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Before and After the 1999 Chi-Chi Earthquake: Traumatic Events and Depressive Symptoms in an Older Population

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Christopher L. Seplaki

Noreen Goldman

Maxine Weinstein

Yu-Hsuan Lin
Bureau of Health Promotion, Center for Population and Survey Research, Department of Health, Taichung, Taiwan

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Abstract

Natural disasters may have dramatic consequences for well-being. We investigate variability in resilience to depressive symptoms in the aftermath of a massive earthquake in Taiwan. Data come from a national, longitudinal survey with interviews before and after the 1999 earthquake. We estimate regression models testing complex relationships among depressive symptoms, earthquake experiences and socio-demographic characteristics. Persons of low SES, socially isolated individuals and women reported higher levels of depressive symptoms, as did persons who experienced damage to their homes. The effects of damage were strongest among those aged 54-70. The results suggest that people who experience damage to their home during a disaster are at risk of experiencing depressive symptoms, with the elderly being more resilient than the near-elderly.

Keywords: earthquake, depressive symptoms, Taiwan

1. INTRODUCTION

Natural disasters, such as earthquakes, can have enormous human and economic costs. At the community level, they may destroy resources, damage infrastructure, and place overwhelming demands on local authorities. On an individual level, they may have deleterious consequences for both physical and psychological health. The effects on mental well-being, which often persist long after the disaster, have been shown to vary according to individuals' exposure to and experiences emanating from the event. Studies also indicate that these effects depend upon basic socio-demographic characteristics – e.g., age, sex, and socioeconomic status (SES) – sometimes in complex and unanticipated ways. For example, recent work suggests that earthquakes may have less of a psychological impact on the elderly than on younger adults (see review by Norris, Friedman, and Watson, 2002; and Norris, Friedman, Watson et al., 2002), even though the elderly are generally more likely to suffer physically from the disaster (Lin et al., 2002; Osaki and Minowa, 2001).

In this analysis, we consider the psychological impact of the massive earthquake (7.3 on the Richter scale) that struck the island of Taiwan on September 21, 1999, an event considered to be the most devastating disaster to have struck Taiwan during the past century (Chen et al., 2001). This earthquake, with an epicenter near the centrally-located city of Chi-Chi, resulted in about 2,400 deaths, over four times as many injured, and caused the collapse of over 100,000 homes (Lin et al., 2002). We use data from a longitudinal survey that provide a unique opportunity to identify whether a broad range of risk factors are associated with vulnerability or resilience to depressive symptoms in the aftermath of this catastrophic event. As described later, the design of the survey and

the breadth of the information collected permit us to analyze potentially complex relationships among these risk factors and to avoid many of the methodological limitations that characterize previous research on psychological morbidity associated with natural disasters.

2. BACKGROUND

Norris and colleagues (Norris, Friedman, and Watson, 2002; Norris, Friedman, Watson et al., 2002) provide an extensive review of studies published during the past 20 years that examine the psychosocial consequences of disasters. Slightly more than half of the 160 samples included in their synthesis, derived from 29 countries, are based on natural disasters (primarily earthquakes, hurricanes, typhoons, cyclones and floods). Among those that focus on specific psychological problems, most examine symptoms associated with either post-traumatic stress or depression.

Although the nature of the explanatory and outcome variables varies considerably across studies, their synthesis of the disaster literature combined with our own review indicates that socio-demographic variables are generally significantly related to the presence of psychological problems in the aftermath of disasters. The findings regarding age are complex, discordant across studies, and inconsistent with early theoretical predictions. In contrast, there is more uniformity across time and place regarding the associations between psychological problems and both sex and the social and economic environment.

Elderly individuals, like other segments of the population, often experience reduced psychological wellbeing subsequent to natural disasters (Chiu, Hu, Lue, Chen, and Hsieh, 2002; Lewin, Carr, and Webster, 1998; Lin et al., 2002; Phifer and Norris,

1989). However, Knight and colleagues (Knight, Gatz, Heller, and Bengtson, 2000) point out that while early research in this area proposed that older individuals should be at greater risk of adverse emotional effects of natural disasters, in part because they have fewer resources and poorer health than others, recent empirical research has more often demonstrated that older adults fare better with regard to post-disaster emotional distress than younger ones. Norris and colleagues (Norris, Friedman, and Watson, 2002; Norris, Friedman, Watson et al., 2002) cite additional work demonstrating that the psychological impact of disasters among adults declines with age. There are, however, exceptions to this pattern, a result that may reflect cultural and social differences across populations (Norris, Friedman, Watson et al., 2002).

Researchers have posed several hypotheses to explain why middle-aged persons may experience higher psychiatric morbidity than the elderly. One explanation, termed the *maturation hypothesis,* suggests that the psychological maturity and improved coping styles that come with age may lead older individuals to have less emotional reactivity in response to stressful events than their younger counterparts (Knight et al., 2000). A second proposition, sometimes referred to as the *inoculation hypothesis*, suggests that older individuals may be protected from strong emotional reactivity, relative to younger cohorts, by having had more experience in the past with similar traumatic events (Knight et al., 2000). A third explanation, referred to as the *burden perspective*, posits that middle-aged adults experience poorer coping capacity than others because their responsibilities to society (e.g., working) and to the family (e.g., often providing support to both children and parents) render them more psychologically vulnerable in the

aftermath of the disaster than younger and older cohorts (Thompson, Norris, and Hanacek, 1993).

A considerable amount of attention has also been given to how the impact of natural disasters varies by sex. A recent review of over 100 studies pertaining to gender issues in disasters concludes that there are relevant differences between females and males with regard to multiple stages of the disaster process (Fothergill, 1998). For example, women's roles as the primary caregiver of the family are thought to increase their exposure to risk and to make them more vulnerable to psychopathology during and after disasters. Women's relative lack of mobility and social isolation in some societies, and their relative absence from leadership roles, are believed to lower their preparedness for the disaster and hamper recovery from it. As a result, women apparently suffer greater psychological morbidity than men in the aftermath of disasters. The majority of disaster studies reveal that women report greater emotional distress, trauma, and mental health problems than men, although men are more likely to increase their alcohol consumption (Fothergill, 1998; Norris, Friedman, Watson et al., 2002; Rubonis & Bickman, 1991). A recent analysis of persons seeking psychiatric care in a district of central Taiwan in the month following the Chi-Chi earthquake (Chen et al., 2001) also finds a higher prevalence of psychiatric symptoms among women, although another community-based study of the Chi-Chi earthquake finds no significant sex difference in psychological distress among inhabitants of a community in central Taiwan (Chiu et al., 2002).

A person's social and economic position is hypothesized to affect his or her psychological response to disasters, and to life challenges more generally, through

several pathways. First, poor financial status (e.g., lower income or wealth) places an individual and his or her household at greater risk of damage from disasters, because, for example, of poor housing quality, inferior residential location, or inadequate safety features (Asgary and Willis, 1997). Second, for a given level of exposure or challenge, additional assets or a higher level of education can cushion the impact of the challenge and enhance recovery by access to better information and relevant resources. A third potentially important set of mechanisms pertains to an individual's level of social support – a factor which is often, although not necessarily, related to their socioeconomic status (SES). Higher degrees of social embeddedness – an aspect of social support that focuses on the size, level of activity, and closeness of a person's social ties – may buffer the deleterious consequences of disasters as well as provide additional important sources of information pertaining to the disaster and the recovery process (House et al., 1994; Norris, Perilla, Riad, Kaniasty, and Lavizzo, 1999). Despite the fact that many disaster studies fail to examine the effects of SES or social support, those that do report consistent results. Studies with significant findings almost invariably demonstrate that lower SES individuals and persons with smaller and weaker social networks have higher levels of post-disaster psychiatric morbidity than their more advantaged counterparts (Norris, Friedman, and Watson, 2002; Norris, Friedman, Watson et al., 2002).

Not surprisingly, research has demonstrated that the psychological impact of a disaster is a function not only of an individual's characteristics but also of his or her experiences regarding the event and the severity of exposure – i.e., the number and types of stressors resulting from the disaster (Norris, Friedman, Watson et al., 2002). These stressors include numerous experiences at an individual level (e.g., injury to the person;

injury or death of friends and family members; loss or damage to the home, property or other possessions; loss of job; and relocation) as well as community-level loss and damage. Norris and colleagues (2002) note the difficulties of comparing the impacts of these stressors across studies of different types of disasters and the many inconsistencies in the literature regarding which stressors are associated with the most severe psychosocial consequences. With regard to earthquakes, the literature suggests that damage to the home and property is associated with both physical health problems (Armenian, Melkonian, and Hovanesian, 1998; Kario and Ohashi, 1997; Matsuoka et al., 2000) and psychological problems (Bland, O'Leary, Farinaro, Jossa, & Trevisan, 1996; Chen et al., 2001; Knight et al., 2000). Consistent with this finding are two recent studies of psychological symptoms after the Chi-Chi earthquake in Taiwan. Chen et al. (2001) and Chiu et al. (2002) find higher psychological morbidity among those who experience damage to their home and property.

A key component of much of the disaster literature has been an examination of individual differences in psychological outcomes, i.e., identification of which socio-demographic groups are most susceptible to psychological distress in the aftermath of the disaster. At the same time, there has been substantial interest in the potential moderating role of socio-demographic factors on psychopathology emanating from disaster-related stressors. That is, researchers seek to determine whether some groups (e.g., males or persons with high education or income) are more resilient than others *to the impact of particular losses or traumas* (e.g., property damage). The latter type of question is based on a more complex relationship among explanatory variables than a determination of subgroup differences – it requires the inclusion in the statistical model of interaction

terms between the appropriate socio-demographic variables and the relevant losses or experiences.

Some studies have investigated the moderating role of basic characteristics on the psychological impact of disasters. For example, studies focused on explaining the resiliency of the older population in the aftermath of a disaster have assessed the statistical importance of interaction terms between age and disaster-specific experiences or losses (e.g., Knight et al., 2000; Thompson et al., 1993), and a few studies have considered how SES modifies the impact of disaster-related experiences (e.g., Phifer, 1990; Ginexi, Weihs, Simmens, and Hoyt, 2000). Nevertheless, and despite a pervasive interest by disaster researchers in understanding how and why individuals vary in their vulnerability to stress, most disaster studies have not incorporated interaction terms in their statistical models (Phifer, 1990; Norris, Friedman, Watson et al., 2002). In addition, most studies have failed to consider potentially complex relationships among the socio-demographic variables themselves (e.g., between age and sex), although the relatively few that have done so have identified some important associations. For example, Norris et al. (2001) find that the effects of sex on post-disaster psychological distress vary by ethnicity, probably as a consequence of cultural differences in sex roles.

Beyond the failure to consider potentially complex relations among risk factors, disaster studies are frequently characterized by several statistical and methodological limitations that compromise the generalizability of the findings and limit the strength of the resulting inferences (Norris, Friedman, Watson et al., 2002). First, most disaster studies are not based on random or probability samples of well-defined (e.g., community- or national-level) populations (Ginexi et al., 2000). Indeed, many are restricted to

persons seeking medical, psychological or personal assistance. Second, most sample sizes are small: for example, the median size of the 169 samples included in the Norris reviews (Norris, Friedman, and Watson, 2002; Norris, Friedman, Watson et al., 2002) is 149. Third, longitudinal data are rare in the field of disaster research, especially in developing countries (Norris et al., 2001). The most serious aspect of this limitation is that most disaster studies have no psychological assessment prior to the disaster, a drawback that severely limits the analyst's ability to attribute effects to the disaster itself rather than to the persistence of preexisting pathologies. Indeed, previous research that has included controls for pre-disaster distress has found that one of the strongest predictors of psychological morbidity after a disaster is the corresponding measure before the disaster. The absence of measures of pre-disaster psychiatric morbidity in the majority of studies is exacerbated by the failure of most studies to control more generally for health and well-being prior to the disaster – a source of potential bias given that a person's physical and cognitive status as well as their psychological health prior to the disaster are likely to be important sources of post-disaster psychopathology. A fourth limitation of many existing studies is the lack of information on relevant background variables such as SES, and disaster-related exposure such as objective measures of the magnitude of the disaster or losses emanating from it.

As described below, the data used in the present analysis are not subject to these shortcomings. The survey is based on a large national sample of the Taiwanese population; contains data on depressive symptoms and physical and cognitive function that were collected before the Chi-Chi earthquake, as well as data on depressive symptoms obtained after the disaster; and includes extensive information on individual

and family characteristics and earthquake-related exposure and experiences. In subsequent sections, we analyze these data in an effort to examine risk factors associated with depressive symptoms in the aftermath of the earthquake, controlling for health status and the presence of depressive symptoms prior to the disaster. We pay special attention to potentially complex associations among risk factors, focusing on the extent to which socio-demographic factors moderate the psychological impact of earthquake-related experiences.

3. METHODS

3.1. Data

The data for this analysis were originally collected as part of the Survey of Health and Living Status of the Near-elderly and Elderly in Taiwan. This longitudinal survey began in 1989 with a national sample (including the institutionalized population) of persons aged 60 and older, and was extended in 1996 to include near-elderly persons aged 50 to 66 in 1996. Both groups of respondents were re-interviewed in 1999.

In 2000, a national subsample of the 1999 cohort was selected randomly for the Social Environment and Biomarkers of Aging Study (SEBAS). Among the 1713 respondents selected, 1497 provided interviews (92% of survivors). Elderly respondents and those in urban areas were oversampled relative to their counterparts. This analysis uses data from the 1999 wave of the Survey of Health and Living Status, which provides most of the baseline measures, and the 2000 SEBAS, which provides data on earthquake-related experiences and the post-disaster outcome.

In-person interviews for the 1999 survey were conducted between April and December, primarily during the summer. Thus, some interviews occurred after the Chi-

Chi earthquake of September 21. A total of 41 (out of 1497) individuals were excluded from the analysis because their interviews occurred after September 20 (and thus they did not have a pre-earthquake assessment of depressive symptoms) or because they were missing the date of interview. The 2000 SEBAS follow-up interviews were conducted between June and December of that year, again primarily during the summer. For persons whose 1999 interviews preceded the earthquake, follow-up information in 2000 is obtained within 15 months of the earthquake, with an average duration of 11.6 months.

An additional 256 respondents were excluded from the analysis if they were missing necessary information. Over half of these (133) were missing some or all information pertaining to depressive symptoms. (Many of these cases involved persons whose interviews were done by a proxy.) The final analysis sample comprises 1,160 respondents. A comparison of excluded respondents with the analysis sample reveals only one significant difference between the two groups with regard to earthquake experience measures (more individuals in the analysis sample felt the October 22 aftershocks).

3.2. Measures

Depressive symptoms are measured in 1999 and 2000 using a ten-item version of the original 20-item Center for Epidemiologic Studies Depression Scale (CES-D) (Radloff, 1977). The measurement properties of the 20-item CES-D, which generates a score between zero (no depressive symptoms) and sixty (maximum), are well-established (Hertzog, Van Alstine, Usala, Hultsch, & Dixon, 1990). The 10-item scale used here generates a score ranging between zero and thirty. However there is evidence that the sensitivity and specificity of shortened forms of the CES-D are not significantly reduced

from the full item scale (Kohout, Berkman, Evans, and Cornoni-Huntley, 1993; Shrout and Yager, 1989). The CES-D has also been shown to perform well in cross-cultural studies of elderly depression (McCallum, Mackinnon, Simons, & Simons, 1995), including Chinese populations (Krause and Liang, 1992; Ofstedal, Zimmer, and Lin, 1999). Recent work by Boey (Boey, 1999) indicates that a 10-item Chinese version demonstrated satisfactory reliability and validity properties in a sample of elderly Chinese. The Chronbach's alpha scale reliability coefficients for CES-D in 1999 and 2000 for the analysis sample are 0.86 and 0.81, respectively.

In addition to the CES-D score in 1999, the statistical models incorporate extensive controls for health status and cognitive function prior to the earthquake. Health status in 1999 is assessed by five variables: (1) an indicator for "health not so good/poor" (derived from a self-rating of current overall health on a 1-5 scale); (2) a count of impairments in activities of daily living (0-6); (3) a count of mobility impairments (0-10); (4) a count of the major health conditions the individual reports having in 1999 (0-9); and (5) an index of cognitive performance (0-14). The index of cognitive function, calculated as the number of items that a respondent answers correctly, is derived from three tests: the modified Short Portable Mental Status Questionnaire (Pfeiffer, 1975), the modified Rey Auditory Verbal Learning Test (Lezak, 1983), and a modification of the Digits Backward test (Wechsler, 1981).

We include various dimensions of earthquake exposure and experience in the models. Seven measures pertain to personal experiences of the respondents, namely whether the respondent: (1) felt the earthquake on September 21st; (2) felt the aftershocks on October 22nd; (3) had damage to the house; (4) had damage to other property

(household items, automobiles, land or other possessions); (5) was temporarily or permanently displaced; (6) was scared by the earthquake or its aftershocks; and (7) was injured or a relative or friend was injured or killed. Each of these earthquake-related experiences is represented by a binary variable. We incorporate an additional variable that provides an objective measure of the magnitude of earthquake as measured by the Richter Scale (ML), obtained from the Taiwan Central Weather Bureau. Magnitudes are average values over areas within a respondent's primary sampling unit (i.e., averages over possibly several towns and townships). For townships that did not have a measuring station, a value was imputed based on the magnitude from the nearest station.

Socioeconomic status is measured by five variables: (1) the education of the male head of household (using indicators for "illiterate" and "1-6 years of education or literate," with "7 or more years of education" as the reference group); (2) an index reflecting the status of the male or husband's primary lifetime occupation; (3) a measure indicating whether the respondent (and spouse) had difficulty meeting their monthly living expenses in 1999; (4) the quintile of the distribution of the annual income of the respondent in 1999 (combined with the income of spouse for married respondents); and (5) a question asked in 2000 in which individuals place themselves on one of ten rungs of a ladder describing their social status relative to other Taiwanese (Goldman, Cornman, & Chang, 2003). The level of education of the husband is used to assess the status of the female respondents because about half of women in the survey have no formal education. These women, however, are likely to gain social and economic benefits from the educational attainment of their husbands. Similarly, because about one-third of the female respondents were never employed, the index of occupational status reflects the

prestige of the primary lifetime occupation of male respondents and of the husbands of female respondents; this measure was developed for Taiwan, based on earlier similar measures for the U.S., and has a theoretical range of 55 to 76 (Tsai and Chiu, 1991). Information on the male's education and occupation are derived from early waves of the survey (1989 and 1996). For formerly married women (most of whom are widowed, because divorce is rare in Taiwan), this information pertains to the former spouse. Never-married women are not included in the sample (i.e., they were excluded by virtue of their having missing values on variables pertaining to the husband's status).

An additional variable pertaining to the social environment denotes the embeddedness of the respondent's social network in 1999. This variable is defined as the total number of social ties with whom a respondent has frequent contact. Ties include children, grandchildren, other relatives (excluding spouse), close friends and neighbors. Only those friends or relatives who co-reside with the respondent (e.g., older Taiwanese frequently live with children and grandchildren) or who have contact with the respondent on at least a weekly basis are included in the count.

Along with the key measures of age and sex, two additional demographic variables are included in the statistical models: ethnicity and marital status. Both of these factors are considered as potentially important predictors of physical and mental health among older Taiwanese (Cornman et al., forthcoming). In the models, age is represented by a dichotomous variable indicating those older than 70 in 2000 (relative to the age group 54-70) and sex by an indicator for female. A binary variable denoting whether the respondent was married (or with a partner) and lived with him or her in 1999 is used to denote marital status. Finally, the ethnicity variable identifies Taiwanese in contrast to the

omitted category of Mainlanders. Mainlanders refer to the approximately one million Nationalist military and civilian supporters who migrated to Taiwan from the Mainland in 1949, many of whom assumed high-ranking posts upon their arrival (Gates, 1981; Tsai, 1992).

3.3. Analysis

Basic summary statistics for all variables are given in Table 1. Ordinary least squares regression is used to estimate the association of the measures of earthquake experience and demographic characteristics with the CES-D score in 2000, controlling for CES-D and health status in 1999. Two models are estimated and results are presented in Table 2: Model 1 includes all of the main effects described above and Model 2 incorporates select interaction terms.

Because of the potential role of age, sex, SES, and social support as variables that moderate the psychological impact of earthquake-related experiences, we estimated a series of exploratory models that included interaction terms between earthquake measures and these basic characteristics. We also evaluated the effects on depressive symptoms of interaction terms between these demographic characteristics themselves. In the exploratory models, we incorporated one interaction term at a time to a model that included only main effects. Because of the potentially large number of interaction terms (earthquake experience and SES are each captured by many variables), we restricted the inclusion of interaction terms to age, sex, and the four social/economic environment variables and the one earthquake experience that emerged as statistically significant in Model 1. Interaction terms that were individually significant ($p<0.10$) in the exploratory models were included in the final model (Model 2).

Table 1: Descriptive Statistics of Analysis Sample (unweighted)

Variable	Total N = 1,160			
	Mean	(S. D.)	Min	Max
CES-D Scores				
CES-D Score 2000	5.60	(5.73)	0	30
CES-D Score 1999	5.18	(5.82)	0	30
Change in CES-D Score (2000-1999)	0.41	(6.60)	-24	25
Health in 1999				
Self-Rated Health Not So Good/Poor	0.25		0	1
Number of ADL Impairments[a]	0.11	(0.66)	0	6
Number of Mobility Impairments[b]	1.94	(2.65)	0	10
Number of Current Health Conditions[c]	1.38	(1.45)	0	9
Cognitive Function[d]	7.76	(3.13)	0	14
Earthquake Experience				
Magnitude (PSU Average)	4.64	(0.72)	3.33	6.50
Felt Sept 21 Earthquake	0.95		0	1
Felt Oct 22 Earthquake	0.83		0	1
Earthquake Caused Damage to House	0.13		0	1
Earthquake Caused Damage to Other Property	0.10		0	1
R Temporarily Displaced by Earthquake	0.09		0	1
R Scared by Earthquake and Aftershocks	0.81		0	1
R Injured, or Fam/Friend/Rel Injured/Killed	0.04		0	1
Social and Economic Characteristics				
Male/Husband Illiterate	0.15		0	1
Male/Husband Literate or 1-6 Yrs Educ.	0.51		0	1
Occupational Status of Male/Husband	62.12	(4.94)	55.1	76.10
Ladder of Social Status	3.88	(1.93)	1	10
Some/Much Difficulty Meeting Expenses	0.25		0	1
R's + Spouse's Income (Quintiles)	3.23	(1.39)	1	5
Number of Social Ties	17.78	(12.91)	0	92
Demographic Characteristics				
Age > 70	0.48		0	1
Urban	0.57		0	1
Female	0.41		0	1
R is Taiwanese	0.81		0	1
Married/Has Partner & Lives With	0.70	0.46	0	1

[a]ADL activities include difficulty bathing, difficulty dressing or undressing, difficulty eating, difficulty getting out of bed, standing, or sitting, difficulty moving around house, and difficulty using the toilet. [b]Mobility impairments include difficulty squatting, walking up 2-3 flights of stairs, lifting or carrying 11-12 kg, working around the house, walking 200-300m, standing continuously for 15 minutes, running 20-30m, standing for 2 hours, reaching, and grasping. [c]Current health conditions include high blood pressure, diabetes, heart disease, cancer, respiratory problems, arthritis, ulcers, liver problems, cataracts, kidney problems, gout, and spinal problems. [d]The cognitive function score represents the number correct out of a possible total of 14.

The CES-D scores in both 1999 and 2000 comprise integer values between zero and thirty, with a significant massing at zero (approximately 25%). Given that this distribution violates basic assumptions of OLS, Tobit and ordered probit models were estimated to assess the robustness of results. The main findings are consistent across these alternative specifications. The OLS estimates of the coefficients are displayed here because they are straightforward to interpret. Robust variance estimates (from the Huber/White estimator) are used to correct for the potential effects of heteroskedasticity and potential clustering by PSU. All estimates are unweighted; however the model includes covariates for age and area of residence (urban vs. rural) to account for the sampling scheme. All analyses are done using Stata 7.0 (StataCorp, 2001).

4. RESULTS

Descriptive statistics for the analysis sample of 1160 respondents depict large variation in the prevalence of earthquake experiences (Table 1). For example, because of the small size of Taiwan, almost all respondents felt the earthquake and most were frightened by it. On the other hand, damage and injuries were not as widespread: e.g., about 13 percent of the national sample suffered damage to their homes and 10 percent experienced damage to other property. The descriptive statistics also reveal an unusual characteristic of this population compared with most Western societies: about 40 percent of the older population is female – an imbalance that results from the selective migration of males (primarily soldiers) after World War II. The estimates in the first panel suggest a modest but statistically significant ($p<0.05$) rise in the CES-D score between 1999 and 2000, an increase that may be attributable in part to the experience of the earthquake and its sequelae.

The statistical models in Table 2 explore the extent to which specific earthquake losses and experiences, as well as characteristics of the respondents, are in fact associated with increases in depression scores over this short time period. The results for Model 1 indicate that, among the eight earthquake-related variables, only damage to house is statistically significant. On average, individuals who report that their house was damaged in the disaster have a CES-D score in 2000 that is 1.09 points higher than those reporting no damage, in the presence of controls for other factors. Although the importance of home damage is consistent with the literature, other variables that were hypothesized to be important predictors of post-disaster distress are in fact not statistically significant. In particular, the magnitude of the earthquake, whether the earthquake was felt by or frightened the respondent, whether the respondent was displaced, whether the earthquake resulted in damage to other property, or whether it led to personal injury or death of a family member or friend were not significantly associated with the CES-D score in 2000. As anticipated, higher levels of social or economic status are associated with lower depression scores in 2000. Specifically, the higher an individual's subjective assessment of his or her relative social position or the higher the couple's income, the lower the expected depressive symptom score in 2000. Similarly, individuals who experienced difficulty in meeting expenses in 1999 have higher expected CES-D scores in the aftermath of the earthquake than those who did not experience these financial problems. The estimates further reveal the hypothesized association between social embeddedness and depressive symptoms: the higher the number of close social ties, the lower the post-disaster CES-D score.

Table 2: Coefficients and Robust 95% Confidence Intervals from OLS Regression Predicting CES-D in 2000

Outcome Variable: CES-D Score in 2000 (N = 1,160)	**OLS Coefficient Estimates [Robust 95% C.I.]**			
	Model 1		**Model 2**	
CES-D Score 1999	0.15***	[0.08, 0.22]	0.15***	[0.08, 0.22]
Health in 1999				
Self-Rated Health Not So Good/Poor	1.52***	[0.59, 2.45]	1.49***	[0.56, 2.42]
Number of ADL Impairments	1.20***	[0.61, 1.79]	1.20***	[0.62, 1.79]
Number of Mobility Impairments	0.07	[-0.12, 0.26]	0.10	[-0.08, 0.29]
Number of Current Health Conditions	0.42***	[0.17, 0.67]	0.40***	[0.15, 0.65]
Cognitive Function	0.00	[-0.11, 0.12]	0.01	[-0.11, 0.12]
Earthquake Experience				
Magnitude (PSU Average)	-0.34	[-0.83, 0.15]	-0.32	[-0.81, 0.17]
Felt Sept 21 Earthquake	0.44	[-1.02, 1.91]	0.37	[-1.10, 1.83]
Felt Oct 22 Earthquake	0.04	[-0.76, 0.83]	0.08	[-0.72, 0.88]
Earthquake Caused Damage to House	1.09**	[0.03, 2.15]	2.68***	[0.89, 4.46]
Earthquake Caused Damage to Other Property	0.04	[-1.24, 1.32]	-0.03	[-1.29, 1.23]
R Temporarily Displaced by Earthquake	-0.84	[-2.20, 0.51]	-0.77	[-2.13, 0.59]
R Scared by Earthquake and Aftershocks	0.16	[-0.54, 0.86]	0.23	[-0.48, 0.94]
R Injured, or Fam/Friend/Rel Injured/Killed	-0.19	[-1.60, 1.21]	-0.23	[-1.67, 1.22]
Social and Economic Characteristics				
Male/Husband Illiterate	0.11	[-1.01, 1.22]	0.10	[-1.01, 1.20]
Male/Husband Literate or 1-6 Yrs Educ.	0.02	[-0.68, 0.72]	0.01	[-0.69, 0.70]
Occupational Status of Male/Husband	0.00	[-0.07, 0.08]	0.00	[-0.08, 0.07]
Ladder of Social Status	-0.31***	[-0.49, -0.12]	-0.29***	[-0.47, -0.11]
Some/Much Difficulty Meet Expenses	1.17***	[0.36, 1.98]	1.19***	[0.39, 1.99]
R's + Spouse's Income (Quintiles)	-0.32**	[-0.59, -0.04]	-0.32**	[-0.60, -0.05]
Number of Social Ties	-0.05***	[-0.07, -0.02]	-0.04***	[-0.06, -0.01]
Demographic Characteristics				
Urban	-0.49	[-1.21, 0.23]	-0.48	[-1.19, 0.24]
Aged > 70	-0.40	[-1.10, 0.30]	0.42	[-0.40, 1.25]
Female	0.61*	[-0.07, 1.28]	1.02**	[0.17, 1.87]
R is Taiwanese	-0.69	[-1.60, 0.23]	-0.67	[-1.58, 0.24]
Married/Has Partner & Lives With	-0.20	[-0.95, 0.54]	-0.31	[-1.06, 0.44]
Interaction Terms				
Aged > 70 and Female			-1.50**	[-2.75, -0.25]
Aged > 70 and Damage to House			-2.31**	[-4.17, -0.44]
Female and Damage to House			1.46	[-0.46, 3.38]
Number of Social Ties and Damage to House			-0.08***	[-0.14, -0.02]
Constant	7.86**	[1.82, 13.90]	7.63**	[1.68, 13.58]

As suggested by the previous literature, women have significantly higher expected CES-D scores in the aftermath of the earthquake than men, independent of their prior scores, health, earthquake experiences and socio-demographic factors. The nature of the age effect in Model 1 is also in the expected direction – i.e., lower post-disaster depression scores among the elderly compared to near-elderly persons – but the effect is not statistically significant. Finally, the estimates indicate that neither ethnicity nor marital status is significantly associated with the level of depressive symptoms in 2000.

The estimates in Model 1 underscore the importance of including control variables in the statistical model. The CES-D score prior to the disaster and three of the five health measures (poor self-assessed health, ADL limitations and current health conditions) are significant predictors of the depression score after the earthquake.

In contrast to Model 1, which provides estimates of the extent to which particular socio-demographic groups have lower or higher levels of psychological morbidity after the earthquake, Model 2 permits us to evaluate whether these characteristics moderate the consequences of damage to the home – the single earthquake experience that is associated with a significant increase in depressive symptoms. Specifically, Model 2 allows us to assess whether the elderly are less affected psychologically than the near-elderly by damage to the home and whether the psychological consequences of the damage vary by sex, SES, or social support.

Only one interaction term pertaining to the social and economic environment was statistically significant – the term involving number of social ties and damage to the home. Thus, although there is no evidence that persons of lower socioeconomic status are more psychologically vulnerable to the effects of home damage than those better-off,

persons with few social ties appear to be more susceptible than their counterparts. The results also reveal that the interaction term between age and damage to the home is significant, a finding that suggests variation by age in resilience to the psychological consequences of home damage. The interaction term between age and sex is significant as well, a result that indicates differences between men and women in the association between age and the post-disaster CES-D scores. Although the interaction between sex and home damage is not significant in Model 2, it is included here because it was statistically significant in the exploratory models.

Because of the difficulty of interpreting the coefficients in Table 2 in the presence of several interaction terms, we summarize the impact of age, sex, and damage to the home in Table 3. These estimates denote the combined effects of age, sex and house damage on the post-earthquake CES-D score. The estimates are based on the assumption that all other variables in the model are held constant and that the number of social ties is equal to zero; because model 2 incorporates an interaction term between the number of social ties and home damage, an alternative value for the number of social ties would lead to a different set of estimates in Table 3, but the basic patterns by age and sex would remain the same. By construction of the model, the reference group (i.e., zero effect) comprises men aged 54 to 70 with no damage to the home.

The estimates for both men and women, shown in the next-to-last column, suggest that persons aged 54 to 70, but not their older counterparts, experienced an increase in depressive symptoms as a consequence of home damage. These estimates underscore the vulnerability of near-elderly men and near-elderly women to the psychological consequences of home damage: e.g., the difference for women amounts to more than

Table 3: Effects on Depressive Symptom Scores of Age, Sex, and Damage to House[‡]

		Coefficients		Difference between damage and no damage	Difference between Age 54-70 and Age > 70 among those with damage
		No House Damage	House Damage		
Men	Age 54-70	0.00	2.68	2.68***	1.89**
	Age > 70	0.42	0.79	0.37	
Women	Age 54-70	1.02	5.15	4.13***	3.39***
	Age > 70	-0.06	1.77	1.82	

*p < 0.10; **p < 0.05; ***p < 0.01; [‡]Table entries are the sum of coefficients and interaction terms for age, sex, and damage to house, controlling for other factors and setting number of social ties equal to zero.

four points on the CES-D score. In contrast, the elderly appear to be fairly resilient – the effects of damage for this group are small and not statistically significant. The estimates in the final column of Table 3 reveal that the difference in effects between the two age groups is statistically significant for both women and men who experienced home damage.

5. DISCUSSION

The data available in SEBAS allow us to improve upon the study designs used in previous disaster research in several important ways. We are able to explore the role of a broad range of socio-demographic variables and earthquake-related risk factors on the prevalence of depressive symptoms in the aftermath of the Chi-Chi earthquake, allowing for potentially complex associations among the variables. In addition, the availability of longitudinal information permits us to introduce extensive controls for mental, cognitive, and physical health prior to the disaster, thereby increasing the likelihood that significant results can be attributed to the earthquake itself rather than to preexisting events or conditions. And, by virtue of using a national probability sample, the results can be generalized to the older population of Taiwan.

The findings of the statistical analysis underscore the importance of damage to one's home for psychological morbidity, even at a duration of approximately one year after the earthquake. The results also demonstrate a surprising lack of significance of other measures of earthquake experience. In particular, in the presence of controls for other variables, depressive symptoms are not associated with any measure of the impact

of the earthquake – i.e., either the objective measurement for the community or individual subjective assessments.

Estimates from the statistical models also shed light on the subgroups that experienced significant increases in depressive symptoms after the disaster: women, individuals with low social status or inadequate financial resources, and persons with fewer social ties. Many of these findings are consistent with the previous literature. However, these results go beyond prior studies by demonstrating the importance of interaction terms between socio-demographic variables and earthquake losses and between the socio-demographic variables themselves. For example, Model 1, which includes only main effects, does not reveal significant variation in post-disaster depression scores by age. In contrast, Model 2 demonstrates that the near-elderly with home damage experience higher depression scores in the aftermath of the earthquake. Although the interaction between sex and home damage is not statistically significant ($p< 0.14$), the estimates suggest that the psychological impact of home damage may be larger among near-elderly women than near-elderly men. The analysis also reveals the importance of pre-disaster controls: the level of depressive symptoms and various measures of physical well-being are significantly related to depression scores after the earthquake. Failure to include these variables could lead investigators to incorrectly attribute the increase in the depression score between the two time points to other risk factors.

This study raises a number of important questions about why some groups experience more depressive symptoms than others in the aftermath of the earthquake. Unfortunately, these questions cannot readily be answered with the data available. The

higher risks experienced by near-elderly persons are likely to be consistent with all of the hypotheses presented earlier. *Maturation* – e.g., improved coping styles – may underlie the resilience of the elderly. But it is also likely that the elderly have experienced more traumatic events in the past that have increased their resilience to emotional distress from the recent earthquake; the SEBAS data do not include information that would permit us to test this *inoculation hypothesis* explicitly. And, consistent with the *burden hypothesis*, it is possible that the near-elderly have greater susceptibility to disaster-induced psychological morbidity than the elderly because the near-elderly are more likely to be providing financial and other types of support to their children and relatives and to be facing challenges at work and an impending retirement. This level of responsibility almost certainly intensified in the aftermath of the disaster.

In spite of the breadth of data collected in SEBAS, this study has several limitations. First, there is a lag between the earthquake and 2000 interview, leaving open the possibility that depressive symptoms may have been higher shortly after the earthquake. However, this lag of about one year is short relative to similar work, and the literature suggests that stress from disasters may persist for longer durations (Krause, 1987; Logue, Hansen, and Struening, 1981). Second, with the exception of a measure of the magnitude of the earthquake, this study relies on subjective assessments of earthquake experiences. These assessments, which depend on the recall of information about one year after the event, may be affected by an individual's psychological state. Third, some of the earthquake experiences are relatively rare – e.g., only four percent of respondents experienced an injury or had close relatives and friends that were injured or died – thereby limiting the statistical power to test some of the associations with the CES-

D score. And fourth, the sample is restricted to those aged 54 and older in 2000, which prevents us from investigating the psychological impact of the Chi-Chi earthquake for younger cohorts and obtaining a broader depiction of age effects.

This research has important implications for policy because, as with prior disaster research, it suggests that the needs of older individuals may not be adequately met in the aftermath of earthquakes. Our results indicate that interventions focusing on the psychological impact of such traumatic events should give special attention to those who experience damage to their homes, particularly among the near-elderly. Women, as well as persons who are socially isolated or have low socioeconomic status, may also be psychologically vulnerable in the aftermath of an earthquake. Other researchers have shown that post-earthquake assistance can be effective (Wang et al., 2000) and that individuals at risk of psychopathology can be identified shortly after the disaster strikes (Norris, Friedman, & Watson, 2002). Knowledge of which segments of the population are most at risk can help agencies more efficiently provide assistance in the aftermath of such events.

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