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Long Term Mortality and Morbidity Related to Degree of Damage Following the 1988 Earthquake in Armenia

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To assess the relation of increased mortality and morbidity to personal loss and damage following the 1988 earthquake in Armenia, the authors conducted a prospective study of mortality and a nested case-control analysis of incident morbidity. Employees of the Armenian Ministry of Health and their immediate families (n = 35,043) who survived the disaster formed the study population. Two sets of interviews with the employees, carried out over a period of 4 years of follow-up, were used as the primary source of data for this study. The highest numbers of deaths from all causes and from heart disease were observed within the first 6 months following the earthquake. The nested case-control analysis of 483 cases of newly reported heart disease and 482 matched non-heart-disease controls revealed that people with increasing levels of loss of material possessions and family members had significant increases in heart disease risk (odds ratios for "loss scores" of 1, 2, and 3 were 1.3, 1.8, and 2.6, respectively). The findings were similar with regard to the relation of damage and loss to newly reported hypertension, diabetes mellitus, and arthritis. The findings of this study support the hypothesis that longer term increased rates of heart disease and chronic disease morbidity following an earthquake are related to the intensity of exposure to disaster-related damage and losses. People sustaining such losses should be closely monitored for increased long term morbidity. *Am J Epidemiol* 1998; 148:1077–84.

heart diseases; morbidity; mortality; natural disasters; stress

Investigators who have studied mortality and morbidity resulting from earthquakes have limited their investigations to the period immediately following the disaster and have studied primarily injuries and their effects (1–5). Katsouyanni et al. (6) compared death rates within the first week after the 1978 earthquake in Thessalonika, Greece, with predisaster mortality using death registration records. They reported a threefold increase in cardiac deaths and a 1.6-fold increase in risk for deaths from all causes following the earthquake (6). Similar results were reported following the Athens earthquake of 1981 (7). Trevisan et al. (8, 9), comparing employees of an Olivetti factory before and after the 1980 earthquake in Naples, Italy, reported higher heart rates and serum cholesterol and triglyceride levels within the first few weeks after the earthquake in the exposed sample. Although higher rates of morbidity and mortality, particularly from coronary heart disease, have been reported following a number of earthquakes, the direct relation of such increases in mortality and morbidity to damage and personal loss, as well as to various exposures incurred during the earthquake, has not been demonstrated (10–12).

On December 7, 1988, at 11:41 a.m., an earthquake registering 6.9 on the Richter scale hit the northern part of the Armenian Republic (13). Half a million to 700,000 persons were made homeless, with deaths estimated at 25,000. More than 21,000 residences were destroyed (14). To document health and illness patterns in the affected population in the aftermath of the earthquake, we initiated a number of epidemiologic studies that investigated determinants of mortality and morbidity resulting from the disaster (15). Our initial case-control study, conducted in the summer of 1989 in the city of Gumri (known as Leninakan at the time of the earthquake), identified a number of structural and behavioral characteristics that put individuals at higher risk of injury during the earthquake (16). On the basis of the findings from the case-control study in Gumri, a larger cohort study involving the whole of the region exposed to the earthquake was started to monitor the long term health effects of the earthquake. This paper presents the findings of the larger cohort

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study with regard to the effect of personal loss and damage due to the earthquake on long term mortality and morbidity from causes other than injuries. For a follow-up period of approximately 4 years, we analyzed incident morbidity from heart disease and other chronic illnesses using a nested case-control approach, to test whether loss and damage were independent predictors of long term morbidity at the level of the individual persons who were studied.

MATERIALS AND METHODS

To develop an appropriate cohort for this study, we considered a number of options, including sampling based on residences. What was needed was a study population for which we could obtain a listing of membership on the day preceding the earthquake and that would be relatively easy to trace during follow-up. We decided to use employees of the Armenian Ministry of Health who were living in the earthquake region on December 6, 1988, and their immediate families. Listings of these employees were obtained from the payroll, personnel, and information systems departments of the Ministry of Health in Yerevan. From an unduplicated list of 9,017 employees, we were able to locate and interview 7,016, primarily at the workplace but also at home. We also interviewed 705 new employees who had started working at the Ministry of Health after the earthquake. Of the 2,001 employees who could not be located, 927 had moved outside of the earthquake region without providing a follow-up address; 73 had died and their families had relocated; 106 refused to be interviewed; and for 895 names on the initial list, no information was available and no contact could be established after a number of attempts. We interviewed colleagues to obtain information on the vital and migration status of each employee who could not be located. Persons who could not be traced included larger proportions of physicians and of employees who were posted in the city of Gumri (Leninakan) in comparison with those whom we were able to locate.

The final study population of 35,043 persons comprised the 7,721 employees who had survived the disaster on December 7, 1988, and their family members. Two series of interviews were attempted with each of these employees or their families during the 4 years following the earthquake. These interviews were carried out between 1990 and 1992. During the second interview—which in most cases was conducted 2 years after the baseline interview—only 237 families could not be located for interview. Thus, we had follow-up information on 33,882 persons, or 97 percent of the baseline population, 4 years after the earthquake

This study was conducted at a time of major transitions in this geographic area. The aftermath of the earthquake was characterized by major disruptions of public services. These disruptions were further accentuated during the follow-up period by the state of war in the Nagorno-Karabagh region and the declaration of independence of Armenia from the Soviet Union in 1991. A review of death certificates and medical records under these circumstances was not very encouraging in terms of the reliability of these sources for obtaining information on causes of mortality and morbidity.

The questionnaire was developed in Armenian and was pretested in Armenia on a small sample of employees. In addition to a large number of questions dealing with structural and environmental factors that are important for the study of deaths and injuries due to an earthquake, the questionnaire inquired in detail and for each family member about general health, health behavior, morbidity, and mortality before and after the earthquake. Thus, the questions on mortality included: "Were there any deaths in your family after the earthquake? If any, please indicate which member of the family died and the day, month, year, and cause." The questions about morbidity included individual checks of 17 common diseases. One of the questions inquired, "What were the chronic diseases that any member of the family had had up to the earthquake? What are some new diseases that have been identified since the earthquake? Please record the disease, the measures taken, the results, the medical institution involved, and the date." Considering the fact that respondents to the interview were either health professionals or employees of the Ministry of Health with better than average access to the health care system and to diagnostic facilities, it is not surprising that the information obtained on causes of morbidity and mortality was very detailed and involved over 1,000 different diagnoses or categories. The current analyses excluded all deaths and morbidity directly related to injuries sustained during the earthquake.

The questionnaire administered during the second interview was custom-printed for each family and incorporated the information obtained from the first interview. Thus, every item from the first interview, particularly information on health outcomes, was validated during the second interview, which in most cases was conducted by a different interviewer. We decided to use the validated information from the second interview to study outcomes. There was no discrepancy between interviews with regard to events of death.

To study the cumulative effect of various types of

personal losses resulting from the earthquake, we developed a scoring system. Loss of a family member and loss of a house contributed one point each to this score, while injuries sustained in the family and loss of household goods contributed half a point each. A variety of weights were applied to the variables in a number of models. These weights did not elicit any results that were significantly different from those presented.

"Coronary artery disease" was one of the 17 medical conditions that the questionnaire inquired about. Although the inquiry was focused on coronary artery disease, we decided to take the more conservative approach of calling it "heart disease." To assess the contribution of various potential risk factors to incident heart disease, we conducted a nested case-control analysis within the larger cohort. The 483 new incident cases of heart disease in the post-earthquake period among persons aged >30 years were matched by incidence density sampling to 482 controls with no heart disease from the study cohort who were alive within 3 months of the case (17). The matching variables were age (within 1 year) and sex. Following simple frequency distributions and cross-tabulations, multivariate logistic regression analysis was used to adjust for various potentially confounding factors. Both conditional and unconditional models were tested. In addition to adjustments, other multivariate models were also used to test for potential interactions between the different variables. Case-control analyses were also carried out for reported incident post-earthquake hypertension, diabetes mellitus, and arthritis in this same cohort, to test whether the relations observed for heart disease were maintained across other chronic diseases.

RESULTS

Mortality

As figure 1 indicates, there were higher numbers of observed deaths from all causes and from heart disease within the first 6 months following the earthquake in this cohort. During the follow-up period of up to 4 years, death rates were maintained at the lower levels of the second half of the first year of follow-up. Table 1 shows the distributions of the deaths by various characteristics of interest within the first 2 years of follow-up. Unadjusted death rates increased with age and were higher among males and persons with less education. In addition, these death rates were higher in smokers, regular alcohol drinkers ("Do you regularly use any alcohol?"), persons who did not exercise regularly ("Do you exercise regularly?"), and those with a body mass index (weight (kg)/height $(m)^2$) greater

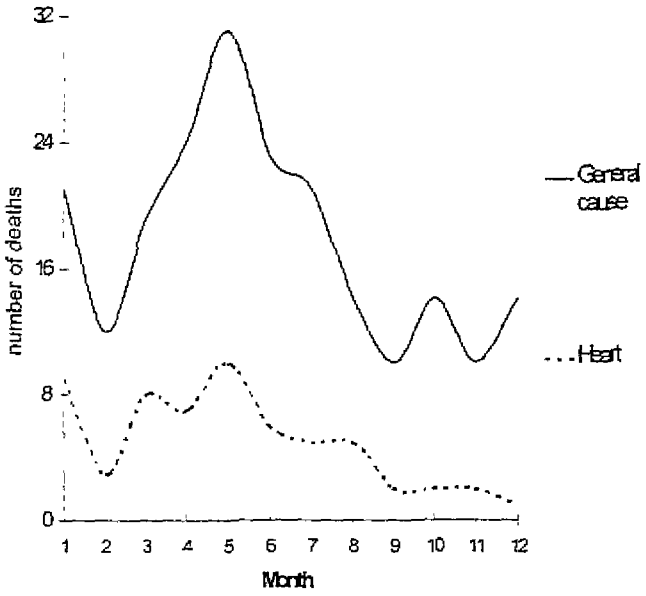

FIGURE 1. Deaths from all causes and from heart disease following the 1988 earthquake in Armenia in a cohort of 35,043 Ministry of Health employees and their families

than 30. Deaths from heart disease showed findings similar to those of deaths from all causes (table 1). For each of the variables of interest, death rates during the first post-earthquake year were higher than those seen during the second year.

Our analysis of the effects of various exposures at the moment of the earthquake on mortality revealed that persons who were inside a building and those who were on the first floor of a building at the moment of the earthquake were at higher risk of dying during the first year after the earthquake (table 2). The increased mortality for people on the first floor of a building was not maintained following adjustment for age. To assess the effect of being inside a building at the moment of the earthquake, we performed multivariate logistic regression analyses that adjusted for a number of potential confounders and that used different models. These analyses revealed that age and lower levels of education were predictors of death from all causes in these models. In separate stratified analyses using deaths from all causes and from heart disease during the first year as the outcomes of interest, the association with being inside a building was significant only in males (table 3). The multivariate analyses of deaths from heart disease gave results that pointed in the same direction with regard to mortality from all causes, except that education was no longer a predictor of heart disease death. Both general and heart disease mortality during the follow-up period were not related to other descriptors of the status of the individual at the moment of the earthquake. In addition, none of the

TABLE 1. Frequency distributions and rates of deaths from all causes and from heart disease, by demographic and other risk factors, for the first 2 years following the 1988 earthquake in a cohort of 35,043 Ministry of Health employees and their families, Armenia

	Deaths from all causes				Deaths from heart disease				Total no.
	First year		Second year		First year		Second year		
	No	Rate per 1,000	No.	Rate per 1,000	No	Rate per 1,000	No.	Rate per 1,000	
Age (years)									
0–10	15	2.02	7	0.94	2	0.27	1	0 13	7,425
11–20	2	0.34	4	0.69	0	0.00	1	0.17	5,811
21–30	9	1.29	9	1.29	2	0 29	1	0.14	6,993
31–40	12	2.38	7	1 39	2	0 40	0	0.00	5,041
41–50	11	3 38	12	3.69	4	1.23	4	1.23	3,250
51–60	41	9.74	27	6 42	17	4.04	6	1.43	4,208
61–70	40	24.59	32	19.67	13	7 99	15	9 22	1,627
>70	79	114 83	61	88.66	18	26 16	8	11.63	688
Gender									
Female	80	4.34	72	3 91	13	0.71	14	0 76	18,420
Male	129	7.76	87	5.23	45	2.71	22	1.32	16,623
Location									
Gumri	80	6.59	49	4 04	26	2.14	10	0.82	12,139
Spitak	17	8.02	14	6.60	4	1.89	4	1.89	2,120
Other	112	5.39	96	4.62	28	1 35	22	1.06	20,784
Educational level									
Secondary school	148	7.18	122	5.91	38	1.84	26	1.26	20,626
Higher	61	4.23	37	2 57	20	1.39	10	0.69	14,417
Current smoking									
Yes	71	10 18	41	5.88	24	3 44	12	1.72	6,976
No	136	4.85	115	4.10	33	1.18	23	0.82	28,056
Regular alcohol drinking*									
Yes	64	8.78	40	5 48	17	2.33	11	1.51	7,293
No	143	5.16	116	4.18	40	1.44	24	0 87	27,733
Regular exercise†									
Yes	5	1.10	5	1.10	0	0.00	1	0.22	4,534
No	204	6.70	154	5 06	58	1.90	35	1.15	30,461
Body mass index‡									
0–30	143	4.57	117	3 74	35	1.12	28	0.89	31,321
>30	34	10 11	24	7.14	15	4.46	5	1 49	3,363

* "Do you regularly use any alcohol?"
† "Do you exercise regularly?"
‡ Weight (kg)/height (m)^2

other variables in these analyses showed any significant association with mortality, particularly variables related to loss following the earthquake.

Morbidity

As figure 2 illustrates, there were higher reported numbers of incident cases of hypertension, heart disease, arthritis, and diabetes within the first 6 months following the earthquake. In the nested case-control comparison between the 483 incident heart disease cases and 482 incidence density-matched controls, odds ratios were highest for persons with death and injury in their family resulting from the earthquake (table 4). Compared with persons who did not experience any major losses during the earthquake, people with increasing loss scores of 1, 2, and 3 had significant odds ratios of 1.3, 1.8, and 2.6, respectively, in multivariate logistic regression analyses that adjusted for age, sex, education, and body mass index (table 5).

The case-control analyses for reported incident morbidity due to diabetes, hypertension, and arthritis also revealed significant relations with degree of damage and loss resulting from the earthquake for each of these chronic conditions.

DISCUSSION

Our observation of higher rates of death from all causes and from heart disease within the first year after

TABLE 2. Frequency distributions and rates of deaths from all causes and from heart disease, by disaster-related factors, for the first 2 years following the 1988 earthquake in a cohort of 35,043 Ministry of Health employees and their families, Armenia

	Deaths from all causes				Deaths from heart disease				Total no.
	First year		Second year		First year		Second year		
	No.	Rate per 1,000	No	Rate per 1,000	No	Rate per 1,000	No	Rate per 1,000	
Location during earthquake									
Inside a building	179	6 40	123	4.40	51	1.82	27	0.96	27,985
Outside a building	30	4 28	35	4.99	7	1.00	8	1.14	7,016
Height of building (if inside)									
1 story	89	12.11	55	7.49	23	3 13	12	1.63	7,347
2–4 stories	62	3.80	51	3.13	21	1.29	14	0.86	16,309
5–8 stories	29	6.60	18	4.09	9	2.05	3	0.68	4,396
≥9 stories	2	2.83	3	4.25	5	7.08	8	11 33	706
Location in building (if inside)									
First floor	114	7.97	77	5.39	32	2.24	19	1.33	14,295
Second floor	46	5.05	33	3.62	14	1.54	7	0.77	9,114
Floors 3–4	17	4.09	13	3.13	5	1.20	1	0 24	4,158
Floor 5 or above	5	4.41	3	2.64	2	1.76	1	0 88	1,135
Earthquake-induced death in the family									
Yes	14	6.13	10	4.38	5	2.19	4	1.75	2,282
No	195	5.95	149	4.55	53	1.62	32	0.98	32,761
Earthquake-induced injury in the family									
Yes	35	6.21	20	3.55	9	1.60	2	0.35	5,637
No	174	5.92	139	4.73	49	1.67	34	1.16	29,406
Personal loss score*									
0	124	6.03	103	5 01	35	1.70	27	1.31	20,570
1	56	6.41	39	4.47	17	1.95	6	0.69	8,730
2	23	5.18	18	4.05	4	0.90	4	0.90	4,443
3	11	8 46	2	1.54	4	3.08	0	0.00	1,300

*For definition, see "Materials and Methods."

the earthquake is consistent with reports from previous studies of earthquakes (6, 7). The fact that this increase was mostly limited to the first 6 months of the post-earthquake period reinforces our belief that this finding is probably genuine. For heart disease, the increase in deaths is more of a problem in the male population. Except for being inside of a building, none of the earthquake-related factors of exposure and loss were able to explain the higher mortality seen during the first 6 months in this population. The effects of some of the classical coronary heart disease risk factors that were studied pointed in the expected direction.

In contrast to mortality, loss and adversity resulting from the earthquake was predictive of reported incident morbidity from heart disease. There was a dose-response type of relationship between loss resulting from the earthquake and morbidity from heart disease. The findings for reported heart disease morbidity were replicated for hypertension, diabetes, and arthritis. Thus, factors that represent the immediate impact of

TABLE 3. Estimated relative risk of death from all causes and from heart disease upon follow-up, by gender, among persons who were inside a building at the moment of the 1988 earthquake, Armenia

Gender	Deaths from all causes				Deaths from heart disease			
	All 4 years		First year only		All 4 years		First year only	
	Age-adjusted OR*	95% confidence interval	Age-adjusted OR	95% confidence interval	Age-adjusted OR	95% confidence interval	Age-adjusted OR	95% confidence interval
Male	1.3	0.9–1.7	1 8	1.0–3.0	2.2	1.2–4.0	4.0	1.2–13.0
Female	1.0	0.6–1.7	1.9	0.6–6.0	0.8	0.3–1.9	0.9	0.1–6.8

* OR, odds ratio.

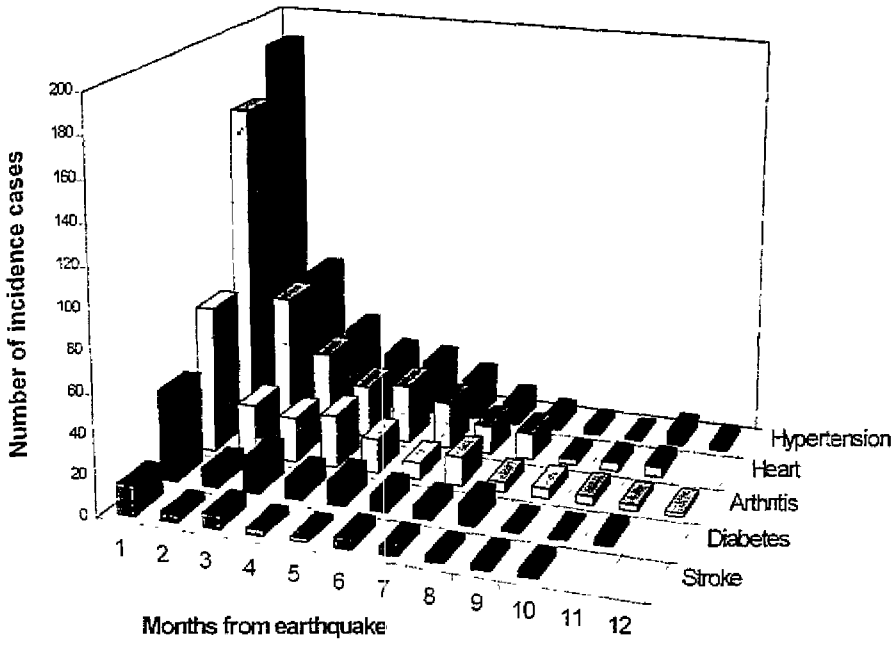

FIGURE 2. Patterns of morbidity following the 1988 earthquake in Armenia.

the earthquake, such as bereavement and injuries in the family, as well as material loss, were independent predictors of long term adverse physical illness.

In assessing the findings of this study, o address a number of issues. These include validity of the reported causes of mortality a

TABLE 4. Frequency distribution of 483 incident heart disease cases and 482 age- and gender-matched controls following the 1988 earthquake in a cohort of 14,814 adults, by personal losses related to the disaster, Armenia

	No of incident heart disease cases	No of controls	Odds ratio	95% confidence interval
Earthquake-induced death in the family				
Yes	61	27	2.4	1 5–4.0
No	422	455	1.0	
Earthquake-induced injury in the family				
Yes	119	61	2 3	1.6–3 2
No	364	421	1.0	
Loss of family apartment or house				
Yes	181	153	1.3	1.0–1.7
No	302	329	1.0	
Material possessions loss score (within family)*				
0	32	49	1.0	
1	100	115	1.3	0.8–2.3
2	239	246	1.5	0.9–2.5
3	112	72	2.4	1 4–4 2
Total loss score†				
0	231	286	1 0	
1	132	122	1.3	1 0–1 8
2	81	56	1.8	1.2–2.7
3	39	18	2.7	1.4–5.0

* One point each for loss of money, loss of furniture, and loss of household appliances.

† One point each for death of a family member and loss of a house or apartment, half a point each for injury in the family and material loss

TABLE 5. Relative odds of developing incident heart disease following the 1988 earthquake, Armenia*

Variable	Odds ratio†	95% CI‡
Age group (years)		
51–70 vs. 31–50	1.0	0.8–1.4
71–100 vs. 31–50	1.2	0.6–2.3
Gender (female vs. male)	0.9	0.7–1.2
Education (0–10 years vs. >10 years)	1.5	1.1–1.9
Body mass index§ (≥30 vs. <30)	1.4	1.1–1.9
Total loss score¶		
1 vs. 0	1.3	1.0–1.8
2 vs. 0	1.8	1.1–2.6
3 vs. 0	2.6	1.5–4.7

* Results of multivariate logistic regression analysis based on a comparison of 483 cases and 482 age- and gender-matched controls in a cohort of 14,814 adults.

† Odds ratios were adjusted for all other risk factors listed in the table.

‡ CI, confidence interval.

§ Weight (kg)/height (m)^2.

¶ For definition, see "Materials and Methods."

bidity, 2) ascertainment of losses following the earthquake, and 3) the differences in the findings between the analyses of mortality and morbidity.

Ascertainment of the event of death has a high level of validity in field survey situations. The possibility that some deaths occurring during the first month after the earthquake could have been missed by this study was minimized because of our ascertaining the study population on the day before the earthquake and tracing them through their families during the follow-up period. As a population-based study of long term post-earthquake mortality and morbidity, this investigation had the unique feature of defining a study population as it existed on the day before the earthquake and tracing the outcomes in that same group following the disaster.

Although proxy-reported cause of death may have a low degree of validity in other studies, the reports obtained from these Ministry of Health employees were probably more valid than those obtained from lay interviewees. The health professionals interviewed for this study had greater than average access to the health care system and its diagnostic facilities. The vast majority of the reported death and morbidity due to heart disease in persons over 30 was probably due to coronary heart disease. In other studies of post-earthquake mortality based on death certificates and patient examinations, there was a significant increase in morbidity and mortality from coronary heart disease but not from cardiomyopathy, hypertensive heart disease, valvular heart disease, or cerebrovascular disease (10–12).

The initial increase in mortality that was observed during the first 6 months following the earthquake could not be explained by the intensity of exposures incurred during the disaster and in the immediate postdisaster period. One may first consider measurement problems as a possible explanation for the lack of an association between earthquake-related losses and stressors and postdisaster mortality. However, much of our questionnaire dealt with these presumed stressors, and this questionnaire has demonstrated its usefulness in establishing associations with earthquake exposures in our previous studies of injuries and mortality resulting directly from this same earthquake (5, 16). It is possible that some combination of stressors not measured in our questionnaire may explain some of the increase in mortality. We also considered the possibility that a number of these factors were interacting and thus masking a specific effect for some of the earthquake-related stressors. As was demonstrated in table 3, gender is potentially such a factor. Higher risk of postdisaster mortality was more pronounced in the males when we assessed the effect of being inside a building at the moment of the earthquake.

In contrast to mortality, the finding of increased risk of morbidity from heart disease as a result of exposure to loss and the stressors of the earthquake is consistent with the previous literature documenting such increases in risk under similar conditions. For example, in our study of arteriographically defined coronary artery disease in Lebanon during the civil war there, we were able to document that risk increased with exposure to the stressors of the war (18). However, it is also important to note that this relation is not very specific: it may be part of a more generalized predisposition to morbidity following exposure to major stressors, or it may be due to biases in the reporting of and/or detection of higher levels of morbidity in people with higher levels of hardship. For example, our finding of an association between reported arthritis and loss score may be attributable to differential pain perception between persons exposed to various levels of loss as a result of the disaster. In addition, we cannot rule out differential recall as an explanation for this finding. In a few reports following previous disasters, increases have been reported for a number of disease outcomes (19, 20). Logue and Hansen (21) conducted a case-control study of hypertension in female flood victims in a 5-year postdisaster survey. A number of stressors related to the disaster were significantly associated with hypertension in that study.

To our knowledge, this is the first longitudinal follow-up study carried out during the post-event phase of an earthquake that has allowed investigators to link personal risk of exposure and damage to mortality and morbidity. The approaches used in this study will help to improve the investigation of the complex

relations among factors related to survival following earthquakes (22).

The observations of this study support the hypothesis that the longer term increased rates of heart disease and other chronic disease morbidity following an earthquake may be related to the intensity of exposure to disaster-related damage and losses. The observed higher risk of morbidity, particularly for incident heart disease and other chronic diseases, among persons exposed to such losses encourages us to consider designing focused preventive strategies to implement in such persons following a disaster. People sustaining disaster-related losses should be closely monitored for increased long term morbidity.

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