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The Management of Medical Services in the Early and Late Phase of Tsunami: A Preparation for Humanitarian Health Assistance

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1. Introduction

Tsunami is a series of ocean waves produced by a submarine earthquake, landslide, or volcanic eruption. These waves may reach enormous dimensions and may have sufficient energy to travel across the entire ocean and to destroy human lives near the beach up to a distance of some kilometers from the shoreline. Severe damage can be caused by large tsunamis to boats and other fishing equipments, to houses, to tourist resorts, to schools, to water and sanitation, and to infrastructures. In addition they can cause substantial damage to health services, which becomes an essential issue since these services are immediately needed for a quick medical response. If the medical response is late, then it leads to prolonging the provision of medical assistance especially to persons severely injured as well as to spreading of infectious diseases [1]. Indeed, suddenly after tsunami strikes the land, many people suffer traumatic injuries, that are caused by the impact of sharp or blunt objects. In this phase, sometimes there can be a further trouble when treating traumatic patients, because medical equipments might be broken as a consequence of the tsunami. Tsunami produce mud, causing contamination of water, which in turn results into sanitation and hygiene problems that may cause infectious diseases that may be complicated to treat. There are conditions that can be more difficult compared to other types of disasters. For example, the logistical problems of distributing goods could be very difficult due to bad weather, problematic access and limited transportation. Air, sea and land transportations need much more effort for distribution of medical services. Because of the tsunami damage, aircrafts could not land, ships or boats could only anchor at 500 m – 1 km far from the new coastline, made by tsunami, and trooper cars, trucks, and other land transportation vehicles could find it impossible to reach the disaster area. Usually, there is only one way to distribute the medical supplies in the early phase of tsunamis, i.e. by helicopter. Based on this situation, the medical assistance can be divided into two phases, that is the early and the late phase of a tsunami attack.

2. Time periods of medical assistance

Disastrous tsunamis have a bad impact on human beings causing severe health problems, that can be typically distinguished into critically ill patients due to traumas in the early phase and into infectious diseases in the late phase of the disaster. Indeed, the time period and the characteristics of the medical assistance after a tsunami attack can be divided into two phases, that is, an early phase and a late phase as shown in Fig. 1.

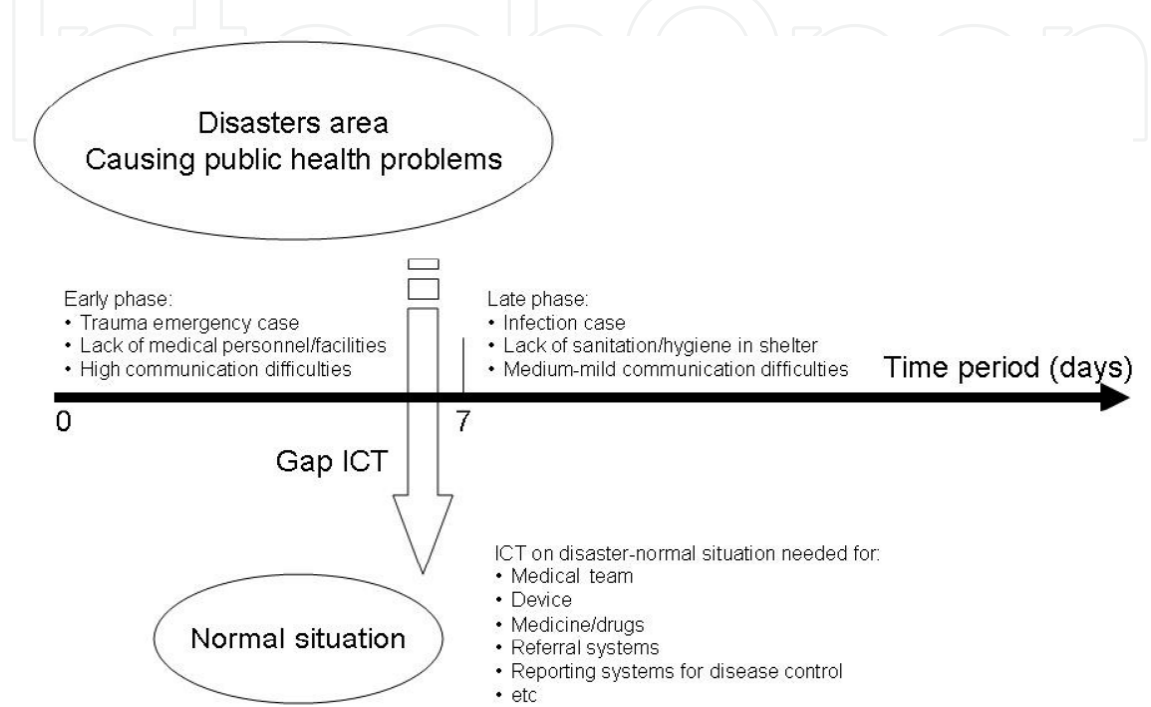


Fig. 1. Early and late phases after a tsunami attack

In the early phase, most patients are surgical cases due to traumas. This period is within 7 days after the tsunami. For the first 2-3 days, usually access to the disaster affected area is very difficult, especially in rural zones. The medical team should be formed by persons with different expertise. There should be not only medical personnel in the team, but it should consist for example of 1 medical doctor, 2 nurses, 1 telecommunication amateur radio staff, 2 members from the army (for security), some logistic support and 2 red-cross staff. Basic surgical devices and medicines, VHF (very high frequency) and HF (high frequency) radio communication devices should be brought by the medical team for backing up communication according to request or to order further medical devices and medicines. The team should perform rapid health assessment as well as provide medical services for the basic emergency treatments. It should also try to explore the remaining medical services that can be used to treat the patients. And further it should prepare the portable devices for sanitation water.

After 7 days, the disease pattern usually changes, because of lack of clean water, sanitation and hygiene, and at the same time, the immune systems get weaker due to lack of food distribution. Therefore contagious diseases start to appear, such as upper respiratory tract infections, diarrhea, and water transmitted diseases like typhoid [2]. This period can be called the late phase of a tsunami. In this phase, the medical team should focus on the infectious diseases and on wounds remained after surgical treatments that mostly are done

in the early phase of disaster. The order of medical devices, of medicines and referring patients to other hospitals can be requested through amateur radio links since official communications systems may have collapsed and satellite telephone still remains expensive in several countries, and especially in developing countries. Consider that even radio communications sometimes cannot be used properly, but it is certain that unavailability of communications can be a fatal drawback for patients and the medical team.

3. Medical care in the early phase

In fact, the first 7 days after tsunami are a critical period because many traumatic injured patients have to be evacuated as well as the critically ill ones. The existing hospitals next to the tsunami-affected area take the highest responsibility role of being referral hospitals before other health facilities can come and be set up. This situation becomes worse in case that electricity, drugs, medical devices, personnel might not be available properly [3]. Looking at past tsunami experiences, it is necessary to devise plans for health service centers that are found in areas having potential for a tsunami. For the local health officers, a referral hospital should have drugs and medical supplies stocks that can cover at least 20% of the total population, because this percentage may reflect the number of injured and critical victims after the strike of a tsunami. The hospital has to be established at least more than 5 km away from the sea coast or, if it is located closer to the coast, the minimum altitude above the sea should be more than 20 meter for contingency plans. Extra beds, clean water machines, helipads, electric generators, communication devices need also to be available.

In the day after the disaster, there should be at least one medical team already operational and ready to access the affected area, and in days 2-4 further medical teams could come possibly facing a lot of difficulties in transportation on land. If a hospital unfortunately is not available as back medical post, a field hospital needs to be installed with specific drugs and medical devices. Among them, one could mention aseptic materials, antiseptic drugs, broad-spectrum antibiotics, analgesics, local-general anesthesia, resuscitation drugs, portable oxygen cylinders with masks and nasal canules as well as endotracheal tubes for children and adults, resuscitation solutions like NaCl 0.9%, lactated ringer solutions, glucose 5% and 10%, neck collars and boards for evacuation. During the early phase, the most important issue is patients stabilization from life threatening, before providing definitive treatment. One crucial operation is a proper triage by labeling patients into red (critical), yellow (emergency, but not critical) and green (walking wound) categories, followed by black (dead), since making decision on priorities is very important for management of mass casualties.

Further, for the medical first responders working in disaster areas, personal kits should be prepared, including among others flashlights with extra batteries, portable batteries, emergency ready-to-eat food and water, cash and credit cards. The basic idea is that the team should be autonomous and should not depend on local society or resources, because the purpose of the team is to help the victims, not to annoy them.

4. Medical care in the late phase

In the late phase which starts about 7 days after the occurrence of the tsunami, health problems and medical needs differ from those found in the first 7 days. In the late phase, the emergency surgeries usually decrease and become elective surgeries. It is the beginning of

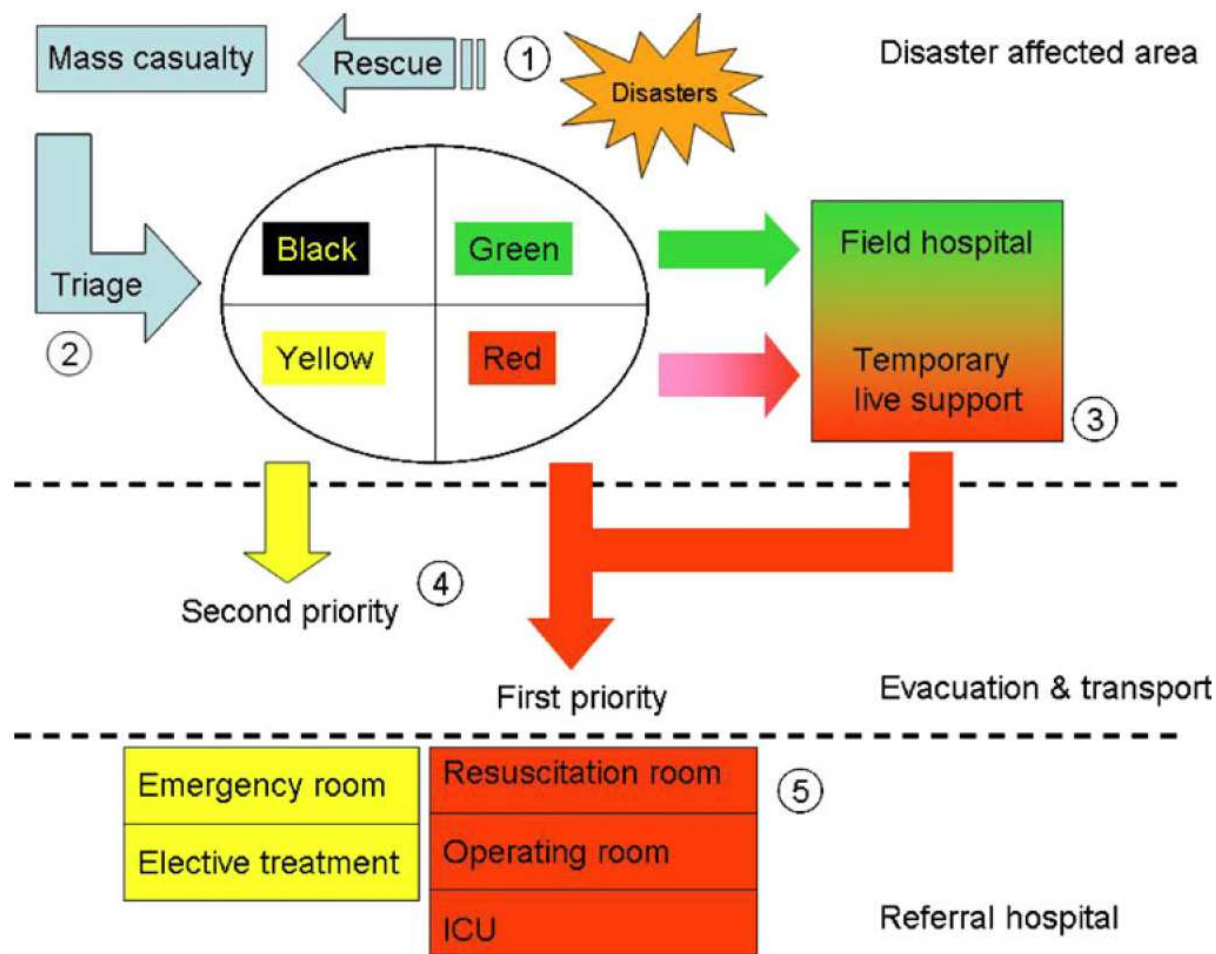
sub-acute and chronic medical problems which may be indicative also of lack of adequate healthcare infrastructures before tsunami [4]. Usually, at this stage, international medical teams come to bring medical care, medicines and supplies to all people affected by the massive disaster. There should be still a great concern in this phase, since shortage of clean water, lack of electricity, improper shelter, sanitation and hygiene problems may arise. The new medical teams should consider carefully what they have to bring with. At clinical examination, survivors could show upper respiratory tract infections as the beginning of infectious diseases. Gastrointestinal infection can occur due to lack of sanitation and hygiene, if clean water cannot be supplied immediately, and furthermore febrile illness and wound infection can manifest. This was the experience after the 2004 Indian Ocean tsunami of eight countries, namely, India, Indonesia, Malaysia, Maldives, Seychelles, Somalia, Sri Lanka, and Thailand [5]. In the late phase, the medical assistance teams should consist of not only medical doctors and paramedics, but should also include sanitarians, epidemiologists, water technicians, social workers, volunteers, and psychologists for post traumatic stress disorder (PTSD) treatment. This phase could last from months to several years. Therefore multidisciplinary teams must be formed in order to adapt to the chronic situation. Medical equipments such as quick laboratory test devices, portable x-rays, elective surgical instruments, antibiotics for aerobic and anaerobic bacteria, multivitamins, field hospital with extra beds and infuse hangers, bedside vital signs monitoring devices and portable ventilators with oxygen are needed.

5. Difficulties in medical assistance

In the first phase, when casualties start to arrive at a hospital from a disaster area, the initial step is the triage of patients, and the main concern at triage is trying to preserve the capacity of the hospital to treat those casualties with serious injuries or illness, but with a high probability of survival. The estimation of victims is difficult during the early phase, and therefore the cooperation among team members as well as the communication staff and logistic staff is important. The logistic staff has the task of searching for other hospitals where it is still possible to refer and distribute patients, and at the same time the communication staff should connect with other medical facilities.

The concepts of undertriage and overtriage are important to the overall understanding of the triage process. Undertriage is associated with triage sensitivity in identifying patients needing critical care interventions. This skill can be practiced on the daily activities in the emergency room for speeding up the triage ability. Undertriage occurs when the triage evaluation underestimates the severity of injuries and classifies the patient as noncritical. This has an obvious impact on the morbidity and mortality of the individual patient. Because no triage system is perfect, our acceptable undertriage rates have been defined as 5% or less. Overtriage occurs when a noncritical patient is triaged as a critical casualty. Rates of overtriage up to 50% have been historically defined as acceptable in our experience in an effort to reduce undertriage. Initial efforts in disaster triage have been directed at decreasing the level of undertriage with its logical and apparent adverse impact on the individual casualty. In the reality of triage, very high overtriage rates have been detected during mass casualty disaster settings like tsunami. Typical victims in tsunami become critical not only as the effect of traumatic injuries, but also in association with the drowning after they have been swept by water. Further, it is also to mention that it is more difficult to identify the level of triage because sometimes all of the body is covered by mud. A scheme of trial is shown in Fig. 2.

The main difficulties found in the late phase are related to the public health control. In the aftermath of tsunami, public health must often address issues such as damage to health, to sanitation, and water facilities, as well as to housing and agriculture. This may lead to a rapid increase of malnutrition and of communicable diseases, like measles, infectious diarrhea and pneumonia or even tetanus due to open wounds contamination. Fortunately, the provision of adequate clean water and sanitation, timely immunization, simple treatment of dehydration, supplementary feeding, micronutrient supplement and an adequate surveillance system greatly reduce the health risks associated with the harsh environment of refugee camps. Notice that after the early phase, usually the latrine construction begins for excreta disposal, but initial sanitation measures may be nothing more than simply designating an area for defecation in each camp. This preparation also has to be considered for the medical team during humanitarian assistance.



Source: Sutiono et al. [1]

Fig. 2. Communication network in emergency disaster

6. Discussion

A tsunami is a series of traveling ocean waves of extremely long length generated by disturbances associated primarily with earthquakes occurring below or near the ocean floor. Tsunamis are a threat to life and property for anyone living near the ocean [6]. In addition to

the impact on infrastructures, there is a direct impact on human beings, who may be killed or severely injured. The first phase of the medical assistance is defined here as the one needed in the first 7 days after tsunami. The medical team should be equipped with food, water, tents, generators and sleeping equipments. It should be a multidisciplinary team including also security members that can join from army forces/police to guard the team itself, as was experienced in Aceh, Indonesia, in case of the 2004 tsunami where protection was needed due to a long civilian conflict going on in the affected area. The most significant deficit in this phase is the lack of surgical equipments that usually are not sufficient to treat the so many injured victims [7]. Team should be supplied with stocks at least for one week of medicine and medical equipments. Such teams should be organized into three working shifts, namely morning to evening, evening to night and night to morning. Each team member can work for a maximum period of two weeks. The rapid health assessment is one of the tasks of the first team. Later, it should be replaced by the next medical team ready for this major humanitarian assistance, that works in the late phase of tsunami.

The main surgical problems are the vital signs monitoring and wound stabilization before continuing to the elective surgical treatment. This condition will be worse for elderly victims due to previous pre-existing chronic or underlying diseases.

Another important item is the network communication system. In developed countries like Japan these networks are well established, while in developing countries they are not, so that radio amateur communications or other data transmission systems are to be used (see for example the utilization of low-altitude platforms for emergency communication [1, 8]). Without communication systems, the medical assistance in this period faces great obstacles, because some of the victims have to be evacuated to other hospitals, and one has to order medical devices or medicines for surgical treatments from other places.

For a big city in which other hospitals may still be operative, the referral distribution of victims should be done in order that no hospitals be overloaded by patients. However, in a rural area where only one hospital is located the situation may be different. This was the case for the small hospital in Phi Phi island, Thailand. They considered that effective communication facilities must be ensured, by making a simple evacuation plan in advance. These plans should be made to ensure automatic reinforcement of remote areas with evacuation vehicles, medical equipments and personnel, efficient cooperation with medical volunteers, and every member of the hospital has to participate in an educational program periodically [9].

The late phase starting 7 days after the tsunami disaster has clinically and epidemiologically the same profile as that of a cyclone or a hurricane with resulting flooding. The causes of death are drowning and traumas from blunt or sharp objects, and injuries among survivors arise from complications of near drowning and traumas [10]. The short-term public-health needs of the surviving population are familiar: water, sanitation, food, shelter, and appropriate medical care administered to persons remaining in place and to the thousands who live in self-settled displaced communities. At this phase, the medical team consists of sanitarians, epidemiologists, social workers, technicians. Indeed the major public health priorities of ensuring the availability of clean water, adequate sanitation, emergency food rations and temporary housing are not technically complex, but accomplishing these goals in such a large geographic area as the one affected by a big tsunami presents tremendous challenges in terms of coordination and logistic capacities for transporting and delivering the necessary goods. Usually in this stage, international or national humanitarian assistance is also present to help the affected people.

Categories	Early phase (first 7 days)	Late phase >7 days
Team members	1 surgeon, 1 anesthesiologist, 1 general doctor, 3 nurses (from emergency and intensive care), 2 logistic staff, 1 communication staff, 1 security staff (army forces/police)	2 surgeons, 2 anesthesiologists, 2 general doctors, 4 nurses (emergency and intensive care), 3 logistic staff, 1 communication staff, 1 security staff (army forces/police), 2 epidemiologist, 3 social workers.
Medicines and equipments	Analgesics, antipyretics, aseptic antiseptics, anesthesia, broad-spectrum antibiotics, oxygen portable, 2 sets of minor and major surgical instruments including other supporting sets (neck collar, sterile gaze bandage, etc), sanitation water devices	Analgesics, antipyretics, aseptic antiseptics, anesthesia, antibiotics for aerobic and anaerobic bacteria, antitussives for coughing due to upper respiratory tract infections, anti- diarrhea due to lack of sanitation hygiene, surgical instruments
Transportation to access the disaster area	Mainly helicopter (or vehicles if possible)	Helicopter, vehicles, aircraft if possible (Hercules)
Working periods	Maximum 2 weeks	Maximum 1 month
Communications	If telecommunication infrastructure collapsed, use VHF radio communication for short distances (less than 2 km) and HF over long distances (more than 2 km). Satellite mobile phone if available, but very expensive.	Use telephone if already available. If not, radio communication is still necessary. Alternatively low-altitude communication platforms can be set up for broad connection access to internet network and mobile phone.
Personal equipments	Flashlight with spare batteries, ready foods and small snack like bread, water drinking, personal hygiene (toothbrush, soap, etc), sleeping bag, multiple penknife and scissor, matches, anti-mosquito cream e.g. endemic malaria, boot shoes, rain coat, etc	The same like in early phase, but the amount is more than in early phase due to long period of humanitarian assistance.

Categories	Early phase (first 7 days)	Late phase >7 days
Activities	Security assessment, triage mass casualties, resuscitation and stabilization for injured victims as well as surgical resuscitation, wound debridement and treatment, rapid health assessment for medical needs, preparing communication network to the remaining hospitals and field medical post, preparing other disaster possibility (e.g. nuclear, chemical contamination)	Security assessment, continuing medical treatment and scheduling elective surgery, sanitation and hygiene action promotion to the people, ordering the lack of medical tools and medicine using telecommunication network, managing referral patient, helping people from post traumatic stress disorder (PTSD), preparing other disaster possibility(e.g. nuclear, chemical contamination)

Table 1. The difference of medical activities between early and late phases after tsunami

The medical activities are mainly for elective surgical treatments and sanitation hygiene actions. The team may work for the maximum period of one month and can be replaced by the next team for the next one month. In Table 1, the main differences of medical activities between the early and late phases after tsunami are summarised. Although the late phase is not as busy as the early phase, however, the medical activities should be prepared properly. Preventing the complication after the initial and the stabilization medical treatments is also difficult. The long period of rehabilitation will make the patients to fall into the post traumatic stress disorder (PTSD) as well as into infectious diseases, and it may occur not only to the victims but also to the relief forces and medical workers. By this reasons, limiting the work of the medical team involved in humanitarian assistance operations in the tsunami affected area is very important [11].

Helping children after tsunami is also another challenge for the medical team. As tsunami is a rapid-onset type of disaster, children are at substantially increased risk for death. Typically, this is due to the dependent non-autonomous nature of a child and the relative lack of physical abilities to escape danger. Additionally, when children suffer severe traumas or near drowning submersion episodes (as they did in the recent 2004 Asian tsunami), the relative lack of pediatric expertise in critical care and tertiary pediatric facilities add to the mortality rate. The large number of refugees created by tsunami along with the frequent separation of children from families substantially increases the rate of child trafficking, baby snatching, and child conscription following the tsunami. This is unfortunately a common phenomenon to face for the medical teams in humanitarian assistance. An aggressive effort is needed to identify and register unaccompanied children displaced by the tsunami and a great deal of energy has to be consumed in the first 7 days (early phase) following the event. Respiratory illness and enteric disorders resulting in fluid loss are the most common causes of pediatric mortality in the immediate follow-up of the tsunami. Deployment of health care resources and rapid reconstitution of at least a basic public health infrastructure in the hit area will do much to alleviate the impact of such illnesses.

7. Conclusion

In tsunami aftermath, one can distinguish between two kinds of medical assistance activities. The first one is the early phase, which means that surgical cases are dominant as well as the preparation of security team, telecommunication staff, sanitation portable devices that are very important and should be dispatched by helicopter as soon as possible for early rapid health assessment. Instead, in the late phase of tsunami, the pattern of disease usually changes into infectious diseases due to lack of sanitation, hygiene and clean water, that among others may impact on infected wounds. Therefore, medical devices and teams must be prepared in a different way according to the time period where they are expected to operate in the post-tsunami.

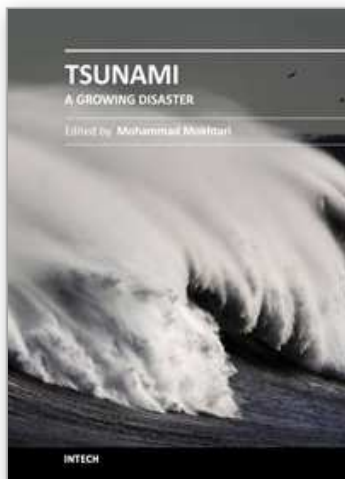
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The objective of this multi-disciplinary book is to provide a collection of expert writing on different aspects of pre- and post- tsunami developments and management techniques. It is intended to be distributed within the scientific community and among the decision makers for tsunami risk reduction. The presented chapters have been thoroughly reviewed and accepted for publication. It presents advanced methods for tsunami measurement using Ocean-bottom pressure sensor, kinematic GPS buoy, satellite altimetry, Paleotsunami, Ionospheric sounding, early warning system, and scenario based numerical modeling. It continues to present case studies from the Northern Caribbean, Makran region and Tamil Nadu coast in India. Furthermore, classifying tsunamis into local, regional and global, their possible impact on the region and its immediate vicinity is highlighted. It also includes the effects of tsunami hazard on the coastal environment and infrastructure (structures, lifelines, water resources, bridges, dykes, etc.); and finally the need for emergency medical response preparedness and the prevention of psychological consequences of the affected survivors has been discussed.

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