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Physical health impacts of disasters

Penelope Burns, Colin Myers, Joris Yzermans, Michel Dückers

Introduction & objectives

The World Health Organisation (WHO) defines health not merely as an absence of dis- ease, but as a state of physieal, mental and social well-being [1]. A potential omission of this definition is 'the ability to adapt and self-manage in the face of social, physi- cal, and emotional challenges' [2]. Disasters are an extreme source of such challenges, and health risk exposure, with notable profound effects on human physical, mental and social health [3], as well as economie and environmental effects [4], and access to healthcare services.

Although we discuss the physieal health consequences of disaster in this chapter and the mental health consequences in the next chapter, substantial evidence and knowledge clearly identify the need to consider a person's health holistieally across physical and men- tal health and, as alluded to by WHO, the broader social determinants of health [1]. This is important as different aspects of health are interrelated, health vulnerabilities (or risk factors) fitting within one domain (e.g., mental, physieal, functional of social) can be a predictor for health effects in another domain [3, 5].

Epidemiologie studies in disasters provide the distribution and determinants ofhealth- related states in disaster populations, allowing clinicians to prepare for, and monitor, these presentations, as well as presenting opportunities for early identification and management to improve disaster health outcomes. Predietable patterns of illness, disease and injury effects can be shown over time, and identify more affected subgroups [6].

Under the realisation of this complex interplay of physieal, mental, social and environ- mental factors, the aim of this chapter is to provide an overview of the impact of disaster on the physieal health, to identify higher-risk groups and to consider disaster risk reduc- tion (DRR) strategies to improve disaster health outcomes.

On completion of this chapter students should be able to:

1. Discuss the physieal health effects associated with all hazard disasters.
2. Recognise the temporal nature of these physical health impacts.
3. Identify factors creating a higher risk of adverse health outcomes.
4. Identify higher risk groups and understand the rationale for their higher risk.
5. Consider DRR strategies that might improve physical health and well-being outcomes following an acute disaster incident.

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Physical health impacts of disasters

Chapter 21, Natural Disaster, details hazard-specific health effects such as increased fractures and crush injuries in earthquakes, increased drownings in floods and tsunamis, increased mortality rates during extremes of temperatures and increased suffocation in landslides and avalanches. However, a substantial proportion and volume of disaster health effects are consistent across hazard types [7]. Therefore this chapter discusses the health impacts associated with all hazard disasters.

The disaster literature demonstrates an association between many symptoms and clinical conditions with exposure to a disaster [7]. Researching this association immediately after disasters is challenging. Issues include the unpredictable nature of disasters requir- ing rapid development of ethical, relevant research protocols; access and safety in chaotic, dangerous environments; inclusion of vulnerable potentially traumatised populations; and potential impedance of rescue activities [8]. Cross-sectional and cohort studies in the latter half of the 20th century have provided a view of potential associations between health effects and disasters. Randomised controlled trials are ethically and practically difficult in the disaster environment. Over the last 20 years, increasing numbers of longer-term prospective cohort studies have provided stronger evidence of an increase in prevalence, incidence and association of many health conditions and symptoms following disasters, over immediate, intermediate and long-term periods, along with new incident conditions, and deterioration of pre-existing, chronic conditions. Case studies have contributed by describing new conditions such as tsunami lung and tsunami sinusitis.

For example, large prospective longitudinal cohort studies are ongoing following the 2001 World Trade Center (WTC) attacks involving the hijacking and crashing of two planes into the Twin Towers in New York City (NYC). The early death toll due to trauma and injury was 2,973.

> I heard a turbine smash into one of the buildings. I remember the sounds and the people jumping... Muzak was playing... People were jumping, and debris was flying. It was awful. Perez, licensed emergency medical technician and volunteer [9]

The people of NYC, survivors and rescuers, were televised layered with a thick grey dust that blanketed Ground Zero. The majority of long-term damage to physical health in these survivors is now attributed to this dust. Local residents, school children, rescuers, emergency services, volunteers and recovery workers were all exposed to this dust in the Lower Manhattan area for many months. Over 400,000 people are now thought to be at risk for long-term health effects including predominantly respiratory, but also cardiovascular, endocrine, gastrointestinal, psychological, ophthalmological and otic diseases. Twenty years later the effects of that exposure are still emerging from longitudinal scientific studies. Potential associations between disasters and diseases with a longer latency period such as cancer, peripheral neuropathy and autoimmune disease are beginning to emerge [10].

Longer-term studies have also affirmed the association between physical and mental health effects. For example, in a large prospective longitudinal study con- ducted two to six years after the WTC, researchers found that measures of <lust cloud exposure, personal injury on 9/11 and post-traumatic stress disorder (PTSD) were all associated with an increase in heart disease almost three years after the attacks [11]. This was supported by Brackbill et al. who showed that comorbidity of physical injury and PTSD increased the likelihood of developing heart disease [12]. Broader life effects are also being studied examining the effect of income loss, or earlier retirement, in those with multiple 9/11-associated health effects.

Communicable, or infectious, health effects

In well-resourced countries, infectious outbreaks are uncommon following disasters, except where the primary disaster is infectious itself (e.g., the global SARS-Co V-2 (Severe Acute Respiratory Syndrome-associated Coronavirus 2) pandemic discussed in Chapter 24). Even with significant disruption to utilities, studies from Hurricane Katrina and Hurricane Sandy showed no significant increase in infectious disease outbreaks [13, 14].

However, in lower-resourced countries and in humanitarian disasters, infectious diseases are a major concern, predominantly due to increases or changes in locally endemic organisms including acute respiratory infections and gastroenteritis. Disruption of water and sanitation, displacement of populations, crowding in evacuation centres, poor pre-event health status and disruption of health services, may all impact on the risk of water, food or air- home infectious disease. In poorly vaccinated populations, vaccination programs for highly infectious and deadly diseases such as measles and tetanus, need to be urgently established.

Infectious disease tends to present a different time course to acute injury in disasters. Following the Great East Japan Earthquake Tsunami (GEJET) a significant increase in infectious disease hospitalisations occurred later, at two weeks, and was predominantly pneumonia due to usual community-acquired pathogens. Mortality attributed to pneumonia was significantly increased in the first 12 weeks peaking in the second week [15]. Half the cases of pneumonia were contracted whilst in evacuation centres [16].

Non-communicable, or non-infectious, health effects

The scientific literature reports disaster health effects on most body systems, including cardiac, respiratory, endocrine, dermatologic, musculoskeletal, gastrointestinal, ocular, otologic and neurological effects. This section aims to provide a broad overview of non-communicable health effects with discussion of new incident disease and symptoms, including Medically Unexplained Physical Symptoms (MUPS), and of chronic disease.

To fully realise the physical health impact of disasters it is crucial to understand the temporal nature of these effects. The physical health epidemiological disaster knowledge base is more nascent and possibly less rich than the mental health dimension [5]. That said, we are making progress in developing insights on the temporality of physical health impact [7], although we are not yet at the point where we can reliably plot the prevalence or risk for particular health problems over the course of weeks, months and years in detail.

Cardiac effects

An increase in the incidence of acute cardiac events such as hypertension, acute myocardial infarction (AMI), cardiomyopathy and non-cardiac chest pain (NCCP) following disasters is increasingly well-documented with early evidence of an influence on heart failure (HF) and ventricular tachyarrhythmia [17-20].

Hypertension was considered one of the greatest burdens to healthcare in the early stages of the GEJET and Hurricane Katrina. A high background prevalence of pre-existing hypertension in these populations was compounded by an increase in blood pressure (BP) in those with no history of hypertension (92%), and in those with pre-existing hypertension, both in those taking their usual medications (10%), and those not taking them [21].

A significant increase in AMIs was associated with the 2010 Christchurch earthquake, occurring during the first two weeks post-event [18]. The WTC attack was associated with a significant increase in cardiovascular admissions of lower Manhattan residents to NYC hospitals within the first five weeks. During the second week there was a 72.7% relative increase in cardiovascular admissions compared with 14.7% in the control area [22]. Post Hurricane Katrina an increased incidence of AMI was sustained at two years [23] and three years [24] with a three-fold increase observed over both

periods [23, 24]. Linking back to mental health, an association has been reported between PTSD and vascular con-ditions following disasters [25].

Early evidence suggests that the time of day of an earthquake may affect cardiac presentations. Cardiac admissions following the Christchurch earthquakes increased significantly but showed very different presentations for each quake. Significant increases in AMI and NCCP presented following the first early morning quake; with significant stress cardiomyopathy presentations following the second midday quake [18).

Following Hurricane Katrina, langer-term change in the chronobiology of AMI was seen where onset of AMI increased significantly during nights and weekends, and decreased significantly during the more expected times of mornings and weekdays [26).

The contemporary evidence on the temporal nature of cardiovascular events following all hazards disasters can be summarised as immediate, covering the first days to weeks, intermediate, covering weeks to months, and longer term, covering one year to over a decade [7]. Immediate effects are particularly hypertension, AMI, cardiomyopathy, NCCP, cerebrovascular accidents (CVA) and arrythmias. Intermediate effects include exacerbations and deteriorations of chronic disease including hypertension, HF and CVA. Longer-term effects include AMI, CVA, HF and hypercholesterolemia [7]. This longitudinal effect suggests that targeted early preventative management for these conditions in those at higher risk should be worthwhile.

Respiratory effects

Extensive literature exists on the respiratory effects of disasters on adults and children, particularly in incidents with increased particulate matter such as the WTC attack in 2001, and increasingly from huge wildfires such as the 2019 Black Summer bushfires in Australia [27]. An estimated 417 excess deaths, and exacerbation of cardio-respiratory conditions, were attributed to the latter during 19 weeks of continuous fire activity resulting in extensive prolonged bushfire smoke along the eastern coast of Australia [27].

Following the WTC attacks, those most exposed to the <lust cloud were most at risk [28, 29]. In the first days immediate health effects included new or worsening upper or lower respiratory symptoms, with almost a quarter experiencing gastroesophageal reflux [30, 31]. Over half the children who were residents, schooling or volunteering in the dust- affected area, reported symptoms post 9/11 including shortness of breath, cough, wheezing and sinus or throat irritation [32].

New conditions such as WTC cough, tsunami lung [33], tsunami sinusitis [33] and thunderstorm asthma are also being described and documented in the immediate disaster period.

Tsunami lung, due to submersion during a tsunami, may involve aspiration of oil, waste and soil in the water, resulting in a chemical-induced pneumonitis complicated by infection from organisms. Contaminated sludge has also been found in sinuses and stomachs. The majority of deaths following the GEJET were attributed to drowning in the tsunami [33].

Power outages contribute to effects on health including respiratory. In the first two weeks post-landfall of Hurricane Sandy in NYC in 2012 significant numbers of carbon dioxide exposures were reported, attributed to activities such as indoor grilling, inappropriate generator placement and residential fires [34]. Other effects seen included aggravation of existing respiratory disease [16]; respiratory infections [15, 16]; sinusitis and chest injuries.

From a temporal perspective, examples of deleterious effects of disasters on respiratory health can be found over ten years post-disaster [7]. An increased incidence of asthma and ongoing deterioration in pulmonary function with persistent lower respiratory symptoms (LRS) has been seen for over ten years following exposure to <lust during the WTC attack [29, 35, 36]. The most prevalent physician-diagnosed respiratory conditions post-WTC attack were asthma, chronic bronchitis and chronic sinusitis [36].

Effects on diabetes

People with diabetes in particular, face increased risk in disasters due to reliance on regular medication, exercise, diet and routine for glycaemic control. The effect of the acute disaster, difficulty accessing medications and monitoring equipment, alterations to diet provided in evacuation centres, and increased exercise in the clean-up, can all affect glycaemic control.

From a temporal perspective, several key messages arise from the diabetic literature. Firstly an increase in new incident diabetes is seen in the immediate aftermath [37, 38], in the first years in evacuees [38], and over at decade later in those post-WTC attacks with PTSD [37]. Secondly, potential higher-risk groups have been identified including pregnant women exposed to traumatic experiences during disasters [39]; those with existing Insulin Dependent Diabetes Mellitus (IDDM) [40]; evacuees [38]; and those with mental health co-morbidity [37]. Thirdly the literature demonstrates a variable worsening control of pre-existing diabetes [40-43], both in the short term and the long term, emphasising the need to optimise post-disaster care to minimise this effect. Examples of effects on diabetes are described in the literature up to ten years after the disaster [7].

Dermatological effects

Skin effects are predominantly seen in the first days to months. Sunburn, inflammatory and traumatic skin conditions are frequent in residents and clean-up workers in the post- incident environment [44]. Less common effects may include severe fire or chemical burns, or traumatic wounds, and may be life-threatening. Other apparently less urgent dermatological conditions, such as more minor wounds, may become life-threatening due to infection if not treated promptly and may contribute considerable distress and morbidity.

Chronic diseases

Immediate management of acute injuries and environmental risks is the priority of cur- rent disaster management. However, continuity of care for chronic diseases has been identified as the major healthcare provision after disasters reflecting the substantial prevalence of pre-existing chronic disease in disaster-affected populations. In Australia, for example, a significant proportion of younger adults now have chronic conditions, with almost half of the population having at least one chronic condition.

Individuals with chronic conditions have greater healthcare needs [45]. Following the Northbridge earthquake in Los Angeles, a longitudinal cohort study examined burden of illness at one year pre-, and three months post-earthquake. A significant difference in post-earthquake healthcare needs was seen between those with zero, one or two+ chronic conditions for pain for two days, difficulty refilling prescriptions, severe stress of> two weeks, lack of necessary medical equipment and inability to access medical help [46].

Those with a chronic condition are also three times more likely to present with an acute presentation, either an exacerbation of their chronic condition or a separate acute condition that might also adversely affect their underlying chronic condition [45]. During the week following Hurricane Sandy there were statistically significant increases in emergency department presentations for chronic conditions including diabetes, AMI, hyper- tension, chronic bronchitis, kidney disease,

dialysis dependence, prescription refills and drug dependence; usually for several conditions at the same time [42].

Miscellaneous symptoms

MUPS, or non-specific symptoms, are subjective symptoms with no objective pathological condition or external cause found to explain them. Post-disaster explanations for 'non- specific symptoms' can be ambiguous and disputable. Symptoms, most commonly fatigue and headache, but also dyspnoea, back pain, muscle pain, gastrointestinal symptoms, palpitations, dizziness and sleeping problems have all been described post-disaster. However pre-disaster studies are often not available for comparison and study methodologies vary widely, so it is difficult to draw conclusions. A review by Yzermans et al. suggested the prevalence of MUPS ranged from 3% to 78% with longitudinal studies demonstrating a waning of symptom prevalence with time [3].

The next section examines some of the subpopulations considered at high risk of poor health outcomes in disasters.

Risk and protective factors, and vulnerabilities

It is essential to understand the degree of risk from exposure to a hazard, and the protective value of available personal and community resources. People, and communities, experiencing the same disaster can experience very different health outcomes. Based on the existing literature we can attempt to provide an overview of the factors that might affect this experience, categorising them in Table 11.1 by:

- time period prior, during and post disaster incident, and
- levels ranging from individual, community to society [47-50].

[Table 11.1]

While the additional impacts of factors such as war, famine and population displacement must be acknowledged they will be covered in detail in Chapter 22 - Complex Humanitarian Emergencies. These temporal and societal effects are linked:

- an individual with multiple chronic conditions taking multiple medications pre- disaster will have more need for ongoing access to medication and healthcare during the disaster when it may not be available, and this may contribute to a greater risk of deterioration in their conditions post-disaster [7].
- a low-income country with, low level of private and public health expenditure, poor access to GPs and hospitals offers less opportunity to detect and treat physical (and mental) health problems than a high-income better-resourced country [51].

Vulnerabilities: specific high-risk groups

Characteristics of specific population groups can create higher risk in disasters hut can also bring strengths and capabilities. In this section we discuss key populations with characteristics that place them at higher risk, however this is not a comprehensive list, and you may be able to identify other high-risk groups.

Babies, infants, children and **adolescents** are a high-risk group physically and psychologically, and account for 30-50% of all global disaster-related deaths [52]. Children are not small adults. Depending on their age, and stage of development, children are at risk due to differing anatomy, physiology, immunology, cognition and psychology. Childrens' vulnerabilities are compounded by the need for particular equipment, dosages, and approaches to treatment, and the need for paediatric

disaster knowledge and skills. As with all high-risk groups, children's resilience can be augmented by recognising their strengths and facilitating their contribution to disaster preparedness, response and recovery activities.

Pregnant women are physiologically and physically higher risk in disasters due to their immunocompromise, increased risk of gestational diabetes, and restricted mobility. Mendez-Figueroa et al. [53] reported an increase in maternal and neonatal morbidity post Hurricane Harvey of 27% and 50% respectively. For those caring for young infants, disruption of breastfeeding, or of supply of appropriate infant formula if bottle feeding, are important issues in the chaotic disaster environment.

The **elderly** may have increased risk in disasters related variously to physical limitations, including sensory restrictions (reduced vision and hearing); reduced balance, physical strength and mobility; reduced immunocompetence; cognitive effects exacerbated by stress and evacuation; [54] all compounded by an increased prevalence of chronic diseases and multi-morbidity. This greater risk continues after the disaster. Following the GEJET, women over 84 years had the highest mortality risk over the first three months [55]. Following Hurricane Katrina and Sandy the elderly were at higher risk for morbidity in the first three months. Following Hurricane Sandy Restricted access to food and water significantly increased hospitalisation rates for dehydration in those over 65 years, and an increased prevalence of cardiovascular disease, respiratory disease, and injury was seen in the first 12 months [56].

The elderly may also have increased resilience due to previous experience and successful management of disaster exposures, or prior immunity to infectious agents. For example, during the 2009 H1N1 pandemic elderly populations were less vulnerable, with lower morbidity and mortality, due to presumed previous exposure to the similar H1N1-like viruses. Compared with usual seasonal influenza outbreaks, where those over 65 years accounted for over 90% mortality, during H1N1 it was 13% [57). However, during the 2019 SARS-CoV-2 pandemic, the elderly were, in fact, more vulnerable, due to their physiology and a lack of prior exposure and hence immunity.

Disaster risk reduction

The essence of a disaster is that there is chaos, risk, uncertainty and a serious lack of resources, including professional healthcare service capacity; a problem that is exacerbated in poorly resourced low-income countries. Substantial opportunities exist for DRR of disaster health effects, in primary and secondary prevention. The Sendai Framework 2015-2030 calls for timely integration of DRR, and resilience-building strategies, into policies, planning and programs at all levels of disaster management [58). Knowledge of the epidemiology of the health effects of disasters and the time period post-disaster when these may occur creates an opportunity for DRR in disaster healthcare across all phases of PPRR, and across all levels of healthcare. Through ongoing surveillance, early diagnosis, early management and targeted review of chronic conditions, the potential to improve disaster health outcomes for individuals and populations exists. Knowledge of the risk of deterioration of social determinants of health suggests benefit in health promotion activities ranging from protective and preventive measures, screening to healthy lifestyle activities (including good diet, exercise, weight control, sleep and limited substance use) and establishing an operational and accessible stepped care healthcare system.

Many health-focused DRR activities, increasingly being realised as an indispensable aspect of emergency management, are similar or even identical to routine non-disaster healthcare delivery. For many potential physical health effects, affected individuals/populations, especially potentially vulnerable groups, might benefit from general practitioners or more specialised rehabilitation expertise that is not always available in disaster settings.

Conclusion

Knowledge of the epidemiological patterns of illness and disease following disasters can inform DRR activities at all levels of healthcare; activities that are similar to 'normal' evidence-based health practice across the stages of illness and disease. The growing knowledge base of disaster epidemiology provides opportunities for prevention, and health and well-being promotion, with the potential to improve disaster health outcomes for individuals and communities over the short, intermediate and longer-term periods post disaster incident.

Activity

Consider being asked to undertake a locum as a resident doctor in the days following a bushfire disaster in a small rural community, in either a local community general medical practice or in the local hospital emergency department. Considerable environmental smoke presence continues for the whole four months of your locum.

1. What medical conditions might you expect to see in the first weeks, and alternatively after four months?
2. How do the two roles - community general medicine and hospital emergency medicine - differ in their contributions to disaster healthcare management in a disaster?

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Table

Table 11.1 Risk and protective factors

Pre-disaster

- Pre-existing population health and well-being.
  - Prevalence and incidence of illness and disease.
  - Social determinants of health, and lifestyle including health-risk factors.
  - Level of public and preventive health activities (including vaccination and population screening rates).
  - Demographics (higher risk at extremes of age).
- Local population resources - community connectedness and resources, culture, social support, physical and socioeconomic environment, health services.
- Pre-existing individual health and well-being.
  - Number and severity of existing (chronic) diseases and chronic illnesses
  - Social determinants of health

- Individual resources - strength and resilience, family, community/social support and connectedness, employment, economic/financial, gender/age.

During disaster

- Impact, duration, and characteristics of the particular disaster incident.
  - Malevolent events may have greater psychological impact.
- Size of effect on basic needs, including damage to infrastructure, shelter food, water, health services, local community.
- Duration of effect including evacuation and long-term displacement.
- Individual experience and loss during the disaster, including personal injury and experience of loss of loved ones including pets.

Post-disaster

- Sustainability of all levels of primary, secondary, and tertiary healthcare services.
- Duration of community disruption and evacuations.
- Resilience and connectedness of local community.
- Active surveillance and early management of adverse disaster health effects including changes to social determinants of health.
- Secondary events (e.g., floods may follow bushfires due to changes to soil and vegetation) and 'new' life events.
- Level of impact on personal and community economics and business viability.