Disaster Epidemiology and Medical Response in the Chi-Chi Earthquake in Taiwan

Nai-Jen Liang*
Yaw-Tang Shih, MD, DrPH*||
Fuh-Yuan Shih, MD¶
Hsiu-Mei Wu, PhD*||
Hsian-Jenn Wang, MD*§
Shu-Feng Shi, PhD*#
Ming-Ying Liu, MD* **
Bill Binglong Wang, PhD*‡

From the Graduate Institute of Life Sciences, the Department of Medical Research,‡ and the Department of Surgery,§ National Defense Medical Center; the Division of Health Policy Research, National Health Research Institutes||; the Department of Emergency Medicine, National Taiwan University Hospital¶; and the Department of Nursing# and the Department of Emergency Medicine,** Tri-Service General Hospital, National Defense Medical Center, Taipei, Taiwan.*

Author contributions are provided at the end of this article.

Received for publication October 2, 2000. Revisions received March 21, 2001, and July 3, 2001. Accepted for publication July 30, 2001.

Presented in part at the Society for Emergency Medicine of Republic of China annual conference, Taipei, Taiwan, June 2000.

Supported by grant No. DOH 89-TD1226 from the Department of Health of the Republic of China.

***Address for reprints:** Bill Binglong Wang, PhD, Graduate Institute of Life Sciences, National Defense Medical Center, Nei-Hu, PO Box 90048-500, Taipei 114, Taiwan, Republic of China; +886-2-8792-4831, fax +886-2-8792-3111; E-mail billwang@ndmctsgh.edu.tw.*

0196-0644/2001/$35.00 + 0
47/1/118999
doi:10.1067/mem.2001.118999

See related article, p. 556.

Study objective: We examine the mortality and morbidity associated with earthquakes in the Chi-Chi earthquake in Taiwan in 1999.

Methods: Crude casualty data were collected from the reports of the government, local health bureaus, and 97 hospitals. The demographic data from the annual report of the Department of Interior were also employed for data analysis. Cross tables showing incidence of deaths and injuries by age, sex, time, and geographic distribution were generated to compare the mortality among different subgroups. Multiple regression models were established to explore the risk factors related to the mortality caused by earthquakes.

Results: The following results were found: the mortality rate increased with proximity to the epicenter, mortality was higher among the elderly than among young people, 30% of the victims died from head injuries caused by the collapse of dwellings, and the peak of medical demand was 12 hours after the earthquake and significantly increased demand for care lasted as long as 3 days. Furthermore, the regression model indicated that 78.5% of the variation of locality-age-sex–specific mortality was explained by the intensity of the earthquake, age, population density, distance to epicenter, medical beds per 10,000 people, and physicians per 10,000 people.

Conclusion: The results implied that fragile minorities, specifically the elderly and children, require special consideration and attention in regard to disaster rescue and emergency medical care allocation. Epidemiologic analysis can guide disaster response and preparation.

[Liang N-J, Shih Y-T, Shih F-Y, Wu H-M, Wang H-J, Shi S-F, Liu M-Y, Wang BB. Disaster epidemiology and medical response in the Chi-Chi earthquake in Taiwan. *Ann Emerg Med.* November 2001;38:549-555.]

INTRODUCTION

Taiwan, located between the Philippines and the Euro-Asia tectonic plates, has suffered from frequent earthquakes as a result of its location on the most active seismic belt of the Pacific Rim in Asia. According to the record of the Central Weather Bureau of the Republic of China, the average number of earthquakes is more than 2,200 per year. Of these, more than 200 are perceptible,[1] and a few have resulted in heavy casualties, collapsed buildings, and property and other economic losses. At 1:47 AM on September 21, 1999, one of the most powerful earthquakes of the 20th century hit Taiwan. The earthquake, which registered a magnitude of 7.3 on the Richter scale and had its epicenter in Chi-Chi near the center of Taiwan,[2] affected some 20 million people on the island. Although the government and the people took part in rescue activity immediately after the earthquake, the salvage was not very effective, most likely because telecommunications and transportation systems were damaged and information gathering was poor. Relief from various sources, especially in the disaster-handling medical response, was not well coordinated. As a result of the earthquake, 2,347 people were killed, 8,722 people were injured, and property damage was estimated at more than US$92 billion.[3]

In Taiwan, there are 700 private and public hospitals that can provide more than 120,000 beds for inpatient care.[4] More than 95% of citizens are covered by national medical insurance, which covers nearly all personal health care expenses. The island is divided into 17 emergency medical service regions that incorporate emergency medical care facilities and local fire departments. This system has been in place since 1989, but no mutual aid network had been established before this earthquake. Fire fighters provide out-of-hospital medical care and ambulance services. All of them have received emergency medical technician (EMT)-1 training (a 60-hour course), and half of them have received EMT-2 training (a 260-hour course). Before this earthquake, fire fighters and some volunteer groups were responsible for search and rescue work. Most of them had received light rescue training and were equipped with simple extrication equipment. Few medical professionals in Taiwan have experience or expertise in the management of multiple casualty incidents.

An earthquake disaster can seldom be predicted with precision. A sudden, fast shaking of the earth can strike without warning. According to the 1997 report by Noji,[5] earthquakes have caused more than 1 million deaths globally in the 20th century. The 1976 Tangshan earthquake in China, with a magnitude of 7.8, killed more than 240,000 people.[6] Recently, earthquakes in India, Turkey, and Greece have imposed high costs in terms of mortality, disabilities, and economic losses.[7] Although studies related to earthquakes are abundant, few of them have focused on the analysis of emergency care needs to reduce mortality and morbidity. For example, Pretto et al[8] reported that deaths might have been prevented if victims had received appropriate medical attention in the first 6 hours after the Armenia earthquake. Schultz et al[9] indicated that response time is critical in the administration of emergency medical care and that special field hospitals established 1 week or more after the earthquake would be too late to prevent early mortality. Guha-Sapir and Carballo[10] reported that appropriate medical response should be based on epidemiologic assessments at the earthquake site. Several studies[11-16] have examined the association of mortality and morbidity associated with earthquakes using cohort and case-control methods within the period immediately after the disaster. These investigations have reported moderate to high correlation of deaths and injuries with demographic and geographic factors. These results consistently suggest that identification of risk factors is crucial to disaster management. Regarding earthquake disaster management in Taiwan, the identification of risk factors is a key to gaining insight into factors critical to the efficient handling and optimal salvage of large numbers of casualties.

In this study, we examined the patterns and relationship of age, sex, cause of deaths and injuries, and geographic distributions of casualties. The identification of the risk factors associated with earthquakes may help to improve current strategies for preventing casualties and distributing resources efficiently during disaster response.

MATERIALS AND METHODS

Crude casualty data were collected from the reports prepared by the central government, local health bureaus, and the 97 hospitals that had provided treatment for the casualties. The demographic data of disaster-affected localities were also abstracted from the annual report of the Department of Interior.[17] Statistical data on deaths and injuries were obtained from the official reports provided by the Chi-Chi Earthquake Command Post.[18] More detailed mortality data were obtained from the Ministry of Justice[19] and the Department of Health. All other data were collected from the field surveys conducted at the 97 local hospitals and bureaus of health. These field data consisted of hospitalization data from the medical records of 7,605 injured patients given ambulatory and emergency treatment.

The death toll was 2,347, as reported by medical examiners, forensic physicians, and clinical physicians. Incidence of deaths by age, sex, location, time, and causes was determined. To understand and respond to the pattern of demand for emergency services, our analysis concentrated on the injured who were found within the first 3 days after the earthquake.

The information collected on every victim was supplemented by all available data from hospital medical records, coroner reports, or direct interviews. When mismatching information was identified, additional interviews were performed during a second survey. In the few cases in which the second survey did not clarify the discrepancy, the data were excluded from the analysis. Few of the victims received autopsies, so the major cause of death could be incorrect. Some people did not seek regular medical care, such as those people who received alternative medicine, and therefore the data could not be reported in our study. Therefore, the number of patients seeking formal medical help could be underestimated.

All the data were processed and analyzed by personal computer with SPSS 8.0 for Windows (SPSS Inc., Chicago, IL). The techniques applied to data analysis included descriptive statistics generating and multiple regression modeling. The frequency tables were produced to describe the mortality of groups according to age, sex, location, and time frame and to identify the causes of deaths and injuries. In addition, multiple regression models were used to determine the risk factors for mortality resulting from the earthquake. The dependent variable in the model was region-age-sex–specific mortality. Mortality rates were stratified by 12 regions, 9 age classes, and 2 sex groups. Log transformation was based on mortality rates because of the positive distribution of the data. On the basis of a review of the medical literature and the availability of data, explanatory variables included sex, intensity of earthquake, age, population density (persons/100 km^2), distance to epicenter (km), and local medical resources, which were beds and physicians per 10,000 people. Multiple regression modeling was used for the statistical analysis and the goodness of fit was judged by F value, with significance level set at α=.05.

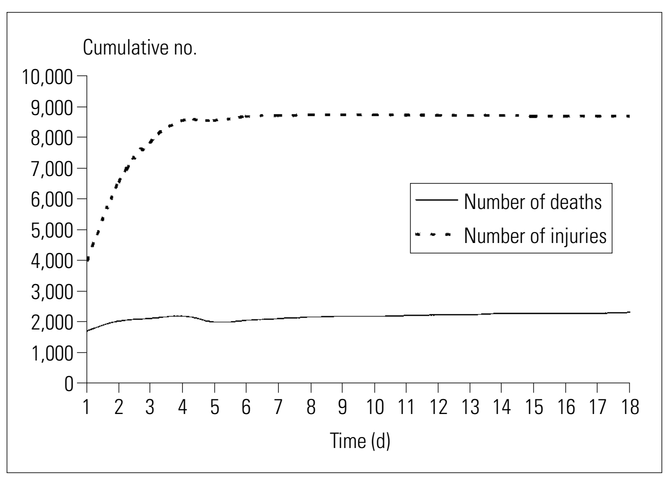
RESULTS

By October 9, the devastation from the Chi-Chi earthquake had resulted in a cumulative toll of 2,347 deaths and 8,722 injuries (Figure 1). Approximately 2,903 victims were sent to the local hospitals within the first 10 hours after the earthquake, and the number increased rapidly until September 24.

Although the earthquake had affected the entire island, the most serious damage was caused on the west coast. Nantou County, which was located at the epicenter, had the highest mortality of 155.11 per 100,000 persons, and neighboring Taichung County had 78.12 per 100,000 persons (Table 1). Mortality was higher in localities that were nearer to the epicenter, where the earthquake was consequently stronger (Figure 2). According to the death registry, most of the victims (76.9%) died in their own houses. Of the other 23.1%, 7% died in hospitals and 16.1% died outdoors. In both high and low casualty areas, women had a slightly higher mortality than men at a ratio of 1.1:1.

From the distribution of age-specific mortality rates, it was found that the extreme elderly (aged ≥80) had the highest mortality at 79.80 per 100,000 people, followed by those between the ages of 70 and 79 years at 50.04 per 100,000 people. Those between the ages of 20 and 29 years had the lowest mortality at 6.86 per 100,000 people (Table 2). Young children (>0 to 9 years) had a mortality rate of 12.65 per 100,000. Figure 3 shows that the mortality for those 20 years and older increased with the increase in age; and mortality for those less than 20 years increased

Figure 1.
Cumulative number of deaths and injuries during the 18 days after the Chi-Chi earthquake. The Y-axis indicates cumulative number of deaths and injuries. The X-axis indicates the time interval after the Chi-Chi earthquake.



with the decrease in age. Female mortality was higher throughout all age groups, except for women from 50 to 59 years of age and 60 to 69 years of age.

The potential risk factors including sex (X_1), the intensity of earthquake (earthquake strength, X_2), age (X_3), population density (persons/100 km^2, X_4), the distance to epicenter (km, X_5), hospital beds per 10,000 people (X_6), and physicians per 10,000 people (X_7) were tested for their association with locality-age-sex–specific mortality (Y). The final regression model indicated that all variables but sex were statistically significant (Table 3). The final model used for locality-age-sex–specific mortality in an earthquake is

$$\log_{10}Y = -4.088 + 0.015\ X_1 + 1.006\ X_2 + 0.101\ X_3 + 0.022\ X_4 + 0.003\ X_5 + 0.012\ X_6 - 0.153\ X_7$$

F value was equal to 76.175 and *P* value was less than .001. Overall, 78.5% of variation of locality-age-sex–specific mortality was explained by the intensity of quake, age, population density, distance to epicenter, medical beds per 10,000 people, and physicians per 10,000 people.

Coroners examined almost all of the dead victims (94.1%); medical physicians and prosecutors examined the remaining 5.9%. According to their examination reports, almost all of the deaths (91.1%) occurred on the same day as the earthquake, and 1.8% occurred the next day.

Regarding the causes of all fatalities in this earthquake, trauma caused by compression of the body was the primary cause of death, mainly as a result of head injury (32.34%), traumatic shock (29.27%), and traumatic asphyxiation (29.06%). Other causes included organ injury, cervical spinal cord injury, burns, and carbon monoxide poisoning.

During the first 3 days after the earthquake, the clinical profiles for the injured victims indicated that the majority (90%) of these patients suffered from head injury, open wounds, contusions, and fractures. The injury patterns occurring on the second and third days differed from

Figure 2.
Mortality of men and women by locality in the Chi-Chi earthquake. The Y-axis indicates the mortality rate per 100,000 people. The numbers in the parentheses on the X-axis indicate the intensity of the earthquake for individual localities.

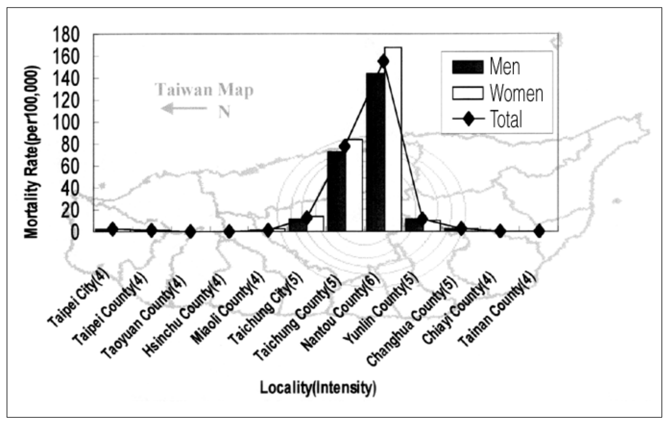


Table 1.
Deaths and mortality rates by locality and sex associated with the Chi-Chi earthquake in Taiwan in 1999.

	Population[17]			No. of Deaths			Mortality Rate (per 100,000)		
Locality (Intensity)	Men	Women	Total	Men	Women	Total	Men	Women	Total
Taipei City (4)	1,295,637	1,302,856	2,598,493	37	35	72	2.86	2.69	2.77
Taipei County (4)	1,733,428	1,687,107	3,420,535	23	24	47	1.33	1.42	1.37
Taoyuan County (4)	834,135	780,336	1,614,471	2	0	2	0.24	0	0.12
Hsinchu County (4)	402,261	371,160	773,421	1	2	3	0.25	0.54	0.39
Miaoli County (4)	294,720	265,624	560,344	2	6	8	0.68	2.26	1.43
Taichung City (5)	448,268	453,693	901,961	52	64	116	11.60	14.11	12.86
Taichung County (5)	744,377	703,384	1,447,761	544	587	1,131	73.08	83.45	78.12
Nantou County (6)	286,080	260,627	546,707	410	438	848	143.32	168.06	155.11
Yunlin County (5)	397,292	354,621	751,913	45	35	80	11.33	9.87	10.64
Changhua County (5)	673,396	624,348	1,297,744	19	17	36	2.82	2.72	2.77
Chiayi County (4)	432,311	398,206	830,517	1	1	2	0.23	0.25	0.24
Tainan County (4)	568,164	528,087	1,096,251	2	0	2	0.35	0	0.18
Total	8,110,069	7,730,049	15,840,118	1,138	1,209	2,347	14.03	15.64	14.82

those of the first day, in that nontrauma patients were in the majority of those seeking local medical services.

DISCUSSION

The Chi-Chi earthquake was the worst earthquake to hit Taiwan in the 20th century, causing 2,347 deaths and 8,722 injuries. We analyzed data to determine the factors associated with increased morbidity and mortality after the earthquake, in the hope that this work would guide us in actions to prevent deaths after future events.

Not surprisingly, we found that mortality was higher in areas closer to the epicenter, where the magnitude of the earthquake was stronger. In addition, Nantou (the county at the epicenter), has only 8 physicians per 10,000 people compared with the city of Taipei, which has 24 physicians per 10,000 people. Nantou is thus relatively very poor in medical care resources, which also could have been a reason for higher fatalities there.

The time that the earthquake occurred also could be a reason for the heavy casualties. Its sudden occurrence at midnight, when most people were indoors (most likely sleeping), probably prevented most people from escaping outdoors, and also delayed deployment of resources for rescue. Most casualties occurred in private houses and not in public places or work sites. The situation was similar to the Hanshin-Awaji earthquake of Japan, which took place at 5:46 AM on January 17, 1995.[20] In contrast, the 1980 earthquake in southern Italy, which had a mortality of 9.3% reported by de Bruycker et al,[13] occurred at 7:34 PM and killed more people in bars and dancing places.

Specific mortality according to age group reveals that the extreme elderly (aged ≥80) had the highest mortality, and those between the ages of 70 and 79 years had the second highest mortality. The mortality of the elderly was approximately 12 times that of those between the ages of 20 and 29 years. Mortality had a positive association with age for those aged 20 years and older. This finding was similar to that of Tanida[21] regarding the Great Hanshin

Figure 3.
Mortality by age and sex in the Chi-Chi earthquake. The Y-axis indicates the mortality rate per 100,000 people. The X-axis indicates the interval by age group.

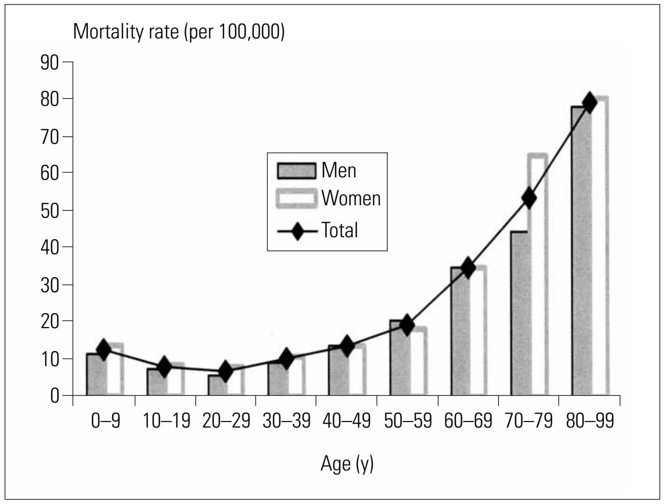


Table 2.
Deaths and mortality rates by age and sex in the Chi-Chi earthquake in Taiwan in 1999.

	Population[17]			No. of Deaths			Mortality Rate (per 100,000)		
Age Group	**Men**	**Women**	**Total**	**Men**	**Women**	**Total**	**Men**	**Women**	**Total**
>0–9 y	1,245,442	1,141,787	2,387,229	146	156	302	11.72	13.66	12.645
10–19 y	1,397,253	1,314,121	2,711,374	103	110	213	7.37	8.37	7.86
20–29 y	1,350,337	1,303,326	2,653,663	81	101	182	6.00	7.75	6.86
30–39 y	1,426,224	1,392,355	2,818,579	134	149	283	9.40	10.70	10.04
40–49 y	1,149,197	1,120,485	2,269,682	155	153	308	13.49	13.65	13.57
50–59 y	601,904	609,576	1,211,480	124	113	237	20.60	18.54	19.56
60–69 y	522,143	479,686	1,001,829	182	167	349	34.86	34.81	34.84
70–79 y	330,743	268,818	599,561	148	176	324	44.75	65.47	54.04
80–99 y	86,826	99,895	186,721	68	81	149	78.32	81.09	79.80
Total	8,110,069	7,730,049	15,840,118	1,141	1,206	2,347	14.07	15.60	14.82

earthquake. Additionally, this result is similar to observations in other natural disaster studies.[22,23]

Some possible reasons for the association were that the elderly were less able to react to emergencies and were physically weaker. Meanwhile, the mortality of children (>0 to 9 years) was lower than expected, possibly because family adults provided them with better protection.[11]

The mortality for women was 1.1 times that for men. In the Hanshin earthquake in Japan, the mortality for women was 1.5 times the mortality for men. Lower mortality for men may be because of their generally greater physical strength. On the other hand, women in the 50 to 59 and 60 to 69 age groups had lower mortality rates. The reasons for this require further study.

The number of casualties increased with time after the earthquake. Most of the deaths took place on the first day after the earthquake. Trauma was the most common cause of death. Pretto et al[8] suggested that deaths might have been prevented if the victims had received medical attention in the first 6 hours after the earthquake. Safar,[24] studying the 1980 earthquake in Italy, concluded that 25% to 50% of victims who were injured and died slowly could have been saved if lifesaving first aid had been rendered immediately. Therefore, rapid response is required for effective emergency medical service.[9] In the Chi-Chi earthquake, most of the lifesaving responses were needed within 24 hours, and medical care for a large number of patients was needed for 3 days. Additionally, hospitals were too overloaded to provide adequate quality medical care. Because of interruptions in transportation services, some victims were not able to obtain any appropriate emergency medical care in time, and either died or suffered from increased morbidity.

Potential risk factors including sex, the intensity of earthquake, age, population density, distance to epicenter, hospital beds per 10,000 people, and physicians per 10,000 people were tested for their association with the locality-age-sex–specific mortality. The final regression model indicated that all the variables, except sex, were statistically significant, and 78.5% of the variation of locality-age-sex–specific mortality was explained by these variables. The casualty estimation model can help us understand and model the different factors associated with mortality in earthquakes. This information is essential for rapidly assessing the intensity of the earthquake's impact, for anticipating medical service demands after a major earthquake, and for predicting the amount of supplies and number of personnel needed. The model can also be used by planners and responders for planning, mitigation, and medical responses. However, the model is still limited by the lack of casualty data collected through systematic mechanisms in Taiwan. Further studies are needed to improve and enhance the current model.

As a result of this analysis, many actions have been initiated by our government and medical community to reduce the effect of the next disaster. Two disaster medical assistance teams, with modular design and adequate logistic support, have been set up to respond to future events. In addition, there are several locally based disaster medical teams with basic logistic capabilities to provide urgent medical care for victims in small- to moderate-scale disasters. In addition, an urban search and rescue

Table 3.
Risk factors analysis associated with the Chi-Chi earthquake in Taiwan in 1999.

Variables	Coefficients	Standard Error	*P* Value	95% Confidence Interval Lower	95% Confidence Interval Upper
X_0: Constant	–4.088	0.431	<.001	–4.939	–3.236
X_1: Sex	0.015	0.061	.803	–0.105	0.136
X_2: Earthquake strength	1.006	0.076	<.001	0.856	1.156
X_3: Age	0.101	0.012	<.001	0.076	0.125
X_4: Population density	0.022	0.004	<.001	0.013	0.031
X_5: Distance	0.003	0.001	<.008	0.001	0.006
X_6: Medical beds/10,000 people	0.012	0.005	.013	0.003	0.022
X_7: Physicians/10,000 people	–0.153	0.029	<.001	–0.210	–0.095

R^2=0.785; F=76.175; P<.001.

team composed of rescue workers, medical personnel, structural engineers, and technicians for confined space rescue has been established. All health care facilities are now obligated to reduce their own nonstructural hazards and prepare themselves for internal and external disasters.

The devastating effects of earthquakes on human life have been demonstrated repeatedly in the past decade, as several major earthquakes have struck in urban areas. The earthquakes in 1999 in India, Turkey, Greece, and Taiwan collectively took the lives of more than 10,000 individuals and injured perhaps hundreds of thousands more. There have been several devastating earthquakes in Taiwan in this century resulting in heavy casualties, collapsed buildings, and heavy losses in property. With rapid economic development, increased population, and higher concentration of tall buildings, disaster medicine has become more urgently needed. Well-organized local emergency medical response systems are pivotal to providing a successful disaster response. The findings of epidemiologic studies on disasters are helpful to establish strategies for reducing mortality for the next disaster.

Author contributions: BBW and YTS designed the study and obtained research funding. NJL and FYS drafted the manuscript. NJL, BBW, YTS, FYS, and HJW supervised the conduct of the study and data collection. HMW, SFS, and MYL provided statistical advice on study design and analyzed. All authors contributed substantially to its revision. BBW and YTS take responsibility for the paper as a whole.

REFERENCES

1. Central Weather Bureau, Ministry of Transport and Communication, Republic of China. Available at: http://scman.cwb.gov.tw/EDUCATION/100/056.htm. Accessed October 5, 1999.

2. The 43rd report from the Central Weather Bureau, Ministry of Transport and Communication, Republic of China. Available at: http://www.cwb.gov.tw/V2.0/frames_html/cwb1.html. Accessed October 5, 1999.

3. Directorate-General of Budget, Accounting and Statistics Executive Yuan, Republic of China. Available at: http://www.dgbasey.gov.tw. Accessed February 23, 2000.

4. Department of Health, Republic of China. Available at: http://doh.gov.tw/lane/statist/88. Accessed March 5, 2001.

5. Noji EK. Earthquakes. In: Noji EK. *The Public Health Consequences of Disasters.* New York, NY: Oxford University Press; 1997:135-178.

6. Sheng ZY. Medical support in the Tangshan earthquake: a review of the management of mass casualties and certain major injuries. *J Trauma.* 1987;27:1130-1135.

7. Guha-Sapir D, Carballo M. Disaster in Turkey: lessons for health preparedness. *Lancet.* 1999;354:1649-1650.

8. Pretto EA, Ricci E, Klain M, et al. Disaster reanimatology potentials: a structured interview study in Armenia: results, conclusions, and recommendations. *Prehosp Disaster Med.* 1992;7:327-337.

9. Schultz CH, Koenig KL, Noji EK. A medical disaster response to reduce immediate mortality after an earthquake. *N Engl J Med.* 1996;334:438-444.

10. Guha-Sapir D, Carballo M. Medical relief in earthquakes. *J Royal Soc Med.* 2000;93:59-61.

11. Glass RI, Urrutia JJ, Sibony S, et al. Earthquake injuries related to housing in a Guatemalan village. *Science.* 1977;197:638-643.

12. De Bruycker M, Greco D, Annino I, et al. The 1980 earthquake in southern Italy: rescue of trapped victims and mortality. *Bull World Health Organ.* 1983;61:1021-1025.

13. De Bruycker M, Greco D, Lechat MF, et al. The 1980 earthquake in southern Italy: morbidity and mortality. *Int J Epidemiol.* 1985;14:113-117.

14. Noji EK, Kelen GD, Armenian HK, et al. The 1988 earthquake in Soviet Armenia: a case study. *Ann Emerg Med.* 1990;19:891-897.

15. Roces MC, White ME, Dayrit MM, et al. Risk factors for injuries due to the 1990 earthquake in Luzon, Philippines. *Bull World Health Organ.* 1992;70:509-514.

16. Armenian HK, Melkonian A, Noji EK, et al. Deaths and injuries due to the earthquake in Armenia: a Cohort Approach. *Int J Epidemiol.* 1997;26:806-813.

17. Ministry of Interior, Republic of China. Available at: http://www.ris.gov.tw/ch4/static/. Accessed March 30, 2000.

18. National Fire Department Administrations, Ministry of Interior, Republic of China. Available at: http://www.nfa. gov. tw/report/earthquake.heml. Accessed November 16, 1999.

19. Ministry of Justice, Republic of China. Available at: http://www.moj.gov.tw/921/Search.asp. Accessed March 30, 2000.

20. Yasuhiro U, Akiyoshi N, Yoshitsugu T, et al. Analysis of the results of inquests in the great Hanshin earthquake. In: Yamamoto M. *Comprehensive Medical Studies on the Earthquake Victims.* Kobe, Japan: Kobe University School of Medicine; 1998:27-34.

21. Tanida N. What happened to elderly people in the great Hanshin earthquake. *BMJ.* 1996;313:1133-1135.

22. Schmidlin TW, King PS. Risk factors for death in the 27 March 1994 Georgia and Alabama tornadoes. *Disasters.* 1995;19:170-177.

23. Bolin R, Klenow DJ. Response of the elderly to disaster: an age-stratified analysis. *Int J Aging Hum Dev.* 1983;16:283-296.

24. Safar P. Resuscitation potentials in mass disasters. *Prehosp Disaster Med.* 1986;2:34-47.