*Chapter 4*

# AN ALTERNATIVE PERSPECTIVE FOR ADDRESSING MASS CASUALTY INCIDENTS IN EXTREME EVENTS

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# ABSTRACT

As the aftermaths of climate change and socioeconomic crises grow, disasters and emergencies of all types become more intense and frequent, resulting in catastrophic Mass Casualty Incidents (MCIs). The MCIs usually affect large groups of people; consequence that disrupts the emergency health sectors, as well as the Emergency Medical Service (EMS) systems, since the surge of unexpected patients overwhelms the EMS transportation and the emergency departments (EDs) of emergency hospitals. Saving the prehospital time and smoothing the patient flow are the prime goals for the researchers of the field. In this chapter, a comprehensive blueprint of MCI management (MCIM) is presented after evaluating related innovative strategies, pioneering scenario designs, and creative implementation plans. This article is divided in five domains to explicate a wide spectrum of MCIM for efficient lifesaving matters: the Know-How Domain, worldwide inspection of the current MCI responses; the Casualty Distribution Domain, alternative approaches for prehospital emergency care; the EMS Transportation Domain, "smart" emergency transportation schemes; the MCIM Cloud Domain, emergency response information and data transfer; the On-Scene Safety Domain, control and protection of the affected population and territory. These five domains are fundamental elements for addressing MCIs; that is to say, they should be connected in order to produce their maximum potential. The main purpose of this review is not only to exhibit sufficient results as a token to boost the MCIM perspectives, but also to aware all the involved parties regarding the challenges they have to face during extreme events.

**Keywords**: mass casualty incident management, extreme event, emergency medical service, prehospital emergency care

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# INTRODUCTION

Over the last decades, the catastrophic impacts of climate change have drawn the attention of several researchers worldwide [1-4]. Diseases, injuries, as well as deaths are the outcome of storms, floods, droughts, wildfires and heat waves that appear to be on the increase. Moreover, manmade disasters, such as terrorist attacks, chemical, biological, radiological, nuclear, and explosive (CBRNe) threats and significant public safety incidents have also arisen at a concerning level [2, 4-9]. As a consequence, such phenomena lead to unpreventable large casualty caseloads.

For the term of “mass casualty incident” (MCI), there are various definitions; however, MCI can be described in general as any incident in which the emergency medical service (EMS) resources, including personnel and equipment, are overwhelmed by the number and severity of casualties [10]. Each EMS system should carry out an adequate adaptation based on the effects of MCIs. Indeed, a plethora of published articles document how the changing impacts of natural and manmade disasters modify the EMS and emergency medicine strategies.

Natural hazards and more specifically water-based disasters are a major cause of extreme MCIs, especially in Asia and Africa. Over the last 20 years, such calamities resulted in over 150,000 deaths and affected more than 2.3 billion people [11]. These numbers prove that disaster management policies are still unprepared for extreme weather events; fact that also influences the EMS systems.

Additionally, there are many recorded MCIs in extreme manmade disasters that have changed the perspectives of global society in matters of safety and fear of crime [12]. Bombings used to be considered as the deadliest terrorist attacks; however, other types of strikes can be equally lethal , such as the airline attacks on the World Trade Center and the Pentagon, the anthrax mail delivery or the random shootings in crowded areas [13]. Shooting attacks at schools, squares, transportation stations, and other public spaces where the possibility of an MCI is high, have increased dramatically [14]. The shooting cases at Westside Middle School in Arkansas and Columbine High School in Colorado describe the numerous insufficiencies in school preparedness [15]; whereas, the suicide attacks in London, England point the lacking response mechanisms in public spaces [16].

To further deal with such phenomena, the United Nations, and other international or regional organizations tend to bring humankind even closer towards a common strategy for dealing such events, primarily by promoting international cooperation and participation in major fields, such as disaster risk reduction, resilience and response.

In this chapter, a comprehensive blueprint of MCI management (MCIM) is presented after evaluating related innovative strategies, pioneering scenario designs, and creative implementation plans and it is divided in five domains to explicate the wide spectrum of MCIM for efficient lifesaving matters: 1. The Know-How Domain, that carries out the worldwide reviews of the current MCI responses in order to detect the weaknesses of respective MCI plans; 2. the Casualty Distribution Domain, that highlights alternative approaches for pre-hospital emergency care so to provide new thinking and solutions to the policy- or decision-makers; 3. the EMS Transportation Domain, that introduces some “smart” emergency transportation schemes for promoting the efficiency of pre-hospital emergency transportation; 4. the MCIM Cloud Domain that focuses on collecting and integrating emergency response information and transferring reliable and robust data to the end-terminal users, or even to the decision-makers; 5. the On-Scene Safety Domain, that describes how to prevent secondary threats that could harm the injured and nearby crowds by controlling and protecting the affected populations and territory.

The aforementioned domains as illustrated in this chapter are fundamental elements for addressing MCIs; that is to say, they should be connected in order to produce their maximum potential. The main purpose of this article is not only to exhibit sufficient results as a token to boost the MCIM perspectives, but also to aware all the involved parties regarding the challenges they have to face during extreme events.

## KNOW-HOW DOMAIN

During MCIs, the volume of casualties tends to become higher than normal in a short period of time [17]. In order to deal with such incidents, both the Emergency Medical Technicians (EMTs) and Emergency Departments (EDs) of the response hospitals prepare to care this large amount of patients based on national related regulations and drill scenarios. Therefore, it can be stated that the preparedness level of the medical and response units can highly determine the success or failure result during any MCI response operation. Although organized emergency response mechanisms should be primarily highlighted, it is essential to mention that not all MCI cases can be treated the same, as well as generic response systems cannot be applicable in every MCI response without modifications; each emergency response mechanism should be designed under multi-dimensional perspectives in order to minimize human losses and secondary impacts.

As experience shows, the nearby public is the first that will provide assistance during emergency incidents. For that reason, emergency response and preparedness designs should not only be a privilege of the experts but also of the common populations, starting from the local levels, when relevant education and training are provided [18]. Unfortunately, this is not the only problem that can be detected in the MCI health system preparedness. Several documented cases all around the world, especially those related to terrorism, fire incidents, biochemical accidents, etc., describe a long list of deficiencies [19-21]; specifically, a notable amount of references is focusing on the communication between the first responders, response hospitals and decision-makers [19, 22]. The EMTs, after completing the on scene-triage, send the patients to the nearest response hospital, ignoring the level of injury or the patient saturation of the hospital; this phenomenon unavoidably leads to patient overcrowding [23, 24]. In simple words, casualties with minor traumas may be sent to nearby response hospitals, while patients in severe condition may need to transfer farther. This emergency transportation “routine” is accepted and applied by many countries with no or poor MCIM.

Adjustable to changing risks and well-designed education and training strategies are perhaps the only ideal templates that in combination with the effective partnership of the involved parties can effectively upgrade the current response systems. As the threats continue to grow and expand, so should the response mechanisms. The recent impacts of climate change in North America and East Asia, as well as the increasing terrorist attacks in Europe show the insufficiencies of the current MCIM models. As this issue continues to exist, it attracts the attention of relative experts and stakeholders. A great deal of information, frameworks and mechanisms that are delivered mainly by professional organizations, local, national regional and international agencies aim to change the emergency response approach of the previous decades [25, 26].

One great example is the World Health Organization (WHO) that promotes national emergency management policies and plans, regarding the command, control and coordination responsibilities during MCIs. More specifically, the WHO suggests that regardless the administration unit that supervises the operations, national emergency actions should include the identification of the involved authorities from local to national level, the release of funds for emergency works, the arrangements that can allow the smooth operations of local/central government and populations, the immediate availability of national resources for the relief of affected populations and areas, the establishment of a database that includes experts and professionals that can assist when required, as well as the activation of protocols and diplomatic negotiations that allow assistance from third parties, including foreign countries, regional/international organizations, etc. [23]. As the global perceptive towards common threats steadily changes, the role of science and technology and could be a key factor that, if used properly, may allow innovations in global MCIM models [27]. Therefore, actions such as the promotion of multi-cooperation in local, national, regional and international level in combination with the know-how exchange between different countries could be the paradigm shift the emergency medicine requires to deal with the risks that threat both the society and the environment.

## CASUALTY DISTRIBUTION DOMAIN

Once an MCI occur, two major casualty distribution scenarios can be observed, the focal and diffuse. For example, on June 27, 2015, the dust explosion incident of the "Color Play Asia" party at the Formosa Water Park in Taiwan is a focal burn disaster that ended with 499 casualties [28-31]; whereas, the Kaohsiung gas explosions on July 31, 2014 in Taiwan, is a classical diffuse disaster, since the explosions that occurred along the underground petrochemical pipe caused numerous injured, road blasts and damages in infrastructures [32, 33].

These two types of incidents result in different challenges regarding the casualty evacuation and collection. As a general policy of EMS when disasters occur, patients must be triaged, medical cared, and transported to the competent response hospitals. In the case of focal MCIs, the rapid evacuation of all the casualties forces the EMS experts to find a radical solution. On the other hand, in the cases of diffuse disasters, patients are distributed randomly; therefore, the patient collection, as well as the solicitation of EMS teams are two major challenges.

This domain introduces the alternative scheme of an emergency medical regulation center (EMRC) in order to overcome the aforementioned problems [34]. The EMRC is a transient location or building between the disaster area and response hospitals. While it receives the moderate and mild patients, the supported medical teams will provide first aid and stabilize the condition of the patients. The EMRC is a conceptual term, since its format is modified based on the demands of each incidents. For example, in Boston marathon bombing in USA [35-37], the EMRC included tents and carpets, while during the Chi-Chi earthquake disaster [38, 39] in Taiwan, schools and stadiums were provided in order to cover the patients' needs. A diagram for illustrating the EMRC is shown in Figure 1.

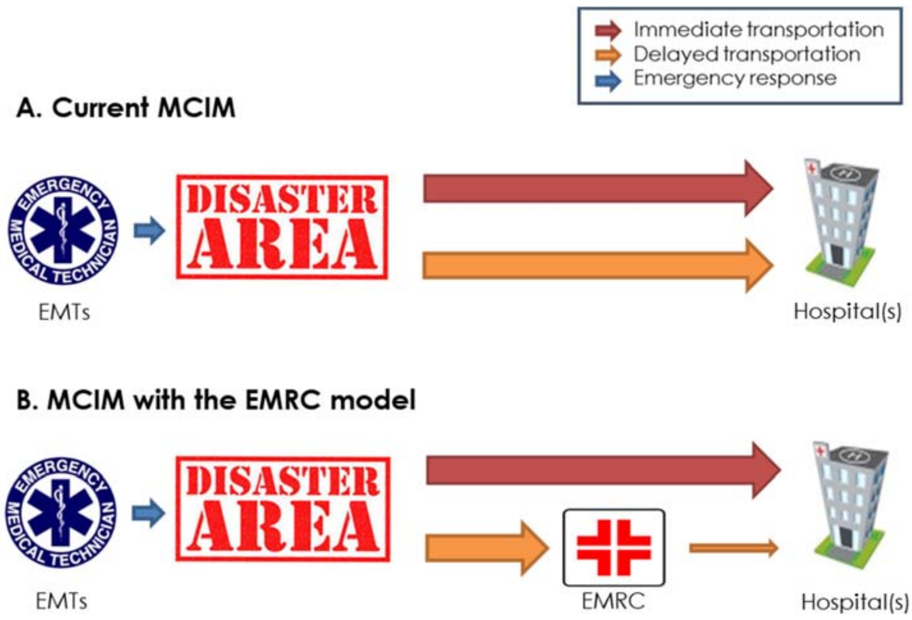


Figure 1. The scenario of EMRC in MCIM. The moderate and mild injured will be retented by the EMRC to regulate the patient flow and to prevent the overcrowding in the response hospitals.

There are several benefits for using EMRC operations in focal type disasters:

1. Minimizing the mortality and medical expenses - After the on-scene triage, the heavily injured patients are transported to the response hospitals directly; whereas, the moderate and mild patients are transferred to the EMRCs. Emergency cases can receive intensive medical care without any interference, while the moderate and mild cases are stabilized by the EMRC medical teams. Once patients' condition turns worse while they are in the EMRC, the medical professionals will contact the response hospitals and pass all the medical records to the EDs. In the opposite scenario, minor injured could departure after a basic treatment. By following such procedures, the mortality and medical expenses can be significantly reduced.

2. Promoting EMS system efficiency - Based on the results of previous researches, by applying the EMRC model in the real case study of Typhoon Morakot that occurred on August 8$^{th}$, 2009, the EMS transportation time and distance efficiency was improved by 52.15% and 56.02%, respectively [34].

3. Alleviating ED overcrowding of response hospitals - Since the moderate and mild patients are retented by EMRCs, only heavily injured patients are transported to the response hospital directly; therefore, the surge pressure of MCIs can be notably reduced [24].

4. Preventing chaotic or non-scheduled patient transportation - In Taiwan, the EDs of the response hospitals are classified into three levels: Emergency, Urgency, and Non-urgency, for receiving the severe, moderate, and mild cases, respectively. During an MCI, the injured are always sent to the nearby response hospitals without following the principles of this classification. Consequently, moderate and mild patients may occupy medical centers that will not be able provide medical services to the cases of emergency; this condition may cause unexpected effects, including death to severe patients.

5. Smoothing the communications among the emergency medical teams - The information exchange between EMTs and EDs' staff are of critical importance in MCI scenarios. The EMTs ought to be informed regarding the available beds of the response EDs in order to make transferal decisions; on the other hand, the response EDs must be aware of the patients' condition in advance, so to prepare accordingly.

In the case of a diffuse disaster, two major problems can be noticed during the emergency response, how to collect patients in the wild open fields and transport them to the response hospitals, and how to integrate the external support EMS teams, so to cooperate with each other closely. Both problems can be addressed by the scenario design of EMRC. The patients collected in a diffuse disaster can be sent to the EMRCs to receive first aid support or emergency medical treatment. Because the EMRCs are constructed in the vicinity of the disaster area, the ambulances can frequently reciprocate between EMRCs and the diffuse disaster zone in order to prevent transportation delays of the injured in situ. Furthermore, the supporting EMS teams can be gathered within the EMRCs' facilities for sharing the life-saving missions and exchanging the relevant information. The role of EMRC in such scenarios can be depicted in Figure 2.

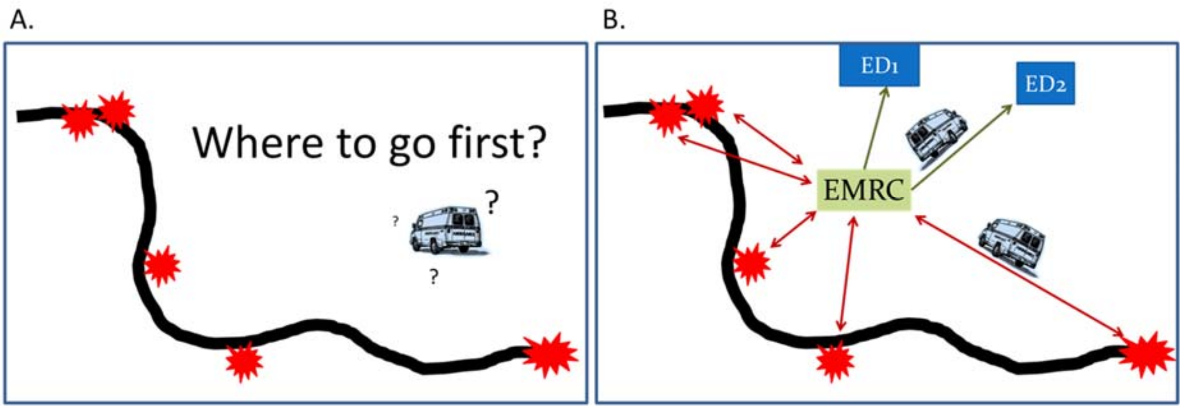

Figure 2. The EMS transportation under different scenarios. Panel A shows the traditional EMS transportation. Panel B describes the role of EMRC in an alternative EMS transportation.

## EMS TRANSPORTATION DOMAIN

It can be observed that comprehensive strategies in emergency transportation can significantly affect the patient survival rate, regardless the type of MCI, although different countries apply a variety of the EMS systems, depending on the program of the transportation model they use [40, 41]. More specifically, for the EMS transportation, the Anglo-American model is based on the "patient to doctor" plan; whereas, the Franco-German model on the "doctor to patient" plan [42-44]. Different transportation models will result in the setup of different EMS teams that are consisted of EMTs, nurses, and doctors for the prehospital patient care.

During an MCI, the EMS transportation will be overwhelmed by a heavy caseload of casualties. A plethora of relative researchers and planners focus on shortening the referral and saving the "golden time" [45-49]. For instance, three phases of pre-hospital patient care are followed by experts after the occurrence of an earthquake in order to reduce immediate mortality [50]. Furthermore, the Geographic Information System (GIS) can be widely applied by researchers for path designs in order to improve time-saving transportations [51]. In addition, aero-transportation is another main force that is suggested to overcome the defects of on-land transportation in the event of extreme conditions [52].

For the EMS transportation, one alternative plan that is worth to be highlighted, is the sequential-conveyance method [34]. This method is always implemented with the execution of an EMRC. By applying this transportation plan, ambulances are allocated to two different lines. First-line ambulances that reciprocate between the disaster area and an EMRC, so to save time and shorten the working distances and second-line ambulances that are highly regulated between EMRCs and the requested hospitals.

As mentioned in the casualty distribution domain, the patients with moderate and mild injuries can be retented by EMRCs; thus, the first-line ambulances have two destinations, the EDs for severe patients and the EMRCs for the other two kinds of patients. As a result, this scheme allows fast-track casualty transportation which could lead to a radical evacuation. In this scenario, the time required for communicating and selecting the most appropriate EDs of the response hospitals can be significantly reduced. The second-line ambulances on the other hand, are assigned by the doctors in the EMRCs for patient diversion. In this case, the contact of medical personnel between EMRCs and EDs of response hospitals determines the destination of the EMRC cases. As a result, the attendance of the second-line ambulances is less frequent, while the transportation efficiency is further enhanced.

According to a previous case study, one natural catastrophic event in Taiwan, the Typhoon Morakot, that is also called 88 wind-caused disasters [53], was reviewed and analyzed for the sequential-conveyance method to understand the effect of such ambulance services on transportation time and distance. An EMRC scenario was designed in a safe zone near the disaster area. Ambulances in an EMRC (second-line) were ready to sequentially convey the casualties with unstable conditions to an assigned response hospital that was far from the disaster area for treatment. First-line ambulances primarily reciprocated between an EMRC and the disaster area. Second-line ambulances were highly regulated between an EMRC and requested hospitals. The ambulance service of the sequential-conveyance was found to be more efficient than the conventional method for EMS transportation in a mass-casualty catastrophe.

The results of this method presented 52.15% and 56.02% in time efficiency and distance efficiency, respectively, for the case study of Xiaolin, that is a mountain village in Taiwan heavily damaged by a devastating mudslide during the occurrence of Typhoon Morakot [34]. The discoveries of this study showed that the ambulance service of the sequential-conveyance method was found to be more efficient compared to the conventional method and was concluded to be more profitable and logical accurate on paper for adaptation in MCIs of similar extreme events.

Another relevant research of EMS transportation that evaluates the performance of the medical personnel in the EMS actions by a standard metric focuses on the benefits of the registered nurses in the EMS teams [54]. Although different EMS teams have been established based on the diverse features of different countries, the performance evaluations of registered nurses in the EMS teams remain a challenge for the EMS experts, especially for the critical EMS cases, such as out-of-hospital cardiac arrest (OHCA) patients. A random participation of the registered nurses in the EMS teams for prehospital emergency care has successfully been implemented since 2005 at the ChangHua Fire Bureau in Taiwan [55]. The findings of this case study showed that the registered nurse-attended teams appear to have more medical benefits in saving the on-scene time for EMS system compared to the original EMS teams.

In addition to that, the attended registered nurses could give practical medical advices and decision-makings during the on-scene emergency care, place the collar or spinal apparatus to trauma cases needing collar and spinal board fixation (T-CS), as well as facilitate the immobilization of the injured portions, among other duties. For the OHCA cases of this research, the return of spontaneous circulation within two hours ($ROSC_{2h}$) rate was 7.14% in the original EMS teams, while for the registered nurse-attended teams was 20.00%. The participation of the registered nurses reached a 12.86% promotion in $ROSC_{2h}$ rate for OHCA patients, percentage which proves that the saved on-scene time can contribute to the real medical benefits of a life-saving purpose. Conclusively, in OHCA and T-CS cases, the attendances of the registered nurses in an EMS team can save the on-scene time with a statistical significance and a medical importance in prehospital care [55].

In this domain, the presented EMS transportation models reduce not only the response time of the EMS teams but also increase the efficiency of the involved parties. Future studies of similar approaches could further promote successful emergency transportation strategies and save the “golden time” of critical casualties.

## MCIM CLOUD DOMAIN

Communication is the key to success, especially if human lives are in danger in discrete areas [56, 57]. Nevertheless, when several EMS teams under different lead are involved, the situation becomes complicated. Updating the data in real-time is essential for identifying the patients’ condition, position, diversion, as well as the available resources. The MCIM Cloud Domain is a pioneering design that tries to bring an integrated cloud-based concept in the communication and information aspects, regarding a MCI. Under realistic conditions, all the related groups of the EMS providers act separately; yet via the MCIM Cloud, the data exchange and update will be indispensable in order to implement the patient regulation plan and to satisfy the information requirements of the terminal users.

In a patient-centered MCIM, all the involved physicians, regardless their location and team, must be able to receive the medical record of the patients immediately, the EMTs must be able to obtain accurate and updated information about the conditions of the disaster area, transportation roads, involved personnel, available emergency beds in response hospitals, etc. Furthermore, the administration units should be informed and updated about the on-scene processes and conditions of the MCI response in real-time, the relatives of the casualties should know their beloved ones’ condition and location, etc. The concept of the MCIM Cloud tries to resolve the aforementioned problems in communication and data transfering during an MCI. This idea is illustrated in Figure 3.

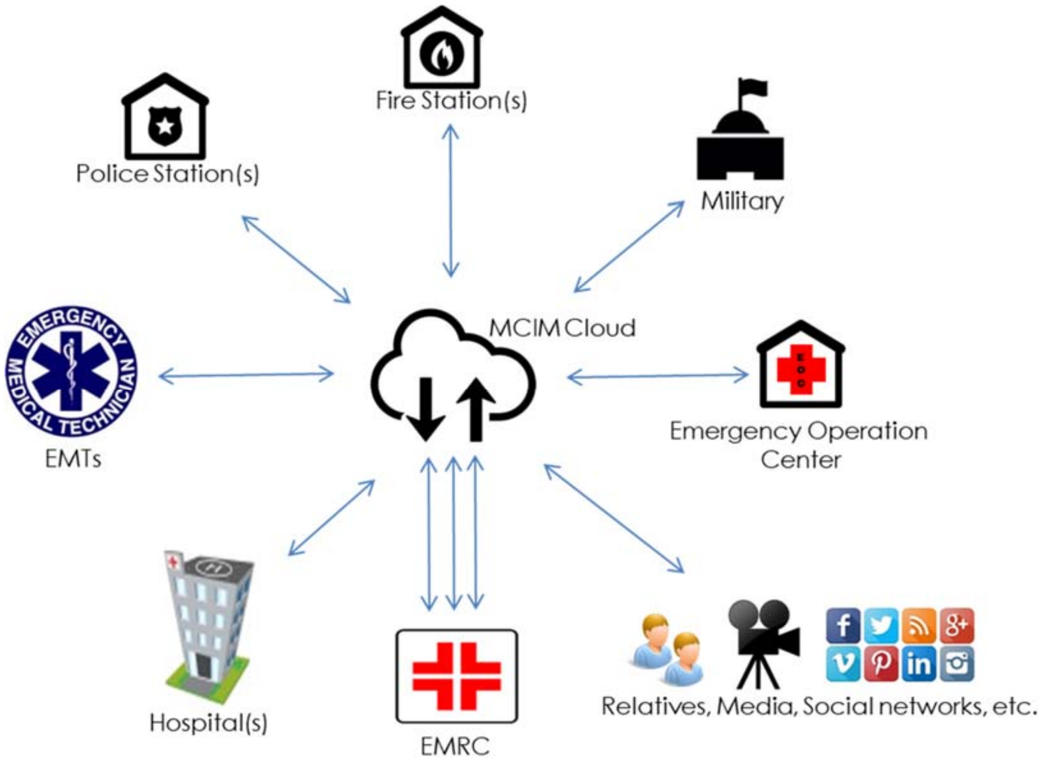


Figure 3. Diagram of the MCIM Cloud.

It should be stated that the numerous sources of information in data collection process must be emphasized in the initial phase of this domain. Every MCI can be described as a series of unexpected events that cause primary and/or secondary disasters that may have an impact on human life, surrounding systems and the environment. Such disasters could affect critical resources, networks and infrastructures; forcing the first responders to operate with limited amount of resources. Therefore, it is extremely important to properly handle all the available networking, physical and human information data in order to provide sufficient treatment to critically injured, in short time. Information systems for health matters have been successfully embodied in daily ED operations; nevertheless, connecting prehospital data smoothly and turning such systems into an integral part of the MCIM Cloud still challenges the researchers of this field [17].

Another obstacle in this domain is that the information released by a number of sources in extreme events is not always accurate and sometimes it can be deceiving. Audiovisual communication and information transfer are necessary for the efficient work of EMTs and the other emergency personnel, including the civilians that are operating on-scene. Moreover, response hospitals, authorities, witnesses and decision-makers are involved in a network of communication channels that exchanges information in real-time. The speed of transferring information is crucial, as it determines the “golden time” of casualties in critical conditions or prevents secondary disasters [58, 59].

Currently when MCIs occur, social media have a leading role in information that is shared by the witnesses [60-62]. Although this type of information transfer is accepted in emergency medicine, witnesses are not always in position to describe an event of disasters as detailed as the experts. Furthermore, the lack of relevant education and training for witnesses may result in false information that will perplex such matters. In such situations, it is up to the first responders to describe the incident to the other involved parties, including the media and relatives. Re-filtering information could lead to time loss that could affect the health condition of severe casualties. Cloud technology in combination with educational and training courses that provide the public knowledge of proper “witnessing” could be the innovative tools this domain acquires.

In Taiwan, a real-time report of the traffic conditions has been well implemented by the Police Broadcasting Service (PBS; National Police Agency, Ministry of Interior, Taiwan; besides the radio program, it is also available on http://www.pbs.gov.tw/cht/index.php) since 1990. The PBS collects all the incoming information from the witnesses and then disseminates the received information to the road users and to the competent agencies in order to do adequate responses as well as treatments. However, once this system is designed for extreme cases, such as MCIs, the quality and accuracy of the messages from the witnesses should be reliable and detailed. Each time there is an extreme phenomenon or a notable situation that may influence the traffic and the safety of the route, the witnesses can report (via SMS, phone calls, mobile applications, social media posts, etc.) the incident to a traffic service agency.

Additionally, the current (or a more advanced) monitoring system of cameras and the multi-monitoring system along the route can confirm the existence of such incidents and assist in trustworthy conclusions. So, the data collected from the witnesses can be evaluated more effectively and transmitted faster; as a result the provided information will become more reliable and helpful for the data mining process.

It is known that cloud technology and Wi-Fi systems allow the connection all received information. An emergency database that filters incoming information and crosschecks collected data could result in time efficiency for all the operations of MCIM. Furthermore, real-time updates that are presented simultaneously to all the involved principles encourage authorities for direct decisions. Although there are examples of the promising use of such communication systems [58, 63], emergency information platforms can be inefficient when the data are not accurate or precise. For that reason, it is essential to educate and train the public so to be able to respond explicitly to a certain level, and inform the emergency response authorities in a proper way.

Currently, professional communication systems for emergency incidents are mainly used by EMS personnel, while social media and phone contact are preferred by witnesses. This differential condition does not allow a comprehensive data collection that can validate emergency incidents precisely. The combination of all the available data resources under a “smart” filtration process could be the only way to improve the existing approaches, if and only if, witnesses are able to respond as “sensors” by providing truthful and essential information.

This can be further explained in the following example in which, an earthquake with a moment magnitude of 6.4 struck southern Taiwan at 03:57 on Feb 6, 2016, and caused 513 injured [64]. Remarkably at 04:05, several messages and images were reported in a discussion group of the widely used instant communication/social media application “LINE” in Taiwan, organized and administrated by the local EMTs. The major EMS responders were dispatched to the disaster area few minutes later via the understanding the condition of damage by the decision maker. Additionally, all the information was noticed forthwith by the Fire Bureau, the response hospitals, and the local Government. Owning to the high quality information from the local EMTs, the temporary Emergency Response Center was set up immediately by the local Government at 06:00 to manage and control the event.

The incident command system responded efficiently, due to the precise information given primarily by specified witnesses; nevertheless, this does not always apply in general witness cases. Two individuals shared fake posts on social media causing panic to people during an earthquake with a moment magnitude of 6.0 that occurred in the same city one year later, at 01:12 on Feb 11. Such phenomena appear globally and although there are mechanisms to prevent such incidents; retrieving rigorous information from witnesses is yet a challenge to the related researchers. The cultivated and qualified witnesses could cover the validation and dependability communication gaps towards a paradigm shift in social media. As the technological inventions and social networking become an integral part of daily life; their contribution in this domain could result in a more productive information flow for the other domains mentioned in this chapter.

## ON-SCENE SAFETY DOMAIN

Each time an MCI occurs, the EMS units set not only the triage but also the on-scene safety as their highest priorities [65]. In general, 5 social processes are followed within the emergency scene during the emergency operations, the establishment of a safety zone, the reduction of all kinds of uncertainties, the trajectory control of the scene, the current management (temporality) and the collateral monitoring of the scene [66]. Nevertheless, several post-MCI investigations show that failures in emergency response may occur, regardless the level, training or experience of the first responders [67-70]. Errors such as the miss-adhering to triage protocols, poor communication between the involved parties and the insufficient detection of secondary disasters or and late impacts are usual phenomena that highly affect those priorities [69-72]. This phenomenon can be widely observed during extreme weather events or unpredicted manmade disasters.

Due to unexpected events during the operations it is important to consider safety plans for the casualties, personnel, as well as the nearby populations. The EMS units, including the paramedics, are not always able to guarantee the safety, as each of the involved individuals could be threatened at any time, depending on the impacts of the MCI. Cases of current terrorist attacks for instance, prove that on-scene safety operations, do not always response effectively; the space inspection is done empirically or based on the available instruments that are not always proper, since they cannot detect late or random attacks especially in overcrowded areas [35, 73].

While emerging and IT technologies upgrade or alternate completely current emergency response mechanisms, it is essential to adapt such technologies in the vital operations of MCIs, such as safety [27]. Nanotechnology, as one of the very promising new technologies could assist the safety operations at a great level [74]. Nano-sensing could be an efficient early warning system for assisting paramedics, security units and local individuals to protect themselves and their properties against secondary threats, such as CBRNe attacks. Their accurate result data in real-time could increase the survival rate, as well as minimize or eliminate secondary threats [75].

Nevertheless, the on scene safety during MCIs is a sensitive issue, since the current operations may sometimes violate basic human rights for the sake of the public safety [76]. While such controversial techniques can be widely questioned, they are widely allowed and applied in such incidents. It is a crucial necessity, the safety operations to be designed and managed in a way that do not cause confusion with civilians while simultaneously are based on their needs [77].

Moreover appropriate education and training schemes for the civilians' behavior during MCIs could enhance all operations of this domain and allow the first responders to focus on care and transportation of the patients for an immediate evacuation. MCIM policies, in order to become more anthropocentric, require to be developed based on the affected populations' needs, the surrounding environment which may differ from previous incidents and the current conditions. Scenarios that solely focus on theoretical approaches of professionals do not always correspond to the reality of the casualties' perspective. Hence, the continuous involvement of experts, local communities and affected populations is vital for increasing the percentage of international safety strategies that can surpass the many obstacles this domain faces.

## CONCLUSIONS

Nowadays, MCIs have become not only a frequent but also a calamitous phenomenon; their unpredictable nature and consequences perplexes the response of the EMS systems and the related decision makers. While there are many MCIM mechanisms, they are not always able to deal with every type of MCI. Furthermore, deficiencies in on-scene operations, casualty distribution, EMS transportation, communication and information flow, as well as safety control, decrease the efficiency of the current MCIM models worldwide. Although international organizations investigate frameworks for a more sufficient emergency response, a lot more need to be accomplished in order to reach a satisfied level.

More specifically, new approaches must be adopted in management and operational procedures that will adjust every response between the involved emergency teams. What is more, "smart" EMS plans that increase the patients' survival rate should be followed. Emerging technologies could highly contribute in the field of communication and information so to minimize unnecessary delays or false data. Safety strategies could become more effective by including the possibility of secondary disasters or side effects. Training and education programs related to disaster management for the civilians/volunteers could improve the quality of information and services obtained by the witnesses,

Last but not least, successful cases of disaster medicine have one criterion in common, the team effort. Only by investigating and planning such events together, training and learning from past mistakes together the current policies can respond positively. This chapter introduces some alternative perspectives for the MCIM that could change the current viewpoint of the researchers and professionals, focusing on this field. The purpose of this article is to initiate pioneering approaches that could further advance the wide spectrum of MCIM and its products.

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