Disease-specific Mortality Associated with Earthquake in Taiwan

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Objectives. On September 21, 1999, an earthquake of magnitude 7.3 on the Richter scale occurred in Chi-Chi, Nantou county in central Taiwan. Two thousand three hundred forty-seven persons were killed and many buildings were damaged. The objective of this study was to investigate the mortality rates of cardiovascular disease, injury and suicide associated with the earthquake.
Methods. Age-standardized cause-specific mortality rates and mortality rate ratio (MRR) were calculated for 1998 and 1999 in disaster and non-disaster areas.
Results. Changes in mortality rates for injury among men and women significantly increased after the earthquake (124.4% and 438.1%, respectively). The mortality rate of suicide was higher in 1999 compared with 1998 for men and women. There were no significant differences between 1998 and 1999 for cardiovascular disease (CVD). MRR for injury was highest in September 1999 for men and women. The MRR peaked in October for suicide, but there was no difference for CVD.
Conclusions. There was a considerable increase in the number of suicides after the earthquake. In addition to treating the physical symptoms of earthquake survivors, it is also very important that public health personnel meet the psychological and emotional needs of the victims. **(Mid Taiwan J Med 2003;8:157-64)**

Key words

cardiovascular disease, earthquake, injury, standardized mortality, suicide

INTRODUCTION

On September 21, 1999 at 01:47, an earthquake of magnitude 7.3 (Richter scale) occurred in Chi-Chi, Nantou county in central Taiwan resulted in the death of 2347 people. The crude death rate in 1999 was 5.73/1000 compared with 5.64/1000 in 1998 (Taiwan Department of Health, DOH). The suicide rate in 1998 was 10.36/100,000 compared with 10.64/100,000 in 1999 and was higher for men (14.49/100,000) than for women (7.63/100,000) [1]. Krug et al compared suicide rates following different kinds

of natural disasters occurring from 1982 to 1989 and found that the suicide rate increased the most after earthquakes [2]. Quake victims are vulnerable to stress and anxiety which can exacerbate existing medical conditions such as cardiovascular disease (CVD) and ischemic heart disease (IHD). As a result, mortality rates of these diseases often significantly increase in the months following an earthquake. Kloner et al reported that in the week following the Los Angeles earthquake in 1994, mortality rates of both CVD and IHD increased and then rapidly decreased a week later to levels lower than normal. This phenomenon is known as overcompensation [3]. Kario et al showed that the incidence of CVD increased markedly after the Great Hanshin-Awaji

Table 1. Age-standardized mortality rates (1/100,000) of injury, cardiovascular disease and suicide in 1998 and 1999 among men in disaster and non-disaster areas

	1998		1999		Rate change (%) (95% CI)	Rate difference (1/100,000) (95% CI)	Morality rate ratios (MRR)
	n	Rate	n	Rate			
Injury							2.02
Disaster area	570	90.4	1168	202.9	+124.4*,** (9.6 to 231.4)	+112.5*,** (23.6 to 198.7)	
Non-disaster area	786	75.4	1154	8.35	+10.7** (−7.9 to 48.8)	+8.1** (−4.9 to 16.5)	
Cardiovascular disease							1.03
Disaster area	397	61.1	302	60.3	−1.3 (−7.5 to 12.3)	−0.8 (−4.7 to 7.3)	
Non-disaster area	579	55.0	636	52.8	−4.0 (−9.9 to 7.9)	−2.2 (−2.8 to 3.8)	
Suicide							1.12
Disaster area	111	18.0	98	19.9	+10.6** (−4.8 to 13.6)	+1.9 (−9.7 to 11.9)	
Non-disaster area	133	13.1	161	12.9	−6.1** (−20.7 to 2.5)	−0.2 (−2.7 to 30.1)	

*Rate change and rate difference in 1998 and 1999 were compared by Z-test, **Rate change and rate difference in disaster and non-disaster areas were compared by Z- test.

earthquake, particularly among the elderly living near the epicenter [4]. Many studies [5-7] have shown that there are significant increases in mortality rates of suicide, CVD and injury after a quake. As such, the Taiwan government intends to implement measures to minimize the risk of death due to these factors in the period following future disasters. The purpose of this study was to compare mortality rates of suicide, injury and CVD before and after the Chi-Chi earthquake to identify which one poses the greatest risk.

MATERIALS AND METHODS

Data were collected for the period 1998-99 from original death certificates which are centralized in the Taiwan DOH, Office of Statistics. Age-standardized mortality rates were calculated using the direct method, and mortality rates of suicide, injury and CVD were recorded. The nationwide population in 1996 in Taiwan was chosen as the standard population. The international classification of disease (ICD-9) was used to define causes of death by suicide (ICD-9, 950), injury (ICD-9, 800-949), and CVD (ICD-9, 390-392, 393-398, 410-404, 420, 429). Population data (including geographic location, gender and age) were obtained from the Taiwan

Ministry of the Interior [8].

Disaster areas and non-disaster areas were defined according to government classifications and were provided by the Ministry of the Interior. However, for our data, one district within Taichung city was not included in the disaster area because the damage was not severe. Mortality rates in 1998 and 1999 were compared using three parameters: rate change, rate difference and mortality rate ratio (MRR). Rate change was defined as the difference in mortality rates from 1998 to 1999 divided by mortality rates in 1998. Mortality rate differences were defined as the 1998 mortality rate subtracted from the rate in 1999. MRR was defined as the ratio of mortality rates in 1999 and 1998 in the disaster area divided by the same ratio in the non-disaster areas. If the MRR was greater than 1, then the mortality rates in 1999 in the disaster areas were higher than in the non-disaster areas, after adjusting for mortality rates of disaster and non-disaster areas in 1998. The data were analyzed by SAS/pc+ 6.12 software. The Z-test examined the statistical differences between mortality rates in disaster and non-disaster areas in 1998 and 1999. We also compared the mortality rate change and rate difference in the disaster and non-disaster

Table 2. Age-standardized mortality rates (1/100,000) of injury, cardiovascular disease and suicide in 1998 and 1999 among women in disaster and non-disaster areas

	1998		1999		Rate change (%) (95% CI)	Rate difference (1/100,000) (95% CI)	Morality rate ratios (MRR)
	n	Rate	n	Rate			
Injury							5.18
Disaster area	201	31.8	918	171.1	+438.1*,** (52.8 to 735.8)	+139.3*,** (27.8 to 291.2)	
Non-disaster area	280	31.5	561	32.7	+3.8** (−2.3 to 7.9)	+1.2** (−1.1 to 2.5)	
Cardiovascular disease							1.00
Disaster area	349	57.6	226	50.4	−12.5 (−40.7 to 7.3)	−7.2 (−23.8 to 4.0)	
Non-disaster area	446	49.6	500	43.3	−12.7 (−23.6 to 19.9)	−6.3 (−12.8 to 8.7)	
Suicide							1.72
Disaster area	41	6.9	51	9.7	+40.6*,** (−17.1 to 48.3)	+2.8 (−7.4 to 10.8)	
Non-disaster area	77	8.7	78	7.1	−18.4*,** (−21.4 to 17.3)	−1.6 (−14.7 to 8.3)	

*Rate change and rate difference in 1998 and 1999 were compared by Z-test, **Rate change and rate difference in disaster and non-disaster areas were compared by Z-test.

areas by the Z-test.

RESULTS

Table 1 shows age-standardized mortality rates of injury, CVD and suicide in 1998 and 1999 among men in the disaster and non-disaster areas. Injury mortality rate was significantly higher in the disaster areas (202.9/100,000) in 1999 compared with the previous year (90.4/100,000). However, for men in the non-disaster areas there was no significant difference in injury mortality rate. MRR for injury was 2.02 which indicates that the mortality rate in 1999 in the disaster areas was approximately double that in the non-disaster areas. CVD mortality rate was consistently lower in 1999 compared with 1998. MRR for CVD was 1.03 which indicates that the CVD mortality rate was not significantly affected by the earthquake. The suicide mortality rates were higher in the disaster areas compared with the non-disaster areas for both 1998 and 1999. In the disaster areas, the suicide mortality rate was slightly higher in 1999 (19.9/100,000) compared with 1998 (18.0/100,000). MRR for suicide was 1.12, which was slightly higher in the disaster areas compared with the non-disaster areas in

1999.

Table 2 shows age-standardized mortality rates of injury, CVD and suicide in 1998 and 1999 among women in the disaster and non-disaster areas. The injury mortality rate was significantly higher in 1999 (171.1/100,000) compared with that in 1998 (31.8/100,000) in the disaster areas. MRR for injury was 5.18. The CVD mortality rate was lower in 1999 (50.4/100,000) compared with that in 1998 (57.6/100,000) in the disaster areas. MRR for CVD was 1.0 which indicates that the CVD mortality rate was not related to the earthquake. The suicide mortality rate was higher in 1999 (9.7/100,000) compared with the rate in 1998 (6.9/100,000) in the disaster areas. However, in the non-disaster areas the suicide mortality rate was lower in 1999 compared with the rate in 1998. MRR for suicide was 1.72.

Table 3 compares injury, CVD and suicide mortality rates in the disaster and non-disaster areas among men from August to November in 1998 and 1999. MRR for injury was highest in September, followed by October. The CVD mortality rate was highest in October 1999 in the disaster area and MRR was greater than 1 for this

Table 3. Mortality rate ratios of injury, CVD and suicide in 1998 and 1999 among men in disaster and non-disaster areas from August to November

	Disaster area		Non-disaster area		Morality rate ratios (MRR)
	1998	1999	1998	1999	
Injury					
August	7.74*	6.91	7.93	7.63	1.08
September	6.47	7.69	6.05	128.1	17.81
October	5.98	7.11	6.63	9.64	1.22
November	6.47	7.69	5.48	6.76	1.04
Cardiovascular disease					
August	3.43	3.31	4.18	3.45	0.86
September	3.63	4.28	4.47	3.17	0.60
October	3.53	4.09	4.61	5.47	1.02
November	4.51	4.77	4.61	4.46	0.91
Suicide					
August	1.47	1.66	1.44	1.44	0.89
September	1.18	0.78	1.30	1.29	1.50
October	1.08	1.07	1.59	2.45	1.56
November	0.39	0.88	0.80	1.58	0.81

*Age-standardized mortality rates (1/100,000).

Table 4. Mortality rate ratios of injury, cardiovascular disease and suicide in 1998 and 1999 among women in disaster and non-disaster areas from August to November

	Disaster area		Non-disaster area		Morality rate ratios (MRR)
	1998	1999	1998	1999	
Injury					
August	3.27*	2.51	4.45	2.60	0.76
September	2.03	5.23	1.69	147.49	33.88
October	4.06	2.41	1.53	7.80	8.59
November	3.16	3.35	3.07	2.29	0.70
Cardiovascular disease					
August	4.85	3.14	2.91	4.28	2.27
September	4.18	4.19	3.07	4.59	1.49
October	4.29	3.56	4.60	2.60	0.68
November	4.18	3.66	4.14	2.14	0.59
Suicide					
August	0.68	0.52	0.61	0.61	1.62
September	0.56	0.52	0.15	0.31	2.23
October	0.90	0.73	0.46	1.07	2.87
November	4.45	0.31	0.77	0.76	1.46

*Age-standardized mortality rates (1/100,000).

month only. MRR for suicide was greater than 1 in September and October, and peaked in October 1999 (2.45/100,000).

Table 4 shows injury, CVD and suicide mortality rates in the disaster and non-disaster areas among women from August to November. MRR for injury was highest in September (33.88), followed by October (8.59). Overall, MRR in September was twice that of men. MRR

for CVD was highest in August (2.27), followed by September (1.49), and was higher in the disaster areas compared with the non-disaster areas. MRR for suicide exceeded 1 in all four months, and peaked in October (2.87). Suicide mortality was highest in the disaster areas in October (1.07/100,000). Female mortality rates were lower than male mortality rates in each of the four months. However, MRR for suicide was

consistently higher for women than men.

DISCUSSION

Earthquakes of the magnitude that shook Taiwan on September 21, 1999 occur about once every 100 years. As such, there are no data about the effects that earthquakes have on mortality in Taiwan. The Chi-Chi earthquake in 1999 resulted in the death of 2347 people and the hospitalization of over 10,000 people. Most deaths and injuries were caused by collapsing buildings. In Taiwan, many elderly people live on the ground floor for reasons of convenience, disability or cultural reasons and this helps to explain why a large proportion of the earthquake victims were elderly. Life expectancy of women in Taiwan is about 5 years longer than that of men, so a larger proportion of the elderly victims were women. MRR for women was 5.18 compared with 2.02 for men. For all mortality causes, competitive risk did not appear to be significant because data were collected during a short time period and two areas were compared within that duration. The Great Hanshin quake in Japan in 1995 (Richter scale 7.2) killed 6,308 people and injured more than 41,000. Ueno et al analyzed 3660 quake-related deaths in Kobe and found that 53% of the victims were aged over 60 years, and that 74% of them died of traumatic asphyxia due to collapsed buildings [9]. It was found that severity of injury was inversely related to distance from the epicenter and increased with increasing ground motion and building damage [6]. These findings are similar to those in the current study. In 1998, the Taiwan government implemented a law requiring motorcyclists to wear safety helmets which resulted in a decrease in the injury mortality rate (50.5/100,000). Injury went down from the third leading cause of death to the fourth. However, in 1999, due to the earthquake, injury was the second leading cause of death, an increase of 8.3/100,000.

Previous studies [10,11] have associated earthquakes with CVD onset. The sudden increase in stress caused by the earthquake might cause heart attacks, although there is little evidence to support this hypothesis. Kario et al reported that major earthquakes increase the incidence of death by CVD during the period from night-time to morning, especially among the elderly living near the epicenter [4]. Aoyama et al investigated the incidence of bleeding gastric ulcers, which has been associated with stress, after the Hanshin-Awaji quake of 1995 and found that the quake caused and exacerbated gastric bleeding, especially among the elderly [12]. Ogawa et al reported that the standardized mortality ratio (SMR) of acute myocardial infarction (AMI) significantly increased about eight weeks after the Great Hanshin-Awaji earthquake and was positively correlated with the number of houses completely destroyed by the earthquake ($r = 0.53$, $p = 0.062$) [11]. However, Dobson et al reported that there was no increase in AMI or ischemic heart disease in the four weeks following the Newcastle earthquake in 1989 [10]. The current study did not find any significant differences between CVD mortality rates before or after the quake for men or women. This may have been due to the definition of CVD used which included a wide range of heart diseases. Specific heart diseases were not analyzed separately because the sample size was small. When specific types of CVD were analyzed separately, no significant correlations were found in the current study (data not shown). Dobson investigated the incidence of heart attacks after the Newcastle earthquake in 1989, and the results showed that acute emotional and physical stress may have triggered myocardial infarction and coronary death [10]. Also, CVD data were collected from just one year. For men in the disaster areas, CVD mortality peaked in October 1999, but was lowest in September. For women, CVD mortality peaked in September 1999 but decreased gradually in each following month. These results were consistent with Kloner's study [3] on the impact of the Los Angeles earthquake in that CVD mortality rates increased after the earthquake and then decreased to levels lower than normal. Our findings do not support the hypothesis that a long-term increase in rates of CVD following an earthquake are related to the intensity of exposure to disaster-related damage

and losses. Further research is required to investigate how natural disasters affect CVD mortality rates.

Suicide mortality rates were slightly higher in the month following the earthquake, peaking in October 1999 (2.45/100,000 for men, and 1.07/100,000 for women). The factors affecting suicide after an earthquake are complex and health workers must conduct further research in order to reduce the suicide rate after future disasters. MRR for suicide amomg men was 0.81 in December, but for women the MRR was 1.46. The mortality rate for suicide was consistently higher among men compared with women in each of the four months from August to Norember. However, MRR for suicide among women was higher than among men. This suggests that the psychological effect of the earthquake in the disaster areas was far greater for women than for men. For men and women, suicide mortality rates were highest in the 25 to 39 year age group. Suicide rates among the 22 townships in the disaster areas varied markedly and were significantly correlated to severity of damage (number of injuries and number of collapsed/ partially collapsed buildings) within the township. The mortality rate of suicide in Chung Liao township in Nantou county was 38.74/100,000 for men and 16.60/100,000 for women, compared with the national average for 1999 of 10.36/100,000. Krug et al reported that suicide mortality rates were highest among earthquake victims compared with victims of other natural disasters. Suicide mortality rates increased from 19.2/100,000 (before the earthquake) to 23.0/100,000 (one year after the earthquake), and increased by the greatest amount in the 10 to 29 year age group [2]. These data are consistent with the study by the Taiwan DOH which showed that suicide mortality rates increased from 9.97/100,000 in 1998 to 10.36/100,000 in 1999, and 10.64/100,000 in 2000. The increase in the number of suicides after the earthquake may have been due, in part, to financial problems caused by the quake. In all of the 21 districts in Taichung county, the post-quake suicide rate was higher

among men than among women in our study. This may have been due to differences in social support and coping strategies employed by men and women. Gender differences in suicide are complex and have been shown to be affected by numerous factors [13]. Phillips (2002) reported that risk factors for suicide in China included depression, number of previous suicide attempts, acute stress at the time of death, and low quality of life. The suicide rate may have been underestimated because of the social stigma of suicide in Chinese society [14]. The increase in unemployment rates and the financial burden of having to reconstruct homes after the quake may have contributed to the rise in suicide rates, especially in rural areas. Cheng assessed the demographic profiles of suicide victims and found that the most important risk factors were as follows: male gender, divorce, unemployment, social isolation, and lack of support from friends and family [15]. However, Shioiri et al reported that there was a decrease in suicide rates among Japanese men after the Kobe earthquake. This may have been due to cultural differences and/or efficiency of the medical support systems in Japan [16]. Bleich et al reported that suicide rates of post-traumatic stress disorder (PTSD) sufferers were lower than among non-PTSD subjects. The effect was greater among PTSD victims who were also suffering from depression and anxiety [17]. Goenjian et al indicated that adults are at a higher risk of developing severe and chronic PTSD if they have experienced chronic anxiety and depressive reactions after exposure to severe trauma, such as an earthquake or violence [18]. Moreover, Aremenia et al studied the relationship between PTSD and severity of earthquake experience and reported that provision of early support to survivors with high levels of loss may reduce PTSD following an earthquake [19]. To help promote mental health after a natural disaster, the Taiwan government has implemented various programs, such as the establishment of centers for mental health in areas most affected by the quake. High-risk individuals are now monitored and provided support in the form of

counseling or economic assistance by social workers and health professionals. These measures have been undertaken to reduce suicide rates, and the impact of these programs will be evaluated in the future.

In conclusion, the Chi-Chi earthquake resulted in a significant increase in injury mortality rates and a slight increase in suicide mortality rates. MRR for injury and suicide were higher among women than men. However, CVD mortality rates were not significantly affected. Further studies are needed to assess the effectiveness of the programs implemented by the government to reduce suicide mortality rates.

ACKNOWLEDGMENTS

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台灣中部地區九二一地震與特定疾病死亡率之相關性研究

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目的　　在1999年9月21日台灣地區在集集鎮發生芮氏7.3級的大地震。造成2347人死亡及許多房屋倒塌不幸的事件。本研究之目的在比較地震前後災區及非災區民眾三種疾病包括心臟血管、意外事故及自殺之標準化死亡率變化。

方法　　收集內政部1998及1999年中部地區人口及衛生署死因統計資料，經年齡標準化計算1998及1999年之災區及非災區民眾總死亡率及原因別心臟血管、意外事故及自殺之死亡率。災區地區之劃定是依內政部消防署劃定為依據。

結果　　在傷害事故之死亡率因地震所增加之比率在男性為124.4%及女性為438.1%。不論男女別在1999年自殺死亡率皆高於1998年，但在心臟血管疾病卻無顯著的差異。計算兩年間災區與非災區之死亡率比值(MRR)皆以1999年9月傷害事故最高。在自殺方面MRR主要尖峰(peak)在10月份，但在心臟血管標準化死亡率在8至11月份並無明顯差異。

結論　　台灣中部地區發生921地震後，在災區自殺死亡率有增加現象，然而心臟血管疾病死亡率並未有明顯之增加現象。然而，如何處理地震過後災民在身體上及心理上之影響，是公共衛生及其他社福機關人員主要救援工作的重點。（中台灣醫誌 **2003;8:157-64**）

關鍵詞
心臟血管疾病，地震，傷害事故，標準化死亡率，自殺