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Chapter

Outbreak of Traumatic Defeat Earthquakes: Health Consequences and Medical Provision of the Population

Diana Dimitrova

Abstract

Earthquakes are described as the most destructive and unpredictable disasters around the world. Many types of consequences are presented as possible negative effects including health-related of them. Identifying and categorizing the various health risk factors is an initial goal in an uncomplicated earthquake setting. Effective organization of the health care system (HCS) in case of complicated medical situation due to earthquakes and tsunamis is a serious challenge. The healthcare system operates at high speed with considerable difficulties in the event of a large magnitude outbreak of a traumatic defeat an earthquake. Possibilities to take adequate solutions in conditions of the worst-case earthquake scenario with the subsequent provoked multi-secondary disasters as tsunamis and with multi-secondary risk factors are highly motivating for the medical community with critically low resource constraints. On the one hand the analysis of the structure of mass victim and medical triage in a complicated scene due to earthquakes is a difficult process. On the other hand medical provision of the population in highly destructive earthquakes is limited by time.

Keywords: earthquakes, health consequences, medical provision of the population, emergency and disaster medicine

1. Introduction

In case of emergencies and disastrous situations (EDS) the medical provision of the injured population (MPIP) is a key point in the emergency plan of the health system (HS) [1–3]. This is strongly regulated by the HS of the country [2]. The action plan of EDS is a consistent, up-to-date annual task in order to maintain a highly optimal readiness for rapid response [2–4]. The availability of action protocols for each individual critical care potion guarantees confident firmness and readiness for an operational response [5–7]. Medical provision of the population with sufficient resources is the basis step to solve during managing the situation [7, 8]. Interaction with other systems is essential for rescuing and providing effective medical care to the affected population [8, 9]. The coordination of the EDS activities on a large scale is a solid fundament principle for the correct direction of the actions [7–9]. The participation of international organizations, forces and resources is a possible option in case of the EDS with a serious territorial scope and severely affected available resources [10].

A special type of disasters, which is characterized not only by mass but also by the diversity of damage to the population are high magnitude earthquakes and tsunamis [2, 7–9].

According to the World Health Organization (WHO), on average more than a million tremors occur annually in the world, of which about 100,000 have a magnitude of 3–8 Richter and are felt by humans. Some of the strongest earthquakes in the world are: the Assam (June 12, 1897) in Northeast India; The Japanese (September 1923), in which the cities of Tokyo and Yokohama were destroyed; Gobi - Altai (December 4, 1957); Chilean (May 29, 1960); the Alaska Earthquake (March 28, 1964); the Armenian Earthquake (December 7, 1988); the earthquake and tsunami of December 26, 2004 after which almost 230,000 missing and presumed dead [11]; the earthquake in Haiti (January 12, 2010) that killed more than 230,000 people and another 300,000 were injured [12]; the earthquake and tsunami in Japan (March 11, 2011), which killed more than 15,800 people, injured more than 6000 and disappeared more than 2500 people [13].

2. Medical provision of the population: Goals, principles and tasks

The medical provision of the population (MPP) is an element of an activity and a plan of the health care system especially due to EDS [7]. In case of emergencies it is based as much as possible on the existing health care system and only with an organizational approach moves to a new mode of work with available staff and sources [8–10]. MPP according to real practice, results of an epidemiological survey and documentary research is defined as a complex of interconnected organizational, medical and hygienic-anti-epidemic measures [7–10, 14].

It seems that the Aim of MPP is organized in a few groups of actions:

1. *Preservation of the health* and strengthening of the physical condition and working capacity of the population.

2. *Saving the lives* of the affected people and reducing mortality and disability and the fastest recovery of health and work ability.

3. Prevention of long-term diseases.

4. *Preventing infection diseases*.

The occurrence of different types of traumatic defeat due to huge EDS with diverse injuries [7–10, 14, 15] determines the main principles of MPP [7–10].

The main Principles of MPP due to contemporary scientific knowledge are collected in some main key points [7–10, 16]

1. *Universality* of using of medical resources.

2. *Maximum allowable economy* of using of available resources.

3. *Implementation of the medical evacuation* into a MPP activity.

4. To *use correctly* Unified rescue system with unified emergency number for providing MPP.

5. To use *unified doctrine* for rendering medical aid and treatment from the epicenter of defeat to the ends in the multi-profile and specialized medical establishments until the final outcome.

For the correct understanding and optimization of the activities connected with EDS the tasks of the MPP are divided into three groups depending on the time for their implementation – before, during and after disaster strike [7–10, 16–18].

1. Before:

   - Study of the devastating effect of various factors in EDS and the means for prevention, diagnosis and treatment.
   - Planning the activities of the health system for MPP.
   - Construction and maintenance of formations and resources of the MPP.
   - Creation of the medical and sanitary property.
   - Training, drills, workshops for preparing medical staff to react as better as possible.
   - Constant and regular current hygienic control.

2. In case of threatening and an ongoing EDS:

   - Deployment of the medical formations according to the operational plan, keeping them ready for work and protection.
   - Bringing the health risk management system into readiness.
   - Strengthening the medical provision (MP) system and teams and start MP of the evacuated population from epicenter, during transport to emergency room.
   - Strengthening and targeting the operational and special preparation of medical staff to starting and working into epicenter.
   - Strengthening the epidemiological surveillance of the territory.

3. After:

   - Medical reconnaissance.
   - Introduction of the formations in the center of defeat.
   - Organization and rendering the first medical aid in the center of defeat.
   - Removal and evacuation of the victims for appropriate care and subsequent treatment.
   - Provision of complex of hygienic and anti-epidemic measures.
   - Continuous management and maneuver for the most appropriate use of the medical forces and means.
   - Conducting a forensic medical examination of the victims and their identification.

Proper performance of these tasks is a prerequisite for providing in the shortest possible time the optimal amount of medical care to the largest possible number of victims [2, 7–11, 14, 16–18].

3. Earthquakes as an outbreak of traumatic damage: Risks and consequences

3.1 Mass destruction after earthquakes

Affecting large areas with mass destruction and mass loss is a typical effect after hug magnitude earthquakes [2, 7–10, 13, 19–22]. A typical example of possible consequences in large-magnitude earthquakes is presented in **Figures 1** and **2** in Bulgaria due to some of the most destructive earthquakes in XX century (**Figures 1** and **2**) In Gorna Oryahovitsa region, M = 7, 1913 and in Blagoevgrad region, M-7,8, 1904 are described the biggest earthquakes in Bulgaria. Totally are destroyed respectively Gorna Oryahovitsa and Kresna. Industrial sites, homes, hospitals, public buildings, utilities, underground and aboveground technical facilities, transport hubs, etc., are damaged or destroyed [2, 7–10, 13, 19–22]. This significantly impedes rescue operations, effective enough immediately after the earthquake occurs [7–10].

3.2 Secondary disasters due to earthquakes

Analysis of primary and secondary statistical data [2, 19–21, 23–26] shows that occurrence of secondary defeats after an earthquake is a common effect [7–10]. This increases number of risks factors and character of injuries among the affected population. According to analysis some of possible secondary disasters after earthquakes are [2, 7–10, 13, 19–21, 23–26]:

1. *An outbreak of chemical contamination* by industrial poisons. Observed in the area of the incident due to the destruction of chemical enterprises, warehouses with agricultural or industrial poisons. The chemicals produce not only acute intoxication but also long-term heath effect and cancer diseases as well [7, 10, 19].

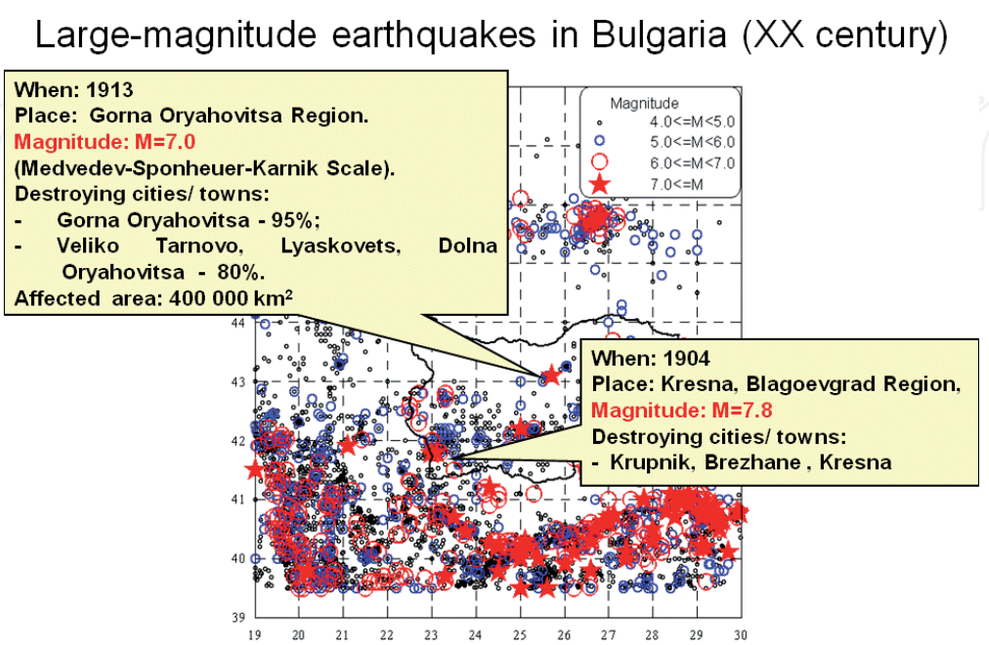


Figure 1.
Large-magnitude earthquakes in Bulgaria-in Kresna and in Gorna Oryahovitsa. Evidence-base practice database (XX century) (Sources: National Institute of Geophysics, Geodesy and Geography (NIGGG) in Bulgaria.)



Figure 2.
Large-magnitude earthquakes in Bulgaria-in Kresna and in Gorna Oryahovitsa. Photos (XX century) (Sources: National Institute of Geophysics, Geodesy and Geography (NIGGG) in Bulgaria).

2. Occurrence *of explosions and fires* due to destruction of flammable or explosive objects as petrol station after large magnitude earthquakes. They can develop dangerous additional consequences as fire burn, chemical burn, traumas, toxicological injuries etc [7, 10].

3. Destruction of buildings and severe *air pollution* with fine dust particles in large enough areas because of an earthquake leading to casualties, poisoning and suffocation [7, 10, 13, 19, 23–26].

4. *An outbreak of nuclear damage* such as Fukushima Daiichi nuclear accident, 2011 due to the large earthquake and tsunami is a real consequences. Radiation as danger risk factor produce particular health problems, which can be: acute, or chronic; somatic or genetic; stochastic and non-stochastic diseases; and long-term effects [7, 10, 13, 23–26].

5. *A tsunami* is generated often by underwater earthquakes. Fukushima 2011 and Haiti 2010 are significant examples and it is shows that many health problems influence not only primary effected county, but also much more people around the world for many years [1, 7, 8, 13].

6. Occurrence of *catastrophic floods* [1, 7–9, 11–13] after earthquakes can increase number of traumas due to new risk factors with leading place and role for the speed and depth of the water flow. On the other hand can cause hypothermia [7, 10, 27] especially for infants, adults, for the chronically ill and for people with special needs like people with compromised vision or limbs. Can be formed a new defeat of waterborne disease such as Cholera as well (like Haiti, 2010) [1, 7–9, 12].

7. *An outbreak of biological contamination* and infectious diseases can be created after a destructive earthquake within or without a tsunami wave (Like Haiti, 2010; like Nepal, 2015) [1, 7–9, 21, 22].

8. Occurrence *of landslides and avalanches* (Nepal, 2015) [1, 21, 22].

9. *An ecological disaster* and even local environment can be changed totally (Kresna, Bulgaria, April, 1904, with 7,8 M) [7–9].

10. *A volcano* generated by an earthquake as a secondary disaster. Discarded volcanic ash and toxic substances affect the environment and people [7–9].

11. *Traffic accidents* due to earthquakes [7–10].

12. *Social related and financial crisis* due to earthquakes [1, 7–10, 13, 17].

3.3 Victims: Main structure and frequency of traumatic health related effects

It seems that after huge earthquakes a large number of victims and injuries are occurred. According to experts, many numbers of victims need emergency medical care at the same time [7–10]. The nature and structure of the injuries can be very diverse [7, 13]. Injuries to the musculoskeletal system, extensive burns, prolonged compression syndrome due to prolonged compression of individual limbs or parts of the body, injuries to large blood vessels predominate [7–10]. A significant percentage of victims may be in a state of shock [7, 10, 27], with acute respiratory and cardiovascular insufficiency, in need of urgent respiratory and cardiovascular resuscitation [7, 10], neuropsychiatric disorder due to the experienced mental stress and others. According to scientific research [7, 10], by severity, medical losses are divided into the following groups: lightly injured (40%), moderately severely and severely injured (60%), of which 20% need specialized medical care.

3.4 Pollution from different origin as health risk factor

Creating a severe hygienic-epidemiological situation on the territory of the outbreak of traumatic defeat is defined as a big health risk factor. Prerequisite for this is the pollution of the territory from the destruction of water supply and sewerage systems, difficulties in finding the corpses of dead people and animals, the appearance of rodents, insects etc. The appearance of diseases of infectious and non-infectious origin is possible, as well as the appearance of epidemics - typhoid fever, paratyphoid fever A and B, salmonellosis, hepatitis, cholera etc. [7–10].

4. Health risk management: Essential principles

4.1 Role and place of the medical forces and resources for MPIP

4.1.1 Emergency care system (ECS)

Usually the signals for victims of an accident or disaster are received by the medical director (manager) of the emergency room and emergency hospitals as medical institution from ECS. Firstly, emergency medical care center (EMCC) as a front line of health system is informed by Unified rescue and emergency number 112 (UREN-112). (**Figures 3** and **4**) A general scheme of UREN-112 system in Bulgaria is presented in **Figures 3** and **4**. By National System – 112 among affected area, start working together teams of EMCC and Fire Safety and Civil Protection directorate (FSCPD). Police as a part of Ministry of Interior (MI) take place and



Figure 3.
A general scheme of UREN-112 in Bulgaria.

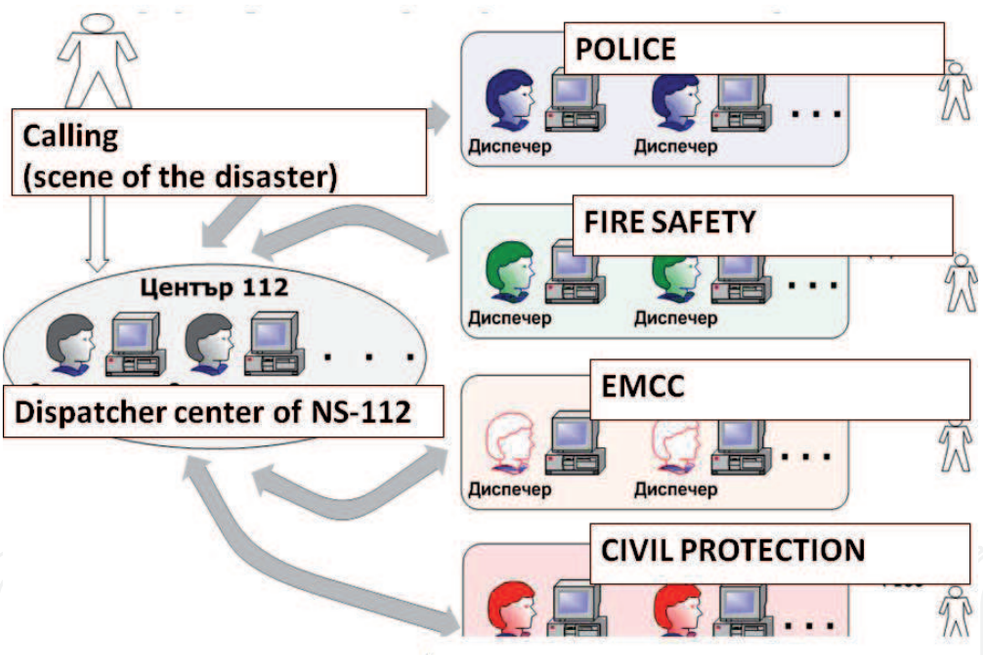


Figure 4.
A general scheme of NS-112 in Bulgaria.

control the entrance and exit of the affected area. The teams of EMCC are the first to go to the scene of the EDS as disaster event [7–10, 14, 16–18, 27].

In large-scale disasters, the EMCC teams are not enough to provide the necessary amount of medical care to those in need. This requires in advance being formed, prepared and equipped additional teams of staff of medical institutions for their inclusion in the provision of medical care. In addition to these medical teams for the population, especially in earthquake-prone areas or areas with chemical sites in anticipation of numerous medical losses, emergency hospital medical teams and emergency military teams can be used. These are medical formations built on a functional principle with opportunities to provide emergency qualified therapeutic and surgical care for vital indications [7, 14, 16–18, 27].

4.1.2 Hospitals

The main tasks of the hospitals in EDS are the provision of medical care and treatment of the victims and hygienic and anti-epidemic provision of the affected regions, and by order of the chairman of the respective commission (district, municipal) and neighboring regions [7].

The network of health facilities and their infrastructure must be ready to provide timely emergency and specialized medical care to the population in emergency and disaster situations [2, 7–9, 16–18, 27].

Knowledge of the factors that can lead to damage to health or endanger the lives of people in EDS allows them to predict the medical consequences, to clarify ways to combat them, to take the necessary preventive measures to limit the medical consequences, to organizing emergency medical measures and eliminating the consequences of emergencies [7, 8].

The hospitals provide the necessary human and material-technical resources, create an effective organization and keep in constant readiness the forces for immediate action in EDS [2, 8].

Before the occurrence of the disaster, the head of the medical institution – hospital must make a comprehensive assessment of the condition and the ability of the health institution to work in such a situation. During this period, the action plan for the EDS and the work of the medical institution for the medical provision of the population of the respective territorial unit must be developed, in accordance with the plan of the Ministry of Health [2, 8, 16–18, 27].

The plan is developed in different variants depending on the expected nature and severity of the medical losses and includes the following [7, 8]:

1. Creation and maintenance of a system for notification of the employees of the hospital.

2. Calculation of the medical losses and of the necessary forces and means for rendering medical aid to the victims.

3. Necessary medical teams and formations for rendering emergency and urgent medical aid, as well as inpatient medical care.

4. Creation of an appropriate structure (restructuring) of the bed base of the medical institution if necessary.

5. Organizational scheme for providing medical care at the site of the lesion, during transportation and in the medical institution.

4.1.3 Regional health inspectorates (RHI)

The Regional Health Inspectorates (RHI) are developing a work plan for the Hygiene and Epidemiological Provision and Inspectorate in the disaster area. It must be in accordance with the plan for conducting rescue and other urgent works of the regional and municipal commission [7, 8].

In case of disasters, the director of RHI [7–9] clarifies the place and nature of the event, then organizes and conducts research and control of environmental hygiene parameters in the affected areas, in industrial and other sites in terms of toxic substances, dust, noise, vibration, microclimate, radiation and other harmful factors. This activity is carried out by pre-formed and trained anti-epidemic teams of RHI on the territory of the disaster [7].

The main task of the RHI is the organization and implementation of disinfection, disinsection, deratization and control of the degassing and decontamination activities in the affected areas after the normalization of the situation [8].

The number and nature of foodstuffs affected by the disaster, the type and quantity and the nature of the damage must be clarified, and enhanced sanitary control must be organized over all foodstuffs in the disaster area. This requires organizing and conducting intensive laboratory control over the affected catering establishments and food industry establishments.

Based on the conclusions of the analysis, the RHI prescribes measures for compliance with hygiene standards and requirements for all factors of the working environment. After conducting a control for hygienic efficiency of the conducted measures, a conclusion is given for safe working conditions with a view to resuming regular operation of the affected sites [7, 9].

4.2 Organization of MPIP

4.2.1 Surgical and trauma care

The relevant clinics from the Multidisciplinary Hospital for Active Treatment (MPHAT) and Hospital for Emergency Medicine, as well as the clinical departments of surgery, orthopedics and traumatology, resuscitation and anesthesiology in the district, regional and municipal hospitals are used as a base. If necessary, the bed capacity of the same hospitals is used. In some cases, staff and facilities from other surgical units (ophthalmology, maxillofacial surgery, etc.) of hospitals can be used. This allows in EDS for a short time and without significant difficulties to be included in the organizational scheme of medical care. About 60% of the inpatients can be discharged and a specialized bed stock can be released for the needs of the victims. For work in a trauma center, if necessary, medical teams (trauma, surgical, etc.) are formed on a functional principle, without seriously violating the readiness of these wards for admission and treatment of victims. These teams must arrive at the scene no later than one hour after the emergency medical teams. At this time, the medical situation, the scope of work and the possible number of required specialized surgical teams should be clarified. If necessary, they can be strengthened with teams from medical institutions in neighboring regions [7, 8].

4.2.2 Radiological care

In case of accidents at the NPP, in case of incidents with sources of ionizing radiation, in case of cross-border transfer of radioactive substances in the therapeutic wards of the MPHAT, an opportunity must be created to provide radiological assistance to the victims. All therapeutic wards of the medical establishments, in the vicinity of the NPP, must be ready for possible admission of radiation patients and those with combined radiation injuries. For this purpose, it is necessary for physicians-therapists to have radiobiological training and in case of radiation conditions to organize the work of the ward in radiological terms and to conduct radio protective measures in the medical institution. The existing departments of radiotherapy and isotope diagnostics, based most often in oncology dispensaries, oncology hospitals, etc., have a corresponding place in this functional radiological system. The medical staff from these radiology departments are involved in providing radiological assistance to the victims [7, 20–26].

The duty and responsibilities according to the International Atomic Energy Agency (IAEA) require doctors to have the relevant knowledge of radiation

protection, which enables them to initiate preliminary treatment and provide assistance to specialized units in the event of a radiation accident. Another task of health care in the section of radiological care is the control of the radiation parameters of the working and living environment, which directly affect the person [22]. The radiation control department must organize and conduct the necessary radiation-hygienic measures on the given territory.

The organization of the radiological assistance is related to the plan for radiation protection of the country in case of an accident at the NPP, which ensures the implementation of the plan in its medical section [7, 20–26].

4.2.3 Toxicological care

The organization of toxicological care uses a mixed approach, including the establishment of staff and functional units. The expanding chemical pathology necessitated the establishment of full-time clinics and toxicology departments in the settlements with large sites of the chemical industry. These units, in addition to providing toxicological assistance to the population, also serve to train medical personnel in this field. In the other hospitals, the therapeutic wards are re-profiled into toxico-therapeutic ones for admission of toxicologically ill patients for emergency toxicological care. Good interaction should be ensured with the intensive care unit of the hospital [7, 10].

On the basis of the staff clinics and toxicology departments, specialized medical teams are established, provided with medical and sanitary equipment and transport [7]. These teams must be constantly prepared to work in a chemical outbreak or to strengthen the therapeutic wards of neighboring hospitals where toxicologically ill patients are hospitalized [7–10].

4.2.4 In outbreak of biological contamination (OBC)

When creating an outbreak of biological infection all types of medical care (first medical, qualified and specialized) [7] are within the area of the outbreak. For this purpose, the medical and prophylactic establishments on the territory in the OBC mainly are used [7–10].

4.2.5 In the outbreak of combined defeat

The first medical and qualified medical care for vital indications is provided at the medical center according to various schemes [7]. Most often, two groups of medical forces are created for rescue operations in the center of a combined defeat: in the biologically infected area and outside it [8, 9].

5. Medical triage in an OTD

Medical sorting [7] is performed in the OTD. According to the severity of the OTD [7, 9], the distribution of the victims by sorting groups allows for homogeneous treatment and prevention measures [8, 10, 16, 17].

Depending on the severity of the injuries the victims are sorted into two main groups in Bulgaria [7, 10]:

a. Slightly injured (40%). This group includes victims of soft tissue injuries who do not need hospital treatment;

b. Moderately and severely injured (60%). These are victims who need urgent medical attention and inpatient treatment. This group can be divided into four subgroups:

- Group T1. Persons with immediate vital disorders (20–40%). This group includes victims with respiratory failure, cardiac arrest, ventricular fibrillation, huge bleeding, shock, increased intracranial pressure, burns of the face and respiratory tract, or extensive burns occupying more than 20% of the body surface; poly-trauma. The victims of this group receive emergency first aid in order to stabilize the basic vital functions and have priority in treatment;

- Group T2. Persons to whom medical care can be postponed for 6–8 hours (20%). These victims have an advantage in transportation, but do not need extreme treatment. These include victims with some thoracic and abdominal injuries, injuries to the uro-genital tract and some blood vessels, burns less than 20% of the body surface;

- Group T3. Injured with some cranio-cerebral injuries, some spinal cord injuries and slightly injured (40%). These are persons with injuries of the small bones of the frontal part of the skull (mandible, nose, orbits), medium and small soft tissue injuries, etc.;

- Group T4. Dying and agonizing.

Particular attention in medical sorting should be paid to groups dangerous to others and in need of urgent medical attention. Dangerous for others are those infected with poisonous substances, radioactive substances, bacterial agents and patients with particularly dangerous infections (PDI), mental disorders etc. This danger imposes the need for sanitary treatment of the infected and isolation of patients with PDI, mental disorders as well.

6. Preventive measures for primary risk reduction

Prevention of the population in favor of public health and the future of the nation is fundament for stabilization of the health system in case of EDS [7, 8, 16, 17]. Prophylaxis measures (PM) used for primary risk reduction is only first group of tasks and primary step for government and national health system. **Figure 5** presents the main groups of measures for prevention of destructive earthquakes distributed in time: before, during and after. (**Figure 5**) According to science society some main PM are:

1. Earthquake forecasting.

2. Establishment of well-equipped and prepared seismic stations and a notification system.

3. Scientifically based anti-seismic construction.

4. Compilation and timely updating of a map of OTD threats.

5. The approaches to the hospitals should be known and organized in case the entrances are covered with destructions. For each hospital, which is located in an area with high seismicity, a helipad should be provided.

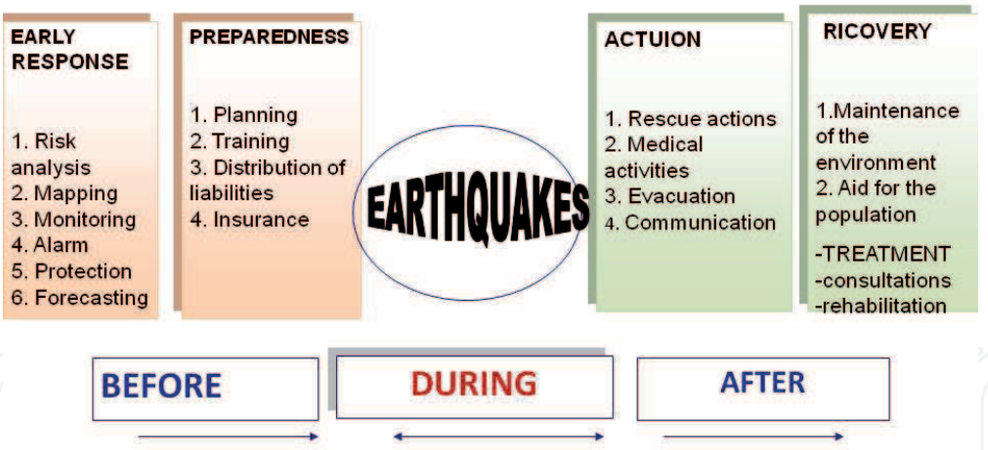


Figure 5.
The main groups of measures for prevention of destructive earthquakes distributed in time: before, during and after.

6. Systematic training of medical forces

7. Systematic preparation of the population to react and provide main first medical aid steps.

7. Conclusion

Earthquakes, unlike other disasters, are characterized by sudden onset and rapid flow. An in-depth analysis of earthquakes shows that they are characterized by a number of specific features. In earthquakes the response time is practically a very limited resource. The multi-factorial nature of the risks due to an earthquake and the possible consequences require good preparation and collaboration of various institutions with the healthcare system in the OTD. The medical provision of the affected population includes all levels of management of the health care system. The field work on the medical provision of the injured people is based on the EMCC. Proper medical triage and the provision of medical care in OTD is a staged process. In case of traumatic defeat of EDS it is use the two-stage system with evacuation by appointment as method for MPIP.

Conflict of interest

The author declares no conflict of interest.

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Author details

Diana Dimitrova
Emergency CC, Department of EM and MCS, Stanke Dimitrov, Bulgaria

*Address all correspondence to: d.dimitrova.phd.md@abv.bg

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