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Reports and Comment

A Survey of International Urban Search-and-rescue Teams following the Ji Ji Earthquake

Wen-Ta Chiu
Taipei Medical University

Jeffrey Arnold
Baystate Medical Center

Yaw-Tang Shih
Natl Health Research Insts

Kuang-Hua Hsiung
Central Police University

Hsueh-Yun Chi
Dept of Health

Chia-Huei Chiu
Taipei Medical University

Wan-Chen Tsai
Taipei Medical University

William C. Huang
Taipei Medical University

On 21 September 1999, the Ji Ji earthquake killed 2,347 people. In the immediate aftermath the international community mobilised rapidly and sent urban search-and-rescue (US&R) teams to the scene. This paper will present an annotated survey of the expertise and standard of equipment of international US&R teams following that earthquake which could serve as a blueprint for the establishment of US&R teams elsewhere at risk from earthquakes.

Keywords: Taiwan, earthquake, search-and-rescue efforts.

Introduction

September 21 at 1:47 a.m., the Ji Ji earthquake, measuring 7.3 on the Richter scale, hit central Taiwan near the Nantou area. The epicentre of the earthquake was only one kilometre underground, and the rippled shaking that extended to the most northerly tip of the island had a magnitude of 3.0. The shallowness of this earthquake's epicentre thus brought catastrophe to the whole island. The results were great loss of life and massive damage to the economy.

Immediately after the earthquake, the international community mobilised rapidly to send urban search-and-rescue (US&R) teams to Taiwan. US&R task forces are a multidisciplinary resource with a mission to locate, reach, medically treat and safely extricate victims trapped within collapsed structures beyond the capability of local fire and rescue services (Macintyre et al., 1999). There were 37 US&R teams from 21 nations and

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international organisations, and none had any tie with the Taiwanese government. Rescue activity was based on simple humanitarian motives.

This paper will present an annotated survey about the expertise and standard of equipment of international US&R teams following the Ji Ji earthquake. The information could serve as blueprint for setting up US&R teams in other countries threatened by earthquakes.

Method and materials

The impact of the Ji Ji earthquake was severe and extensive. Massive damage is reflected in the death and injury data, based on government estimates. Data on the dead are strictly limited to those deaths caused directly by the earthquake. The Central Weather Bureau provided the time, seismological information including location of epicentre, depth and magnitude of the earthquake. The Directorate-General of Budget, Accounting and Statistics (DGBAS) provided data of economic losses caused by the earthquake (Executive Yuan, 2000).

Data to do with the US&R teams' activities were based on registration records kept by both the Fire Department and Department of Foreign Affairs (Fire Department/Ministry of the Interior, 1999). The total number of US&R teams and their members were gathered from arrival records kept by the Department of Foreign Affairs. Other teams were later deployed by the Fire Department based on expertise and equipment capability, accompanied by personnel from the Department of Foreign Affairs. Based on Fire Department data, we were able to map the rescue areas of the individual US&R teams. Combining the expertise and equipment capability data from the Fire Department as well as the entrance record from the Department of Foreign Affairs, we obtained essentially complete data of all foreign US&R rescue activities. In the chaos of the disaster, however, some data may have gone missing or been miscounted.

The US Federal Emergency Management Agency (FEMA) categorises emergency equipment into five major groups: rescue, medical, technical, communication and logistical according to function. These categorisations were used for summarising the huge amount of data about the standard equipment list and descriptions supplied by the Fire Department. Outcomes and details of US&R teams' activities were also gathered from other sources such as the internet, journals, magazines, local reports and newspapers.

Results

Earthquake casualties

The Ji Ji earthquake caused 2,347 deaths and injured 11,305 people (Department of Health, 1999). DGBAS estimated the total economic loss from the disaster at US$11.5 billion, including $8.4 billion in property loss and $3.1 billion in potential revenue losses.

Foreign rescue teams

Immediately after the earthquake, the international community (21 countries or international organisations) deployed 37 US&R teams (see Tables 1 and 2). Table 1

summarises the US&R teams according to their expertise and equipment. As shown, there were nine countries consisting of 18 teams from Europe, 13 teams from eight countries in Asia, four teams from three countries in the Americas and two UN teams. All together, the teams had 728 personnel and 103 trained rescue dogs with only 674 personnel and 96 rescue dogs recorded due to the missing data. These nations or international organisations included Australia, Austria, Canada, Czech Republic, France, Germany, Hong Kong, Hungary, Japan, Mexico, Russia, Singapore, Slovak Republic, South Korea, Spain, Switzerland, Thailand, Turkey, the UK, the UN and the US.

As indicated in Table 2, most international assistance efforts were concentrated in the most heavily damaged central part of Taiwan. Taichung had the largest number of deaths (1,177), followed by Nantou (824). Eight and 18 US&R teams were deployed in the Taichung and Nantou areas, respectively. A total of 30 rescue teams and 75 per cent of total manpower effectively reinforced rescue activity in central Taiwan which includes Nantou, Taichung, Chang Hua and Yun Lin prefectures. Although not reflected in Table 2, many teams also provided rescue activities in the Taipei prefecture although they maintained their main focus on central Taiwan. The Hong Kong team was the only team to work exclusively with rescue activities in the Taipei prefecture. Table 2 does not include Russia and Canada's missing data. In the meantime, two UN and one Australian US&R team devoted their efforts to helping coordination and evaluation of rescue activities in central governmental agencies.

Table 3 shows the five FEMA functional grouping of equipment the teams brought with them (FEMA, 1999). Of all available rescue equipment, rescue dogs are the most essential and preferred; nearly half of the US&R teams brought rescue dogs. The second-best type of equipment are devices that can detect signs of life. These were brought by one-quarter of US&R teams.

Six civilians were saved unharmed and thousands of injured were also rescued. Most of those saved were residents of central Taiwan prefectures.

Discussion

According to a Health Department survey, the Ji Ji earthquake caused 2,347 fatalities. From the study by Dr de Ville and others, the ratio of injured to dead following an earthquake is roughly 3.5 on average (de Ville de Goyet et al., 1976), in the case of Ji Ji it was 4.8 — which is unusually high. The numbers of dead owing to the Ji Ji earthquake makes trauma the second-leading cause of death in Taiwan, next to cancer. Traumatic death, which was the third-leading cause of death from 1967 to 1997, dropped to the fourth-leading cause in 1998 in the wake of a law requiring riders to wear motorcycle helmets (Chiu et al., 2000). In 1999, the earthquake's 2,347 death rate drastically reversed the downwards curve of traumatic death when it suddenly rose to the number-two position. The data indicate the significance and importance of disaster prevention.

To minimise earthquake casualties, several interventions may be made before, during and, especially, after an earthquake. To reduce injuries following building collapse, more effective search-and-rescue methods and more emergency medical care are both necessary (Armenian et al., 1997). Disaster prevention is as important as other public health issues, and a positive consequence of this earthquake is that it prompted the Taiwanese government to improve its existing disaster prevention programme.

Table 1 Summary of 37 international US&R teams according to nationality, expertise and equipment

No.	*Country*	*Rescue team*	*Personnel*	*Expertise*	*Equipment*
1	Australia	Queensland Fire and Rescue Authority	5	Coordination of rescue activity	—
2	Austria	Internationale Rettungshunde Organization	14	Rescue	• Rescue dogs (10)
3	Austria	Austrian Forces Disaster Relief Unit	10	Prevent chemical disaster from the destroyed areas	—
4	Canada	—	—	—	—
5	Czech Republic	Adventist Development and Relief Agency	6	Search for survivors and identify the dead	• Rescue dogs (5)
6	France	Association Nationale des Equipes Cynophile de Recherche et de Sauvetage	6	Rescue and rescue dog training	• Rescue dogs (6)
7	France	Comite des Secours Internationaux	6	Rescue and medical Assistance	• Life detectors • Sonar detectors • Emergency med • Rescue dogs (4) • Tents, sleeping bags • Food
8	German	Bundesanstalt Technisches Hilfwerk (THW)	25	Rescue	• Life detectors • Sonar detectors • Emergency med • Rescue dogs (6) • Electricity gen
9	German	German Federal Association for Rescue Dogs	12	Rescue dogs training and management	• Safety equipment • General rescue equipment • Tents • Rescue dogs (7)
10	German	Internationale Rettungshunde Organization	25	—	—
11	German	Der Nundesverband des Deutschen Bestattungsgewerbes e. V.	17	—	• Remains disinfection and antiseptic equipment

No.	*Country*	*Rescue team*	*Personnel*	*Expertise*	*Equipment*
12	Hong Kong	Hong Kong Fire Services Department	16	Life and gas detection	• Life detectors • Gas detectors • Explosive equipment
13	Hungary	Miskolic special Relief and Rescue Service	5	Life detection	• Satellite phone
14	Japan	Japan Rescue Association	14	Life rescue	•Lightening equipment • Satellite phone • Rescue dogs (8)
15	Japan	International Fire Assistant Team	105	Special disaster assistant	• Life detector • Destruction equipment • Lights
16	Japan	Fuji Disaster Rescue Dog Association	10	Rescue dogs training and rescue	• General rescue equipment • Rescue dogs (5)
17	Japan	Rescue Dog Trainer Association	6	Rescue dogs training and rescue	• General rescue equipment • Rescue dogs (5)
18	Japan	International Disaster Relief Team (Medical Team)		—	—
19	Korea	National 119 Rescue Service	16	Rescue	• Rescue dogs
20	Mexico	Brigada de Rescate Tops Mexico AC	5	Rescue	• Hand tools • Power tools • Life detectors
21	Mexico	Fratemidad Socorro Alpino de Mexico	4	Rescue	• Hand tools • Power tools • Life detectors
22	Mexico	Brigada de Rescate Topos de Tlatelolco AC	9	Remains disinfection and antisepsis	• Remains disinfection and antiseptic equipment
23	Russia	Rescue Team of The Ministry for Civil Defence and Emergencies	73	—	• Rescue dogs (3)
24	Singapore	Singapore Army Medical Team	17	Field medical service	• Car •Communication equipment • Sharp resusci-tator +oxygen tanks • Lardeal suction unit
25	Singapore	Singapore Civil Defence	44	Disaster assistance	•Saw blades •Rescue dogs (4) •Detector equipment

No.	*Country*	*Rescue team*	*Personnel*	*Expertise*	*Equipment*
26	Slovakia Republic	Camage Rescuse Service Slovakia Republic	5	Rescue	• Rescue dogs (4)
27	Spain	Asociacion Espanola de Perros de Rescate e Intervencion	4	Rescue	• Rescue equipment •Telecom • Rescue dogs (3)
28	Spain	Consorcio Provincial Contra Incendios y Salvamento de Huelva	12	Rescue	• Satellite phone • Life-maintaining equipment, • Rescue dogs (8)
29	Swiss	Rettungskette Schweiz in Taiwan	42	Search for survivors in collapsed building	• Rescue dogs (12)
30	Thailand	Thai Medical Team	9	Medical service	• Med
31	Turkey	AKUT(Arama Kutarma)	18	Rescue and primary emergency care	• Life detectors • Equipment for emergency care
32	Turkey	Sivil Savunma	20	Rescue and primary emergency medical service	• Electricity generators • General search tools • Rescue dog (1) • Tents
33	Turkey	GEA-SAR (Rescue and Preparedness in Disaster, RAPID, in Turkey)	7	Search for survivals	• General rescue equipment • Emergency med
34	UK	RAPIDUK (Rescue and Preparedness in Disaster UK)	5	Personnel management and training	• Life detectors • Sonar detectors • GPS • Electricity generator • Emergency med
35	UN	UN Office for the Coordination of Humanitarian Affairs (OCHA)	4	Coordination of rescue activity	—
36	UN	UN Office for the Coordination of Humanitarian Affairs (OCHA)	6	Evaluation of rescue activity	—
37	US	Fairfax Country Urban Search and Rescue Team	92	Search and rescue in ruined areas	• Camera, • Listening device • High-pressure airbag • Rescue dogs (5)

Table 2 Distribution of international urban search and rescue teams, total number of personnel and corresponding number of deaths

Location	*Number of deaths*	*Country*	*Number of US&R teams*	*Number of US&R personnel*
Taipei	132	Hong Kong	1	16
Nantou	824	Japan	4	135
		Germany	1	17
		Korea	1	16
		UK	1	5
		Czech Republic	1	6
		Spain	2	16
		Thailand	1	9
		Austria	1	14
		Mexico	3	18
		Slovak Republic	1	5
		Turkey	1	5
		Hungary	1	5
Taichung	1,177	Singapore	2	61
		Germany	2	50
		Switzerland	1	42
		Austria	1	10
		France	2	12
Chang Hua	49	Germany	1	12
		Turkey	2	38
Yun Lin	88	US	1	92
Total	2,270		31	584

As indicated in Table 2, most US&R teams concentrated their efforts in the Nantou prefecture. The deployment of foreign rescue teams was according to geographical location with Nantou as the earthquake's epicentre. Taichung prefecture had the highest number of recorded deaths (1,177), but had fewer (eight) rescue teams than Nantou's 18. The Taiwanese government was blamed for inexperience demonstrated in the immediate response, and then its poor preparation and loose coordination when deploying US&R teams. The casualty data from the earthquake proved that population density is as crucial as the magnitude of the earthquake when rescue manpower is coordinated.

Studies showed that death and injuries occurring within 48 hours of the earthquake were associated with the collapse of houses (de Bruycker et al., 1985). Proper rescue resources and procedures are essential. As indicated in Table 3, 18 of the 37 US&R teams had rescue dogs and 10 owned the detective equipment. Despite progress in new technology, sniffer dogs have not been superseded, but are still considered the most useful tools in disaster rescue although they take years to train and are inconvenient to transport. This view prompted government officials to determine the priority of equipment procurements and to look for established programmes to train rescue dogs.

From the experience of US&R teams, six countries brought medical supplies as essential standard equipment versus a total of seven countries which consider destructive tools and equipment as their most standard list item. Evidence shows that

Table 3 List of task-force equipment, teams of utilisation and percentage

Five categories of task-force equipment and numbers	*Numbers of utilised team*	*Utilised percentage*
Rescue		
Rescue dogs	18	48.6
Destructive equipment	7	18.9
Saw blades	1	2.7
Sustaining equipment	1	2.7
Hand tools and power tools	2	5.4
Explosive equipment	1	2.7
General rescue equipment	8	21.6
Medical		
Emergency medicine	6	16.2
Remains disinfection and antiseptic equipment	1	2.7
Technical		
Lights	2	5.4
Detective equipment	10	27.0
Life detectors	8	21.6
Sonar detectors	4	10.8
Gas detectors	1	2.7
Listening devices	1	2.7
Cameras	3	8.1
High-pressure airbags	2	5.4
Electricity generators		
Communications		
Car	1	2.7
Telecommunications	3	8.1
Satellite phone	2	5.4
Global positioning satellite	1	2.7
Logistics		
Camping equipment (tent, sleeping bags)	5	13.5
Food and drinking-water	3	8.1

most deaths are immediate or rapid, and relatively few are delayed (Sapir, 1993). Thus, the crucial component of the health-care system for reducing deaths is immediate pre-hospital care for casualties with life-threatening injuries and must be provided within the first six hours (Fawcett and Oliviera, 2000). Disaster prevention should concentrate not only on the training of the rescue activities, but also on post-rescue medical treatment. In the Ji Ji earthquake, crushing syndrome and head injury were two major causes of death within the first hour following a successful rescue. A total of 330 out of 639 and 142 out of 208 victims had both intra-cranial and crushing injuries, respectively, and died within the first hour after successful rescue. Nearly half of all deaths were due to inappropriate medical treatment immediately after rescue (Department of Health, 1999).

Studies of earthquakes in Turkey and China also indicate that two to six hours after entrapment, less than 50 per cent of people buried under collapsed buildings will still be alive (de Bruycker et al., 1985; de Bruycker et al., 1983). The casualty data from the earthquake and the survey of the US&R teams in Ji Ji have led government officials to

realise that the importance of disaster medicine in disaster prevention requires better research on possible causes of death and the provision of proper medical treatment on site.

The expertise of US&R teams is summarised in Table 1. Major expertises of the US&R teams include skilful rescue, rescue dog training, medical assistance and coordination and management. In planning a programme of disaster prevention, the personnel must be well trained in the knowledge of the above-listed expertises. The importance of the rescue dog training and immediate medical intervention has been discussed previously. Rescue activities require the full range of equipment of the five groups as listed in Table 3 and the maintenance of this equipment can be economically burdensome. Usually, only people in developed countries can afford to maintain well-equipped rescue programmes. Fortunately, rescue dog training is time consuming but less economically burdensome and could be easily managed by most countries. In the meantime, rescue techniques such as 'confining space rescue' requires delicate and systematic procedures. Training for 'confining space rescue' needs not only more research but also extensive field experience.

Poor results in the field deployment of the US&R teams by the Taiwanese government has highlighted the importance of coordination and management. This expertise is essential to any leader of a local or federal emergency department to coordinate information about the catastrophic event and then manage the appropriate immediate response. Even with help from the two UN US&R teams, the lack of effective communication precluded anything but a poor performance for the emergency response in the context of the Ji Ji earthquake.

The Taiwanese government has learned from a survey of the US&R teams after the Ji Ji earthquake, and from the symposium of disaster medicine it organised in March 2000. Officials have also recognised that inadequate research is a major reason why the earthquake was able to cause such extensive damage. Research had been done, papers published and information deseminated in the area of disaster medicine in many countries (including Japan, Armenia and Iran), but this has only been sporadic in Taiwan. More research of disaster in all areas is urgently needed for the future development of global disaster prevention. Using the current survey to collect data about the 37 US&R teams is only one attempt to develop disaster prevention in Taiwan.

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Address for correspondence: William C. Huang, Institute of Injury Prevention and Control, Taipei Medical University, 250 Wu-Hsing Street, Taipei 110, Taiwan. E-mail: <<wtchiu@tmu.edu.tw>>