diseases were formerly common after natural disasters. But in the natural accidents studied by KAMEDO there have not appeared any serious epidemics of typhus, cholera, plague or other diseases associated with poor hygiene. This may be presumably be ascribed to the great attention devoted to associated problems. Health-promoting measures have had high priority. Sometimes the eagerness to carry out vaccinations and other preventive treatments has even appeared exaggerated (8, 18).

The mental trauma inflicted by a natural disaster may be great.

Following the earthquakes in Sicily with the main shock on the night of 15 January 1968, there long occurred among the population what was termed "paura", a remarkably powerful fear of being indoors. The probability of there being a new powerful quake was small.

In the Peru earthquake (18), where part of the population in, chiefly, mountainous areas are of Indian origin, apathy was reported among those living in seriously affected areas. But there is also a description of uncommonly high survivability. People with serious bodily injuries survived with great suffering for weeks while waiting for qualified medical treatment.

There are no descriptions of serious mental reactions following the earthquake in Kobe (66) apart from some pictures in the weekly press. The cause of this is probably that very little was noticeable. Traditionally the Japanese are reluctant to show their feelings. It is considered unworthy to show great emotion over setbacks and grief. Nevertheless a voluntary organisation was started in Japan to help people needing psychological support following severe traumatic stress.

More detailed reports of mental reactions to natural disasters are given in the report on the Tuve landslide (37). Many of those affected are described in this report as emotionally numbed but aware of what had happened. They came to the house where people were waiting for information – cried and rested or sat silently pale with fixed stares. Some exhibited paranoid reactions, or were afraid of being prevented by the staff from leaving the place. Many thought they were going to be forced to take sedatives. One young man was confused and nervous. Some children sat still and gripped their chairs. But there were also children who sat down directly and watched television.

In connection with this accident the need for psychosocial help in serious accidents emerged clearly. Here psychiatrists were involved but simple mental first aid was also given. Many of those affected managed to be active on the evening of the disaster helping others or taking part in the searches. It became clear that meaningful work could be good psychotherapy.

Following the landslide the community spirit among those affected became more important. Groups exposed to threats or ungentle treatment bind more closely together as became evident in their contacts with the insurance companies; jealousy in the economic issues could hardly be observed at all.

Fires and explosions

In this chapter an account is given of serious fire accidents and also explosions. The latter are energy releases during very rapid combustion which can give burn injuries. In the use of nuclear weapons and in accidents with nuclear power stations energy may also be released in the form of heat.

Many of KAMEDO's reports so far published deal with fire and explosion disasters, and two others have been published as textbooks. Some of these disasters are treated in other chapters as well as in this one, under other headings in view of their nature and effects. To give an example – a serious fire with heavy development of smoke on board ship (60) was at the same time a fire disaster, a sea disaster and a disaster involving toxic substances. This accident is therefore discussed in three different chapters in view of the special problems it entailed. The earthquake in the Kobe region is another example, a natural disaster which triggered violent fires (66).

In the KAMEDO report entitled "Nuclear warfare" (52) the very serious injuries caused by pressure waves and heat are described, but also the enormous effects of ionising radiation. In the Chernobyl nuclear power station accident (59) there were explosions and serious fires. The dominating consequence of the breakdown, however, was the release of radioactive material. These two KAMEDO reports, which treat nuclear reactions, with consequences of an entirely different dimension from those of other disasters, are discussed in more detail in the chapter "Ionising radiation".

Injuries to people

Thermal burn injuries occur if the body is exposed to excessive temperatures. The various layers of cells in the skin and mucous membranes die to varying degrees depending on temperature and exposure time. Resistance to the effect of heat also varies with skin thickness and moisture, clothes worn at the time, the person's age and the occurrence of any other simultaneous strain (48). In extensive burn injuries large fluid losses occur early and there is a shift in the body's fluid volumes.

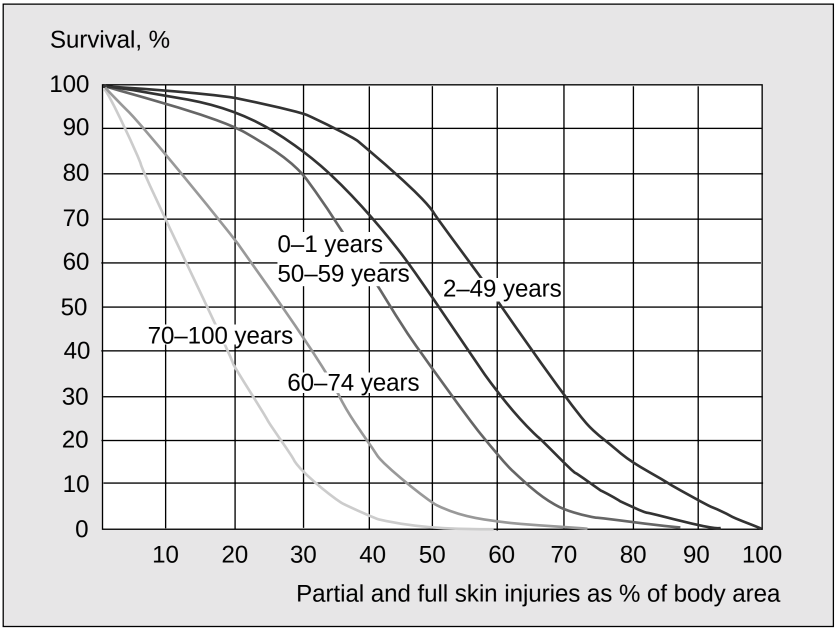
Injuries to some body areas are more serious than to others. Thus for example, injuries to head, neck and thorax regions give increased risk of complications from the lungs and respiratory passages. Hot air causes injuries to the throat, air passages and bronchi. The same volume of hot water vapour contains greater quantities of heat and thus gives injuries reaching further out into the bronchial tree. Damage all the way to the finest bronchial tubes and alveoli occurs if inhaled air contains chemically corrosive substances or smoke. The most serious injuries occur in explosions in enclosed spaces or in violent fire.

Age also affects the outcome. Children below five and people older than fifty run a greater risk than others of dying from burn injuries.

Equally, the prognosis worsens if a person with burn injuries has other injuries or diseases at the same time, such as diabetes, heart failure, lung disease; or has been exposed to ionising radiation.

Exposure to toxic agents is common in fires. Among the dead, carbon monoxide poisoning and/or hydrogen cyanide poisoning are often the primary cause of death and not thermal injury (50). In poorly ventilated areas, lack of oxygen can also contribute to the fatal outcome. In addition, in thermal decomposition of building and fitting materials, other gases are also formed, many of which are poisonous or strongly irritant to the mucus membranes. These toxicological problems are discussed further under "Chemical disasters".

External violence not infrequently afflicts the victims of an accident. In explosions people are injured by, among other things, the pressure



Expected survival following skin burn injuries in relation to size of burned area and patient's age.

wave, splinters and falling roofs and walls. But in fires without explosive components, people are also injured when buildings collapse or when people who are shut in jump from windows and balconies when the heat becomes unendurable. For this reason, in a burn casualty the possibility of simultaneous injury to the back, head or an inner organ must always be considered.

Studies and compilations of facts

Accidents when handling inflammable gases and liquids

In the handling of inflammable gases and liquids great demands are placed upon equipment, handling and security systems. In the case of shortcomings or disturbances entailing ignition, the consequences are often devastating (table 3).

Table 3. Studies of accidents during the handling of inflammable gases and liquids.

Report	Event	Number of deaths	Number Injured survivors	Type of fire	Cause	Notes
1	Coliseum accident in Indianapolis, USA 1963	66	436	Gas explosion	Functional fault	Refrigeration plant
23	Gas explosion in Clarkston, Scotland 1971	20	110	Town* gas explosion	Gas leakage	Shopping centre
24	Gas explosion in Argenteuil, France, 1971	18	113	Town gas explosion	Gas leakage	Block of flats
51	Fire in San Juanico, Mexico 1984	300	7,000	LPG explosion	Gas leakage	Filling of cistern
40	Gas accident in Los Alfaques, Spain 1978	About 200	Some hundreds	Propane explosion	Tanker truck accident	Gas cloud camping site
42	Chlorine release in Mississauga, Canada 1979	0	Few	LPG fire	Train derailment	Chlorine gas leak
54	Tanker truck accident in Herborn, Germany 1987	5	38	Petrol	Truck overturned	Leakage fire
66	Earthquake in Kobe, Japan 1995	5,000	30,000	LPG, etc	Earthquake	Gas leakage, landslide etc

Tunnel fires

Fires in tunnels exhibit special problems related chiefly to the development of smoke and to firefighting, together with the difficulties for those afflicted to escape from the tunnel. Two fires in tunnels have been studied (Table 4).

Table 4. *Studies of fires in tunnels.*

Report	Event	Number of deaths	Number Injured survivors	Type of fire	Cause	Notes
19	Train fire in Wrandukt tunnel, Jugoslavia 1971	33	120	Fire in the locomotive		Tunnel filled with smoke
56	Fire in underground railway, King's Cross, London 1987	37	60-plus	Smoke gas ignited	Fire started in escalator	Underground railway station burned out

Fires in restaurants, hotels and hospitals

In fires in restaurants, hotels and hospitals people are exposed to special risks since they most frequently are unfamiliar with the premises and the emergency exits and seldom realise how rapidly fire and smoke can spread (Table 5).

Table 5. *Studies of fires in restaurants, hotels and hospitals.*

Report	Event	Number of deaths	Number Injured survivors	Type of fire	Cause	Notes
29	Restaurant fire on Rhodes 1972	32	At least 15	Restaurant	Sparking in fusebox	Sudden flash-over
39	Hotel fire in Borås 1978	20	Approx 30	Restaurant	Glowing cigarette	Sudden flash-over
47	Fire at MGM Grand Hotel, Las Vegas 1980	84	700	Restaurant	Electrical fault in restaurant kitchen	Flash-over with severe smoke
61	Fire at Huddinge hospital 1991	0	18	Hospital	Arson	Severe smoke, evacuation

Fires on board ship

Fire on board a ship creates special problems regarding evacuation, rescue service, medical work and rescue operations. Smoke gases also represent a lethal threat.

Table 6. *Studies of ship fires.*

Report	Event	Number of deaths	Number Injured survivors	Type of fire	Cause	Notes
35	Oil fire at Corunna, Spain 1976	1	Few	Oil fire	Grounding, release	Environ-mental effects
60	Fire on Scandinavian Star 1990	158	About 30	Ship	Arson	Severe Smoke

Aircraft fires

The large quantities of fuel on board an aircraft can cause violent fires in the event of a crash.

Table 7. *Studies of aircraft fires.*

Report	Event	Number of deaths	Number Injured survivors	Type of fire	Cause	Notes
36	Aircraft accident on Teneriffe 1977	581	About 60	Aircraft fire	Collision on ground	Two jumbo jets
57	Air crash in Ramstein, Germany 1988	About 40	Hundreds	Aviation fuel	Air collision	Witnesses burnt
58	Aircraft fire, Manchester, England 1985	54	About 70	Aircraft fire	Engine fault	Fire and smoke in the cabin
64	Jumbo jet disaster in Amsterdam, Netherlands 1992	About 50	33	Aviation fuel	Engines broke loose	Crash caused fire in dwellings

Miscellaneous

Table 8. *Studies of other types of fire.*

Report	Event	Number of deaths	Number Injured survivors	Type of fire	Cause	Notes
30	Multiple collision, motorway, England 1971	About 15	About 80	Car	Crash	Fuel ignited
46	Terrorist attack in Bologna, Italy 1980	73	218	Explosion	Sabotage	Central station
59	Reactor breakdown in Chernobyl, Ukraine 1986	31	Unknown	Meltdown	Functional fault	Fire and radiation
62	Tram accident in Gothenburg, Sweden 1992	13	29	Vehicle	Crash	Incorrect break action
67	Explosion at World Trade Center, New York, USA 1993	6	Over 1,000	Explosion	Sabotage	Fire with severe smoke

Two publications are available as textbooks in this field:

- *Brännskadebehandling* (Thermal Burn Injury Treatment) (49) was written to fill the gap in textbooks on fire injury care during the disaster conditions that prevailed during the 1980s. It gives advice on treatment at three levels – normal medical care, disaster medical care and extreme mass injury care.

- *Kärnvapenkrig* (Nuclear Warfare) (52) is a survey of the various effects of nuclear weapons. It was published in 1986. A chapter on heat injuries is included. This book is discussed in the chapter "Ionising radiation".

Experience

A dominant medical problem in fires is the effects of smoke and toxic gases. But persons poisoned by smoke without other serious injuries who are alive on arrival at hospital have great possibilities of surviving without serious after-effects.

In the Manchester disaster (58) the fire started in the rear part of the aircraft. Hot black toxic smoke soon filled the whole cabin. Breathing, vision and mental function deteriorated rapidly for those on board. There was a panic-like evacuation of the aircraft. Those who were unable to get out died mainly in consequence of the inhalation of smoke and toxic gases. Only six of those who died did so as a direct consequence of thermal influence.

To improve the possibilities of getting out of burning aircraft it has been suggested that there should be transparent smoke hoods for each seat, which the passengers can pull over their heads. These should give passengers some protection against smoke for a minute or so.

Smoke was also the dominating medical problem in the Wrandukt tunnel accident (19), the Borås fire (39), the fire at the MGM Grand Hotel in Las Vegas (47), the Scandinavian Star disaster (60), the fire in Huddinge Hospital (61) and the explosion in the World Trade Center, USA (67). Many toxic gases are produced in a fire. Apart from carbon monoxide, toxic and irritant gases such as hydrogen cyanide and hydrogen chloride (hydrochloric acid) are often formed from synthetic materials. On board the Scandinavian Star almost 60% of those who died had no visible external injuries.

When smoke casualties arrive at hospital they often exhibit a very dramatic picture (19, 36, 39, 47, 56, 58, 61). They are black with soot, including the mouth and the nose. They are coughing and have breathing difficulties. The mucus membranes of the upper airways and eyes are greatly irritated. Respiratory assistance is needed in some cases. But the majority, if they have not incurred other injuries, can often leave the hospital fairly free from trouble after a period of treatment.

People often do not realise that a fire can be lifethreatening.

It is easy to misjudge the danger of a fire in its initial creeping stage. A little and apparently innocent source of fire can in a very short time develop into a blaze with a great deal of smoke.

In the Wranduct tunnel (19) the passengers remained sitting in the train until it was too late to make their way past the burning locomotive. They had to make their way backwards through the long and smoke-filled tunnel. Ambulances and physicians arrived forty minutes after the alarm but another half hour passed before smoke divers were on the scene. Of the passengers, by that time, fifteen were unconscious and thirty-three dead. The need for smoke diving and extra oxygen equipment had not initially been sufficiently considered.

In Rhodes (29) there was first a very limited fire in an electrical cable cabinet on the ground floor of a restaurant, for which reasons the guests on the floor above were not warned until it was too late. In the Borås fire

The west German town of Herborn in flames in 1997. A petrol truck overturned and the contents ran out and ignited some five minutes later. The majority of people in the surroundings managed to make their way to safety.

(39) the youths did not take seriously the warnings from the restaurant staff. In the King's Cross station fire (56), even fire-fighting personnel were surprised by the sudden flash-over of the fire gases that had collected.

The ship fire on board the Scandinavian Star (60) was a case of arson which, within a short time, developed into a powerful, smoking fire. It caused the deaths of some hundred passengers since they were not warned until it was almost impossible to save themselves by getting out. The fire in Huddinge Hospital (61) was also arson. A nurse recounted how quickly the fire spread: "The most frightening thing was how quickly everything happened. Even though I quickly got to know about the fire it had already become pitch black from the smoke in the corridor when I gave the alarm".

The Herborn accident (54), in which a tanker truck crashed, on the other hand, is a good example of how people can rescue themselves and many others by immediately recognising a danger – in this case leaking petrol.

In a serious explosion or fire accident, spontaneous rescue efforts often save lives.

A number of people in a fire or explosion risk losing their lives unless they get help almost immediately. The exposure to heat and smoke gases must be stopped and free respiratory passages established. It is important for people in the surroundings to be able to give “first aid” since as a rule too much time elapses before professional help can arrive or the casualties reach a hospital. If medical resources are near at hand the casualties can quickly receive medical help.

In the aircraft fire in Manchester (58) staff from the BEA airline quickly came to help and cleaned soot and dirt from the mouths and upper air passages of those passengers who had managed to get out of the aircraft and were showing signs of breathing difficulty. Artificial respiration was also given where needed.

Many of the disasters studied by KAMEDO afford further examples of how people in the surroundings have intervened to help those in distress in fire and explosion accidents (1, 24, 29, 39, 46, 47, 51, 54, 57, 58, 61, 64) and how in this way a large number of people have been saved. It may be assumed that the number of survivors would have been even greater if knowledge of first aid had been more widespread among the people nearby in the accident.

But in such spontaneous interventions, injuries requiring special care, e.g. back injuries, or the need of ABC measures before and during transport to hospital may easily be overlooked. It is therefore important that as many of the population as possible have been taught elementary knowledge of how to help injured people.

Yet here is also a danger that the “helpers” themselves may be injured if buildings collapse or if further explosions occur. Moreover, improvised and rapid removal from the scene of the accident without triage can, in a mass injury situation, lead to an impossibly large number of people arriving at hospitals and hampering their work (1, 39, 46).

Medical resources are needed at the accident scene.

First aid cannot replace the need for professional care at an accident scene with a large number of casualties. On the contrary first aid may give the medical teams a larger number of people to look after – casualties who are alive only thanks to the immediate measures. The need for acute care at the accident scene may be very large (1, 40, 51, 61). Sufficiently large care resources should therefore be sent to the accident area or to a break-off point. In some cases this has not been done, with negative consequences (1, 24, 40, 60). The Clarkston gas explosion (23), on the other hand, was a good example of how hospital staff were able to perform ABC measures at the accident scene, give pain relief, stabilise fractures and also conduct an acute leg amputation. About one hundred casualty cases were taken to the nearest hospital.

Medical tents or equivalent should be called up if need for them is anticipated and if such are available. The possibilities of gaining an overall picture of the damage outcome increase if the injured are cared for in tents or buildings and the risk of duplicating work is reduced. Medical staff gain better opportunities of examining and treating the casualties, who are protected from rain, cold and unauthorised persons. This was the case with the Amsterdam jumbo jet disaster despite the relative proximity of hospitals (64). In the Herborn fire, also, (54) medical care teams arrived from Frankfurt with tents and vehicles for surgical operations. While the acute life-saving interventions were then over, the group cared for people who had been injured while putting out the fire and searching for victims.

To avoid over-large gatherings of staff and material at the accident scene, which may jeopardise the efficiency of the operations, units may be held in readiness at a breaking point or if protracted work is expected, kept on call "at home". In this way there are rested staff who can relieve others at the accident scene or reinforce the operation (54). The time it takes before work at the accident scene is complete is often underestimated.

Vigorous and co-ordinated management of the rescue operation is necessary.

In fire or explosion disasters the confusion and spontaneous unorganised help of the first half hour is followed by police, rescue forces and medical resources starting to arrive and assume responsibility. They must rapidly organise an effective operation. There are many examples where this has happened (23, 24, 42, 47, 51). But not infrequently there have been organisational shortcomings (1, 19, 36, 40, 46, 57, 60, 66) with a weak management function and poor use of available resources. Co-operation between and even within the various rescue units has been insufficient and there has been duplication of work. This applies not only in the case of fires, but in most types of extensive accident.

At the Coliseum accident in Indianapolis (1), during the first hour total confusion reigned. When the police, fire service and Red Cross staff arrived they immediately started helping to put casualties in private cars and similar vehicles for the quickest possible transport to hospitals. The area was not cordoned-off immediately despite the great risk of further explosions. There was traffic chaos. No management organisation was established until more than an hour after the explosion. The hospitals learned of the accident when casualties started to arrive. The physicians involved in the operation have judged that more could have been saved if an early, vigorous and efficient management had been established at the accident scene.

Following the explosion in the Bologna railway station (46) many hundreds of people worked to relieve those in distress without any functioning overall leadership. Military and civilian personnel worked side-by-side without exchanging information. Scarcely any account was taken of the great risk of a collapse. It was even impossible to obtain temporary silence to listen for victims buried in the rubble.

Triage is extremely difficult in fire accidents. Not infrequently the lightest casualties arrive first at hospital.

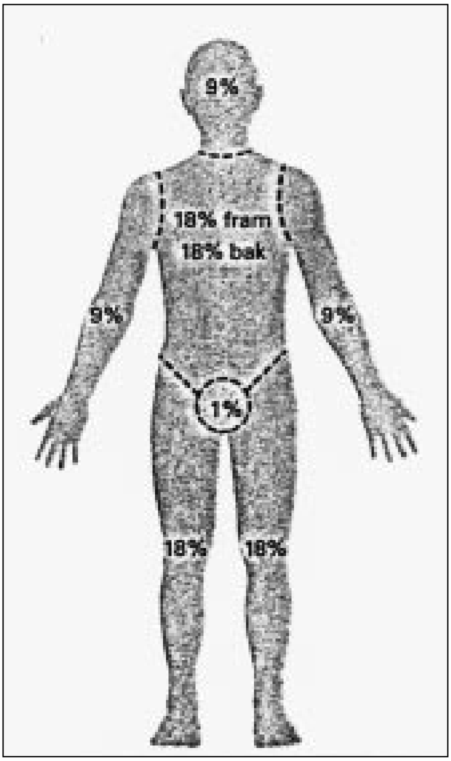
In accidents with personal injuries of traumatic type such as bruises, cuts, bleeding or skeletal injuries there are simple rules for medical triage. It is considerably more difficult to decide quickly about a person with thermal injuries. He can often speak, is mental clear and can move despite life-threatening injuries. The serious circulatory effects do not show immediately (40).

There are some rules for prognostic assessment. The extent, depth and localisation of the injury are considered, together with the person's age and general state of health. The extent is reckoned as a percentage using the "nine-rule". The depth of the thermal injury may be hard to judge. Some help is afforded by particulars of how the injury came about. Scalding often causes a partial skin injury while burning clothes give full skin injuries (48). The appearance of the wound and the response of the wound surface to pain stimuli and pressure give assistance in the assessment. Fire injuries from electric current through the body are often more extensive than they may first appear.

When a thermal burn injury is located in the face, neck or chest, the respiratory function may be affected. Deep circular burn injuries on an extremity can give serious disturbances of circulation far from the actual trauma.

When assessing the degree of severity it is important to talk to the injured person and check vital functions such as respiration, pulse, blood pressure and locomotive ability in arms and legs. Simultaneous occurrence of fractures, haemorrhages, lacerations or injuries to the cervical spine may easily be overlooked.

Injured people themselves attempt to make their way to a hospital as quickly as possible (39, 54). If the hospital is near the scene of the dis-



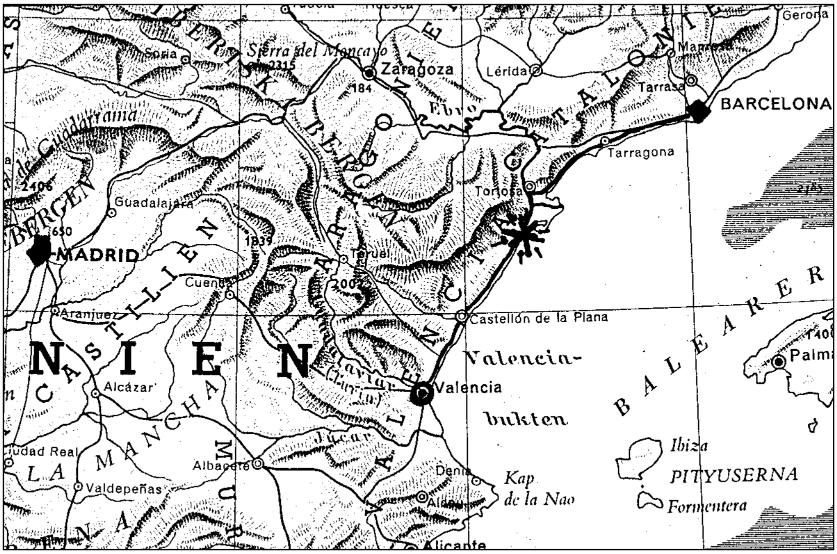
The nine-rule for rough assessment of body surface in the adult human. The palm of a hand represents about one percent of body surface.

aster, the least injured will get there before the others since they find it easiest to move about. Persons with serious injuries, thus those in greatest need of medical treatment, must often await help and ambulance transport at the scene of the injury.

In the Borås hotel fire a large number of slightly injured youths and accompanying friends suddenly arrived at the town's hospital. All were worked up and many under the influence of alcohol which contributed to the disorder. When the most seriously injured arrived by ambulance somewhat later, the staff were fully occupied with less serious cases. When it can be anticipated that seriously injured people may arrive later, it is important that hospital staff save and mobilise resources for this.

In extensive thermal burn injuries fluid supply must be started as soon as possible.

Guided by the severity of the injury and the injured person's body weight, it is possible to assess the volume and the composition of liquid required in the acute phase (48). Without early liquid therapy, mortality

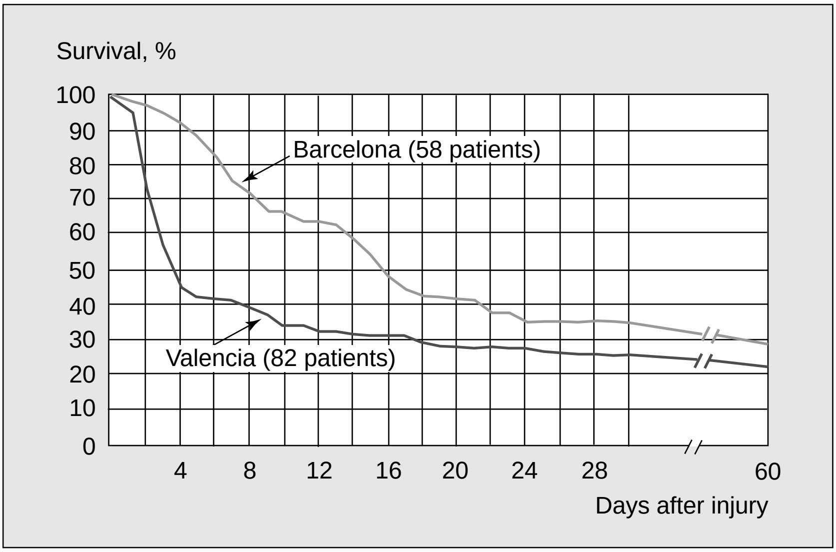


Los Alfaques (see note) is situated on the east coast of Spain between Barcelona and Valencia. A summer day in 1978 a truck loaded with propane gas got wrecked and the gas was set on fire. More than 100 people died immediately and about 125 persons got very badly burned and were brought to hospital.

increases rapidly in serious thermal burn injuries. The Los Alfaques accident (40) is an example of this.

Following the explosive fire, seriously burned people were transported north to Barcelona. Infusion therapy was commenced early at a fairly small hospital near Los Alfaques before onward transport to the burns clinic in Barcelona. An almost equally large number of people with burn injuries were transported *without treatment* south to the burns clinic in Valencia which is about the same distance from Los Alfaques as Barcelona is. On arrival after the seven-hour journey many of the latter were in circulatory shock.

In a comparison between the two groups with approximately the same age distribution and severity of burn injuries, four days after the accident 93% of those taken to Barcelona were alive but only 45% of those taken to Valencia. The difference in survival is probably explained by inadequate fluid therapy before and during the transport to Valencia. Large quantities of liquids would have needed immediately during the first few hours following such extensive thermal burn injuries. But note that there are also examples of occasions where "excess fluid supply" has taken place with pulmonary oedema as a consequence (51, 64).



Comparison of percentage of survivors among thermal-burn-injured persons transported to Barcelona or to Valencia. Note the large mortality in the first few days among those transported to Valencia without liquid treatment, and how the curves then approach each other.

In a follow-up study of the Los Alfaques disaster (40), two months after the accident there was only a very small difference in survival between the two groups.

The thermal burn injuries may have been so serious that the majority of casualties would have died after a few weeks despite optimal care.

Not infrequently, people with burn injuries do not initially realise how serious the injury is. Nor can their relatives to start with understand the physician's pessimistic assessment. Serious infections have not yet set in. The injured person is conscious, can move and is being cared for by experts at a special clinic.

In the Los Alfaques gas accident (40) Spanish physicians preferred to give casualties whom it was known would die within some weeks only positive information – including untruths. Such is not accepted in Sweden. If people are to have confidence in medical care staff it is necessary to keep to the truth.

Burn injuries are particularly heavy on resources. Long term prognoses must therefore be observed.

A single large burn injury requires an isolated ward at a hospital for about six weeks and at least eight to ten operations under general anaesthesia. Such a patient commonly also requires parenteral nutrition and this takes about six litres of blood, five litres of blood plasma, seventy litres of saline solution, eighty litres of sugar solution, forty litres of amino acids and thirty litres of emulsified fat for this one patient (48, 52).

In triage in a mass burn injury situation, therefore, great attention must be paid to the long term-prognosis. One must not lose somebody with a good prognosis for a meaningful life because of excessively large allocation of resources to “almost hopeless cases”. If the medical resources are insufficient, older people with burn injuries exceeding 50% of body surface should not load the burn injury clinic since their probability of survival is low (48). As opposed to this, the best possible treatment at another clinic should be offered.

However, in the acute stage it is very hard to judge injuries. A “second opinion” from physicians fully conversant with burn injury treatment is often required. In addition, the severity of smoke and gas poisoning in connection with burn injuries may be very hard to determine.

Where possible collect ongoing information from casualties.

While still at the accident scene, much information can be obtained from survivors. This concerns not only particulars of injuries, the cause of the accident and the particulars of the injured person, but also details of others in the area affected by the accident. The injured person may have spoken with one or other of these or noted details that may be of use.

The collection of information should start as early as the situation permits without delaying medical assistance. There is always a risk that a person with burn injuries will be in circulatory shock a few minutes later or in some other way will not longer be capable of giving information (36, 40, 51). The same also applies to many other injuries with a risk of insufficient circulating blood volume. As far as possible one should avoid the same questions being asked on repeated occasions by police, the fire service, medical care etc. The injured person will be tired out and greatly irritated by continually being required to give the same information to different people (63).

When collecting information it is convenient to use small portable tape recorders. This is particularly so if because of darkness, cold or loss of time, it is hard to take notes. The need for such equipment was pointed out by rescue personnel in the King's Cross fire (56).

In many of the accidents KAMEDO has studied rescue personnel have moved dead people without first noting the positions of the bodies. In this way identification has been rendered more difficult (36, 40, 46, 51, 57). Details of position, posture, belongings nearby etc may be a very great help in subsequent police enquiries and identification.

The number of physicians present and the scope of care at the accident scene are controversial questions.

In extensive accidents in many countries, medical teams are sent from nearby hospitals to give qualified first aid at the accident scene. People with burn injuries in this way get an early assessment of their injuries and need of care. Infusion therapy can be started even before transport to hospital.

But this principle is not applied in all countries. In e.g. England and the USA medical teams are not sent out as a rule. One reason is that one should not send personnel out from hospitals in a situation where they are most needed there. In the aircraft fire in Manchester (58) physicians did not come to the airport. In the King's Cross, London, (56) fire, physicians from a voluntary organisation did not arrive until an hour after the fire started. In the air crash at the Nato base in Ramstein, Germany, (57) physicians were present on the base since it was an air show, but they were without acute equipment. Red Cross stations were in readiness at the air base, but were equipped only for simple medical measures. No medical care teams were sent from the nearby American Military Hospital.

When discussing the need for physicians' assistance at the accident scene, one must consider the varying levels of training of ambulance staff. A New York paramedic has training that in certain respects can be compared with that of a Swedish nurse trained in emergency medicine. In addition, he has practice in giving acute care at accident scenes (67). In Sweden there are a number of acute ambulances with nurses and sometimes doctors. But so far we have not entirely implemented the current raising of competence among ambulance staff.

Views on how much medical care should be given at the scene of the injury also diverge. In some European countries qualified first aid and sometimes also certain other treatment is given at the scene of the injury (“stay and play”). The Americans, with experience from the wars of the past ten years, prefer to reduce measures to a minimum so as not to delay transport to hospital (“load and go”). Certainly, if the transport time to hospitals prepared to rapidly to care for seriously injured persons is short and the availability of medical transport resources very good, this principle has its advantage (57). Life-maintaining measures must always be taken at the scene of the injury where needed.

But in Sweden it is often a long way to a hospital. It is therefore not infrequently necessary to send medical teams to the scene of injury for initial care in explosion and fire accidents where many people are injured. People with thermal burn injuries need among other things early infusion therapy (40, 48) and smoke casualties need ventilatory support and oxygen (47, 48, 60, 61). Meanwhile there is an opportunity to call in extra staff to the hospitals if required.

Hospital disaster plans should retain normal routines as far as possible.

Medically speaking, the difference between a “normal” accident, a large accident and a disaster is that in a disaster regular care resources are insufficient. It becomes necessary to mobilise extra personnel and material resources and, at the expense of the hospital’s normal and partly planned activity, to concentrate on meeting the great medical needs created by the accident. It may also be necessary to change certain routines and e.g. use waiting rooms and equivalent spaces for medical care and to discharge or send away those patients that can be cared for elsewhere.

According to the disaster plan for Borås hospital in 1978, in the case of extensive accidents the main entrance and the cafeteria were to be used as a reception unit (39). But this was not known to people outside the hospital and in many cases not by hospital staff either. When the fire at the Town Hotel occurred, private vehicles, taxis and ambulances drove as usual to the emergency department. Hence the disaster plan was not followed. Nor in the King’s Cross fire disaster (56), Ramstein (57) or Manchester (58) were disaster plans known by all those involved, and were therefore not applied.

To minimise the negative effects of disaster plans not being followed, the routines laid down in the plans should as far as possible correspond

The fire at Borås Town Hotel in 1978 in which twenty young people lost their lives. More or less seriously injured people were helped in various ways to get to the hospital.

to normal medical routines. This naturally also applies to different types of accident even though it was particularly evident in the above-mentioned fires.

In hospital fires special and serious problems may arise.

Hospitals often consist of several buildings connected with corridors and culverts. There are lifts between the various floors. Many patients at outpatients' clinics and on the wards have difficulties in moving about. Few know about the emergency exits. Hence a fire is serious threat. For this reason there are smoke or fire detectors at a number of strategic points. There are also fire hydrants and hospital staff should have certain training in putting out fires and in evacuation. Mattresses and bedclothes are of fireproof material – but may ignite. To prevent the spread of fire and smoke in the buildings there are doors that shut automatically in the event of fire. Despite these preventive measures, fires and particularly smoking fires, represent a serious problem.

The fire at Huddinge Hospital (61) shows how serious the consequences of a hospital fire can be – even though in this case no disabled patients were involved. The evacuation was impeded by thick smoke that reduced sight and gave eye and airway irritation. Despite the fire doors, the smoke spread rapidly throughout the building since the doors were opened as the help operation proceeded. Via lift shafts the smoke spread to upper floors. Lift mechanisms caused the lifts to go down to the bottom floor when the doors were opened. They could not then be shut since the smoke broke the light beam to the photocell. People in lifts risked losing their lives.

Since the clinic involved was a psychiatric one the majority of doors were kept locked. The windows had unbreakable glass and were also locked. Rescue teams had difficulties in distinguishing between patients and staff since no special hospital uniform was worn and the name badges gave only a first name. Some patients were criminal patients. Police escort was required in the evacuation. The cardex cards which record medication were not always brought by those evacuating the building and this made treatment more difficult. The appropriateness of sending care teams from their own hospital to the site of the fire has also been questioned. If the number of injuries had been high, these resources would have been needed at the emergency department, operating theatre and IVA.

Routines for operations in an internal fire disaster at a hospital should be the object of special planning and training (61). Special regulations are needed for fires at psychiatric departments since fire incidents there are common and staff must be responsible for early and vigorous firefighting.

Rescue in the case of fire or explosion in tall buildings shows particular difficulties.

In the gas explosion in a residential block in Argenteuil (24) over a hundred injured people needed to be cared for and taken to hospital. Evacuating the tall building was particularly difficult since not only the lifts, but also the stairwells had been destroyed and the fire service ladders did not reach sufficiently high. It is always a very large problem that fire ladders only reach to about the seventh floor.

In the Las Vegas hotel fire (47) the fire itself was at ground level, but the smoke followed lift shafts and stairwells and killed or injured a large number of people high up in the buildings. Hotel guests attempted to get down through emergency exists, but were confined in stairwells. Many guests, however, managed to make their way to the roof where they were rescued by helicopters. Some could not get out of their rooms because of the smoke in the hotel corridors and attempted to be saved by helicopters via the window or to make their way down to lower levels using sheets tied together. Much assistance from smoke divers was needed. Three casualty assembly points were established. More than 4000 people were taken there and cared for by ten emergency medical service physicians and about thirty paramedics. Seriously injured (approximately 700) were then transported to one of the town's four hospitals.

In the explosion at the World Trade Center in New York (67) enormous quantities of thick black smoke were also generated which, through the chimney effect, spread up within the tall building. Lighting and other electrical equipment had been damaged in the explosion and the reserve generators functioned only for about twenty minutes since their cooling system had been damaged. Tens of thousands of people were in the building and exposed to the smoke. One thousand were injured and six died.

Even at the planning stage of projects of this type particularly strict requirements must be placed upon fire safety, protection against the spread of smoke and evacuation paths. Disaster plans must be practised – if possible even in darkness or smoke. Luminous lines on the floor or other form of visible emergency information should be present. Lifts and lift shafts have proved to have weaknesses in fires and these may need to be remedied.

Rescue and medical care at the scene are extremely demanding in serious fires.

Smoke diving is physically particularly demanding. Special requirements as to health and physical condition are therefore placed on such personnel. But other personnel at the accident scene too, e.g. when fire fighting or giving medical care at the site of a fire, are often exposed to very great physical and mental strains. The heat can be intensive, requiring clothing that gives protection against the heat radiation. The sound level is high. The risk of explosion or collapse of burning buildings may be great. Bodily fluid losses are often considerable. Plenty of

The gas explosion in Clarkston in Scotland in 1971. A car park collapsed in the explosion, falling down into a shopping centre. About twenty people were killed and just over one hundred injured. Medical care teams took part in operations at the accident scene without special protective equipment.

water or other fluids to drink is required and the working shift may need to be shortened (42, 51, 56, 59).

When medical staff are used at the site of a fire, allowances must be made for their lack of experience of such work and varying physical conditions. Explosions, collapses or poisonous gas may suddenly change the conditions in which they must work.

The need for debriefing and crisis processing after fires is often great.

A threat to life from a fire and heavy smoke involves a serious mental trauma. But experiences in which one is not oneself exposed to a direct threat of death but sees how surrounding people cannot be saved or are being seriously injured also leave deep marks. In recent years, the profound mental changes that disasters can give have been increasingly noted.

To limit injurious psychological effects of violent events, attempts are made to carry out debriefing and early crisis processing. The first time this was described in a KAMEDO report was in 1977 concerning the Tuve landslide (37). No fire was involved in this case. But not six months later there occurred the Borås fire (39) in which the severe mental effects of the accident were particularly noted. That year, KAMEDO published its "Psykiska reaktioner" (Psychological Reactions) (38), briefly describing common reactions to disasters.

Sweden and many other countries now have crisis clinics and psychology-psychiatry disaster management groups (PDM) for support following extensive accidents. In the Huddinge hospital fire report (61) the hospital PDM group wrote: "The worst-off have been those who themselves have been exposed to life-threatening events, been shut in or experienced having abandoned comrades or seen others being injured. Even those who were confined to a passive role or who felt that they have been able to make an active effort for patients or colleagues felt bad". The Swedish municipalities also have groups for psychological and social support, termed psychological and social management (POSUM) groups.

Debriefing of staff who have taken part in extensive rescue operations is now seen as a natural part of the work (60, 61).

Ionising radiation

Definitions of units

- Amount of radioactivity is given as the number of decaying atomic nuclei per unit of time. One decay per second = one becquerel (Bq). Formerly the unit curie (Ci). One Ci = the activity in one gram of radium.
- Ionising radiation converts electrically neutral atoms to charged ions. The number of ionisations in the air is measured in roentgen (R)
- Gray (Gy) is a unit of absorbed radiation dose and corresponds to the absorption of an energy of one J/kg tissue.
- Sievert (Sv) is a unit of the product of radiation dose in Gy and a factor giving the relative biological efficiency of the radiation. For gamma and beta radiation this factor, is however, one. One thousandth of an Sv is written 1 mSv. Background radiation in Sweden gives five to seven mSv/year.
- Dose rate = mSv/unit of time.

General

An atomic explosion or a severe accident involving radiation differs from other "man-made disasters" partly through its enormous consequences.

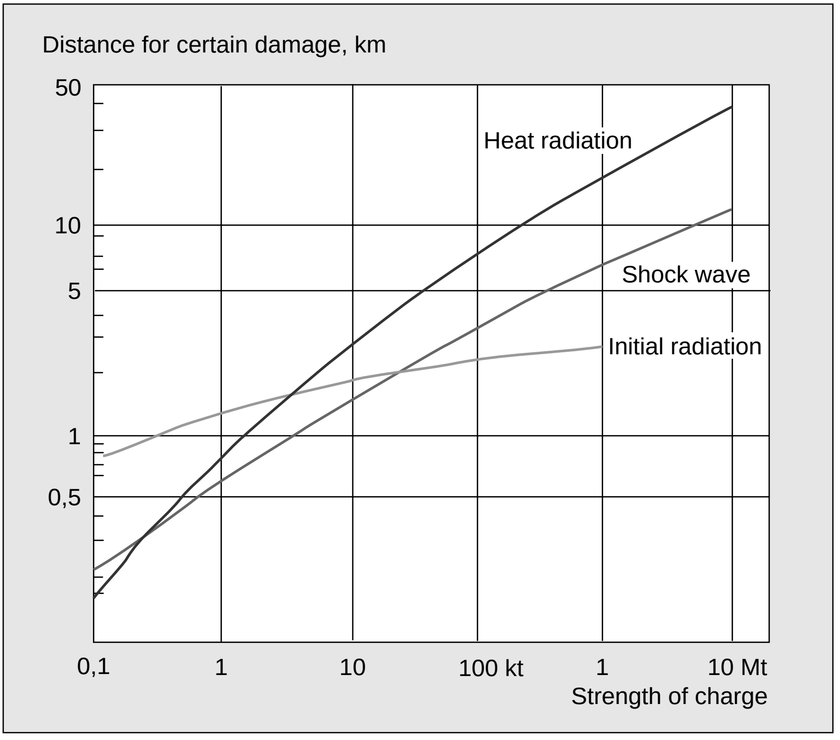
Nuclear weapons

The risk that atomic weapons may be used is not limited to conflicts between superpowers. A number of other states also have nuclear weapons. In addition the large stocks of nuclear weapons represent a certain danger that nuclear charges may fall into the "wrong hands". Leakage and waste consequent upon e.g. the scrapping of obsolescent nuclear weapons may also represent a risk factor.

The effects of a nuclear charge are *aerial shock wave*, *heat radiation and ionising radiation*. How the energy is apportioned between the different forms is determined by nuclear-physical and other processes at the instant of the explosion and through the early interplay of the energy with its surrounding medium (52).

An aerial shock wave arises when surrounding air is heated up, compressed and accelerated outwards. As this shock wave crosses an area there is a powerful rise in pressure that may have a duration of more than one second and also an air current (shock wave wind, blast wind) that can reach far above hurricane strength. Buildings collapse, trees are broken down and the air is full of flying splinters and debris.

The fireball in an exploding nuclear charge first emits a brief pulse consisting chiefly of ultraviolet light. This is followed by a heat pulse that may last many seconds. In connection with this 35% of the bomb's total energy is released as heat radiation. A rapidly growing fireball is seen. When the shock wave expands it is cooled down, the fireball



How damage distance varies with strength of charge in atomic weapons where the explosion is assumed to take place at an optimal height for the strength. It will be seen that heat radiation increasingly dominates the aggregate effect profile the stronger the charge is.
Initial radiation is of the greatest relative significance at the lowest charge strengths.

ceases to expand and the shock wave leaves the fireball behind it. Since the interior, hotter parts of the fireball are no longer masked by the shock wave its surface temperature rises again. Following this second temperature maximum the ball's surface temperature sinks relatively slowly. Heat radiation from this spreads at the speed of light, decreasing in strength by the square of the distance. In addition, a portion of the heat radiation is absorbed by the air. Serious fires break out.

The ionising radiation has left the fireball before this is fully formed. The initial ionising radiation is normally defined as the radiation emitted from the fireball and which then changes into an explosion cloud during the first minute. The cloud has then risen so high that the radiation is negligible. Initial radiation comprises many components. This radiation also declines by the square of the distance, and also through absorption. Gamma and neutron radiation is absorbed strongly in the air, for which reason there is rapid attenuation with distance.

An electromagnetic pulse (EMP) arises through part of the initial gamma radiation being absorbed in the air, ionising it. At the same time a powerful electrical field is generated round the explosion. There is also an electromagnetic field round the explosion point from which "radio waves" are emitted over a broad frequency range.

Fission products formed in the explosion are radioactive. There may be around a hundred different radioactive nuclides which all decay at their own rates and contribute to the aggregate activity. For practical purposes one can roughly reckon that the dose rate diminishes in inverse proportion to time.

Where the activity goes and what damage it causes depend greatly on the height of the explosion over the ground. In an aerial explosion particles will fall to the ground under the influence of prevailing winds. The time they take to fall may be from days to years and the result can be global fallout. No significant coverage arises in the vicinity of the explosion. In a surface explosion, i.e. near the ground, the ground material close to ground zero is pulverised and partly vaporised. The air current tears up thousands of tons of this material. Following a surface explosion the larger particles can reach the ground within a few tens of minutes and a large proportion of the active quantity falls during the next few hours. At a distance of several tens of kilometres downwind, radiac coverage is formed. The fallout is also beta-active.

The effects of a reactor accident

In a reactor accident, unlike a nuclear explosion there is no area around "ground zero" (the point on the surface of the earth perpendicularly under the centre of the explosion) within which the explosion is directly life-threatening. It is possible that circumstances within the plant may lead to directly lethal effects, including those caused through high radiation doses (59).

Instead persons outside the installation are exposed to circumstances resembling those that arise further from ground zero in nuclear explosions near the ground. They would be exposed to radiation in connection with the passing of the radioactive cloud – and, most importantly, from the radioactivity deposited on the ground.

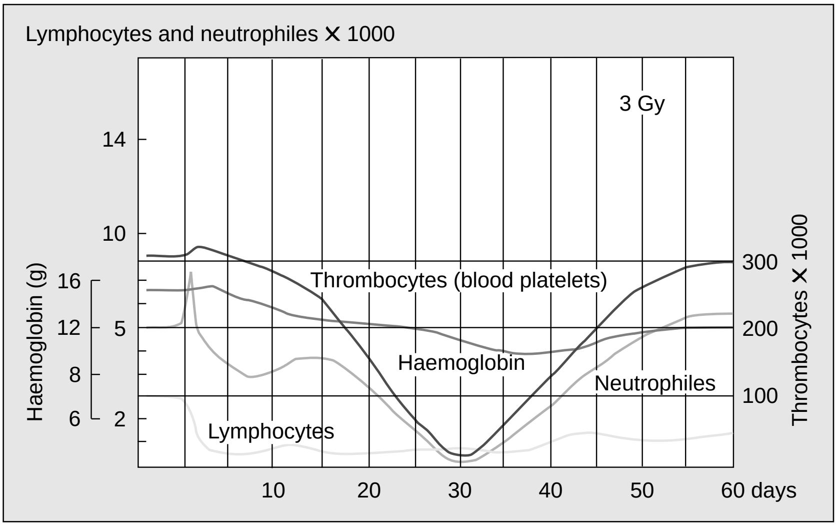
There are three important differences between a reactor accident and a nuclear explosion.

1. The relative proportion of long-living radioactive substances is greater in a reactor accident, for which reason ground coverage will diminish considerably more slowly at least during the first few years.
2. The smaller particle size in a reactor accident gives a different dispersal of radioactive fallout, with less effect close to, but greater further away.
3. It is considered that the products of radioactive fission in reactor accidents may also be inhaled and that the airborne particles are so small that they can penetrate to most peripheral parts of the pulmonary tree. Note also that the energy released in an explosion of a nuclear charge is many times greater than what was released from the Chernobyl reactor. The most serious consequence of a nuclear weapons explosion is the total destruction owing to the shock wave and heat effects over a large area. This has no correspondence in a reactor accident.

Injuries to human beings

Even a very small quantity of energy in the form of radioactivity can cause serious biological damage. Through a few ionisations in critical cell structures the capability to continue dividing is destroyed. Whole-body irradiation of a human with 5 Gy is life-threatening even though the radiation corresponds only to an energy absorption that would raise the temperature of water by a hundredth of a degree. Since it is primarily the genetic material that is susceptible to radiation, it takes a certain time before a radiation injury becomes manifest.

On detonation, nuclear weapons emit beta, gamma and neutron radiation. Neutron radiation is produced only initially while beta and gamma radiation is emitted both initially and from subsequent fallout.



Changes in blood profile following exposure to 3 Gy (Andrews 1980).

Residual fission material, in addition, contains alpha-radiating material (52). Thus radiation occurs as initial radiation at the time of the explosion and as radiation from subsequent fallout.

Where a person is exposed to radiation from a radioactive source outside the body, the radiation is said to be external. If instead radioactive material has entered the body, the radiation is said to be internal. In external radiation doses it is primarily gamma radiation that is of importance while alpha and beta radiation represent the dominant risk if the substance has entered the body.

Gamma radiation has a much longer range than alpha and beta have. Beta radiation is absorbed already at 1–2 cm depth in the body and alpha radiation has an even shorter range. One of the most dangerous products of fission (strontium 90) emits only beta radiation, which makes it dangerous only when it enters the body with food or inhaled air or is caught on the skin. The fallout from detonated atomic charge has fairly high strontium 90 contents. This is termed a "bone seeker" i.e. is collected in bone tissue if it enters the body. In this way the radiation-susceptible, blood-forming tissues in bone marrow can be exposed to significant amounts of strontium which remains there for a long time. Biologically, therefore, strontium 90 is a considerably more dangerous fission product than the cesium 137 that dominated the risk profile after the Chernobyl accident. Cesium 137 disperses fairly homogeneously and is eliminated considerably more quickly.

Studies and compilations of facts

Karnvapenkrig (Nuclear Warfare) (52) was published in 1986. A number of specialists describe the various effects of nuclear weapons. Using these as a basis, an attempt is made to assess the consequences for Sweden in terms of disaster medicine.

A whole chapter is devoted to thermal injuries. Thermal burns arise partly as a result of the heat pulse emitted and partly in the fire storms that may be generated. The following shock wave increases the intensity of secondary fires. Resources for assisting people with burn injuries are considered to be small.

The effects of ionising radiation on the human body are also described, as are attempts to treat these. This concerns the acute effects where survival under optimal conditions is scarcely judged to be possible at radiation doses exceeding 5–6 Sv whole-body irradiation. Following an attack with nuclear weapons in which other types of bodily injury are most frequently also present, the figure for possible survival is very much lower.

The reactor meltdown in Chernobyl, Ukraine on 26 April 1986 (59) led to the development of extremely high temperatures and fire that required great efforts to extinguish.

Even though the firefighting personnel were aware of the radiation risk, in the initial phase no account was taken of radioactive emissions. People were more troubled by the heat radiation and the smoke from the fires. Some people sustained burn injuries.

After some hours signs of acute radiation injury appeared. Following treatment at the power station clinic, those affected were sent to the hospital in Pripjat. More than one hundred people with serious radiation injuries were then sent to Moscow for specialist care. Thirty-one persons died as a direct consequence of the accident. Two died directly at the accident scene. In nineteen cases, skin injuries were an important contributory factor to death. In seven of the deceased, the direct cause of death was radiation pneumonitis.

Close on two thousand physicians took part in a follow-up medical operation in the Ukraine during which iodine was given to the population and large scale follow-up investigations were carried out. In the report, the consequences of the accident are analysed and certain experience is reported.

For casualties, opportunities to get help following a nuclear attack are very small. There is probably no advanced thermal injury care.

The number of dead and injured following a detonated nuclear charge depends on many factors, e.g. type of nuclear weapon, explosion height, atmospheric and geographical conditions, nature of building and where the people were at the time of the detonation and later.

Within a given radius from ground zero, survival is impossible except with extremely good protection. Outside this radius there may be survivors whose lives it may be possible to save if they get help and treatment. But any relief units have an almost impossible task to help those in distress during the first few hours and days following the detonation. Fires, radioactivity, blocked roads and streets, poorly functioning signals equipment, inadequate information and the enormous scope of the disaster mean that by and large only those casualties who can themselves get out of the area will reach treatment in time.

As mentioned above, following an aerial explosion the risk of local radioactive waste is small while a surface explosion is followed by radioactive fallout in the proximity. It is particularly hard for an individual to determine what type of detonation it has been and to decide whether he should remain in possible shelter or attempt with well fitting clothes and respiratory protection to make his way out of the area.

In the case of a detonating nuclear weapon (52) radiation decreases by the square of the distance from ground zero. Fog and rain help to reduce the size of the damage area. In addition, everything that “shades” direct heat radiation gives some protection against this. At a certain distance from the centre of the explosion, therefore, there may be a large number of burn casualties who are alive. These are affected by the synergetic effects of heat, ionising radiation, shock wave and toxic gases from secondary fires.

In Hiroshima there were 56,000 burn injuries to be cared for following the detonation of a 14 kt bomb. Of the city’s 54 hospitals, 42 were destroyed. Only some thirty physicians and about a hundred nurses had survived. Under such conditions, what we mean by medical care can scarcely be carried out. Only slightly injured burn cases survive.

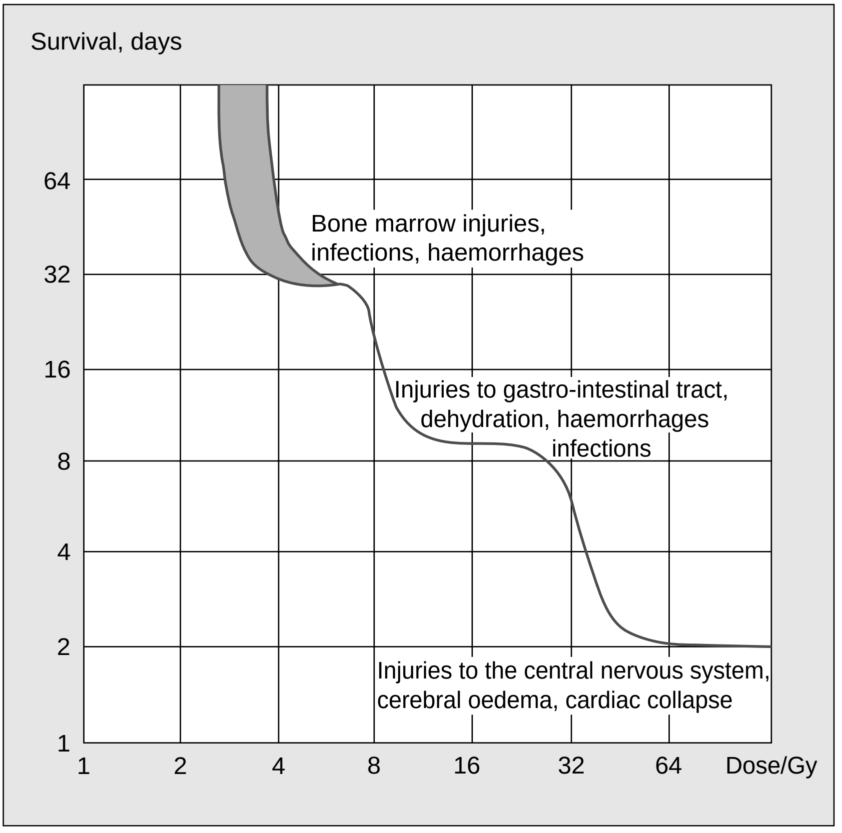
It is very hard to determine the seriousness of a radiation injury at an early stage.

Physical dosimetry is as a rule impossible and it becomes necessary to rely on biological parameters in the assessment of the scope of radiation injuries. The symptoms appearing and the latency time before they appear stand in relation to the size of the radiation dose. But casualties have also been afflicted by many other effects of the nuclear charge, which clouds the symptom picture. In addition, the powers of resistance of the vegetative nervous system to radiation are to a certain extent individual. If the number of lymphocytes in the blood can be determined this is a good method of examination which may be used even the first twenty-four hours. But in a mass injury situation, there are probably no resources for this. One can roughly follow the rules below in the assessment of those exposed to radiation.

- In radiation doses below 2 Gy there is sometimes slight nausea during the first two to six hours. But the absence of prodromal symptoms does not necessarily mean that the dose has been insignificant. The number of lymphocytes in blood can decrease towards 1.2×10^9 per litre of blood during the first two days.
- If the radiation dose exceed 2 Gy there is often emesis within one to two hours and the trouble persists for a day or two. The injured person is dull and weak. The number of lymphocytes in blood decreases during the first twenty-four hours to values below 1.2×10^9 per litre of blood. In Chernobyl it was considered that definite radiation disease was present when the number of lymphocytes was below 1.0×10^9.
- In radiation doses exceeding 6 Gy, emesis, diarrhoea, circulatory effects and great exhaustion appear directly after an hour or so and persist for a few days. The number of blood lymphocytes decreases to values below 0.3×10^9 per litre of blood.

In a nuclear weapons situation the possibilities of treating radiation injuries are extremely limited.

As will be seen in the diagram overleaf, fatality increases rapidly with rising whole-body irradiation. Medical treatment has in some cases a positive effect if the whole-body dose is under about 6 Gy. For doses under 3 Gy no particular treatment is recommended apart from general



Whole-body irradiation of adult human. Survival as a function of average radiation dose.

medical measures prompted by the patient's symptoms (52). For doses over about 3 Gy during peacetime conditions, it is recommended that the patient be isolated in a sterile environment and given antibiotics. Blood transfusions may be required.

Hence even if treatment of radiation injuries can increase survival in radiation doses of some Gy it is doubtful whether such treatment is possible following the use of nuclear weapons. It is more important to attempt to persuade the population to keep under cover until the radiation from the covered area has sunk.

In a nuclear weapons situation there must be rough triage with respect to prognosis of survival, requirements on treatment efforts and available resources for treatment. The affected person has probably also been exposed to a number of stress factors that affect radiation tolerance unfavourably. But despite the uncertainty, in triage three groups can be distinguished:

- *Group one* consists of those exposed to a radiation dose below 2 Gy who have no injuries, diseases or other conditions that would reduce the resistance to radiation. Survival is sure or probable. Medical treatment can be confined to rest, warmth, liquid and simple aid measures. If care resources are extremely limited, the exposed person should not burden institutional medical care unless it is a case of a child or pregnant woman. Infected environments should be avoided.
- *Group two* have received a dose of between 2 and 6 Gy. Injuries, diseases or conditions entailing lowered resistance to radiation are not present. Survival is possible to doubtful depending on the size of the dose. Treatment is necessary. Supply of liquid and monitoring of circulation are required. The injured person should be protected from further stress factors and should be kept resting. If institutional care is available he should be conveyed there. After a few weeks the susceptibility to infection is so great that isolation is required.
- *Group three* have been exposed to whole-body irradiation exceeding 6 Gy. Treatment is without prospects, for which reason in a mass injury situation, these cases should have a lower priority in favour of group two.

Children resist radiation less well and probably receive higher average doses, partly because of the lesser degree of attenuation of radiation in a smaller body. Foetuses represent a particular problem. Abortion is recommended following higher radiation doses than 0.1 Gy in the eighth to the fifteenth week of pregnancy. (52)

To limit radiation doses for rescue personnel there must first be checks of the area, and the time spent within a contaminated area must be kept brief.

All detonations of nuclear weapons must be considered as surface explosions until the opposite has been confirmed. Even if there has been no radioactive fallout, radiation monitoring should be carried out in view of the possible presence of neutron induced activity. This means that no rescue action can be commenced until measurements have given an answer concerning possible radioactivity. Checking and reconnaissance groups are sent from different directions into the area below the earlier aerial detonation (the hypocentre). Rescue units are kept on hold. Assembly points and cordons are established. In some cases it may be an advantage to work as if peeling a fruit, in towards the hypocentre. The vehicles used should be designed and equipped so that they as far as possible afford protection against radioactive fallout and ambient radiation. Sufficiently many workers are needed since the rescue operation may need to continue for a long time and there will be many uncertainties concerning how much protection those affected may have. Where there is a risk of high radiation doses or contamination, work shifts are kept short. Later decontamination and recovery may need to be carried out over very long periods and may require the co-operation of specialists, qualified leadership and large material and personal resources.

In nuclear power accidents the population must quickly receive correct information.

Accidents in nuclear power stations do not give the same total destruction at ground zero as the detonation of a nuclear charge. People in the surroundings do not necessarily notice anything of what has happened but nevertheless may risk exposure to radioactive releases. With their senses there is no way that they can record whether there has been dangerous exposure until this reaches a level where symptoms start to appear. Nor do they know where to go to avoid exposure; and their knowledge of radioactive substances, their biological effects and how one can protect oneself is as a rule small. The population greatly needs easily-understood and correct information.

Later, too, after the most acute phase, the population will long need ongoing information. There is a risk that rumours and incorrect particulars will be given. After Chernobyl there turned up in the then Soviet Union a number of "experts" and politicians who attempted to exploit the situation for their own or their party's purposes. The chance of gaining more economic allocations etc caused them to exaggerate the radiation risks and even to use disinformation. In addition, people delighted in making pronouncements for purely exhibitionistic reasons with very poor knowledge in the area.

In the Chernobyl disaster parts of the population of Ukraine and Russia exhibited what was termed radiophobia. This was an almost psychotic fear of radiation. The people felt exposed to something they could not see or feel but which dogged them everywhere. They had no confidence in the authorities. The information given was not infrequently contradictory. The fears of being outside and partaking of the already scanty foodstuffs induced sicknesses and undernourishment, particularly among children. Deficiency diseases became a greater threat than calculated future radiation injuries. Even among the physicians the health effects of the low radiation doses were misinterpreted as a consequence of their poor knowledge of radiation biology. This radiophobia was reinforced by the people not being able to obtain clear and unambiguous information.

To begin with cordons should be placed at a great distance. At assembly points and road blocks competent medical personnel are needed.

Following the fire in the Chernobyl reactor, road blocks were erected first at ten kilometres then at thirty and forty kilometres and finally also at a hundred kilometres from Pripjat in the direction of Kiev. It turned out to be a great mistake initially only to measure the coverage within the vicinity of the power station and to place the blocks so near the disaster area. It would have been more correct to erect blocks at a greater distance instead, e.g. a hundred kilometres, and then successively reduce the distance as measurements showed what the extent of radioactivity within different parts of the area was.

Groups of physicians, nurses, radiation protection technicians etc were organised and sent to places to which evacuees had been conveyed. Equipment had to be brought out for this work. Even though competent physicians contributed it was difficult for them under field conditions to interpret small changes in the blood samples taken. In their assessment of the health state of the person examined it was also necessary to consider psychological effects. Not radiation doses but worry in many cases caused people to feel sick. More than one thousand medical students were sent out to talk reassuringly with those who were still suffering from “radiophobia”.

Planning is needed for the work of medical teams examining and assisting in the evacuation from contaminated areas following the release of radioactive material or fallout from nuclear reactors in relative proximity.

Clothes, shoes and blankets are needed for evacuation from contaminated areas. The problems associated with food and water must be addressed.

About 8,000 of Pripjat’s 48,000 inhabitants left the city of their own accord in their own vehicles or in other ways. The total evacuation was commenced thirty-six hours after the accident. At the first roadblock, ten kilometres from Pripjat, a contamination check point had been established where evacuees had to remove their clothes and shoes and wash. At the check point forty kilometres from Pripjat measurements of radioactivity showed that many of the evacuees still had such high values that they must leave their clothes, shoes and some other possessions. Large quantities of clothes and other necessities had to be requisitioned. In a situation like this it is thus necessary to be able at short notice to produce large quantities of clothing. Evacuees were also dissatisfied with the fact that their examination comprised only measurements of radiation. They wished to have medical examinations and to have blood samples taken.

Immediately after the accident a prohibition was issued on the use of wells and watercourses for the supply of drinking water within a 30-kilometre radius of Pripjat. Certain areas further downstream later could not be used either. Kiev got a whole new water supply seven weeks after the accident. Special checks on foodstuffs were introduced in Kiev one week after the accident and later shops were required to show certificates that the foodstuffs they were selling had been checked.

Without going into more details of the limits applied regarding radioactivity, we can note that we in Sweden must have planning competence and sufficient resources to meet problems of this nature in possible radioactive fallout. Economic austerity with great cutbacks in the public sector increases the risk that our preparedness for such situations would be insufficient.

Chemical disasters

General

By chemical disasters are meant disasters in which a large number of people are affected by serious toxic influences. The rescue service and medical care are subjected to great pressure and not infrequently to very special problems. Large areas may need to be cordoned off. Often special equipment and training are required if people are to be able to operate within a cordoned-off area. Staff participating in the operation at the accident scene must protect themselves at the same time as they are required as soon as possible to remove people from the area where health is at risk (47, 53, 56, 60, 61,71).

Medical personnel remain outside the risk zone and care for casualties who are brought to them. Decontamination may be necessary to end the exposure to noxious agents as soon as possible and to protect staff from contact with the noxious substance (25). Even during transport of casualties and their reception at hospital the risk of contamination from, and dispersal of, the substance must be considered. There must be the resources and knowledge to care for such patients. In certain cases, hospitals or their approach roads are also affected by the toxic substances, and cannot then not be used or must even be evacuated (42, 53).

Hazardous substances

Petroleum products are quantitatively the largest group of "hazardous materials" transported, stocked and used in industry. But here it is chiefly the fire risk and the threat to the environment that cause problems. Their toxicity to man is as a rule of less significance in connection with disasters. Nor do accidents with toxic substances in solid or fluid form normally give rise to mass injury situations unless the substances are released into watercourses or are extremely volatile.

The greatest risk of mass injury to man comes from toxic substances in gas form. There may be leakage in a container of compressed, condensed gas. If the leak is above the surface of the fluid, the pressure sinks and the liquid gas starts to boil because of its own heat, i.e. adiabatic evaporation, which continues until the temperature has sunk to the boiling point of the gas. This is followed by slower evaporation using the heat supplied from the surroundings. The leaking container should in this situation not be sprayed with water since in this way heat is added and the evaporation increased.

If instead, there is a hole in the tank below the level of the fluid, fluid runs out into the surroundings and evaporates there very rapidly since apart from its own heat, heat is added from the surroundings.

Condensed gases such as chlorine, ammonia, sulphur dioxide and phosgene are examples of gases which when released can reach such high concentrations that fatal injuries occur to airways and lungs. Particularly ammonia, chlorine and sulphur dioxide are hazardous since they are stored and transported in large quantities. Examples of other substances dangerous to health which are normally transported by rail and road are phenol, acids, alkalis, certain hydrocarbons and substances that give off ionising radiation (50).

Carbon monoxide poisoning is a common cause of death in fires (50, 60). Particularly in smouldering fires, apart from carbon monoxide, other poisonous gases are also formed (50, 56, 58, 60, 61). Examples of these are hydrocyanide from e.g. wallpaper and upholstery fillings and hydrochloric acid from certain clothing material, plastics and insulation material.

War and terrorist attacks

In war the risk increases that noxious substances may leak out if stores containing such substances come under bombardment. Nor can it be excluded that chemical weapons are used despite international agreements prohibiting these. The weapons currently of greatest interest are the nerve gases *Tabun, Sarin, Soman and VX*. These achieve their toxic effect by inhibiting the enzyme cholinesterase. Nerve gas antidotes should be applied as soon as possible with autoinjectors. Mustard gas remains relevant, particularly since stores from the second World War may exist dumped into the sea. Such gas was also used during the war between Iraq and Iran in the 1980s.

On 29 April 1997 the Chemical Weapons Convention came into force. This implies briefly that it is forbidden to possess, develop and use chemical weapons. Countries that possess chemical weapons undertook to destroy these. Many states acceded to the agreement – including the USA and China. The proposal was also subject to voting in the Russian Duma. But Russia possesses very large stocks of chemical weapons and would find it difficult to destroy these without outside help. Iran, Iraq, Libya, Israel and Israel's neighbouring countries did not accede to the convention.

Another problem with military associations is smoke ammunition.

When certain smoke bombs or smoke grenades are ignited a zinc chloride aerosol is formed that can give serious lung injuries. Accidents have happened in connection with exercises, but it is more common that smoke bombs have fallen into the wrong hands and have been ignited indoors with effects on the airways as a result (65 A).

Studies and compilations of facts

In a large number of the events that KAMEDO has described, toxic substances have represented a deadly threat. In addition, two textbooks have been published which treat associated problems. On one occasion it was possible to study the medical effects of the use of chemical weapons in a terrorist attack (71). Also, during the Iraq crisis and Desert Storm in 1991 Israel was bombarded by Iraq using Scud missiles that were wrongly believed to be fitted with chemical warheads. In a conference in Tel Aviv between 8 and 12 March 1992, attended by two KAMEDO observers (unpublished), Israel reported its preparations for protection against chemical attack and how the rescue services and medical care functioned during the attacks.

Table 9 reports the events in which KAMEDO, through observer trips and subsequent collection of facts has obtained material for KAMEDO reports in which toxic effects have represented a serious problem.

Table 9. *Accidents when handling poisonous substances.*

Report number	Event	Deaths survivors	Injured substance	Toxic	Cause	Notes
25	Phenol accident at Simmersted, Denmark 1972	0	20	Phenol	Tanker accident	Also environmental effects
34	Release of poison in Seveso, Italy 1976	0	Approx 500	Dioxin	Safety valve	Environmental effects
42	Chlorine release in Mississauga, Canada 1979	0	0	Chlorine	Train derailment, leakage, fire	Evacuation
53	Poisonous gas accident in Bhopal, India 1984	2,500	100,000	Methylisocyanate	Exothermic reaction in tank	Mass injury care
65	Chlorine gas accident at Vanadis pool, Stockholm 1993	0	33	Chlorine	Mix up during filling	

Table 10. *Fires with poisoning.*

Report number	Event	Deaths survivors	Injured substance	Toxic	Cause	Notes
19	Train fire in Wrandukt tunnel, Jugoslavia 1971	Approx 30	Approx 100	Smoke gas	Train fire	
35	Tanker at Corunna, Spain 1976	2	Few	Oil smoke with fire	Running aground	Environ-mental influence
39	Hotel fire in Borås, Sweden 1978	20	Approx 30	Fire gases	Fire	Student party
47	Fire at MGM Grand Hotel Las Vegas, USA 1980	84	700 to hospital	Fire gases	Fire	
56	Fire at King's Cross, London, England 1987	37	60^{+}	Fire gases	Fire	Underground railway station
58	Aircraft fire in Manchester, England 1985	54	Approx 70	Fire gases	Fire	Cabin rapidly filled with smoke
60	Fire on board MS Scandinavian Star 1990	158	Approx 30	Fire gases	Fire	Arson
61	Fire at Huddinge Hospital, Stockholm 1991	0	18	Fire gases	Fire	Arson
70	Fire at Düsseldorf Airport, Germany 1996	16	60	Fire gases	Fire	

These accidents are also dealt with in the chapter "Fires and explosions".

Table 11. Sabotage with chemical injury.

Report number	Event	Deaths survivors	Injured substance	Toxic	Cause
65	Smoke grenade in Uppsala, Sweden 1993	0	Approx 150	Zinc chloride	Foolishness
67	Terrorist action World Trade Center, New York 1993	0	1,017	Fire gases	Explosive charge
71	Nerve gas attack Tokyo, Japan 1995	12	3,227	Sarin	Terrorist attack in under-ground railway

Experience

Chemical accidents can occur in places not foreseen as being in the risk zone.

The chemicals industry is expanding. Many formerly used natural materials are being replaced with synthetic products. Certain raw materials in their manufacture can be hazardous to health. Even the final products, e.g. plastics and synthetic textiles may if heated or attacked by chemicals form corrosive and poisonous substances (47, 50, 60, 42). The chemicals industry is producing an unknown number of toxic substances, fluids and gases that represent an intermediary product in the manufacture of e.g. artificial fertilisers, insecticides, herbicides, cleansing materials and pharmaceuticals. An accident in which such substances leak out may have serious medical consequences (34, 53). The risk of release is not only localised to the proximity of the factory but also exists along railways, roads, pipelines and on board ships.

It has become hard for authorities responsible for public safety and health to keep up with this development and be able to predict and minimise all risks associated with the manufacture, transport and use of these varying substances. This also applies to possible effects on the environment. Frequently, economic considerations must affect the evaluation of possible risks and preventive security measures.

The phenol disaster in Simmersted in Denmark is an example of how a region entirely unprepared for chemical accidents may suddenly be afflicted by a severe release of poison (25). Down the road comes a tank truck loaded with 23 tons of liquid phenol. It has lost its way. At a cross roads it overturns. Apart from the fact that people are injured, the effects on the environment are devastating. Readiness and knowledge of how to deal with the release and care for those exposed to phenol in the acute phase has not been practised. This event and the ensuing KAMEDO report had as a consequence that a start was made in Sweden on creating readiness plans for accidents involving hazardous materials.

Further examples of unforeseen chemical accidents are the release of chlorine that occurred at a swimming bath right in the middle of Stockholm in 1993 and the ignition of a smoke grenade in a school in Uppsala (65 a, b).

Chemical warfare has once again become a factor to reckon with. Despite international agreements on the prohibition of such weapons many countries hold large stocks of these. They are cheap and particularly effective weapons. They can be dispersed in many different ways and strike all living beings indiscriminately. A war or terrorist situation can affect regions that are entirely unprepared for such attacks. The nerve gas attack against the Tokyo underground railway in 1995 (71) is a frightening example of this.

As we saw in the chapter ”Fires and explosions” smoke gases are in the majority of cases poisonous and often represent the primary cause of death in serious fires. Apart from carbon dioxide poisoning, hydrocyanide poisoning should always be suspected (56, 58, 60, 65). People on board ship (60), in aircraft (36, 58), in tunnels (19, 56) and in buildings (29, 39, 47, 61, 67) become blinded by heavy smoke. Their airways are irritated, nervous system function deteriorates. Soon unconsciousness occurs, followed by death unless the exposure is terminated and adequate treatment given.

But there are often high-risk areas.

People in factories and in surrounding built-up areas are frequently aware of possible risks involving their factory’s operations. Responsible companies have strict safety requirements, carry out disaster exercises, inform people living in the surroundings and have well established cooperation with local rescue services, medical care etc.

But in KAMEDO’s studies it has been noted how safety aspects are sometimes neglected. In Seveso and Bhopal (34, 53) people were permitted to live near the factories. The population had poor or no information on possible risks in the manufacture or on possible rescue measures in the case of accidents. The hospitals were also unprepared. Their staffs had no particulars of what toxic substances and gases could be involved in possible poisoning.

We must often accept that transport of hazardous materials is permitted to pass near densely-populated areas. Development of the railway network started over one hundred years ago to connect such areas. For this reason our railways as a rule go right through our cities. Release of an irritant or poisonous gas from a goods train may have devastating effects. To reduce the scope of this in a possible accident the principle is followed that large quantities of hazardous materials may not be carried at the same time in the same train. In a derailment with a resulting fire and a release of chlorine in Mississauga (42), however, thirteen of the derailed trucks contained LPG, three caustic soda, one styrene, one toluene and one chlorine. The LPG fire rendered it impossible to stop the chlorine leak. In Sweden, too, there have been incidents in the transport of hazardous materials. Responsible authorities are aware of the risks and attempt to regulate such transports.

Turning to road transport, the problem is similar. Vehicles are large and difficult to manoeuvre. They frequently have trailers. Even though there are often by-passes, somewhere along the road cities or harbours are affected by the transport when the goods are discharged. A particular problem is that of vehicles with hazardous materials being transported aboard car ferries with many passengers.

International and national regulations exist for how hazardous materials should be transported and coded. Sweden has laws and ordinances on the transport of hazardous materials. Not infrequently there are special regulations. All this is necessary to improve safety.

Many factors affect the degree of seriousness of a chemical accident. There must be the competence to evaluate the toxicological risks. The need of well-functioning rescue and medical organisation is great.

In a chemicals accident the *chemical properties* of the substance involved and the consequent biological injurious effects determine the serious medical effects of the accident. However, many other factors are of great importance, e.g. the size of the release and the *physical properties* of the substance. Is it heavier than air or lighter? Is it in solid, fluid or gas form? The latter in turn often depends on ambient temperature and pressure. But other climatic conditions are also important. Is it raining? How high is the air humidity? Is it windy? Is an inversion layer preventing the gas cloud from rising?

Decisive for how severe the accident proves to be is also the number of people exposed, the possible protection they get from their clothing, equipment and buildings, and the exposure time. Another extremely significant factor affecting the number of dead and permanently handicapped as a result of the accident is the size and efficiency of the rescue services and medical care.

Resources must be available to put a watch on the risk object. Since it may be a matter of complicated processes, the authorities or organs approving and exercising supervision of this activity must have the competence and the means to do their job. If an accident happens nevertheless there must be well practised plans for both the rescue services, police, medical care, information to the public, and evacuation. Medical staff in Sweden, particularly at hospitals situated relatively close to factories with hazardous handling or manufacture, have become very aware of the toxicological problems that may suddenly afflict them. There is often exchange of information between the hazardous industry in question, medical care and the rescue services. Medical staffs know what type of noxious agent is involved, what symptoms it gives and what treatment is possible. Resources for decontamination have in many cases been provided at the hospital emergency department.

Weakened county council economy has, however, in a number of cases meant that hospitals have been closed down or ceased to be used as emergency hospitals. Care has been concentrated to a number of large hospitals. The risk exists that knowledge of local problem objects has thus been lost. Another possible danger is that the large hospitals cannot alone manage all cases of poisoning or perhaps cannot be used to the full if they are situated close to the risk zone.

Economic frameworks and working timetables must allow time for training of medical personnel in the majority of hospitals for work in chemical accidents (50).

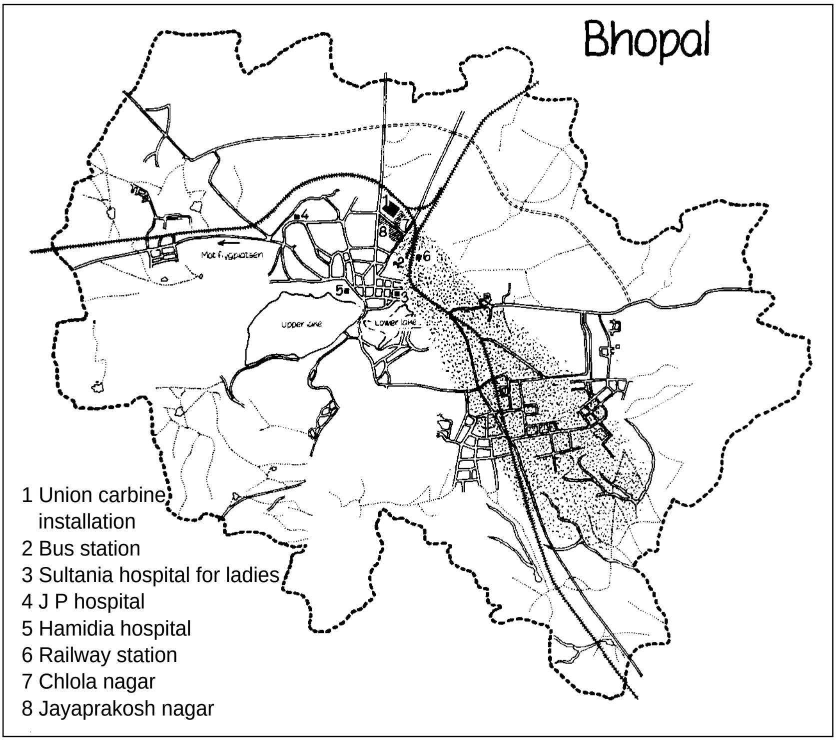
In chemical accidents and attacks using toxic substances the numbers affected may be very large and the care problems enormous.

The release of poisonous gas in Bhopal (53) showed what great damage the release of toxic gas (aerosol) can cause. Thousands of people near the factory, living in hovels that gave no protection against the gas, were surprised in their sleep by severely irritating gas. Almost 500 of them died as a direct result of exposure. Approximately 6,000 sustained serious injuries and a further 2,000 died during the next few weeks. Some 100,000 people needed some form of medical treatment.

In the terrorist attack on the World Trade Centre (67) more than 1,000 people were injured by smoke more or less seriously and the nerve gas attack on the Tokyo underground (68) could have developed into an enormous mass murder.

In the event however, deaths were limited to just over ten, although close to 500 of the over 3,000 that made their way to hospitals had to be admitted.

Thus there is a risk that a particularly large number of people may need acute aid and qualified medical care at the same time. In Tokyo (67) the casualties were distributed over forty-one hospitals although St. Luke's International Hospital, which was closest, admitted the majority of those seeking care – 640 patients. In Bhopal (53) there were five hospitals to look after all the thousands who were exposed and who



The poisonous gas release in Bhopal, India, 1984. Methylisocyanate (MIC) dispersed many kilometres as a low-lying cloud in the light wind. Apart from residential areas, the railway and bus station were also affected. The hospitals, however, were outside the gas plume.

streamed in to obtain help. To offer normal medical care under such conditions was naturally impossible. It is doubtful whether all those who were seriously poisoned could have been given medical care in a corresponding accident in Sweden.

With a vigorous and efficient disaster organisation large medical care resources can be created rapidly. Standardised treatment is possible to some extent. Secondary injuries must not be overlooked.

To admit thousands of people needing acute care to a hospital at the same time may be devastating for its own operations – particularly if the people have been exposed to poisonous or irritant gas. In Bhopal (53) medical care stations were set up outside the hospitals using all

Treatment outdoors of people exposed to methyl isocyanate in Bhopal.

available medical resources and a large number of volunteers. The majority of those seeking help were looked after by these elements. Only those who were examined there and judged to be in absolute need of the hospital's resources were admitted. At various places throughout the city, treatment points were also established.

Administrators and physicians in leading positions gathered at the city's university hospital. A medical disaster commissariat was organised and all available medical personnel were given care tasks. Non-profit-making and political organisations helped with volunteers who were able to help in different ways with practical tasks. Chemists' shops opened even though it was night-time and drugs and medical requisites were requisitioned.

In a corresponding situation in Sweden it would be necessary to use space in hospitals not used for care in normal circumstances. Gymnasiums, schools and certain other buildings with water and drainage would need to be taken into use. These could, in the first instance, be used as primary reception units but also for more definitive care of lighter injuries. There would be medical equipment and staffing with medical personnel who had been brought in. Health centres would also be involved in disaster work.

The poisons information centre would be informed of what had happened and consulted when recommendations for treatment or antidotes were needed (68). Since the people had been exposed to the same agent, which had given injuries of the same nature even though the degree of severity varied, it would be possible in a mass-injury situation to apply standard treatment to some extent. Hence it would be possible to delegate many treatment tasks (53).

In planning, therefore, the possibilities of mass-injury care with alternative care resources should be reviewed. This applies in places with only one or a few hospitals. The hospitals and their approaches may be affected by the poisonous substance (61). In the case of accidents involving irritant gases the need for ventilatory equipment may be very great, and of staff competent to operate this. In many areas in Sweden the availability of equipment for respiratory care is insufficient for a mass-injury situation. Ventilation may need to be continued for a long time, which has been planned for in, among other places, Israel.

Where many people arrive at hospital exhibiting dramatic symptoms of toxic injury, it is easy for other serious injuries or conditions to be overlooked. One must therefore remember note secondary effects of exposure such as cardiac infarct or traumatic injuries arising in the flight from the dangerous area.

Ongoing information should be given with particulars of risks and cordoning-off. The cordoned-off area should be made sufficiently large right from the beginning.

During the daytime many listen to the radio in cars and homes or at their workplaces, and hence can be reached very rapidly with important information (42, 65, 67). Radio and TV reporting has proved able in an efficient manner to convey up-to-date information in extensive accidents to hospital staff and the population affected by the events (35, 42, 63, 67). In built-up areas, there is also a possibility to use alarm signals with requests to the public, for example, to listen to radio announcements. It is however doubtful whether people in general are familiar with the meaning of the signals.

In the case of toxic release there is a risk that its size and extent are initially underestimated. Meteorological or geographical conditions may create plumes of gas extending far from the accident scene (34, 42, 53). Early on, the information available is insufficient or even incorrect. It is therefore necessary to start with a well-dimensioned cordoned-off area, in order later if possible to reduce the area successively as the situation clears. Where there is a risk of explosion or fire, account must also be taken of a possibility that shock waves and heat radiation from a possible ignition can cause injuries far outside the gas cloud.

If the risk zone is large and the spread of the gas within it varies, it may be hard to prevent people from entering the area. This applies particularly where the perceptibility threshold is high, i.e. a high concentration of the substance is needed for people to be able to perceive it with their sense organs. It is hazardous if the threshold of perceptibility of the substance is higher than the threshold of its toxic effect during short-term exposure. It is simpler if the threshold of perceptibility for the gas is low. People do not willingly go into an area with a perceptible smell of gas. A disadvantage of over-large risk-zones is that they become hard to monitor and that rescue personnel must wear protective equipment and follow special routines in unnecessarily large areas. This should be considered when the size of the risk zone is being determined.

Traffic control of roads crossing the risk area should often be started a long way outside the cordoned-off area to avoid traffic jams. The roads must be kept free for rescue vehicles and transport of casualties.

Decontamination of people exposed to certain corrosive or poisonous substances should be commenced as soon as possible. Medical assessment of exposed people may be difficult.

To minimise the time of exposure to the toxic substance and prevent other people being contaminated, decontamination of exposed persons should be started even near the accident scene if the substance represents a danger to the surroundings or to those affected. Decontamination stations may suitably be established at the assembly point sited outside the risk zone (50). Decontamination is as a rule carried out prior to medical examination and possible treatment. It may be necessary to take special consideration of the eyes if they have been contaminated with corrosive or irritating substances. The eyes are irrigated with water or Ringer acetate. Here drip aggregates may be used. If the contaminated person has difficulty in opening the eyes, local anaesthetics may be needed.

Opportunities for more detailed medical examination are limited at the accident scene. Rescue personnel not infrequently need to content themselves with a rough grading of the condition of those under care, e.g. (50)

- needs stretcher transport and is generally affected
- needs stretcher transport but is not generally affected

- can walk but is injured or confused
- is without obvious symptoms.

Further decontamination may be necessary on arrival at hospital, if the injured person is heavily contaminated with corrosive or toxic substances. Many hospitals possess prepared locks with decontamination facilities where the rinse water used is also treated. There must be generous possibilities for oxygen treatment where airways and respiratory organs have been affected or the patient has been poisoned with carbon monoxide or hydrogen cyanide.

As a rule registration and some collection of information are carried out at the assembly point. But exposed people may have made their way out of the injury area and been transported to hospital in private cars (65). Registration and collection of information are also carried out in hospitals. In Uppsala (65) it proved that the data routines were too slow for the particularly large flow of acute patients. It was necessary to have a number of staff conduct registration with paper and pen.

In exposure to e.g. to phosgene and nitrous gases, symptoms of serious injury, e.g. pulmonary oedema, may not manifest themselves until after a latency period of one to two days. It is therefore important that all those exposed are identified and registered (50, 65, 71) and that they possibly remain in hospital for observation.

People living within a risk zone are not always evacuated.

People living in buildings that give relatively good protection should not always leave their homes in the acute phase unless there are fires or there is a risk of explosion. With windows closed it may be safer to stay than to escape through the risk zone (50). If required, evacuation is carried out later when it can take place under more secure conditions. Rescue staff must, following the first phase, check the condition of remaining persons and continue to search cellars, garages and other areas where people may have sought shelter. As was seen under "Fires and Explosions", there are cases where people attempted all too late to escape from poisonous smoke gases (19, 39). The decision may therefore be difficult.

Divergent laboratory values and signs of reduced health need not be related to exposure to toxic substances.

In follow-up medical enquiries after exposure to toxic substances a large number or more less “pathological” laboratory values and morbid changes are found that often have other causes than the current exposure during the accident. For this reason it may be very hard to evaluation the medical effects of a chemical accident through medical examinations (34). This also applies to mental symptoms such as abnormal tiredness, anxiety, difficulties in concentration, increased irritability and so on.

Those exposed naturally find it very difficult to accept other explanations than the accident.

Air accidents

Military aviation

Military flying was earlier affected seriously by aircraft crashes. Looking back to the early years of the Swedish Air Force one finds that almost one quarter of those then trained as pilots later lost their lives in crashes. The background to the high figures included the requirement to behave in the air almost as combatively as under wartime conditions. Limitations in the function of materials and security systems, together with inadequacies in pilot functions were other factors contributing to the high frequency of crashes. Other countries' figures were no less frightening.

With the help of vigorous air safety work including better medical and psychological selection of staff in the flying service, more effective training, the technical development of rescue systems and navigation aids, improved security regulations, etc the number of crashes with fatal outcome has been dramatically reduced in the Swedish Armed Forces and now amounts to a few cases annually.

Civil aviation

Civil aviation has also been burdened with serious accidents. Private flying has been particularly vulnerable, and here the accidents have been largely ascribable to shortcomings in training, experience and judgement in the holders of private pilots' certificates. But since the aircraft have been relatively small, the numbers of injured and killed has, as a rule, been low and thus the accidents have seldom had relevance to disaster medicine.

During the past one hundred years, commercial aviation has developed into one of the safest ways of travelling long distances. But even though the frequency of accidents connected with flying counted per 1,000 km or per 10,000 flying hours has been very low, aircraft accidents with a large number of fatalities have occurred. Not only have passengers and crew been injured but also third parties have sometimes been affected. It has frequently happened that an aircraft following take off or on its approach to landing has been wrongly handled or exposed to some disturbance. But even at high altitudes, collisions, technical faults, bad weather or sabotage have caused disasters.

Studies conducted

KAMEDO has published six reports addressing the medical consequences of serious air accidents (table 12), none covering crashes into water. In two cases, third parties have been the worst affected in terms of the numbers of killed and injured (57, 64). Medical care has been heavily loaded but the resources have been sufficient.

Table 12. Studies of air crashes.

Report number	Event	Deaths	Injured survivors	Course of accident	Notes
33	Disaster exercise at Sturup, Sweden 1975	Unknown	80–90	Crash with civil aircraft	Exercise with 280 people
36	Air crash on Teneriffe 1977	581	Approx 60	Ground collision, two jumbo jets	Fire broke out
57	Accident at air display in Ramstein, Germany 1988	Approx 40	Approx 200	Air collision, three aircraft	Burning fuel over spectators
58	Aircraft fire in Manchester, England 1985	54	About 70	Engine fire ignited on takeoff	Smoke-filled cabin. Fire with evacuation
63	Air crash at Gottröra, Sweden 1991	0	6–7	Engine failure; emergency landing	Slid 110 metres, broke apart
64	Jumbo jet disaster in Amsterdam, Netherlands 1992	50	33	Engines separated	Crash onto dwelling houses: fires

Experience

In crashes where there is a possibility of survival, placing in the aircraft and correct fastening in positions as instructed are paramount.

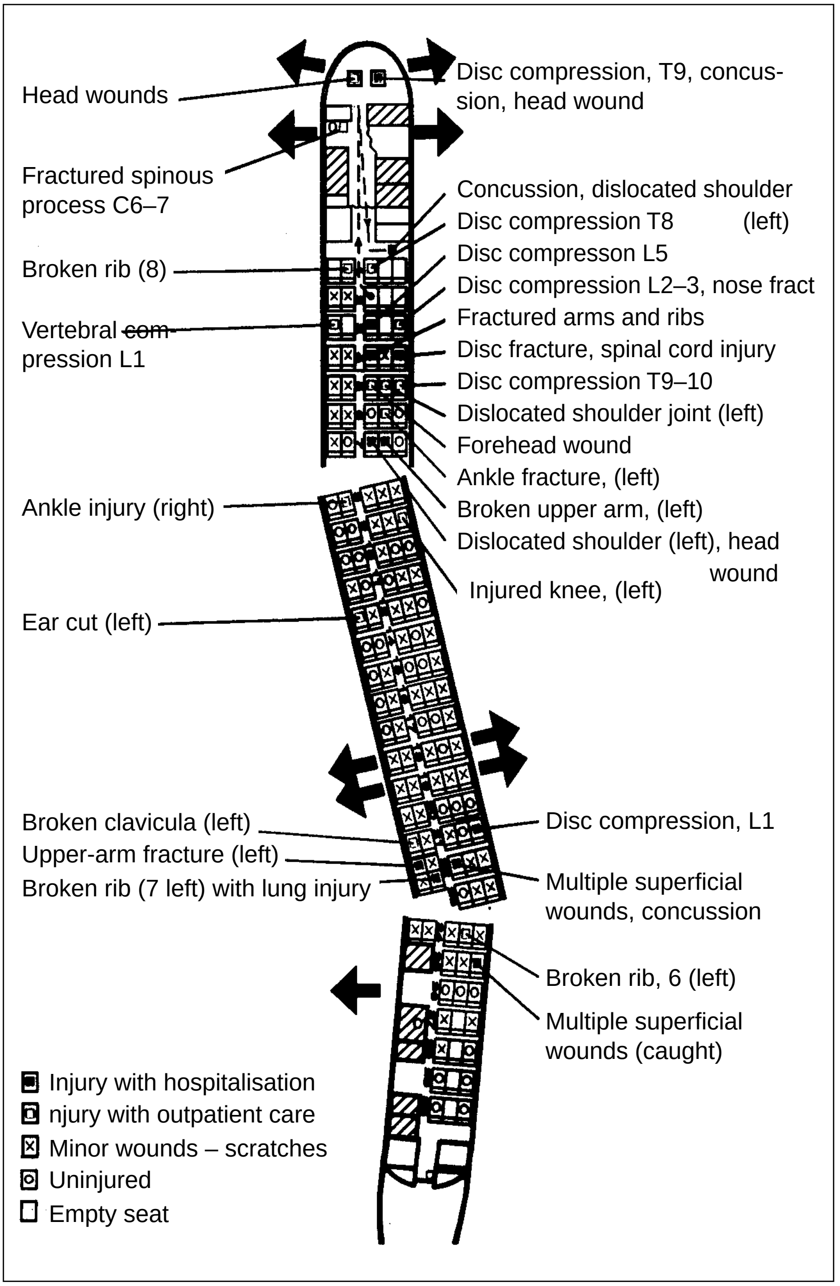
Serious air crashes have been of but limited disaster-medicine interest if by disaster medicine one means that a very large number of persons have been seriously injured but are alive and need acute rescue and medical service exceeding normally available resources. Most often only a few or none of those on board survive a crash. The medical aspects will be dominated by forensic issues and the search for possible underlying medical causes of the crash. If on the other hand many survive a total

Two fully-fuelled Boeing 747 jumbo jets collided in 1977 on Teneriffe during takeoff and caught fire.

crash, the number of those on board with serious injuries is relatively small (63). KAMEDO has therefore studied only a few of the many air crashes in the past few years.

If fire breaks out in an aircraft before it has taken off or on impact with the ground, time margins are very small. Organised evacuation may seldom be expected. Each passenger will attempt to save himself and his relatives without much regard for others (36, 58). For this reason it is clearly an advantage to be near an exit which is important to reach quickly (36, 58). The effects of smoke gases and heat on vision and respiration worsen one' chances of getting out. Smoke hoods of transparent material and easy to put on would give passengers and crews another minute or so in which to get out (58).

In the Gottröra crash (63) fire did not break out. Most of the fuel had been released after a wing had been broken off in collision with treetops during the descent towards the field. Speed had been reduced in this collision and the retardation after striking the ground was relatively low since the braking distance was also just over one hundred metres. The aircraft's tail struck the ground first, without much vertical force. The vertical forces increased further forwards in the aircraft. Those on board in the forward part therefore sustained the most serious injuries. But with some few exceptions there were no serious bodily injuries since all had their seat belts fastened and assumed the position ordered.



Injuries among those on board aircraft type DC 9-81 which crashed on 26 December 1991 at Gottröra.

A number of upper baggage lockers were broken open, fell and remained on the seat backrests. Since the passengers sat leaning forward, head injuries were avoided. Certain other injuries occurred in some cases where the waist belt had not been tightened sufficiently or where the protective posture was not optimal. A few cases of arm and shoulder injuries may have been affected by the passenger leaning against the seat-back in front.

Medical teams should be despatched early where there is a risk of a crash. Tents are often needed at the accident scene.

If a serious problem is reported from an aircraft hospitals are alerted and send medical teams to the airport or break-off point in question (63). Most often, the aircraft manages to land without any personal injuries being incurred. For medical personnel it may be wearing to need to interrupt their normal work at the hospital if their help then turns out not to be needed. But if a crash with personal injuries occurs, many of those on board need qualified primary care within the first few minutes if they are to survive. It is therefore important to bring up medical resources quickly. In the Manchester accident (58) many of the passengers who had managed to get out of the aircraft did not have free airways. In this case they were helped by members of the crew of another airline. In the Gottröra crash (63) medical teams were called out as soon as it became clear to those responsible for giving the alert that an aircraft was in distress.

It must again be stressed how important it is that as many people as possible are familiar with simple ABC measures and dare undertake to help those in distress pending the arrival of qualified medical care. The risk of being infected with hepatitis B or C must be considered, however. This also applies in many other accidents. As opposed to HIV virus, which hardly survives outside the host organism, hepatitis B virus can stay alive for several days in splashed blood and body parts. In an aircraft with over 100 people, the probability is great that somebody is a hepatitis carrier. Gloves and masks give protection.

The equipment available to the rescue services or medical care in Sweden often includes tents. These give warmth and protection from wind and rain/snow, and improve the facilities for medical staff to examine and treat accident victims and survey the situation. In addition, tents offer protection against the telephoto lenses of spectators' and reporters' cameras. In the Amsterdam jumbo jet disaster (64) a military hospital tent was erected at the scene of the damage where a medical team could carry out certain of its tasks. In the Gotträra crash (63) no tents were brought to the accident scene because it was judged that all survivors could be rapidly transported away, a judgement that was all too optimistic. Injured people were obliged to sit and wait in rescue vehicles so as not to become chilled. In this way it was harder for medical personnel to obtain an overview of the situation.

Many shortcomings remain regarding the rescue services and medical care in air accidents. Effective cordoning-off and traffic control are required.

Traffic jams, poorly marked stopping places, insufficient marking of personnel, poor radio connections, delayed transport of survivors from the site and errors in the management of the medical operation were noted in both the disaster exercise at Sturup in 1975 (33) and in the aircraft crash at Gottröra 1991 (63). Despite development, training and exercising during the years between 1975 and 1991, mistakes were repeated and many shortcomings remained.

Following air crashes as in many other types of accident, among those helping at the site of the accident there are often persons with imperfect knowledge of the meaning of various markings on helmets and jackets worn by rescue personnel (57, 63, 64). Easily read text showing the service one belongs to and the job one has are needed so that people with different responsibilities can be rapidly identified. The control point must also be clearly marked. This was not the case in e.g. Gottröra (63).

Despite the rapid development of radio- and telecommunications, communications often demonstrate weaknesses (58, 63, 64). For example, the accident site may lie within radio shadow, radio channels and mobile telephone networks may be overloaded, radio traffic may be monitored by the mass media, the rescue service and the police may use different radio frequencies and be unable to communicate with one another, etc.

In Ramstein (57), an American Nato base on west German territory, in connection with the disaster during the air show in 1988 there was hardly any co-operation at the accident scene between the German and the American rescue and medical forces. The disaster plans that the Germans applied were not known to the Americans and, in addition, were written only in German. Co-ordination across natural borders is needed regarding the principles to apply for rescue work in air crashes including medical assistance. The International Civil Aviation Organisation, ICAO, has promulgated certain recommendations for rescue equipment, etc, at airports of any size but international co-operations needs further development. Joint Aviation Rules (JAR) for Europe are being developed.

Massive help needs to reach survivors at the scene of the damage rapidly. Opportunities must be created to search for casualties and fatalities. In Teneriffe (36) the police kept the roads efficiently closed the whole distance from the airport to the hospitals. The ambulances had no difficulties on their way. But not infrequently, the capacity of approach roads is very limited (63, 64). Relieving forces find it difficult to make their way to the site of the crash, particularly since the mass media and spectators are also attempting to get there. In the Gottröra crash (63) the road to the scene of the damage was of poor quality and in addition rapidly became lined with vehicles belonging to spectators and the mass media. The delays arising in the removal of casualties by bus may partly be ascribed to the poor access allowed by the road. Efficient traffic control, possibly with one-way through traffic and reinforcement of road quality, may be needed. At the scene of the damage, too, the rescue operation may be hampered by limited space, a concentration of help units and the presence of a large number of unauthorised persons. Immediate and vigorous cordoning-off and traffic control are necessary.

The capacity of the hospitals, following some reinforcement, has always been sufficient (36, 57, 63). For natural reasons, large airports are located near large cities with good access to hospitals.

Resources must be created for collecting information and social care. There may be language difficulties.

As also mentioned in earlier sections, it is important to attempt to collect certain particulars from survivors as soon as possible, particularly as those on board may belong to many different nationalities and may have or have had diseases not common in Sweden. Apart from symptoms and personal particulars, and a brief account of what happened during the flight and the crash, and particulars of who was sitting near the person being examined may assist in the enquiry. Details should be taken while still near the damage scene provided the victim's general condition permits this and necessary medical treatment and removal to hospital are not delayed. There is a risk that the person's condition will worsen so that he cannot later give particulars, or his memory becomes clouded after few hours. Tape-recordings with small tape recorders are a help in gathering information.

The crew and passengers in commercial air transport are a very heterogeneous population representing many cultures, races, language groups and religions. In a crash they need not only medical help but also access to telephones and acute economic support. Multitudes of practical problems may turn up and need solving. Among the casualties there may be passengers living on the other side of the globe (36). Relatives must be informed. Transport must be arranged. Religious aspects may also be of increased importance as may social background. The air disaster in Teneriffe (63) gave examples of language difficulties. The survivors were Americans and not all the rescue and medical personnel understood English. Even where language difficulties mean that rescue personnel and those in distress cannot understand one another, it may be a good idea to make tape-recordings for later interpretation. The injured Americans were fetched already after a few days, despite serious injuries and against the advice of the Spanish physicians, by American medical personnel and were flown by Hercules to the USA.

The need for comfort and information is great – even after the most acute phase is over. Acute psychological reactions are often undemonstrative.

In the exercise at Sturup (33) as in many other exercises, psychological trauma was marked by a person who ran around screaming and could not be held. In KAMEDO we have never seen such reactions following an accident. They are probably not common in Sweden but presumably represent a myth that should not be encouraged during exercises. The need of psychological support, nevertheless, may be great even where reactions are less violent. Powerful emotional reactions are however, more common in other cultures.

It is important that those afflicted also get help with crisis processing following a life-threatening air disaster. In Sweden resources have grown at least for the acute phase. But it has proved that after the first few days of grief many people are left alone with their experience (63). In air crashes this can be a natural consequence of the passengers returning to their homes, sometimes at great distances from the scene of the accident, or continuing their journey to the planned destination.

In the emotional state in which survivors often are following an air crash it is necessary that somebody from the rescue and medical units arriving on the site speaks direct to them and gives information on what is happening and on what may be expected to happen next.

After the crash on the field at Gottröra (63) the aircraft's captain gathered the passengers around him and attempted to tell them what had happened. He also gave details of the help that could be expected. His openness and ability to give information were greatly appreciated. Less popular were representatives of the rescue services when they arrived. None of them addressed themselves to the passengers to tell them what was going on and what could be expected.

Accidents at sea

General

A great problem in many accidents at sea is the difficulty of rapidly getting sufficiently large and efficient rescue and medical resources to the scene of the accident. Possibilities of rescuing those in distress are therefore limited. Characteristic of sea rescue is also that both those in distress and their rescuers must perform physically demanding work, particularly if the accident has taken place in bad weather conditions. Seasickness can reduce physical performance (44, 68).

Regarding the medical injury panorama, too, sea accidents represent a particular type of disaster (44, 55, 68). The risk that the distressed person has breathed or swallowed sea water is great, with complicated disturbances of respiratory functions and electrolyte balance as a consequence. The cold water leads rapidly to chilling, reducing the ability to save oneself. In underwater accidents there is also a risk of pressure-fall sickness, bends (44).

Civilian operations

During the twentieth century there was a powerful expansion of shipping and vessels' passenger capacity. The possibility of a very large number of people needing rescue and medical care at sea thus increased since technical developments did not reduce the risk of serious sea accidents in all respects. Apart from storms, running aground and collisions between vessels, ship fires (60) have also become a not uncommon cause of disaster. During the latter part of the twentieth century sea accidents have increasingly had technical causes in combination with "the human factor" (55, 68).

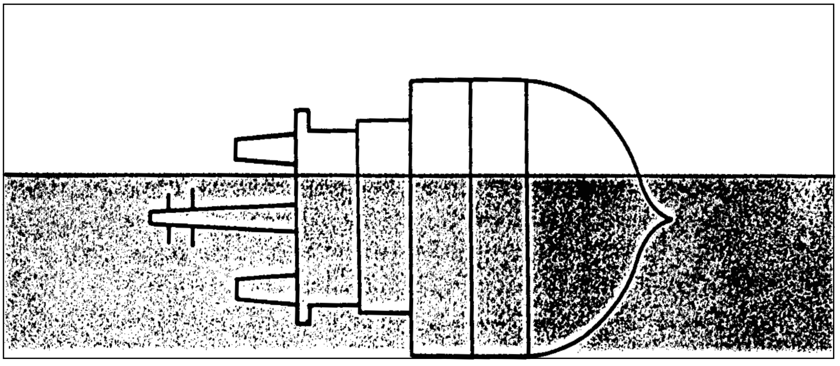
Particularly in Scandinavian waters, the passenger and car ferry traffic has increased strongly. Sweden has ferry traffic with many European harbours. More than thirty-five million people travel aboard these ferries, which may take up to three thousand persons. Vessels can be considered as a combination of rafting hotel, restaurant and department store with a parking garage.

If corresponding installations were found on land they would be subjected to strict provisions regarding preventive protection and emergency exits. It would also be expected that fire service and ambulance vehicles could rapidly come to the rescue. At sea, however, one must rely on one's own resources until other ships and helicopters can come to assist. Further, in heavy weather it is both difficult and risky for rescuing forces and medical staff to carry out rescue operations. Narrow stairways and corridors may hamper the care of casualties.

During the past fifty years there have been great finds of oil at sea. The prospecting for oil consequent upon this has created new types of vessel and a new way for man to work and live. Thousands of people are employed on oil platforms far out at sea and live there on special living platforms. Obtaining oil is about new methods, in which qualified diving is included.

Military operations

Apart from surface vessels there are also submarine operations. The latter can entail certain special medical problems. As with flying it is necessary to observe the effects on the human being of great changes in surrounding pressure. A crew that needs rescuing from a submarine at depth must be protected from injuries following a rapid pressure drop when brought up. There may be pulmonary injuries following what is termed free ascent, or the release of gases dissolved in the human body. In other forms of diving also, particularly if the diver has spent a long



Water flowing onto the car deck of the Herald of Free Enterprise in 1987 caused the vessel to capsize and lie on her side on a sandbank, two-thirds under water. The vessel's cafeteria formed a deep basin fifty metres long and 2.5 metres broad. A number of people there were saved by a frogman but the majority died of hypothermia or drowning.

time under high pressure (days – weeks) corresponding problems arise. In emergency situations, special equipment is needed for the rescue and following decompression. When depth charges are used, the shock waves in the water following detonations can give bodily injury.

Studies carried out

Table 13. Studies of disasters at sea

Report number	Event	Deaths	Injured survivors	Course of accident	Notes
35	Tanker off Corunna, Spain 1976	1	Few	Running aground, fire	Oil smoke, environmental damage
44	Alexander L Kielland, Atlantic 1980	Approx 126	Approx 85	Shipwreck, storm	Oil platform capsized
55	Ferry accident at Zeebrugge, Belgium 1987	Approx 180	No information	Capsizing, open bow door	539 on board
60	Fire on board Scandinavian Star, North Sea 1990	158	About 30	Arson	Smoke poisoning
68	Estonia sinking in the Baltic 1994	Approx 860	137	Storm, damage to bow door	

Experience

Measures are necessary to prevent ferries from turning turtle if water flows into the car deck. Evacuation possibilities should be improved. Warning of threatening danger should not be delayed.

Two KAMEDO reports (55, 68) show how water flowing in has caused ferries to capsize. Even some decimetres average water height on a car deck have a devastating effect on the vessel's stability if the water is then able to collect along e.g. one side. Measures are needed to guarantee that water does not flow into a car deck. If nonetheless this happens, devices for e.g. distributing the water must prevent the vessel from capsizing. The housing platform Alexander L Kielland too leaned heavily before it turned over when one of its supporting stays was broken off (44).

The accidents studied have shown how difficult it is for people to escape from vessels and living platforms that capsize. Floors, staircases and ladders lean all too steeply. One cannot make one's way to doors, windows or other possible exits. Loose objects in large quantities pile up, blocking corridors and exits. Also in fires, even if the vessel does not list, the possibility of getting out is very much worse. In the fire on board the Scandinavian Star (60) many people lost their lives as a consequence of the fire smoke reducing visibility and giving symptoms of poisoning.

Emergency lighting, lighting loops, lifeboats, life jackets, films and written and verbal information about assembly points and measures to be taken in the event of danger, represent attempts which have been made to improve passengers' chances of escape. But they are in an unfamiliar environment. Possibilities for finding out where they are and acting rationally under dramatic circumstances are small. Many of the passengers also lack the physical preconditions for escape without help. Even at the design stage of a vessel, these problems must be considered so that there are acceptable facilities for making one's way out of vessels with a heavy list, on fire and in other acute emergency situations.

The crew of a vessel faced with an emergency situation need sufficient time to prepare for possible evacuation. In the Estonia disaster (63) notification to the crew regarding danger would have been warranted some fifteen minutes earlier than what happened. It is doubtful how early the passengers should have been warned, but it is clear that the warning came too late. Many had no possibility of making their way out of the listing vessel.

It is sometimes impossible to launch lifeboats in heavy weather and when a vessel is listing heavily. Rescue rafts and life jackets have serious shortcomings.

Both in the foundering of the living platform Alexander L Kielland (44) and in the Estonia disaster (68) it proved very difficult to get the lifeboats into the sea in the heavy wind and with the vessel listing at the same time. Nor did the crews on relieving vessels judge it possible to launch their lifeboats under the prevailing heavy weather conditions.

The rescue rafts had great advantages. They were not bulky on board the vessel with regard to the size and design they had when activated. Even when the vessel was listing heavily they could be got into the water and inflated. But it proved in the foundering of the Estonia that in many cases the rafts were upside down, which reduced their utility. They should therefore be designed so that the right side always comes up or that both sides can be used equally effectively.

Another great problem was that those in distress proved to find it difficult to get up onto the rafts without help when they were in the water. Chilling led deteriorated muscle strength and co-ordination. Devices that make it possible even for people affected by cold to climb on board are needed. A further problem was the water in the rafts. As those in distress became tired and no longer had the strength to bail, they lay in a basin. The "tent" often gave insufficient protection. Many of the shipwrecked froze to death or drowned on board the rafts, or were washed overboard. Continual development of rafts is necessary to make it easier for people to get on board and there be able to shelter from cold wind and cold water.

In both the Zeebrugge accident (55) and the Estonia's foundering (68) those in distress often had great problems with their lifejackets. Once in the water many slipped down in their jackets which threatened to suffocate them. In some cases the people used more than one lifejacket but without a satisfactory result. Even in difficult conditions and without earlier experience people must be able to handle life jackets or corresponding aids correctly. The life jackets must not hinder getting on board a raft or a boat and must keep the shipwrecked person's head above the water surface even when the person is unconscious.

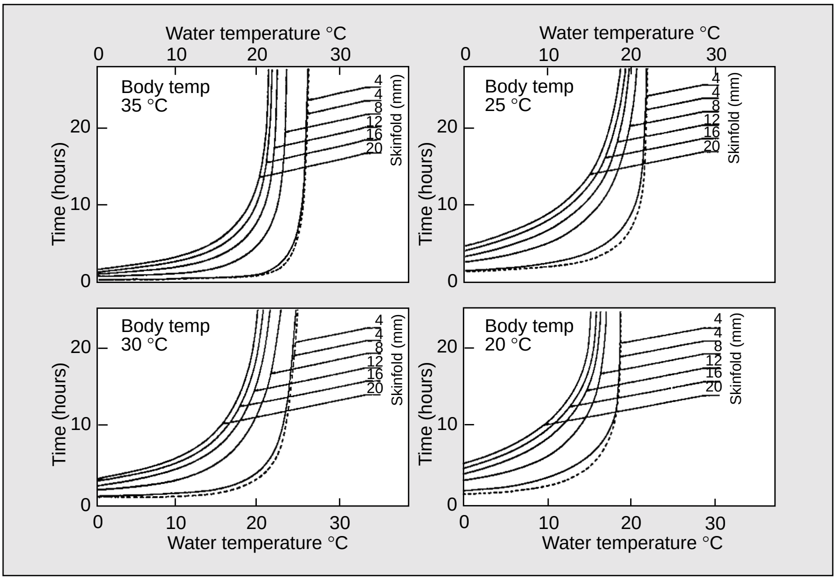
Victims must be got up out of the water as soon as possible.

In the Alexander L Kielland accident (44), the Estonia foundering (68) and the Zeebrugge accident (55) many people died because of being chilled in the water. The number of survivors would have been much larger if some form of net or basket had been available to "fish people up in" as a first step in the rescue action.

The person-baskets the Edda platform used in the Alexander L Kielland disaster saved a number of people from the sea.

There have always been large problems with chilling among people who have landed in the water following shipwreck or aircraft crashes. Through retrospective studies and laboratory trials attempts have been made to produce diagrams showing the possibilities of survival at different temperatures and situations (lying in the water or on a life raft with different alternative clothing and wind conditions). The curves are of help when planning rescue, but individual variations have proved to be great and to depend on e.g. the amount of subcutaneous fat and the person's health state, activity and age.

It is important for the victim to come up very rapidly from the cold water even though the air temperature may be lower than that of the



Human beings in still water. The curves show the calculated time before body temperature sinks to 35, 30, 25 and 20 degrees for different water temperatures and thickness of subcutaneous fat (measured as skinfold). Body temperature sinks rapidly at low water temperatures but in those with copious subcutaneous fat somewhat more slowly. The dashed line represents a child of height 1.30 cm, weight 27 kilos and skinfold 4 mm.

water. Cold water on direct contact with the body gives a much greater heat loss unless a wet suit is being worn. In the latter the water nearest the body is retained and warmed up. The temperature difference between skin and water is thus smaller. With survival suits, too, heat losses are reduced in cold water, for which reason it become possible to manage for longer in cold water (44).

Facilities for taking victims on board assisting vessels must be improved. Helicopters need to be able to land on vessels even in heavy weather.

The Estonia foundering (68) demonstrated what difficulties vessels have in rescuing people from the sea in heavy weather. It was impossible to launch manned lifeboats or rescue rafts and then winch them up again following a rescue. Only some thirty victims were rescued

Photo: Gösta Bolander/Försvarets bildbyrå

Helicopter crews include rescue men tasked to go down and rescue those in distress in the water.

directly from the water or rafts to vessels. A large number of people drowned or froze to death while waiting for helicopter assistance.

The helicopters had time-consuming distances to dry land. Finnish Uto, which was appointed to receive victims in the first instance, was however only thirty kilometres away. In some cases Finnish helicopters were able to place people winched up from the sea on rescuing ferries, which allowed time for more lifts during the first few hours. The Finnish helicopter crews had earlier practised such manoeuvres. The pitching of the ferries in the heavy seas, however, made the landings very risky.

In extensive accidents at sea it may be an advantage to nominate one or some special evacuation vessels to which those rescued may be taken. Preparations for medical help may be made on board by equipment and medical teams being conveyed there prepared to receive those who arrive chilled, injured, sick or dead. To facilitate landing the vessel should adopt a suitable course and speed with reference to wind direction and waves. In this way helicopters can be used efficiently to help victims from the sea. Helicopter endurance with regard to fuel, however, limits their time at the accident scene.

Rescue men's maximum physical capacity may be a strongly miting factor. Other rescue personnel must also be physically and mentally strong.

Where many victims are to be rescued and particularly if the weather is bad, the tasks of a rescue man are particularly exhausting. Requirements as to fitness and strength must therefore be applied during selection and in subsequent periodic health checks. In the Estonia accident the rescue men suffered injuries. To reduce the risk that the mission cannot be completed because the rescue men cannot manage any more or have been injured, a doubling of the surface rescue function should be considered. In addition rescue men risk being chilled when performing repeated rescues, being alternately in the water and waiting in the helicopter (68). But the work is a strain and often dangerous also for other categories included in rescue units. Personnel who are to work in rescue operations at sea must have been selected for the physical and psychological preconditions for such work, and must also have undergone training and practice in such activity (44, 57, 68).

Medical personnel should be included in rescues. There is a risk that a person in deep hypothermia is judged to be dead.

While part of the helicopter's load capacity is lost if medical personnel accompany a rescue operation following shipwreck, this is to be recommended. The availability of medical care improves the rescued person's chances of being resuscitated and getting expert help. The crew is also relieved of the responsibility of caring for people who may be seriously injured or chilled; they can instead concentrate on the rescue operation. One condition is that the medical staff involved have experience of helicopter work and can be fetched quickly so that the operation is not delayed.

In low body temperatures the need for oxygen sinks in various organ systems. The heart is affected and the pulse can often not be felt. Breathing depth and frequency also decrease. It may be hard to decide whether the person is breathing. It is natural that chilled victims found unconscious in the water with cold, stiff extremities, water in the mouth and airways and no perceptible pulse are judged to be dead. But in both the Zeebrugge and the Estonia accidents (55, 68) it proved to be possible to save unconscious people with a body temperature of approximately 26 C through warming including peritoneal dialysis. After a number of days they could be discharged from hospital without signs of permanent damage from the chilling they had undergone. However in the Estonia accident with its imbalance between need and available helicopter resources it was correct to rescue first those in distress who showed signs of life.

The operation is often an international one with a need of efficient co-operation and vigorous direction.

Apart from the Corunna tanker accident (35) all the sea disasters studied by KAMEDO have prompted comprehensive rescue operations from many countries. It has not always been easy to exploit these rapidly assembled resources effectively. In Zeebrugge (55) many vessels placed themselves near the capsized ferry, but lacked equipment and other possibilities of helping confined people. In the Scandinavian Star fire (60) there was no possibility either of rescuing confined passengers until smoke divers, unfortunately all too late, were taken out to the ferry. Vessels which in the Estonia's founding came to the rescue had very limited possibilities of picking up victims from the water or from rafts in the heavy weather. The rescuers were obliged to rely on helicopter sorties which unfortunately sometimes demonstrated technical and other problems. In the capsizing of the Alexander L Kielland (44) vessels and ships also hurried to the spot to help. None of those remaining on the capsized living platform could be rescued. However, almost ninety were saved from lifeboats and rafts and direct from the sea.

Common to these accidents is that everything happened very quickly. The capsizing took place without much warning and the fires produced heavy smoke. There was a need to bring a large number of victims to safety very quickly. Yet it takes time to give the alert, gather information, organise a rescue function and bring help out to the victims. Many are lost before an effective rescue operation with a well-functioning command can be established.

Medical capacity on land has always been sufficient. In four of the accidents studied by KAMEDO a number of hospitals on land have received survivors from vessels in distress (44, 55, 60, 68). From the hospitals medical teams have also been sent out to the accident scene and to certain assembly points ashore. The hospitals' resources have been sufficient with the existing preparedness for disasters. As a rule it has taken quite a long time following the alert for the first patients to arrive at the hospitals and there has been ample time for calling in extra staff and making other preparations.

Train and car accidents

General

KAMEDO has studied twelve traffic-accidents on land judged to be of disaster-medicine interest. In seven of these accidents mechanical violence dominated the injury profile (22, 26, 30, 41, 45a, 45b, 62). In two cases toxic substances were released (25, 42). In three cases fires have caused the greatest medical problems (19, 40, 54).

Studies conducted

Railway accidents

Table 14. *Studies of railway accidents.*

Report no	Event	Number of deaths	Injured survivors	Cause	Notes
19	Train fire in Wrandukt tunnel, Jugoslavia 1971	Approx 30	Approx 100	Locomotive fire	Smoke gas in tunnel
22	Train accident in Rheinweiler, West Germany 1971	23	130	Derailing at high speed	Medical injury panorama reported
26	Train accident in Ngoya, Japan 1971	25	400	Train crash in tunnel	Inaccessible area
41	Train accident at Lugnvik, Sweden 1978	11	25	Crash between train and rail bus	Group of confirmees seriously hurt
42	Train accident at Mississauga, Canada 1979	0	No information	Derailing, fire	Release of chlorine, evacuation
45	Train accident at Storsund, Sweden 1980	11	Approx 40	Frontal crash between two trains	Psychosocial antagonism
45b	Train accident at Upplands-Vasby, Sweden 1980	9	37	Express train derailed	Good spontaneous help
62	Tram accident in Gothenburg, Sweden 1992	13	29	Crash between tram, cars and people	Incorrect braking

Road accidents

Four road accidents have been studied, and three of these are also referred to in other chapters (table 15). The three concern single lorries carrying hazardous materials which have overturned or driven off the road (25, 40, 54). The fourth accident was a serial collision on a motorway in England (30).

Table 15. *Studies of road accidents.*

Report no	Event	Number of deaths	Injured survivors	Cause	Notes
25	Phenol disaster, Simmersted, Denmark, 1972	0	Approx 20	Tank truck overturned	Release of phenol
30	Serial collision on motorway, England, 1971	Approx. 10	Approx. 60	Serial crash in fog	
40	Gas explosion, Los Alfaques, Spain, 1978	Approx. 200	No details	Tank truck crash	Propane ignited
54	Tank truck accident at Herborn, Germany, 1987	5	Approx. 40	Tank truck accident	Petrol set town on fire

The railway crash in a tunnel on the Ngoya – Osaka line in Japan in 1971 occurred in a very inaccessible area.

Experience

In railway accidents heavy equipment is often needed for the rescue work.

In both train collisions and derailments many carriages can be demolished or overturned (22, 26, 41, 45a, b). Injured people are caught and squeezed and often difficult to reach for necessary medical attention. The special attention needed for freeing them is not always available nearby. It is not even sure that there are roads in the vicinity of the railway along which the equipment can be brought up (26).

Transport that can be effected along the undamaged part of the railway line may be time-consuming and very limited in extent.

In railway and rescue service disaster plans, such situations should be taken into account since the time factor is so important with regard to casualties' chances of survival. This applies particularly to sparsely-populated areas. Rescue from train crashes in tunnels is extremely difficult.

Medical personnel must also be prepared to be able to make their way to trapped and inaccessible casualties to give lifesaving and pain-relieving

Rescue and medical work following a frontal collision in Lugnvik, near Östersund, 1978.

treatment on the spot. Equipment, clothing and the staff's physical capability for doing such work must be considered.

The injury panorama in a train accident varies greatly. Passengers often suffer different types of injury

In a train collision or a derailment a number of factors affect the nature and severity of personal injuries. A dominating factor is the person's place in the train. In frontal crashes (26, 41, 45a) the locomotive and carriages are pressed together or up onto one another, whereupon passengers are squeezed or crushed. Passengers in the front carriages are therefore the worst afflicted. In other carriages in the same train set people are

Derailment of a train in Rheinweiler, West Germany, 1971. The engine and six of the railway-carriages fell down the embankment and into the village.

injured if they are catapulted about in the hard braking or if their carriage overturns. In addition, damage is caused by breaking windows, luggage flying about, leaking batteries etc (45b). In the rear part of the train set carriages and passengers may be virtually unharmed. In the Upplands-Väsby accident it was the rear carriages that derailed. The cause was a defective wheel. However, it cannot be ruled out that passenger trains may collide with goods trains whose trucks contain inflammable or other hazardous loads.
In derailments (22,45b) some carriages may roll down slopes or steep inclines while others have a softer landing or remain on the track (45). It is hardly possible to predict where in the train is "safest" if a derailment should occur but carriages of stouter construction give better protection. Apart from this chance will play a large part in the occurrence of passenger injuries. KAMEDO has not met with any fires in connection with passenger train collisions or derailments.

The medical outcome of a train derailment or collision may represent a pattern card of many different types and degrees of severity of bodily injuries afflicting the head, thorax, back, abdomen, extremities and organs of circulation (22, 41, 45). There are often multiple injuries. Serious railway accidents, as many other traffic accidents thus require "broad" and good medical competence in the medical teams, and adequate acute equipment. The demands upon receiving hospitals, too, are great with regard to traumatological competence and equipment.

Pending the arrival of medical teams, help is needed from surviving passengers and people in the surroundings.

A good example of the need and opportunities for spontaneous work in the phase immediately following an accident was given in the Upplands-Väsby, derailment (45b). While this occurred relatively near to Stockholm with its large medical resources, it took half an hour before a medical team arrived. But among the uninjured passengers was a female anaesthesiologist and the leader of a group of mountain walkers. Together they organised medical assistance at the accident scene while waiting for help to arrive.

People with any form of medical care training were given the job of watching over casualties and notifying immediately if help with medical assessment was needed. Other passengers brought out from the train rugs and other material needed at the casualty assembly point. In this way, deaths among casualties because of shortcomings in ABC measures

Rail bus collision at Lugnvik near Östersund, Sweden, 1978.

were avoided. Note that seriously injured people were not allowed to be moved until back injuries had been ruled out.

In the train accident in Lugnvik (41), too people living nearby came to help and took over simple medical tasks. When the rescue and care forces arrived the local people continued to look after the uninjured or slightly injured.

In the Herborn tank truck accident (40), it was the immediate reactions of people on the spot that in many respects prevented the fire from assuming a greater extent. The driver was helped from the scene and surrounding houses evacuated before the escaping petrol had ignited. The police and fire services had not arrived before the explosive fire started.

Efficient management of the medical contribution is needed. It may be necessary to resort to temporary or simplified treatment.

The medical care material needed in the train accident in Japan (26) arrived at the accident scene late or not at all. Contributing to this was the lack of acceptable central command of the medical contribution. In Rheinweiler (22) large rescue units arrived rapidly but the allocation of casualties to different hospitals was poor – an expression of unsatisfactory medical direction. Nor in the Lugnvik, Östersund, accident (41) did the medical direction at the accident scene function well. People moved about everywhere without any co-ordination of effort. There was no triage. It is important that one or a few people involved in the medical assistance gain an overall grasp of the situation so as to make optimal use of available resources.

Express trains carrying large numbers of passengers not infrequently cross sparsely-populated areas on their way between urban areas. A risk exists that an accident involving many casualties may occur at a spot without large medical resources in the vicinity. In the Upplands-Väsby accident (45b) the express had come from Lappland in the north of Sweden. The defective wheel that caused the accident could just as easily have failed in some unpopulated northern area. Apart from strict triage it could then have become necessary to resort to temporary or simplified treatment at the receiving hospitals. This was the case in the Rheinweiler (22) derailment even though the area was not exactly sparsely populated. The hospital in Mülheim, which was nearest the scene of the accident, had to receive 66 casualties during two hours, of whom 33 had to be admitted. Fifteen were in shock. This small hospital had only one operating theatre.

Uninjured persons and the slightly injured also need help. Psychological reactions among relatives of those afflicted by disaster may complicate the situation.

In Upplands-Väsby no assembly point was established for uninjured persons and the slightly injured, and no real psychosocial support was organised for them Many had had clothes and bags spoiled, had missed connecting trains or needed help in other ways. After a while it was announced that buses were leaving for Stockholm but no information was given as to what would happen then.

In Lugnvik (41), however, people living in the neighbourhood helped survivors after the accident. Blankets and clothes were lent, things to drink offered, etc. At the hospital, too, support groups were organised which gave help later. It is important that even survivors without severe physical injuries who may have been affected both emotionally and purely practically receive the help they need. In recent years the need of psychosocial support has been much noted among those concerned with disaster medicine.

Many of the children in the group of confirmees involved in the Lugnvik accident had severe injuries and had to stay in hospital for a long time. Parents were given ample opportunities of spending time with them and even staying at the hospital. Initially they showed great gratitude and appreciation for the help the children and they themselves received. But as the days passed they became increasingly critical of the staff and complained about the care the children were receiving. The staff for their part, who felt that they had made an effort and done everything they could to help, grew irritated by this. The physicians tried to explain that these were natural reactions among the parents who had feelings of guilt and felt powerless. The situation grew worse. Some of the children had to move with their parents to another department.

Another example of unexpected mental reactions among the parents of children affected by a disaster is given by the train collision in Storsund (45a). In this accident which occurred on a school excursion at the end of a spring term, eleven lost their lives and twice as many were injured. In the autumn the vicar invited parents and school staff affected by the accident to a discussion. This revealed a deep gap between parents who had lost children and those whose children had survived. The former reproached the latter for their behaviour and claimed that they were avoiding them. At a new meeting the same atmosphere prevailed and there were quarrels. Only thirteen people came to the next meeting. These also met thereafter. That the antagonisms could not be overcome may depend on differing existential conditions but also on the fact that a sense of community had started to develop during the summer among the group that had lost children. In some cases the event brought to the surface internal unprocessed conflicts within the families.

It is hard to prevent antagonism in situations such as these but one must prepared that they may arise. One must attempt to tackle the problem early.

Correct psychosocial care requires resources.

In the earlier train accidents documented by KAMEDO there was hardly any organised psychosocial help for those afflicted or their nearest and dearest. In the Storsund train accident (45a), however, it is described how social workers and clergymen were called to the hospital in Falun. At one point the crisis group included six social workers, two psychologists and six clergymen. But more important was that since many of the children were from Leksand, a group from Leksand also came, consisting of the school's administrative head and head teacher, the chairman of the school board and the vicar. It was considered valuable that people with deeper relations with those afflicted took part. Their responsibilities included being present when notice of death was given by physicians, comforting and helping with a number of practical problems. They also assisted in the funeral arrangements and visited the afflicted families in the evenings. In the school involved, class discussions were also arranged about what had happened, so as to help pupils handle crisis feelings.

In the tram accident in Göteborg (62) psychosocial work among relatives took up large resources for many days. Particularly demanding were situations in which relatives of those who had lost their lives sought support before the fatalities had been firmly identified. Among the police, too, support was needed for staff exposed to heavy strains in connection with the accident. In this, help was given by a special support group created for the European football championships the same year.

The "Load and Go" principle can in some cases be preferable. A complete care chain is needed for multitrauma cases.

In the Göteborg tram accident (62) there was good transport capacity and sufficient highly-qualified medical resources close by, where the casualties could quickly obtain treatment. For this reason there was no treatment requiring much time at the accident scene. Only simple ABC measures, e.g. freeing airways through semi-prone position, were carried out. Circulatory shock was treated or prevented with raised bed foot and oxygen. Extensive bleeding wounds were bandaged. As early as forty minutes after the accident, thirty-six casualties had been taken to hospital. Forensic examinations of thirteen fatalities confirmed that none of these could have been saved with further medical treatment at the accident scene. No fatal complications in the form of sepsis, adult respiratory distress syndrome (ARDS) and multiple organ failure that occur following trauma from blunt violence were diagnosed in this accident. This indicates that serious and protracted shock was avoided despite (or thanks to) "load and go". For this, competent ambulance staff are necessary. The medical care at the accident scene thus did not follow the general rules normally applied in Sweden. But here it was possible in a very short time to bring casualties to qualified treatment. It would also have taken some time to call out and establish more qualified medical activity at the accident scene, which in this case would have been a wet, rainy city street. The assessment that *in this case* "Load and go" was preferable proved to be correct, but presupposed that the availability of transport was very good and the distance to a hospital prepared to receive the casualties short. An advantage was that a competent doctor in command was at the site who could assess and put priorities on casualties, and if necessary control transport. It is however not certain that even large hospitals at night and during holidays can offer sufficient resources. Effective and vigorous control of patient transport is necessary.

Using the information flowing in from the accident scene the Göteborg hospitals (62) established an efficient and complete care chain with teams caring for seriously multitraumatised casualties. Assessment and relative priorities of the casualties took place at the same time as shock treatment was started. When several injuries required the highest priority more than one specialist could operate simultaneously.

From other countries it has been reported that some twenty percent of those who die following traffic accidents do so between one and twenty-four hours after the accident from intracranial bleeding or from parenchymatose organs in the abdomen (62). Seven patients from the tram accident had these types of injury. Six of them were operated upon immediately and survived. The seventh was judged inoperable. It was therefore possible to save the majority of those through very early basic ABC and transport to adjacent hospitals where teams immediately took care of them for diagnosis and operation.

Correct decisions on how available hospital resources are to be employed presuppose adequate information from the accident scene. The mobile telephone network and the regular telephone network were in this case, as so often, rapidly overloaded and blocked.

Heavy transport vehicles are often involved in serious traffic accidents. Not infrequently third parties or people in private cars are the worst afflicted.

In the Simmersted phenol disaster (25) the vehicle consisted of a traction vehicle and tank trailer containing phenol, which overturned. The driver was strongly affected by the phenol fumes and required hospitalisation. Other people who were exposed were afflicted during the following days with symptoms of poisoning and were taken to hospital. Watercourses were also poisoned, with fish and bird death as a consequence.

The serial collisions on the M6 motorway (30) started with a collision between two articulated lorries in fog. Of ninety-four vehicles involved, seventy were transport vehicles. In these seventy vehicles only two people died. Of the people travelling in the twenty-four private cars involved, at least eight died. Four of them had fatal burn injuries.

In the Los Alfaques gas accident (4) the driver of the tank truck died when the vehicle left the road. Most destructive, however, was the BLEVE

(Boiling liquid expanding vapour explosion) and the fire which the contents of the tank truck caused, which directly killed 102 persons at a camp site, and was the reason for a further hundred or so later dying of thermal burn injuries.

The disastrous fire in Herborn (54) was also caused by a tank truck. People were heavily afflicted by the fire that arose when the petrol that had escaped caught fire. The driver survived.

Relations with the mass media must be considered.

In the train derailment in Storsund (45a) the survivors and their families were troubled with reporters. The accident was felt to be of great news value since a large number of school children were among the fatalities and casualties. Even at the hospital the press coverage was great and it culminated on the day of the funeral in Leksand. Intrusive photo reporting portrayed the families' grief. Photos were even taken during the one-minute silence. For families and friends all this was experienced as particularly burdensome.

As against this, the tram accident in Göteborg (62) was an example of mutual good contact between medical care and the mass media. The need for undisturbed rescue work and medical care was respected. Reasons are considered to have included early initiative from police, the rescue services and medical care, who realised that the mass media needed information. There were showings of the accident scene. Repeated press conferences were held at which well-informed staff were responsible for the information. Medical care also made repeated press announcements regarding the casualties' condition.

Epidemics

General

Bacteria, viruses and many other forms of micro-organism are normal components of human everyday life. Many of them live in our bodies without causing illness or other damage under normal conditions. We have developed defence mechanisms against their attack but in all ages they have also been able to cause severe infectious diseases which in some cases have taken the form of serious epidemics. Often these have occurred when hygienic conditions have been poor or people have been undernourished, with reduced resistance.

On four occasions KAMEDO has had observers within areas afflicted by epidemics (table 16). Studies have covered one epidemic of smallpox, two of cholera and one of sickness caused by Ebola virus. Two of the epidemics occurred in Europe but were caused by infection introduced from Asia and Africa, respectively. The other two occurred in Africa.

Studies conducted

Table 16. Studies of serious epidemics.

Report number	Event	Number of deaths	Numbers ill	Notes
16	Smallpox epidemic in Meschede, Germany 1970	4	About 20	Primary case infected in west Pakistan spread the infection in Germany
32	Cholera epidemic, southern Italy 1973	23	Several hundred	Tunisian mussels gave secondary infection
32B	Cholera epidemic,	Unknown	15,000	Continued between 1987 Angola 1989 and 1989; polluted water
69	Ebola epidemic, Zaire 1995	Over 50	No information	Forest worker→family →hospital staff →population

Severe epidemics can be prevented through relatively simple measures.

In the Israeli attack on Beirut in 1982 (49) the sanitary situation was such that epidemics could be feared. The summer was hot and there were periodic shortages of water, electricity and fuel. West Beirut was greatly overpopulated since almost fifty thousand refugees had made their way there. Buildings had collapsed and many people had to stay in cellars, garages and shelters. Refuse collection was not working. In spite of all this no real epidemic took place even though a certain increase was noted in upper airway infections and gastro intestinal infections.

Many causes contributed to the avoidance of serious epidemics. A comprehensive programme of vaccination had been carried out prior to the siege of Beirut. But, more importantly, the inhabitants were aware of the dangers of an epidemic since the authorities had informed the population using loudspeakers regarding hygienic and epidemic preventive measures. Refuse and other rubbish was collected in open places and burned. Care was taken that the wells with drinking water were not polluted. The population suffered no serious lack of foodstuffs, but was well nourished since conserves and dried food were available. Good basic knowledge and cultural traditions also contributed to the relative freedom from serious infection.

Particularly in natural disasters, an important measure is to arrange for the population as soon as possible to have access to good quality water in sufficient quantities to cover personal hygiene etc. In one or more cases it has proved possible following purification and disinfection to use even polluted water to drink. Dealing with dead animals is also of high priority, through burning bodies before the ground water is affected. But the handling of waste must also be given a high priority.

Epidemics of diseases with a risk of fatal outcome not infrequently induce exaggerated reactions among the population. Hasty and unnecessary measures are sometimes undertaken.

In Meschede and it surroundings (16) the population became seriously worried when they learned that there were cases of smallpox in the town's hospital. It was felt that there was a great risk that several hundred people had been infected during the week prior to the diagnosis. Demands were put forward that schools, factories and shops shops should be closed. But according to experts on epidemics this would have lacked preventive value. Many rumours flourished. Situations were misinterpreted.

There is a very great need for correct and easily understood information from competent and trustworthy physicians and other representatives of medical care in epidemics. The authorities are subjected to great pressure from worried people in their surroundings, demanding a quick and efficient stop to the epidemic (16, 32, 69). Only to isolate and treat the infected people, search for the primary source of infection and otherwise await developments is felt to be insufficient. Mass vaccination, prophylactic use of antibiotics and the closing of factories and schools were also resorted to in the cholera epidemics even though the effect of these in many cases was nil or negligible. There is a risk that measures are carried out by authorities only to show their vigour and to suppress the population's disquiet.

Serious infectious diseases are a global problem. Continual collection of epidemiological data is important.

In tropical countries and developing countries there are epidemics of diseases that have their basis in the countries' particular ecological and climatological circumstances with the presence of organisms, insects and other "bugs" together with different animal species that can act as intermediate hosts and spreaders of infections. Contributory factors are shortcomings in sanitary conditions and poorly developed health and medical care for large parts of the poor population. Cholera, typhus, plague and malaria are examples of such diseases. In addition, what for us are fairly "new and unknown" diseases occur occasionally and may then spread widely.

Such infections sometimes turn up in Europe and the USA and other countries in the industrialised world (16, 32) often introduced from tropical areas or some developing country. Increasing tourism, immigration, international trade and well developed global communications create the conditions for permitting serious epidemics to arise occasionally anywhere. Swedish medical training includes certain instruction in tropical medicine and diseases uncommon in Sweden.

Through agreement between the National Board of Health and Welfare and the Swedish Institute for Infectious Disease Control together with the University of Linköping, there is a special preparedness for the care of patients with (suspicion of) extremely infectious diseases.

War and terrorist attacks

General

Armed conflicts between population groups, nations and religions have, during human history, left incalculable numbers of dead and injured among the combatants. Even though the civilian population has also been injured in connection with hostilities, they have not earlier represented primary targets or been as sorely afflicted by warfare as the soldiers have. But in this respect there was a change during the twentieth century. A contemporary war is a total war in which the whole population including civilians is affected equally severely.

In many cases the war is not even confined to certain areas of the earth. Through operations with nuclear submarines, aircraft carriers, aircraft that can be refuelled in flight, long-distance missiles etc it is possible to strike anywhere in the world. Nor is it always military units that inflict the injuries and damage. It has become increasingly common that terrorist groups through sabotage and other attacks attempt to injure their opponent or make the world aware of circumstances that they do not accept. People can be affected by terrorist action at any time since such attacks also occur during peacetime.

Wartime medical care

The borderline between the medical care of combat units and the civilian community has become less clear. Shot injuries, detonation injuries, burn injuries, shrapnel injuries, gas injuries etc in wartime are as common among the civilian population as in military units. In Sweden chiefly the civilian hospitals are responsible for the final treatment of the severely injured and sick regardless of whether they are military personnel or civilians. This applies both in peacetime and in war. What remains of the armed forces medical care are only resources for day-to-day care and the acute care of the injured and ill, including qualified first aid. In addition to this, during wartime, a number of mobile hospitals, (field hospitals and marine combat hospitals) may be set up as a supplement where civilian medical care coverage is sparse.

Turning to work in certain extreme environments e.g. flying and diving, however, the armed forces have better resources than those on the civilian side. This work covers man's physiological capacity to carry out his tasks in changed ambient pressures and under high G loads.

In the area of nuclear, biological and chemical weapons (NBC) protection, treatment and training have become a matter for the total defence services. The equipment being tested should be usable both by civilians and the military.

Studies conducted

KAMEDO has published nine reports on war and terrorist actions (table 17). Five of these describe medical care in wars, of which two took place in Israel (7, 31), one in Jordan (20) and one in Lebanon (49). One report treats American military surgery during the Vietnam war (27). Four describe the effects of terrorist actions (46, 67, 71, 72). No report has been published covering military medical care under winter conditions.

Table 17. *Studies of war and terrorist actions.*

Report number	Event	Number of deaths	Injured survivors	Countries/ groups involved	Notes
7	Six Day War, Israel, June 1967	700 Israelis	3,000 Israelis	Israel versus Egypt, Jordan and Syria	Fronts: Sinai Desert, Jerusalem and Golan
20	Studies in Jordan 1970	4,000	30,000	Civil war	Red Cross, Swedish surgical team
27	American military surgery, south east Asia, Japan 1972	Unknown	Unknown	North Vietnam, South Vietnam and USA	Studies at hospitals on Okinawa
31	Yom Kippur war, Israel 1973	2,412 Israelis	6,388 Israelis	Israel versus Syria and Egypt	Fronts: Golan and Sinai Desert
46	Terrorist attack in Bologna, Italy 1980	73	218	No information	Blowing up of railway station
49	Beirut, Lebanon 1982	Approx 6,000	Approx 25,000	Israel versus PLO	Attack on southern Lebanon
67	Fire, World Trade Center, New York 1993	6	1,017 sought medical care	No information	Attack, explosives
71	Poisonous gas release in Tokyo, Japan 1995	12		No information	Nerve gas in underground railway
72	Attack on bus, Israel 1996			No information	

Apart from these, KAMEDO has published two summaries in textbook form treating special problems associated with war and disaster.

Barn under krigs- och katastrofförhållanden (Children under war and disaster conditions) (43) is a brief compilation of documented experience and knowledge of children's experience, behaviour and psychological difficulties in war. In the foreword it is stressed that the developmental level of a nation's defence planning can be measured in the care and precision there is in the plans for looking after children in connection with war and disasters. The work was published in 1981. At that time there were in Sweden 1.5 million children under fifteen years old. About half were under 7 and needed continual adult care. At that time the number of children with immigrant and refugee backgrounds was not yet large. The book reports especially on children's reactions to external violence and threats and the separation to which the family was not infrequently subjected.

Kärnvapenkrig (Nuclear war) (52) is a compilation of facts on nuclear weapons. Fifteen experts contributed. The purpose of the book is primarily to increase knowledge among medical personnel regarding the physical and biological effects of nuclear weapons and the ensuing injuries, together with possible treatment. Attempts are also made with scenarios to apply the knowledge to Swedish conditions. Possible rescue operations and medical care are discussed. The result gives a particularly pessimistic picture of the circumstances that would prevail if nuclear weapons were used.

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KAMEDO's two scientific secretaries also took part in a conference in Tel Aviv after the Gulf War in which the Israelis reported the experience of Iraq's missile bombardment of Israel. They also visited a number of hospitals in Israel and studied preparations for care of people exposed to chemical weapons (unpublished).

Experience

Medical personnel require training in war and disaster medicine. Co-ordinated military and civilian medico care are assumed to operate in war time.

The need for medical preparedness for war and terrorist action has emerged clearly in the Middle East. Since Israel, ever since its birth as a State, has lived under threat of war, medical personnel have been trained for both wartime and disaster conditions. The physicians who served at military unit locations during the 1973 Yom Kippur war (31) had at least two and half years' conscript service behind them with training in, among other things, acute medical care, surgery and anaesthesiology. All the country's physicians should be able to manage certain acute care regardless of medical speciality. The knowledge was kept up to date through current refresher periods. Dentists completed part of their military service in anaesthesia departments. Medical orderlies in the army had undergone a three-and-a-half month medical care training course which, among other things, gave them the competence to administer drip. The hospitals often had disaster exercises.

The co-ordination of the civilian and military medical care in wartime was prepared and to some extent applied even under peacetime circumstances. Responsible for this co-ordination, with the right to issue directives to all hospitals, was a disaster medical council consisting of the head of the health ministry, the Surgeon General and the chief of the Histadruts medical funds. All hospitals were prepared to increase their capacity under wartime conditions. Israel was able rapidly to bring up the medical resources needed to cover care requirements on several fronts.

Israeli wartime medical care in the combat line during the 1973 Yom Kippur war. An injured soldier has been intubated and received pleural drainage. A subclavial catheter is being introduced.

In the attack on Beirut in 1982, too, (49) the hospitals in Lebanon received patients belonging both to the civilian population and to military units.

Even though Sweden is not at present exposed to military threats, one can never exclude international changes that would make Sweden the scene of military or terrorist action. Serious accidents requiring disaster medical help cannot be excluded either. Swedish collaboration in international work in areas where armed conflicts are going on has come to the fore during the past decade. It is important for physicians, nurses and certain other medical personnel to be trained also to function in such situations and for medical care to be adapted to both peace and war.

Since 1997–98 a preparedness resource of special trauma specialists consisting of surgeons, orthopaedic surgeons, anaesthesiologists and operating – or anaesthesiological – and emergency department nurses has been trained. The training comprises one week’s trauma course in Sweden and a month’s observation at trauma centres overseas (USA).

Small, easily-mobile medical units that can accompany combat units are an important resource. But units further behind the lines are needed for more qualified medical care.

For qualified first aid and care at the front in Israel (7, 31), mobile first aid stations accompanied the combat units. The work was done in tents. Despite limited resources and continual moves, casualties were cared for here very efficiently. Through rapid care, the wounded person’s possibilities of survival were considerably improved. The stations also gave an important psychological support and valuable “near service” for slight wounds and ailments.

Somewhat further to the rear there were battalion dressing stations tasked to be responsible for checking the condition of casualties and if necessary correcting dressings and treatment prior to rearward transport to more qualified care. Yet further to the rear there were field hospitals with X-ray, laboratory resources and operating theatres.

In Sweden by and large the same type of military medical care chain is applied during preparedness and war. Every rifle group includes a medical orderly with eighty hours medical training over and above the training that everyone in the group receives. He carries simple equipment. At platoon level there is a platoon nursing orderly with four hundred hours’ medical training, of which three weeks are clinical practice. He is also intended to work near the front. Somewhat further to the rear there is a company assembly point with a nurse (male) and two nursing orderlies. Their work is intended to ensure that the wounded person is in a state to be transported further without his condition worsening. Another important task is triage. The aim is that casualties needing operative intervention will be able to lie on the operation table within six hours – within two if there is more extensive internal haemorrhage.

At the dressing station qualified first aid is given. Two junior physicians and a dentist (dental assistant) plus four nursing orderlies make it possible to carry out less extensive, life-saving surgery. The most slightly wounded receive full treatment. Those who need operations or care are sent on to hospital. Civilian medical care is here responsible for seventy to eighty percent of care, but where civilian resources are insufficient there should be field hospitals and naval combat hospitals.

The medical injury panorama in combat varies depending on ground conditions and the nature of the fighting.

During the Six-day War (7), in the desert warfare shrapnel injuries from shells and mines dominated among the Israeli soldiers. The Egyptians used small plastic anti- personnel mines spread out in the sand in their thousands. But burn injuries also occurred among Israeli tank crews. On the Syrian front the injuries were mostly to the upper half of the body since the operations were in mountainous areas and soldiers sought shelter in hilly countryside. Any burn injuries came from napalm.

During the Yom Kippur War (31) the number of burn injuries increased greatly, mainly because of heavy Egyptian attacks against Israeli tanks. The crews here were also afflicted by lung injuries.

The injury panorama of a civilian population varies greatly depending on the war situation. Multiple injuries and burn injuries are common in attacks against fairly large towns. In west Beirut (49) more than 80% of those admitted to the American Hospital had multiple injuries and the proportion of burn casualties exceeded twenty percent. Mines and undetonated ammunition were for long after the war a great danger to the population.

Technical development of weapons has increased the risk that weapons with special effects are used. In Beirut it is reported that “cluster bombs” had been used, i.e. bombs that on detonation disperse large quantities of metal balls or other shrapnel. Probably the FAE bomb was also used, a form of “suction bomb”. In addition, phosphor bombs created serious and very special problems. It happened that patients came in to the American Hospital contaminated with yellow (white) phosphor which self-ignites in air. The burning was extinguished, but as soon as the dressing was removed the phosphor started to burn. Often some people attempted to scrape off the burning phosphor. Copper sulphate which may be used as an antidote was probably not available at the hospital then.

It is also necessary for wartime medical care to be prepared to meet the very large variations in the medical injury panorama that may be expected and that will depend upon the type of combat and weapon, surrounding countryside, climate, buildings etc.

Early shock treatment is necessary. But there may be exceptions?

It has emerged from the reports that the effects of early and energetically prosecuted shock treatment has been one of the positive medical experiences of war (7, 31, 49). The disaster medical council in Israel had issued instructions regarding the treatment of shock in which physicians were recommended to use primarily Ringer lactate and only thereafter blood if it became necessary. Central blood pressure measurement was often used in shock therapy. Acidosis treatment was commenced early. No case of primary renal failure was noted. Vasodepressor substances were not used.

In the work of the Red Cross in Jordan (20) the Swedish operating team lacked blood for transfusions. Patients arriving had often been injured up to twelve hours before arrival and were anaemic. The late arrival to qualified treatment meant that the surgical interventions were extensive and time-consuming, demanding infusion therapy.

The results of more recent research presented at disaster medical congresses indicate that, in perforative injuries to large blood vessels the use of immediate infusion treatment is sometimes a matter for discussion. Following the initially very serious bleeding with accompanying hypotension, e.g. a hole in the aorta, bleeding starts to lessen after some minutes. If one gives saline solutions with accompanying rise in blood pressure without having dealt with the injury, bleeding increases again and the injured person dies of loss of blood. If on the other hand, he can be brought rapidly to qualified care and the wound can be repaired within less than an hour there would be a possibility of dealing with the shock.

In bullet wounds, vigorous debridation and sometimes fasciotomy are required.

During the visit of KAMEDO to Zama Camp Hospital and Okinawa Hospital during the Vietnam War (27) the American physicians pointed out that surgeons often debrided wound injuries too little and not infrequently neglected to perform fasciotomy (cuts in connective tissue) with complications as a result.

At Zama camp hospital a start was made by first debriding carefully. The incision was then lengthened in both directions. Going in under the fascia, one often found that the injury was much larger than expected. This applied particularly to injuries from shell splinters or blunt violence. If there was more than one wound in an extremity, both wounds were united with a long section. It had happened that anti-personnel mines had only given slight injuries at the ankle but that earth had been driven in subcutaneously and into muscles right up to the groin without this being suspected. The surgeons were also generous with fasciotomy where there was a risk of compartment syndrome.

Large numbers of civilians were also killed or injured. Collapsed houses and inaccessible streets following the shelling of cities delay the possibilities of giving hospital care.

During the attacks against the PLO and Beirut in 1982 approximately 30,000 of the 600,000 people in west Beirut were injured. About 6,000 died. Approximately 20% of the casualties were military personnel or combatants belonging chiefly to the PLO or the Syrian army. The other eighty percent were civilians – 40% younger than fifteen years, 30% women and 10% men over sixty.

The proportion of casualties who died before arrival in hospital was just over 10%. This is a lower value than military figures from other wars (approximately 20%). Average mortality among patients admitted to twenty medical centres in western and southern Beirut was calculated to 10%–15%. The corresponding figure at the American Hospital in west Beirut was 3.1%. These figures can be compared with the 2% noted for the United States army during the Vietnam War and Israel's October War of 1973.

In connection with Israel's bombardment of Beirut in 1982 it became necessary to develop care units in sheltered premised, in case a garage.

Following the attacks on Beirut (49) often many hours passed before the seriously injured started to arrive in the hospitals. One cause was that it took time to dig out people who had sought shelter in cellars if the buildings had already collapsed. But it was also hard or impossible for ambulances and other vehicles to make their way to the most severely afflicted areas where the majority of the wounded and dead were. In this respect it was a great advantage that there was a large number of small medical units in garages and other protected premises close by to which the casualties could be taken for qualified medical care. These resources became particularly valuable when activity at many hospitals was forced to stop because of hostilities. Unfortunately in consequence of shortcomings at the small provisional care units, treatment results were not always entirely satisfactory. The large American Hospital was almost entirely spared from direct attack and was able to continue its work. Special difficulties arose through shortcomings in technical supplies and in cuts in the water and electricity supplies. Lifts, refrigeration plants, pumps, X-ray equipment and other apparatus could not be used. There was no radio connection between the hospitals, the scenes of injury and the ambulances.

It is therefore important that hospitals and other health care installations have resources for emergency reception, operations, intensive care and other important activities in premises with acceptable shelter and with assured technical supplies. In war or disasters, they must also be able to be "self-supplying" for a period regarding personnel, foodstuffs, drugs, material and technology.

There must also be preparations for taking care of and treating people exposed to chemical warfare. Serious epidemics have not occurred but the risk of biological warfare cannot be excluded.

During the Gulf War Israel was bombarded with missiles, initially expected to be carrying chemical warheads since Iraq had large quantities of chemical weapons. The population had been given information on how to act. Rescue and ambulance staff in protective clothing stood by, provided with antidotes to some known chemical weapons. At the hospitals a large number of outdoor showers had been prepared. As they arrived patients were to be received on a marked-out area of ground by personnel wearing protective clothing. After removal of their clothes (if this had not happened earlier before transport), examination, showering and other decontamination, the patient was allowed to enter an area considered as “clean”. Medical care continued there. On the hospital premises there was equipment for advanced treatment of casualties.

Chemical warfare against Sweden is a realistic threat for an aggressor: it is a “cheap” way of waging war in relation to its dramatic effects. Nor can attacks from terrorist groups be excluded (71). On several occasions, fishermen have brought up mustard gas containers dumped in the sea, in many cases rusted. Added to this is the ever-present risk of accidents in the peacetime handling of various chemicals. Very good knowledge of these issues, together with satisfactory personnel and material resources is required.

As emerged from the chapter on “Epidemics”, while there has been a certain increase in infectious diseases in connection with war, it has been possible with relatively simple means to avoid serious epidemics. The threat that an assailant or terrorists resort to biological “warfare” of entirely different effectiveness is always present. KAMEDO have not studied problems associated with this.

Helicopter transport of casualties greatly improves the prognosis.

In the attacks on Beirut in 1982, west Beirut was largely a surrounded city and the Israelis had air supremacy. For the inhabitants of the city and the PLO, therefore, there was hardly any possibility of using helicopters for medical transport or in other ways removing casualties to safer places. Nor in the war in Jordan (20) was there any helicopter

The Yom Kippur war of 1973. Transport of casualties to hospital was to a large extent by helicopter.

transport of casualties. Many valuable hours had passed following the injury before the patient reached the Red Cross surgical teams. Because of this, the necessary surgery became more extensive and the prognosis worse.

The situation has been entirely different in other wars studied by KAMEDO. During the Korean War and the Vietnam War (27) the USA had full air supremacy. The availability of helicopters was good. Casualties, following simple medical measures near the accident scene, were rapidly transported by helicopter to field hospitals for more qualified care and then if necessary further air-lifted to Japan or the USA. The prognosis for surviving and limiting invalidity greatly improved. Israel, too, in the Six Day War and the Yom Kippur War (7, 31) was entirely superior in the air. Helicopters were used to a large extent in the transport of casualties. Within a very few hours casualties could receive qualified treatment at civilian hospitals.

Terrorist actions studied by KAMEDO have occurred in places with large medical resources nearby, for which reason helicopter transport has not been necessary.

A war situation represents severe psychological stress. Under war conditions temporary homes may be needed for the children of medical personnel.

KAMEDO has not conducted any real studies of psychological problems among people afflicted by war. Physicians contributing to the medical effort in Beirut (49), however, reported that they noted signs of instability in the adult population in the form of increased consumption of alcohol, narcotics and tranquillisers. Nightmares were common. The children exhibited sleep disturbances, increased aggressiveness and sometimes psychosomatic symptoms. In many cases protracted psychological trouble and behaviour changes were expected. In the book *"Barn under krigs-och katastrofförhallanden" (Children under war and disaster circumstances)* (43) some common problems and simple measures to minimise the effects thereof are described.

In the larger hospitals in Israel there were, during the wars, possibilities for mothers working in the hospitals to leave their children at special temporary homes with 24-hour service in connection with the hospital (7, 31). In a modern society it is necessary that such resources are available. The men and also some of the women are called up to the armed forces. Medical personnel may need to serve for long connected periods or have no possibility of moving between the hospitals and their homes because of the hostilities (49). Grandparents do not always live in the vicinity or for other reasons are unable to take care of the children. Our peacetime organisation with nurseries and after-school centres may be afflicted by disturbances. For the child it is a security to know that its mother is working nearby. For the mother, too, it is an advantage to have the child in her vicinity.

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3.	Katastrofmedicinska studier i Turkiet: Jordbävningskatastrof i Varto-området, augusti 1966	1967	Göran Eriksson Gustav Weissglas
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40.	Katastrofmedicinska studier i Spanien: Gasolyckan i Los Alfaques 11 juli 1978	1979	Gösta Arturson Rune Blomberg Kaare Brandsjö
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64. SoS-rapport 1994:16 Jumbojetkatastrofen i Amsterdam den 4 oktober 1992	1994	Gösta Arturson Henry Lorin Pär Olofsson Jan Wisén

65.	SoS-rapport 1996:11 Rökgranatolyckan i Uppsala den 25 augusti 1993 och Klorgasolyckan vid Vanadisbadet i Stockholm den 2 augusti 1993	1996	Lars Holmberg Helena Unger Anders Asplund Håkan Lindberg John Grubbström Sammanställd av Per Kulling
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Copies of summaries may be obtained free of charge from KAMEDO, Socialstyrelsen (National Board of Health and Welfare), S-106 30 Stockholm, Sweden, and complete reports may be obtained from Socialstyrelsens kund-tjänst, Finspångsgatan 51, S-163 53 Spånga, Sweden.

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