Disaster Medicine

Michelangelo Bortolin and Gregory R. Ciottone

Abbreviations

| Abbreviation | Description                                    |
|--------------|------------------------------------------------|
| CBRN         | Chemical, biologic, radiological, and nuclear |
| EMS          | Emergency Medical Services                    |
| EOP          | Emergency operations plan                     |
| HIV          | Human immunodeficiency virus                  |
| HVA          | Hazard and vulnerabilities assessments        |
| IAP          | Incident action plan                          |
| IC           | Incident commander                             |
| ICS          | Incident Command System                       |
| PTS          | Posttraumatic stress                           |
| SARS         | Severe acute respiratory syndrome             |
| SOP          | Standard operating procedures                 |

Introduction

Devastating events such as natural disasters like the typhoon in the Philippines (2013) and the earthquake in Haiti (2010), intentional events like the terrorist attack in New York (2001), and the sarin attack in Tokyo’s subways (1995) demonstrate that disasters are both unpredictable and ubiquitous.

Disaster is defined as any event that causes “a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources” [1].

Considering that any number of different events could hit a population at any time, there is no place on earth completely immune to disasters. Therefore, disaster medicine was created as a broad specialty grounded in emergency medicine, but utilizing the skill sets of other surgical and medical specialties, and only able to become operational in combination with the systems supported by disaster management. For example, during an earthquake, several specialties are involved in the response and immediate care of the victims: emergency physicians, surgeons, anesthesiologists, and orthopedics; however, other subspecialties are also required in the ongoing care of victims. These include nephrologists to treat acute renal failure related to crush syndrome, both during and following the event, and psychosocial and rehabilitation specialties for continued care. These medical and surgical specialists are only able to perform their roles under the umbrella of disaster management. Without being enabled by the logistics and operations capabilities seen in a large-scale disaster response, these specialists would not be functional.

Natural or Man-Made Disaster

Disasters are typically categorized as natural or man-made events. Natural disasters, such as floods, tsunamis, and earthquakes, typically have a more extensive impact on population centers, causing more disruption. Hurricane Katrina in 2005 ravaged Louisiana, Mississippi, Alabama, and Florida causing death, numerous casualties, mass evacuations, and disruptions. Natural disasters also include epidemics. In the past, cholera, bubonic plague, and other diseases affected entire continents causing millions of casualties. Today, non-intentional outbreaks and pandemics such as influenza...
outbreaks and human immunodeficiency virus (HIV) are just two examples of natural disasters that for several reasons can spread quickly, ravaging entire communities. The Spanish flu in the early 1900s caused more than 50 million deaths, and severe acute respiratory syndrome, (SARS) that arose from China in 2003, resulted in thousands of death in that part of the world and concern for a global pandemic. Another virus that afflicts and kills millions of people, particularly in the poor areas of Africa and developing countries, is HIV. It is estimated that from the 1980s, HIV has caused more than 30 million deaths around the world. An estimated 97% of natural disaster-related deaths occur in developing countries (World Bank, 2000–2001) [2].

Man-made disaster is defined as any event that is caused by the activity of human beings. Explosions, building collapse, civil wars, and nuclear accidents are some examples. The collapse of the Hyatt Regency Hotel in Kansas City in 1981 is one such example. Investigations found that the cause of the collapse was due to an engineering problem. There were more than 100 deaths and more than 200 casualties from that disaster. The transportation industry is commonly involved in incidents that cause large numbers of injured and dead. In 1998 in Eschede, Germany, a high-speed train derailed causing 101 fatalities. Other industrial sectors, such as the chemical industry, have also been involved in man-made catastrophes. In December 1984 in Bhopal, India, more than half a million people were exposed to methyl isocyanate. In the immediate phase after the leak, almost 10,000 people died. The Indian Government has calculated that this event has caused over the years almost 600,000 casualties due to lingering effects of the chemical exposures [3, 4].

The 9/11 terrorist attack in New York and the Oklahoma City bombing (1995) are also man-made disasters. It is important to recognize and underline that disasters also result from war, the conduct of repressive regimes, the use of sanctions, as well as economic and social policies, particularly in developing countries [5]. The Syrian Civil War arose in the 2011 and has caused more than 120,000 deaths and more than 2.3 million refugees since 2013 [6].

The Disaster’s Cycle

Disasters and the response to them follow a pattern called the disaster cycle, which is defined in four phases: mitigation and prevention, preparedness and planning, response and recovery.

Mitigation and prevention involve measures designed either to prevent hazards from occurring or to lessen the effects of the disasters [7]. These measures involve multiple different agencies and commissions, for example, policymakers introducing regulations regarding the storage, transportation, and disposal of chemical substances. Another example of mitigation is to empower a public health system to monitor and conduct surveillance for infection diseases and at the same time introduce rules regarding health screening at the borders. The importance of the mitigation phase is to avoid disaster or to reduce the impact on the population. It is clear if we compare the 2010 earthquake in Haiti, with a magnitude of 7.0, and similar earthquakes in Japan where despite the same magnitude the number of dead and injured were more limited, that we see the effect of a disaster is often dependent on the underlying condition of the area affected. For decades, Japan has introduced strict building codes that follow seismic regulations. Nevertheless, it is not possible to fully mitigate against all disaster events. For instance, the 2011 earthquake in the Pacific Ocean produced a tsunami that hit the east coast of Japan and caused severe damage, in particular a failure of the nuclear plant in Fukushima, with release of radiation that affected the local community.

The preparedness and planning phase includes all activities conducted on an ongoing basis, in advance of any potential incident. Preparedness involves an integrated combination of assessment; planning; procedures and protocols; training and exercises; personnel qualifications, licensure, and certification; equipment certification; and evaluation and revision [8]. The first step of preparedness is defining what events are more likely to hit a community. The Hazard and Vulnerabilities Assessment (HVA) is a way to objectively risk-stratify those hazards that are more likely to strike a given community. The HVA takes into account different events: natural, man-made, and CBRN (chemical, biologic, radiological, and nuclear). The output from an HVA prioritizes the risks to which a population is most susceptible and should therefore be prepared for. After the HVA, it is possible to then establish standard operating procedures (SOP) and the emergency operations plan (EOP) for the community or hospital. It is a good rule that the EOP adopts an all-hazards approach to preparedness, with annexes and appendices specific for every type of probable event [9]. An important part of the preparedness phase is training. In particular, every healthcare professional must be trained when to activate a disaster response and their own specific roles and responsibilities within the framework of the response. The typical drills commonly used are tabletop and full-scale exercises. They are important also to identify shortfalls, bottlenecks, and gaps in the EOP. The staff should take part in the training, and the EOP should be tested, reviewed, and updated at least once per year.

Response is the phase in which agencies and sections with responsibility to deploy to disasters activate their emergency response plan as a result of specific threats or situations and can incorporate local, regional, and federal response agencies [10]. The response is conducted through the intervention of several agencies and must be flexible and adaptable for any type of event. It is important to immediately establish a response framework with a unified command structure that establishes a chain of command, control, and coordinate the resources, in terms of staff, stuff, and
structure. The Incident Command System (ICS) provides a structure to enable agencies with different legal, jurisdictional, and functional responsibilities to coordinate, plan, and interact effectively on scene [11]. The medical response is provided at the scene by the emergency medical services (EMS), with triage, treatment, and transport to the hospitals. EMS plays a crucial role in the immediate phase of the response to disaster. The response must be quick and effective on the scene as well as in the determination of hospital destinations for every patient, to guarantee an appropriate standard of care and to avoid bottlenecks and congestion at hospitals. Rarely, EMS is able to triage, treat, and transport every single patient from the scene. Often some casualties reach the closest hospital on their own, giving rise to disruption in the chain of triage and to the hospital. The ability of a healthcare system to suddenly expand its capacity beyond normal services to meet the increased demand for qualified medical staff and services during a large-scale event is defined as “surge capacity” [12]. The surge capacity depends on the features of the healthcare system, but also by an effective EOP and training of the staff.

The post-impact period revolves around disaster recovery in which the goal is to eliminate impairment caused by a disaster and rebuild communities and infrastructures [13]. Also this phase involves several agencies and may be long lasting, ranging from weeks to years. People affected by a tremendous disaster must face a long recovery phase. Survivors from the September 11, 2001, terrorist attacks on the Twin Towers not only had immediate treatment in the field and in the hospitals that day, but their treatment has continued for years. The majority of people exposed to disasters do well; however, some individuals develop psychiatric disorders, distress, or risky behaviors such as an increase in alcohol or tobacco use [14]. The Department of Health and Human Services spent months and years following the 9/11 attacks and has gone on to provide health care, both physical and mental, to those who were, and continue to be, affected and in need [15]. The recovery phase often also involves rescue workers as their exposure to the traumatic event has a severe impact on their mental health. Studies confirm that rescue workers are prone to have diseases or documented behavioral health disturbances following events. For example, several articles describe how the acute and prolonged exposures were both associated with a large burden of asthma and posttraumatic stress (PTS) symptoms years after the 9/11 attack.

The Incident Command System (ICS) is a standardized, on-scene, all-hazards incident management concept and allows its users to adopt an integrated organizational structure to match the complexities and demands of single or multiple incidents without being hindered by jurisdictional boundaries [16].

The ICS was developed in the 1970s in California to manage, command, and control fire brigades during their operations to extinguish wild fires. Shortly after that, it was adopted by EMS and other agencies, as well as endorsed by the U.S. Department Homeland Security as a fundamental element of incident management.

The ICS is used for all events and is modified depending on the size of the incident. Its goal is to manage and to resolve the incident with an efficient use of resources while protecting all persons involved. The ICS is a modular and flexible organizational system that can be standardized for multiple uses. The ICS is modified according to the size and complexity of the incident, specifics of the hazard, environment affected by the incident, the incident planning process and incident objectives (ICS expansion and contraction) [17].

The ICS establishes an incident commander (IC), who is in charge of all the activities regarding the incident, a chain of command, and unified command between the agencies. The priorities of the IC are three: the safety of the casualties and the rescue team, incident stabilization, and property preservation. Every incident must have an incident action plan (IAP) that establishes incident goals, operational period objectives, set activities, and the response strategy defined by the IC during response planning [18].

The IC manages and carries out his responsibilities with three features of command that are important for every role within the framework of the ICS: the chain of command, the unity of command, and the span of control. The chain of command is a key part of the ICS and is defined as a structure with a clear line of authority. The unity of command infers that every responder knows without question who his/her supervisor is. Span of control describes the typically 6–7 people a supervisor directly leads.

During a disaster, it is extremely important to establish a unified command, because it enables all responsible agencies to manage and coordinate an incident together by establishing a common approach and a single IAP. It permits the integration of staffing and shared facilities, with everyone having the same objectives and not replicating efforts [19].

The IAP describes activities, responsibilities, and the communication procedures. This system is fundamental to avoid confusion and lack of communications. Adequate and redundant communication systems are very important during the response to disaster. It is essential that the ICS use common terminology and integrated communications among agencies and establish precise ways of communications. The communication systems should be: interoperable between agencies; reliable to function in the context of any kind of
emergency; portable, built on standardized radio technologies, protocols, and frequencies; scalable as the needs of the incident dictate; resilient to perform despite damaged or lost infrastructure; and redundant to enable the use of alternate communications methods when primary systems go out [20].

The ICS is supported by a command staff that includes a safety manager, a liaison officer, and a public information officer. It is organized into four sections, the general staff, which supports the ICS: operation, planning, logistics, and finance/administration.

The operation section is in charge of managing all the tactical operations on the scene; tactical operations include fire brigades, EMS, and every agency required for the incident. The planning section is responsible to draft the IAP; to get, receive, elaborate, and share information; and to track all the resources. The logistic section provides the supplies, needs, and the facilities and supports the personnel with food, water, and first aid. The finance/administration section is in charge of tracking all the costs and to negotiate and supervise contracts.

These sections, like the ICS, are modular organizations and can be further expanded into: units (the organizational element with functional responsibility for a specific incident planning, logistics, or finance/administration activity), divisions (only for operation section, used to divide an incident geographically), groups (only for operation section, established to divide the incident management structure into functional areas), and branches (used when the number of divisions or groups exceeds the span of control and can be either geographical or functional for major aspects of incident operations) [21].

**Triage**

Triage in a disaster event places casualties in four classes: black (or expectant), red (or immediate, priority 1), yellow (or delayed, priority 2), or green (or minor, priority 3) in agreement with the severity of the injuries. When sorting casualties, it is important to give immediate medical care to critical patients that have a chance of survival with prompt, advanced treatment. In minor patients and patients who are so severely injured that they have very little chance of survival treatment is delayed. The goal is to provide the greatest good for the greatest number of patients, forcing the triage officer to decide whether the chance of a patient surviving is so low in comparison to the burden such care would place on the medical system that the patient must be consigned to the “expectant” category (dying; little or no treatment) [22].

The concept of triage must be seen in a wider context and is composed of the following elements: rapid evaluation of all disaster victims, assessment of the nature and severity of the injuries and its consequences on the vital functions of the casualties, and categorization of the casualties, resuscitation, stabilization, and conditioning for transport, distribution, and evacuation of the casualties [23].

Triage is a quick and dynamic process. This means that it must be repeated often and at every moment in which a new healthcare professional takes control of a patient, for example, during transport, at arrival at the hospital, or if there is the suspicion that the state of the patient has changed. Triage will be discussed further in the Chap. 26.

**“Second Hit” Phenomenon**

The “second hit” is a classic tactic and pattern seen in terrorist attacks. It is defined as second incident caused by the terrorists, following the first event, with the goal of striking the first responders that are on scene. Typically, it is a second explosion close to the scene and often more powerful than the first detonation. This is because the intention is to create casualties during the first blast and to attract people to the scene and then striking them with a larger detonation. This achieves the goal of a terrorist attack: to cause additional chaos thereby delaying the response and causing great physical and psychological impact on the populations and on the rescuers.

An example of this was the terrorist attack in 2002 in Bali. Two bombs detonated within a short period of time. The first was concealed in a vest worn by a suicide bomber. The second charge was in a minivan about 15 m away when the first explosion happened. The force of the car bomb was enormous [24].

Terrorist attacks are very challenging and difficult to manage, because they are designed to create loss of life and property damage, disruption of the agencies involved in the response, and fear and harm to the population.

The Israel response system is very seasoned to terrorist attack and has specific guidelines and protocols in case of attacks to avoid damage from a “second hit.” Traditionally, medical teams do not enter the scene of the explosion until it is deemed safe by police or army personnel. With many of the terrorist attacks in Israel, a secondary explosion or bomb is set off timed to cause additional injuries to the emergency personnel and bystanders responding to the primary event. However, because time is critical, often EMS does not wait for such security clearance and attempts to rapidly remove the casualties from the immediate vicinity of the initial event. The only medical care given before this initial evacuation is external hemorrhage control [25]. They apply the “scoop and run” approach on the scene (minimal resuscitation on the scene and immediate transportation to the trauma center) to clear the casualties from the area of the event but in the meantime minimize the risk for the rescuers. Therefore, in case of a terrorist attack, it is imperative to maintain the role of the incident commander, the coordination between the agencies, and training of the rescuers to guarantee the safety of all the workers involved in the response.
Key Points

• Disaster is defined as any event that causes serious disruption of society which exceeds the ability of the affected community to cope using its own resources.

• Disasters are usually categorized as natural or man-made, and response to them follows the same pattern, called the disaster cycle, defined in four phases: mitigation and prevention, preparedness and planning, response, and recovery.

• The Incident Command System (ICS) is a standardized and modular organization, on-scene, and all-hazards incident management concept and allows its users to adopt an integrated organizational structure to match the complexities and demands of single or multiple incidents.

• The word triage means “to categorize, to sort.” The purpose of triage in a disaster event is to catalogue the casualties in agreement with the severity of injuries. Sorting casualties is important to give immediate medical care among critical patients that have a chance of survival. The goal is to provide the greatest good for the greatest number of patients.

• The “second hit” phenomenon is a classic tactic and pattern of terrorist attacks. It is defined as a second incident caused by the terrorists, a little bit later than the first event that is geared to injure the first responders that are on the scene.

References

1. The United Nations Office for Disaster Risk Reduction, Terminology [Internet]. 2013. http://www.unisdr.org/we/inform/terminology. Last Accessed 8 Dec 2013.

2. Bendimerad F. “Disaster Risk Reduction and Sustainable Development,” World Bank Seminar on the role of local governments in reducing the risk of disasters, Istanbul, Turkey, 28 April to 2 May 2003, World Bank. Washington D.C. http://info.worldbank.org/etools/docs/library/114715/istanbul03/docs/istanbul03/05_bendimerad3-n%5B1%5D.pdf. Last Accessed 8 Dec 2013.

3. http://en.wikipedia.org/wiki/Bhopal_disaster#cite_note-4. Last Accessed 2 May 2014.

4. http://www.princeton.edu/~achaney/tmve/wiki100k/docs/Bhopal_disaster.html. Last accessed 2 May 2014.

5. Harding S. Man-made disaster and development—the case of Iraq. Int Social Work. 2007;50(3):295–306.

6. United Nations High Commissioner for Refugees, Stories From Syrian Refugees [Internet]. 2013. http://data.unhcr.org/syrianrefugees/syria.php. Last accessed 18 Dec 2013.

7. World Health Organization. Community emergency preparedness: a manual for managers and policy-makers. WHO 1999. p. 12. http://apps.who.int/bookorders/anglais/detart1.jsp?codlan=1&codcol=15&codchc=464.

8. U.S. Department of Homeland Security, National Incident Management System (NIMS) December 2008, p. 7.http://www.fema.gov/pdf/emergency/nims/NIMS_core.pdf.

9. U.S. Federal Emergency Management Agency. Guide for all-hazard emergency operations planning. September 1996. p. 2–11. http://www.cdc.gov/nceh/ehs/Docs/State_and_Local_Guide_101_HEOP.pdf. Last accessed 18 Dec 2013.

10. Lee CY, Riley JM. Public health and disasters, Chapter 2. In: Ciottone GR, editor. Disaster medicine. 3rd ed. Philadelphia: Mosby; 2006. p. 8.

11. U.S. Department of Homeland Security National Response. National Response Framework (NRF), January 2008, p. 10. http://www.fema.gov/pdf/emergency/nrf/nrf-core.pdf.

12. Bey T, Koenig KL, Barbisch DF. Das Konzept von “Surge Capacity” im Katastrophenausfall Notfall Rettungsmed. 2007, p. 1–5.

13. Kano M, Wood MM, Siegel JM, Bourque LB. Disaster research and epidemiology. In: Koenig KL, Schultz CH, editors. Koenig and Schultz’s disaster medicine: comprehensive principles and practices. Cambridge: Cambridge University Press; 2010. p. 8.

14. Ursano RJ, Fullerton CS, Weisaeth L, Raphael B. Individual and community responses to disasters, Chapter 1. Textbook of disaster psychiatry. Cambridge University Press; 2007, p. 8.

15. Agwunobi JO. Testimony before the Committee on Oversight and Government Subcommittee on Government Management, Organization and Procurement United States House of Representatives, on 9/11 Health Effects: HHS’s Monitoring and Treatment of Responders. http://www.hhs.gov/asl/testify/2007/02/t20070228a.html. Last accessed 8 Dec 2013.

16. U.S. Federal Emergency Management Agency “ICS-100. A: introduction to ICS EMI Course Number: IS100.” Student Manual Version 2008. U.S. Department of Homeland Security Unit 2. p. 2–4.

17. U.S. Federal Emergency Management Agency “ICS-200: Single Resources and Initial Action Incidents” EMI Course Number: IS200 Instructor Guide Version 2.0 April 2008 December 2008, Unit 6. p. 6.

18. U.S. Department of Health & Human Services, Office of the Assistant Secretary for preparedness and Response. What is an incident action plan? [Internet]. 2013. http://www.phe.gov/Preparedness/planning/mscc/handbook/pages/appendixc.aspx. Last accessed 28 Dec 2013.

19. U.S. Federal Emergency Management Agency “ICS-300 Intermediate ICS for Expanding” Student Manual April 2012, Unit 1. p. 1.20. http://www.in.gov/dhs/files/ICS_300_SM.pdf. Last accessed 23 Jan 2014.

20. U.S. Federal Emergency Management Agency “IS-700.A: National Incident Management System, An Introduction” Student Manual January 2009, Unit 4. p. 4.9. http://training.fema.gov/EMIWeb/is/IS700a/SM%20files/IS700A_StudentManual.pdf. Last accessed 23 Jan 2014.

21. U.S. Federal Emergency Management Agency. Introduction to the Incident Command System (ICS 100) Student Manual August 2010. http://training.fema.gov/EMIWeb/IS/IS100b/SM/ICS100b_StudentManual_Aug2010.pdf. Last accessed 23 Jan 2014.

22. Burstein JL. Mostly dead: can science help with disaster triage? Ann Emerg Med. 2009;54(3):431. doi:10.1016/j.annemerg.med.2009.02.012. Epub 2009 Mar 13.

23. Debacker M. “Triage” [unpublished lecture notes]. Universiteit de Piemonte Orientale Vercelli (Italy) and Vrije Universiteit Brussel (Belgium) Lecture given during the European Master in Disaster Medicine (EMDM); 2008.

24. Swedish Defense Research Agency, Unit for Emergency Preparedness, Committee for Disaster Medicine Studies. The terror attack on Bali, 2002. Kamedo report 89. http://www.socialstyrelsen.se/Lists/Artikelkatalog/Attachments/9209/2007-123-35_200712335.pdf. last accessed the 27 Dec 2013.

25. Singer AJ, Singer AH, Halperin P, Kaspi G, Assal J. Medical lessons from terror attacks in Israel. J Emerg Med. 2007;32(1):87–92.