

Mortality of the 921 Earthquake in Nantou and Taichung Counties

Abstract

Early in the morning on September 21, 1999 (921), a devastating earthquake registering 7.3 on the Richter scale struck Taiwan. The epicenter was at Chichi in Nantou County, a rural township southwest of Sun-Moon Lake. This severe once-in-a-century earthquake was then named the "Chichi" earthquake by the Central Weather Bureau. According to the statistics of the National Fire Administration, Ministry of Interior (NFA), by October 11, 1999, the casualties numbered 2,329 deaths and 8,722 injured. This survey collected information concerning deaths due to the earthquake in both Nantou and Taichung counties by age, sex, and township, to establish a basic epidemiological database on the mortality rate of the earthquake. Information was collected from the quake-ravaged townships of Nantou and Taichung counties. Earthquake mortality rate and mortality rate by sex and age were calculated for each township by using the 1998 year-end population as the denominator, and the deaths directly caused by the quake as the numerator. In Nantou county, the sex ratio of quake deaths was 1.0:1.08 (the sex ratio of the current population being 1.0:0.91). Puli township, had the highest death toll of 181; though Chimgliao township had the highest mortality of nearly 1%. Sex-specific mortality rates did not show significant differences by age ($p=0.33$ by t-test). None of the 21 townships in Taichung county sustained quake deaths; the sex ratio being 1.0:1.06 (the sex ratio of the current population of the 21 townships being 1.0:0.95). Tungshi township had the highest death toll of 322; though Shihkang township had the highest mortality of 1.14%, the highest of

all townships. Sex-specific mortality rates did not show significant differences by age ($p=0.42$ by t-test).

Introduction

At 1:47:12.6 in the morning on September 21, 1999, a devastating earthquake registering 7.3 on the Richter scale struck Taiwan. The epicenter was located at Chichi township in Nantou County at 23.85°N and 120.78°E, some 12.5 km southwest of Sun-Moon Lake, with a depth of 1.0 km. The magnitude of the quake in both Nantou and Taichung counties was as high as 6. This quake-of-the-century was named by the Central Weather Bureau the "Chichi" earthquake⁽¹⁾. The Chichi earthquake was, of the ten most devastating earthquakes of Taiwan in the last 100 years tabulated by SN Cheng, the most severe. The extent of damage was second only to that of the one in Miaoli county in 1935 (at 7.1 magnitude, with casualties numbering 3,276 deaths and 12,053 injured). According to the statistics of the National Fire Administration, Ministry of Interior (NFA), by October 11 1999, the casualties totalled 2,329 deaths and 8,722 injured.

This survey collected information on the quake-deaths in both Nantou and Taichung counties by age, sex, and township to build a basic epidemiological database for the reference of authorities concerned.

Background

The epicenter of the 921 (September 21) earthquake was located 5 km below the surface. It simultaneously triggered two faults. Prof CY Wang in his report, "How the Chelungpu Fault Moved", speculated that "the 921 earthquake was induced primarily by the simultaneous activities of two faults, the Chelungpu fault and Tamaupu-Suantung fault. The Tamaupu-Suantung fault is 10 km to the east of the Chelungpu fault, both running in parallel. The Chelungpu fault, at least 80 km in length, runs northbound along the east edge of the Taichung basin from Tungtou of Yunlin county, through Chushan, the Mingchu bridge, Mingchien, Nantou, Chungshing New Village, Tsaotun, the Wuhsi bridge, Wufeng, Chelungpu, Taiping, Takeng, Fengyuan, and turning 70 degrees to Shihkang, the Shihkang dam, the Changkeng bridge, the Tahsi river, the Taan river, and to Naiwan of Tsuolan township. The Chelungpu fault charged up from east to west at 30 degrees; the Tamaupu-Suantung fault charged up at 70 degrees. The Chelungpu fault turned eastward after Fengyuan to run into the Tamaupu-Suantung fault. The two faults bore down hard upon each other, the accrued force resulting in an enormous shake in Tungshih township with serious casualties. Most buildings on the upper end of the fault line between Chushan and Fengyuan, primarily a reverse charge fault, had collapsed; whereas most buildings on the lower end of the fault, including those only 2 to 3 meters away from the fault, remained standing. Buildings on the

line between Fengyuan and Tsulan were not so fortunate. The shearing power of the parallel movement moving diagonally damaged a large area of roads and houses, the most serious damages, occurring particularly in the Shigkang area.”⁽²⁾

Materials and Method

1. Subjects for study: the population of the quake-devastated townships of Nantou and Taichung counties were used for study. Earthquake mortality rate and mortality rate by age and sex for each township were calculated by using the 1998 year-end population as denominator and deaths directly caused by the quake as the numerator.
2. Sources of information: statistics of the National Fire Administration, Ministry of Interior (NFA) on the 921 earthquake, death tolls registered by the fire departments and social affairs bureaus of Nantou and Taichung county governments, and statistical yearbooks (1998) of Nantou and Taichung counties.
3. Method of study: descriptive epidemiological study.
4. Definitions:
 - 1) deaths: deaths caused directly by the collapse of buildings, land sliding, and others factors directly related to the 921 earthquake and its aftershocks. Data were collected up to October 11, 1999, the closing date of the statistics issued by the National Fire Administration, Ministry of Interior (NE A) Missing population was not included.
 - 2) earthquake mortality rate: number of deaths due to the earthquake in a given area/1998 year-end population of the area
 - 3) trapping death rate: number of deaths as a result of being trapped in buildings or buried under earth and stones/number of persons trapped. The number trapped was taken from the statistics of the National Fire Administration, Ministry of Interior (NFA) up to October 11, 1999. The number included deaths, missing, buried, and rescued, but not the number of persons trapped or buried in motor vehicle (i.e. under landslides etc.).

Results

1. Trapping death rate

Statistics of the National Fire Administration, Ministry of Interior (NFA) by October 11, 1999, showed that the total number of persons rescued, buried, missing, and deceased was 7,367. the total number of deaths being 2,328, giving a total trapping death rate of 31.6% (28.0% for Nantou county, and 44.5% for Taichung county).

2. Earthquake mortality rate in Nantou county

Statistics of the Nantou County Fire Department provided a total death toll of 863; 410 males and 445 females (8 of unknown sex), yielding a sex

ratio of 1.0:1.08 (the sex ratio for the current population of the whole county was 1.0:0.91). Puli township had the largest number of deaths, a total of 181; Chingliiao township had the highest mortality rate of nearly 1% (Table 1). The average age of the victims (the standard error) was 49.7 years (24.9); 50.7 years (24.58) for men, and 49 years (25.35) for women. Age-specific mortality rates ranged from 0.02% for the 20-24 age group to 22.2% for the 100 and above age group. The earthquake mortality rates increased from 0.06-0.10% for age groups 0-44 (excluding that of the 20-24 age group) after 55 years of age (Figure 1). Sex-specific mortality rates did not differ significantly by age ($p=0.33$ by t-test).

3. Earthquake mortality rate in Taichung county

Statistics of the National Fire Department gave a death toll of 1,131 for Taichung county. In the 21 townships, there were ten reported deaths. Tungshih township had the largest number of deaths, a total of 322; Shihkang township had the highest mortality with 1.14%, also the highest of all townships (Table 2). According to statistics furnished by the Taichung County Social Affairs Bureau, of the 1,019 victims, 493 were males and 526 females, giving a sex ratio of 1.0:1.06. The sex ratio of the current population of the ten townships was 1.0:0.95. The average age of the victims (the standard error) was 42.8 years (24.8); 45.5 years for men (24.8), and 40.4 years (24.8) for women. By using the current population of the ten townships as denominator, the lowest earthquake mortality of 0.056% was found in the 15- 19 age group. Mortality increased with age after 60 (Figure 2). Sex-specific mortality rates did not differ significantly by age ($p=0.42$ by t-test).

Discussion

In the area where the two faults intersected, the earthquake produced serious collapse of buildings and landslide. The trapping death rate, as high as 31.6%, was lower than the 35.0% rate of the earthquake in Italy in 1980. The quake hit the area in the early morning when most people were either indoor or sleeping. Death certificates and postmortem examination reports of victims revealed that the major preceding causes of deaths were either building collapse or landslide. Had the earthquake struck the area during daytime, the destroyed bridges, damaged roads, and collapsed office and school buildings would have resulted in more serious damages and casualties and might even have caused fire as demonstrated in the Hanshin earthquake of Japan⁽⁴⁾.

The collapse of buildings brought about by the earthquake was the major cause of deaths⁽⁵⁾. Prof TS Hsu et al. of the Civil Engineering Department, the Fengchia University, in their report on cases of landslide realignment and structure reinforcement, pointed out that higher number of deaths per area due to this earthquake occurred in buildings with "weak pillar but heavy beam" and

“vast basement without reinforcement”. Studies elsewhere indicated that the height of a building, and the building floor where the victim was at the time of the disaster were also risk factors related to earthquake deaths⁽⁶⁾. Whether one was indoors or outdoors was also considered to be a risk factor, however, at the time of a devastating earthquake, most people would attempt to run outdoors if they could. The structural integrity of a building as a risk factor was more important than the behaviors of the individuals at the time of earthquake. The geographic position of faults was another contributing factor in this earthquake. The types and designs of building construction (without considering human negligence), and the terrain where the buildings were located, were some of the factors requiring further study for making recommendations to architecture and construction authorities.

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Table 1. Earthquake Mortality Rates by Township, Nantou County

Township	Population	No. of Deaths	Earthquake Mortality Rate
Nantou City	104,777	92	0.0088%
Shueili	23,425	7	0.030%
Chichil	12,250	37	0.302%
Chungliao	18,252	178	0.975%
Mingchien	42,754	39	0.091%
Tsaotun	96,833	87	0.090%
Chushan	62,269	118	0.190%
Puli	88,271	181	0.205%
Kuohsing	24,643	86	0.349%
Luku	21,279	22	0.103%
Yuchi	17,894	14	0.078%
Jenai	15,358	2	0.013%
Total	545,874	863	0.158%

Table 2. Earthquake Mortality Rates by Township, Taichung County

Township	Population	No. of Deaths	Earthquake Mortality Rate
Hsinshe	27,089	119	0.44%
Shihkang	15,573	177	1.14%
Tali	169,239	121	0.07%
Taiping	161,615	109	0.07%
Wufeng	68,307	94	0.14%
Hoping	11,018	24	0.22%
Tungshih	59,647	322	0.54%
Fengyuan	160,256	158	0.10%
Tantse	84,828	6	0.01%
Chingshuei	84,624	1	0.001%
Total	843,196	1,131	0.13%

Figure 1. Age-Specific Earthquake Mortality Rates, Nantou and Taichung Counties

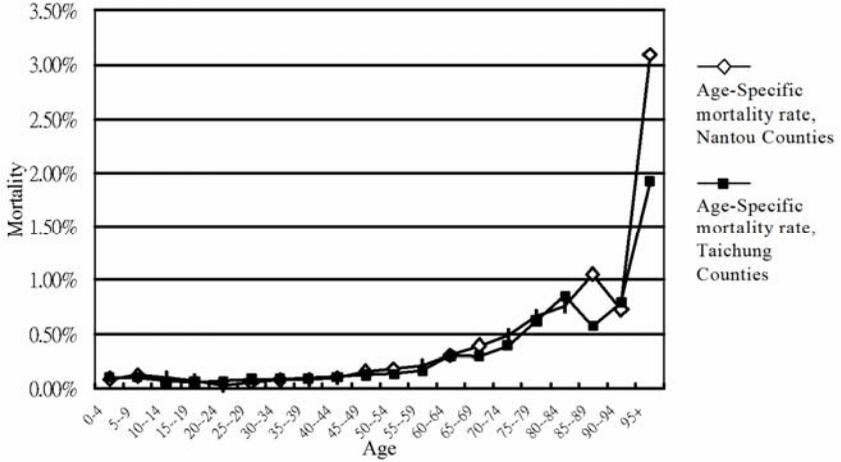


Figure 2. Sex and Age-Specific Earthquake Mortality Rates, Nantou County

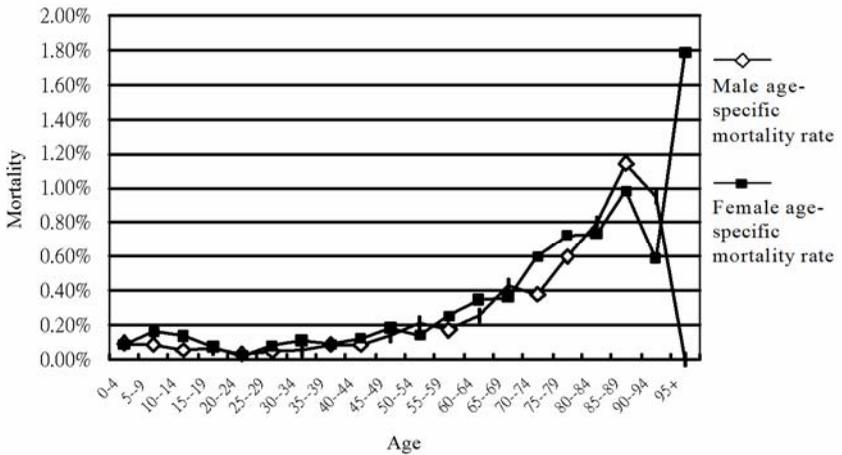


Figure 3. Sex and Age-Specific Earthquake Mortality Rates, Taichung County 3.00%

