Emergency Medical Assistance Team Response following Taiwan Chi-Chi Earthquake

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Abbreviations:
EMATs = emergency medical assistance teams

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Abstract

Introduction: On 21 September, 1999, an earthquake measuring 7.3 on the Richter scale, struck central Taiwan near the town of Chi-Chi. The event resulted in 2,405 deaths and 11,306 injuries. Ad hoc emergency medical assistance teams (EMATs) from Taiwan assumed the responsibility for initiating early assessments and providing medical care.

Objective: To determine whether the EMATs served a key role in assisting critically injured patients through the assessment of number and level of hospitals responding, training background, timeliness of response, and acuity of patient encounters.

Methods: Local and national health bureaus were contacted to identify hospitals that responded to the disaster. A comprehensive questionnaire was piloted and then, sent to those major medical centers that dispatched EMATs within the first 72 hours following the quake. In-depth interviews also were conducted with team leaders.

Results: A total number of 104 hospitals/clinics responded to the disaster, including nine major medical centers and 12 regional hospitals. Each of the major medical centers/regional hospitals that dispatched EMATs during the first 72 hours following the quake were surveyed. Also, 20 individual team leaders were interviewed. Seventy-nine percent of the EMATs from the hospitals responded spontaneously to the scene, while only 21% were dispatched directly by national or local health authorities. Combining the phases of the disaster response, it is estimated that only 7% of EMATs were providing on-site care within the first 12 hours following the earthquake, 17% within <18 hours, and 20% within <24 hours. Thus, 80% of these EMATs required >24 hours to respond to the site. Based on a ED I-IV triage system (Level-I, highest acuity; Level-IV, lowest acuity), the vast majority of patient encounters consisted of Level-III and Level-IV patients. Fewer than 16% of teams encountered >10 Level-I patients, and <28% of teams evaluated >10 Level-II patients.

Conclusions:

1. The response from EMATs was impressive, but largely uncoordinated in the absence of a pre-existing dispatching mechanism.
2. Most of the EMATs required >24 hours to reach the disaster sites, and generally, did not arrive in time to affect the outcome of victims with preventable deaths. Therefore, there is an urgent need to strengthen local prehospital care.
3. A central governmental body that ensures better horizontal and vertical integration, and a comprehensive emergency management system is required in order to improve future disaster response and mitigation efforts.

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Introduction

Taiwan is located in a seismically active region in the Pacific Rim of Asia and experiences frequent quakes of varying magnitude. On 21 September 1999 at 01:47 hours, an earthquake measuring 7.3 on the Richter scale struck central Taiwan near the town of Chi-Chi. The event resulted in 2,405 deaths and 11,306 injuries.[1] A total of 468 healthcare facilities sustained significant damage during the earthquake, including 79 hospitals, 199 clinics, three long-term care facilities, two nursing homes, 64 public healthcare stations, two stand-alone laboratories, and 117 pharmacies.[2] The total repair costs have been estimated at USD$92 billion.[3] During such earthquakes, early assessment and prompt treatment of life-threatening injuries are required to improve survival outcome.[4,5] While the healthcare systems were impacted substantially by the event, ad hoc emergency medical assistance teams (EMATs) from around Taiwan assumed the responsibility for initiating early assessment and care of the wounded, as well as for restoring the public health infrastructure.

Shortly following the Taiwan earthquake, the EMATs were among the first to respond to the affected areas. These ad hoc teams were not part of a national response plan and varied in composition and capacity. Generally, the EMATs were organized by individual hospitals, and were comprised of a wide range of healthcare professionals with varying levels of disaster training and experience. In addition, over the next several days, >30 rescue teams from 20 countries arrived in Taiwan, bolstering disaster relief operations.[2]

The objective of this study was to determine whether Taiwan's EMATs served a key role in assisting critically injured patients using assessments of the number and level of hospitals responding, training background, timeliness of response, and acuity of patient encounters. The logistics and effectiveness of the EMATs' response following the Chi-Chi earthquake are reviewed and implications for future disaster preparedness, response, and mitigation efforts in Taiwan are discussed.

Methods

This investigation was carried out using an observational study design. Institutional review board exemption from full review was obtained. Local and national health bureaus were contacted three weeks after the earthquake to identify hospitals that responded to the disaster areas. In Taiwan, the Department of Health has categorized larger hospitals into 14 medical centers, 29 regional hospitals, and 16 district hospitals.[2] Although numerous hospital-based EMATs responded to the earthquake to some extent, most of the EMATs were comprised of unorganized healthcare providers representing major medical centers and regional hospitals that provided the bulk of the care.[6] All major medical centers and regional hospitals that dispatched response teams during the first 72 hours were surveyed and international teams were excluded. The study questionnaire was developed to include items on team composition and demographics, prior disaster training, timeliness and logistics, preparedness, and patient encounters and acuity. It also included a self-assessment section of the emergency medical response using Likert-scale scoring. A pilot survey was conducted at several local hospitals. In addition, in order to gain a better understanding of the details of the emergency medical response and team dynamics, in-depth interviews were conducted with 20 team leaders. Data were stored in Excel 9.0 (Microsoft, Redmond Washington, USA). Statistical analysis was conducted using SPSS 8.0 for Windows. (SAS Institute, Cary, North Carolina, USA)

Results

A total number of 104 teams from hospitals or clinics responded to the disaster, including nine major medical centers and 12 regional hospitals. Surveys from 30 individual teams representing nine major medical centers and seven regional hospitals (76% of major medical centers and regional hospitals) were obtained.

Team Activation and Composition

Seventy-nine percent of the EMATs from the hospitals responded spontaneously to the scene, while national or local health authorities directly dispatched only 21% of the EMATs. Medical doctors comprised 39% of surveyed teams; 61% were nurses and other supporting staff. Among medical doctors, 25% were emergency medicine specialists, 46% were surgical specialists, and 23% were doctors from other specialties. Although 93% of team leaders had training in advanced cardiac life support (ACLS) and 87% had training in advanced trauma life support (ATLS), <25% of team leaders had prior disaster training or experience.

Timeliness

Approximately 10% of the EMATs received notification within three hours of the quake, 17% within six hours, and 53% within 12 hours of the quake. Only 63% of the teams received notification within 24 hours of the quake (Figure 1A). Of all of the responding EMATs, 29% departed within less than one hour after notification, 61% of teams departed within three hours, and 79% of teams departed within six hours (Figure 1B).

Travel time was defined as the time from hospital departure to arrival at the final site where patient care was delivered. Of all the teams that responded, 33% arrived at the final site within three hours of departure from their base hospital, 53% within six hours of their departure, and 73% within 12 hours of departure (Figure 1C) Approximately 47% of EMATs began providing initial care at the disaster site within one hour of arrival. Sixty-seven percent of the teams began providing initial care within three hours, and 80% of teams began providing initial care at the disaster site within six hours of arrival (Figure 1D).

Combining the times of the disaster response phases, it is estimated that only 7% of EMATs were providing on-site care within 12 hours following the earthquake, 17% within <18 hours, and 20% within 24 hours; 80% of these EMATs required >24 hours to begin the delivery of patient-care services.

Level of Acuity

Based on a ED I-IV triage system (Level-I, highest acuity; Level-IV, lowest acuity), the vast majority of patient encounters consisted of Level-III and Level-IV patients.

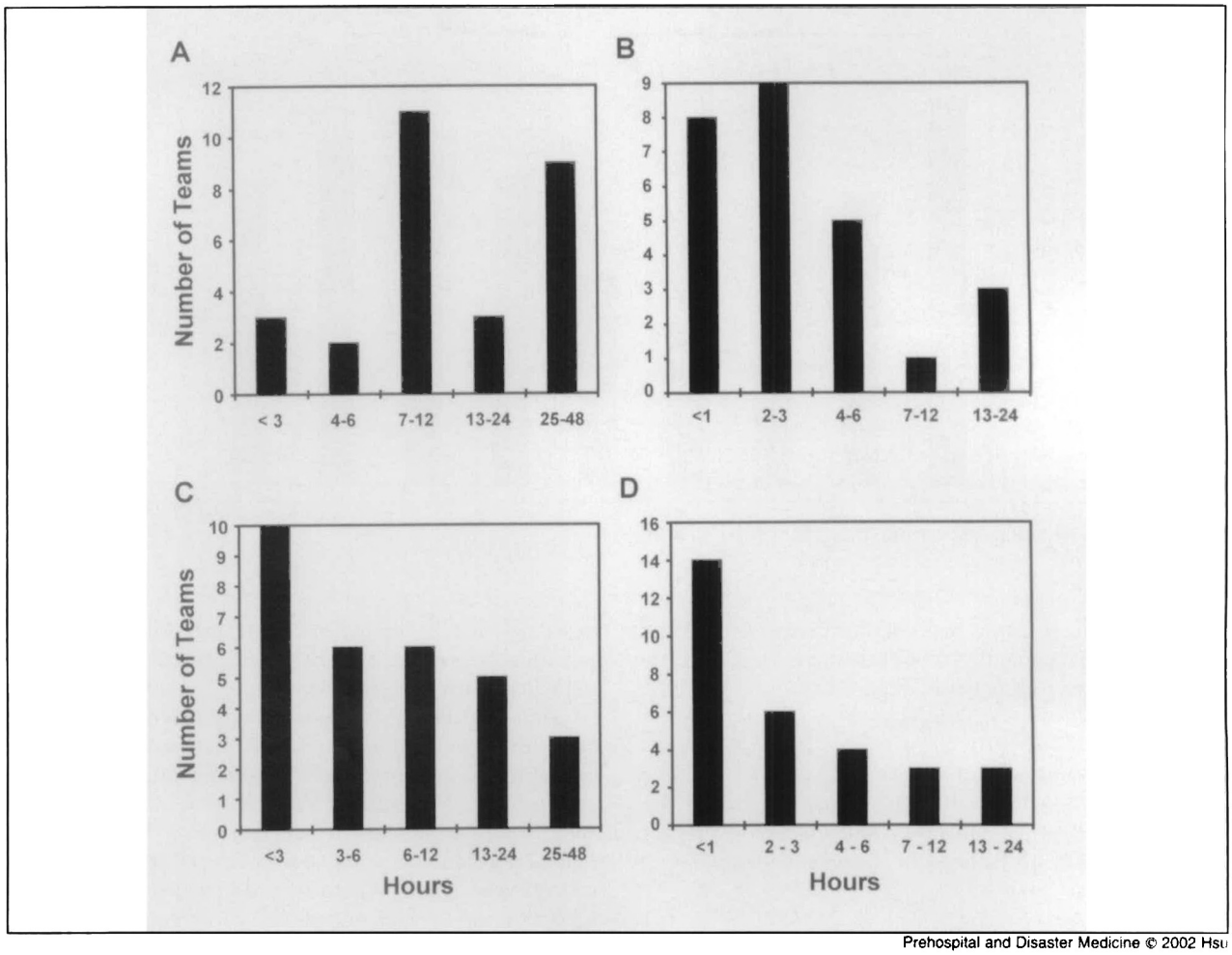

Figure 1—A Time to notification; **B**—Time to departure; **C**—Time to travel; **D**— Time to initial care

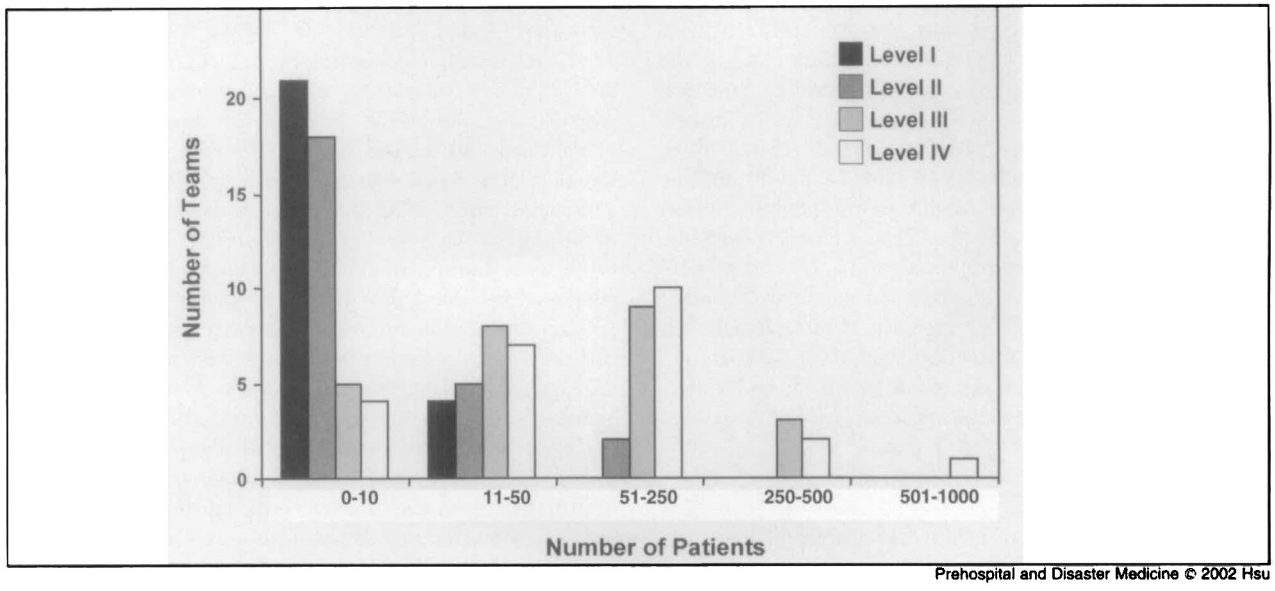

Figure 2—Types of patient encounters

Fewer than 16% of the teams encountered >10 Level-I patients and <28% of the teams evaluated/treated >10 Level-II patients. In contrast, >48% of the teams attended to >50 Level-III patients, and 10% of teams saw >250

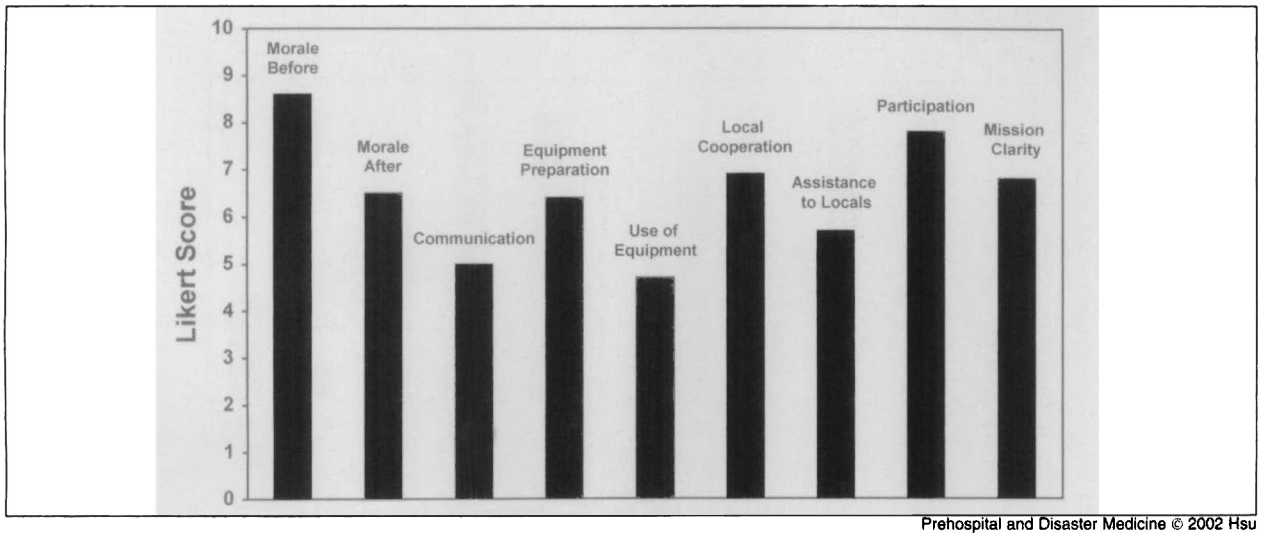

Figure 3—Likert scale self-assessment by EMAT leaders

Level-III patients. More than 54% of the teams attended to >50 Level-IV patients, 4% of the teams assumed care for >500–1000 Level-IV patients (Figure 2).

Supplies

The most frequently team-transported supplies included first aid kits (90%), IV fluids (87%), suture materials (77%), airway/intubation equipment (70%) and splints (70%). Only 13% of EMATs brought along emergency power generators.

Self Assessments

The survey included a self-assessment of perceptions of elements of the emergency medical response efforts. Scored on a scale between 1 (lowest) and 10 (highest), these assessments provided a subjective view of the EMAT response from 20 team leaders. The level of morale within the EMATs before initiation of the actual emergency medical response efforts averaged 8.6, while the level of morale after the operation concluded averaged 6.5; a mean decrease of –2.11; 95% CI = –2.48 to –1.74, t = -11.63. The adequacy of communications during the response effort was rated at an average of 5.0. Teams characterized the adequacy of their equipment preparation at an average level of 6.4, while actual use of equipment brought was rated at an average of 4.7. On the average, the teams gauged their level of participation at an average level of 7.8, cooperation by locals at 6.9, and their degree of assistance to locals at 5.7. On average, EMATs reported the clarity of their mission at an average level of 6.8 (Figure 3).

Discussion

The Chi-Chi earthquake resulted in widespread damage and loss of life. Since Taiwan did not have a recognized central coordinating disaster authority prior to the quake, many hospitals assumed the initiative by organizing individual, ad hoc EMATs. In the aftermath of the earthquake, the emergency medical response could be characterized best as spontaneous, reactive, and uncoordinated. In some cases, individual hospitals found themselves at odds with early directives issued by health authorities. As a result, initial relief efforts were fragmented.

Although the level of medical experience and training of these teams varied widely, only a select few had any prior disaster training or experience. The limited disaster experience among the leadership and absence of higher-level coordination added to the inherent chaos following the natural disaster. One of the lessons learned from this event is that Taiwan could benefit from developing leadership in disaster response and mitigation. Clear designation of a chain of command in response to a national level disaster should be implemented.

Emergency medicine and surgical specialists comprised most of the physicians on the EMATs. Frequently, however, it was reported that when the skills of specialists were in need, they were unable to perform procedures or operations due to lack of supporting equipment or power supplies. This is suggested by the findings that almost one-quarter of the teams left for the disaster sites without a prior designated disaster cache, and fewer than 13% carried power generators. Thus, in any disaster response, careful planning in terms of logistics and equipment is paramount. Otherwise, significant under-utilization of skilled health personnel will occur despite ideal response times.

Communications among the health sectors, including early damage assessment and reports were extremely limited, especially during the early hours to days following the quake. Similar accounts of communications breakdown during disasters are cited by Aghababian *et al.*[7] Cellular phones were cited as a principal means of relaying early information from the disaster zone, but once the batteries became exhausted, a communications vacuum enveloped the area. Poor communication and lack of established channels also hampered horizontal coordination among key government agencies and local authorities including fire departments for search and rescue, and military for aeromedical transport.[8] Although helicopters were deployed within 12 hours following the quake, other com-

munication shortfalls impacting reconnaissance, critical needs assessment, and relief coordination kept many EMATs from responding more quickly. Thus, establishing reliable communication systems must be a top priority in any disaster planning.[9]

Since the vast majority of these EMATs were self-directed, they proceeded without specific mission assignments and uncertainty regarding where to report. In addition to delays presented by earthquake disruption of normal travel routes, there were numerous accounts of delays in actually locating a site that required assistance. Assuming that the normal travel time from most hospitals to the disaster area ranged between one to three hours, even after factoring in damage to roads, a travel time of over 12 hours strongly points to other reasons for delays. Pretto *et al* suggested that deaths during the 1988 Armenia earthquake and 1991 Costa Rica earthquake might have been prevented had victims received medical attention within the first six hours after the quake.[10,11] Thiel *et al* suggested that the greatest demand for medical attention occurs during the initial 24 to 48 hours following a major earthquake.[12] According to observations during earthquakes in Tangshan, China (1976), Campania, Italy (1980), and Armenia (1988), 85–95% of the victims who survived being trapped in collapsed buildings were extricated within the first 24 hours.[13–15] Schulz *et al* concluded that timeliness of response is critical to the administration of medical care and reduction of immediate mortality after an earthquake.[16] Only 20% of EMATs arrived from outside the immediate disaster zone within the first 24 hours, the oft-cited "golden-hour" for rescue and treatment of potentially salvageable victims and hence, mitigation of disaster mortality.

In the immediate aftermath of the earthquake, an Emergency Operation Center (EOC) was established within the Department of Health (DOH). A DOH liaison was dispatched to the Central Disaster Response Center located within the National Fire Administration. Despite this, early coordination between government health authorities and hospitals deploying EMATs was very limited. The DOH Liaison Office also established emergency operations within the Disaster Command Center in Nantou County Stadium in central Taiwan. However, these personnel were not disaster trained, and in most cases never had had any prior contact or working experience with each other. The ad hoc nature of such arrangements contributed to significant confusion and raised questions of who was to assume ultimate authority for management of the disaster.

Consistent with typical earthquake injury patterns, the majority of fatalities were due to head injury (32.3%), traumatic shock (29.3%), or traumatic asphyxiation (29.1%). Organ injury (5.3%), burns (1.6%), crush injury (1.4%), cervical spinal cord injury (0.3%), and carbon monoxide poisoning (0.1%) were other causes of mortality.[17,18] Most of the victims trapped under collapsed structures extricated themselves, while others were freed within the first 24 hours.[6] Due to the disruption of local healthcare facilities including power supplies and operating capability, most injured patients requiring emergent surgery were transported via helicopter to hospitals in central Taiwan for definitive care; >250 patients were evacuated in the first three days.[6]

The vast majority of patients seen by the EMATs were Level-III and Level-IV patients involving minor lacerations, contusions, and non-traumatic complaints such as viral illnesses. Relatively few teams attended to many critically or seriously injured patients. As evidenced by discussions with team leaders and the equipment brought versus equipment actually used, this appears to be in contrast to what was anticipated by the EMATs. This is consistent with previous literature suggesting that outside medical assistance typically is delayed from providing immediate care and arrives only after local health services already have provided emergency medical assistance.[19] The bulk of victims with serious injuries requiring emergent surgery were evacuated before most of the EMATs arrived. These findings support previous studies that suggest that initial emergency medical needs are met best by local providers.[20] Strengthening local prehospital care will be key to future disaster planning and response in Taiwan. Although EMATs believed that they had a high level of participation in the disaster response, the degree of assistance they felt they actually provided to locals was modest. Absence of a clear authoritative chain of command, less than ideal cooperation with local authorities combined with impaired communication systems and sub-optimal resource utilization may explain the decline in morale among EMATs following relief efforts.

In the aftermath of the quake, an emergency monitoring center was established within the Bureau of Disease Control on the second day to oversee sanitation measures and monitor for disease outbreaks. No major disease outbreaks were reported. Beginning six days post-disaster, the DOH assigned 22 medical centers and hospitals to direct medical care and public health issues in disaster affected towns. These institutions were charged with helping to restore destroyed or heavily damaged local, health infrastructure. After the earthquake, residents in the disaster-affected region were issued temporary national health insurance cards, and exempted from the premium and co-payment. Relief measures continued until the end of March 2000. The total health care costs associated with the earthquake, from early treatment to follow-ups alone are estimated to be 4.87 billion NT dollars (USD$160 million).[2]

Following the Chi-Chi earthquake, several important policy level changes have taken place. A National Institute of Disaster Management was established as a controlling authority in the event of future disasters. This agency has been charged with organization and activation of emergency response. In addition, this agency has the responsibility of activating military resources, including helicopters for reconnaissance. Volunteer lists with contact information of emergency medical personnel are maintained and routinely updated. In Taiwan, 17 independent emergency medical service regions incorporating healthcare facilities and local fire departments have been in existence since 1989, but the earthquake a mutual aid network has been added.

In recognizing the need for strong local prehospital care in disaster response, focus on emergency medical technician training, including EMT-1 (60 hours) and EMT-2

(260 hours) for firefighters and other prehospital personnel is becoming the standard. Two disaster medical assistance teams under the National Institute of Disaster Management have been established to respond in the event of future disasters. Individual teams are based in the northern and southern part of the country, and have conducted disaster drills jointly with the military as well as educational activities to improve disaster awareness. Specially designated equipment has been upgraded and now includes satellite phones. In Taipei, an urban search and rescue team (USAR) comprised of 70–75 medical, logistics/structural engineering, and rescue personnel has been established. After an intensive training program including time spent with USAR teams in the United States, they assisted rescue efforts during the earthquake in El Salvador in 2001. Additionally, several locally based medical teams have been created to provide emergency medical care in the event of smaller scale disasters.

Conclusion

Despite sustaining a tremendous impact from the earthquake, the tenacity and large-scale response from the medical community during the Taiwan earthquake was impressive. However, in the absence of a clear command system, stable communications and preexisting dispatching mechanism, rescue and relief operations were hampered. Although EMATs from outside the affected areas eventually arrived, they generally did not arrive in time to affect the outcome of victims with preventable deaths.[16] Despite this, EMATs can be important in providing essential relief during subsequent phases of disaster response. The results of the current study are consistent with this view. Augmenting local prehospital care through special training and equipment is a critical component of disaster planning and response. Given Taiwan's propensity to natural and man-made disasters, a central governmental body that ensures better horizontal and vertical integration of various government and civilian agencies and a comprehensive emergency management system are needed to improve future disaster response and mitigation efforts.

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