Within a 24-month period, Los Angeles County and the San Francisco Bay Area, two of the most earthquake-prone urban areas of the United States, experienced significant earthquakes. On October 1, 1987, at 7:42 A.M., an earthquake of magnitude 5.9 on the Richter scale occurred in the Whittier Narrows area of Los Angeles County. Three persons were killed, 1,349 reported injured, and damage to private and public property was estimated to exceed $358 million. On October 17, 1989, at 5:04 P.M., an earthquake of magnitude 7.1 on the Richter scale occurred on the San Andreas Fault 60 miles southwest of San Francisco and 50 miles northeast of Monterey between Santa Cruz and San Jose. Sixty-three persons were killed, 3,757 reported injured, and more than 12,000 displaced.

While stressful life events are known to have deleterious effects on both physical and psychological well-being, few systematic studies have examined the specific traumatic event of an earthquake. In this paper, data collected from representative community-based samples are used to examine the severity and characteristics of physical injuries and psychological distress reported by respondents following the Whittier Narrows and Loma Prieta earthquakes. Our analyses will examine the number of injured persons reported by respondents, the relationship of each injured person to the respondent, how each injury occurred, and the severity of each injury. Reports of injury and psychological distress are examined by proximity to the epicenter, respondents' location at the time of the earthquake, amount of damage and dislocation experienced, and demographic characteristics of the respondent.

Background

Injury can occur as a result of physical trauma, disease, or psychological distress. In considering an earthquake, injury resulting from physical trauma at the time of the earthquake immediately comes to mind; however, when communities are heavily damaged or destroyed by an earthquake, the incidence of infectious disease may also increase during the post-disaster period. Psychological distress may precede the earthquake, be exacerbated by the earthquake, be caused by the earthquake, or result from individual and social disruption following the earthquake.

To date most studies of injury and earthquakes have depended on " . . . crude estimates based on superficial observations of limited technical and statistical validity" (Noji, 1989, p. 260). While a few post-earthquake household surveys have been conducted (e.g., De Bruycker, Greco, and Lechat, 1985), the data reported in the majority of studies have come from official statistics, newspaper reports, the records of hospitals or disaster relief organizations, or anecdotal reports. As a result, the data obtained probably overrepresent more serious injuries, those that come to the attention of an official or relief worker, and those that present at hospitals or other facilities after record-keeping procedures are instituted. For example, records of patients who sought care on the evening of October 17, 1989,

following the Loma Prieta earthquake are known to be incomplete (Trent, 1990).

Physical Injuries and Earthquakes.

The number of deaths and the number and severity of physical injuries that occur following an earthquake have been hypothesized to differ with the magnitude of the earthquake, proximity to the epicenter, soil conditions, characteristics of buildings and other man-made structures, density and distribution of population in the area, environmental conditions, location and behavior of persons, level of preparedness, time of day, day of the week, season, opportunity for warning, and socioeconomic resources available in the community (e.g., Lechat, 1979; Sapir and Lechat, 1986). If rates of death and injury are used to determine the severity of a disaster, earthquakes are among the most common of the catastrophic disasters (e.g., Mahoney, 1987; Shah, 1983; Sapir and Lechat, 1986), due in part to their unpredictability and widespread impact area. Mahoney (1987) suggested that earthquakes exceeding 6 on the Richter scale usually result in death and injuries if they occur in populated areas. It has been asserted that the ratio of injuries to deaths is between 3 and 4 to 1, with this average ratio varying " . . . within the context of a single catastrophic earthquake along a continuum from many deaths and relatively few injuries close to the epicenter to the opposite at the periphery of the affected area" (Alexander, 1985, p. 57; Mahoney, 1987). Reported research findings, however, suggest that this ratio is either incorrect or overly simplistic. When Alexander (1985) examined the number of deaths and injuries that occurred in 111 earthquakes between 1969 and 1984, he found a ratio of 3:1 in only 17 earthquakes. Other studies reported that the numbers of deaths and injuries varied directly with the number of severely damaged buildings, number of persons trapped, and efficiency, appropriateness and availability of post-earthquake medical services, and inversely with the efficiency of search-and-rescue operations (Sheng, 1987; De Bruycker, Greco, and Lechat, 1985; Ortiz et al., 1986; Noji et al., 1990).

Although crush injuries associated with collapsing buildings are a major concern in earthquakes, lacerations (cuts), contusions (bruises), and broken bones are most frequently reported in the literature. Heads and legs are the body parts most frequently reported injured. In the 7.7-magnitude Philippines earthquake of July 16, 1990, the three most frequently reported injuries were contusions (35%), fractures (14%), and lacerations (12%). "The most common causes of injury were being hit by falling objects (37%), being crushed or pinned by heavy objects (29%), and falling" (MMWR, 1990). Similar patterns were reported by Glass et al. (1977) in Guatemala, Sapir and Lechat (1986) and Noji et al. (1990) in Soviet Armenia, De Bruycker, Greco and Lechat (1985) in Italy, Beinin (1981) in Russia, and Pollander and Rund (1989) in a review article. In a study of residents of 203 houses in the Whittier area that were

damaged in the Whittier Narrows earthquake, Bolin (1989) found that 18 injuries occurred to residents of the households as a result of the earthquake itself, and an additional 26 injuries occurred during cleanup activities or as a result of aftershocks. "Most of the injuries were scrapes and bruises as a result of being knocked down. In one case a fall resulted in a broken hip, the most serious injury reported" (p. 62). In O'Brien and Mileti's (1991) study of Santa Cruz and San Francisco residents following the Loma Prieta earthquake, 5.9% of Santa Cruz residents and 1.4% of San Francisco residents " . . . reported that the quake injured a member of their household. . . ." (p. 11). No details are available on the cause or severity of the injuries experienced, but 3.6% of Santa Cruz respondents and 1.9% of San Francisco respondents reported providing medical assistance to others.

Psychological Injury and Earthquakes.

Natural disasters have the potential to evoke considerable psychological distress because of their life-threatening quality. Since they are undesirable, uncontrollable and, frequently, unanticipated, disasters exemplify the type of acute major life event that is most likely to be psychologically distressing (Thoits, 1983). When compared to other major life events, natural disasters are distinctive in simultaneously affecting large social collectivities rather than isolated individuals. The social readjustment necessitated by disasters, therefore, may generate not only individual disorder, but also regions of concentrated disorder within a society. Moreover, this regional impact may disrupt the social and institutional resources that individuals might otherwise rely upon to cope with major life crises. Yet, compared to other sources of stress, relatively little is known about the mental health consequences of natural disasters in general and earthquakes in particular.

The research literature concerning natural disasters is equivocal with regard to mental health consequences. Some argue that natural disasters cause high and persistent levels of psychological distress, citing the severe floods in Buffalo Creek, West Virginia (e.g., Green et al., 1990). Others conclude that psychological distress following natural disasters is minimal and transient at worst (e.g., Quarantelli, 1985; Tierney, 1986). In general, research utilizing standardized measures of psychological distress demonstrates only modest disaster effects, with considerable inconsistency across studies (e.g., Logue et al., 1979). While some groups show modest increases in obsessive-compulsive behaviors, others exhibit elevated levels of anxiety, depression, or somatization, while still others experience intrusive images and thoughts about the disaster. Most studies report a dose-response relationship between distress and proximity to the disaster or experiences of loss and dislocation. Elevated levels of distress have been reported for as long as five years (e.g., Melick and Logue, 1985-1986). Several considerations may contribute to the diversity of these

findings.

First, the impact of the disaster may depend upon the context within which it occurs, just as the impact of other life events depends, at least in part, upon the social and economic context (Wheaton, 1988). Thus, the lack of a strong overall mental health impact may mask strong effects among certain subgroups of the population defined by proximity to the disaster, the availability of socioeconomic resources, and social support (Kessler et al., 1985). A second consideration with regard to the diversity of disaster findings is variability in previous conceptualizations and operationalizations of psychological disorder. Many investigations have used study-specific measures (e.g., Baum et al., 1987), which raise questions about validity and generalizability of findings.

A third factor contributing to variability in the mental health impact of various natural disasters is potential variability in secondary sources of stress generated by the disaster. While the natural disaster may occur as a discrete life event, the process of adaptation and rebuilding is more appropriately conceptualized as a chronic stressor. In more mundane life situations, recurrent or chronic stressors help to explain the persistence of psychological distress over time (Aneshensel, 1985). Adapting this perspective to earthquakes, we would expect that prolonged psychological distress following an earthquake occurs more as a result of earthquake-related experiences such as relocation rather than because of the event itself. Indeed, the post-World War II origins of disaster research emphasized just such an orientation by focusing on the circumstances under which disaster produces social disorganization in the form of breakdowns in basic societal structures and community infrastructures (e.g., Quarantelli, 1985). While early work assumed that social structures are fragile and easily damaged by disasters of any substantial magnitude, the accumulating research evidence suggests that social organizations are amazingly resilient (Fritz, 1961; Janis, 1951).

Earthquakes are distinctive from many other natural disasters in that a earthquake of substantial size will be followed by multiple substantial aftershocks. The presence of aftershocks, the regular occurrence of minor earthquakes in the same region, the threat of a more devastating earthquake, and the occurrence of massive earthquakes in distal regions may coalesce to create a chronic source of threat. In this regard, it must be noted that the majority of disaster research in the U.S. has concentrated upon floods, hurricanes, and tornadoes, an emphasis apparently due to the frequency and regularity of the occurrence of these events in the Eastern and Midwestern regions rather than to any characteristics of these events that are unique or generalizable. Only three past U.S. earthquakes have received significant investigation (Committee on the Alaska Earthquake, 1969; Tierney, 1985; Bourque et al., 1973), despite the frequency of earthquakes in certain regions and the known threat of a

devastating earthquake to Northern or Southern California, areas of major population size and density. In his study of Whittier residents whose homes were damaged in the Whittier Narrows earthquake, Bolin (1989) found that "Victims with higher levels of loss, fewer resources for recovery, and those with fewer social supports available all appeared to report higher anxiety and depression levels" (p. 135). However, standard multi-item diagnostic measures were not used to assess psychological distress, and findings suggest that basic demographic and pre-impact characteristics of respondents were more important than earthquake-related experiences in predicting psychological distress at the time of the interview.

Current Studies.

The current studies are unique in providing information about the extent to which respondents in two representative samples reported being injured or experiencing psychological distress following the Whittier Narrows and Loma Prieta earthquakes. In this paper we first describe the design of the two studies, the demographic characteristics of the two samples, and respondents' earthquake-related experiences. We then describe characteristics of the injuries reported, the amount of psychological distress reported, and the extent to which injury and psychological distress differed with respondents' proximity to the earthquakes, their demographic characteristics, and their earthquake-related experiences. It must be emphasized that all bivariate analyses reported are preliminary and should not be referenced without permission of the authors.

METHODOLOGY

Telephone interviews were conducted with 690 residents of Los Angeles County following the Whittier Narrows earthquake and 656 residents of five counties in the San Francisco Bay Area following the Loma Prieta earthquakes. Largely identical questionnaires were used to collect the data.

Whittier Narrows Sample.

Between October 1, 1988, and May 1, 1989, 30-minute telephone interviews were conducted by staff at the Institute for Social Science Research at UCLA. Random digit dialing (rdd) was used to obtain a representative sample of Los Angeles County, with intentional oversampling of predesignated high-impact areas (Frankel, 1983; Sudman, 1983). These areas comprised communities in which the Modified Mercalli Intensity isoseismals equalled 7 (Monterey Park, Rosemead, El Monte and South El Monte) or 8 (Whittier). Within contacted residences, all persons over age 18 who resided in the household on the day of the earthquake were enumerated and one resident was randomly selected for interview using the Kish method (Kish, 1965).

A total of 191 adults residing in the high-impact area and 499 adults residing in other areas were interviewed. The

probability that residences with telephones were selected was 9 in 10,000 for the high-impact area and 7 in 10,000 for the rest of the county. Response rates were between 75.2% and 79.9% in the high-impact area and between 41.9% and 56.9% in the rest of the county. In the high-impact area, interviews were conducted an average of 511 days after the earthquake and 9.9% were conducted in Spanish. In the rest of the county, interviews were conducted an average of 504 days after the earthquake and 6.2% were conducted in Spanish.

Loma Prieta Sample.

Between April 29, 1990, and August 1, 1990, 30-minute telephone interviews were conducted. Modified rdd procedures were used to obtain a representative sample of 656 residents of San Francisco, Alameda, Santa Cruz, Santa Clara, and San Mateo Counties. Intentional oversampling was conducted in the two areas where Modified Mercalli Intensities equalled 8 or 9: the northeast edge of the San Francisco peninsula and Oakland, and the Boulder Creek-Santa Cruz-Watsonville area. Within households, respondents were selected as in Los Angeles County.

A total of 83 residents of San Francisco-Oakland, 122 residents of Boulder Creek-Santa Cruz-Watsonville, and 451 residents of the rest of the five-county area were interviewed. The probability that residences with telephones were selected was 5 in 10,000 for San Francisco-Oakland, 31 in 10,000 for Boulder Creek-Watsonville-Santa Cruz, and 5 in 10,000 for the rest of the five-county area. Response rates were between 70.3% and 80.6% in San Francisco-Oakland, between 74.4% and 79.7% in Boulder Creek-Watsonville-Santa Cruz, and between 68.9% and 74.4% in the rest of the five-county area. In San Francisco-Oakland, interviews were conducted an average of 217 days after the earthquake and 4.8% were conducted in Spanish. In Boulder Creek-Watsonville-Santa Cruz, interviews were conducted an average of 223 days after the earthquake and 1.6% were conducted in Spanish, while in the rest of the five-county area, interviews were conducted an average of 226 days after the earthquake and 1.3% were conducted in Spanish.

Data Collected.

The questionnaires used for data collection in both surveys were adapted from questionnaires developed by Turner, Nigg, and Heller Paz (1986) and Bourque and colleagues (1973). Data were collected to assess the type and extent of response actions, including information about damage and injury to self and others, earthquake preparedness both before and after the earthquake, orientation toward and use of media after the earthquake, exposure to earthquake predictions, and contact with officials and agencies after the earthquake. Detailed information about household composition at the time of the earthquake and at the time of the interview, and other demographic information, were collected.

Injuries. In the Whittier Narrows study, information about injuries was solicited with three questions:

15. In this earthquake was anyone you know injured?

A. Who was that?

B. You said (...) was injured in the earthquake. Can you tell me about that? Who exactly was this, and how were they injured?

Pre-coded responses were provided in the questionnaire for questions 15 and 15(A). Following content analysis, data solicited in response to question 15(B) were post-coded to record the number of injured persons described by the respondent, the relationship of each injured person to the respondent, the way the injury occurred, and the nature of the injury. The last three variables were repeated for each injury described. No respondent described more than two injuries, so seven variables were created out of answers to the open-ended question. The codes created allowed for the possibility that the respondent did not know or did not report information for one or more of the variables.

For the Loma Prieta study, the third question was modified to read: "You said (...) was injured in the earthquake. How were (you/she/he) injured? What exactly was the injury?", and a question was added: "How many people in all do you know who were injured?" Answers were again post-coded but, reflecting the greater severity of the Loma Prieta earthquake, codes allowed for as many as six injuries to be described by each respondent, and two additional pieces of information were coded about each injury. If provided, information was recorded about the part of the body that was injured, and coders assessed whether medical care was sought by the injured person.

Psychological Distress. In both surveys, psychological distress at the time of the interview was assessed using the Brief Symptom Inventory (BSI) developed by Derogatis and colleagues (1982, 1983). A single question used by Bourque and colleagues in earlier studies was included in both surveys to assess respondents' overall feelings about the earthquake and their experiences during and after the earthquake.

Following preliminary analysis of the Whittier Narrows survey, it was decided to add a measure of post-traumatic stress disorder (PTSD) to the Loma Prieta questionnaire. Thus, all questions but one from the civilian version of the Mississippi Scale for Combat-Related Posttraumatic Stress Disorder, as it existed at the time of data collection, were added to the Loma Prieta questionnaire (Keane et al., 1987, 1988). The omitted question was replaced because pre-testing suggested that it did not work well in a telephone interview. The Mississippi Scale

was supplemented with five questions developed out of suggestions made by Norris (1989) for the study of PTSD. These questions assessed the extent to which respondents felt their lives were in danger during and after the earthquake, the frequency of intrusive thoughts about the earthquake, and whether respondents had experienced other non-earthquake-related traumas in the year preceding the interview.

PTSD Subscale from the BSI. To allow levels of PTSD to be compared between the two samples, a PTSD subscale was created from the Brief Symptom Inventory using the Mississippi Scale as the criterion for selection of items. Within the Loma Prieta sample, the total score from the Mississippi Scale was regressed on the 53 items of the BSI using step-wise procedures to select the best set of items.[1] In the current analyses, this 9-item scale of post-traumatic stress disorder is the primary measure used to examine psychological distress following the Whittier Narrows and Loma Prieta earthquakes.

FINDINGS

Demographic Characteristics.

Tables 1 and 2 summarize the demographic characteristics of the two samples. Women comprised 57% of the Whittier respondents, 53% of the Los Angeles County respondents, 52.5% of the Santa Cruz respondents, 59% of the San Francisco respondents, and 56% of the five-county respondents (p = N.S. within each sample). Bay Area respondents were, on average, somewhat older than Los Angeles respondents, with the mean age ranging from 43.7 years for Los Angeles County to 46.8 years for San Francisco and Oakland (p = N.S. within each sample).

Self-reported ethnic identification differed both within each sample and across the two samples. Santa Cruz respondents were predominantly white (89%) with an additional 7% identifying themselves as Chicano. San Francisco-Oakland respondents were white (57%), black (22%), Chicano (9%), other Hispanic (6%) or Asian (4.9%), while five-county respondents reported themselves

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[1]. The nine items identified were: feeling tense or keyed up, feelings of worthlessness, trouble concentrating, suddenly scared for no reason, feeling that people will take advantage of you if you let them, numbness or tingling in parts of your body, feeling nervous when you are left alone, feeling hopeless about the future, and having urges to break or smash things. Fifty-one percent of the variance in the total score on the Mississippi Scale within the Loma Prieta sample was explained with this set of 9 items. The Cronbach's alpha for the nine items is 0.76. The combination results from multiple regression, and the internal homogeneity analyses suggest that this set of items is an adequate surrogate indicator of post-traumatic stress disorder.

to be white (69%), Asian (10%), black (7%), other Hispanic (7%) or Chicano (5%). Whittier respondents reported themselves to be white (48%), Chicano (36%), other Hispanic (6%)) and Asian (6%), while Los Angeles County respondents reported themselves to be white (56%), Chicano (16%), black (11%), other Hispanic (7%), or Asian (6%).

Living arrangements differed both within each sample and across the two samples. Fifty percent of Los Angeles County residents were married at the time of the interview, as contrasted with 56% of Whittier respondents, 51% of the five-county respondents, 21% of the San Francisco respondents, and 46% of the Santa Cruz respondents. Household size, number of persons contributing to household income, and number of adults and children dependent on the income likewise varied across the sample strata; San Francisco-Oakland respondents reported the smallest households and Whittier reported the largest households.

Consistent with differences in household composition, San Francisco respondents were least likely to own their own residences (28%) and most likely to live in an apartment or duplex (65%), while Whittier respondents were most likely to own their own residences (69%) and, along with Santa Cruz residents, were least likely to live in an apartment or duplex (19%). Respondents had resided in California for an average of 25 years (San Francisco) to 32 years (Santa Cruz) and in their neighborhoods for an average of 10 years (Santa Cruz) to 14 years (Whittier).

While the number of years of schooling completed did not differ within samples and was not appreciably different across samples, the percentage reporting a college degree varied from 13.1% in Whittier to 60.6% in the five-county area. Mean socioeconomic status[2] scores and the proportion of households with incomes over $40,000 tended to reflect differences in education, but trends in median household income were more similar to differences across the samples in household size than to differences in education. When per capita income was computed and adjustments for inflation applied, per capita income within each household was remarkably similar across the five sample strata: $13,332 for Whittier, $14,799 for Los Angeles County, $15,000 for the five-county area, $16,208 for San Francisco-Oakland, and $15,625 for Santa Cruz (Hoffman, 1991, p. 115).

Religious affiliation across the two samples reflected differences in ethnicity and living arrangements. Where 54% of the Whittier respondents reported themselves to be Catholic, no more than 31% of any other strata did. Thirty-one percent of respondents in both San Francisco and Santa Cruz reported having

[2]. Occupations were coded using the Alphabetical Index of Industries and Occupations from the 1980 U.S. Census. Socio-economic index scores were then assigned to each occupation as derived by Stevens and Cho (1985) from the income and educational attributes of the total, rather than the male, 1980 labor force.

no religious affiliation, while no more than 20% of the other three strata did.

Experiences in the Earthquake.

Consistent with the magnitude of the two earthquakes and how sample strata were defined, the mean Modified Mercalli Intensity (MMI) for the location where the respondent resided was highest in San Francisco-Oakland at 8.3 and lowest in Los Angeles County at 6.2 (see Tables 3 and 4). In the Loma Prieta study, we asked respondents which community they were in at the time of the earthquake. This allowed us to calculate the estimated MMI for that location. The average MMI dropped for all three groups, primarily because persons who were not at home at the time of the earthquake were in less vulnerable buildings and geographic locations.

It has been hypothesized that the response to a disaster varies with prior experience in disasters. In the case of earthquakes, it is thought that as prior experience increases, knowledge of what to do during and immediately after an earthquake also increases, while risk of serious injury and earthquake-induced psychological distress decreases. It is interesting, therefore, to note the reported differences that existed across these samples in response to the question: "Prior to the (...) earthquake, how many times had you experienced an earthquake?" Residents of the five-county area reported experiencing almost twice as many prior earthquakes as did residents of Los Angeles County or San Francisco-Oakland, while residents of Santa Cruz reported almost half again as many.

Other data in Tables 3 and 4 were consistent with expectations. Respondents in the Bay Area, regardless of sample strata, reported more damage, were more likely to have evacuated or to have had others who evacuated stay with them, to know persons who were injured, and to know families who had suffered substantial losses. Over half of the Santa Cruz respondents (66%) reported damage, 22% reported knowing someone who was injured, and 75% reported knowing someone who experienced substantial losses. In contrast, only 12% of Los Angeles County respondents reported any damage, 4% reported knowing someone who was injured, and 2% reported knowing families who had suffered substantial losses.

Injuries: Whittier Narrows.

Following the Whittier Narrows earthquake, 31 respondents reported 33 injuries to themselves or others (Table 5). While the overall propensity to report injuries did not differ significantly by impact strata, the identity of the person injured did tend to differ. Five of the eight injuries reported by respondents to themselves occurred in the high-impact area. This represents a rate of 26 injuries for every 1,000 people in the high-impact area and a rate of 6 per 1,000 in the rest of the county.

Women, Chicanos or other Hispanics, and respondents with

less education and lower incomes were somewhat more likely to report injuries to themselves or others. Of 85 persons who reported damage to their homes, 8 (12%) reported injuries to themselves or another member of their household. Of the 8 injuries reported to respondents themselves, 7 were reported by women, 5 occurred to whites, and 5 occurred to respondents who reported damage to their homes. These patterns in ethnic and damage distributions largely reflected differences that existed between the two strata in demographic characteristics and the association that existed between reported damage/injuries and proximity to the epicenter.

Injuries occurred primarily because objects fell from shelves or walls, because parts of buildings fell, because of how the injured person behaved during or immediately after the earthquake, or because the person fell during the earthquake (see Table 6). Nine injuries occurred because objects such as pictures fell, and six because of damage to buildings. Two persons were injured as they tried to take cover, and four were injured because the earthquake caused them to fall. Four persons were injured because they ran during the earthquake or jumped out of a window immediately following the earthquake.

Although one respondent knew the young woman who was killed at California State University, Los Angeles, the most frequently reported injuries were cuts, bruises and minor head injuries (see Table 7). Two heart attacks were reported, one person reported panicking at the time of the earthquake, and one person reported post-earthquake emotional problems. In general, the severity of the reported injury varied with the injured person's detachment from the respondent. Injuries to the respondent or to the respondent's household members or relatives tended to be minor, while those that occurred to co-workers, friends, and acquaintances tended to be more severe. No information was collected on use of medical care for the injury, but the nature of the injuries reported generally suggested that those occurring to respondents, their relatives, or household members did not require medical care.

Injuries: Loma Prieta.

Injuries to Respondents. Table 8 shows that the Loma Prieta earthquake resulted in significantly more injuries being reported, and that the propensity to report injuries, the number of injuries reported, and the identity of the injured person differed with sample strata. Eighty respondents reported a total of 121 injuries. Whereas less than 5% of respondents in the Whittier Narrows study reported injuries to self or others, 12% of Loma Prieta respondents reported injuries to self or others. Ten percent of the respondents in the five-county area and in San Francisco-Oakland reported injuries, with 5% of the reported injuries in the five-county area occurring to respondents themselves and an additional 8% occurring to household members or relatives. In contrast, 22% of respondents in Santa Cruz reported injuries, with 9% of the injuries reported occurring to

respondents themselves and an additional 23% occurring to household members or relatives. When rates per 1,000 were calculated, residents of the five-county area were slightly more likely to report having been injured than were residents of Los Angeles County (6.7 per 1,000 vs. 5.2 per 1,000), and residents of Santa Cruz were more likely to report having been injured than residents of Whittier (32.8 per 1,000 vs. 26 per 1,000). Interestingly enough, none of the respondents in the San Francisco-Oakland strata reported injuries to themselves.

The major difference in injuries reported to respondents occurred with proximity to the earthquake's epicenter. Persons who lived in Santa Cruz or Whittier and the immediately surrounding area were more likely to report having been injured. At the same time, differences in reported injuries to the respondent across sample strata also reflected differences in the respondent's location at the time of the earthquake. Five of the seven respondents injured in the Loma Prieta earthquake were in a private home at the time of the earthquake; the remaining two were in public places. Santa Cruz respondents were most likely to be at their own homes when the earthquake struck (61%), followed by residents of the five-county area (49%) and San Francisco-Oakland (42%). Thus, the differential propensity of Santa Cruz residents to be injured appears to reflect both their proximity to the epicenter and their greater tendency to have been inside a private home at the time of the earthquake.

Injury as the Unit of Analysis. Unlike Whittier Narrows, where only two respondents reported as many as two injuries, Loma Prieta respondents reported and described injuries of as many as six injured persons. To examine associations between various characteristics of injuries and the respondents who reported them, the reported injury rather than the respondent was made the unit of analysis. When analyses involved both characteristics of respondents and characteristics of the injury, this strategy resulted in characteristics of those who did not report injuries being somewhat underestimated relative to those who did report injuries. When only characteristics of the injuries were examined within analyses, estimates of associations were assumed to be valid to the extent that we assumed that reports of injuries to self and others differed with characteristics of earthquake experiences and not with other characteristics of respondents. To the extent that this assumption was incorrect associations were incorrect.

Reported Injuries by Demographic Characteristics of Respondents. Reports of injuries did not differ with the sex or education of the respondent, but did differ with the respondent's ethnicity, marital status, age, income, and length of residence in California. Of the seven respondents who reported injuries to themselves, all were white and five were married. They were significantly older than other respondents (57 years) and, consistent with their older age, had higher incomes and had lived

in California for more years (mean = 36 years). Divorced or separated blacks and Chicanos were most likely to report injuries to household members, relatives, or co-workers, while Asians and other Hispanics were least likely to report any injuries. Those who reported injuries to household members were also older with higher incomes, while those who reported injuries to co-workers were younger (mean = 36 years) with lower incomes.

The extent to which reports of injuries differed with demographic characteristics of respondents largely reflected existent differences in demographic characteristics across the three sample strata, rather than differences in propensity to be injured. Since residents of San Francisco and Oakland were less likely to be white, married, or to live with others, and also less likely to report themselves or household members injured, it was not surprising to find that reports of who was injured varied with ethnicity and living arrangements. More intriguing was the differential rate of injury with age. Mean age did not differ by sample strata; thus, our data suggested that older respondents may indeed be more vulnerable to injury in the event of an earthquake.

How Injuries Occurred. In contrast to the Whittier Narrows earthquake, an injury in the Loma Prieta earthquake was less likely to be reported as caused by the injured person's behavior or by objects or parts of buildings falling, and more likely to be reported as caused because of glass, earthquake-induced falls, or the collapse of buildings or freeways (see Table 9). The cause of a substantial number of injuries was unreported or unknown by the respondent. Of the seven injuries to respondents, glass caused one, the respondent's own behavior caused one, an earthquake-induced fall caused three, and unreported factors caused two (Table 10).

Severity of the Injury. The injuries reported generally were minor (cuts, bruises) or severe (paralysis, death) (see Table 11), with the severity of the injury tending to vary with the identity of the injured person. When the respondent or another household member or relative was reported injured, the majority of injuries were minor, but the severity of the injury increased as distance from the respondent increased (Table 12). Twenty percent of those injuries occurring to friends or acquaintances and 14% of those occurring to co-workers were reported to have resulted in death. It is interesting to note that when respondents were asked about injuries to themselves and others, no respondent reported psychological distress or "injury" to him/herself following the earthquake; some respondents reported, however, that household members, relatives or friends experienced psychological distress after the earthquake that they (respondents) attributed to the earthquake.

The severity of an injury also varied with its cause (see Table 13). When an injury occurred because of objects falling, broken glass, the individual's own behavior, or an earthquake-

induced fall, it generally resulted in cuts and bruises. When structures collapsed or parts of buildings fell, injuries were more severe and often resulted in death. Consistent with other research reports, the arm, leg, and the head were the body parts most frequently reported injured.

Psychological Distress.

Psychological distress at the time of the interview was measured in two ways in the Whittier Narrows study and in four ways in the Loma Prieta study. In this section we describe levels of psychological distress across the sample strata of the two studies as measured using two of the available measures of psychological distress, examine the association between the two measures, and preliminarily examine the extent to which psychological distress varied with demographic characteristics of respondents and their earthquake-related experiences.

Level of Fear. Both studies included a single question which asked, "Thinking back to your feelings and experiences during and immediately after the . . . earthquake, which of the following best describes your overall feelings?" Table 14 shows the distribution of answers by strata within each sample. A clear dose-response pattern is observed. Persons who were closer to the epicenter and who experienced a more severe earthquake were more likely to say they were frightened and upset by the experience. Over 40% of Santa Cruz respondents stated that they were very frightened and upset by the earthquake. Comparable rates dropped to 36.1% for San Francisco-Oakland, 32.3% for Whittier, 28.2% for the five-county area, and 23.5% for Los Angeles County respondents.

Post-Traumatic Stress Disorder. While no specific measures of post-traumatic stress disorder (PTSD) were included in the Whittier Narrows questionnaire, the Mississippi Scale for Post-Traumatic Stress Disorder was added to the Loma Prieta questionnaire. Using the Mississippi Scale as a criterion validator, a set of nine items in the BSI was identified that can be assumed with some confidence to represent PTSD. The possible range on the created scale was 0-4. Table 15 shows that mean levels of PTSD were low in all strata of both samples. In the Whittier Narrows sample, the score of Whittier respondents was lower than that of Los Angeles County respondents. In the Loma Prieta sample, PTSD was slightly higher among residents of Santa Cruz-Watsonville-Boulder Creek but again lower for residents of San Francisco-Oakland. Similar magnitudes and differences across sample strata were observed when scores on the full BSI or its traditional subscales were examined.

Level of Fear and PTSD. When the relationship between PTSD and the reported level of fear following the earthquake is examined, a mild association is observed (Table 16). Persons who reported being very upset were somewhat more likely to report

symptoms of PTSD, particularly following the Loma Prieta earthquake. Levels of PTSD are not substantial, however, even for this group.

PTSD and Demographic Characteristics. Since reported levels of psychological distress in population-based studies consistently have been found to differ with demographic characteristics, scores on the BSI PTSD measure were examined in relation to demographic characteristics of the two samples (Table 17). In the Whittier Narrows sample, PTSD differed with respondents' gender, ethnicity, marital status, age, education and income. Symptoms of PTSD were higher for women, other Hispanics, those who rent rather than own their homes, those with less education and income, younger persons, and those who are currently unmarried. Distress did not differ with number of children in the household or with length of residence in California.

In the Loma Prieta sample, psychological distress differed with gender, age, income, home ownership, and marital status of respondents, but not with their ethnicity, education, number of children in the household, length of residence in California, or religious affiliation. Younger women with lower incomes who were renting, and who were either never married, divorced, or separated reported higher levels of psychological distress when measured using either the BSI or the PTSD measure.

Whittier Narrows: PTSD and Earthquake Experiences. Even though rates of psychological distress did not differ by sample strata in either study, it is possible that the sample strata created were not sufficiently sensitive to earthquake-related experiences. To examine this possibility, reports of PTSD symptomatology were examined in relation to respondents' reports of whether or not they experienced damage, evacuated, knew persons who were injured, or knew others who suffered severe loss as a result of the earthquake (see Table 18). Following the Whittier Narrows earthquake, we see that PTSD symptoms were elevated for those who reported damage or dislocation following the earthquake, but differences reached significance only for those who reported evacuating after the Whittier Narrows earthquake. Since this was the only indicator for which preliminary analyses suggested a clear dose-response relationship between earthquake proximity, experiences, or loss and psychological distress, we examined both the demographic and earthquake-related experiences of the evacuees in more detail.

Evacuation Following the Whittier Narrows Earthquake. Evacuees were significantly more likely to be Chicano or other Hispanic (N = 13), to have been interviewed in Spanish, and to have more of their own children living in the household. They were more likely but not significantly more likely to be female and less likely to have college degrees. Evacuees were comparable to non-evacuees in age and length of residence in California.

Evacuees were not exclusively located in the high-impact area, and most evacuees were out of their homes for only a few hours or days. In the high-impact area, 9 respondents or 4.3% reported evacuating, and they stayed out of their homes an average of 4.3 days. In the rest of the county, 11 respondents or 2.2% evacuated and stayed away an average of 1.7 days. This contrasts sharply with other indicators of earthquake-induced dislocation such as reports of damage and knowledge of other families who had experienced substantial loss, both of which differed significantly with impact strata. Evacuees were significantly more likely to report injuries to self or others and to report knowing families who suffered substantial losses. They were more likely to have been at home at the time of the earthquake and more likely to report damage, but the differences were not significant. Furthermore, the average dollar amount of damage reported by evacuees ($219) was less than that reported by the rest of the sample ($430) so it is unlikely that evacuees experienced severe amounts of damage. Only one person among the 20 who evacuated cited structural damage as a main reason for leaving. The major reasons given were subjective: respondents reported that they were "too upset to stay" (75%), were concerned about the occurrence of another earthquake or large aftershock (25%), or were afraid of further damage.

Interestingly enough, although evacuees had lived in California as long as non-evacuees, they reported having experienced fewer prior earthquakes. Finally, evacuees were more likely than non-evacuees to report having been very upset by the earthquake and its aftershocks.

Loma Prieta: PTSD and Earthquake Experiences. Similar relationships between earthquake experiences and psychological distress were found following the Loma Prieta earthquake (see Table 18); but, where differences were insignificant following Whittier Narrows, all differences were significant following Loma Prieta. Persons who reported damage, evacuation, housing others, knowing injured, or knowing others who experienced substantial losses reported significantly higher levels of PTSD. This difference in levels of significance results from two interrelated factors. First, substantially more people reported being affected by the Loma Prieta earthquake, but this, in turn, largely results from the greater magnitude of the Loma Prieta earthquake. For example, whereas 151 persons reported damage following the Whittier earthquake, 254 persons reported damage following the Loma Prieta earthquake. Furthermore, the average amount of damage experienced and the proportion of persons reporting substantial damage similarly was greater following the Loma Prieta quake.

Evacuation and PTSD Following Loma Prieta. As in the Whittier Narrows sample, persons who evacuated reported greater levels of PTSD symptomatology, but while only 20 persons

evacuated following the Whittier quake, 145 reported evacuating following the Loma Prieta earthquake. In contrast to Whittier, 82 of those people left because of structural damage, lack of utilities or some other threat to public safety. However, as in Whittier, a substantial group (N = 63) left their homes primarily because they were upset. This latter group tended to stay out of their homes only overnight. PTSD symptomatology varies not only with evacuation status but also with the reasons given for evacuation. Persons who said that they evacuated both because of structural damage or lack of utilities and because they were upset reported the highest level of PTSD symptomatology (.57). Those who said they evacuated only because they were upset are next highest, but significantly lower that the first group (.33), followed by those who did not evacuate (.26), and those who cited only structural damage or loss of utilities as the reason for their evacuation (.20).

Two-Way Analysis of Variance. In order to better understand how people' experiences during the earthquake interact with other characteristics to predict psychological distress, we conducted a series of two-way analyses of variance. Tables 19-22 present the findings from some of these analyses.

Recall that women in both studies reported higher levels of distress at the time of the interview, and that for persons who experienced the Loma Prieta earthquake, psychological distress was higher among those whose homes or property were damaged. Table 19 shows how these two variables combine to predict distress in the two samples. Women in both samples were more likely to report being distressed regardless of whether or not they reported damage. Following the Loma Prieta earthquake, however, people whose property was damaged were also more likely to be distressed; this was not true following the Whittier earthquake (see Table 19).

In contrast, when we examined how the sex of the respondent interacted with whether or not a person evacuated, we see that both the sex of the respondent and their evacuation status independently predicted psychological distress following both earthquakes (see Table 20).

Similarly, renters showed higher levels of distress in both studies, but following the Loma Prieta earthquake being a renter and experiencing damage to one's home or personal property resulted in substantially higher distress than these factors did following the Whittier Narrows earthquake (Table 21). The relationship between evacuation and whether a respondent owned or rented his home showed a different relationship. Following the Whittier earthquake, persons who decided to evacuate and who owned their homes were more psychologically distressed than those who rented, but following the Loma Prieta earthquake, renters who evacuated were more likely to be distressed (Table 22).

Finally, we looked at how psychological distress following the two earthquakes related to age and evacuation and ethnicity and evacuation (no tables). Following the Whittier earthquake,

we found that younger persons were more distressed and that those who evacuated were more distressed, regardless of age. Similar relationships are observed following the Loma Prieta earthquake. When the relationship between ethnicity and evacuation is examined, we found that following the Whittier earthquake, the decision to evacuate is related to psychological distress while ethnicity is not. In contrast, following the Loma Prieta earthquake, ethnicity and decisions to evacuate interact in predicting psychological distress. In other words, the decision to evacuate is associated with having been more psychologically distressed at the time of the interview. This relationship exists for everyone in the sample but it is most pronounced for persons who identified themselves as Chicano or of other Hispanic origin.

SUMMARY

We would summarize our preliminary findings as follows.

Injuries.

First, the number of injuries reported by respondents to themselves was comparable in number, severity, and cause in the two samples, and consistent with data reported by Bolin (1989) and O'Brien and Mileti (1991). In spite of Loma Prieta's greater severity, respondents were no more likely to report being injured than were Whittier respondents, nor were their injuries more severe. There is some evidence, however, of a dose-response pattern in the injuries experienced. Persons who were closer to the epicenter were more likely to report being injured, and the probability of injury was higher in Santa Cruz-Watsonville-Boulder Creek and Whittier than in other areas. A dose-response pattern is also evident in respondents' reports of injuries to others. Loma Prieta respondents reported knowing of many more injuries and of more severe injuries than did Whittier respondents.

Although the number of injuries reported to respondents was small, our data suggests that some groups are at greater risk of injury, particularly in larger earthquakes. Injuries most often occurred to persons who were indoors at the time of the earthquake, and some injuries resulted from respondents' attempts to take cover or leave the building. In the Loma Prieta sample, older persons disproportionately reported being physically injured as a result of the earthquake, but reports of physical injury by older persons did not necessarily correlate with elevated psychological distress following the earthquake.

Psychological Distress.

The level and distribution of psychological distress in these two populations is comparable to what we would find in other groups in the United States. Few respondents, if any, exhibited clinical evidence of post-traumatic stress disorder at the time of the interview. In general, those who are disenfranchised show higher levels of distress than do the

enfranchised. Younger persons, women, minority groups, and renters are somewhat more likely to be distressed than others. Persons who were closer to the earthquake's epicenter and who experienced a larger earthquake stated that they were more upset by the experience, but their "upsetness" does not necessarily express itself as diagnosable psychological disorder at the time of the interview. On the other hand, the tendency to experience psychological distress and the magnitude of the distress experienced following an earthquake do seem to increase with the magnitude of the earthquake, the extent of damage experienced, injury to self or others, housing others following the earthquake, evacuation, and knowing others who experienced substantial losses.

The decision to evacuate and the reason for evacuation may be an important signal in targeting those at risk of psychological distress. These data suggest that there may be two different groups of evacuees. The first group evacuates because of earthquake-induced events that make it difficult for them to stay in their homes: structural damage, absence of utilities, and the advice of officials. The second group evacuates because of (possibly pre-existing) psychological distress. In these studies, both groups show elevated but not excessively high levels of psychological distress which may be either caused or exacerbated by the earthquake.

Possibly of particular interest in this data is the extent to which renters appear to be more vulnerable to distress following an earthquake of substantial size such as the Loma Prieta earthquake but less vulnerable to distress following a less substantial earthquake. This group appears to be particularly vulnerable when they live in areas such as Santa Cruz where the rental population, at least in this sample, is a very small proportion of the overall population. We have no ready explanation for these differences at this time. One possible explanation certainly is that renters in the Loma Prieta sample differ in important but as yet undetermined ways from those in the Whittier sample. Another possibility is that there is some "threshold" at which renters become vulnerable to the effects of an earthquake, or perceive themselves to be vulnerable. Even though the renters in our samples were not necessarily forced to evacuate because of the earthquake, destruction of rental housing in their communities may have increased their feelings of vulnerability to dislocation. Finally, home ownership is correlated with other, traditional indicators of socioeconomic status. Thus, to the extent that less advantaged persons in both samples show higher levels of distress, home ownership may simply be a surrogate for socioeconomic status and life style. We hope that future, more sophisticated multivariate analyses will help elucidate these relationships.