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The Suicide Mortality Rates between 1997–1998 and 2000–2001 in Nantou County of Taiwan Following the Earthquake of September 21 in 1999

ABSTRACT: The paper aims to show the different suicide mortality rate between 1997–1998 and 2000–2001 in Nantou County of Taiwan with earthquake on September 21 (often referred to as the “9-21 earthquake”) in 1999. In addition, it also identifies the preventive strategies for the high-risk suicide population. The age-standardized mortality rates for suicide in Nantou County were calculated for the years 1997–1998 and 2000–2001. The suicide standardized mortality ratio (SMR for townships in Nantou were calculated by “type of township” as the standard rate). There is a statistically significant difference in male suicide rates for the years prior to the earthquake (1997–1998) when pooled and compared to the suicide rates for the years after the earthquake (2000–2001). The rate for four age groups (under 25, 25–44, 45–64, 65 and above) all increased, yet all but one (the group of age 45–64) was not statistically significant. The male SMR has slightly increased after the 9-21 earthquake. Yet there are no statistical significances in most townships, except in Kaohsiung and Puli after the 9-21 earthquake. The Kaohsiung SMRs were 1.36 (95% CI: 0.54–2.80) before the earthquake (1997–1998) and 2.01 (95% CI: 1.04–3.52) after the earthquake (2000–2001). The SMRs before and after the earthquake in the Puli Township were 1.51 (95% CI: 0.95–2.29) to 1.56 (95% CI: 1.03–2.27). This study suggests that monitoring high-risk population, especially males or 45–64 years of age who experienced the highest statistically significant suicide rate in this study. The study provides support for providing both the psychological restoration program and, to the extent feasible, financial support for the unemployed as useful public health strategies for suicide prevention in Taiwan.

KEYWORDS: forensic science, earthquake, suicide, age-standardized mortality rate, standardized mortality ratio

On September 21 in 1999, Taiwan experienced one of the worst natural disasters—an earthquake measuring 7.3 on the Richter scale occurring 12.5 km to the southwest of Sun Moon Lake in Nantou County of Taiwan. The epicenter was in Central Taiwan, and the devastated areas included the counties of Taichung, Nantou and Yunlin, with Nantou County taking the worst punishment (1). The event resulted in more than 2,000 deaths, 10,000 injuries, and 100,000 buildings collapsed or damaged (2).

The mental health impact on survivors following the 1999 Taiwan earthquake has attracted considerable attention. Previous studies show that victims of earthquakes can suffer from short- or long-term somatic and mental disorders (3). In recent study, it showed that there are elevated risk for developing posttraumatic sequelae following the 1999 Taiwan earthquake (4). Suicide represents the terminal outcome in the spectrum of potential major mental health issues spawned by severe earthquakes. Yang’s study (5) found that the mean monthly suicide rate for earthquake victims greater for the high-exposure group than for the low-exposure

group. However, it does not show that suicide rates increased after the Northridge earthquake (6). A previous study, by US Center for Disease Control and Prevention researchers, discovered that suicide rates increase during the year after severe disasters (such as earthquakes, floods, and hurricanes) (7). However, after this was published the researchers found that there was a statistical mistake. The new result concerning suicide mortality rates was actually non-significant before and also after an earthquake. The earlier study was retracted in 1999 (8). A study in Japan showed that the male suicide mortality rate was strikingly decreased after the Hanshin-Kobe earthquake (9). Moreover, the suicide rate was recorded as being the lowest rate following World War II. Yet, the impact of earthquakes on the suicide mortality rate remains inconsistent.

If suicide rates do increase after major earthquakes, then high-risk populations susceptible to suicide should be identified as early as possible. Therefore, the paper aims to show the different suicide mortality rate between 1997–1998 and 2000–2001 in Nantou County of Taiwan with earthquake on September 21 (9-21 earthquake) in 1999, and furthermore to identify the preventive strategies for the high-risk suicide population.

Methods

This study utilized the damage reports of the 9-21 earthquake in 1999, from the Department of Interior’s National Fire Agency, health statistics, and demographic information to analyze the suicide mortality rate before and after the 9-21 earthquake. The computerized national mortality registry database, (obtained from the Department of Health, Executive Yuan), contained 1997–1998 and

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2000–2001 coded death certificates (10). The variables included age, gender, residency, and causes of death. Suicide deaths were identified by an International Statistical Classification of Disease, Injuries and Causes of Death, ICD-9 code E950-E959 (11).

As Taiwan requires all residents to maintain registration within a district government office, Taiwan's census registry data is reliable and complete. The mid-year population was obtained from the document: "Demographic Statistics for Taiwan-Fuchien Area" (12). Age categories were divided into 18 age groups (age 0–4, 5–9, 10–14, ..., 80–84, 85 and above). The source of the 9-21 Earthquake damage report, which states the number of death and injured and the partial damaged or destroyed buildings, was obtained from the National Fire Agency, Department of Interior (1).

In order to improve reliability, the researchers took the data from the two calendar years before and after the 9-21 Earthquake in 1999 (1997–1998 vs. 2000–2001) for this study. We utilized age-adjusted standardized mortality rates (ASR) to calculate male and female suicide mortality rates. Also, in order to stabilize the data and explore the mortality rate by different age groups, the researchers categorized age into 0–24, 25–44, 45–64, and over 64, without separating gender, and computed the suicide mortality rate in the two calendar years before and after the 9-21 Earthquake.

This study used the crude earthquake death rate per 100,000 person-years, i.e., the death toll from the earthquake divided by the mid-year population times 100,000 person-years as the index of severity of the earthquake for each town. Furthermore, for stability reasons, we applied the standardized mortality ratio (SMR) instead of the ASR to compare suicide mortality rates among Nantou townships. This study used the individual town-group ("type of township") as the standard rate to calculate the SMR. The researchers segregated the Taiwan 309 townships according their characteristics, into seven groups: newly developed towns, mountain villages, business towns, mixed towns, hilly towns, remote towns, and service towns (13). To calculate the SMRs, age categories were divided into 18 age groups: 17 5-year intervals for age 0–84, and one category for age 85 and above. The 18 age-specific rates of each town-group served as the standard rates while computing the SMR for the Nantou townships. The sum of age-specific populations in each township of Nantou County times the corresponding standard age-specific suicide mortality rates. That was the expected number of suicides for each township. The SMR was the observed number of suicides divided by the expected suicide number. For instance, the k year, j town SMR _{jk} as follows ($k = 1$ is for the year of 1997–1998, $k = 2$ is for the year of 2000–2001):

$$SMR_{jk} = \frac{\sum_{i=1}^{18} D_{ijk}}{\sum_{i=1}^{18} P_{ijk} \times R_{ijk}} = \frac{\text{Observed no. of death}}{\text{Expected no. of death}}$$

D_{ijk} is the number of suicides for the i age group at j township of Nantou in k period. P_{ijk} was the mid-year population for the i age group at j township of Nantou in k period. R_{ijk} is the standard age-specific suicide mortality rate for the i age group in k period.

Results

Table 1 shows the number of suicide deaths, ASR, the number of age-specific deaths, age-specific mortality rates, increase rates, and a 95% confidence interval (95% CI) before and after the 9-21 Earthquake in Nantou County. According to Table 1, the male suicide mortality rate for the two calendar years after the event

TABLE 1—ASR, age-specific mortality rate, and 95% CI before and after the 9-21 Earthquake in Nantou County.

	1997–1998		2000–2001		Increase Rate (%)	95% CI
	No. of Suicide Death	Rate	No. of Suicide Death	Rate		
Gender						
Male	110	16.3	162	23.6	45*	10% to 81%
Female	43	7.0	63	10.1	43	–13% to 100%
Age						
Under 25	11	2.6	17	4.2	63	–61% to 186%
25–44	74	21.0	90	26.2	25	–13% to 64%
45–64	35	17.1	71	32.5	90*	13% to 167%
65 and above	33	31.5	47	41.0	30	–28% to 88%

ASR, age-adjusted standardization mortality rates; CI, confidence interval.

(2000–2001) increased from 16.3 to 23.6 per 100,000 person years. The rate shows an increase of 45%. The increase was statistically significant. In contrast, the female rate also increased by 43%, yet was not statistically significant. The rate for four age groups (under 25, 25–44, 45–64, 65 and above) all increased, yet all but one (the group of age 45–64) was not statistically significant. Additionally, the group aged 65 and above showed the highest suicide mortality rate among all groups investigated either before or after the Earthquake.

Table 2 shows the Nantou County township's SMR by the "type of township" as the standard rate and 95% CI before and after the 9-21 Earthquake. The characteristics of the Nantou County townships fall into three of seven town-groups. Group 2 (mountain villages), includes Chichi, Yuchi, Shueili, Jenai, and Hsienyi. Group 4 (comprised mixed townships), Puli, Tsaotun and Nantou city. Group 5 (hilly townships), consists of Chungliao, Kuohsing, Chushan, Luku, and Mingchien. The results in Table 2 show that the male SMR has slightly increased after the 9-21 earthquake. Yet there are no statistical significances in most townships, except in Kuohsing and Puli afterward. It is worth noting that the SMRs of Kaohsiung and Puli showed no significance before the earthquake, but they did reach statistical significance after the earthquake. The Kuohsing SMRs were 1.36 (95% CI: 0.54–2.80) before (1997–1998) and 2.01 (95% CI: 1.04–3.52) after the earthquake (2000–2001). The SMRs before and after in the Puli township were 1.51 (95% CI: 0.95–2.29) to 1.56 (95% CI: 1.03–2.27). Four townships, Chungliao, Kuohsing, Chichi, and Puli, suffered most during the earthquake. Chungliao township, the most damaged area, shows no significant value in SMR. In addition, there was no significant change in the Chichi township, with a SMR of 1.29 after the earthquake. The female SMRs in all study townships, except Hsingyi township, show no significant changes in both periods before and after the earthquake. The SMRs for the Hsienyi township (mountain villages) were 2.83 and 2.53 before and after the earthquake, respectively. Nevertheless, the value of 2.53 after the earthquake is not of archived statistical significance.

Discussion

Previous studies show that social change affects the suicide rate in Taiwan; for example, a higher unemployment rate increases the number of suicides (14). Gender, age, time periods, and townships have different impacts on suicide mortality. In order to adjust the known and other potential confounders due to social change when understanding the difference in suicide rate before and after the

TABLE 2—SMR and 95% CI for the Nantou County townships with the individual township group as the standard rate before and after the 9-21 earthquake.

Gender	Township	Crude Mortality Rate in Earthquake Per 100,000 person-years	Group	1997–1998				2000–2001			
				Obs	Exp	SMR	95% CI	Obs	Exp	SMR	95% CI
Male	Chungliao	990	5	4	4.12	0.97	0.26–2.49	4	4.71	0.85	0.23–2.18
	Kuohsing	365	5	7	5.15	1.36	0.54–2.80	12	5.97	2.01*	1.04–3.52
	Chichi	309	2	3	3.13	0.96	0.19–2.79	5	3.88	1.29	0.42–3.01
	Puli	234	4	22	14.57	1.51	0.95–2.29	27	17.31	1.56*	1.03–2.27
	Chushan	190	5	17	11.33	1.50	0.88–2.41	18	13.43	1.34	0.79–2.11
	Luku	109	5	4	4.35	0.92	0.25–2.35	5	5.10	0.98	0.32–2.29
	Tsaotun	92	4	16	14.95	1.07	0.61–1.74	22	18.03	1.22	0.76–1.84
	Nantou city	87	4	14	16.28	0.86	0.47–1.44	25	19.53	1.28	0.83–1.89
	Mingchien	82	5	6	8.11	0.74	0.27–1.60	15	9.87	1.52	0.85–2.51
	Yuchi	78	2	2	4.76	0.42	0.05–1.52	6	5.71	1.05	0.38–2.28
	Shueili	34	2	2	5.88	0.34	0.04–1.23	8	7.02	1.14	0.49–2.26
	Jenai	7	2	6	3.68	1.63	0.60–3.55	6	4.48	1.34	0.49–2.91
	Hsienyi	0	2	7	4.14	1.69	0.68–3.48	9	5.06	1.78	0.81–3.39
	Female	Chungliao	990	5	1	1.64	0.61	0.01–3.38	1	1.96	0.51
Kuohsing		365	5	5	2.00	2.50	0.81–5.83	5	2.39	2.09	0.67–4.87
Chichi		309	2	1	1.79	0.56	0.01–3.11	2	1.72	1.16	0.13–4.18
Puli		234	4	7	6.48	1.08	0.43–2.23	13	7.43	1.75	0.93–3.00
Chushan		190	5	2	5.00	0.40	0.04–1.44	6	6.19	0.97	0.35–2.10
Luku		109	5	1	1.85	0.54	0.01–3.03	4	2.25	1.78	0.48–4.56
Tsaotun		92	4	3	6.98	0.43	0.09–1.26	3	8.11	0.37	0.08–1.09
Nantou city		87	4	8	7.48	1.07	0.46–2.10	13	8.61	1.51	0.80–2.58
Mingchien		82	5	0	4.43	0.00	–	4	4.30	0.93	0.25–2.38
Yuchi		78	2	2	2.56	0.78	0.09–2.83	1	2.38	0.42	0.01–2.31
Shueili		34	2	4	3.31	1.21	0.33–3.10	3	3.06	0.98	0.20–2.86
Jenai		7	2	3	1.90	1.58	0.32–4.63	3	1.79	1.68	0.34–4.92
Hsienyi		0	2	6	2.12	2.83*	1.03–6.16	5	1.98	2.53	0.81–5.90

Group 1: newly developed town; group 2: mountain village; group 3: business town; group 4: mixed town; group 5: hilly town; group 6: remote town; and group 7: service town.

$$SMR = \frac{\text{Observed number of death}}{\text{Expected number of death}} = \frac{Obs}{Exp}$$

$$95\% \text{ CI } SMR_L = \frac{Obs}{Exp} \left[1 - \frac{1}{9(Obs)} - \frac{Z_{\alpha/2}}{3\sqrt{Obs}} \right]^3 \quad SMR_U = \frac{Obs+1}{Exp} \left[1 - \frac{1}{9(Obs+1)} + \frac{Z_{\alpha/2}}{3\sqrt{Obs+1}} \right]^3$$

where SMR is the standardized mortality ratio and CI is the confidence interval.

9-21 earthquake, this study utilizes the SMR index by “type of township” as standard. The previous studies for earthquake suicide mortality mainly focus on a year after the earthquake without explanation. Yet, the studies for psychological and social health impact have concentrated on the 20 months (15,16) or the 3–4 years after the earthquake (17). Taking sample size limits into consideration, our study utilized data from the two calendar years before and after the 9-21-1999 Earthquake (1997–1998 vs. 2000–2001). This study assumed that the estimated suicide mortality rate was independent in calculating the 95% CI for mortality increase rates.

The Japanese study based on the ecological level shows that the suicide mortality rate for male victims only significantly decreased after the Hanshin-Kobe Earthquake (9), the result is different from that in Taiwan. Our study, an ecological study, shows that the suicide mortality rate increases by age after the earthquake (see Table 1). The result is similar to Chou’s (18) finding on the level of personal data analysis. One of the possible reasons for the differences between Taiwanese and Japanese study is that there are differences in the community re-building activities and resources. The findings show that the suicide mortality rate of males or aged between 45 and 64 years is statistically significantly higher than in other age groups, especially so in the townships that suffered most during the earthquake. The possible explanation for this is that the 45–64 years age group is always responsible for family financial support, and they became unemployed because of the earthquake.

The crude death rate due to this event in Kaoshiung and Puli, two of the townships that suffered most during the earthquake, (the 2nd and 4th highest level of devastation of all townships in Nantou County), showed that the male suicide rates are significantly higher

than those of the same “type of township” after the earthquake (Table 2). The rates are not significantly higher before the earthquake. On the other hand, the rates for Changliao and Chichi, the 1st and 3rd most damaged townships, did not increase after the earthquake. This is similar to the Japanese study mentioned earlier (9). It is possible that the community re-building activities after the earthquake, i.e., postearthquake recovery psychology helped (5), or successful access to health care after suicide may have helped to minimize suicide mortality rates. In addition, it may also be attributable to the small population size in these two townships.

The methods used by the reported individuals to commit suicide are compared between the studied population and the general population. We compare the different methods to commit suicide between the Nantou County (population in this study) with Taiwan (general population). Two main suicide methods used commonly are “solid or liquid substances” and “hanging, strangulation and suffocation.” In Nantou County, “solid or liquid substances” is the most commonly used suicide methods (accounting for about 42–51% of all suicides), and “hanging, strangulation and suffocation” is the second commonly used suicide methods (about 28–36% of all suicides). In general population, “hanging, strangulation and suffocation” is the most commonly used suicide methods (about 42–51% of all suicides). The “solid or liquid substances” is the second commonly used suicide methods (about 25–34% of all suicides) (data not shown).

Martikainen and Valkonen (19) finds that the death of one’s spouse may trigger attempted suicides. The data from the National Fire Agency, Department of Interior, did not distinguish the number of deaths by gender. According to suicide reports in the

October 1999 to August 2000 data set, the main factor affecting earthquake victims' suicide tendencies were economic factors. This corresponds with the findings of this study that the 45–64 years are always responsible for family financial support and they became unemployed because of the earthquake. Therefore, the suicide mortality rates show higher in 45–64 years than for other age groups. This study suggests that monitoring high risk population, especially males or 45–64 years of age who experienced the highest statistically significant suicide rate in this study. The study provides support for providing both the psychological restoration program and, to the extent feasible, financial support for the unemployed as useful public health strategies for suicide prevention in Taiwan.

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References

1. Taipei Ministry of the Interior. 921 earthquake statistics. Taiwan: National Fire Agency, Ministry of the Interior, 1999.
2. Han SN, Chen KT. Mortality of the 921 earthquake in Nantou and Taichung counties. *Epidemiol Bull* 2000;1:1–8.
3. Lin YP. Effects of earthquakes on health. *Chin J Public Health* 2001;20:93–111.
4. Chang CM, Connor KM, Lai TJ, Lee LC, Davidson JR. Predictors of posttraumatic outcomes following the 1999 Taiwan earthquake. *J Nerv Ment Dis* 2005;193:40–6.
5. Yang CH, Xirasagar S, Chung HC, Huang YT, Lin HC. Suicide trends following the Taiwan earthquake of 1999: empirical evidence and policy implications. *Acta Psychiatr Scand* 2005;112:442–8.
6. Shoaf K, Sauter C, Bourque LB, Giangreco C, Weiss B. Suicides in LOS Angeles county in relation to the Northridge earthquake. *Prehosp Disaster Med* 2004;19:307–10.
7. Krug EG, Kresnow M, Peddicord JP, Dahlberg LL, Powell KE, Crosby AE, et al. Suicide after natural disasters. *N Engl J Med* 1998;338:373–8.
8. Krug EG, Kresnow M, Peddicord JP, Dahlberg LL, Powell KE, Crosby AE, et al. Retraction: suicide after natural disasters. *N Engl J Med* 1999;340:148–9.
9. Shioiri T, Nishimura A, Nushida H, Tatsuno Y, Tang SW. The Kobe earthquake and reduced suicide rate in Japanese Males [letters to the editor]. *Arch Gen Psychiatry* 1999;56:282–3.
10. Taipei Department of Health. Vital statistics, 1997–2001. Taipei (ROC): Department of Health, 1998–2002.
11. World Health Organization. Manual of international statistical classification of disease, injuries, and causes of death. 9th rev. Vol.1. Geneva: WHO, 1977.
12. Taipei Ministry of the Interior. Taiwan-Fuchien demographic fact book, 1997–2001. Taipei (ROC): Ministry of the Interior, 1998–2002.
13. Luo QH. A study on the equitable regional development in Taiwan. [dissertation]. Taipei (ROC): University of Chinese Culture, 1992.
14. Taipei Department of Health. Suicide trends in the Taiwan area. *Epidemiol Bull* 1986;11:85–90.
15. Fukuda S, Morimoto K, Mure K, Maruyama S. Posttraumatic stress and change in lifestyle among the Hanshin-Awaji earthquake victims. *Prev Med* 1999;29:147–51.
16. Fukuda S, Morimoto K, Mure K, Maoyama S. Effect of the Hanshin-Awaji earthquake on posttraumatic stress, lifestyle changes, and cortisol levels of victims. *Arch Environ Health* 2000;55:121–5.
17. Bland SH, O'Leary ES, Farinero E, Jossa F, Krogh V, Violanti JM, et al. Social network disturbances and psychological distress following earthquake evacuation. *J Nerv Ment Dis* 1997;185:188–94.
18. Chou YJ, Huang N, Lee CH, Tsai SL, Tsay JH, Chen LS. Suicides after the 1999 Taiwan earthquake. *Int J Epidemiol* 2003;32:1007–14.
19. Martikainen P, Valkonen T. Mortality after the death of a spouse: rates and causes of death in a large Finnish cohort. *Am J Public Health* 1996;86:1087–93.

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