



# 2018 Taiwan Hualien Earthquake—Disaster Lessons We Learned in the Emergency Department of a Tertiary Hospital

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**Background:** On February 6, 2018, a magnitude-6.2 earthquake on the Richter scale struck Hualien, and that disaster killed 17 people and injured more than 300 people. Our hospital, the only tertiary hospital in eastern Taiwan, responded to a mass casualty incident (MCI) in two hours. Such a devastating earthquake influenced the health of the general population and the mental health of hospital staff. Thus, we aimed to analyze the medical problems in earthquake victims, the MCI response's operation, and the prevalence of post-traumatic stress disorder (PTSD) among healthcare providers.

**Methods:** We reviewed the medical records to investigate the information on the medical requirement of victims. Questionnaires were collected from emergency department staff regarding the operation of the MCI and the effect of regular MCI drills. For a survey of PTSD among healthcare providers, we used the Chinese version of the Davidson Trauma Scale for the psychiatric assessment.

**Results:** Among the 113 victims who entered the emergency room, almost 90% had a minor injury. The results of the operation of the MCI revealed that 71.5% of them knew the response process of the MCI and performed well. The hospital staff's mental health assessment showed 17.5% met the diagnostic criteria for PTSD one month after the disaster, and 3.2% met the criteria seven months after the earthquake. Personal psychiatric histories were the only risk factor for PTSD.

**Conclusions:** Most earthquake victims presented to the emergency room with trauma injuries. Thus, we need to prepare more resources to manage surgical problems. To be well prepared for mass casualty events, the annual exercises play a significant role. Besides, we can't ignore the mental health condition of healthcare providers after the disaster. We record this tragic earthquake's valuable experience and lessons and share them with others.

**Key words:** *Hualien earthquake, disaster medicine, mass casualty incident (MCI), post-traumatic stress disorder (PTSD)*

## Introduction

Taiwan situates on the western side of the Circum-Pacific seismic belt. Since ancient times, devastating earthquakes have occurred frequently and

caused severe casualties and property losses. The followed social costs are enormous. There are 15 earthquake records of more than 100 death victims in Taiwan's history.<sup>1</sup> Twenty years ago, the Chi-Chi earthquake hit the center of Taiwan on September

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21, 1999. The earthquake's magnitude was 7.3 on the Richter scale. The earthquake caused about 2,471 dead and 11,305 injured. Over 10,000 buildings collapsed, and economic losses were US 14 billion directly.<sup>2</sup> After that, the emergency disaster response was considered in official institutions in Taiwan.<sup>3</sup> And we started to understand epidemiologic analysis on how to guide disaster response and preparation.<sup>4</sup> Almost 100 years ago, in June 1920, the Hualien area was struck by an earthquake over magnitude-7 on the Richter scale,<sup>5</sup> then a magnitude-6.2 earthquake on the Richter scale struck Hualien on February 6, 2018. Four buildings collapsed completely sooner after the earthquake attack. In this small eastern city of Taiwan, the population is only about 300,000. The disaster killed 17 people and injured more than 300 people. Most of the victims were sent to nearby hospitals as soon as possible. One hundred thirteen patients were crammed into the emergency department (ED) of a nearby tertiary hospital within two hours, and then the mass casualty incident (MCI) response was activated. The earthquake occurred at 11:50 pm, and twenty min later, we started MCI responses. Almost 500 hospital staff responded to the recall messages and engaged with emergency medical management.

Following the Chi-Chi earthquake, we learned many lessons and constructed the system of disaster medical response in Taiwan.<sup>6</sup> Moreover, Japan's new earthquake response system also referred to Taiwan's experience.<sup>7</sup> Though the scale of the Hualien earthquake was smaller than the Chi-Chi earthquake, that was still a big challenge for the medical system in Hualien. Only four hospitals are participating in emergent responses, including one major medical center, two regional hospitals, and one district hospital. Through 20 years, prehospital care and precise disaster planning progressed, and that helped us to face the disaster well. We want to record this experience and reveal the improvement of disaster medical response in Taiwan in this article.

An MCI is defined as an event in which the number of casualties cannot be managed with the current facilities, resources, and usual operational processes of organizations.<sup>8</sup> As disasters happen, many victims need medical assistance, which surges the medical loading of the hospitals. Once the burden is over the capacity of hospitals, which will be a catastrophe. Thus, health care facilities should have mass casualty management plans and should develop hospital incident command systems (HICS), and that drills and

exercises must be conducted annually. However, there are many differences between real events and training, and real disasters challenge the effectiveness of the usual drills.

After suffering from such a severe disaster, psychological problems may increase not only in the survivor group but also in the health care providers. It was estimated that the probability of post-traumatic stress disorder (PTSD) after life-threatening events was 12%,<sup>9</sup> and the lifetime prevalence of PTSD ranged from 1.0% to 9.2% in different countries.<sup>10</sup> In another study, 16.7% of the rescue workers who responded to the terrorist attack in New York developed PTSD.<sup>11,12</sup> However, there are rare studies reported regarding the mental health of healthcare providers who work in hospitals. To analyze the prevalence of PTSD among healthcare providers and to explore the possible risk factors would be very significant.

After this devastating earthquake, we would like to share valuable experience. Three aims are in our article. First, we analyze the types of medical problems in this earthquake, including injury sites and patterns of victims. The second is to analyze the operation of the MCI response of our hospital, including efficiency and effectiveness. The last one is to investigate the prevalence of PTSD among healthcare providers and to explore the possible risk factors.

## Methods

### Collecting Patients' Data to Analyze the Trauma Pattern in Earthquake Disaster

We collected the patients' data from our hospital medical records. We also remedied as much as possible by telephone access and obtained permission from the research ethics committee. We reviewed the medical records of the diagnosis, the trauma mechanisms, and the sites of injury, and evaluated trauma severity by the injury severity score (ISS). We only surveyed one hospital detail data and confirmed that 113 patients visited our ED that night. According to the websites of the incidental registry system from the government, there were 179 victims of earthquakes who needed medical services in the other three hospitals.

### Questionnaire

#### To Study MCI Participators' Performance

We enrolled all our ED staff who participated in the MCI response in this study. Thirty-six persons engaged

in the reaction of MCI, and all of them received the investigation. One week after the earthquake, we collected questionnaires from them. The main opinion of the questionnaires is about the effect of the regular MCI drill, and they just answered the questions with yes or no.

### To Study PTSD of Medical Staff

We included all 63 ED team members in the PTSD study. They received the assessment twice, one and seven months after the earthquake. Before the evaluation, all participants needed to obtain the illustrating of those scales and then complete paper-based scaling. We used the Chinese version of the Davidson Trauma Scale (DTS) in the psychiatric assessment. Previous studies had confirmed this version of excellent reliability and validity.<sup>13</sup> The diagnosis criteria of the DTS base on the Diagnostic and Statistical Manual of Mental Disorders 4th Edition (DSM-IV). Demographic data collected included age, sex, occupation, educational background, job tenure, marital status, whether or not living with family, whether or not with religious belief, and personal medical or psychiatric diseases. The risk factors for PTSD were evaluated based on the demographic variables. Besides, we divided them into two subgroups by whether participating in the MCI or not and to compare the differences between the two subgroups.

### Statistical Analysis

The risk factors for PTSD were evaluated based on the demographic variables. We used multiple logistic regression models to analyze the possible risk factors for PTSD. We also analyzed the data of two subgroups according to whether participating in the MCI response. Independent t-test and Chi-squared tests were used to compare the differences between the two subgroups.

## Results

### The Earthquake Victims' Medical Needs

There were 113 earthquake victims visiting our ED that night within the first two hours, and the other 179 victims who needed medical assistance in the following weeks or other three hospitals. We collected and analyzed all patients' medical records (Table 1), and 89.4% of patients visited EDs due to trauma. Only 8.2% of the patients had medical problems. Many patients had more than one trauma pattern or injury site, so our calculating according to the trauma,

not to people. Table 2 showed that the most substantial proportion of trauma patterns was the contusion, which occupied 42.3% of traumatic victims. The second-highest portion of the traumatic model was the laceration, 38.5%. Among them, there were 13 patients with traumatic cardiac arrest before arriving hospital, accounting for 4.9%. The first two injured sites are the lower limbs and the head, accounting for 36.9% and 34.9%, respectively (Table 3). Some patients had more than one trauma pattern or injury site. There were 248 patients with an ISS of less than nine, which was in a minor injured group, accounting for 93.58%. Only 5% of trauma patients had ISS more than 16, which was in a severely injured group. Therefore, most of the victims were minor injuries.

**Table 1.** Reasons for visiting emergency department (N = 292)

Problem	n	%
Medical problems	24	8.2
Trauma injuries	261	89.4
Both medical and trauma problems	4	1.4
Psychiatric problems	1	0.3
Obstetric and gynecological problems	2	0.7

**Table 2.** The patterns of trauma

Pattern	n	%
Contusion	112	42.3
Laceration	102	38.5
Abrasion	35	13.2
Fracture	25	9.4
Traumatic OHCA	13	4.9
Burn	11	4.2
Strain	6	2.3

OHCA: out-of-hospital cardiac arrest.

**Table 3.** The sites of trauma

Part	n	%
Lower extremities	93	36.9
Head	88	34.9
Upper extremities	76	30.2
Spine	29	11.5
Chest	17	6.7
Abdomen and pelvis	9	3.6

## The Efficacy of Regular MCI Drill

At the moment soon after the earthquake attack, almost 500 staff of our hospital gathered in the emergency room to participate in the MCI response. There was 36 ED personnel participating in the reaction, and they accounted for 57% (36/63) of our ED medical staff. The composition was 25 nurses (69.4%) and 11 physicians (30.6%). The average age was 31.4 years old, average job tenure was 6.9 years, and more than 86% of their educational background was university degree or above. Among the 36 staff, 77.1% had received training courses of the MCI of the HICS. 48.7% of them were on the responder's list and received the recall message that night. The others volunteered to participate in the MCI response due to watching the media news. Table 4 revealed that 69.4% of the responders knew the location of the check-in station and received a clear task assignment and briefing. During the process, 72.3% of participants knew who their leader was, and 75.0% knew how to look for resources. According to the results of the questionnaires, the most common concerning problem was too noisy to communicate in the emergency room at that time.

## The Condition of PTSD

In Table 5, we showed the report of all 63 ED personnel with PTSD. Fifty-seven percent of them (36/63) participated in the earthquake response. One month after the disaster, 11 staff (11/63, 17.5%) met the DSM-IV criteria for PTSD. Seven months after the earthquake, only 2 (2/63, 3.2%) met the criteria (not shown in Table 5). The analysis revealed that personal medical and psychiatric histories were the

only risk factor for PTSD. Evidence also indicates that people with PTSD are less willing to participate in the future MCI event because 19.2% of persons with PTSD are unsure whether they are eager to join in another MCI response (Table 5).

Among the respondents, 36 people participated in the earthquake MCI response, and 11.1% (4/36) met the DSM-IV criteria for PTSD one month later. Seventh months after the earthquake, no one among them was with the disorder. The other 27 ED staff were not in the ED that night, but they still experienced the same earthquake catastrophe at the same time in Hualien. 25.9% met PTSD criteria one month later, and in the seventh month, there were 7.4% of people with PTSD. However, there is no statistical significance between these two groups.

## Discussion

Our article presented three things about the 2018 Hualien earthquake. First is the victims' trauma patterns, which could be a suggestion of logistic preparation. The second is the efficacy of regular exercises of MCI in Taiwan's most hospitals. Every year, we spend so much time and personnel to conduct those drills, is it worth? The last one is about the subject of PTSD of medical staff. PTSD is always a valuable issue in disaster medical management.

Trauma cases represented nearly 90% of all patients in the emergency room during the 2018 Hualien earthquake, and the result was similar to the previous study.<sup>11</sup> It is reasonable that the logistics unit needs to prepare more materials for trauma management during an earthquake attack. In our experience, the majority of patients had minor trauma, whose ISS is

**Table 4.** Questions about MCI operation

Question	Answer	
	Yes (%)	No (%)
Knew the registry site	69.4	30.6
Received clear assignment of task and briefing	69.4	30.6
Knew who the leader was	72.3	27.7
Knew the distribution of each work zone	77.7	22.3
Knew the management process for MCI	71.5	28.5
Knew the travel routes for patients	57.2	42.8
Encountered problems during work	34.3	65.7
Knew whom to ask for help from	75.0	25.0

MCI: mass casualty incident.

**Table 5.** Analysis of PTSD of ED staff, after the earthquake one month

Variable	Meet DSM-IV criteria for PTSD		<i>p</i> value
	Yes	No	
Number	11	52	
Age (years)	33.55 ± 12.29	33.10 ± 9.53	0.893
Female (%)	45.5	55.8	0.533
Occupation (%)			1.000
Doctor	27.3	28.8	
Nurse	72.7	71.2	
Education background (%)			0.676
Junior college and lower	9.1	17.3	
University and higher	90.9	82.7	
Job tenure (years)	7.32 ± 5.40	8.83 ± 8.19	0.561
Marital status (%)			0.523
Married	54.5	43.1	
Unmarried (i.e., single, divorced, widowed)	45.5	56.9	
Living with spouse (%)	36.4	32.7	1.000
Living with parents and/or siblings (%)	0	21.6	0.188
With religious belief (%)	55.6	62.7	0.721
With personal medical history <sup>a</sup> (%)	36.4	9.6	0.042*
With personal psychiatric history (%)	18.2	0	0.028*
Any loss in the earthquake (%)	36.4	34.6	1.000
Had discussion on the earthquake (%)	81.8	82.7	1.000
Seeking for medical assistance (%)	9.1	0	0.175
Willing to participate in the MCI again (%)			0.038*
Very willing to	72.7	82.7	
Have the will to	9.1	17.3	
Not sure	19.2	0	

<sup>a</sup>Hypertension, diabetes mellitus, asthma, thyroid diseases, and bipolar disorder.

\*Statistically significant.

DSM-IV: Diagnostic and Statistical Manual of Mental Disorders 4th Edition; ED; emergency department; MCI: mass casualty incident; PTSD: post-traumatic stress disorder.

less than nine. That was the reason why we only spent 2.5 hours to treat the event, and most patients were discharged within a few hours. Only 20 patients were hospitalized for further management. Lower extremities might be more vulnerable during the evacuation in an earthquake, and thus, lower extremities were the most common injury site. The second most common site of injury was the head, which could lead to mortality and morbidity. That evidence suggests that we need more orthopedists and neurosurgeons recalling in response to the earthquake. In the public policy of self-protection as an earthquake happening, protecting lower extremities, and heads must be an issue.

In-hospital management, MCI is a rare but high-impact event. It is very challenging due to the unpredictable and time urgency characteristic, and the features of different disasters complicate the management. Although the accident will not follow the script of the usual exercise, the regular annual exercises still reveal the benefit during the disaster response. In our experience, most participating employees followed the rules from the regular exercises. They knew the location of the check-in station, task assignment, leader, and how to seek resources. Even the chaotic and anxious situation might compromise the performance of the participants. Our study showed that annual ex-

ercises ensure the performance of employees in MCI participating.

Thirty-seven percent of the general population developed PTSD after the 1999 Taiwan Chi-Chi Earthquake,<sup>12</sup> and 16.4 % of healthcare providers had post-traumatic psychiatric disorders after the 2017 Tainan Earthquake.<sup>13</sup> According to previous studies, the medical staff seem to be less likely than the public to get PTSD. In our research, the prevalence of PTSD among healthcare providers was around 3.2–17.5 % in different periods. Other studies reported that nurses had an increased risk for PTSD after exposure to missile attack,<sup>14</sup> and women were at higher risk than men.<sup>15,16</sup> Our study showed that underlying medical and psychiatric diseases, such as hypertension, diabetes mellitus, asthma, thyroid diseases, and bipolar disorder, were the only risk factor for developing PTSD in emergency staff. Besides, other factors are without statistically significant. The small sample size in our study is the limitation, and we plan to keep following this issue in our ED. There is an interesting phenomenon in our study of PTSD. PTSD score was lower in those who participated in the MCI than not, although there was no statistical significance between these two groups. However, the paradox is that participants' willingness to participate in MCI again is lower. Maybe this implies a more complicated psychological process.

There are some limitations to our research. First, we only collected medical records of earthquake victims from the ED of the four local hospitals, so we lacked complete information on all victims. It was challenging to retrace medical records from out-patient-department. The emergency room was jam-packed that night, and the medical records were usually incomplete; thus, we remedy as much as possible by telephone access. Second, the sample size of the questionnaires was relatively small, and we only surveyed the personnel in our ED. Due to the lack of other hospital staff's data, the respondents had high homogeneity.

The earthquake disaster is a significant challenge that the government of Taiwan needs to face. The history of the earthquake reflected the history of disaster management in Taiwan. Therefore, it is necessary to record these valuable experiences and lessons of these tragic earthquakes correctly.

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