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Factors Associated with Earthquake Deaths in the Great Hanshin-Awaji Earthquake, 1995

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The authors conducted descriptive and case-control studies to find factors associated with earthquake deaths due to the Great Hanshin-Awaji earthquake on January 17, 1995, in Nishinomiya, Japan. In the case-control study, cases included all 1,104 deaths. Controls were randomly selected from survivors. Earthquake mortality increased for people over age 50 years. Mortality among people who had lived in dwellings that were completely destroyed was much higher. One risk factor was physical disabilities (odds ratio = 1.9, 95% confidence interval (CI): 1.0, 3.4). When the analysis was limited to the people who had lived in intact or partially destroyed dwellings, the odds ratio rose to 5.6 (95% CI: 1.6, 19.8). *Am J Epidemiol* 2001;153:153–6.

case-control studies; mortality; multivariate analysis; natural disasters; risk factors

On January 17, 1995, the great Hanshin-Awaji earthquake, registering 7.2 on the Richter scale, hit the southern part of Hyogo Prefecture, Japan. The immediate victims included 5,502 deceased and 41,527 wounded. By December 1995, the earthquake-related death and casualty toll numbered 6,308 deceased and 43,117 wounded.

To find factors associated with earthquake deaths, we conducted two epidemiologic studies. Descriptive epidemiologic analyses were used to evaluate the impact of age and the degree of damage to dwellings. A case-control study was conducted to identify factors associated with earthquake-related deaths other than age and degree of damage to dwellings. We chose the city of Nishinomiya, in which the second largest number of victims was observed, because the city government had a database on social welfare covering all city occupants. This city, with a population of about 400,000, is the eastern neighbor of Kobe. One year after the earthquake, there were 1,104 earthquake-related deaths and 6,386 casualties in the city.

MATERIALS AND METHODS

Descriptive epidemiologic study

Age-specific mortality related to the earthquake was categorized by sex and the degree of damage to dwellings, which was divided into three categories: completely destroyed, partially destroyed, and intact. Age-specific population data from March 1994 were used as the standard population for the calculation of age-specific mortality.

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Case-control study

Cases included all deaths due to earthquake injury in the city of Nishinomiya for 1 year after the earthquake. All cases were first examined by the attending physician and then reviewed and approved by the city judgment committee for earthquake deaths. Almost all deaths in this city were due to suffocation and/or injuries from the collapse of dwellings. Almost all (95 percent of 1,104) deaths occurred during the first week after the earthquake. Controls were randomly selected from survivors living in the same neighborhood as each case. We further matched on sex, age, and the degree of damage to the dwellings. Thus, the number of controls was also 1,104 (table 1).

We created five variables by using the information gained from the city database: 1) elderly aged 80 years or more who lived alone; 2) elderly aged 65 years or more in need of care; 3) individuals with physical disabilities; 4) individuals with intractable diseases; and 5) individuals receiving public assistance. The data were obtained from the Nishinomiya government through the necessary formalities. Multivariate analyses were performed by using data most recently updated on January 16, 1995 (i.e., just 1 day before the earthquake).

The above variables were defined as follows: "Individuals with bedridden elderly" means elderly people aged 65 years or more in need of care who had been bedridden for 6 months or more. Physical disabilities include only first- and second-degree disabilities (severe cases). Patients with intractable diseases were those with specific diseases designated by the national government who had received public assistance for medical expenses. There were 36 of these diseases, including systemic lupus erythematosus, ulcerative colitis, Parkinson's disease, idiopathic thrombocytopenic purpura, multiple sclerosis, spinocerebellar degeneration, sarcoidosis, and dermatomyositis.

TABLE 1. Frequency of factors used in the case-control study, by gender, Nishinomiya, Japan, 1995

	Male				Female			
	Cases (*n* = 464)		Controls (*n* = 464)		Cases (*n* = 640)		Controls (*n* = 640)	
	No.	%	No.	%	No.	%	No.	%
Degree of damage to dwellings (matching variables)								
Intact	53	11.4	53	11.4	49	7.7	49	7.7
Partially destroyed	18	3.9	18	3.9	18	2.8	18	2.8
Completely destroyed	393	84.7	393	84.7	573	89.5	573	89.5
Elderly aged ≥80 years who lived alone	10	2.2	15	3.2	29	4.5	41	6.4
Bedridden elderly aged ≥65 years	2	0.4	3	0.6	9	1.4	8	1.3
Individuals with physical disabilities (first and second degree)	13	2.8	6	1.3	20	3.1	12	1.9
Individuals with intractable diseases	0		1	0.2	2	0.3	0	
Individuals receiving public assistance	10	2.2	10	2.2	13	2.0	12	1.9

Statistical methods

A conditional logistic regression analysis was adopted to assess the odds ratio of the variables used in the case-control study. All variables were dichotomous without missing data. This analytic process was performed by using SAS for Windows (SAS Inc., Cary, North Carolina).

RESULTS

Descriptive study

Age-specific mortality increased after age 50 years. A difference in mortality by gender was not observed. When the number of deaths caused by the earthquake was compared with the number of deaths in 1994 (the year before this earthquake), an unusually high number of deaths was observed in younger generations (figure 1). When the mortality among people who had lived in completely destroyed dwellings was compared with the mortality of the combined total of the other groups, namely the group living in partially destroyed and intact dwellings, the mortality among the group living in completely destroyed dwellings was much higher (figure 2). Even among people who had lived in completely destroyed dwellings, mortality increased with age (figure 2).

Case-control study

The gender ratio of subjects (male:female) was 0.67. No pair of variables with a high correlation was observed, so all variables were applicable for analyses. When conditional logistic regression analyses were conducted, a possible risk factor was physical disabilities (odds ratio = 1.9). However, the degree of model fitness was not high (table 2). Elderly who had lived alone were less likely to become victims, but this pattern did not rise to a statistically significant level.

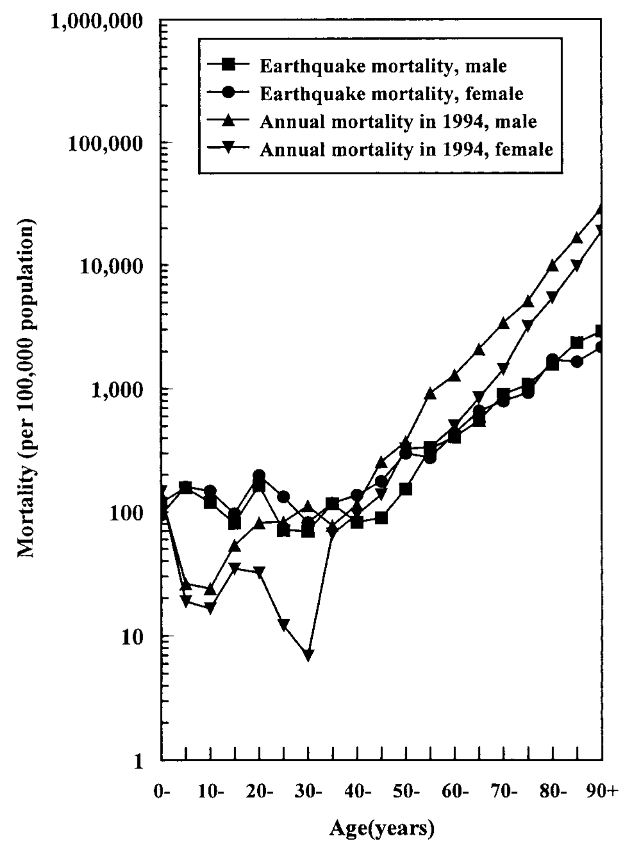

FIGURE 1. Comparison of earthquake mortality with mortality in the previous year, Nishinomiya, Japan, 1995.

We created a new variable called "physical handicaps" that combined three variables, namely, bedridden elderly,

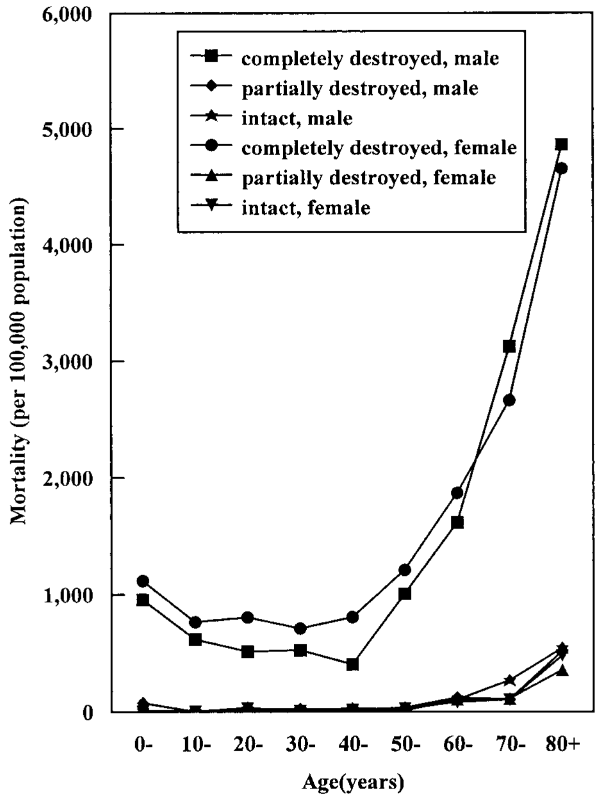

FIGURE 2. Earthquake mortality by age and degree of damage to dwellings, Nishinomiya, Japan, 1995

physical disabilities, and intractable diseases, because of the small number of subjects with these conditions. When analysis was conducted using living alone, having physical handicaps, and being on public assistance as three independent variables, a significant risk factor was physical handicaps (odds ratio = 1.7), with a high model chi-square level (table 2).

When the analysis was limited to the people who had lived in completely destroyed dwellings, no related factors were observed. When the analysis was limited to the people who had lived in either intact or partially destroyed dwellings, individuals with physical disabilities were 5.6 times more likely to have become victims of this earthquake (table 3).

DISCUSSION

The number of people injured by this earthquake was the highest among earthquakes that occurred between September 1993 and February 1996 (1). Mortality from earthquakes also varied in each case due to the following factors: the magnitude of the earthquake, the characteristics of the buildings, which floor people lived on, and the availability of medical services (2). Although a previous paper (3) had shown that earthquake mortality increases with age, our study analyzed age-specific mortality by degree of damage to dwellings. Our analysis clearly demonstrates that age and the degree of damage to dwellings were the most important risk factors.

The age distribution in earthquake mortality is different for each case. The Guatemalan earthquake recorded high mortality for both the elderly and children (4). In the Indian earthquake, a high mortality rate was observed for the elderly and among boys (5). Also in the Indian earthquake, higher

TABLE 2. Results of conditional logistic regression analyses, Nishinomiya, Japan, 1995

Variables*	Odds ratio	95% confidence interval
Analysis using all cases and controls (total no. of cases and controls = 2,208)		
Elderly who lived alone (vs. others)	0.63	0.40, 1.01
Bedridden elderly (vs. others)	0.89	0.35, 2.22
Physical disabilities (vs. others)	1.86	1.03, 3.37
Intractable diseases (vs. others)	2.04	0.19, 22.47
Public assistance (vs. others)	1.09	0.59, 2.00
Model chi-square = 8.87, p = 0.11		
Analysis using a new, combined variable (physical handicap = bedridden elderly, physical disabilities, or intractable diseases) (n = 2,208)		
Elderly who lived alone (vs. others)	0.64	0.40, 1.02
Physical handicap (vs. others)	1.66	1.00, 2.75
Public assistance (vs. others)	1.07	0.58, 1.98
Model chi-square = 8.05, p = 0.045		

* Matching variables (sex, age, and degree of damage to dwelling).

TABLE 3. Results of conditional logistic regression analyses by the degree of damage to dwelling, Nishinomiya, Japan, 1995

Variables*	Odds ratio	95% confidence interval
Analysis limited to completely destroyed dwellings (n = 1,932)		
Elderly who lived alone (vs. others)	0.63	0.37, 1.05
Bedridden elderly (vs. others)	0.68	0.23, 2.02
Physical disabilities (vs. others)	1.14	0.55, 2.38
Public assistance (vs. others)	1.24	0.63, 2.46
Model chi-square = 3.89, p = 0.42		
Analysis limited to intact or partially destroyed dwellings (n = 276)		
Elderly who lived alone (vs. others)	0.64	0.21, 1.95
Bedridden elderly (vs. others)	3.34	0.47, 23.65
Physical disabilities (vs. others)	5.64	1.61, 19.78
Public assistance (vs. others)	0.67	0.16, 2.91
Model chi-square = 12.43, p = 0.01		

* Matching variables (sex, age, and degree of damage to dwelling).

mortality among females was observed, whereas this gender difference was not observed in our study. The age-specific mortality tends to be higher in the younger generation in earthquakes in developing countries. This finding may be related to their nutritional status and functional fitness.

The age-specific mortality from this earthquake tended to be higher for the younger generation compared with deaths for the younger generation in the preceding year, but tended to be lower among the elderly. We observed an unusually high number of deaths in younger age groups, which is consistent with an earlier report about victims among Kobe University students (6). The relatively low mortality of elderly may indicate that the earthquake had a relatively equal influence on human lives in contrast to the usual causes of death.

There is one previous study that analyzes earthquake mortality according to the degree of damage to dwellings (7). In that study, the mortality ratio of people who had lived in dwellings that were completely destroyed compared with deaths of people living in other dwellings was lower than the ratio in our study. This difference may be due to some characteristics of the earthquake, the structure of and/or materials used in the dwellings, and/or the population density in the affected area. Previous reports of earthquake deaths and injuries referred to some information collected after the earthquake (7–10).

A cross-sectional study of an earthquake in Italy found some preventive and risk factors for injury or death: Staying in the house was a preventive factor, whereas staying on a higher floor was a risk factor. Living alone was also a significant risk factor for death or injury (7).

Case-control studies of injuries reported some risk factors, such as remaining on a higher floor (8), a delay in rescue and/or difficulty of access to medical services (9), living alone (10), staying in a concrete building (10), or staying on the middle floors (10). These studies also reported preventive factors, such as being on a road when the earthquake struck (8) and running out of a building just after the first quake (8). A recent cohort study about the earthquake in Armenia described the findings on deaths and injuries after the earthquake and found that building height was an important factor in predicting earthquake deaths (11).

Our study did observe a new probable risk factor—that of physical disability. This risk factor was significant for people who had lived in intact or partially destroyed dwellings. This indicates that the degree of damage to dwellings is an important risk factor, to the point that other risk factors could be greatly reduced for people who had lived in dwellings that were completely destroyed. This suggests that people who are physically vulnerable when earthquakes strike are also often politically or socially underrepresented. Our results suggest the importance of continued investment in and maintenance of living environments during normal times.

We found a possible preventive factor, i.e., the elderly who lived alone. The functional fitness of elderly who live alone may not be different from those who do not (12–14). It is difficult to imagine that the elderly who live alone inhabit stronger dwellings. The reasons that this is a preventive factor may be that those people were staying on a lower floor and/or the timeliness of the rescue activities for these elderly.

Recently, a 4-year follow-up study was conducted in Armenia. The study suggested that during the longer term increased morbidity from heart disease and chronic disease after an earthquake is related to the intensity of exposure to disease-related damage and losses (15). In the future, it will be necessary, using vital statistics, to study the increased mortality from chronic diseases after a major earthquake.

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