

10.3.8 Disasters

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10.3.8 Disasters 1713 Dainiak N, et al. (2011). Literature review and global consensus on management of acute radiation syndrome affecting non-hematopoietic organ systems. *Disaster Med Publ Hlth Preparedness*, 5, 183–201. Gourmelon P, et al. (2010). European consensus on the medical management of acute radiation syndrome and analysis of the radiation accidents in Belgium and Senegal. *Health Physics*, 98, 825–32. Mettler F, Upton A (2008). *Medical effects of ionizing radiation*, 3rd edition. Saunders Elsevier, Philadelphia, PA. Radiation Emergency Assistance Center/Training Site (2013). *The medical aspects of radiation incidents*. Oak Ridge USA, Publications & Radiation Resources. <https://orise.orau.gov/reacts/documents/medical-aspects-of-radiation-incidents.pdf> Rojas-Palma C, et al. (2009). *TMT Handbook: handbook for the management of the public in the event of a malevolent use of ionising radiation*. <http://www.tmthandbook.org/> Waselenko JK, et al. (2004). Medical management of the acute radiation syndrome: recommendations of the Strategic National Stockpile Radiation Working Group. *Ann Int Med*, 140, 1037–51. Websites Advisory Group on Non-Ionising Radiation (2002). *Health effects from ultraviolet radiation*. Documents of the NRPB. Vol. 13, No. 1. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/414185/NRPB_Doc_series_vol13_no1.pdf Advisory Group on Ionizing Radiation (2009). *High dose radiation effects and tissue injury*. Documents of the Health Protection Agency

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Southeast Asian tsunami (2004), Hurricane Nargis, Burma (2008), and the Haiti earthquake (2010)—were followed by the Tohoku earthquake (2011), Japan, in which tsunami waves caused over 18 000 deaths and severely damaged the supposedly earthquake-resistant Fukushima nuclear plant that had been built along the same coast with tsunami protection that proved to be inadequate. This ‘domino’ or cascading effect triggering a technological disaster in its wake demonstrated the problems that can be faced even in advanced industrial nations prone to natural cataclysms.

Introduction A natural disaster is the massive ecological breakdown in the relation between humans and their environment, a serious and sudden (or insidious, as in drought) event on such a scale that

SECTION 10 Environmental medicine, occupational medicine, and poisoning 1714 the stricken community needs extraordinary efforts to cope with it, often with outside help or international aid. Very high mortality is not necessary in this definition, which is not specifically health based. Between 300 and 400 natural disasters occur throughout the world every year. The occurrence rates of geophysical hazards like earthquakes and volcanic eruptions have not varied much since the time of Neanderthals over 40 000 years ago, but there is evidence in recent years for a rise in the number of weather-related disasters, such as severe floods and windstorms. Furthermore, the potential for increasing losses of life and property as populations expand in regions of high natural risk was exemplified by the Southeast Asian tsunami that devastated the Indian Ocean region on 26th of December 2004 leaving more than 250 000 people dead and at least 1.7 million displaced from their homes in 10 countries. Natural disaster risk reduction is one of the targets embedded in the UN Sustainable Development Goals with 187 member states adopting the Sendai Framework for Disaster Risk Reduction 2015 to 2030. By 2030, the Framework calls for substantial global reductions in the following areas: mortality, the number of people affected, direct economic losses, and damage to critical infrastructure. Countries will have to make their own plans to support the implementation of the Framework, with greater international cooperation to support developing countries. For access to early warning systems, disaster risk information and assessment are priorities, while health features more strongly than in the previous UN decadal initiatives. Natural disasters are by definition chaotic, but communities in disaster-prone countries can plan and prepare against them. Scientists are working on improving forecasting and on the modelling of their impacts. Most deaths in sudden-onset disasters happen before outside aid arrives, hence strengthening local response capacity in the first hours is crucial. However, international disaster relief can be rapidly and effectively dispatched to needy countries that are politically willing to accept it: although medical relief teams might arrive too late to treat most of the critically injured, teams with engineering and disaster relief skills will have an important role in restoring roads and bridges, bringing in potable water, ensuring solid waste management, food protection, vector control, and sanitation. Even in disasters that have major human impacts, attendances at medical facilities can return to normal levels even within a few days of the acute phase, once the injured have been cared for, when the priority becomes the restoration of primary healthcare and the needs of survivors. Rehabilitation in the post-disaster phase should be an essential consideration in the emergency response phase, and ultimately directed towards measures for reducing the pre-disaster vulnerability. Yet many financial donors view disasters as mere temporary interruptions in development. In April and May 2015 two earthquakes in Nepal killed some 8000 people and reduced 300 000 houses to rubble. On 25 April, a 7.8 magnitude earthquake struck with its epicentre 77 km northwest of the capital Kathmandu which suffered widespread destruction along with the collapse of mud and stone housing in rural areas. The

impact was so widespread that an avalanche was triggered on Mount Everest. For a poor country it will take many years to recover—blowing away the myth that life gets back to normal in a few weeks after a disaster. History should not have to repeat itself—with the limited progress in the past over strengthening building codes, reinforcing old buildings, protecting health facilities, and educating the population about risks in a country where seismologists had warned for years about the severe earthquake risk. Pre-disaster measures Accurately forecasting the timing and size of these sudden-onset natural disasters is rarely possible. This fact constrains efforts to prevent loss of life by timely evacuation of people from the areas at risk before disaster strikes. Disasters leave a trail of devastation and are quite different from the major incidents hospitals usually plan for, in that normal lifelines and infrastructure break down in the devastation. Thus, essentials such as transport, communications, and power will be the first to fail or will be severely curtailed, thereby crippling the immediate emergency response. In the worst examples hospitals can be severely damaged and the staff being among the victims. But despite their chaotic aspects, disasters are amenable to scientific study and a growing body of physical scientists in various fields are directing their energies towards disaster mitigation, particularly in devising hazard warning systems, engineering solutions, and disaster risk information and assessment. There is a growing need for social scientist involvement in implementing risk reduction interventions and developing community resilience in disaster-prone areas. As well as implementing forecasts and warnings, the traditional approach to disaster risk reduction, depending upon the hazard, relies on a platform of engineering measures such as constructing river and coastal flood defences, ensuring regulations are followed to build seismic resistant buildings in earthquake zones, cyclone shelters, and land-use planning to minimize the occupation of risky zones—the commonest example being floodplains. Community preparedness and emergency planning should include the full involvement of the health sector. We should add to this traditional list improving resilience and communicating risk, as well as effectively translating into practice the findings of the latest scientific research. Poverty and social marginalization in mid- to low-income countries, especially, remain potent sources of global vulnerability to natural disasters. Less well-publicized are disasters occurring in regions of conflict and humanitarian crisis, or complex emergencies, for example, in the Democratic Republic of Congo, Darfur (Sudan), and Eritrea (Ethiopia). International relief organizations might not be able to safely or freely move in their response. Hence, in the Southeast Asian tsunami, access to some regions of Indonesia and Thailand was prevented by security issues. In 2008, Burmese people living in the Irrawaddy Delta had no warning from the government of the approach of Cyclone Nargis and hurricane preparedness measures were nonexistent. Over 138 000 people died, most from drowning, but the crisis was made worse when, in the immediate aftermath, 1.5 million homeless survivors were left without food, water, or shelter while the Burmese government vacillated for weeks over accepting international aid. International disaster relief is nowadays capable of being rapidly dispatched to needy countries and is on such a global scale that epidemics and

10.3.8 Disasters 1715 famine are no longer the feared Horsemen of the Apocalypse they once were. Earthquakes Over time more deaths are caused by earthquakes than by any of the other causes of natural disaster. Many parts of the world lie along fault lines and are known to be vulnerable to devastating earthquakes, but it remains impossible to predict precisely where and when a quake will strike. Most deaths and injuries are caused by collapsing buildings, but secondary causes such as fires can take their toll. When timber, masonry, reinforced concrete, and other types of buildings collapse, they inflict injuries to occupants in different ways and with

different degrees of severity. In the collapse of masonry buildings, an important cause of death is often suffocation from the weight and dust shaken from the wall or roof material which may also bury the victims. Falling masonry causes crush injuries to the head and chest, external or internal haemorrhage, and chest compression (traumatic asphyxia). Little is known about the survival times of people when they get trapped in collapsed buildings, but most victims will die immediately or within 24 hours from their injuries if they are not rescued, depending upon such factors as the severity of after-shocks, fire outbreaks, cold, and rain. Rapid extrication of survivors and application of first-aid by the uninjured immediately after the event could potentially save up to 25–50% of injured victims. Greatest demand for emergency medical care is within the first 24 hours and the need for emergency treatment quickly fades, though search and rescue teams might continue trying to find survivors for three to five days. Multiple trauma is the main feature, with the risk of doctors missing internal injuries in the stress of the emergency. Causes of delayed death include dehydration, hypothermia, crush syndrome, and postoperative sepsis. Most of those requiring medical assistance suffer minor injuries such as lacerations and contusions. In the Southeast Asian tsunami, an earthquake of magnitude 9 on the Richter scale off the coast of the island of Sumatra on 26 December 2004 suddenly forced the seafloor upwards by some 10 m, creating a wave that surged through the Indian Ocean. The surface perturbation was initially small, but when the water grew shallow, near the coast, the tsunami waves formed. Without warning, the waves hit Indonesia and Thailand within an hour, and then Sri Lanka and India, ultimately reaching as far as East Africa. The province at the north-western end of Sumatra, Aceh, suffered overwhelming devastation. More than 20 000 homes were destroyed, over a 100 000 people were killed, and some 700 000 people were displaced. Many victims were health service staff, which hampered the emergency response. In all countries affected by the tsunami the main public health infrastructure remained intact as the devastation was limited to coastlines, so the feared epidemics of vector-borne diseases, such as malaria and dengue, as well as cholera and dysentery, were able to be prevented. Large numbers of dead and small numbers of major injuries in survivors in comparison are typical of flood disasters in general, as the severely injured quickly succumb in the water; the injured survivors were mainly treated by local health teams. Many of the patients requiring surgery had infected wounds following contamination by sand and mud. Respiratory tract infections and pneumonia were common among patients who had come close to drowning. Psychosocial needs were identified on a massive scale, but the appropriateness and effectiveness of specific interventions in such disasters to prevent post-traumatic stress disorder remains a controversial issue. The power of tsunamis was demonstrated again in the Tohoku earthquake in 2011, which had its epicentre off the south-east coast of Japan and triggered a tsunami that swept the Japanese coastline leaving total devastation and 15 891 dead with 2579 missing. Many more people would have died but for the tsunami warnings that are routinely practised in the shoreline towns. But the tsunami waves also overcame the engineering defences of the Fukushima nuclear power plant, which in retrospect had not been built to withstand tsunami of this size. The resultant severe damage to the plant's nuclear cores led to the release of substantial amounts of radioactive material into the environment. The evacuation of 170 000 residents within a radius of 30 km of the power plant was urgently undertaken, but concern grew that the possible spread of contamination in the atmosphere could have gone as far afield as Tokyo and beyond. These fears were later shown to be groundless, but they raised anxiety in Japan and neighbouring countries. Studies have shown that although no discernible physical effects are expected from the radiation leak, psychological and social problems largely stemming from heightened risk perceptions have had a devastating effect on people's lives. One immediate economic casualty was the fishing

industry along the coast due to market fears over radioactive contamination of the sea. The evacuation itself was not without risk, however, with 50 deaths attributed in hospital patients; in the first three months of the evacuation mortality rates in older people needing nursing or hospital care rose significantly. A rare example of the importance of disaster preparedness was the earthquake in Bam, Iran, on 26 December 2003, which resulted in 26 271 deaths and the nearly complete destruction of the city of 80 000 inhabitants. The loss of about one-third of the inhabitants, including 200 out of 500 doctors, was attributed to the weak, mud brick construction. The health infrastructure was destroyed, but within 48 hours some 11 972 of the 15 000 injured survivors had been air evacuated by the military to hospitals in the rest of the country, and others were transported to treatment facilities by relatives. By the time foreign medical teams arrived, their main task was to provide routine healthcare to the residual population living in shelters. By contrast, the Pakistan earthquake on 8 October 2005 hit the impoverished mountainous north of the country where access to hundreds of remote villages was hindered by damaged and blocked roads. Over 73 000 people died and 69400 people had serious injuries; over 3 million people were left homeless. As houses were mostly constructed of weak, rubble masonry walls supporting concrete slabs for roofs, the violent shaking easily razed buildings to the ground or triggered landslides. Roof slopes then fell on top of the occupants (Fig. 10.3.8.1) and caused multiple trauma, such as spinal and pelvic fractures. Significant numbers of amputations were performed, and post-disaster reconstructive plastic surgery was frequently needed to treat the often severe and localized soft tissue damage caused by entrapment (Fig. 10.3.8.2). In 2008, the recent rapid economic development and accompanying building boom in China lay behind the destruction caused by the largest earthquake to strike the country in recent times (7.9 on the Richter scale), when entire towns collapsed in the mountainous

SECTION 10 Environmental medicine, occupational medicine, and poisoning 1716 Sichuan province, leaving 80 000 people dead and at least 5 million homeless. Poor building quality has been blamed for the catastrophic failure of homes and schools, the latter being a major psychological issue for parents with one child families. Despite the rapid mobilization of thousands of troops to the area, only a few survivors were retrieved from the rubble, sadly emphasizing the country's failure to incorporate seismic resistance in the new community developments. Poverty profoundly influenced the impacts of the January 2010 earthquake in Haiti, one of the poorest countries in the world. The earthquake ranked as the deadliest to have occurred in western hemisphere history. Despite the island's position along a known major earthquake fault line, there was a total lack of preparedness. Devastation was immense with 220 570 people killed and 3.7 million people directly affected. Haiti was left helpless and massive international help was desperately needed. Casualties with multiple trauma were so numerous that they were sent for treatment to hospitals all over the Caribbean region. Tragically, UN soldiers sent to provide logistical help were evidently the source of the cholera epidemic that struck the island in October 2010, leading to 8000 further deaths and another 650 000 islanders infected at a time when half the population still had no access to clean water. Volcanoes About 500 to 600 volcanoes around the world are known to be capable of eruptive activity and several major eruptions occur every year. The vast majority of dangerous volcanoes are explosive and unpredictable in their behaviour, whereas the less common lava flow eruptions normally allow people to escape from their path. Most deaths and injuries in explosive eruptions (such as the one that engulfed ancient Pompeii and Herculaneum in AD79) are caused by pyroclastic flows and surges, which are clouds of intensely hot gas and ash that can travel at hurricane speeds. Survivors are uncommon, but will have

severe, extensive skin burns and inhalation thermal injuries. The scope of the destruction was shown in the worst volcanic disaster in the 20th century at St Pierre, Martinique, in 1902, when 28 000 people were killed in a laterally directed pyroclastic surge, leaving only two survivors in the totally devastated city. Vesuvius in Italy is an example of one of the world's most dangerous volcanoes, and uncontrolled development has left over one million people living in an area which could be devastated by pyroclastic flows. Another major cause of death is the lahar (wet, debris flows) formed by newly erupted ash mixed with heavy rain or unstable masses that are mobilized by meltwater from glaciers or by crater lakes. The eruption of the Nevado del Ruiz volcano, Colombia, in 1984 triggered a huge lahar through the rapid melting of ice in the summit glacier: no warning was received in the towns below where some 24 000 people were buried by mud. By contrast, in one of the largest eruptions of the 20th century, at Mount Pinatubo in the Philippines in 1991, 50 000 people were successfully evacuated from the threat of pyroclastic flows, but over 300 died from the collapsing of roofs burdened with accumulated rain and ash, while sheltering inside their homes. The eruption of the Soufrière Hills volcano on the tiny Caribbean island of Montserrat, a UK Overseas Territory, began in July 1995 and was to last over 15 years. After a slow start it gradually escalated, forcing the evacuation of thousands of people from their homes because of the threat of pyroclastic flows and surges. By 1997, these currents had devastated the southern part of the island, evicting three-quarters of the total island population of 12 000 people. Air pollution from volcanic gases and ash emissions was a major consideration because of the close proximity of the population to the volcano and the frequent eruption of fine, respirable-sized ash.

Fig. 10.3.8.1 Pakistan earthquake, 2005. Collapsed concrete roof slab, typical example of vulnerable building construction in the impacted area (see text). Source: Emily So.

Fig. 10.3.8.2 Pakistan earthquake, 2005. Treating severe soft tissue crush injuries in a patient rescued from a collapsed building. Source: Emily So.

10.3.8 Disasters 1717 containing hazardous amounts of crystalline silica, a mineral that causes silicosis.

Hurricanes are one of a broad class of extreme weather phenomena that include winter storms (snow, sleet, freezing rain), thunderstorms (e.g. tornadoes, heavy rains, lightning, wind, and hail), extreme precipitation (e.g. flood and flash floods), and windstorms. Hurricanes (or typhoons as they are called in the Western Pacific) are tropical cyclones that form over warm oceans with ocean surface temperatures over 26°C. Once overland they soon run out of energy and rapidly abate, but can still cause severe flooding from heavy rain. Very high wind speeds, up to 250 km/h, are restricted to a relatively narrow track, usually no more than 150 km wide, within which localized gusts may even achieve tornadoes speeds and be extremely destructive. Most deaths and injuries, however, are not from the effects of wind on people (who normally shelter indoors for protection) or from building damage (building collapse or being struck by flying debris). Instead, deaths and injuries are commonly the result of flooding by the sea surge as the hurricane strikes land, or concurrent heavy rainfall (typically up to 60 cm over a larger area and extending further inland than high winds) triggering landslides. Hurricanes lift the sea, forming a sea surge that typically rises 3–4 m above existing heights, and the wind generates waves on top of these. Some storm surges can hit coasts well ahead of the landfall of the actual storm and can travel with nearly the same rapidity, and destructiveness, as tsunami waves. Over 90% of fatalities in hurricanes are drownings associated with storm surges or floods. Other causes of death include burial beneath houses collapsed by wind, penetrating trauma from broken glass or wood, blunt trauma from floating objects or debris, or entrapment in mudslides. The greatest need in the post-impact phase is the provision of adequate shelter, water, food, and clothing, and sanitation. Most victims suffer from lacerations caused by flying glass or other debris, or minor trauma such as

closed fractures and puncture wounds. Katrina was the third most powerful storm ever to make land-fall in the United States of America, attaining hurricane category five status before it struck the Louisiana coast on the morning of 29 August 2005. It left breaches in the levee system of New Orleans that created catastrophic flooding of an area of more than 400 km², submerging half a million homes and trapping tens of thousands of people. Critically, the city's mayor did not issue a mandatory evacuation order until the day before the hurricane hit, which was too late for many to evacuate in time, including the poor, who had no means of transport. In Louisiana and Mississippi 1700 people died, most by drowning. The emergency response was woeful. Up to 20 000 evacuees were abandoned in the city's Superdome sports stadium for five days before being evacuated to other shelters. One crowded public hospital left cut off for five days without electrical power, clean water, and medical supplies was rendered helpless by the engulfing floodwater. The victims were predominantly black and poor. In the aftermath, nearby states were able to absorb several hundred thousand evacuees from the city in a few days. Despite forebodings, epidemics of diarrhoeal diseases, respiratory tract infections, and mosquito-borne disease, in particular West Nile virus, did not occur. Increases in suicide and psychiatric morbidity were found in follow-up studies of evacuees, and although psychological distress was common, it resolved in most of the people over time. Recent advances in meteorology on tracking the paths of hurricanes in time and space are now making inroads into reducing loss of life by forecasting their landfall far enough ahead for thousands of people to be directed to safety, provided the warnings are effectively communicated by government officials. A dramatic example was in the Indian state of Odisha (Orissa). In 1999 one of the largest cyclones to strike the coast left 10 000 dead in its wake: although it was forecast, no warnings were disseminated, and no preparedness to move the population to safety was in place. In October 2013 an almost identical cyclone hit the same coast, but with the loss of only 17 people—the difference was that the warning was followed by 1 million people being temporarily evacuated from the coastal area by the Indian army. Floods In addition to the major losses of life that can be caused by hurricanes and their associated sea surges, floods mostly result from moderate to large events (heavy rainfall, snowmelt, high tides) occurring within the expected range of streamflow or tidal conditions. In the United Kingdom, as in many countries with low-lying coastal land, the hazards of coastal flooding from sea surges and high tides dominates over river flooding, although the latter is becoming more frequent, particularly in the last few years when there has been a trend of abnormally wet winter months and localized repeated flooding, though it is not yet possible to attribute this to climate change. Flood warning and forecasting, combined with effective land management, community preparedness, and evacuation planning, are as essential as engineered river and coastal defences. The primary cause of death from floods is drowning, but trauma from impact with floating debris and by hypothermia due to cold exposure are also important. The proportion of survivors requiring emergency medical care is small as most injuries are minor, such as lacerations. This absence of survivors with severe or multiple trauma is likely to reflect the delay in search and rescue through the flood waters, and victims drown or die from their injuries and the effects of exposure before help arrives. Increased morbidity and mortality in survivors of floods was reported in the year after the UK East Coast flood in 1953, in which over 300 people drowned. An increase in suicides and mental health problems arose after the severe flooding caused by heavy rains in central Europe in July 1997. The mental health impacts of floods as a cause of enduring disaster morbidity requires further epidemiological study, especially as flooding is likely to become more disruptive and more widespread as a consequence of climate change. Bangladesh is one of the most flood-prone countries in the world. A quarter of its 151 million population are at the mercy of cyclones and almost three-quarters live in regions prone to a variety of flooding types: coastal floods, riverbank flooding, flash floods and monsoon

rains, and meltwater from the Himalayas. The probability is that under climate change the flood hazards will get worse. Over the last 50 years, targeted improvements in disaster management, reducing poverty, and stepping up civic resilience measures have made

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