Mass Casualty Incident: Definitions and Current Reality

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1.1 Definitions of MCI and Related Concepts

The Pan American Health Organization (PAHO), which is the world's oldest international public health agency (N/A), defines a *Mass Casualty Incident* (MCI) "as an event which generates more patients at one time than locally available resources can manage using routine procedures. It requires exceptional emergency arrangements and additional or extraordinary assistance. For this reason, it can also be defined as any event resulting in a number of victims large enough to disrupt the normal course of emergency and health care services" [1].

These incidents are caused by a sudden and dramatic event, which can have a varying degree of severity depending on the place where it happens. For example, a bus crash in a small rural community with tens of injured survivors would fulfill the PAHO definition, as would a major natural disaster, such as a severe earthquake, affecting a heavily populated area. Both of these events can be considered MCIs, even if they pose very different challenges for the affected community and the emergency personnel that have to respond to them.

Before going on, some terms, with their related concepts, should be clarified.

A *hazard* is an event which has the potential to cause harm or loss. It may be natural or man-made.

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A *disaster* results from the interaction between a hazard and a community. This is a natural or man-made, sudden or progressive event, resulting in serious disruption of the functioning of the society, causing human, material, or environmental losses, exceeding the ability of the affected community to cope using its own resources. If a hazard impacts an isolated area, not affecting a community in any way, it will not cause a disaster [2].

The American College of Emergency Physicians (ACEP) focuses its attention on the health care resources when defining what a disaster is, stating that it occurs "when the destructive effects of natural or man-made forces overwhelm the ability of a given area or community to meet the demand for health care." Other definitions exist, but the common denominator is the inability of the organization, infrastructure, and resources of a community to return to normal operations without external assistance in the aftermath of the event [3].

The main features of a disaster are:

- Disasters interrupt the normal functioning of a community.
- Disasters exceed the coping mechanisms (capacity) of the community.
- External assistance is often needed to return to normal functioning of a community [2].

The *risk* is the probability of harmful consequences (expected loss of lives, injuries, property or environmental damage, disruptions in livelihood, and economic activity) resulting from a particular hazard for a given area in a certain period of time [2].

Vulnerability is the extent to which a community (with its structure, services, and environment) is likely to be damaged or disrupted by the impact of a hazard. For example, if a community has a high risk to be exposed to a flood, it can decrease or increase its vulnerability depending on the grade of preparedness that it develops. This is the reason why disasters do not occur every time a community is exposed to a hazard.

Vulnerability is therefore the combination of two factors: susceptibility and resilience. Susceptibility is the degree of exposure to a given risk (e.g., a community built by a river is more susceptible to floods than one built far from any watercourse is). Resilience is how well a community is able to face loss (e.g., a community that in the aftermath of a flood reconstructs safe houses with all facilities for its population in a small period of time is resilient).

To sum up, it is possible to express the relationship existing among risk, hazard, and vulnerability using the following formula: Risk = hazard × vulnerability [2].

1.2 Classification of Disasters, Levels of MCI, and Their Effects on Health and Hospitals

Disasters, and consequently the MCIs provoked by them, are generally classified into natural and technological (or human-made). However, in some situations, this distinction is not so neat, as there are frequent crossovers. Human actions can

increase the risk of certain types of disasters (e.g., deforestation leading to landslides).

For these reasons, the most efficient system to manage an MCI would be an all-hazard approach, focusing on the level of MCI rather than on its causing event in order to be able to address both natural and man-made disasters.

1.2.1 Natural Disasters

Natural disasters can be classified as follows:

- Geophysical (earthquake, mass movement, volcanic activity, etc.)
- Hydrological (flood, landslide, wave action, etc.)
- Meteorological (storm, extreme temperature, fog, etc.)
- Climatological (drought, glacial lake outburst, wildfire, etc.)
- Biological (animal accident, epidemic, insect infestation, etc.)
- Extraterrestrial (impact, space weather, etc.) [4]

Tornadoes may be quite lethal but are generally short-lived. Hurricanes are more destructive than tornadoes; they tend to last longer and have more long-term recovery effects. They are, however, more predictable than other types of natural disasters thanks to modern technologies [5, 6].

Wildfires may persist for months and cause significant long-term damage. Volcanic eruptions can lead to a high number of fatalities but, as well as hurricanes, have become more predictable in recent years [2].

One of the most devastating natural phenomena are earthquakes. The number of deaths and injuries mainly depends on three factors: (1) building type/construction materials; (2) time of the day/night when the earthquake occurs; and (3) the population density of the area. Earthquakes tend to remain unpredictable, and populations have no time to evacuate or prepare for an impending event. In addition, local health care structures and hospitals can be largely affected. Specialized training and operation plans have been advocated to reduce morbidity and mortality in earthquake-prone regions [7].

Natural disasters may affect human health in many different ways. In fact, injuries and deaths occur directly not only from the event itself but also from its environmental consequences; malnutrition and increased morbidity and mortality from both communicable and non-communicable diseases (including mental diseases, e.g., posttraumatic stress disorder and psychological impairment) can be caused by malfunctioning in sanitation and reduced accessibility to health care [2].

Only advanced warning systems, structural and design improvements, and disaster planning may significantly decrease the devastation caused by many natural disasters. However, as populations occupy and develop areas that are at greater risk of specific types of natural disasters, the human and economic impact of these incidents keeps being likely to rise [3].

1.2.2 Technological (Man-Made) Disasters

Technological disasters tend to be more contained in terms of damages and losses than natural ones, but can also deliver a significant impact on life and property. Structural fires, toxic spills, and nuclear mishaps are included in this category of disasters, the first ones having caused some of the largest numbers of casualties in the USA.

In chemical, biological, radiological, or nuclear (CBRN) events, life or death is often determined within the first few minutes of their onset. For this reason, even before the detection and analysis of responsible agents can be undertaken, zoning, triage, decontamination, and treatment should be initiated as soon as possible [8].

Major transportation accidents, such as train derailments and airplane crashes, may quickly overwhelm the existing local emergency response system [3].

Other incidents having the potential to turn into mass casualties include war and terrorism, with bombings and blast injuries increasing in frequency with larger numbers of injuries and fatalities. Blasts also have the potential to involve radiological dispersion devices, the so-called dirty bombs. In these scenarios, chemical weapons have emerged as a serious potential threat, along with biological agents [3].

1.2.3 Levels of MCIs

MCIs are classified by levels, based on the number of potential victims generated by the causing incident. The emergency service response should be tailored and planned according to the level of the MCI:

- Level 1: 1–10 potential victims
- Level 2: 11–30 potential victims
- Level 3: 31–50 potential victims
- Level 4: 51–200 potential victims
- Level 5: More than 200 victims
- Level 6: Long-term operational period(s) [9]

Another way to classify MCIs is to consider the entity of the response—in terms of resources—required to face them:

- Level I MCI—requires local emergency response personnel and organizations to contain and deal effectively with the disaster and its aftermath.
- Level II MCI—requires regional efforts and mutual aid from surrounding communities.
- Level III MCI—is of such a magnitude that local and regional assets are overwhelmed, requiring national assistance.
- Level IV MCI—sometimes included in Level III; this MCI is of such magnitude that it requires international assistance and resources [2].

1.2.4 Direct and Indirect Impact of Disasters on Hospitals

A hospital/health care institution can directly be affected by a disaster when it is located in the impacted area, being damaged or destroyed. Hospitalized patients have limited mobility, so they are more vulnerable than the general population and may experience higher rates of morbidity and mortality; this must be taken into account when redacting an MCI management plan [2].

Indirect impact of disasters on hospitals occurs when they are located in the fringe of impact, triage, or organized aid area, as they will be inevitably called upon to play an important role in the response. In this case, hospitals may be asked to provide assistance in the form of manpower, materials supply, and logistics. Another aspect that has to be taken into account is that people from the local community may take shelter in the hospital [2].

During disasters, the points of care and the therapeutic strategies are completely different from the ones of "normal emergencies." This is well clarified in the following ACEP statement: "emergency medical services routinely direct maximal resources to a small number of individuals, while disaster medical services are designed to direct limited resources to the greatest number of individuals." This shift in priorities may represent a challenge for emergency services and physicians who are accustomed to dedicate all available resources to the most critical patients; damage control procedures may be more valuable than definitive diagnostics and treatments in these settings [3].

1.3 Epidemiology

According to historical data, the number of both natural and man-made recorded disasters has increased since 1900. The same has been registered as regards the number of victims [1].

According to the annual report of the Centre for Research on the Epidemiology of Disasters (CRED), in 2015, 346 disasters have been reported, the majority of which occurred in Asia (Fig. 1.1), with 22.773 million people dead and 98.6 million people affected (Fig. 1.2). The economic damage was estimated at 66.5 billion US dollars [4].

However, the MCIs that most countries experience more routinely are major accidents with tens of victims, rather than disasters with a larger number of victims. It will suffice to consider the example of September 11 attacks, which caused 2819 deaths; this number is only a small fraction of the 44,065 deaths from motor vehicle accidents occurred in the United States in 2002 [10]. Moreover, for each disaster listed in official disaster databases, about 20 other smaller emergencies with destructive impact on local communities are unacknowledged (Maskrey, cited in WHO 1999) [1].

As far as terrorism is concerned, some clarifications are needed. According to the fifth edition of the Global Terrorism Index (GTI), in 2016, there was a global decline

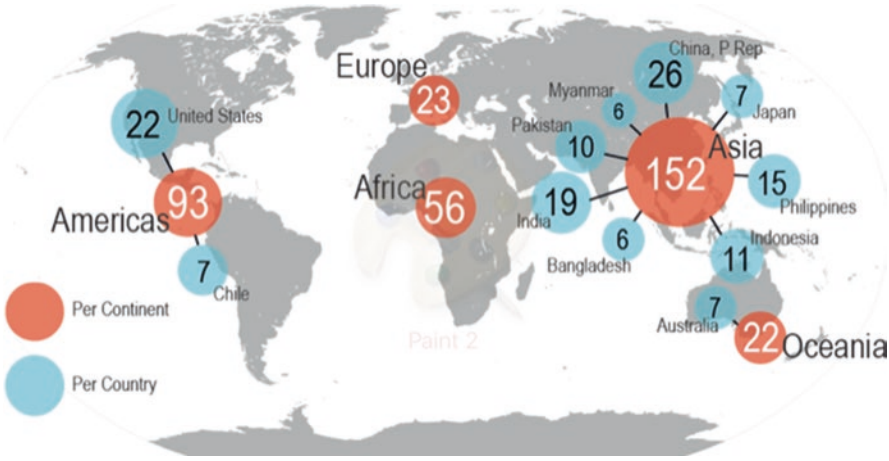

Fig. 1.1 Number of reported disasters per Country and Continent in 2015. The Countries indicated were the most affected. EM-DAT (25th January 2016): The OFDA/CRED—International Disaster Database www.emdat.be Université catholique de Louvain Brussels—Belgium

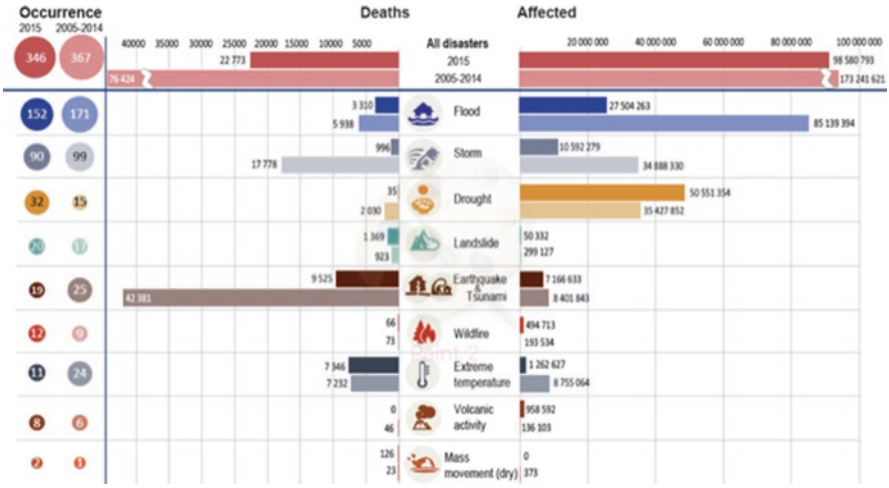

Fig. 1.2 Human impact by disaster types in terms of deaths and total people affected, comparing 2015 with the period 2005–2014. EM-DAT (25th January 2016): The OFDA/CRED—International Disaster Database www.emdat.be Université catholique de Louvain Brussels—Belgium

in the number of deaths from terrorism for the second successive year, with 25,673 people dead, which is a 22% improvement from the peak in 2014.

Over the last 15 years, South Asia experienced the majority of terrorist activity and the MENA region (Middle East and North Africa, N/A) had the sharpest increase in terrorism. The five countries most affected by terrorism are Iraq, Syria, Pakistan, Afghanistan, and Nigeria, which accounted for three quarters of all deaths

from terrorism in 2016. It must be noted how, over the last 17 years, 99% of all terrorist deaths occurred in countries that are either in conflict or have high levels of political terror. Moreover, GTI shows how terrorist attacks are deadlier in conflict-affected countries (2.4 fatalities per attack in 2016 compared to 1.3 fatalities in non-conflict countries). This proves that the great majority of terrorism is used as a tactic within an armed conflict or against repressive political regimes. It also demonstrates the risks of political crackdowns and counterterrorism actions, which can exacerbate existing grievances and the drivers of extremism and terrorism.

In Organization for Economic Cooperation and Development (OECD, N/A) countries, there have been nearly 10,000 deaths from terrorism between 1970 and 2016, with 58% of these deaths occurred prior to 2000. ISIL is only the fourth most deadly terrorist group and accounts for 4.7% of terrorist deaths in OECD countries in the above-mentioned period of time. Separatist groups such as Irish separatists (IRA) and Basque nationalists (ETA) have killed over 2450 people since 1970, which is the 26% of the total deaths. OECD countries accounted for only 1% of global deaths from terrorism in 2016. This is, however, an increase from 0.1% in 2010 [11].

1.4 Principles of MCI Management

The range and unpredictability of where, when, and how events can occur, with all the possible variables that make each incident unique, including the number of victims, imply that planning and training to respond are extremely challenging. Preparedness is therefore the key to success in the effective management of an MCI, as endorsed by numerous resolutions passed by the World Health Assembly since 1981, when it first stated that "despite the undoubted importance of relief in emergencies, preventive measures, and preparedness are of fundamental importance." Preparedness implies consciousness that risk and vulnerability exist, and awareness by both government and local community of the benefit to plan and to have appropriate legislation.

In May 2007, the 60th World Health Assembly adopted a resolution that called, among other things, for WHO to provide guidance for the creation and strengthening of mass casualty management systems [1].

Despite these indications and the vast unfortunate experience of many countries around the world, preparedness toward MCI is not always institutionalized by proper management plans and health care personnel is not always sufficiently trained or updated, as showed for example by the World Society of Emergency Surgery (WSES) survey conducted in 2015 [12] and the report of the National Association of Emergency Medical Technicians (NAEMT) published in 2017 [13]. This outlines the paramount importance and the need to elaborate clear MCI management plans and promote courses—directed to all professionals involved in the response to an MCI, including health personnel—aimed to fill the gaps in MCI awareness and also to improve and optimize practical skills required in these exceptional situations.

An optimal MCI/disaster management should consider all four phases of the so-called disaster cycle: mitigation, planning, response, and recovery [3]. Paying particular attention on certain aspects of the cycle to the detriment of others may increase the harmful impact of events.

1. *Mitigation*: Some of the devastating effects of disasters can be reduced before the actual event. In this sense, useful measures are evacuations orchestrated before hurricanes and floods, as well as early forewarning from tornadoes and approaching hurricanes, in order for population to seek shelter; sprinkler systems in business and homes, to reduce the overall risk of total fire destruction; construction of anti-seismic buildings in earthquake prone regions.
2. *Planning*: In addition to be written, realistic disaster plans involve exercise, practice, and eventually revision, if found faulty or unworkable when applied. As an example, it must be considered that the initial search and rescue begin with victims and bystanders and not with trained rescue teams, and also the majority of patients arrive at hospitals without the intervention of the EMS system, so without having been triaged or decontaminated. Another important aspect to keep in mind when preparing a management plan is that it is impossible to plan for all contingencies: therefore, plans must be relatively general and expandable. Mutual aid agreements or contracts among existing area associations and institutions must be established before an actual event, in order to optimize the available resources as well as planning for funding and reimbursement.
3. *Response*: This phase of the disaster cycle tends to be considered the most important one, but an effective and coordinated response actually depends on the other three aspects of the disaster cycle. Response implies different aspects, which can be summarized as follows:
   - *Activation, notification, and initial response*: Organizations involved in disaster response and the potentially affected populations are notified.
   - *Organization of command and scene assessmen*t: Establishing a command structure is one of the most crucial steps to take once the disaster occurs. This must be prearranged and assembled almost immediately, as well as communication nets established. The Incident Command System (ICS) is an organizational and management tool used during disaster situations and emergency response operations (Fig. 1.3). Early assessment of the incident scene is also important to correctly prepare the arriving aid.
   - *Search and rescue*: Depending on the structure and function of the ICS, search and rescue may fall under the direction of fire, emergency medical services (EMS), police, or security forces. In large disasters, especially ones that are ongoing or that involve terrorist activities, a cooperative approach is necessary and the very act of search and rescue must be highly organized to ensure adequate and complete coverage of all areas.
   - *Extrication, triage, stabilization, and transport*: Extrication is performed by fire departments in most of the countries. Triage involves providing the most efficient aid to as many as possible and prioritizes treatment and transport of victims. Many variables influence the manner in which patients are triaged,

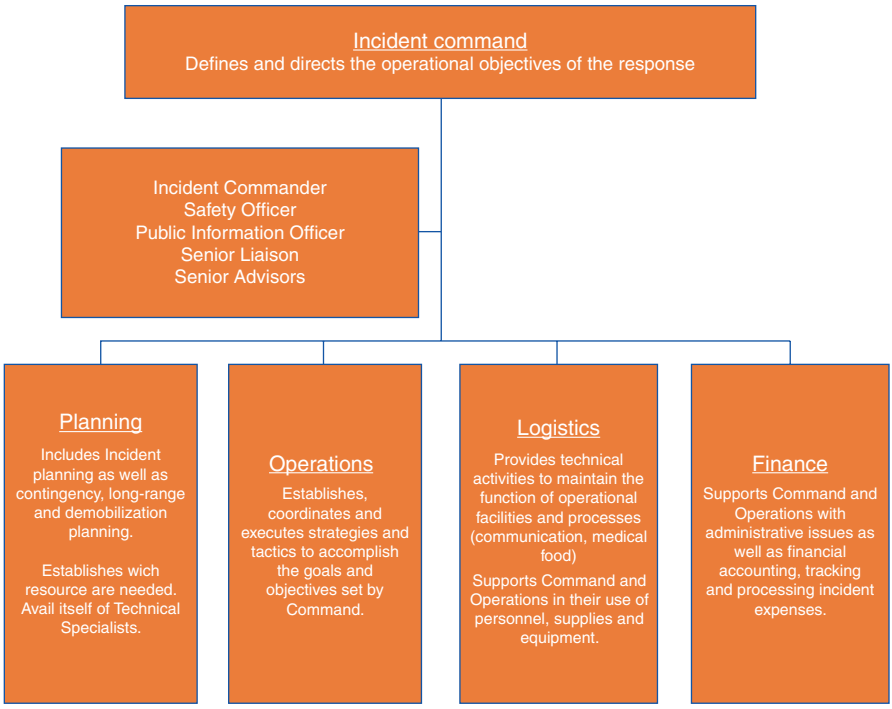

Fig. 1.3 The Incident Command System (ICS) model

transported, and treated: the type of incident, the number of victims, the available resources, the capability of existing infrastructure, and the overall context of the disaster. Patients must be reassessed during every step of the process. There are several algorithms for triage in mass casualty incidents that have been shown to have acceptable sensitivity and specificity in detecting severely injured patients [14, 15]. Errors in triaging may cause misallocation of valuable resources and may lead to worse outcomes among those affected. It is extremely important for health care providers to be familiar and trained in the triage system they are using. In some scenarios, such as extensive earthquakes, infrastructure may be damaged or destroyed to the extent that definitive care, even from outside resources, is not available for several days. In this case, dynamic treatment and recurrent triage of patients should be performed until other sources of medical care become available.

Transport must be both organized and orchestrated to equitably distribute victims to capable receiving facilities. Many of the less critically injured will self-extricate and arrive at the nearest medical facility by their own means. Often, the more critical patients arrive after the first wave of so-called walking wounded, and it is important to distribute these patients to appropriate receiving facilities with the capacity to take care of them. This process lessens the overwhelming impact a disaster may have on the closest hospital and improves

the effectiveness of medical care provided to the victims. Victims may require decontamination prior to transport in order to prevent the spread of a hazardous material or threat.

– *Definitive scene management*

4. *Recovery*: This last phase is crucial for the affected community: order is restored, public utilities are reestablished, and infrastructure begins to operate effectively. Rebuilding and restructuring may include mitigation measures, in order to prevent or, at least, diminish the degree of damage in the case of a new event.

   Treatment of the responders is also important during this phase for critical stress debriefing. Debriefing may teach planners valuable lessons. It is of utmost importance to obtain as much information as possible from all parties involved in the disaster response. Without full disclosure, similar pitfalls may impede improvements in future responses [3].

References

1. World Health Organization. Mass casualty management systems. Strategies and guidelines for building health sector capacity. Geneva: The Organization; 2007.
2. Directorate General of Health Services, Government of the People's Republic of Bangladesh. A guide book on mass casualty management. Aalpoth Media; 2010.
3. Furin MA. Disaster planning. Medscape. 2016. https://emedicine.medscape.com/article/765495-overview. Updated 10 May 2016.
4. Guha-Sapir D, Hoyois P, Below R. Annual disaster statistical review 2015: the numbers and trends. Brussels: CRED; 2016.
5. Doocy S, Daniels A, Dooling S, Gorokhovich Y. The human impact of volcanoes: a historical review of events 1900-2009 and systematic literature review. PLoS Curr. 2013. https://doi.org/10.1371/currents.dis.841859091a706efebf8a30f4ed7a1901.
6. Doocy S, Dick A, Daniels A, Kirsch TD. The human impact of tropical cyclones: a historical review of events 1980-2009 and systematic literature review. PLoS Curr. 2013. https://doi.org/10.1371/currents.dis.2664354a5571512063ed29d25ffbce7.
7. Schultz CH, Koenig KL, Noji EK. A medical disaster response to reduce immediate mortality after an earthquake. N Engl J Med. 1996;334(7):43844.
8. Ramesh AC, Kumar S. Triage, monitoring, and treatment of mass casualty events involving chemical, biological, radiological, or nuclear agents. J Pharm Bioallied Sci. 2010;2(3):239–47.
9. Massachusetts Department of Public Health. The Massachusetts Emergency Medical Services (EMS) Mass Casualty Incident (MCI) Plan. 2016.
10. CDC. Deaths in world trade center terrorist attacks New York City, 2001. Morb Mortal Wkly Rep. 2002;51(Special Issue):1618.
11. Institute for Economics and Peace. Global terrorism index 2017: measuring and understanding the impact of terrorism. Sydney: Institute for Economics and Peace; 2017.
12. Ben-Ishay O, et al. Mass casualty incidents—time to engage. World J Emerg Surg. 2016;11:8.
13. Goodwin J. NAEMT National Survey on EMS preparedness for disaster and mass casualty incident response. 2017. http://www.naemt.org/docs/default-source/ems-agencies/EMS-Preparedness/2017-naemt-ems-preparedness-report.pdf?sfvrsn=0. Accessed X.
14. Benson M, Koenig KL, Schultz CH. Disaster triage: START, then SAVE—a new method of dynamic triage for victims of a catastrophic earthquake. Prehosp Disaster Med. 1996;11(2):11724.
15. Garner A, Lee A, Harrison K, Schultz CH. Comparative analysis of multiple casualty incident triage algorithms. Ann Emerg Med. 2001;38(5):5418.