The Loma Prieta, California, Earthquake of October 17, 1989—Public Response

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SOCIETAL RESPONSE
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CONTENTS

PUBLIC RESPONSE

INTRODUCTION

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INTRODUCTION

Major earthquakes provide seismologists and engineers an opportunity to examine the performance of the Earth and the man-made structures in response to the forces of the quake. So, too, do they provide social scientists an opportunity to delve into human responses evoked by the ground shaking and its physical consequences. The findings from such research can serve to guide the development and application of programs and practices designed to reduce death, injury, property losses, and social disruption in subsequent earthquakes. This chapter contains findings from studies focused mainly on public response to the Loma Prieta earthquake; that is, on the behavior and perceptions of the general population rather than on the activities of specific organizations or on the impact on procedures or policies. A major feature of several of these studies is that the information was collected from the population throughout the Bay area, not just from persons in the most badly damaged communities or who had suffered the greatest losses. This wide range serves to provide comparisons of behavior for those most directly affected by the earthquake with others who were less directly affected by it but still had to consider it very "close to home."

Three of the six studies reported in this chapter involved the collection of data from random samples of the general population in areas affected by the earthquake (Bourque and others; O'Brien and Mileti; Mileti and O'Brien). A fourth examined the experiences of a sample of persons with major mobility limitations (Rahimi). One study involved the comparison of pre-earthquake and post-earthquake thinking about preparedness for samples of college students in conjunction with the Loma Prieta earthquake and other recent earthquakes (Mulilis and Duval). The sixth study provides a description of the emergency housing needs, initial solutions, and responses to the solutions in one of the hardest hit counties, Santa Cruz (Bolin and Stanford).

All of these studies serve to verify the central finding of social scientists across several decades of disaster studies: during and after an earthquake, most individuals and families will engage in rational and directed behavior. That is, they will try to figure out what is happening or has happened, what it means to them, and what their next action will be. It has been the objective of earthquake education efforts to promote behavior that will also be adaptive to the conditions, as changed by the earthquake. Several of the studies provided evidence of adaptive behavior in the populations studied, such as individuals and families engaging in protective actions during the shaking (Bourque and others; Rahimi), creating or finding alternative shelter until they can determine what is safe (Bourque and others; Bolin and Stanford), becoming more interested in preparedness measures (Mulilis and Duval), helping others who have experienced damage (O'Brien and Mileti), or attending to warnings about potential aftershocks (Mileti and O'Brien).

At the same time, the way in which the individual personally experienced the earthquake was a factor in the likelihood that the most adaptive response would be made. Examples of this are findings such as the following: people who were not particularly frightened by the earthquake were less likely to seek further information about what was going on (Bourque and others); those disabled persons who did not perceive themselves as directly vulnerable to the shaking were less likely to actively engage in protective behavior (Rahimi); persons who did not experience damage either to their own home or immediate neighborhood were less likely to provide assistance to earthquake victims elsewhere (O'Brien and Mileti); persons without direct experience with damage were less likely to take seriously the warnings provided about potential damaging aftershocks (Mileti and O'Brien); and views on preparedness among college students were not likely to change after an earthquake if the earthquake was not perceived as particularly damaging (Mulilis and Duval). Since it is imperative that people who live in hazardous regions understand the nature of the earthquake threat, even before experiencing an earthquake, these findings reinforce the belief that it is important to engage in programs to make the built environment resistant to earthquake damage, and to educate the population about what they can do to protect themselves.

Two studies also touched on issues surrounding evacuation behavior following earthquakes. While many of our relief policies are designed to serve persons who have left their dwelling after the earthquake because it is too

damaged to occupy, two of the studies included evidence that post-earthquake evacuation is more complex than that (Bourque and others; Bolin and Stanford). There will be persons who leave their homes because of damage to property or utilities. There also will be those who experience comparable levels of damage to their home but who choose to remain in or by their homes, as well as those who evacuate despite having experienced no overt property damage sufficient to cause evacuation but are experiencing personal stress about the event. This information is important for the design of post-earthquake emergency assistance and relief efforts. So too are the insights provided in the documentation of the sources of the conflict that arose in Santa Cruz County communities related to housing alternatives where populations were ethnically or socially diverse (Bolin and Stanford).

THE LOMA PRIETA, CALIFORNIA, EARTHQUAKE OF OCTOBER 17, 1989:
SOCIETAL RESPONSE

PUBLIC RESPONSE

HUMAN BEHAVIOR DURING AND IMMEDIATELY AFTER THE EARTHQUAKE

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CONTENTS

ABSTRACT

We used random digit dialing procedures to select a sample of 83 residents of San Francisco and Oakland, 122 residents of Boulder Creek, Santa Cruz, and Watsonville, and 451 residents of the remaining areas of San Francisco, Alameda, Santa Cruz, Santa Clara, and San Mateo Counties. They were interviewed an average of 224 days after the earthquake. Analyses examine where respondents were, who they were with, and what they did at the time of the earthquake; their exposure to radio and television during and immediately after the earthquake; the effect of loss of utilities and damage to homes and personal property; and evacuation behavior after the earthquake.

INTRODUCTION

Although the work of geologists, engineers, and seismologists has expanded our knowledge of earthquakes substantially since the San Fernando earthquake of 1971, earthquakes remain the least predictable of the natural disasters. Moreover, systematic documentation of human behavior during and immediately after earthquakes remains an understudied area. The few existing studies are primarily anecdotal, observational reports by persons who entered the affected area to provide services after the earthquake. Such reports usually focus on self-identified victims who presented themselves to a central location for assistance or depend on observations made by a researcher or service provider within the disaster area. In other cases the collection of data on human experience and behavior was incidental, as part of a different study objective (for example, Bolin and Bolton, 1986). Limited exceptions include studies by Bourque and others (1973) after the 1971 San Fernando earthquake, Tierney (1985) after the 1982 Coalinga earthquake, Mileti and others (1990; unpub. data) after the prediction at Parkfield, California, and the 1989 Loma

Prieta earthquake, and Goltz and others (1992) after the 1987 Whittier Narrows earthquake.

In spite of the limited systematic literature available, policymakers and practitioners[1] often are formally mandated and informally pressured to develop programs that will reduce death, injury, and losses to buildings, businesses, information systems, and social institutions such as schools, hospitals, and lifelines. Many of these policies and procedures, by necessity, have been developed in the absence of relevant information. For example, mass media have often been considered a powerful source of disseminating information both before and after a disaster, yet remarkably little information is available about whether and when people use media for disaster-related information. Procedures have been developed which, when followed, are thought to reduce risk of injury and property damage, but few studies have evaluated the extent to which persons know about or follow such recommendations or the effectiveness of the recommended procedures in meeting objectives. Similarly, numerous groups have invested significant time and money to develop an extended emergency infrastructure to assist persons who are displaced at the time of a disaster. Again, however, these programs have been developed in the absence of any systematic information about who evacuates, why they evacuate, where they go, or the length of time they remain away from their homes.

Studies such as this provide information to evaluate the success of some of the existent programs and policies, while simultaneously suggesting fruitful areas for future extension, reduction, or change. This report systematically examines where people were, who they were with, what they did, and what happened to them as a result of the Loma Prieta earthquake. We were particularly interested in examining what people did during the earthquake, their use of broadcast media during and immediately following the earthquake, and the reasons given for evacuating their homes after the earthquake. Following a brief overview of relevant literature, we describe the methodology of the study, present findings pertinent to the questions under examination, and discuss some implications for policy and practice.

[1]For our purposes, practitioners include all those individuals and groups who are involved in the delivery of services before, during, and after a disaster. Some of these groups, such as the staff of the Bay Area and Southern California Earthquake Preparedness Projects and the Red Cross, identify themselves as specialists in disaster relief on a continuous basis. Others, such as police, firefighters, and medical personnel, receive special training in disaster relief and emergency response activities as a result of the jobs they hold and consciously identify themselves as emergency response practitioners under certain circumstances. Others, such as school teachers and building inspectors, receive little direct training in emergency response and may identify with this group of practitionsers only after a disaster occurs.

PAST STUDIES

Although some studies acknowledge the importance of describing human behavior during and immediately after disasters, few systematically describe this behavior; nor has this behavior been examined within the social and physical context in which it occurs (Quarantelli, 1988; Goltz and others, 1992).

RESPONSE BEHAVIOR

It is reasonable to assume that human response options at the time of an earthquake (staying in place, seeking protection, going to others, and so forth) varies with the person's physical situation and proximity to the earthquake's epicenter and that selection of a response may be influenced by others who are present at the time. Several studies support this assumption.

In studying behavior during Kansas tornados, the National Opinion Research Center found that almost all preevent, event, and post-event activities were centered on helping people rather than preserving property (Quarantelli, 1988). How adults reacted was particularly influenced by whether they were with other adults, children, or were alone and was a major factor in adaptive, protective responses. Males tended to assume active leadership roles when they were the only males present, and females tended to assume leadership roles in the presence of children. Male household heads with dependent children, in particular, tended to display the most well-suited and sheltering behavior toward self and others. Overall, response behavior was characterized as controlled and adaptive—frenzied escape, hysteria, and emotional paralysis were extremely rare, if not entirely absent.

Similar conclusions were reached by Goltz and others (1992), who analyzed the behavior of Southern California residents after the 1987 Whittier Narrows earthquake. Taking cover in a doorway, hall, or under furniture during the earthquake was the modal response for those either at home (43 percent) or at work (40 percent), and pulling to the side of the road and stopping was the modal response for those who were driving (46 percent). Of those at home or at work, 20 percent reported remaining in place, whereas 18 percent of those at work and only 9 percent of those at home recalled going outside. Nearly half of those who went outside reported exiting by running. For those at home, protective behavior increased with increased fear and in the presence of children, but not in the presence of other adults. Women sought protection more frequently than men. For those at work, taking cover was associated with higher expressed fear, being white and female, and being with others. Neither gender nor the presence of others was related to responses while driving, and there were too few respondents who were driving to

assess any relationships with other salient demographic factors.

MASS MEDIA

Literature describing the relationship between the mass media (radio, television, and newspapers) and disaster-response behavior has focused on the media's role in pre-event risk perception and preparation as well as their role in disseminating post-event information and describing post-event needs. The mass media seem to intentionally underemphasize the potential threat of predicted or potential disasters, supposedly to protect people from their propensity for panic and maladaptive behavior (Goltz, 1989). Even when increases in perceived risk from an impending disaster are achieved as a result of a mass media campaign, the result is not necessarily a uniform or consistent increase in disaster preparedness (Mileti and Nigg, 1984; Hirose, 1986). Evaluations of several mass communication campaigns have reported that the translation of a mass media message into individual attitude and behavior change is largely dependent on its passage through interpersonal communication networks (Turner and Heller Paz, 1986; Ball-Rokeach and Cantor, 1986). Although largely ignored by disaster researchers and planners, these interpersonal networks deserve further examination.

The media's somewhat paternalistic attempt to "protect" the public from disaster warnings is noticeably juxtaposed against the tone of post-disaster reporting. At this stage, the mass media have been accused of sensationalizing deaths and injuries and overestimating the extent of property damage (Mileti and Nigg, 1984; Hiroi and others, 1985; Palacios and others, 1986). It has also been suggested that the mass media are partially responsible for feeding the myth that disasters inevitably and naturally result in panic behavior as well as increases in criminal behaviors such as looting (Hiroi and others, 1985; Mileti and Nigg, 1984). While other research studies and numerous review articles have stated repeatedly that people rarely panic in response to a disaster (Wenger and others, 1975; Mileti and Nigg, 1984; Goltz, 1989), the idea that panic is common continues to be perpetuated—often by the mass media.

To fully examine the media issues outlined here, disaster researchers need to examine the characteristics of individuals who do and do not use the media before, during, and after a disaster. Few sophisticated studies exist which examine the relationship between the mass media and the community in the context of disasters. An exception is the study of media use after the 1980 eruption of Mount St. Helens (Hirschburg and others, 1986). As predicted by media dependency theory (Ball-Rokeach and Cantor, 1986), media use did not differ with age and gender, because of respondents' common need for information regarding the disaster.

UTILITIES

With some exceptions, the disaster literature has not addressed the effects of utility damage and loss on a community. Recent contributions by Nigg (1990) and Tierney (1991) highlight the importance of functioning utilities or "lifelines" to a community's ability to respond and recover from a disaster. Utility damage most affected gas, sewer, and water systems following the 1983 Coalinga earthquake (Tierney, 1985), the operations of which may significantly impact the health and safety of a community's residents (Nigg, 1990). Whether utilities continue to function affects a person's ability to prepare meals, drink uncontaminated water, keep warm, wash utensils and clothes, bathe, receive messages via electronic media, or communicate with others. Inability to perform these basic activities often motivates people to evacuate their homes after a disaster (Bolin and Stanford, 1991).

Nigg (1990) and Tierney's (1991) case studies of disaster-struck communities illuminate the advantages and disadvantages of functionally interconnected utility and lifeline failures. Among the drawbacks, for example, is that power failure often impacts the functioning of water, sewage, and communication systems. On the other hand, organizational utility interdependence was found to facilitate the recoveries of gas and electricity after the Loma Prieta earthquake (Tierney, 1991). However, Tierney also noted that such centralization of control can be a detriment if the disaster severely affects the control center and its internal recovery efforts. The minimization of post-disaster loss of utilities has been attributed to the coordination of disaster preparedness efforts between a community and its regional utility companies (Tierney, 1991).

DAMAGE

Reported post-disaster damage estimates are usually those of officials rather than of individual homeowners (Drabek, 1986); an exception to this trend is the national household survey conducted by Rossi and others (1983). Rossi and his colleagues surveyed victims of natural disasters which occurred between 1970 and 1980. The national estimate of the total annual household costs incurred as a result of earthquakes was $400,000,000; the largest percentage of this amount was due to losses of real and personal property. Three-quarters of the earthquake events experienced resulted in structural damage to the respondents' homes. The sociodemographic characteristics of the respondent and other household characteristics were not associated with the estimated cost of damage; the extent of regional damage was significantly associated with the dollars needed for household damage repair.

Damage to homes following an earthquake can be related to variables such as the type of structure and construction

of the home, the type of soil supporting the home, the home's proximity to other damaged structures, and the home's proximity to the epicenter (Tierney, 1985; Bolton and Orians, this volume; Bolin and Stanford, this volume). Some of these items are amenable to either structural or nonstructural mitigation. The type and extent of home damage is often related to both the actual and the perceived future safety of its inhabitants, the continued and safe functioning of utilities, the official evacuation orders, and the inhabitant's decision to evacuate.

EVACUATION

According to Mikami and Ikeda's (1985) post-disaster survey of human response to disasters, evacuation decisionmaking is based, in part, on the perception of threat, exposure to evacuation advice, family and demographic characteristics, and community preparedness. Early evacuation is related to acute perceptions of direct threat, repeated exposure to evacuation advice, location of home, and past disaster experience.

Mikami and Ikeda argued that the threat of disaster is understood in the setting of daily life and may be underestimated when considering evacuation (see also Quarantelli, 1984). They found that compliance with evacuation advice varied from 13 percent to 96 percent, depending on the community sampled. Past research suggests that people respond to warnings, in part, because the warnings effectively arouse concerns about personal or family safety. To our knowledge, comparable studies have not examined the role that pre-disaster psychological distress may play in heightening arousal which results in possibly dysfunctional evacuation. Comparable studies are needed to describe factors, such as psychological distress, that may predict evacuation behavior under varying conditions. We believe that a better understanding of the motivations behind evacuation behavior will influence the quality and quantity of future levels of community preparedness for disasters in general, and for earthquakes in particular.

STUDY OBJECTIVE

Our objectives in these analyses were to describe where people were, who they were with, and what they did during and immediately after the Loma Prieta earthquake; what damage, if any, occurred to their homes and personal property; and whether and why they evacuated their homes. In particular, we examined both the geographic area and type of place—home, school, work, public place, or in transit—where respondents were at the time of the earthquake and how their location and companions, if any, determined their actions at that time.

We also were interested in determining whether people made efforts to protect themselves or, at least, to avoid harm, and how such decisions differed with proximity to epicenter, location, and the presence of other people. We also wanted to know whether people sought information from broadcast media (radio and television) during and immediately after the earthquake, and whether such information seeking varied with geographic location, type of place, and a person's companions at the time of the earthquake.

We describe the amount of damage to homes, personal property, and utilities that our respondents reported, and the extent to which reported damage differed with proximity to the areas of more intense shaking. Finally, we describe the number of persons who left their homes after the earthquake, their reasons for evacuation, and the extent to which evacuation behavior was affected by proximity to the epicenter, damage, loss of utilities, presence of other people, and expressions of fear at the time of the earthquake.

SAMPLE

Between April 29, 1990, and August 1, 1990, 30-minute telephone interviews were conducted by staff at the Institute for Social Science Research at the University of California, Los Angeles. Modified random digit dialing (rdd) procedures were used to obtain a representative sample of 656 persons residing in households in San Francisco, Alameda, Santa Cruz, Santa Clara, and San Mateo Counties (Frankel, 1983; Sudman, 1983). To increase the efficiency of the sample and to insure that at least 75 persons were interviewed within each of the areas known to be most affected by the earthquake, intentional oversampling was conducted in the two areas where modified Mercalli intensities (as assessed in monitored buildings) equalled 8 or 9: the northeast edge of the San Francisco Peninsula and Oakland, and the Boulder Creek-Santa Cruz-Watsonville area. Within contacted households, all persons over age 18 who resided in a household in the five-county area on the day of the earthquake were enumerated and one resident was randomly selected for interview using the Kish procedure (Kish, 1965). Across the total sample, 35 potential respondents were lost because they spoke languages other than English, usually Asian.

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 (table 1). 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. Thus, stratification did not increase the probability that households in the northeast edge of the San Francisco

Table 1.—*Sampling characteristics by sample strata for the earthquake (unweighted sample)*

[*n* = total number; pct. = percentage of total number; *p* = significance level for analysis of variance]

Outcome	Area: Five county *n*	Five county Pct.	San Francisco/Oakland *n*	San Francisco/Oakland Pct.	Santa Cruz *n*	Santa Cruz Pct.
Telephone numbers generated	1,100	--	270	--	270	--
Disconnected	218	19.8	76	28.1	47	17.4
Nonresidential	159	14.5	60	22.2	46	17.0
Number changed	25	2.3	3	1.1	7	2.6
No qualified respondent	17	1.5	6	2.2	4	1.5
FAX machine	20	1.8	3	1.1	--	--
Modem	6	0.5	4	1.5	2	0.7
Total unusable	445	40.5	152	56.3	106	39.3
Total usable	655	59.5	118	43.7	164	60.7
Refusal	116	17.7	14	11.9	25	15.2
Language barrier	27	4.1	5	4.2	3	1.8
Resident incapable	11	1.7	1	0.8	3	1.8
No answer (9+ attempts)	24	3.7	8	6.8	6	3.7
Answering machine (7+ attempts)	26	4.0	7	5.9	5	3.0
Completed interviews	451	68.9	83	70.3	122	74.4
Response rate (pct.)	68.9-74.4		70.3-80.6		74.4-79.7	
Probability household selected	5/10,000		5/10,000		31/10,000	
Weights	1.00		0.96		0.16	
No. of days since quake*	226	--	217	--	223	--
Pct. interviewed in Spanish	--	1.3	--	4.8	--	1.6
Pct. willing to be reinterviewed	86.7	--	86.7	--	92.6	--
Mean estimated Mercalli at home**	6.7	--	8.3	--	8.2	--
Mean estimated Mercalli where resident was**[1]	6.7	--	7.3	--	7.9	--

* $p < 0.05$
** $p < 0.001$

[1] Excludes 23 residents who were outside the five-county area at the time of the earthquake.

Peninsula and Oakland would be in the sample. Response rates were between 70.3 percent and 80.6 percent in San Francisco-Oakland, between 74.4 percent and 79.7 percent in Boulder Creek-Watsonville-Santa Cruz, and between 68.9 percent and 74.4 percent in the rest of the five-county area.

In San Francisco-Oakland, interviews were conducted an average of 217 days after the earthquake; 4.8 percent were conducted in Spanish. In Boulder Creek-Watsonville-Santa Cruz, interviews were conducted an average of 223 days after the earthquake with 1.6 percent conducted in Spanish, whereas in the rest of the five-county area, interviews were conducted an average of 226 days after the earthquake with 1.3 percent conducted in Spanish.

SAMPLE LIMITATIONS

The use of rdd to select the sample led to three concerns. First, persons who were homeless or who did not reside in households before the earthquake were significantly less likely to be represented in the final sample. Second, persons who resided in households without telephones before the earthquake and who remained without telephones after the earthquake were underrepresented in the sample. Third, persons whose telephones were disconnected as a result of the earthquake or whose households were destroyed as a result of the earthquake and who either left the area or remained unaccessible by telephone at the time of the interview were underrepresented in the final sample. These three groups of people will subsequently be referred to as those in categories 1 through 3, respectively.

As shown in table 1, respondents who matched the characteristics of category 3 were least likely to be underrepresented in this data set. The total usable numbers identified in this sample ranged from 43.7 percent for San Francisco-Oakland to 60.7 percent for Santa Cruz. These percentages are comparable to national rates and higher than rates obtained in Los Angeles County after the 1987 Whittier Narrows earthquake, where 39.7 percent of the telephone numbers in the high-impact area and 31.4 percent of those generated in the rest of the county were usable (Goltz and others, 1992).

Categories 1 and 2 above were more problematic. Clearly, itinerant farm workers in the Watsonville area and persons in single-room-occupancy hotels (SROs) in the San Francisco-Oakland area were underrepresented or not represented in this sample. Many of these persons would have been missed in a telephone survey at any time, because they did not reside in households with telephones; others probably lost access to telephones as a result of the earthquake. Other information suggests that these groups might have been disproportionately dislocated by the earthquake. For example, 40 percent of the 10,000 dwelling units destroyed or severely damaged in the earthquake were single room occupancy hotels (SROs) or other kinds of housing that displaced persons with low or moderate incomes (R.J. DeMonte, Region IX, Feb. 8, 1990 [written commun.] to J. Kemp, Secretary, U.S. Dept. of Housing and Urban Development), and only 24 percent of the 10,331 households that registered with the Red Cross for assistance were those of homeowners (Peggy Brutsche, written commun., December 16, 1991). We hope that future comparisons of this sample with data available in the 1990 U.S. census will allow us to assess the extent to which residents of SROs, itinerant farm workers, and other groups were underrepresented in this data set.

DATA COLLECTION

The questionnaire used for data collection was adapted from questionnaires developed by Turner and others (1986) and Bourque and others (1973) and largely replicated a questionnaire used to collect data from Los Angeles County residents after the 1987 Whittier Narrows earthquake (Goltz and others, 1992). Data were collected to assess the type and extent of response actions, including information about damage and injury to self and

others; decisions to evacuate; 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.

Modifications made in the questionnaire developed after the Whittier Narrows study for use after the Loma Prieta earthquake reflected differences in residents' experiences during and after the two shocks or resulted from knowledge gained during the collection and preliminary analyses of data collected in Los Angeles. First and foremost, the civilian version of the Mississippi Scale for Combat-Related Posttraumatic Stress Disorder (Keane and others, 1988) and questions that reflect suggestions made by Norris (1989) for the measurement of posttraumatic stress were added to the questionnaire. Second, to obtain a more detailed measure of geographic location than is provided by telephone prefixes, information on each respondent's zip code of residence and, for those not at home, details of the respondent's location at the time of the earthquake were collected. Third, questions such as those on media usage and loss of utilities were modified to reflect differences in the two earthquakes.

ANALYSIS

Analyses in this report describe where people in the five-county Bay Area were at the time of the Loma Prieta earthquake, other people with them and their reported actions during the earthquake, respondents' passive and active exposure to media during and immediately after the earthquake, damage they experienced to personal property and homes, loss of utilities, and decisions to evacuate. We do not present data on preparedness behavior before or after the earthquake, exposure to earthquake warnings, or injuries, and we discuss respondents' psychological distress only as it relates to evacuation behavior. Information on injuries and psychological distress after the earthquake can be found in Bourque and others (1991).

INDEPENDENT VARIABLE: LOCATION

The location of respondents and their homes relative to the epicenter of the earthquake was the independent variable in most of our analyses. The extent to which an individual physically "feels" and is moved around by an earthquake varies with proximity to the epicenter, characteristics of the soil and other geologic features, and the surroundings (indoors, outdoors, or in a car); if indoors, characteristics of the building and locations of furniture and other objects, and so forth. Modified Mercalli intensities (MMIs) were used to provide a rough indication of the extent of shaking that respondents and their residences experienced during the earthquake. MMI scores for the location of an individual's residence were incorporated into the procedures for selecting the sample (see section "Sample"), and three strata were created which varied in intensity of shaking as measured by MMIs. This three-category variable of sample strata was used as the independent variable in many of our analyses.

At the time of the earthquake, only about half of our respondents were at home. For those at home, we assigned the score of the sample strata where the home was located: an MMI of 8 or 9 in northeast San Francisco, Oakland, Boulder Creek, Santa Cruz, and Watsonville; and an MMI of less than 8 in the rest of the five-county area. Persons who were not at home at the time of the earthquake were asked in what geographic area of the five counties they were when the event occurred. They were then assigned the MMI score for that area. A second three-category variable was then created to indicate in which of the three original strata (San Francisco-Oakland, Boulder Creek-Santa Cruz-Watsonville, or the five-county area) a respondent was at the time of the earthquake. Sixty-six persons were in a different strata from where they lived: 20 residents of the five-county area were in San Francisco-Oakland, 17 residents of the five-county area were in the Santa Cruz area, 13 residents of San Francisco-Oakland were in the five-county area, and 16 residents of the Santa Cruz area were in the five-county area. The sample was weighted (see following section) when this "location" variable was the independent variable in analyses.

ANALYSIS STRATEGY

Experiences and behavior were examined by magnitude of shaking experienced as described above, by standard demographic characteristics, and, when warranted, by other relevant variables. Descriptive analyses were conducted and are reported in the form of two- or three-way contingency tables using the chi-square statistic or one-way analysis of variance when appropriate. Chi-square tests were not calculated when a table contained excess numbers of small cells. In recognition of differences among the three sample strata in both demographic characteristics and earthquake experiences, sample strata were incorporated into all analyses in one of three ways: as the independent variable in an analysis, as a control variable, or with sample weights that accounted for the fact that residents of the Boulder Creek-Santa Cruz-Watsonville area were overrepresented when sample strata were combined. When weights were assigned, respondents in the Santa Cruz area received a weight of 0.16, those in San Francisco-Oakland a weight of 0.96, and those in the five-county area a

weight of 1.00. The size of the weighted sample is 551. The title of each table in this report indicates whether a weighted or unweighted sample was used for the analysis reported.

FINDINGS

DEMOGRAPHIC CHARACTERISTICS

Fifty-five percent of the respondents were female. On average, respondents were 46 years of age and had completed more than 14 years of schooling (table 2). Gender, age, and socioeconomic status as measured by modified Duncan scores (see Stevens and Cho, 1985) were comparable across the three sample strata, but those reporting a college degree ranged from 31 percent in the Boulder Creek-Santa Cruz-Watsonville area to 51 percent in the San Francisco-Oakland area. Ethnic composition varied substantially, with Santa Cruz respondents being almost exclusively white (89 percent), whereas 22 percent of San Francisco-Oakland respondents were black and an additional 20 percent identified themselves as being from other minority groups.

Household composition and living arrangements varied significantly across the three sample strata. San Francisco-Oakland respondents, compared with those in the other two sample strata, were least likely to be married (21 percent vs. 46-51 percent), most likely to live alone and without children, and had resided in California for an average of 25 years as contrasted with 30-32 years.

Data on household income reflected information about household composition. The median household income of residents of San Francisco-Oakland was lower than that of residents of the other two areas, as were the number of persons contributing to household income and the number dependent on it. Hence, per-capita income within a household did not differ appreciably across the three sample strata. Residents of San Francisco-Oakland were least likely to own their residences (28 percent) and most likely to live in apartments or duplexes (65 percent).

Possibly the most interesting difference across the three sample strata was respondents' differential reporting of experiences with prior earthquakes. Respondents were asked, "Prior to the October 17th earthquake, how many times had you experienced an earthquake?" San Francisco-Oakland respondents reported experiencing an average of 15 prior earthquakes, five-county respondents reported an average of 20, and Santa Cruz respondents reported an average of 28. Although the reports of San Francisco-Oakland residents were consistent with their reports of living in California for the fewest years, the exceptionally high reports by Santa Cruz area residents were not easily explained by other information available in the data set or by known geological features of the area. It may be that respondents in the Santa Cruz area were "telescoping" (misreporting or overreporting) by combining post-Loma Prieta aftershocks with pre-Loma Prieta earthquakes (see Aday, 1989; Bourque and Clark, 1992).

Table 2.—*Selected demographic characteristics by sample strata for earthquake (unweighted sample)*

[p = significance level in one-way analysis of variance]

	Area		
	Five county Pct.	San Francisco/ Oakland Pct.	Santa Cruz Pct.
Pct. white**	69.4	57.3	88.5
Pct. female	56.1	59.0	52.5
Mean age	45.7	46.8	45.6
Pct. married*	51.0	20.5	45.9
Pct. college degree or more*[1]	39.0	50.6	31.1
Pct. employed fulltime	56.1	60.2	52.5
Mean socioeconomic index[2]	43.3	42.9	42.2
Per-capita income within household[3]	$15,000	$16,208	$15,625
Pct. own residence**	61.2	27.7	59.0
Mean years in California*	30.2	25.3	31.9
No. of prior earthquakes**	20.4	14.6	27.9
Total n	451	83	122

* $p < 0.05$
** $p < 0.001$

[1] There were no significant differences between the sample strata in the number of years of schooling completed.

[2] Total Socioeconomic Index (TSEI) as determined by Stevens and Cho (1985).

[3] Significant differences exist between the strata in median household income, percent with incomes over $40,000, and the number contributing to and dependent on household income. Residents of San Francisco-Oakland reported lower household incomes, fewer persons contributing to the household income, and fewer persons dependent on the income.

DURING THE EARTHQUAKE

Respondents were selected for inclusion in the study on the basis of where they lived at the time the sample was selected, but respondents were not necessarily in their homes or in the geographic area where their homes were located at the time of the earthquake. Consistent with their location at the time of the earthquake, persons in the Boulder Creek-Santa Cruz-Watsonville area were most likely (67.9 percent) to report that there was damage to major structures within five blocks of where they were. In contrast, 52 percent of San Francisco-Oakland respondents and 32.1 percent of the remaining respondents reported such damage (table 3).

The majority (62 percent) of persons who were in the Santa Cruz area were at or in a private home at the time of the earthquake, while 50 percent of those in the five-county area and 42 percent of those in the San Francisco-Oakland area were at a home (table 4). Approximately 25 percent of respondents were at work or school, 15 percent were in transit, and 10 percent were in public places. Persons who were in public places were most likely (54.2 percent) to report that there was damage to buildings around them, whereas those who were in a private home

Table 3.—*Respondents reporting damage within five blocks by sample strata where respondent was at the time of the earthquake (weighted sample)*

[Respondents exclude 23 persons who were out of the area at the time of the earthquake, 13 persons who did not feel the earthquake, and 3 persons who did not know about damage in the area. p = significance level in chi-square analysis]

Any damage within five blocks?	Area: Five county Pct.	Area: San Francisco/ Oakland Pct.	Area: Santa Cruz Pct.
Yes	32.1	52.0	67.9
No	67.9	48.0	32.1
Total *n*	402	80	34

$p < 0.0001$

Table 4.—*Type of place respondent was at the time of the earthquake by sample strata where respondent was at the time of the earthquake (weighted sample)*

[Respondents exclude 23 persons who were out of the area at the time of the earthquake. p = significance level in chi-square analysis]

Location	Area: Five county Pct.	Area: San Francisco/ Oakland Pct.	Area: Santa Cruz Pct.
Own or other's home	49.9	42.1	62.4
Work or school	25.5	25.6	12.0
In transit	15.7	15.6	11.1
Public place or other location	8.9	16.7	14.6
Total *n*	410	87	34

$p < 0.05$

were least likely (29.8 percent) to report such damage ($p < 0.001$).

Whether a person was at home or elsewhere at the time of the earthquake did differ with demographic characteristics of respondents. As age increased, persons were more likely to be at home, with 76 percent of persons over 60 being at home and only 34 percent of those under 32 being at home. Consistent with the time of day and time of year, younger persons were most often at work or school. Married and formerly married persons were more likely (55 percent) to be at home than were never-married respondents (33.6 percent). Those with high incomes (>$62,500) and college degrees were more likely to be at home than were those with less income and less education.

Respondents' reports of who they were with at the time of the earthquake differed with the geographic area where they were at the time of the earthquake (table 5). These differences reflected both reported differences in living arrangements across the sample and differences in respondents' locations at the time of the earthquake. Those who were in transit were most likely to report that they were

Table 5.—*Other people with respondent by sample strata where respondent was at the time of the earthquake (weighted sample)*

[Respondents exclude 23 persons who were out of the area at the time of the earthquake and 13 persons who did not feel the earthquake. p = significance level in chi-square analysis]

	Area: Five county Pct.	Area: San Francisco/ Oakland Pct.	Area: Santa Cruz Pct.
Alone	39.3	45.8	39.5
Children <18	5.7	3.5	4.3
Children and adults	7.7	2.3	15.2
Other adult household members or relatives	16.5	5.9	23.8
Co-workers	20.7	19.9	7.1
Friends or neighbors	5.5	8.3	6.3
Others	4.5	14.2	3.8
Total *n*	403	82	34

$p = .0017$

alone (69 percent) (table 6). Those at work were most likely to report that they were with co-workers (72 percent). Those in private homes were about equally likely to report that they were alone (46 percent) or that they were with other household members, relatives, or children (45.8 percent). It is recognized that, for those not at home at the time of the earthquake, responses may have been influenced by the respondents' perceived distance from home, need and desire to return home quickly, and ability to return home. Although it is possible with these data to calculate a crude estimate of the respondents' distance from home, it is not possible to ascertain respondents' knowledge of the whereabouts of loved ones, or other potential motivations for returning home. Respondents were asked about other household members only if they were with them at the time the earthquake occurred.

RESPONSE BEHAVIOR DURING THE EARTHQUAKE

The modal behavior at the time of the earthquake was to freeze in place or seek protection (72 percent) (table 7), but responses were modified by a respondent's location and companions at the time of the earthquake. Interestingly enough, responses did not change substantially with geographic location. Persons who were at work or school most often sought protection, whereas those in private homes were most likely to be with children and, consequently, to state that they went to a child. Forty-two percent of the 81 persons who said they were with children (either alone or with others) during the earthquake went to a child.

Of greatest concern are the persons who said they ran during or, possibly, immediately after the earthquake. Run-

Table 6.—*Other people with respondent by type of place where respondent was at the time of the earthquake (weighted sample)*

[Respondents exclude 23 persons who were out of the area at the time of the earthquake and 13 persons who did not feel the earthquake. p = significance level in chi-square analysis]

	Own or other's home Pct.	Work/ school Pct.	In transit Pct.	Public place/ other Pct.
Alone	46.0	19.4	68.8	23.7
Children < 18	8.4	0.0	5.4	2.8
Children and adults	12.6	0.0	2.7	6.1
Other adult household members or relatives	24.8	1.5	5.6	15.7
Co-workers	0.0	72.3	5.4	8.1
Friends or neighbors	7.1	0.8	5.4	13.9
Others	1.1	6.0	6.8	29.7
Total n	262	130	75	52

$p < 0.001$

Table 7.—*Respondent's actions during the earthquake by type of place and sample strata where respondent was at the time of the earthquake (weighted sample)*

[Respondents exclude 23 persons who were out of the area at the time of the earthquake, 13 persons who did not feel the earthquake, and one person who could not remember the earthquake]

Action	House Pct.	Work/school Pct.	In transit Pct.	Public place Pct.
		Five county		
Could not move	2.9	0.0	0.0	8.7
Froze	32.3	20.6	21.6	41.8
Froze, then sought protection	16.2	15.4	22.0	12.0
Sought protection	28.5	45.6	3.3	11.4
Ran outside	5.4	8.8	0.0	14.5
Went to child	12.2	5.8	1.7	5.8
Pulled car over	0.5	0.0	38.1	0.0
Continued driving	0.0	0.0	13.3	5.8
Other	2.0	3.8	0.0	0.0
Total n	204	104	60	35
		San Francisco/Oakland		
Could not move	13.1	0.0	9.0	0.0
Froze	47.5	31.7	27.2	23.2
Froze, then sought protection	5.2	13.7	9.0	7.6
Sought protection	18.4	54.6	9.0	22.9
Ran outside	7.8	0.0	0.0	46.3
Went to child	2.6	0.0	0.0	0.0
Pulled car over	0.0	0.0	36.9	0.0
Continued driving	0.0	0.0	9.0	0.0
Other	5.3	0.0	0.0	0.0
Total n	37	21	11	13
		Santa Cruz		
Could not move	7.0	0.0	0.0	0.0
Froze	31.7	7.9	36.7	16.3
Froze, then sought protection	17.3	7.9	22.2	26.8
Sought protection	13.9	68.3	0.0	23.6
Ran outside	21.8	15.8	0.0	9.8
Went to child	7.6	0.0	0.0	23.6
Pulled car over	0.0	0.0	36.7	0.0
Continued driving	0.0	0.0	4.4	0.0
Other	0.8	0.0	0.0	0.0
Total n	21	4	4	5

ning was most often reported by people who were in the Santa Cruz area, where it was reported to occur almost regardless of the respondent's location at the time of the earthquake. In the other two areas, running was most frequently reported by persons who were in public places. Five of the persons who reported running were outside at the time of the earthquake. For these five persons, running was probably less dangerous than it might have been for the 50 persons who reported running while being inside a building at the time of the earthquake. Of the five persons who were outdoors and did run, one said he ran to escape boulders on Highway 17, another was jogging in the Marina at the time of the earthquake, while another reported running into her house during the earthquake!

There were few differences in response behavior at the time of the earthquake by demographic characteristics. In general, women were more likely than men to freeze in place (33.4 percent vs. 24.8 percent) or to go to a child (9.6 percent vs. 4.3 percent). Older persons (over 41 years) were also more likely to freeze in place (34.6 percent vs. 24.6 percent). During the Whittier Narrows earthquake, self-reported fright was associated with seeking cover and protection (Goltz and others, 1992). A similar association was seen in this data set for those respondents who were at work.

RELATIONSHIP BETWEEN LOCATION, DEMOGRAPHIC CHARACTERISTICS, AND RESPONSE BEHAVIOR

Where a person is at the time of an earthquake differs with the time of year, day of the week, and time of day that the earthquake occurs. For example, the distribution of persons across locations was quite different in the Loma Prieta earthquake compared with the 1987 Whittier Narrows earthquake, with 67 percent of persons at home at the time of the early-morning Whittier Narrows earthquake. Although distributions of persons across locations will change, behavior within a given type of location may be constant across earthquakes. To examine these potential commonalities briefly, we assessed whether a person's behavior within a given location differed with the demographic characteristics of respondents.

For those at a home, the tendency to stay in place during the earthquake was associated with increased age, being formerly married, and residing in California for between one and 20 years or between 31 and 87 years; the tendency to run outside was associated with being male. No associations were noted between respondent characteristics and the tendency to seek protection at a home. Respondents at work were more likely to remain in place if they were alone or with children. Workers were more likely to seek protection if they experienced high levels of fear during the earthquake. Respondents with higher levels of earthquake experience were more likely to stay in place

only when low levels of fear were experienced. A positive level of perceived earthquake preparedness appeared to be associated with seeking protection via the experience of high levels of fear. Those more likely to run outside at work were male and had experienced low levels of fear during the earthquake.

Respondents in public places were more likely to stay in place if they were white and in the company of adults only. Males were more likely to seek protection, and females were more likely to run outside in this situation. The tendency of respondents to stay in place in the presence of adults held only under conditions of high levels of fear. Further analyses revealed that gender differences in those who ran outside, regardless of location, held only when the respondents experienced high levels of fear during the earthquake and possessed college degrees. The underlying causes and implications of some of these associations are not immediately evident. Of those who were driving, respondents who were less than 32 or greater than 58 years old were the least likely to pull the auto over and stop.

EXPOSURE TO MEDIA

The Loma Prieta earthquake was unusual in that it occurred at the beginning of the broadcast of the first World Series game in the community where all the games were to be played. In fact, three of our respondents reported being at the Candlestick ballpark at the time of the earthquake. Although we have no way to check, we assume that because of the World Series more people than normal were already listening to radios or televisions when the earthquake occurred. Sixty percent of the sample had no broadcast media on at the time of the earthquake, whereas 28 percent were watching television and 12 percent were listening to the radio.

The number of people listening to radio and television did not differ with the geographic area where respondents were when the earthquake occurred nor with where their residence was located. Interestingly enough and in spite of the World Series game, it did not differ with gender. Females were as likely as males to have radios or televisions on. Exposure to radio or television at the time of the earthquake did differ with respondents' age, education and income, and the type of place in which they were. Persons with college degrees (64.4 percent) and those aged 32 to 41 were least likely to have media on (67.2 percent), whereas those over 58 were most likely to be watching television (39 percent). A person's location at the time of the earthquake was associated with, and at least as important as, demographic characteristics in predicting exposure to media (table 8). When analyses were controlled for whether a respondent was at home or elsewhere, the associations observed between age and media exposure, and education and media exposure, disappear. Persons who were at work or school were least likely to be using media (81.6 percent); those at home were most likely to be watching television (50.3 percent); and those in transit were most likely to be listening to the radio (42.7 percent).

Table 8.—*Exposure to media by type of place where respondent was at the time of the earthquake (weighted sample)*

[Respondents exclude 23 persons who were out of the area at the time of the earthquake, 13 persons who did not feel the earthquake, one person who could not remember the earthquake, and 7 persons missing for other reasons. p = significance level in chi-square analysis]

Media on at time of quake	House Pct.	Work/school Pct.	In transit Pct.	Public place Pct.
Radio on	5.0	11.5	42.7	6.0
Television on	50.3	7.0	4.1	5.8
No media on	44.7	81.6	53.2	88.3
Total n	258	129	73	52

$p < 0.0001$

The earthquake disrupted respondents' listening status, and what happened next is of interest. Of the 242 persons who had radios or televisions on, 141 (58.3 percent) lost the broadcast at least temporarily because the electricity went out, and an additional 16 lost the broadcast for some other reason, including damage to the radio or television set. Of the 157 persons who lost the broadcast signal, 101 (64.7 percent) sought another media source. Loss was associated with geographic location: 75 percent of those in the Santa Cruz area, 65.7 percent of those in the San Francisco-Oakland area, and 52.4 percent of those in the rest of the five counties lost the broadcast signal.

Of the 305 persons who did not have broadcast media turned on, 64.4 percent attempted to turn on a radio or television (table 9). While the propensity to seek information did not differ by geographic location, the media used did differ, with those in the Santa Cruz area being more likely to resort to car radios and those in the San Francisco-Oakland area using portable battery-operated radios. Within the group that was not exposed to media, reported attempts to seek media did not differ with respondents' demographic characteristics but did differ with where they were; those at home sought information from television, and those at work sought information from radios.

PASSIVE AND ACTIVE EXPOSURE TO BROADCAST MEDIA

To summarize people's exposure to the broadcast media at the time of the earthquake, we categorized respondents into four groups according to how passive or active they were in seeking information from the media. The first group was the 184 persons (30 percent) who had no media turned on at the time of the earthquake and reported no

Table 9.—*Media seeking by those who did not have media on at the time of the earthquake, by sample strata where respondent was at the time of the earthquake (weighted sample)*

[Respondents exclude 250 persons who had media on during the earthquake, 23 persons who were out of the area at the time of the earthquake, and 13 persons who did not feel the earthquake. p = significance level in chi-square analysis]

Action	Area: Five county Pct.	Area: San Francisco/ Oakland Pct.	Area: Santa Cruz Pct.
Turned on TV	12.5	5.8	5.9
Tried TV	1.3	0.0	1.6
Used battery TV	3.8	3.7	1.6
Turned on radio	6.4	9.6	0.0
Tried radio	4.3	1.9	1.6
Used battery radio	21.8	33.7	17.0
Used car radio	14.3	9.4	36.7
Did nothing	35.6	35.9	35.5
Total n with media off at time of quake	234	51	20

$p < 0.05$

efforts to gain access to radio or television. These were the "nonconsumers." The second group was the 85 persons (13.9 percent) who had a radio or television on that did not go off. These persons might be considered "passive consumers" of information provided about the earthquake. The third group was the 105 persons (17.2 percent) who were tuned into the media, lost contact because of power outages or other events, and actively sought another station or source. Some proportion of these persons must be assumed to have been more interested in the World Series than in the earthquake. The last group, the "active seekers," were the 238 persons (38.9 percent) who were not tuned into media and then sought media.

When analyses were re-run using this summary variable, the findings reported above generally were replicated. Table 10 summarizes how media-seeking behavior differed with geographic location and type of place. Persons who were in public places were most likely not to be tuned into media at the time of the earthquake and were most likely to seek information after the earthquake occurred, regardless of the geographic area where they were located. There were no particular differences with demographic characteristics of respondents beyond those already noted. However, knowing who a person was with in addition to where they were provided some additional information about those who were not at home when the earthquake occurred (table 11). Persons who were at home alone or with children were least likely to be exposed to media either during or after the earthquake, whereas those who were with other adults outside the home were most likely to seek media after the earthquake.

Level of fear at the time of the earthquake also appears to have a mild curvilinear relationship with media exposure (table 12). Those who were moderately frightened or who enjoyed the earthquake reported somewhat more media-seeking than did those who were very frightened. Persons who were not at all frightened by the earthquake were least likely to seek media information actively.

Table 10.—*Media seeking following the earthquake by type of place and sample strata where respondent was at the time of the earthquake (weighted sample)*

[Respondents exclude 23 persons who were out of the area at the time of the earthquake, 13 persons who did not feel the earthquake, and 7 persons missing for other reasons. p = significance level in chi-square analysis]

	House Pct.	Work/school Pct.	In transit Pct.	Public place Pct.
Five county ($p < 0.001$)				
No media seeking	27.4	38.2	24.2	23.1
Media on & stayed on	22.0	4.8	25.8	9.1
Media on, went off, & sought new media	23.6	7.0	10.6	2.9
No media on; sought media	27.0	50.0	39.4	64.9
Total n	200	103	58	35
Northeast San Francisco and Oakland ($p < 0.05$)				
No media seeking	31.6	39.2	0.0	38.4
Media on & stayed on	8.1	8.6	36.6	7.6
Media on, went off, & sought new media	31.5	4.5	18.3	0.0
No media on; sought media	28.9	47.7	45.1	54.0
Total n	37	22	11	13
Boulder Creek-Santa Cruz-Watsonville (p = nonsignificant)				
No media seeking	31.2	23.8	17.8	33.3
Media on & stayed on	3.1	0.0	36.7	0.0
Media on, went off, & sought new media	40.2	11.9	4.4	0.0
No media on; sought media	25.6	64.4	41.1	66.7
Total n	21	4	4	5

Table 11.—*Media seeking behavior by who respondent was with and whether or not at home at the time of the earthquake (weighted sample)*

[Respondents exclude 23 persons who were out of the area at the time of the earthquake, 13 persons who did not feel the earthquake, and 7 persons missing for other reasons. p = significance level in chi-square analysis]

Response	Alone or with 1+ children Pct.	With adults Pct.
Respondent Was at Home ($p < 0.05$)		
No media seeking	35.0	20.2
Media on & stayed on	15.1	22.5
Media on, off, & sought new media	23.1	29.7
No media on; sought media	26.8	27.6
Total n	141	117
Respondent Was Not at Home ($p < 0.015$)		
No media seeking	29.2	31.7
Media on & stayed on	20.8	7.5
Media on, off, & sought new media	7.9	6.6
No media on; sought media	42.1	54.3
Total n	92	161

Table 12.—*Media seeking behavior by how afraid respondent was at the time of the earthquake (weighted sample)*

[Respondents exclude 23 persons who were out of the area at the time of the earthquake, 13 persons who did not feel the earthquake, and 7 persons missing for other reasons. p = significance level in chi-square analysis]

Response	Very frightened Pct.	Somewhat frightened Pct.	Not very frightened Pct.	Not at all frightened Pct.	Enjoyed experience Pct.
No media seeking	33.3	22.5	28.9	41.4	29.4
Media on & stayed on	10.4	17.5	15.5	22.1	14.0
Media on, went off, & sought new media	19.2	18.0	13.2	12.8	13.5
No media on; sought media	37.2	42.1	42.3	23.7	43.1
Total n	155	179	92	64	22

$p = 0.10$

UTILITIES

Loss of utilities clearly was associated with proximity of a respondent's home to the epicenter or to an area that experienced substantial shaking. Only 2.6 percent of the respondents in the Boulder Creek-Santa Cruz-Watsonville area and 8.0 percent in the San Francisco-Oakland area reported that none of their utilities went out (table 13). Electricity was most commonly lost, and if a single utility was lost, it was almost always electricity. Hardly anyone lost only gas, telephone, or water. The most common combination of utilities lost was electricity and telephone. In the Santa Cruz area, 53.9 percent of the respondents lost two or more utilities, with electricity always being one of the utilities reported lost. In contrast, 23.4 percent of the five-county residents and 33.4 percent of Oakland area residents lost two or more utilities.

Reported losses of utilities did not differ with any of the standard demographic characteristics.

Table 13.—*Respondents who experienced loss of one or more utilities by sample strata (unweighted sample)*

[p = significance level in chi-square analysis]

Utility	Area: Five county Pct.	Area: San Francisco/Oakland Pct.	Area: Santa Cruz Pct.
None went out	26.6	8.0	2.6
Electricity only	45.1	57.3	42.7
Gas only	0.5	0.0	0.0
Phone only	4.4	1.3	0.9
Electricity & phone	14.5	6.7	12.8
Phone & gas	0.0	1.3	0.0
Water & electricity	0.7	4.0	11.1
Electricity & gas	2.6	9.3	5.1
Water & gas	0.2	0.0	0.0
Phone, electricity, & gas	0.7	2.7	0.0
Phone, water, & electricity	0.7	4.0	3.4
Water, electricity, & gas	3.5	2.7	15.4
Phone, electricity, water, & gas	0.5	2.7	6.0
Total n	451	83	122

$p < 0.001$

DAMAGE TO HOMES AND PERSONAL PROPERTY

Reports of damage varied with distance from the epicenter (table 14). Fifty percent of the residents in the Boulder Creek-Santa Cruz-Watsonville area reported damage to their homes, whereas only 22 percent of Oakland area respondents and 17 percent of those in the rest of the area reported damage to their homes. Between 12 percent and 17 percent reported damage to personal property only. The most common structural damage occurred to walls, ceilings, or floors, with persons in the Santa Cruz area reporting the most severe damage. As would be expected, 85 percent of those who reported damage to their homes also reported the loss of one or more utilities, whereas 73 percent of those without residential damage reported loss of utilities.

Consistent with the proportion of respondents who reported damage and the kind of damage reported, residents of the Santa Cruz area reported the highest average amount of damage at $19,940 and two persons reported damage of more than $100,000. Persons in Oakland and San Francisco reported an average of $7,333 in damage, whereas those in the five-county area reported an average of only $2,431 in damage. In contrast to other studies, the type and dollar amount of damage reported did not differ with the respondent's demographic characteristics (Bolin and Bolton, 1986; Bolin and Stanford, 1991; Tierney,

Table 14.—*Damage at respondent's home by sample strata (unweighted sample)*

[p = significance level in one-way analysis of variance]

Damage	Area: Five county Pct.	Area: San Francisco/Oakland Pct.	Area: Santa Cruz Pct.
No damage	67.8	66.3	33.6
Personal property only	15.3	12.0	17.2
Driveway	0.7	0.0	0.0
Chimney/patio/porch	0.4	1.2	6.6
Water heater	0.4	1.2	0.8
Damage to any 1 of: wall/ceiling/floor	7.5	10.8	6.6
Damage to any 2 of: wall/ceiling/floor	2.4	3.6	13.9
Foundation	1.6	2.4	4.9
Pool/water tank	0.7	0.0	2.5
Gas lines broken	0.4	0.0	1.6
Water pipes broken	2.0	1.2	6.6
Collapse of any 2 of: wall/ceiling/floor	0.2	0.0	1.6
Building off foundation	0.4	1.2	1.6
Entire building	0.0	0.0	2.5
Mean dollar amount of damage for those who reported damage*	$2,431	$7,333	$19,940
Total n	451	83	122

* $p < 0.001$

Table 15.—*Reason for evacuating by sample strata for earthquake (unweighted sample)*

[Respondents exclude one deviant case: a woman who left the Santa Cruz area after the earthquake and never returned to her apartment. p = significance level in one-way analysis of variance or chi-square where appropriate]

	Area: Five county (n = 451) Pct.	Area: San Francisco/Oakland (n = 83) Pct.	Area: Santa Cruz (n = 122) Pct.
Pct. who evacuated*	17.5	16.9	42.6
Total n	451	83	122
Those Who Evacuated:			
Mean number of hours evacuated*	41.9	44.3	174.8
Reason for evacuation*			
Official or condition of structure required it	11.4	7.1	36.5
2 or more utilities off	8.9	7.1	17.3
Gas off	2.5	0.0	7.7
Electricity off	22.8	28.6	13.5
Road out	1.3	0.0	0.0
States upset only	24.1	14.3	5.8
Other reasons including invitation from friend or relative, afraid of further damage, prediction of aftershocks, and to make contact with others	29.1	42.9	19.2
n	79	14	52

* $p < 0.05$

1985). This may result, however, from characteristics of our sample (see "Sample Limitations").

EVACUATION BEHAVIOR

As would be expected, evacuation varied with proximity to the epicenter and the amount of damage to a respondent's home, but damage to houses and utilities was not the sole precipitator of evacuation. For example, 55 percent of those in the Santa Cruz area who reported damage to their homes did not evacuate, whereas 15 percent of those in other areas who reported no damage did evacuate. Forty-three percent of Santa Cruz-area respondents evacuated, and 36.5 percent of those evacuated because an official recommended it or because the condition of their homes necessitated evacuation (table 15). In the other two areas, less than 20 percent of the respondents reported evacuating, and more than 50 percent evacuated because of being upset or for other reasons. Persons in the San Francisco and five-county areas also were more likely than residents of the Santa Cruz area to cite the loss of electricity alone as a reason for evacuating.

BOULDER CREEK-SANTA CRUZ-WATSONVILLE

Decisions to evacuate differed with geographic location. Evacuation in the Boulder Creek-Santa Cruz-Watsonville area was largely motivated by damage to homes and utilities. There was also some greater tendency for younger persons (less than 40 years) to evacuate.

FIVE-COUNTY AREA

In contrast, in the five-county area, decisions to evacuate varied with demographic characteristics of respondents, who they were with at the time of the earthquake, and the amount of fear they said they experienced at the time of the earthquake. Women were more likely than men to leave their homes (21 percent vs. 13 percent), and persons under 40 years of age were more than twice as likely to evacuate as those over 40 (24 percent vs. 10.6 percent). This same group (persons under 40) contributed to the finding that persons who had lived in California for between 20 and 40 years were more likely to evacuate after the earthquake than were those who had lived in California either fewer than 20 or more than 40 years.

Forty percent of the 58 persons in the five-county area who reported being with children at the time of the earthquake reported evacuating after the earthquake. Only 10 of these persons evacuated because of structural damage, advice of officials, or loss of utilities. The remainder evacuated because of fear, a need to make contact with other persons, invitations from friends or relatives, or concern about aftershocks or further damage. The contrast between the group with children and those who were alone is

Table 16.—*Percent evacuated and reason for evacuation by sample strata for earthquake and level of fear (unweighted sample)*

[p = significance level in chi-square analysis]

Reason for evacuation	Area					
	Five county		San Francisco/ Oakland		Santa Cruz	
	Very or somewhat fearful Pct.	Not fearful Pct.	Very or somewhat fearful Pct.	Not fearful Pct.	Very or somewhat fearful Pct.	Not fearful Pct.
Did not evacuate	77.8	90.8	78.2	92.9	54.5	64.7
Psychological reasons[1]	11.1	6.1	12.7	3.6	10.2	11.8
Structure or utilities only[2]	2.1	1.2	1.8	0.0	5.7	5.9
Both	9.0	1.8	7.3	3.6	29.5	17.6
Total n	288	163	55	28	88	34
p =	<.01		.39		.61	

[1] Includes either alone or in combination: evacuation because too upset to stay, afraid of further damage, concerned about aftershocks, invitation from a friend, or to make contact with others.

[2] Includes either alone or in combination: evacuation because of structural damage, utilities out, an official advised evacuation, or the road was out.

particularly striking. While 40 percent of those in the five-county area who were with children evacuated, only 16.5 percent of those who were alone and 14 percent of those who were with other adults decided to evacuate. Like those with children, however, only 43 percent of those who were alone (12 of 28 vs. 10 of 23) evacuated because of major structural or utilities problems. Thus, a substantial proportion of evacuations that occurred outside the most damaged areas probably were not motivated by threats to physical safety.

Evacuation behavior in the five-county area probably was motivated in part by fear (table 16). Persons who said they were very fearful or somewhat fearful at the time of the earthquake were somewhat more likely to evacuate, even when structures and utilities did not necessitate evacuation. While this occurred to some extent regardless of geographic location, it was most pronounced in the five-county area, possibly because persons in the Santa Cruz area, at least, had fewer options regarding where they could go if they decided to leave their homes.

SAN FRANCISCO-OAKLAND

In the San Francisco-Oakland area, loss of electricity was one reason given for evacuating. Evacuation was predicted by experiencing few prior earthquakes. Twenty-five percent of persons who reported feeling 10 or fewer prior earthquakes evacuated, in contrast to only 3.3 percent of those who had experienced more than 10 earthquakes. Evacuation was also precipitated by fear, but the numbers were too small to reach significance. Numbers also were too small to examine in detail how the presence of children affected the evacuation behavior of San Francisco-Oakland residents. Only four persons were with children at the time of the earthquake. One of those four evacuated and cited damage to structures and utilities as well as upsetness as the reason for the evacuation.

MARITAL STATUS AND SOCIOECONOMIC STATUS

Marital status and socioeconomic status, as measured by household income and completion of a college education, were not associated with evacuation behavior in any of the three geographic areas.

BEHAVIOR WHILE EVACUATED

Once respondents left their households, persons in San Francisco-Oakland and the five-county area stayed out of their houses for an average of 2 days. Those in the Santa Cruz area stayed out for an average of 7 days. Respondents who evacuated because of structural damage, advice from officials, or absence of utilities were asked a series of questions about their evacuation experiences. Most respondents in this group said that the decision to evacuate was theirs or resulted from a combination of factors (table 17). Evacuees were about evenly divided between staying with friends or relatives and staying outside, with those in the Santa Cruz area most frequently staying outdoors in tents or recreational vehicles. Most persons took only their clothing. Of particular interest is the tendency not to take valuables and documents. The decision to leave documents and valuables behind probably resulted from three things: a feeling that the evacuation was of short duration (at least for those who evacuated because utilities were out), an inability to reach

Table 17.—*Characteristics of evacuation by sample strata for earthquake (unweighted sample)*

[Only respondents who reported evacuating because of structural damage, advice from officials, or absence of utilities were asked this series of questions]

Evacuation characteristics	Area: Five county Pct.	San Francisco/ Oakland Pct.	Santa Cruz Pct.
What finally convinced those who did not leave to evacuate?			
Officials/bldg mgr	5.0	0.0	7.7
Self only	77.5	33.3	71.8
Friends	2.5	0.0	7.7
Absence of utilities	5.0	16.7	0.0
Roads out	2.5	0.0	0.0
Combinations	7.5	50.0	12.8
Where did you stay?			
Relative	22.5	33.3	15.4
Friend	22.5	50.0	23.1
RV or van	2.5	16.7	15.4
Car or truck	12.5	0.0	2.6
Outside	35.0	0.0	41.0
Motel/Apartment	5.0	0.0	2.6
What did you take with you?			
Family/Self only	45.0	0.0	33.3
Clothing only	25.0	50.0	28.2
Supplies only	12.5	0.0	7.7
Valuables only	2.5	0.0	2.6
Pets only	5.0	0.0	2.6
Clothing & supplies	0.0	16.7	12.8
Valuables, documents and other things	10.0	33.3	12.8
Pct. who returned home while evacuated	47.5	83.3	79.5
Total *n*	40	6	39

valuables, when houses were substantially destroyed, and the distance traveled by those staying outside, who usually stayed in their own yard or a nearby area.

DISCUSSION

We are concerned with the implications of our findings for policy, practice, and future research, given the following: (1) Our respondents were at work or school, at home, in a store or other public location, or in transit. (2) Older persons were more likely to be at home, whereas never-married younger persons were equally likely to be at work, in transit, or at home. (3) Those who were in the Santa Cruz area were more likely to be at home, a fact which probably reflects their greater propensity to live in larger households that contain children; it may also reflect closer proximity between workplace and residence for many residents of the Santa Cruz area.

RESPONSE BEHAVIOR

Where a person was at the time of the earthquake largely determined who they were with and what they did during and immediately after the earthquake. In contrast to the 1971 San Fernando and 1987 Whittier Narrows earthquakes, which occurred in the early morning, for the early evening Loma Prieta earthquake, a substantial number of our respondents were not at home. Others have speculated that irrational behavior and activity detrimental to effective response by authorities increases when those in a disaster are separated from loved ones and property. In looking at what people do during an earthquake, we were interested in finding out whether their actions increased or decreased the risk of injury to themselves and others. Although disaster researchers have repeatedly demonstrated that people do not exhibit panic behavior or mass hysteria during an earthquake or other disaster, policymakers and practitioners continue to express concern that they will. At the same time, it is certainly true that programs encouraging people to think in advance about what they would do if a disaster occurs can reduce fear of the unknown and increase the range of safe alternatives available to an individual.

As expected, we saw little evidence that our respondents panicked at the time of the earthquake. Most persons made an active response that was designed to get them to a more protected location in a safe manner, or simply stayed where they were, which, in some cases at least, is preferable to making a move that increases risk of danger to self or others. The propensity to do the "right thing" differed, however, with the geographic area where a person was, the type of place, and the person's companions.

Possibly reflecting the success of worksite earthquake-preparedness programs and the beneficial effect of being with peers who have been exposed to the same information, persons who were at work or school were the most likely to take active measures to protect themselves. Furthermore, the propensity to seek protection increased with proximity to areas that experienced severe shaking. Even when workers did not seek protection immediately, many sought it before the shaking stopped, and the majority of the remainder froze in place, which, while not decreasing their risk of injury, also did not increase it. Respondents who were at home or in a public place were substantially less likely to actively seek protection, at least as the earthquake started. As it continued, some moved to a protected location, and others went to children.

The most problematic response that our respondents made was to run during or immediately after the earthquake. Running in such a situation may indicate a panic response and certainly is unwise. While none of our respondents reported being injured as a result of running, running clearly increases the risk that a person will be thrown against objects or buildings, or that objects or parts of buildings will fall on them as they run past. In an attempt to better understand this small but important group, we examined what, if anything, differentiated "runners" from "non-runners" within each location where running occurred.

Fifty-five people reported running during the earthquake: 14 were at work, 27 were at home, and 14 were in a pub-

lic location. Those who ran at work were younger (12 of 14 were less than 42 years old) and primarily male (11 of 14), with substantial incomes but without college degrees. All but one were with other adults at the time of the earthquake, which may suggest that some level of crowd behavior or mass hysteria occurred. However, runners did not indicate a higher level of fear at the time of the earthquake, which would be consistent with a panic reaction. To the extent that respondents commented on their behavior, little overt evidence of panic on the part of the respondent or others was provided. A typical comment was to say "I ran for the door." In other words, the objective (a door frame) was a worthy one, but the method of getting there left a great deal to be desired.

Interestingly enough, those who reported running at home were also more likely to be younger males (17 of 27) who disproportionately reported themselves as never married but did not differ from nonrunners in socioeconomic status. All were alone (n=17) or with other adults (n=10). Comments by this group resembled those made by the group that was at work, but one young man said, "I dove out the window and ran for open space." The only place where female runners outnumbered male runners was in public places (11 of 14 were women). Here, also, one respondent specifically mentioned concern about her children as the factor that motivated her running, saying, "I wanted to get to my car and get home because my children were with a babysitter."

Our findings on response behavior have at least three implications for policy and practice. First, younger men either have been ignored as a target of disaster-training information or, alternatively, have rejected such information as unnecessary or irrelevant to their concerns. These data suggest that future efforts should consider how to engage the attention of this group. Second, our findings suggest that disaster-preparedness plans and drills in work sites generally have been successful. Persons who were at work reacted actively and appropriately. Although worksite efforts should be continued, these findings suggest that more programs should assist people in learning what to do in private homes and, even more particularly, in public places. Homes and public locations present different kinds of challenges to practitioners. Public locations are particularly problematic, since every public place is different and any one individual spends very little time at widely spaced intervals at a given public location. Procedures need to be developed that allow persons to identify and act on "generic" information about locations which can then be generalized from one location to another. In particular, people need to know how to scan and quickly assess a location for safety, and how to behave in the presence of large numbers of other people so that they do not endanger themselves or others.

While public locations are problematic because of their wide diversity, homes are problematic because of their overwhelming familiarity. To the extent that humans perceive homes as a sanctuary, they probably fail to realize that houses and the furniture, dishes, pictures, and other objects we put in them can become lethal weapons in a severe earthquake. Typically, work sites bolt file cabinets, conduct earthquake drills, have contingency plans for emergencies, and store water and first aid kits on site, but many of the workers never consider taking similar precautions at home. As a result, we saw many more of those who were at home simply freezing in place rather than actively seeking shelter. There are times, of course, when freezing in place may be the behavior of choice. Certainly one is better off staying seated in an overstuffed chair than heading for a door frame, only to get there and have the door slam into one with the force of the earthquake. We doubt, however, that the people who told us they froze in place in this earthquake settled on that behavior because they had systematically considered what they should do in the past or because they rapidly assessed their options at the time of the earthquake and concluded that this was the safest alternative. We need to know more about what "freezing in place" means and the circumstances under which it is the behavior of choice. We also need to encourage people to do more to "earthquake-proof" their homes, so that decisions to stay in place do not result in having objects or buildings pile on top of one.

Finally, we need to examine in some detail what it means to "go to a child" at the time of an earthquake. As the comment demonstrates, in their concern for a child's physical or emotional safety, parents or guardians may place themselves at significant risk. Adults might be better advised to call instructions to children and stay where they are, rather than moving through potentially lethal obstacles to a child who is relatively safe in a crib or play pen. In the case where a woman ran out of a store, had she broken her leg as a result of running she would have been of little use to her children or the babysitter. She should have taken a little more time to consider her alternatives and move safely.

USE OF MEDIA

In the literature review, we pointed out that the mass media has been blamed for spreading false, incomplete, or incorrect information about earthquakes, in general as well as when they occur, while simultaneously being viewed as almost godlike in its potential impact on individuals and populations. Whether right or wrong, all these scenarios assume that individuals and groups turn to the media as their first, best, and undisputed source of information about what to do in preparation for disasters, what has happened in a disaster, and what they should do after a disaster. The recommendation that people should invest in battery-operated radios for use during and after a disaster

reflects, in part, this deification of the power and value of mass media. In fact, how valuable are radio and television in the aftermath of an earthquake?

We did not collect data that allowed us to describe the content of media coverage, evaluate its adequacy, or assess the extent to which our respondents used information transmitted by the media. As reported above, we do know whether respondents attempted to use the media. We also know what they considered their best source of information on the day of the earthquake and afterward, and whether respondents owned battery radios at the time of the earthquake. Clearly, if people do not turn on a television or radio, they cannot progress to the second step of listening to it, or the third step of utilizing and evaluating any of the information provided.

Because of the World Series, we assumed that more people than normal had either radios or television sets turned on when the earthquake occurred on October 17. Forty percent of our sample did indeed have either a radio or television set on. This group tended to be at home at the time of the earthquake and, consistent with being at home, tended to be older and less well educated. When the earthquake occurred, an additional 30 percent of our respondents attempted to turn on a radio or television set. Contrary to other research that would predict that persons of higher socioeconomic status would be more likely to seek information, information-seeking did not differ with demographic characteristics of respondents. Consistent with media dependency theory and behavior following the Mount St. Helens eruption, the need for information appears to have existed for everyone in our sample regardless of factors which normally predispose an individual to seek information (for example, Hirschburg and others, 1986). Media-seeking did differ with who a person was with and where they were. It is particularly interesting to note that those who were alone or with children—the two groups one might hypothesize would be in greatest need of information—were least likely to seek it. This was in spite of being in private homes which were the most conducive location for obtaining access to a radio or television.

It is also interesting to note that those who were already tuned in to radio or television and those who were not tuned in did not differ in their propensity to remain tuned in or to seek access. Sixty-four percent of those who were tuned in and lost their signal and 64 percent of those who were not tuned in at the time of the earthquake sought information from either radio or television. This suggests that a substantial proportion of the population does consider radio and television an important source of information during an emergency. Seventy percent of our total sample (n=472) had access to the media either at the time of the earthquake or immediately after it occurred. Eighty percent of this group (n=387) actively sought access.

This information, in combination with other information available in this data set, suggests that persons who are already "tuned into" the media, either in the sense that they use it for entertainment or see it as a source of important information, are the ones that turn to it in a disaster situation. For example, it is interesting to examine the behavior of the 70 percent of this sample who said they already had a battery-operated radio at the time of the earthquake, since ownership of a battery-operated radio can indicate both valuation of media and acceptance of principles espoused in disaster preparedness. Those with battery-operated radios were more likely to have a radio or television on when the earthquake occurred and, if not, were also more likely to try to tune in radio or television after the earthquake. Seventy-four of the 244 persons who owned a battery-operated radio but who did not have either radio or television on when the earthquake occurred specifically used a battery-operated radio, whereas an additional 43 used a car radio after the earthquake occurred; 30 percent made no effort to turn on media. Of the 125 persons who neither had a battery-operated radio at the time of the earthquake nor purchased one afterwards, 36 percent (n=45) made no effort to obtain information from the media.

At the time of the interview, respondents were asked what their best source of information was on the day of the earthquake. Although 30 percent (n=184) of the sample did not turn on a radio or television at the time of the earthquake, many of them (n=156) still cited radio or television as their best source of information on October 17. Many of these people undoubtedly turned on radios or television sets later in the evening, but we suggest that others accessed the media indirectly through friends and relatives. Thus, even for those persons for whom media were not a source of immediate information, broadcasters had the potential of influencing what residents of the Bay Area did and when they did it. Only 8 percent of our respondents cited a "best" source of information other than radio or television on the day of the earthquake. Some of these persons had access to emergency communications either because they were emergency personnel or because they had access to groups such as police or other emergency personnel. Radio was cited as usually the best source of information by those in San Francisco-Oakland (63 percent) and Santa Cruz (67 percent), whereas television was cited by those in the rest of the five-county area (52 percent). In the days following the earthquake, television became the primary source of information for everyone regardless of area (59.5 percent), newspapers became the second important source (21.6 percent), and radio was cited as important by 14 percent of the sample.

Clearly our findings suggest that radio and television have the potential to be a major source of information before, during, and after an earthquake. At 5:00 p.m. on a weekday a substantial plurality of the population apparently has a radio or television on, regardless of where they are. In the event of an earthquake or other extraordinary

event, a sizable additional group seeks information from the media. Still others obtain information as time passes. Even those who do not actively seek information, at least immediately, cite radio and television as a major, important source of information. The task, then, for practitioners and policymakers is to determine how media might most productively be used in earthquake preparedness, response, and recovery, and how the media might be recruited to the task.

EVACUATION

We usually think of evacuation as being a behavior that occurs when damage to buildings or utilities is severe enough to pose a threat to the physical safety of inhabitants. Indeed, past research has focused on ensuring that people respond to warnings when danger is imminent. This data set suggested, however, that evacuation also occurs in response to other concerns and that evacuation sometimes may be unnecessary, dysfunctional, or even counterproductive to the goals of disaster response institutions. Although a majority of our respondents, regardless of geographic area, experienced loss of one or more utilities, and substantial numbers experienced some damage to their homes, evacuation behavior only partially reflected these disruptions. Three groups of evacuees or potential evacuees of interest to policymakers and practitioners can be identified in these findings: those who evacuated because of substantial loss of utilities or structural damage, those who experienced problems comparable to many in group one but who chose to remain in their homes, and those who evacuated despite reporting no overt property damage sufficient to cause evacuation.

The first group, those who evacuated because of damage to property or utilities, is the group that we would expect to find dislocated in the aftermath of an earthquake. Although some may overstate damage in order to justify their decision to leave, most are, after all, the group that disaster workers are trained to deal with. This is the group for whom we expect to provide services.

Less is known about the second group, but they are of interest for a couple of reasons. First, what is it about their circumstances that allows them to remain in their homes? Do they have no alternative? Or, do they ignore real dangers to self and others in an effort to protect property or to deny the extraordinary nature of the event? These preliminary findings suggest that in the Boulder Creek-Santa Cruz-Watsonville area, many respondents may have stayed in their homes because they had no alternative. For example, although the amount of damage reported by respondents in Santa Cruz suggests that as many as 30 persons might have evacuated because of structural damage to their homes, only 19 persons actually evacuated for such reasons. Similarly, more than half the Santa Cruz respondents reported having two or more utilities out, yet only nine persons reported evacuating for that reason. Thus, it is possible that some respondents simply had no alternative and had to stay in their homes. Other possible explanations are that, even when alternatives existed, respondents stayed in their homes either because of concerns about their property or because they denied the extent of the damage. Finally, there is the possibility that some subset of persons who evacuate—even when structural damage or utilities are cited as the reason—do so when it really is not necessary. Evidence in support of this last possibility comes from a number of sources, including our third group.

Although close to half of the sample, regardless of geographic area, said that their electricity went out, very few respondents found it necessary to evacuate when only their electricity was out. Yet, even in Santa Cruz, where we have suggested that alternative locations for evacuees may have been limited, seven persons stated that they left their homes only because their electricity went out. Whether evacuation under such circumstances represents an overreaction on the part of this group or simple prudence remains for further analysis.

While substantial numbers of reported evacuations in the Santa Cruz area occurred because of at least superficial evidence of damage to structures or utilities, most of the evacuations reported by the rest of the sample occurred because the respondents were upset. Of interest is what this means for practitioners and policymakers. On the one hand, as long as persons who evacuate for such reasons stay out of the way of officials who need access to roads, telephones, and other facilities in order to insure prompt response to groups that need it, we could argue that such evacuations are of no concern to officials. On the other hand, the evacuation behavior of such individuals may be masking other kinds of problems that will ultimately become the concern of officials. For example, in our study after the 1987 Whittier Narrows earthquake, only 20 persons reported evacuating (Bourque and others, 1991). Nineteen of those persons said that they left their homes only because they were upset. At the time of the Whittier Narrows interviews, this group of evacuees was significantly more psychologically distressed, as measured using a standard measure of psychological symptomatology, than were those who did not evacuate. Thus, the decision to evacuate and the reason for evacuation may be an important signal in targeting those at risk of psychological distress following a disaster. The data reported here suggest that there are two different groups of evacuees. The first group evacuate 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. It is quite clear that persons' reports that they "evacuated" cannot be straightforwardly

accepted to mean that damage to homes or to utilities necessitated that they leave their homes for personal safety.

SUMMARY

Telephone interviews were conducted with 656 residents of five counties in the San Francisco Bay Area an average of 224 days after the Loma Prieta earthquake. Analyses examined where respondents were, who they were with, what they did at the time of the earthquake, their exposure to radio and television during and immediately after the earthquake, loss of utilities, damage to homes and personal property, and evacuation behavior following the earthquake. Respondents' reports of what they did at the time of the earthquake differed with whether they were in a private home. Most persons reported seeking protection, freezing in place, or other adaptive behaviors. At the time of the earthquake, 40 percent of respondents had radios or televisions turned on. An additional 30 percent sought information from the media after the earthquake occurred. Attempts and the ability to obtain access to media differed with whether persons were at home or elsewhere and with their proximity to the epicenter. Persons in the Santa Cruz and Oakland areas were most likely to use battery radios or car radios on the day of the earthquake and to report that radios were their best source of information.

Reports of damage to homes, personal property, and utilities varied with proximity to the epicenter, with those in the Santa Cruz area being most likely to report disruptions. Loss of utilities or structural damage did not necessarily result in evacuation. Many fewer persons evacuated than reported damage, and of those who evacuated, many left their homes because they were upset.

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PUBLIC RESPONSE

CITIZEN PARTICIPATION IN EMERGENCY RESPONSE

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CONTENTS

ABSTRACT

This report describes public involvement in Santa Cruz and San Francisco Counties during the first several days after the Loma Prieta earthquake. Additionally, the public's experience with the earthquake and the resulting damage that was incurred are described. Finally, differences in public response to the disaster are explained. It is concluded that the level of victimization and not collective identity determined public involvement in response to the disaster.

INTRODUCTION

A recurring and common theme of sociological investigations of disasters has been that mass emergencies create a consensus of opinion out of which emerges an altruistic collective emergency response. Early empirical work (see Kutak, 1938; Wallace, 1956), initial attempts to theorize upon the empirical observations of others (see Barton, 1970; Fritz, 1961, 1968; Demerath and Wallace, 1957), efforts to catalog research findings (Drabek, 1986; Mileti and others, 1975), and assessments from purely theoretical viewpoints (Wenger, 1985; Turner and Killian, 1986) agree that emergencies produce norms that foster helping behavior and a therapeutic community response (Barton, 1970). Although often stated in the published record, Dynes (1970, p. 84) has provided an articulate summarizing statement:

> disasters create unity rather than disorganization. The consequence of a disaster event on a locality is in the direction of the "creation" of community, not its disorganization, because during the emergency period a consensus of opinion on the priority of values within a community emerges; a set of norms which encourages and reinforces community members to act in an altruistic fashion develops; also, a disaster minimizes conflict which may have divided the community prior to the disaster event.

Additionally, Gillespie (1988) has called for a statistical test of this long-standing theory. Finally, the reasons why disasters minimize community conflict have been cataloged (Dynes and Quarantelli, 1971, as summarized in Drabek, 1986, p. 180):

> Conflict in a disaster community is minimized because: (1) the precipitating event is outside the community system, (2) a consensus on a hierarchy of values quickly emerges within the community, (3) emergency period problems require immediate and apparent actions, (4) disasters produce a "present" orientation which minimizes previous memories of and future opportunities for conflict, (5) disaster reduce status differences, (6) disaster tend to strengthen community identification.

The theoretical basis for observed therapeutic collective response to disaster is linked to the concept of symbolization. Disasters create an image that is simple, compelling, and shared by those who experience the event (Turner and Killian 1986, p. 64). The shared image or symbol becomes a point of object (Blumer, 1951), or a generalized belief (Smelser, 1962), which simplifies an otherwise complex situation that then facilitates human action. More elaborate reviews of the theoretical bases for altruistic disaster response are available from Wenger (1985), Quarantelli (1978), and others. Nevertheless, it seems clear that symbolization of a disaster as an object is central to involvement in collective action.

Symbolization and objectification need not only result from experiencing the event. They can also result from exposure to media accounts of the disaster (Barton, 1970, p. 217), since empathy for victims and media-induced symbolization can result in nonvictim objectification and subsequent collective action.

Consequently, it was hypothesized that citizen involvement in response to the Loma Prieta earthquake emergency would (1) result as a consequence of victimization and (2) increase as a consequence of factors which could enhance symbolization such as pre-event hazard salience and experience. It was also suspected that involvement in response to the emergency would not be influenced by demographic characteristics such as age, ethnicity, gender, socio-economic status, community integration, and role membership since symbolization and objectification would not vary by such structural characteristics.

POPULATIONS AND SAMPLES

Two populations were selected for study. San Francisco County was chosen because residents had high post-mainshock media exposure; the World Series had just began in San Francisco, and the many reporters present readily switched their efforts from sports to earthquake coverage. Santa Cruz County was selected because it was close to the earthquake's epicenter, because it experienced proportionately greater damage than did the Bay Area, and because the area almost experienced a media blackout due to earthquake damage during the first days of the emergency. A comparison of findings from Santa Cruz and San Francisco Counties would enable us to determine if public involvement in emergency response varied because of proportionate damage and media exposure.

A complete enumeration of residents and household addresses in San Francisco and Santa Cruz Counties was purchased from a private firm. These lists were relatively current since they are updated every 90 days. A systematic random sample of households was selected from each population list. A random number generator was used to determine random starts in drawing the samples from the population lists of 369,761 for San Francisco and 86,212 for Santa Cruz. The sampling fraction used was 1 out of 186 in San Francisco and 1 out of 44 in Santa Cruz. Different sampling fractions were used in order to obtain samples of similar size in the two study counties. These fractions produced sample sizes of 1,986 and 1,933 for San Francisco and Santa Cruz, respectively. These sample sizes are larger than the number needed to statistically represent the study populations. We oversampled both populations in order to achieve an acceptable number of completed responses after eliminating nonparticipants.

DATA COLLECTION

The questionnaire was constructed following the Dillman (1978) method to enhance response rates. It had a folded booklet format, a smooth flow of questions, and clear instructions and transitional phrases to make the instrument understandable. The first page of the questionnaire included the cover letter. The questionnaire was pretested on members of the general public, other colleagues, and members of a California earthquake organization who were familiar with both populations. The questionnaire was revised based on these pretests.

The questionnaire, cover letter, and return envelope were mailed to respondents twice. The first mailing occurred on June 6, 1990, and the follow-up mailing occurred on July 13, 1990. The response rate for San Francisco County was 41 percent, and it was 50 percent for Santa Cruz County; these response rates resulted in sample sizes of 734 and 918 for San Francisco and Santa Cruz, respectively (table 1). The original sample sizes were reduced for a variety of reasons including undeliverable mail, moved with no forwarding address, and so on.

The samples were assessed for representativeness by comparing observed sample characteristics with published data on the study populations (table 2). Comparisons were made in reference to gender, home ownership, age, ethnicity, and average household size. Income comparisons were not made since only out-of-date 1980 census data were available on this variable. An inspection of the data in table 2 suggests that the study samples were reasonably representative of the populations in reference to some factors, but not for others. For example, sample and population data on average household size were virtually identical; sample and population data on gender were very close, with the samples overrepresenting females only by about 3 percent; and the age distribution of respondents in the samples was close to those in the populations, especially when one considers that only heads-of-households or their spouses were asked to complete the questionnaire. Whites were overrepresented in the sample for San Francisco, but not in Santa Cruz. Ethnic groups were underrepresented in both samples; for example, Hispanic-American were underrepresented by about 8 percent in San Francisco and 4 percent in Santa Cruz. Ethnic group underrepresentation is not a surprise since the questionnaires were only in English. Additionally, renters were underrepresented by about 23 percent in San Francisco and by about 12 percent in Santa Cruz.

The samples contained some bias since they underrepresent ethnic groups and renters. This suggests that our descriptive study findings may be less than totally accurate and should be interpreted with some caution. Nevertheless, sufficient variation existed on all variables assessed in the study to insure that sample bias would not negatively affect hypotheses testing. Additionally, sample and population data were similar on other characteristics; this was likely the result of our inflated sample sizes.

DATA AND FINDINGS

The data were analyzed in order to answer three questions about public emergency response to the earthquake.

Table 1.—*Sample return rates*

Category	Sample for San Francisco	Sample for Santa Cruz	Total of both samples
Beginning total (n)	1,933	1,986	3,919
Undeliverable from first mailing	144	153	297
Undeliverable from second mailing	6	1	7
Returned too late for inclusion in data analysis	8	8	16
Total sample researched (n)	1,775	1,814	3,589
Total completed questionnaires	734	918	1,652
Response rate (pct.)	41	50	46

Table 2.—*Assessment of sample representativeness*

[Values in percent, except for "average household size"]

Characteristics	San Francisco		Santa Cruz	
	Sample	Population	Sample	Population
Gender[1]				
Female	54.1	51.2	54.1	50.7
Male	45.0	48.7	45.9	49.2
Home ownership[2]				
Own	47.0	33.7	71.7	59.5
Do not own	53.0	76.3	28.3	40.5
Age in years[2,3]				
25-34	27.8	24.5	20.8	22.5
35-44	25.4	13.0	29.1	13.9
45-54	17.6	9.5	16.3	7.8
55-64	9.7	10.2	11.8	8.4
65-74	9.2	8.0	11.2	6.8
75 and above	6.8	6.4	7.0	5.6
Ethnicity[2,4]				
White	73.7	58.2	90.4	90.5
Black	4.9	12.7	.4	1.9
Hispanic	4.1	12.3	4.5	8.7
Asian	12.7	21.7	2.1	2.6
Average[2] household size	2.1	2.1	2.4	2.5

[1]California Department of Finance, 1986, Population projections California counties 1980-2020: Sacramento, Calif., California Department of Finance.

[2]U.S. Bureau of the Census, 1988, City and county data book: Washington, D.C: U.S. Government Printing Office, p. 56, 59, 618.

[3]Age percentages do not add to 100 percent because ages 0-24 have been excluded from the comparison.

[4]Sample data on ethnicity do not add to 100 percent because of missing data and respondent membership in other ethnic categories.

What were people's experiences with the earthquake? What did people do in response to the earthquake? What factors explained differences in public earthquake emergency response?

EXPERIENCE WITH THE EARTHQUAKE

Almost everyone reported that they felt the earthquake; 99.1 percent and 96.9 percent of the respondents in Santa Cruz and San Francisco counties, respectively, reported that they felt the mainshock. Additionally, almost everyone had access to media coverage about the earthquake; for example, 91.7 and 85.7 percent of the respondents in Santa Cruz and San Francisco counties, respectively, reported that they had a working radio and listened to reports about the earthquake. Obviously, the earthquake was in some way experienced by almost everyone in both study counties. The few people who reported that they did not experience the earthquake were out of town when it happened; these respondents also reported that they immediately came back after hearing about it and consequently experienced the emergency.

Most people personalized the Loma Prieta earthquake disaster, whether or not they themselves suffered damage. Reported damage in Santa Cruz was higher than in San Francisco (table 3). For Santa Cruz and San Francisco, 4.7 and 46.9, respectively, percent, of respondents reported no damage to household items, and 13.4 and 37.7 percent, respectively, reported no damage to their residence; however, most respondents personalized the disaster by reporting damage to "their" neighborhood; 98.0 percent reported neighborhood damage in Santa Cruz and 85.3 percent reported it in San Francisco. These percentages suggest that even those who did not personally experience quake damage still perceived themselves to be quake victims. Almost a third of San Francisco respondents reported damage in their neighborhoods even though they experienced no personal damage; only 2.0 percent and 14.7 percent of Santa Cruz and San Francisco respondents reported no damage—household items, residence, or neighborhood—of any kind. The earthquake and disaster losses were personalized by almost everyone regardless of actual personal damage experienced.

People reported greater damage and losses in Santa Cruz than in San Francisco (table 3). For example, almost half of the respondents (46.9 percent) in San Francisco reported no personal damage, but almost everyone in Santa Cruz reported personal damage. Additionally, more damage of all kinds—slight, moderate, and severe—was reported in Santa Cruz than in San Francisco. Damage to household items was reported by 95.4 percent of Santa Cruz residents, whereas only 53.1 percent of San Francisco respondents reported such damage; damage to residences was reported by 86.6 and 62.3 percent of Santa Cruz and San Francisco respondents, respectively. Additionally, more losses of greater magnitude—for example, fallen walls, broken chimneys, uninhabitable dwellings—were reported in Santa Cruz than in San Francisco. Only 7.1 percent of San Francisco respondents reported moderate and severe damage to their residences, whereas such damage was reported by 35.5 percent of Santa Cruz respondents. This gap was even higher when damage to household items was considered. Only 10.0 percent of respondents in San Francisco reported moderate and severe damage to household items, whereas 60.5 percent of the respondents in Santa Cruz reported such damage. Almost 10 percent of Santa Cruz respondents reported that they had lost almost all of their household possessions; this was only reported by 3.8 percent of the respondents in San Francisco. The

Table 3.—*Types and distribution of damage reported by respondents in San Francisco and Santa Cruz Counties*

Reported damage	San Francisco		Santa Cruz	
	Percent	Number	Percent	Number
Neighborhood damage reported				
No damage	14.7	108	2.0	18
Slight damage (for example cracks in walls)	48.1	353	13.0	119
Moderate damage (for example fallen walls or chimneys)	20.7	152	50.0	459
Severe damage (for example uninhabitable residence)	16.5	121	35.1	322
Total	100.0	734	100.1	918
Residence damage reported				
No damage	37.7	277	13.4	123
Slight damage (for example cracks in walls)	55.2	405	51.1	469
Moderate damage (for example fallen walls or chimneys)	6.4	47	31.7	291
Severe damage (for example uninhabitable residence)	.7	5	3.8	35
Total	100.0	734	100.0	918
Household items damage reported				
No damage	46.9	344	4.7	43
Slight damage (several things)	43.1	316	34.9	320
Moderate damage (many things)	9.5	70	50.8	466
Severe damage (almost everything)	.5	4	9.7	89
Total	100.0	734	100.1	918

Table 4.—*Public involvement in emergency response activities*

[Respondents were able to select multiple categories in reference to emergency response activities performed]

Emergency response activity	San Francisco		Santa Cruz	
	Percent	Number	Percent	Number
No emergency activities performed	40.1	294	30.3	278
Search and rescue victims	2.7	20	4.8	44
Provided food and water to others	14.3	105	34.6	318
Provided shelter to others	11.6	85	18.2	167
Cleaned/removed debris	10.6	78	43.7	401
Helped evacuate victims	3.3	24	4.0	37
Counseled victims	8.2	60	16.6	152
Put out fires	.3	2	.7	6
Directed traffic	2.0	15	1.5	14
Provided medical attention to victims	1.9	14	3.6	33
Total		734		918

same pattern is revealed regarding injuries; 5.9 percent of the respondents in Santa Cruz reported that the earthquake injured a member of their household, whereas 1.4 percent of San Francisco respondents reported household-member injuries.

The earthquake caused more injuries, damage, and direct losses in Santa Cruz than in San Francisco, but almost everyone in both counties experienced the event, were exposed to media reports about the disaster, and personalized the event regardless of experienced personal losses.

PUBLIC RESPONSE TO THE EMERGENCY

Despite relatively large differences in the amount of damage experienced in Santa Cruz and San Francisco, a large majority of the citizens in both counties—about 70 and 60 percent in Santa Cruz and San Francisco, respectively—participated in some sort of emergency response activity (table 4). On the assumption that we can generalize from our samples to the study populations, some 450,000 and 200,000 people in San Francisco and Santa Cruz, respectively, engaged in emergency response activities. For example, approximately 107,000 and 83,000 people in San Francisco and Santa Cruz, respectively, provided food and water to victims; 61,000 and 10,000 helped to council victims; and 20,000 and 11,500 engaged in search and rescue activities.

The greater the community need, the more likely people were to get involved in performing emergency response tasks and to do them for a longer period of time. There was more damage in Santa Cruz than in San Francisco, and a larger portion of Santa Cruz respondents reported being involved in response activities than in San Francisco. The percent of respondents providing medical attention to others was 3.6 versus 1.9 percent in Santa Cruz and San Francisco, respectively, whereas it was 43.7 and 10.6 percent for clearing debris, 16.6 and 8.2 percent for counseling victims, 18.2 and 11.6 percent for providing victims with shelter, 34.6 and 14.3 percent for giving people food and water, and it was 4.8 and 2.7 percent for being involved in search and rescue activities. Additionally, Santa Cruz respondents were more likely to engage in these activities for a longer period of time: 54.5 percent of Santa Cruz respondents engaged in these activities for fewer than 24 hours, whereas 11.5 percent helped for more than 24 hours; 34.5 percent of San Francisco respondents helped for less than 24 hours and 3.7 percent participated for a longer period of time. Members of the public in both communities were very willing to help with emergency response and provide assistance, but the proportionately greater need for help in Santa Cruz likely resulted in involving proportionately more people and for a longer period of time.

People were also more likely to help others in ways that required one-on-one interaction with other victims than in indirect ways; these activities included: giving victims food and water, providing shelter, and giving council to victims. The only exception to this finding was clearing debris: 43.7 percent and 10.6 percent of respondents in Santa Cruz and San Francisco, respectively, reported debris-clearance involvement. The large portion of citizen involvement in debris clearance in Santa Cruz was likely demanded by the circumstances of there being so much debris caused by the earthquake.

The public was also inclined to direct their emergency response activities toward nonskilled tasks. Response activities requiring specialized skills were the least likely to be performed in both counties, whereas nonskilled tasks were the most likely to be performed (table 4). For Santa Cruz and San Francisco, respectively, the percentage of re-

spondents engaging in tasks that could require special skills were low: 4.8 and 2.7 percent for search and rescue, 4.0 and 3.3 for helping victims evacuate, 0.7 and 0.3 percent for putting out fires, 1.5 and 2.0 percent for directing traffic, and 3.6 and 1.9 percent for providing medical attention. However, the percentage of respondents participating in nonskilled tasks was relatively higher; respectively for Santa Cruz and San Francisco the number of respondents engaged in providing food and water was 34.6 and 14.3 percent, 18.2 and 11.6 percent for giving others shelter, 43.7 and 10.6 percent for clearing debris, and 16.6 and 8.2 percent counseled victims.

About two-thirds of the public in both counties got involved in some sort of earthquake emergency response activity. Involvement was in direct proportion to the emergency work demands that the earthquake imposed on the community. Additionally, people were more likely to help by engaging in activities that brought them into direct contact with other victims, and in ways that did not require specialized skills that many of them may have lacked. The earthquake was not only personalized by almost everyone, it also elicited an outpouring of identification with victims as people sought to help one another, and they helped in ways that they could and in proportion to what needed to be addressed.

ACCOUNTING FOR DIFFERENCES IN PUBLIC RESPONSE

Everyone did not get involved in emergency response, and in this section we explain why. Multiple regression analysis was performed to determine the relative effects of different explanatory factors on pubic involvement in response. The model proposed cast public emergency response involvement as a consequence of pre-earthquake cognitions such as pre-event salience of the hazard and pre-event earthquake experience; the amount of damage experienced in the mainshock; and standard socio-demographic differences between people that existed prior to the quake. These included level of community integration, being in roles of responsibility for others, age, ethnicity, gender, and socio-economic status. The variables used in the multiple regression analysis were measured and scaled as follows.

MEASUREMENT

The first concept in the model (X_1) was pre-event earthquake salience. It was measured by asking respondents: "Prior to the October earthquake had you ever done anything to prepare for an earthquake?" Responses to this question were coded as a dummy variable.

Pre-event earthquake experience (X_2) was measured and responses were coded for analysis as follows. Respondents were asked about the severity of the largest earthquake they had ever experienced prior to the Loma Prieta quake. Responses were coded as 0="I have never experienced an earthquake," and (or) "I felt it but it caused no damage," versus 1="I have experienced an earthquake and it caused either slight damage (for example, cracks in walls), and (or) moderate damage (for example, fallen walls or chimneys), and (or) severe damage (for example, dwelling uninhabitable)."

Loma Prieta earthquake damage (X_3) was scaled as a composite index of damage to neighborhood, residence, and household items. Respondents were asked if the earthquake caused any damage to their household items, their residence, and to their neighborhood. Responses were coded dichotomously as 0=no damage and (or) slight damage (for example, cracks in walls or several household items damaged) versus 1=moderate (for example, fallen walls or chimneys or more than several household items damaged), and (or) severe damage (for example, almost all household items damaged or uninhabitable residence).

Community integration (X_4) was intervally coded as the number of years that respondents had lived in their current residence. The question asked was: "Before the earthquake, how many years had you lived at your residence?"

The concept of roles of responsibility (X_5) was measured by asking people "Including yourself, how many people for whom you are responsible reside in your household?" The responses to this question were coded intervally, as was the age (X_6) of respondents.

Respondent ethnicity (X_7) was measured by asking the following question. "Which best describes your racial/ethnic identification?" The provided answer categories—Chinese, Japanese, other Asian, African-American, Hispanic, White, and other—were collapsed for analysis into 0=other and 1=white. Gender (X_8) was coded as 0=female and 1=male.

Socio-economic status (X_9) was scaled as a composite index of the respondent's education, household before-tax income, and occupational prestige. Each of these measures was transformed into a dummy variable so that the three could be summed to form a scale for socio-economic status. Education was dichotomized at the less-than high school versus high school graduate division; income was divided at $14,999 or less a year versus $15,000 and above; and occupational prestige was separated into manual and skilled labor jobs versus sales, service, managerial, and professional occupations.

Finally, earthquake emergency response (X_{10}) was measured by asking respondents: "In the first 24 hours after the earthquake, did you in any way (officially, unofficially, or as a volunteer) do any of the following emergency activities?" The list of activities from which respondents could choose included searched for and rescued victims, provided food and water to others, provided shelter to others cleared/removed debris, helped evacuate victims,

counseled victims, put out fires, directed traffic, and provided medical attention/first aid to victims. Responses were coded as dummy variables, and then added to create a scale that varied between 0 and 9.

RESULTS

The results of the analysis to predict involvement in emergency response were almost identical in the San Francisco and Santa Cruz samples (table 5), and our findings follow. First, many of the standard socio-demographic differences that distinguish people from each other in non-earthquake circumstances—for example, ethnicity, gender, socio-economic status, level of community integration, being in roles of responsibility for others such as having children, and so on—made no difference in influencing who did and who did not help with emergency response after the earthquake (table 5). All of the regression coefficients for these factors were not statistically significant in either Santa Cruz or San Francisco.

Second, the explanatory factor that had the strongest positive effect on explaining involvement in emergency response was the same in both study counties. This factor was the amount of damage experienced in the mainshock. The regression coefficient for the effect of mainshock damage experienced on emergency response (X_3) was 0.22 in San Francisco and 0.17 in Santa Cruz. This suggests that the more damage that was personally experienced, the more likely people were to help others.

Third, older age was a major constraint to becoming involved in emergency response. The regression coefficient for the effect of age on response (X_6) was –0.17 and –0.14 in Santa Cruz and San Francisco, respectively. It appears that being older kept people from participating in response. This was likely due to the physical demands that responding to an emergency require, or perhaps older people symbolized the disaster in a unique way.

Fourth, pre-earthquake hazard salience was measured by being concerned enough about the hazard to have performed actions to mitigate risk and prepare. Persons for whom the hazard was more salient before the earthquake were more likely to become involved in emergency response than persons for whom the hazard was less salient. The regression coefficient for this relationship (X_1) was 0.10 in Santa Cruz and 0.11 in San Francisco.

Fifth, pre-Loma Prieta earthquake experience was measured by having experienced damage in a prior earthquake; it increased the likelihood of becoming involved in emergency response in San Francisco (the regression coefficient for X_2 was 0.14), but not in Santa Cruz (the relationship was not statistically significant) (table 5). The effect of having experienced damage in a prior earthquake on enhancing the probability of engaging in emergency response after the Loma Prieta event likely held in San Francisco because about half of that population (46.9 percent) did not have any damage in the Loma Prieta earthquake and the impact of prior events was able to influence behavior. However, almost everyone in Santa Cruz—95.3 percent of the population—had damage from the earthquake. Consequently, the possible effect of pre-Loma Prieta earthquake damage may have been overshadowed by the widespread damage brought about by that event.

Table 5.—*Multiple regression analysis for explanations of public involvement in emergency response*

[N/S, not significant]

Variables[1]		San Francisco[2]		Santa Cruz[3]	
Dependent	Independent	Coefficient	Significance	Coefficient	Significance
X_{10}	X_1	0.11	.01	0.12	0.00
	X_2	.14	.00	--	N/S
	X_3	.22	.00	.17	.00
	X_4	--	N/S	--	N/S
	X_5	--	N/S	--	N/S
	X_6	-.14	.00	-.17	.00
	X_7	--	N/S	--	N/S
	X_8	--	N/S	--	N/S
	X_9	--	N/S	--	N/S

[1] X_1 = pre-event earthquake salience, X_2 = pre-event earthquake experience, X_3 = earthquake damage, X_4 =community integration, X_5 = roles of responsibility, X_6 = age, X_7 = ethnicity, X_8 =gender, X_9 = socioeconomic status, and X_{10} = emergency response.
[2] Total explained variance for the San Francisco sample was 13 percent.
[3] Total explained variance for the Santa Cruz sample was 9 percent.

These findings suggest that being an earthquake victim—in terms of damage experienced from the Loma Prieta event and (or) damage experienced in prior earthquakes—was the main reason why people were motivated to help other victims after the Loma Prieta earthquake. Additionally, pre-disaster hazard salience also led people to help others after the earthquake; that is, having engaged in actions to address the hazard before the disaster fostered engaging in actions to address the impacts of the hazard during the disaster. These findings held regardless of the social and economic differences that distinguish people from one another in nondisaster contexts, for example, ethnicity, socio-economic status, gender and so on. The one exception was that being older in age constrained becoming involved in responding to the emergency, and this may have only held because of the physical demands of emergency response.

CONCLUSIONS

The Loma Prieta earthquake was personalized and symbolized by almost everyone, and this personalization occurred regardless of the amount of actual damage that people experienced. In essence, almost everyone identified with the disaster. Additionally, public involvement in responding to the emergency was in direct proportion to the level of disaster-induced need that existed at the community level: the greater the demand for work in a community, the more individuals became involved in performing response activities and the longer they worked to perform

them. Finally, it seems apparent that being a victim increased the odds of helping other victims.

These conclusions are not a theoretical surprise. It has been long established in the field of collective behavior in general, and in the area of disaster research in particular, that community-wide disasters elicit a therapeutic community response in which disaster victims rise to the occasion and help other victims during the immediate emergency period. This was certainly the case in response to the Loma Prieta earthquake.

Public response to the earthquake may also suggest a theoretical refinement. Our findings suggest that collective identification with the disaster-stricken community is indeed widespread and shared among all community residents—be they direct victims of the disaster or not—as is generally accepted in the research and theoretical literatures. However, our data also suggest that collective identification—symbolization and objectification—may not directly lead to collective disaster response. It appears that the degree of victimization experienced played a major role in determining the likelihood of a person becoming involved in and the amount of time devoted to response. Consequently, collective identification may be a necessary but not a sufficient cause for collective action in response to disaster. It is possible that the degree of victimization experienced may be the better predictor of the degree of collective action observed than is objectification, as is generally theorized.

Our findings also provide some practical insights for earthquake disaster emergency preparedness. For example, victims are an obvious and readily available resource in responding to earthquake disasters, and it is unlikely that the natural tendency for victims to help victims will cease to operate in future earthquake disasters. As was pointed out by Gillespie and Perry (1976), existing preparedness efforts to take advantage of emergent public activities to help others seem well placed.

Additionally, current efforts to motivate communities at risk to take pre-earthquake steps to mitigate and prepare for future earthquakes, if successful, may also function to increase the number of people who engage in emergency response after the occurrence of a future earthquake disaster. Also, despite the willingness of victims to offer help to other victims, people may generally opt for offering assistance in line with activities that they are able to perform. Training to provide skills to people who are likely to experience earthquake disasters in the future may well result in an increase in the amount of skilled emergency response services that victims provide to other victims. Our data suggest that training the public in specialized emergency response skills will likely be worthwhile.

Finally, the greatest needs and problems that must be addressed by organized government response to earthquake disasters may indeed be those generated by victim members of the public. Nevertheless, the victims may be best viewed as part of the solution rather that solely as the source of problems.

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PUBLIC RESPONSE

PUBLIC RESPONSE TO AFTERSHOCK WARNINGS

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CONTENTS

ABSTRACT

This report is on public response to aftershock warnings after the Loma Prieta earthquake. The report reviews the short- and long-term aftershock warnings issued to the public after the earthquake. The results of past research are then synthesized into hypotheses tested in this research. Descriptive findings about public aftershock warning response in both San Francisco and Santa Cruz Counties are then reported. Finally, the causal theory of risk communication was tested on public perception of risk and response to aftershock warnings during the post-impact Loma Prieta earthquake emergency. Findings from samples of households in Santa Cruz and San Francisco Counties were consistent, confirm established propositions, and suggest theoretical refinement. It was concluded that the social psychological process which explains post-impact public warning response is not identical to the one which explains public response to pre-impact warnings. The lack of mainshock damage created a "normalization bias" for nonvictims. This bias limited their perception of risk to damaging aftershocks and protective response to warnings.

INTRODUCTION

Loma Prieta earthquake damage was relatively great in the Santa Cruz area, and difficulties were experienced there in receiving information and news coverage. The earthquake was felt as far south as Los Angeles, the Oregon-California state line to the north, and western Nevada on the east. It caused 62 deaths, injured 3,757 people, left more than 12,000 people homeless, and 18,306 homes and 2,575 businesses damaged. Economic impacts exceeded $6 billion dollars, owing to interruptions in transportation, utilities, and communications. The earthquake was the most costly natural disaster that the United States has experienced since the Great San Francisco Earthquake of 1906 (U.S. Geological Survey, 1989a).

The mainshock was 7.1 in magnitude and was followed with concern over damaging aftershocks. Public aftershock warnings were issued during the emergency and for 2 months thereafter. The first warning was issued at 7:15 a.m. on October 18th. It stated (U.S. Geological Survey, 1989a)

> An analysis of historical earthquake sequences in the past 50 years in California suggests that there is a 1 to 2 in 10 (10 to 20 percent) probability of a M6 or larger aftershock in the first 24 hours following the mainshock and diminishing thereafter.

A different warning appeared in the *San Francisco Examiner* for the same time period (San Francisco Examiner, October 18, 1989). It stated that a possibility existed for a 7.0 magnitude aftershock in the first 24 hours following the mainshock. The U.S. Geological Survey did state that there was a possibility for a 7.0 magnitude or greater earthquake on an adjacent fault in the first 24 hours after the mainshock. They declared (U.S. Geological Survey, 1989a):

> Although the likelihood is remote, there is also a possibility of a M7 or greater earthquake in the coming days on an adjacent segment of the San Andreas Fault.

Another aftershock warning was issued for the 24- to 48-hour period after the mainshock at 5:00 p.m. on October 18. It stated (U.S. Geological Survey, 1989b):

As of Wednesday at 5:00 p.m. PDT, there is only a 2 percent chance of a magnitude 6.0 or larger aftershock in the next 24 hours. In the same period, the probability of a magnitude 5.0 or larger aftershock is 13 percent.

A third aftershock warning was issued on October 21, three days after the mainshock. This warning was made public at 7:00 a.m.; it reduced the probability of a 5.0 magnitude aftershock to 8 percent (U.S. Geological Survey, 1989c):

At this time there is only about a one percent chance of a magnitude-6 or larger aftershock in the 24-hour period beginning at 7:00 a.m. PDT today. The chance of a magnitude 5 or larger aftershock in the same 24-hour period is eight percent.

Finally, one full week after the earthquake, the U.S. Geological Survey issued another warning which was in effect for the balance of the year (U.S. Geological Survey, 1989d):

Seismologists advise that additional aftershocks are expected in the next few weeks to months, some possibly strong enough to cause additional damage, especially to structures weakened in last Tuesday's quake.

These warnings provided an opportunity to test risk communication theory about public response to communicated warnings issued during an ongoing disaster for the first time. This theory has been built upon investigations of public response to risk information disseminated before disaster strikes (see Mileti and Sorensen, 1990; Drabek, 1986; Mileti and others, 1975). However, a case has never been examined when public attention is diverted by a disaster just experienced.

THEORY AND HYPOTHESES

Communicating information about risk to the public occurs for different reasons, for example informing people about the citing of hazardous waste facilities (Kasperson, 1986) or providing warnings of impending disaster (Perry and others, 1981). The latter involves the communication of information to the public when a risk exists in the immediate future, such as for aftershock warnings.

People who receive warnings of risk typically go through stages that shape their risk perceptions and behavior. This process is often modelled as a sequence; for example, hear-confirm-understand-believe-personalize-respond. The sequence may not be the same for every person, and each stage can be affected by characteristics of the people who hear warnings. These characteristics include age, gender, level of education, and other demographics, as well as the characteristics of the information, such as how frequently it is repeated, the source, and so on.

The process begins when someone hears the risk information that is communicated. Second, people then typically attempt to confirm the warning, for example by checking with other people or seeking information from an alternative medium. Third, an understanding of risk is formed; individual meanings are attached to the information heard. The fourth stage is belief that the risk information received is accurate and that it is germane to the receiver. Usually, an individual must believe and personalize a warning in order to act. Fifth, people decide what to do and then perform that behavior. A person typically goes through the stages of the model each time that new warning or risk information is received. Response to communicated risk information thus follows from a series of perceptions.

Research has documented the characteristics of the people who receive warnings that impact how they process risk information. These characteristics are the information receiver's (1) environment, (2) social attributes, and (3) psychological attributes. Relevant attributes of the receiver's environment when the warning is received include physical and social cues; for example, if it is raining when flood warnings are received, or if neighbors are seen evacuating in concert with hearing evacuation advisements.

Social attributes of the receiver include (see Sorensen and Mileti 1987) (1) network characteristics such as whether or not the family is united, social ties and bonds, and having nearby friends and relatives (Clifford, 1956; Quarantelli, 1980; Turner and others, 1981; Perry, 1982, 1987; Bellamy, 1987; Cutter, 1987); (2) resource characteristics such as having access to a car in which to evacuate or economic resources to pay for a hotel (Lachman and others, 1961; Dynes and others, 1979; Flynn, 1979; Mileti and others, 1981); and (3) demographic characteristics, such as sex, age, ethnicity and social class (Moore and others, 1963; Gruntfest, 1977; Wilkinson and Ross, 1970; Flynn and Chalmers, 1980; Yamamoto and Quarantelli, 1982; Perry and others, 1982).

Significant psychological attributes of the risk information recipient are pre-warning knowledge about the risk and protective actions (Sorensen, 1982; Cutter, 1987); pre-warning cognitions such as locus-of-control of the recipient (Sims and Bauman, 1972; Turner and others, 1981; Perry, 1987); and experience with the hazard agent, for example, type and recency of experience (Wilkinson and Ross, 1970; Perry and others, 1980; Tonn and others, 1990). More elaborate summaries are available elsewhere (see Perry, 1982; Drabek 1986; Sorensen and Mileti, 1987), and the following conclusions illustrate how aspects of the risk information received can affect public behavior. The public can better understand communicated emergency risk information if it has the following characteristics: if it is specific regarding the hazard, what the public should do and how much time is available before impact (Drabek and Boggs, 1968; Perry and others, 1980; Quarantelli, 1984); if it is communicated over multiple channels (Turner and others, 1981; Rogers, 1985) and is frequently repeated (Turner and others, 1979; Turner,

1983; Rogers, 1985; Mikami and Ikeda, 1985); if it is from official sources (Quarantelli, 1980); and if it is confirmed (Hammarstrom-Tornstam, 1977; Perry, 1982).

Public belief in communicated emergency risk information is enhanced by similar factors. Specific information is more likely to be believed (Drabek, 1969; Sorensen, 1982; Perry and Greene, 1982; Quarantelli, 1984), as is information that is consistent (Demerath, 1957; Mileti, 1975; Turner and others, 1981; Keeney and von Winterfeldt, 1986), certain (Turner and others, 1979; Perry, 1982; Mileti and others, 1981), frequently delivered (Drabek and Boggs, 1968; Mileti and Beck, 1975; Turner, 1983; Perry and Greene, 1983), from official sources (Quarantelli, 1980; Perry and Greene, 1983; Rogers and Nehrevajsa, 1984; O'Riordan and others, 1989), and then confirmed (Danzig and others, 1958; Drabek, 1969; Perry, 1982; Quarantelli, 1984).

Findings regarding public risk personalization are almost identical to those just reviewed. In brief, personalization of risk is enhanced by information which is specific (Perry and others, 1983), consistent (Foster, 1980), personally delivered (Perry and others, 1980), frequently repeated (Mileti and Beck, 1975), from official sources (Perry, 1979), and confirmed (Hodler, 1982).

Finally, what people do in response to warnings has been documented to be affected by the situational perceptions of risk which people form, and communicated risk information which is specific (Dynes and others, 1979; Perry and Greene, 1982; Houts and others, 1984), clear (Quarantelli, 1980), delivered personally (Gray, 1981), frequently repeated (Fritz and Marks, 1954, Gruntfest, 1976; Perry, 1982), and then confirmed (Drabek, 1969; Liek and others, 1981).

The above research conclusions can be readily synthesized into a theory of public perception and response to risk information, and it can be summarized as follows. Public response to communicated risk information is a direct consequence of perceived risk (understanding, belief, and personalization), the warning information received (specificity, consistency, certainty, accuracy, clarity, channel, frequency source, and so on), and personal characteristics of the warning recipient (demographics, knowledge, experience, resources, social network, cognitions, and so on); and perceived risk is a direct function of both the warning information received and the personal characteristics of the warning recipient. However, several additional hypotheses were added to this model before it was tested. It was necessary to account for the fact that we sought to study public response to risk information that was issued in the context of an ongoing emergency.

Disasters precipitate increased public activity, altruism, and collective identification with victims and community (see Wenger, 1985; Barton, 1970; Fritz, 1961) and theorists have offered varied explanations for why. These explanations include a value-added approach based on a generalized belief (Smelser, 1962), emergent norms (Turner and Killian, 1987; Turner, 1964a, b), symbolization (Drabek and Quarantelli, 1967), emergent social systems (Barton, 1970; Zurcher, 1968), crisis consensus (Dynes and Quarantelli, 1971), and others. Despite alternative emphases, there is agreement that disasters produce community cohesiveness and that people are drawn together in ways which deflate individual motives for behavior in favor of serving collective goals. Consequently, it was hypothesized that experiencing damage during the mainshock would increase the probability of involvement in emergency response—for example helping to rescue people or providing food and water to victims; that involvement in emergency response would divert attention from the receipt of aftershock warnings; and that the more people were involved in responding to the earthquake disaster just experienced, the less likely that they would be to perceive risk from aftershocks and to respond to aftershock warnings with personally motivated protective actions.

POPULATIONS, SAMPLES, AND DATA COLLECTION

Two populations were selected for study. San Francisco County had high post-mainshock media exposure since reporters were there to cover the World Series. Santa Cruz County experienced proportionately greater damage and little media coverage. A comparison of findings between counties would enable us to determine if public response was different because of variation in damage and media exposure.

An enumeration of resident's names and household addresses in both counties was obtained, and a systematic random sample was selected from each sampling frame. The sampling fractions used were 1 out of 186 in San Francisco and 1 out of 44 in Santa Cruz. These fractions yielded samples of 1,986 and 1,933 for San Francisco and Santa Cruz, respectively. The populations were oversampled in order to achieve an acceptable number of completed responses.

A mailed questionnaire was constructed, pretested, revised, and then mailed to respondents twice. The final response rate for San Francisco was 41 percent, and it was 50 percent for Santa Cruz; these rates resulted in sample sizes of 734 and 918 for San Francisco and Santa Cruz, respectively. The original sample sizes were reduced for a variety of reasons beyond nonresponse, and these included undeliverable mail, moved with no forwarding address, and so on.

The samples were assessed for representativeness by comparing sample characteristics with population data. Sample and population data on average household size were virtually identical; data on gender were very close but females were overrepresented by about 3 percent; and

the age distribution of respondents in the samples were well matched to those in the populations. Whites were overrepresented in the sample for San Francisco, but not in Santa Cruz. Ethnic groups were underrepresented in both samples; for example, Hispanic-Americans were underrepresented by about 8 percent in San Francisco and by 4 percent in Santa Cruz. Last, renters were underrepresented by about 23 percent in San Francisco and by about 12 percent in Santa Cruz.

DESCRIPTIVE FINDINGS

PUBLIC EXPOSURE TO THE MEDIA AND WARNINGS

About three-quarters of the people in both counties (73.6 and 76.8 percent in Santa Cruz and San Francisco, respectively) reported that they used the media more than usual because of the earthquake. An even greater number of people reported that they heard warnings of aftershocks (83.8 percent in Santa Cruz and 78.1 percent in San Francisco). The main reason that respondents gave for not hearing them was that their electricity was out (22.5 and 14.4 percent in Santa Cruz and San Francisco, respectively); the next most frequent reason given was that respondents were too busy responding to the earthquake, but this was only mentioned by 9.5 percent of the respondents in Santa Cruz and 5.2 percent in San Francisco.

It seems clear that the Loma Prieta earthquake drew people to the media, and it also appears that the more damage that a community experienced, the more likely people were to hear aftershock warnings. More people in Santa Cruz reported hearing warnings than those in San Francisco despite the fact that Santa Cruz was exposed to less media coverage and had more damage to its infrastructure. Mainshock damage likely increased the salience of aftershock warnings, and most members of the public had access to a working portable radio—for example, 91.7 percent in Santa Cruz—after the earthquake.

PERCEIVED AFTERSHOCK RISK

Most people reported hearing aftershock warnings, but few were able to recall what was said about the risk. For example, only 43.8 and 37.3 percent of the respondents in Santa Cruz and San Francisco, respectively, were able to recall the magnitude and time window of aftershocks in the warnings they heard. This suggests that people tended to dichtomize risk; for example, the specific probabilities associated with aftershocks were not as important to them as was deciding whether or not there was a risk to face.

The public perceived greater risk in Santa Cruz than in San Francisco, even though the level of understanding aftershock warnings was the same in both counties (table 1). For example, 54.8 percent of the respondents in Santa Cruz and 56.0 percent of the respondents in San Francisco reported that they understood the warnings they heard. However, people in Santa Cruz (74.6 percent) were more likely to believe that a damaging aftershock would occur than those in San Francisco (65.8 percent). Additionally, Santa Cruz respondents were much more likely (55.2 percent) to believe that an aftershock would cause additional injury to people than those in San Francisco (39.9 percent).

Aftershock warnings were understood by about half the people who received them, and well over half of the people in both counties did expect that a damaging aftershock would occur. However, more people in Santa Cruz perceived greater aftershock risk—additional damage to structures and injuries to people—than in San Francisco. Residents of Santa Cruz experienced proportionately greater damage in the mainshock, and consequently warnings of aftershocks may have left them with perceptions of greater risk.

Objective risk was actually higher in San Francisco in the first 24 hours following the earthquake; the U.S. Geological Survey warned of a 7.0 magnitude or greater earthquake on an adjacent fault—in the San Francisco area—during this period.

PUBLIC RESPONSE TO SHORT-TERM AFTERSHOCK WARNINGS

The public in both counties did things to mitigate losses from aftershocks by doing what could be easily accomplished; it also appears that the more mainshock damage experienced in their community, the more likely people were to prepare for aftershocks (table 2). People were most likely to perform easy actions like make their household items safer (70.3 and 45.2 percent in Santa Cruz and San Francisco, respectively) and develop an emergency plan (43.8 percent in Santa Cruz and 31.5 percent in San Francisco) than they were to engage in more difficult and time-consuming activities, such as make their dwelling more structurally safe (17.6 percent in Santa Cruz and 7.4 percent in San Francisco). Additionally, a greater proportion of people in Santa Cruz performed each of the activities asked about to ready for aftershocks than the people in San Francisco.

Seeking additional information about what to do to ready for aftershocks appears to have been a second priority for people in both Santa Cruz and San Francisco, perhaps because people were busy responding to the earthquake. For example, only 21.8 percent of the people in Santa Cruz and 21.2 percent of the people in San

Table 1.—*Public perception of risk from aftershocks in the first 72 hours after the earthquake*

Public perceptions	San Francisco		Santa Cruz	
	Pct.	*n*	Pct.	*n*
I understood the aftershock warnings	56.0	411	54.8	503
I believed that a damaging aftershock would occur	65.8	483	74.6	685
I believed that a damaging aftershock would occur causing additional injury and (or) damage	39.9	293	55.2	507

Francisco sought general information about earthquakes; and only 18.6 and 14.6 percent of the respondents in Santa Cruz and San Francisco, respectively, sought information about aftershocks (see table 2). Yet research on pre-impact hazard warnings has typically concluded that the first and most abundant public response is to seek additional information (see Sorensen and Mileti, 1987; Perry, 1982). Data in this study suggest that a mainshock may be a strong environmental cue to aftershocks and that people may not take the time to seek out additional information before acting to protect themselves. In fact, the thing people in Santa Cruz were the least likely to do (13.4 percent) was look in their phone books for the earthquake information insert provided as a public service, yet this was the only recommended public action contained in the warnings disseminated.

PUBLIC RESPONSE TO THE TWO-MONTH AFTERSHOCK WARNING

The probability of occurrence for a damaging aftershock in the two months after the mainshock was relatively low; nevertheless, people in both Santa Cruz and San Francisco took the risk seriously and performed many protective actions. Almost two-thirds of the people in Santa Cruz (63.5 percent) and over a third of the people in San Francisco (37.7 percent) did things to make their household items safer from the anticipated earthquake (table 3). Additionally, 42.4 and 28.9 percent of the people in Santa Cruz and San Francisco, respectively, developed an emergency plan to use in response to a damaging aftershock in the two months following the mainshock. And 27.2 percent of the people in Santa Cruz and 12.4 percent of those in San Francisco made their dwelling structurally safer in anticipation of more earthquake damage. It appears that the public took the two-month warning seriously. As was the case with response to the short-term aftershock warnings, people in Santa Cruz did more to make ready than did those in San Francisco. Again, this was likely the case because the warnings were probably more salient in Santa Cruz due to the greater amount of mainshock damage experienced.

Table 2.—*Public response to aftershock warnings in the first 72 hours after the earthquake*

Public response in the first 72 hours after the earthquake	San Francisco		Santa Cruz	
	Pct.	*n*	Pct.	*n*
Sought general earthquake information	21.1	155	21.8	200
Sought information on what to do about aftershocks	14.6	107	18.6	171
Read earthquake information in phone book	21.9	161	13.4	123
Developed an emergency plan	31.5	231	43.8	402
Made household items safer	45.2	332	70.3	645
Made dwelling structurally safer	7.4	054	17.6	162

Table 3.—*Public response to aftershock warnings two months after the earthquake*

Public response in the two months after the earthquake	San Francisco		Santa Cruz	
	Pct.	*n*	Pct.	*n*
Sought information on aftershocks	14.0	103	18.4	169
Sought information on what to do about aftershocks	13.8	101	16.8	154
Read earthquake information in phone book	17.7	130	11.3	104
Developed an emergency plan	28.9	212	42.4	389
Made household items safer	37.7	277	63.5	583
Made dwelling structurally safer	12.4	091	27.2	250

CAUSAL DATA AND FINDINGS

The general model used to test risk communication theory is described as follows: (1) public response to aftershock warnings is a direct consequence of both aftershock warning information quality and quantity or reinforcement; the personal characteristics of those who received aftershock warnings (for example, age, gender, ethnicity, the amount of mainshock damage experienced, and so on); the emergency mainshock response in which people engaged; and perception of aftershock risk; (2) perception of aftershock risk is a function of aftershock warning information quality and reinforcement, personal characteristics of aftershock warning recipients, and emergency mainshock response; (3) finally, emergency mainshock response is seen as consequence of information quality and reinforcement, and the personal characteristics of warning recipients. The model proposed is parsimonious and well represents risk communication theory at the same time, and it was operationalized as follows.

Warning information quality (X_1) was measured by asking respondents what they thought about all the warnings they heard, and then if they agreed that they were specific, consistent with one another, and if it seemed like people were certain about what they were saying. Answers were coded as dummy variables and then added to form a

quality of aftershock warning information scale; it varied between 0 and 3.

Information reinforcement (X_2) was scaled to represent the number of warnings received through divergent channels and from varied sources. Respondents were asked if they received aftershock warnings from government officials, scientists, friends and relatives, and other community residents; and if any came over television, radio, newspapers, and word-of-mouth. All responses were coded as dummy variables and then added as a scale of information reinforcement which varied between 0 and 8.

Pre-event earthquake salience was measured by asking respondents: "Prior to the October earthquake had you ever done anything to prepare for an earthquake?" Responses to this question were coded as a dummy variable. Pre-event aftershock knowledge (X_4) was measured by asking respondents: Which best described what you knew about aftershocks before the earthquake: (1) "I did not know about aftershocks," (2) "They happen but do not cause additional damage," (3) "They happen and can cause additional damage," and (4) "They can cause more damage than the original earthquake." Responses were collapsed for analysis and coded as: 0=any of the first three response categories, and 1="They can cause more damage than the original earthquake." Pre-event quake experience (X_5) was measured by asking respondents about the severity of the largest earthquake they had ever experienced prior to the Loma Prieta quake. Responses were coded as 0=no damaging quake experience versus 1=damaging experience. Loma Prieta earthquake damage (X_6) was scaled as an index of damage to neighborhood, residence and household items. Responses were coded as 0=no damage and (or) slight damage versus 1=moderate and (or) severe damage.

Community integration (X_7) was intervally coded as the number of years that respondents have lived in their current residence. The concept of roles of responsibility (X_8) was measured by asking people: "Including yourself, how many people for whom you are responsible reside in your household?" The responses to this question were coded intervally, as was the age (X_9) of respondents. Ethnicity (X_{10}) was measured by asking "Which best describes your racial/ethnic identification?" Answer categories were collapsed into 0=other and 1=white. Gender (X_{11}) was coded as 0=female and 1=male. Socioeconomic status (X_{12}) was scaled as an index of education, household before-tax income, and occupational prestige. Each of these measures was transformed into a dummy variable and then summed to form a scale for socioeconomic status.

Earthquake emergency response (X_{13}) was measured by asking respondents: "In the first 24 hours after the earthquake, did you in any way (officially, unofficially, or as a volunteer) do any of the following emergency activities?" The list of activities from which respondents could choose included searched and rescued victims, provided food and water to others, provided shelter to others, cleared/removed debris, helped evacuate victims, counseled victims, put out fires, directed traffic, and provided medical attention/first aid to victims. Responses were coded as dummy variables and then added to create a scale that varied between 0 and 9. Perception of aftershock risk (X_{14}) was operationalized as an index of risk perception that was a composite of warning understanding, belief in the idea that an aftershock would occur and cause additional general damage, and belief that an aftershock would occur and cause the respondent, a member of their family, or their residence injury or damage. People were asked if they agreed with any of the following statements: (1) "I understood the aftershock warnings," (2) "Did you believe that a damaging aftershock would occur in the first 72 hours following the October earthquake," and (3) "Did you believe that a damaging aftershock would occur and cause you, your family, or residence injury or damage." All responses were coded as dummy variables and summed to create a risk perception index. Finally, response to aftershock warnings (X_{15}) was measured by asking people about the activities that they could have performed to ready for aftershocks. Each activity was coded as a dummy variable and them summed to create an index of protective action response.

The operationalized theoretical model was represented as follows. Emergency response (X_{13}) was cast as a direct function of warning information quality (X_1), warning information reinforcement (X_2), pre-event earthquake salience (X_3), pre-event aftershock knowledge (X_4), pre-event earthquake experience (X_5), mainshock damage (X_6), community integration (X_7), roles of responsibility (X_8), age (X_9), ethnicity (X_{10}), gender (X_{11}), and socioeconomic status (X_{12}). Perception of aftershock risk (X_{14}) was taken as a direct function of these same factors and involvement in emergency response (X_{13}). Finally, aftershock warning response (X_{15}) was modelled as a direct function of the same factors as well as involvement in emergency response (X_{13}) and aftershock risk perception (X_{14}).

The model was estimated on the data from both Santa Cruz and San Francisco Counties. The estimated model parameters included path coefficients (betas), explained variance for each equation, and other estimates; these are presented in tables 4 and 5, respectively, for San Francisco and Santa Cruz.

The models were assessed for specification error, multicolinearity, nonlinearity, and heteroscedasticity in order to determine if basic regression assumptions could be reasonably made and if the estimated model parameters were unbiased.

Specification error was not determined to be a problem. The model included all variables suggested by prior research findings and theory. An inspection of the estimated model parameters (tables 4 and 5) did lead to the conclusion that the model contained some irrelevant exogenous variables, given how these data fit the model. The inclusion of irrelevant variables in a model does not bias estimated

Table 4.—*Estimated parameters of the model for San Francisco county*

[N/S, not significant]

Variables		Path		Equation		
Endogenous	Exogenous	Coefficient	Estimate	α	α	r^2
X_{13}	X_1	$\beta_{13,1}$	.00	N/S	.00	.12
	X_2	$\beta_{13,2}$	.09	.04		
	X_3	$\beta_{13,3}$	.11	.01		
	X_4	$\beta_{13,4}$	.00	N/S		
	X_5	$\beta_{13,5}$	.14	.00		
	X_6	$\beta_{13,6}$	.21	.00		
	X_7	$\beta_{13,7}$	-.06	N/S		
	X_8	$\beta_{13,8}$	.00	N/S		
	X_9	$\beta_{13,9}$	-.13	.00		
	X_{10}	$\beta_{13,10}$	.00	N/S		
	X_{11}	$\beta_{13,11}$	-.03	N/S		
	X_{12}	$\beta_{13,12}$	.03	N/S		
		$\beta_{13,e}$	.94	.00		
X_{14}	X_1	$\beta_{14,1}$	.11	.01	.00	.15
	X_2	$\beta_{14,2}$	.25	.00		
	X_3	$\beta_{14,3}$	.00	N/S		
	X_4	$\beta_{14,4}$	.12	.00		
	X_5	$\beta_{14,5}$	.00	N/S		
	X_6	$\beta_{14,6}$	.09	.02		
	X_7	$\beta_{14,7}$	.05	N/S		
	X_8	$\beta_{14,8}$	.06	N/S		
	X_9	$\beta_{14,9}$	.03	N/S		
	X_{10}	$\beta_{14,10}$	-.12	.00		
	X_{11}	$\beta_{14,11}$	-.04	N/S		
	X_{12}	$\beta_{14,12}$	-.01	N/S		
	X_{13}	$\beta_{14,13}$	.01	N/S		
		$\beta_{14,e}$	.92	.00		
X_{15}	X_1	$\beta_{15,1}$	.11	.00	.00	.23
	X_2	$\beta_{15,2}$	.17	.00		
	X_3	$\beta_{15,3}$	.21	.00		
	X_4	$\beta_{15,4}$	-.03	N/S		
	X_5	$\beta_{15,5}$	.04	N/S		
	X_6	$\beta_{15,6}$	.06	N/S		
	X_7	$\beta_{15,7}$	.04	N/S		
	X_8	$\beta_{15,8}$	.05	N/S		
	X_9	$\beta_{15,9}$	.05	N/S		
	X_{10}	$\beta_{15,10}$	-.03	N/S		
	X_{11}	$\beta_{15,11}$	-.10	.01		
	X_{12}	$\beta_{15,12}$	-.01	N/S		
	X_{13}	$\beta_{15,13}$	.11	.00		
	X_{14}	$\beta_{15,14}$	.14	.00		
		$\beta_{15,e}$	.88	.00		

X_1 = warning information quality, X_2 = warning information reinforcement, X_3 = pre-event earthquake salience, X_4 = pre-event aftershock knowledge, X_5 = pre-event earthquake experience, X_6 = earthquake damage, X_7 = community integration, X_8 = roles of responsibility, X_9 = age, X_{10} = ethnicity, X_{11} = gender, X_{12} = socioeconomic status, X_{13} = emergency response, X_{14} = perception of aftershock risk, and X_{15} = response

Table 5.—*Estimated parameters of the model for Santa Cruz county*

[N/S, not significant]

Variables		Path		Equation		
Endogenous	Exogenous	Coefficient	Estimate	α	α	r^2
X_{13}	X_1	$\beta_{13,1}$	.05	N/S	.00	.09
	X_2	$\beta_{13,2}$	.08	.03		
	X_3	$\beta_{13,3}$	.10	.00		
	X_4	$\beta_{13,4}$	.05	N/S		
	X_5	$\beta_{13,5}$	.03	N/S		
	X_6	$\beta_{13,6}$	.16	.00		
	X_7	$\beta_{13,7}$	-.01	N/S		
	X_8	$\beta_{13,8}$	-.02	N/S		
	X_9	$\beta_{13,9}$	-.15	.00		
	X_{10}	$\beta_{13,10}$	-.00	.00		
	X_{11}	$\beta_{13,11}$	.00	N/S		
	X_{12}	$\beta_{13,12}$	.05	N/S		
		$\beta_{13,e}$	.95	.00		
X_{14}	X_1	$\beta_{14,1}$	.17	.00	.00	.15
	X_2	$\beta_{14,2}$	.24	.00		
	X_3	$\beta_{14,3}$	.14	.00		
	X_4	$\beta_{14,4}$	.04	N/S		
	X_5	$\beta_{14,5}$	-.00	N/S		
	X_6	$\beta_{14,6}$	.06	N/S		
	X_7	$\beta_{14,7}$	.01	N/S		
	X_8	$\beta_{14,8}$	.03	N/S		
	X_9	$\beta_{14,9}$	-.02	N/S		
	X_{10}	$\beta_{14,10}$	-.04	N/S		
	X_{11}	$\beta_{14,11}$	-.02	N/S		
	X_{12}	$\beta_{14,12}$	-.02	N/S		
	X_{13}	$\beta_{14,13}$	.02	N/S		
		$\beta_{14,e}$	.92	.00		
X_{15}	X_1	$\beta_{15,1}$	.11	.00	.00	.12
	X_2	$\beta_{15,2}$	.10	.01		
	X_3	$\beta_{15,3}$	.12	.00		
	X_4	$\beta_{15,4}$	-.00	N/S		
	X_5	$\beta_{15,5}$	-.02	N/S		
	X_6	$\beta_{15,6}$	.04	N/S		
	X_7	$\beta_{15,7}$	-.00	N/S		
	X_8	$\beta_{15,8}$	.02	N/S		
	X_9	$\beta_{15,9}$	.03	N/S		
	X_{10}	$\beta_{15,10}$	.03	N/S		
	X_{11}	$\beta_{15,11}$	-.03	N/S		
	X_{12}	$\beta_{15,12}$	.01	N/S		
	X_{13}	$\beta_{15,13}$	.11	.00		
	X_{14}	$\beta_{15,14}$	.14	.00		
		$\beta_{15,e}$	.93	.00		

X_1 = warning information quality, X_2 = warning information reinforcement, X_3 = pre-event earthquake salience, X_4 = pre-event aftershock knowledge, X_5 = pre-event earthquake experience, X_6 = earthquake damage, X_7 = community integration, X_8 = roles of responsibility, X_9 = age, X_{10} = ethnicity, X_{11} = gender, X_{12} = socioeconomic status, X_{13} = emergency response, X_{14} = perception of aftershock risk, and X_{15} = response

betas, but can increase standard errors depending on how irrelevant variables are correlated with other variables. However, as has been pointed out by Berry and Feldman (1985, p. 90) "as long as the number of cases significantly exceeds the number of variables the increase in standard error will be trivial." Since the number of cases used in this analysis were significantly larger (n=734 and 918) than the number of variables in the model, it was concluded that the inclusion of irrelevant variables would not bias estimated model parameters.

Multicolinearity can bias model estimates because it can increase the standard errors of estimated regression coefficients. The models for both San Francisco (table 4) and Santa Cruz (table 5) were assessed for multicolinearity in two ways. First, multicolinearity does not impose a problem unless it approaches perfect multicolinearity. The zero-order correlation matrices for both models (tables 6 and 7, respectively, for San Francisco and Santa Cruz) were inspected to determine if any correlations were around 0.80 or higher—a typical cutoff value below which multicolinearity does not seriously bias model estimates. An inspection of the zero-order correlations in tables 6 and 7 led to the conclusion that coefficients were not sufficiently high for multicolinearity to be a problem. Second, multicolinearity was assessed by regressing each exogenous variable in each equation on all other exogenous variables; and the R^2s for each of these regressions were inspected to see if any approached 1.00, which would indicate a biasing level of multicolinearity (Berry and Feldman, 1985). This assessment also led to the conclusion that multicolinearity was not a source of bias in the estimated parameters of the model in either data set.

The models were then assessed to determine if the assumption of linearity could be met. Exogenous variables in each equation were transformed to conform to alternative nonlinear forms, for example the natural logarithm of X, the square of X, the reciprocal of X, and the squareroot of X. These transformed exogenous variables were then correlated with each of the endogenous variables in both models. None of the correlations involving the transformed exogenous variables increased substantially beyond the linear correlations presented in tables 6 and 7. A visual inspection of scatterplots also confirmed the conclusion that relationships were linear.

The assumption homoscedasticity was also assessed by visual inspection of regression residuals in scatterplots for each relationship in both models, and it was concluded that this assumption was met.

Table 6.—*Zero-order correlation matrix for the San Francisco data*

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}
X_1	---	.499	.083	.057	-.011	.060	-.028	.018	-.096	.008	-.098	.063	.088	.248	.274
X_2	---	---	.071	.091	.085	.058	-.076	.083	-.211	-.047	-.043	.120	.161	.331	.325
X_3	---	---	---	.103	.148	.004	.149	.082	.014	.016	.021	.017	.124	.056	.258
X_4	---	---	---	---	.113	.064	-.030	.022	-.098	.018	.066	.073	.066	.148	.048
X_5	---	---	---	---	---	.117	.091	.065	.028	-.004	.081	.081	.176	.042	.111
X_6	---	---	---	---	---	---	-.077	.028	-.053	.074	-.083	.060	.250	.114	.132
X_7	---	---	---	---	---	---	---	.066	.311	-.036	-.009	-.090	-.097	.019	.033
X_8	---	---	---	---	---	---	---	---	-.151	-.244	.045	-.035	.043	.125	.126
X_9	---	---	---	---	---	---	---	---	---	.067	-.019	-.219	-.176	-.108	-.121
X_{10}	---	---	---	---	---	---	---	---	---	---	-.018	.154	.004	-.137	-.067
X_{11}	---	---	---	---	---	---	---	---	---	---	---	.052	-.033	-.058	-.127
X_{12}	---	---	---	---	---	---	---	---	---	---	---	---	.093	.020	.031
X_{13}	---	---	---	---	---	---	---	---	---	---	---	---	---	.092	.219
X_{14}	---	---	---	---	---	---	---	---	---	---	---	---	---	---	.269
X_{15}	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

X_1 = warning information quality, X_2 = warning information reinforcement, X_3 = pre-event earthquake salience, X_4 = pre-event aftershock knowledge, X_5 = pre-event earthquake experience, X_6 = earthquake damage, X_7 = community integration, X_8 = roles of responsibility, X_9 = age, X_{10} = ethnicity, X_{11} = gender, X_{12} = socioeconomic status, X_{13} = emergency response, X_{14} = perception of aftershock risk, and X_{15} = response

The estimated parameters of the models for San Francisco (see table 4) and Santa Cruz (see table 5) revealed that a very consistent set of conclusions emerged from the model estimates across both counties. These conclusions confirm parts of established risk communication theory and add new insights about risk communication in the context of an ongoing community-wide emergency.

First, as was hypothesized, both the quality (specificity, consistency, and certainty) and quantity (reinforcement) of aftershock risk warning information had positive direct and indirect—through aftershock risk perception—effects on public warning response. The direct effect of warning information quality on aftershock warning response ($\beta_{15,1}$) was 0.11 in both San Francisco and Santa Cruz. The indirect effect of warning information reinforcement on aftershock warning response ($\beta_{15,2}$) was 0.17 in San Francisco and 0.10 in Santa Cruz. The indirect effect of warning information quality and quantity on aftershock warning response through risk perception was revealed by the effect of information quality on risk perception ($\beta_{14,1}$ was 0.11 in San Francisco and 0.17 in Santa Cruz); the effect of warning information reinforcement on risk perception ($\beta_{14,2}$ was 0.25 in San Francisco and 0.24 in Santa Cruz); and then by the effect of risk perception on aftershock warning response ($\beta_{15,14}$ was 0.14 in San Francisco and 0.14 in Santa Cruz). These findings are exactly what would be predicted by existing theory: the quality (see Sorensen and Mileti, 1987; Perry, 1982; Perry and others, 1980) and quantity (see Perry, 1982; Mileti and Beck, 1975; Drabek and Boggs, 1968) of public warnings impact public response both directly and indirectly through the situational perceptions of risk which people form as a result of the warnings they hear. Our data confirm that this portion of risk communication theory—which up to now has been based on pre-impact warning studies—is applicable to warnings issued to a public in the context of an ongoing emergency.

Second, mainshock damage had a positive indirect effect on aftershock warning response through the intervening variable of emergency response. The amount of mainshock damage experienced increased the likelihood that people would get involved in community emergency response ($\beta_{13,6}$ was 0.21 in San Francisco and 0.16 in Santa Cruz) and getting involved in community emergency response increased the probability that people would respond to aftershock warnings with protective actions ($\beta_{15,13}$ was 0.11 in both San Francisco and Santa Cruz). This finding was the exact opposite of the hypothesis proposed at the outset of the study. It had been hypothesized that both mainshock damage and getting involved in community emergency response would constrain the receipt of warnings, perception of aftershock risk, and warning response since these factors could divert public attention. In fact, the opposite was the case. Involvement in disaster response likely increased interaction with other victims, which likely facilitated the interpersonal communication and reinforcement of warnings.

Several other variables in the model also facilitated aftershock warning response indirectly by first getting people involved in community emergency response. These were pre-mainshock hazard salience and experience. Pre-event earthquake salience enhanced aftershock warning response indirectly by getting people involved in community disaster response ($\beta_{13,3}$ was 0.11 in San Francisco and 0.10 in Santa Cruz). Pre-event earthquake experience had the same effect; $\beta_{13,5}$ was 0.14 in San Francisco; this relationship was not statistically significant in Santa Cruz likely because mainshock damage was great there, which could have eliminated the effect of prior earthquake damage from the model.

Third, selected demographic characteristics of the people who received warnings constrained aftershock warning response both directly and indirectly through other variables in the model. Age indirectly constrained aftershock warning response by decreasing the probability that people would get involved in community emergency response ($\beta_{13,9}$ was

Table 7.—*Zero-order correlation matrix for the Santa Cruz data*

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}
X_1	---	.475	.066	.038	.041	.027	.014	.032	-.041	.059	-.065	-.036	.102	.296	.221
X_2	---	---	.065	.009	-.020	.011	-.026	.099	-.127	.010	-.061	.023	.131	.336	.230
X_3	---	---	---	.133	.107	.122	.081	.014	.003	.136	.067	.105	.143	.170	.179
X_4	---	---	---	---	.141	.053	.029	.026	-.071	-.022	.082	.003	.086	.068	.038
X_5	---	---	---	---	---	.175	.042	.006	.044	.022	.112	-.028	.073	.030	.010
X_6	---	---	---	---	---	---	.108	.074	-.045	.027	-.046	.012	.192	.093	.095
X_7	---	---	---	---	---	---	---	.041	.146	-.007	.011	-.093	-.015	.031	.001
X_8	---	---	---	---	---	---	---	---	-.274	-.212	.098	.012	.052	.069	.053
X_9	---	---	---	---	---	---	---	---	---	.096	.007	-.202	-.183	-.035	-.086
X_{10}	---	---	---	---	---	---	---	---	---	---	-.048	.122	.012	-.013	.054
X_{11}	---	---	---	---	---	---	---	---	---	---	---	.032	.007	-.035	-.039
X_{12}	---	---	---	---	---	---	---	---	---	---	---	---	.090	-.017	.046
X_{13}	---	---	---	---	---	---	---	---	---	---	---	---	---	.096	.183
X_{14}	---	---	---	---	---	---	---	---	---	---	---	---	---	---	.238
X_{15}	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

X_1 = warning information quality, X_2 = warning information reinforcement, X_3 = pre-event earthquake salience, X_4 = pre-event aftershock knowledge, X_5 = pre-event earthquake experience, X_6 = earthquake damage, X_7 = community integration, X_8 = roles of responsibility, X_9 = age, X_{10} = ethnicity, X_{11} = gender, X_{12} = socioeconomic status, X_{13} = emergency response, X_{14} = perception of aftershock risk, and X_{15} = response

—0.13 and –0.15 in San Francisco and Santa Cruz, respectively). Gender also constrained warning response directly in San Francisco ($ß_{15,11}$ was –0.10); males were less likely to engage in protective actions than were females. Ethnicity indirectly constrained response by negatively impacting aftershock risk perception in San Francisco ($ß_{14,10}$ was –0.12). Gender and ethnicity did not function as constraints in Santa Cruz as they did in San Francisco, perhaps because mainshock damage was so intense in Santa Cruz that members of both genders and all ethnic groups were convinced of aftershock risk. The constraining effects of demographic characteristics on risk perception and response to warnings is well established in research literature and in the theory of risk communication (see Mileti and Fitzpatrick, 1992; Mileti and Sorensen, 1990; Turner and others, 1986; Perry, 1982); these findings are not a theoretical surprise.

Fourth, pre-mainshock earthquake salience played a strong role in both models in predicting public response to aftershock warnings. It had a direct and positive effect on warning response ($ß_{15,3}$ was 0.21 and 0.12 in San Francisco and Santa Cruz, respectively). This was a theoretical surprise; existing theory suggests that pre-event salience impacts warning response only indirectly through its effect on enhancing perceived risk (see Perry, 1982; Sorensen and Mileti, 1987). This indirect effect was observed in these data, but only in Santa Cruz ($ß_{14,3}$ was 0.14); more important a direct effect of pre-mainshock salience on response was observed in both communities. These data suggest that some people took protective aftershock actions independent of the warnings that were issued; that is, some people sought to protect themselves from aftershocks based on something other than warnings. It is likely that both populations have general knowledge that aftershocks occur after earthquakes. This likely motivated people for whom the hazard was salient to engage in protective actions on their own and independent of warnings. Theoretically, these findings suggest that mainshocks function as environmental cues for aftershock risk. The role that environmental cues play in the theory of risk communication is well established as directly impacting warning response (see Mileti and others, 1975; Danzig and others, 1958). These data confirm this important theoretical relationship.

CONCLUSIONS

The findings which emerged from this study confirm many established propositions in the theory of risk communication: (1) perceived risk has a direct and positive impact on responding to warnings with protective actions, (2) warning information quality and quantity or reinforcement have a direct positive effect on response, as well as an indirect positive effect through risk perception, (3) pre-event hazard salience enhances warning response both directly and indirectly, and (4) selected demographic characteristics can constrain both perception of risk and warning response, for example being old, being male, or being a member of a nonwhite ethnic group. These findings suggest the conclusion that many of the established principles of pre-disaster warning response also apply for public warnings issued in the context of an ongoing disaster.

However, it must also be concluded that the process which explains post-impact public warning response is not identical to the one which explains public response to pre-impact warnings. These data consistently revealed that protective warning response was more likely for residents of Santa Cruz County who experienced much more proportionate damage than did residents of San Francisco; that becoming involved in emergency response had a consistent direct impact on preparing for aftershocks independent of warnings received; and that becoming involved in emergency response was a strong direct consequence of experiencing mainshock damage. These findings suggest a conclusion with both theoretical and applied significance.

Experiencing loss in a disaster may make subsequent warnings more salient, thereby enhancing the likelihood of engaging in protective actions in response to warnings; also, experiencing loss may enhance warning response because loss elicits collective disaster response behavior which may facilitate informal warning notification and reinforcement. These thoughts suggest that those who experience little or no loss in the impact of a disaster may be prone to a "normalization bias" when interpreting post-impact warnings for subsequent risk: "The first impact did not affect me negatively, therefore, subsequent impacts will also avoid me." This bias may also operate in a pre-impact warning circumstance; for example, it may be why persons without any disaster experience are more reluctant to personalize risk and respond to pre-impact warnings, whereas those with experience are more apt to respond, holding all other factors constant. Normalization may operate less in the latter case because of recollected experience with disaster. Nevertheless, it does appear that in post-impact warning circumstances the effect of not experiencing damage in the first impact may be to create a strong normalization which operates to constrain perceived risk and protective response even in the face of warning information.

Practically, this conclusion suggests that successful post-impact public warnings may be both easier and more difficult to achieve at the same time. The aftershock warnings which followed the Loma Prieta earthquake did not possess the characteristics of warnings known to facilitate public response; for example, the warnings were not specific about the risk faced and what people should have done to protect themselves. Nevertheless, they were acted upon by members of the public who experienced mainshock damage. This suggests that simple warnings which would convince few to act in a pre-impact circumstance may be enough to convince post-impact victims to act. It also suggests that post-impact victims who experienced no damage may be harder to convince to take protective actions than is the case with pre-impact warnings.

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PUBLIC RESPONSE

EMERGENCY SHELTERING AND HOUSING OF EARTHQUAKE VICTIMS: THE CASE OF SANTA CRUZ COUNTY

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CONTENTS

ABSTRACT

This report examines selected issues involved in the provision of emergency shelter, temporary shelter, and temporary housing for a large population of victims in Santa Cruz County after the Loma Prieta earthquake. The focus of the report is on the special shelter and housing problems of ethnically diverse disaster victims who are marginalized by demographic and socioeconomic factors. Of specific concern are the elderly, Hispanic and Mexican farm workers, and the chronically homeless. The report concludes with a series of recommendations on dealing with a diverse set of post-earthquake shelter and housing issues.

INTRODUCTION

One of the critical issues following major natural disasters is the sheltering and housing of displaced persons. The Loma Prieta earthquake created, in the course of less than a minute, a homeless population numbering more than 12,000 (U.S. Geological Survey, 1990) in northern California. Although this is only a small fraction of the total population of the stricken area, providing shelter for these newly homeless became a major organizational task for emergency responders in the San Francisco Bay area and in the less urbanized counties to the south.

In this report we will investigate selected issues involved in the provision of short-term shelter and housing for a large population of victims. We will concentrate on the cities of Santa Cruz and Watsonville in Santa Cruz County, sites with the highest proportional losses of housing stocks in the region. Much of our discussion will draw on our research on the particular shelter and housing difficulties that confronted an ethnically and demographically diverse set of marginal groups. Included among these marginalized victims of the Loma Prieta disaster were elders, Mexican-American and Mexican farm workers, and the chronically homeless. Because of the relatively short-term nature of our research, we will concentrate our discussion on emergency and temporary shelter as used in the first three months after the disaster (Bolin and Stanford, 1990).

BACKGROUND

The information presented in this report was obtained during two separate data-gathering efforts in the impacted areas of northern California. The first was for a 9-day period in early November, two weeks after the mainshock had occurred. The second research period took place during the first week of January 1990. Funding for this research was provided by the Natural Hazards Research and Applications Information Center at the University of Colorado as part of their "Quick Response" research program.

The data-gathering strategy during the first period involved interviewing regional and local Red Cross personnel involved in shelter operations in Hollister, Watsonville, Pajaro, Santa Cruz, and San Francisco. In addition, city and county officials involved in shelter and housing activities were interviewed in Santa Cruz, Watsonville, and Pajaro. During the second site visit, interviewing was broadened to include, in addition to Red Cross personnel, representatives from the Federal Emergency Management Agency (FEMA), municipal government representatives, and local community activists involved in temporary shelter and

housing issues. Because temporary housing issues were most pronounced in Watsonville and Santa Cruz, we restricted our second phase interviewing to those sites. In addition to the two phases of interviewing, published accounts of the disaster from local newspapers in Santa Cruz and Watsonville were reviewed to construct a general chronology of emergency and restoration activities regarding shelter and housing during a three-month period after the earthquake. All interview materials were content analyzed to identify key housing issues and problems as well as to reconstruct a broad overview of organizational activities related to the provision of shelter during the emergency.

PREVIOUS RESEARCH

We will rely on Quarantelli's (1982, 1985) typology of post-disaster housing as a general orienting perspective. Briefly, Quarantelli's perspective conceptualizes sheltering as a heterogeneous social process that moves through a series of stages or phases after disaster impact. In temporal sequence from disaster impact the phases are: emergency shelter, temporary shelter, temporary housing, and lastly, permanent housing.

Emergency shelter refers to relatively unplanned and spontaneously sought provisional shelter. Such shelter is used by victims in the immediate pre- or post-impact phases of a disaster and is based on proximity or opportunity, rather than, in many instances, on pre-disaster planning. Often areas become de facto emergency shelters simply because disaster victims gather there. Quarantelli (1982) rightly points out that victims will tolerate relatively harsh conditions in these sheltering circumstances because of the assumed short-term nature of their occupation.

Emergency shelters are frequently established by victims themselves on an impromptu basis. In the case of earthquakes, victims will often camp in their own yards or in parks near their homes. Victims will typically occupy these shelters only until they feel it is safe to return to their homes, or until they move to established temporary shelters (Bolin and Stanford, 1990).

In the U.S., particularly for disasters with forewarning and proactive evacuations, the emergency shelter phase is effectively bypassed as victims go directly to temporary shelters (although these may, in fact, be referred to as emergency shelters by organizations involved). These emergency/temporary facilities are typically mass sheltering arrangements in large public buildings (schools, armories and so forth). These collective shelters are routinely planned for, equipped, and managed by the Red Cross. It is well documented in the disaster literature (Quarantelli, 1982; Drabek, 1986; Davis, 1977) that such emergency collective shelters are avoided by the public if they are able to make alternative sheltering arrangements.

Thus temporary shelters are established when victims remain at a place long enough to require more elaborate facilities and services to sustain them for longer term occupancy (Quarantelli, 1982). Such services require planning and the involvement of emergency management organizations. The Red Cross, as noted above, is the usual provider of such services in temporary shelters. In situations where a portion of the community escapes damage, victims may be "absorbed" as evacuees into the homes of nonvictims, usually relatives or friends, a process obviously dependent on the existence of social support networks (see Bolin, 1982). Mass shelters tend to be underutilized by victims if they have access to these other types of shelter arrangements.

It is difficult for emergency planners to anticipate how many victims will go to the homes of kin or friends for emergency shelter. Thus, it is virtually impossible to predict how many victims may actually show up at emergency or temporary shelter facilities following a significant disaster (Quarantelli, 1982). In planning for these facilities, flexibility is necessary to respond to unanticipated and often fluctuating demands over the course of the emergency period (Quarantelli, 1985; Bolin, 1989).

Temporary housing, the next phase, identifies housing facilities in which victims can reestablish household routines but they have "the understanding that more permanent quarters will be obtained eventually" (Quarantelli, 1985, p.130). FEMA is the agency typically associated with the provision of temporary housing assistance, although a multiplicity of organizations and agencies may be involved in a given disaster (see Bolin and Bolton, 1986; Bolin and Stanford, 1991).

Temporary housing may become permanent housing for low income victims, contrary to the presumed transitional nature of the housing. This may be a significant concern for planners in instances where FEMA provides mobile homes as a form of temporary housing (Bolin, 1982). Disputes over whether to use trailers and where to locate trailer courts can result in delays in the establishment of temporary housing facilities (see Bolin and Stanford, 1990). Likewise, there is ample evidence that mobile homes can be a particularly problematic form of temporary housing, in some instances compounding the stresses that victims experience (Golec, 1983; Erikson, 1976).

The last phase is permanent housing, an issue that generally receives little attention from disaster planners (Quarantelli, 1982). The reestablishment of permanent housing varies directly by social class background of the victims and their corresponding access to aid and related resources (Peacock and others, 1987; Bolin, 1982; Bolin and Bolton, 1986). The privatized approach to permanent housing in the U.S. generally leaves it up to the victims to establish new permanent housing. This is sometimes accomplished with the assistance of government programs, particularly Small Business Administration (SBA) disaster

loans (Bolin, 1989). Preexisting social inequalities will have a marked effect on which victims are able to reestablish permanent housing and how soon after the disaster that is accomplished (Aysan and Oliver, 1987; Bates, 1982; Oliver-Smith, 1986; Wijkman and Timberlake, 1988).

Because post-disaster housing is a complex social process, all the phases may occur simultaneously in an impacted community, with different groups of victims being in different stages of the housing recovery process (Bolin, 1982; Quarantelli, 1982). Thus, some victims may still be in temporary shelter, whereas others have reestablished permanent housing (Quarantelli, 1985). This variability in victim needs can create a wide range of demands on agencies involved in the management of housing programs. In general, poorer victims will take longer to reestablish permanent homes. Consequently post-disaster housing processes will tend to mirror, and sometimes reinforce, preexisting social class differences in the impacted community (Oliver-Smith, 1986).

Social class, ethnicity, and demographic factors have been shown to influence patterns of shelter utilization and aid program access after disasters (Bolin and Bolton, 1986). In general, it is those groups with marginal predisaster resources (ethnic minorities, elderly on fixed incomes, and other lower income households) who are the most likely to use mass care facilities and who have the greatest difficulties in finding suitable temporary and permanent housing. As the number of chronically homeless continues to increase in the U.S., this group is becoming a new marginalized minority group.

Such groups' housing problems are exacerbated by the effects of disasters such as the Loma Prieta earthquake. This is, in part, a consequence of effect of earthquakes on poorly constructed (unreinforced masonry) residential hotels that are often used as housing for low-income persons who would otherwise be homeless. It also derives from the fact that homeless persons are systematically excluded from traditional temporary housing programs as offered by FEMA. When an earthquake destroys residential hotels, it is the chronically homeless who are likely to experience further marginalization.

Disaster research has frequently stressed the altruism and social cooperation that characterizes communities after major natural disasters (Drabek, 1986). However, this "therapeutic community" phase (Barton, 1970; Drabek and Key, 1984) may be short lived, soon to be replaced by preexisting community conflicts that resurface, sometimes in an intensified fashion. Conflicts can emerge rapidly after disasters and may in fact be generated by the disaster, particularly over issues of temporary housing and recovery strategies (Bolin, 1982, 1989; Geipel, 1982). In this sense, disasters can be instrumental in creating structural conditions conducive to collective movements for political action and social change (Peacock and others, 1987; Oliver-Smith, 1986). That is, disasters may disrupt existing patterns of social arrangements, bringing victims in similar circumstances together in mass shelter facilities, and help people to see that their problems are collective rather than individual. As we shall argue later, this has been one of the short-term unanticipated consequences of the Loma Prieta earthquake.

OVERVIEW OF EMERGENCY AND TEMPORARY SHELTERING

The Red Cross began establishing mass shelters within 4 hours of the 5:04 p.m. temblor in the multicounty disaster area. Pre-disaster planning insured that material and facilities were quickly mobilized to provide shelter for many of those displaced. Initial efforts at establishing shelters were hampered by darkness, widespread power outages, and the incapacitation of telephone communications and transportation links. The large number of shelters that were opened in the impacted areas resulted in some initial shortages of trained shelter managers. Training programs were instituted to attempt to address that shortage (Bolin and Stanford, 1990).

Many victims, according to our data from Santa Cruz County, had no systematic source of information on shelter locations during the first night after the earthquake due to the same power outages which hampered local media broadcasts. Police personnel patrolled damaged areas informing victims of the location of the emergency shelters that were opened in the immediate aftermath, although most victims apparently preferred staying near, but not in, their damaged homes.

While no official statistics are available, anecdotal information suggests that many of those displaced created their own emergency shelters in parks and athletic fields in Santa Cruz, Watsonville, mountain communities near Santa Cruz (the Summit area), Pajaro (Monterey County), and Hollister (San Benito County). Many simply took tents and sleeping paraphernalia to nearby parks to sleep, whether their home had sustained significant damage or not. Others used automobiles as emergency shelters, parking them in open areas and sleeping in them for one or more nights.

Our data suggest that fear of aftershocks was a significant factor in residents' decisions not to remain in their homes. However, damage to mountain roads leading to Santa Cruz and the Summit area as well as bridge collapses effectively isolated a number of towns for up to 4 days. These impediments to easy travel complicated victim access to mass care facilities.

According to Red Cross officials in San Francisco, some 44 shelters were operating in the multicounty impact area during the peak of mass care activities approximately one week after the temblor. For some shelters in Santa Cruz and

San Benito counties, shelter populations increased steadily during the first week of the emergency period. At a point three weeks after the disaster, 30 shelters were still open in the federally declared disaster area, although shelter populations were beginning to decline steadily. The Golden Gate chapter of the Red Cross anticipated closing all Bay Area shelters by November 30. At the height of the emergency period a total of approximately 2,500 victims was being sheltered nightly. During the first three weeks after impact a cumulative total of 47,300 "bed nights" was recorded at all shelters in the affected areas.

Given an estimated 12,000 to 13,000 homeless as a direct result of the earthquake (U.S. Geological Survey, 1990), it is clear that only a minority of victims actually evacuated to "official" emergency/temporary shelters. Sheltering in the Bay Area and Santa Cruz was complicated by the presence of a significant chronically homeless population who also sought shelter at Red Cross facilities. The Red Cross attempted to cluster various "social types" (elderly, families with children, homeless men) together as shelters were consolidated, although some victims resisted relocation into shelters away from former residences. Military housing facilities at the Presidio (San Francisco) were used for some of the shelters and a Navy ship in San Francisco Bay was designated as a shelter for some chronically homeless victims.

In Santa Cruz, San Benito, and Monterey Counties, the Red Cross opened a total of 13 shelters, all but two of those being in Santa Cruz County. The maximum population for these shelters was approximately 1,200 nightly, 7 days after the earthquake. An unofficial "tent city" was established by Hispanic victims in a park in Watsonville where an additional 150 victims found refuge. This encampment was not sanctioned by the Red Cross, although that organization did ultimately provide food and health services.

The Red Cross provided mass care services in Santa Cruz County for 66 days, an exceptionally long period for temporary shelters to be open. The last shelter was closed December 21, 1989, with 21 families in that shelter as yet unable to find temporary housing. A total of more than 24,000 bed nights were provided to victims in Santa Cruz and adjacent county Red Cross shelters. In both the Bay Area and in Santa Cruz County, shelters were consolidated as victims located temporary housing or returned to their damaged homes. Shelter populations grew for approximately one week after the earthquake as homes were inspected and some were condemned as unsafe (red tagged). There was also a steady turnover in shelter populations as some victims found housing elsewhere; others went to shelters as their homes were red tagged.

The fact that the Red Cross was providing meals to more than five times as many people as it was sheltering suggests that many were sleeping in damaged homes, often lacking gas, water, or electricity and obtaining meals from a mass care facility. Difficulties in repairing infrastructural damage, especially in the remote mountainous areas of Santa Cruz County, meant that many otherwise undamaged homes could not be used, thereby increasing loads on Red Cross mass care services. For example, 10 days after the temblor, 16,200 homes, most in Santa Cruz County, did not have natural gas service.

By the third week post-impact shelter populations had declined to 480 in 6 shelters in Santa Cruz County. The majority of these victims were in shelters in Watsonville, where a severe pre-disaster housing shortage complicated relocation into temporary housing. With a number of strong aftershocks in the County, some victims were reluctant to use Red Cross shelters located in built structures due to fear of building collapse.

FEMA opened its first Disaster Application Center (DAC) in Santa Cruz and Monterey Counties on October 22, 1989. With the opening of the DAC's, victims could begin apply for temporary housing assistance. The major form of assistance available from FEMA was cash grants to displaced renters and homeowners in the counties with Federal disaster declarations. Dollar amounts available in the housing grants were determined by "prevailing rates" for rental units, in this case $960 per month in Santa Cruz County. For renters, assistance was available for two-months rent, whereas homeowners were eligible for three. Victims who could demonstrate that the money, once granted, was actually used for temporary housing, were eligible for further assistance if they needed additional time in temporary housing.

After some pronounced political pressure as reported in the local press, FEMA agreed in mid-November to provide more than 140 trailers as additional temporary housing. Those trailers, the majority of which were targeted for Watsonville and neighboring Pajaro, were provided as a result of the intractable shortage of low-income housing in the area. FEMA's reluctance to furnish trailers is reflected in one FEMA spokesperson referring to the trailers as "instant slums." The trailers were to be available for up to 18 months with a renewal review every 2 months for the occupants.

To be eligible for either FEMA's temporary housing grants, or the trailers, victims had to be able to demonstrate a 30-day residency at a housing unit that was rendered uninhabitable by the earthquake. Like many other features of Federal relief programs, this requirement was criticized by community activists, although in previous disasters the residency requirement was 180 days. The demand for temporary housing was such that by November 2, 1989, FEMA had received more than 4,000 applications for housing assistance.

SHELTERING AND HOUSING ISSUES

Santa Cruz County was the center of a number of temporary shelter problems. Growing out of these problems

have been more recent related issues regarding the relocation of victims into longer term housing facilities. The issues varied in different parts of the county as well as by the specific victim groups involved. The issues grew out of difficulties associated with providing shelter and housing to a widely divergent multicultural population, many of whom were marginalized by age, poverty, or ethnicity even before the earthquake.

WATSONVILLE

In Watsonville and neighboring Pajaro the delivery of temporary shelter and housing was complicated by a complex set of class and ethnic antagonisms that variously involved the Red Cross, FEMA, and local governmental agencies. These conflicts emerged over preexisting social inequalities and a shortage of low-income housing exacerbated, in Watsonville, by the destruction of 363 housing units and major damage to 574 units. A number of these housing units were substandard and often housed more than one family, a fact that complicated qualifying for housing aid from FEMA. FEMA regulations restrict the provision of temporary housing aid to one family per address.

That those most in need of housing after the earthquake in Watsonville were low-income Mexican-Americans employed in the agricultural sector added cultural and political dimensions to the shelter and housing process. The housing problem in Watsonville was evident in the incommensurability between the low wages Hispanics receive in the agricultural sector and the land values and rents being driven up by wealthy Anglo landowners and real estate speculators. The upshot is that the number of workers necessary to drive a multimillion dollar agricultural production system increasingly could not afford to live in the areas in which they were employed. The earthquake intensified these contradictory tendencies by reducing low-rent housing stock further and engendering what came to be labeled the "housing crisis" in Watsonville.

Of the six temporary shelter facilities in Watsonville, five were official Red Cross operations, and one, Callaghan Park, was not. The latter was a "tent city" established by victims in a city park and occupied by approximately 150 Mexican-American victims. The number of Mexican-American as well as Mexican national victims meant that bilingual emergency workers and shelter managers were both necessary and in short supply.

Some of our respondents indicated a reluctance to go to shelters or use DAC's for fear of their residency status being challenged by Immigration and Naturalization Service (INS) personnel. On October 24, 1989, one week after the mainshock, FEMA publicly announced that their records would not be turned over to the INS and that aid was available to all legitimate victims regardless of citizenship. Other Hispanic victims, particularly recent Central American refugees, were hesitant to use shelter facilities due to the presence of uniformed, armed National Guard personnel, according to officials interviewed in our study. Those with recent experience in the Mexico City earthquake indicated that they simply did not want to go inside buildings, fearing collapse from aftershocks.

The earthquake and the subsequent housing crisis highlighted the preexisting deficiencies and inequities in Watsonville housing and provided the circumstance in which a new political agenda could be formulated, with housing as its focus. What began as a relatively straightforward process of providing temporary shelter evolved rapidly into a highly politicized process intended to redress preexisting class and ethnic inequalities in the availability of housing.

One of the foci of the emergent political struggle was the unofficial temporary shelter facility in Callaghan Park. Due to health and fire hazard concerns (tent flammability) the Red Cross did not want to provide services to victims in the camp, but instead encouraged families living there to relocate to existing shelters elsewhere in Watsonville and Pajaro. Families in the tent camp insisted on remaining there, near their old homes and with their friends and families. Pressure was put on the Red Cross to provide meals and medical services for the Callaghan Park site. Twelve days after the main shock the Red Cross did begin providing meals to the Callaghan Park group, who maintained their resistance to relocation into official shelters for nearly 2 months.

Other events that added to the politicized atmosphere of post-disaster Watsonville included: a demonstration led by Caesar Chavez of the United Farm Workers, in which victims were encouraged to demand low-income housing; charges of racism and insensitivity to cultural needs of Hispanic victims in some Red Cross shelters; a Justice Department investigation into charges of discrimination against Mexican-Americans in the city government; a complaint filed against FEMA by 20 Bay Area and South Bay county citizen groups and community organizations charging systematic discrimination against low-income and non-English speaking victims; assertions that the National Guard forcibly removed victims from one temporary shelter on November 25 after the Red Cross had closed the facility as part of the routine consolidation of temporary shelters.

While these events were transpiring, efforts were being made by a number of different groups, both governmental and private organizations, to find solutions to the housing crisis in Watsonville. The local Community Action Board in conjunction with the county's Housing Recovery Task Force developed a system of motel vouchers to utilize area motels as a source of temporary housing for victims who could not find other housing.

As noted another source of temporary housing was the use of FEMA trailers. Initially FEMA did not intend to

bring in trailers to the Watsonville or Santa Cruz areas because, according to their data, there was adequate surplus housing stock available. After pressure from the Congressional Representative from the area as well as the county Housing Recovery Task Force, FEMA did agree to provide trailers to the Watsonville area if suitable sites could be located and the necessary infrastructure put into place for the trailers. The sites in Watsonville and Pajaro were duly prepared and the first trailers began arriving in the area December 14, 1989. Even after the first one hundred trailers began arriving, FEMA and the county were in disagreement over how many additional trailers were needed, with FEMA arguing for fewer rather than more trailers.

The "unofficial" temporary shelter camp at Callaghan Park was closed on December 9, and a number of its occupants were given FEMA trailers. The Red Cross closed its last shelter at the County Fairgrounds in Watsonville on December 22, placing remaining families in motels with short-term occupancy vouchers. The Buena Vista Migrant Labor Camp near Pajaro was also utilized as temporary housing facilities for several months after the disaster, although it was not considered wholly suitable for habitation during the winter months.

FEMA as well as the local government expressed concern that the trailer camps would become permanent housing, something that is beyond the intent of the housing program. There was initial evidence during the 3-month course of this study that this was a justifiable concern on FEMA's part[1]. For some of the displaced Mexican-American victims, the trailers provided a home that was significantly higher quality than their previous housing. Interviews with residents and local Mexican-American community organizers indicated that many local families were living in substandard housing, including such things as converted garages. Others were living "doubled" up with another family, resulting in combined households of 15 or more members. For some of these victims, the trailers provided the first private family setting, with electricity and water, that they had experienced since moving to Watsonville. Because some see the trailers as a permanent solution to the housing crisis, this will undoubtedly complicate FEMA's efforts to manage the trailer courts as temporary housing, ultimately withdrawing trailers after the 18-month period of availability has expired.

[1]Since this research was completed a number of local programs in Santa Cruz County have been developed to assist victims with the purchase of FEMA trailers to use as permanent housing. Limited space available to locate trailers has complicated their use in Santa Cruz County as replacement permanent housing. The problems involved in reestablishing permanent housing, however, is beyond the scope of this research.

SANTA CRUZ

The shelter and housing issues in Santa Cruz and the Summit area involved similar concerns to those in Watsonville insofar as sheltering was complicated by a lack of available affordable housing. The victim population in Santa Cruz was more diversified by social class and less unified by ethnicity than Watsonville. While the disaster in Santa Cruz created opportunities to address the specific housing needs of marginalized groups such as elders, poor Mexican-Americans, and the chronically homeless, it was not characterized by the rancorous conflict seen in Watsonville.

In managing temporary shelters in Santa Cruz, as with Watsonville, there were shortages of trained shelter managers and nurses, particularly those with bilingual skills. These shortages were complicated by the 66-day period that the Red Cross kept mass-care operations going. This meant that there were several cycles of Red Cross staff moving through on their normal three-week assignments. Both staff turnover and burnout were reported as organizational problems in the delivery of shelter services that had to be managed during the emergency period.

Discussions with shelter managers from several of the Santa Cruz shelters indicated relatively high levels of emotional distress among victims, particularly children. Part of the Red Cross response to this was to station mental health outreach workers in shelters to help victims cope with their stress and anxieties. The Santa Cruz shelters, six in all, dealt with a diverse set of clients ranging from poor Mexican-Americans from the Beach Flats neighborhood to wealthy homeowners from the mountainous Summit area.

As in Watsonville, there were some impromptu tent encampments established early on after the earthquake, but they were quickly closed by police and victims relocated to Red Cross shelters. Sheltering in Santa Cruz was complicated by the number of chronically homeless, including some who were variously described by respondents as "counter-culturals" or street people. While these nondisaster homeless were allowed to use Red Cross shelters, their lack of verifiable addresses meant they were not eligible for temporary housing programs offered by FEMA.

The earthquake did provide the impetus and the opportunity to address the lack of low-income housing and the permanent homeless population in Santa Cruz. In interviews, Red Cross officials indicated that homeless persons from San Francisco were coming to Santa Cruz because that city was more "congenial" to the chronically homeless. At the time of this writing planning was underway to construct low-income housing utilizing surplus Red Cross earthquake relief funds to mitigate the housing squeeze.

Due to the destruction of several residential hotels in downtown Santa Cruz, approximately 500 low-income elders were displaced by the earthquake and 300 were in need of new housing. FEMA worked with local communi-

ty agencies to place homeless elders in suitable temporary facilities. The University of California, Santa Cruz, offered part of its campus as a possible site for FEMA trailers specifically intended to provide temporary housing for the elder victims but that plan was not implemented as of February 1990.

Other significant shelter and housing issues in Santa Cruz involved the mountain communities where problems of access, communication, and landslide hazard complicated emergency response and the use of temporary shelters. Some 300 victims did occupy shelters nightly during the first 2 weeks after the mainshock. Red Cross shelter managers reported that a strong local ethos of "self reliance" made many of the Summit area victims reluctant to utilize Red Cross shelters.

Temporary shelter and housing in the Summit area posed problems because many of the damaged homes were located in an area of historically high landslide hazard. A building moratorium was put into effect by the county of Santa Cruz in the high-hazard mountainous areas until June 1991. This meant that even if victims could secure SBA loans or FEMA home repair grants, they could not proceed with rebuilding. As a result they were held in "limbo" according to one respondent, often living in a camping trailer or tent on their property. The easing of this building moratorium was expected to allow victims to proceed to with home reconstruction, if adequate funding could be secured. However some victims' house lots were so heavily damaged by the earthquake that it seemed unlikely that building permits would be issued or that loans will be approved. Rebuilding in the mountains will also be problematic for those whose homes were constructed before strict building codes were in effect, and who now cannot afford to rebuild to the new codes.

While local officials sought approval from FEMA to locate trailers in the Summit area on house lots, FEMA was reluctant to permit trailers to be situated in hazardous areas near the epicenter. For many areas in the mountains of the county, the FEMA trailers were judged too large to move over the roadways to homesites. One FEMA trailer camp was under construction at the time of this study in the Corralitos area, a foothill agricultural community that had 150 homes heavily damaged and 52 destroyed (out of 1,032) by the temblor. In general, the earthquake was particularly disruptive of water, sewer, and septic systems in the mountain communities, making many homes unusable by victims for weeks after the mainshock.

CONCLUDING OBSERVATIONS

Our discussion has highlighted some of the major issues in shelter and housing in Santa Cruz County. Although our research spanned only a three-month period after the earthquake, it has clearly shown that pre-disaster social conditions combined with the differential effects of the disaster created a number of significant problems in sheltering the victims and in exacerbating longer term housing problems. Given the problems encountered by emergency response organizations in sheltering only a small fraction of the total at-risk population of northern California, shelter and housing problems are likely to be exponentially larger in the case of a strong earthquake in the Bay Area. The increasing numbers of urban poor, the homeless, elders, and ethnic minorities (including recent immigrants) in urban areas of California also will complicate the provision of shelter and longer term recovery processes after a great earthquake in the State (see Rubin and Palm, 1987).

By way of summarizing and generalizing from the specifics presented above, we conclude with a series of general observations and recommendations regarding post-earthquake shelter and housing issues. These conclusions derive from our research on Loma Prieta as well as from previous research on other California earthquakes (Bolin and Stanford, 1991).

1. To improve emergency response programs in areas that have an ethnically and culturally diverse victim population, organizations and agencies involved in such programs should base planning on careful demographic and ethnographic surveys of potential victim populations. Knowledge of how victims might actually utilize disaster shelter services in the event of a great earthquake will make planning for the delivery of emergency and temporary shelter more effective.

2. The social, political, and economic disruption of disasters can create conditions conducive to social change. This is most pronounced in instances where victims view the disaster as an opportunity and a vehicle to obtain social and economic resources historically denied them. These efforts at social change, because they typically challenge traditional patterns of power, privilege, and property, may be resisted, resulting in conflict. Disaster relief organizations may become embroiled in such conflicts or even become the target of disputes over relief and recovery resources, complicating the delivery of services.

3. The presence of disadvantaged persons living in marginal housing is likely to result, after a disaster, in demands on emergency services organizations that are frequently unanticipated within the framework of traditional shelter and housing programs. Highly bureaucratized aid programs, particularly at the Federal level may not have the flexibility to adequately deal with such victims. Ethnic minorities and other marginalized groups may experience pronounced difficulties in working with Federal and State disaster bureaucracies because of language or cultural barriers and are likely to underutilize such programs as a result. Cultural sensitivity training for disaster responders, utilization of local minority residents in the response effort, combined with outreach programs may improve delivery of services to these marginal groups.

4. Protracted emergency periods, involving extended stays by victims in mass shelters, appear to have an enhanced potential for social conflict to emerge over issues of short-term relief as well as restoration and recovery. These conflicts are more likely to appear in circumstances where the class and ethnic divisions of a community are relatively pronounced before the disaster. Such conflicts may be mitigated through liaison efforts and cooperative projects involving coalitions of Federal, State, and local officials along with existing or emergent community groups in the affected communities.

5. While earthquakes provide opportunities for redressing pre-existing problems in housing and seismic safety, the pressure from citizens to respond quickly in the provision of temporary housing and in reconstruction may limit the amount of long-range planning that can be utilized in addressing these concerns. Similarly, without social or political pressures to do otherwise, governmental planning and policies for rehabilitation and reconstruction will tend to reinforce pre-disaster patterns of social inequality and class advantages.

6. The effectiveness of short-term responses to disasters involving ethnically and socio-economically diverse victims will be enhanced by the involvement of citizens and community groups working in conjunction with Federal, State and local organizations. Such coalitions are often able to develop locality relevant policies and programs that address shelter and housing needs not met by more traditional relief programs.

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PUBLIC RESPONSE

BUILDING CONTENT HAZARDS AND BEHAVIOR OF MOBILITY-RESTRICTED RESIDENTS

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CONTENTS

ABSTRACT

Recent literature indicates that preparedness and behavioral response of disabled individuals are important elements in their ability to cope with earthquake hazards inside buildings. A survey questionnaire was conducted to study behavior responses of a small sample of physically disabled residents (with no injuries) during the Loma Prieta earthquake. An action-content analysis was developed and applied to the respondents' sequence of activities. Wheelchair users found it difficult to control their movements. Severe restrictions in the respondents' physical (force and motion) capabilities appeared to expose a few of the respondents to potential injury-producing hazards. Nevertheless, the majority of physically disabled occupants did not feel vulnerable to the potential hazards caused by shaking forces. The majority of those who felt vulnerable, however, took active measures to protect themselves during and immediately after the shaking. The disabled residents in this study had mostly adapted their living environment for their normal daily activities; however, lack of earthquake preparedness was evident before and after the event.

INTRODUCTION

The United Nations Disaster Relief Coordinator estimated that there were 500 million disabled persons worldwide (United Nations Disaster Relief Coordinator, 1982). A survey from the United States indicated that between 12 and 14 percent of the working population are disabled and that about another 10 percent have some activity limitation (U.S. Bureau of Census, 1980). For persons with disabilities related to motor functioning, the estimate is around 23.4 million (9.6 percent of U.S. population) (Elkind, 1990). Estimates show that the percentage of people with disabilities has increased significantly over the past decade (Finch, 1979; Elkind, 1990). Based on the new census data, if elderly (12.5 percent of population more than 65 years of age) and children (7.5 percent of population less than 5 years of age) are added to these estimates, about half of the U.S. population could be classified as people with "special needs" during disasters and emergencies. In relation to earthquake situations, Aroni and Durkin (1985) reported that 50 out of the 133 injured persons they contacted after the 1983 Coalinga (California) earthquake had some type of disability. At nearly 38 percent, this percentage is larger than the overall rate of disability for that community. In an earthquake in Guatemala (February 4, 1976; 7.5 on the Richter scale and lasted 39 seconds), the rate of death was the highest among children and the rate of serious injuries was the highest among elderly (Glass and others, 1977). However, this study did not include a category for disabled people. Moreover, Parr (1987) argued that in disaster situations, the needs and vulnerabilities of children and elderly persons may resemble those of disabled persons. If this is the case, the size of the population in a high risk category is relatively large.

BUILDING HAZARDS AND OCCUPANT BEHAVIOR

The primary cause of death, injury, and destruction in earthquakes results from the collapse of man-made structures (Arnold, 1990; Noji, 1991). From an epidemiological viewpoint, frequency and severity of earthquake casualties should be considered as time-dependent and dynamic processes (Pomonis and others, 1991) that are influenced by a large number of factors ranging from characteristics of ground motions and soil formations, typology of structures, to a multitude of social and behavioral factors. For a summary of research needs in this area, see Murakami and Durkin (1988), Jones and others (1990), and Tierney (1990).

Although structural hazards are the most significant causes of fatalities, recent data tend to support a notion of differential impact of earthquake hazards for death versus injuries (Alexander, 1985; Aroni and Durkin, 1985; Pollander and Rund, 1989; Ohta and Okada, 1989). There is a growing body of evidence that nonstructural elements and building contents can cause deaths and injuries and that the human factors mitigation strategy can be effective in reducing earthquake injuries. For example, the percentage of injuries related to nonstructural and building contents (for example, glass, furniture, fixtures, appliances, chemical substances) appears to be higher than investigators had originally believed (Ohta and Ohashi, 1980; Ohashi and Ohta, 1984; Bourque and others, 1991). In a recent study from the 1987 Whittier Narrows earthquake (M=5.9), Bourque and others (1991) reported that 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." Occupant injuries have also been attributed to the time-dependent behavior responses of individuals (Ohta and Okada, 1989).

BUILDING HAZARDS FACED BY PHYSICALLY DISABLED

The generally accepted belief is that disabled individuals are unable to cope with building hazards during earthquakes. Preliminary observations of residential dwellings of disabled individuals indicated that, generally speaking, our disabled individuals have not been prepared for the devastating consequences of a major earthquake (Tierney and others, 1988; Rahimi, 1990; Eldar, 1991). In a study conducted in Los Angeles, Tierney and others (1988) showed that a significant portion of the disabled individuals in that city live in earthquake-prone areas with significant structural and nonstructural hazards. In cases where total or partial collapse does not occur, ground shaking may restrict disabled occupants' access to their perceived or recommended safety zones, required medications, special aids and equipment, and assistance from others. Also, the severity of a person's disability and type of living arrangement may affect their ability or expectation to receive assistance from others. From a behavioral point of view, disabled occupants may not act in time and in a self-protective mode when faced with life-threatening emergency situations (Levin, 1979; Clive, 1983). On the other hand, there is a factor of experience that may enhance disabled occupants' ability to cope with and negotiate earthquake hazards (Sorensen, 1983).

A hypothesis under examination here is whether a relationship exists between physical disability and an increased risk of injury during and immediately after earthquakes. As mentioned, this relationship is influenced by a number of complicated variables (causal factors) that may be impossible to consider simultaneously in this study. Therefore, the following limitations have been incorporated. The event after which this study was conducted was a magnitude 7.1 earthquake affecting mostly an urban setting during daytime with a relatively low number of death and injuries. Behavioral response data were taken from a section of the physically disabled population with moderate to severe functional disability in upper and lower extremities who received no injuries, mostly self-reliant, and mostly living in single structures which did not suffer significant damage. Selecting the four cities where the respondents resided was a factor primarily of the presence of organizations which helped the research team locate the participants. The research team interviewed any participant who passed the initial screening test within the timeframe available (that is, the sampling was not statistically randomized within the four communities considered). Since these disabled people were living independently, no case-control comparisons were made with the behavioral response of able-bodied individuals living in the same structures. No control for age and earthquake experience of the respondents was considered for selection purposes. With these restrictions, this research was designed as an exploratory study to shed some light on what physically disabled people do during severe shaking which may place them in injury-producing situations. In this sense, this study is designed to gain basic knowledge upon which future comparative research can be constructed.

RESULTS OF THE SURVEY AND INTERVIEWS

An initial step was to design a questionnaire/survey and its associated analysis tool for studying the behavior of disabled persons in an earthquake. The noncontextual

aspects of the questionnaire (spacing, location of questions, font size, and so forth) was based on the recommendations from Berdie and Anderson (1976). Forty-four questions of closed and open-ended format were included in the survey. This survey was designed to elicit detailed profiles and behavioral information from a sample of physically disabled persons affected by the earthquake. Clusters of questions provided detailed information on the respondents' personal characteristics, judgments on hazardousness of the earthquake and building contents, and activities performed during and immediately after the shaking. The content of the questionnaire was based on the recommendations provided by Backstrom and Hursh-Cesar (1981) and Keating and Loftus (1984). This method can be easily used to portray time chronology of occupants' behavior in relation to the potential hazards present in their immediate environments. The questions primarily relied on memory recall by "leading" the respondent through an action-sequence step for their observable behaviors (Friedman, 1987). The sequencing of the activities was made possible by anchoring the beginning and end of the action depiction list within the timeframe of the occupant's perceived danger. In terms of the administration of this questionnaire, single and short interviews were found to be effective and audio tape recording of the interviews was necessary as back-up for data collection and data extraction.

To identify potential interviewees, local organizations offering special services and assistance to disabled persons (for example, United Cerebral Palsy, Community Resources for the Disabled) were contacted. The surveys were administered to physically disabled occupants of residential dwellings in separate interview sessions (about 90 minutes each) in the third month after the event. Face-to-face interviews were conducted with 33 physically disabled persons living in San Francisco, Berkeley, Oakland, and Santa Cruz. Within the time frame available, the research team found it difficult to perform more interviews. This small sample size was considered sufficient for exploratory purposes. The interviewees were screened for their types of disabilities. About 82 percent of the selected sample (27 persons) had a moderate or severe physical disability of the upper and lower extremities (mostly related to cerebral palsy, multiple sclerosis, muscular dystrophy, and spinal cord injuries). This sample was selected with the expectation that moderate to severe disabilities would create difficult conditions for self-protective actions (Tierney and others, 1988). None of the interviewees experienced any significant structural damage and most experienced nonstructural and building content damages. The following sections contain some important findings from this study. This paper presents information on three sets of topics: (1) interviewees' personal characteristics and living arrangement; (2) environmental feature; and (3) interviewees' activities and hazard exposure during and immediately after the earthquake.

PERSONAL CHARACTERISTICS AND LIVING ARRANGEMENTS

The mean age of the interviewees was 37.5 years, and the majority (about 73 percent, 22 persons) were males. When asked about their disability, the categories of disability most mentioned were cerebral palsy, multiple sclerosis, neuromuscular diseases (Parkinson's and muscular dystrophy), and spinal cord injury. The majority of the respondents (about 61 percent, 20 persons) had their disabling condition for over 10 years, about 24 percent (8 persons) had their condition for 2 to 10 years, and about 15 percent (5 persons) for less than 2 years. Table 1 indicates that the majority of the respondents were experienced with their disability at the time of the earthquake. In fact, given that a large number of the interviewees had disabilities which confined them to wheelchairs (73 percent, 24 persons), they were able to perform most routine daily activities in a nonemergency situation.

Moving around is the most frequent activity in earthquakes (see Goltz and others, 1991). For comparison purposes, we need to know whether our sample of disabled individuals was able to move around prior to the earthquake. Table 1 summarizes a number of moving-related capabilities of our sample in normal daily situations. The majority of the respondents (88 percent, 29 persons) were able to move about using their walking aids without assistance from other people. Yet, if their wheelchairs (or walking aids) were inoperable, only 9 percent (3 persons) would have been able to move about their living quarters. Even with their adaptive devices operable, 70 percent of the respondents (23 persons) could not use the stairs for emergency exiting. In reference to their upper extremity abilities, the majority of the respondents were able to use door knobs (79 percent, 26 persons), taps and valves (61 percent, 20 persons), and light switches (85 percent, 28 persons). Overall, this is an indication that although their levels of disability were severe, the respondents were adapted to their living environments for normal daily activities.

In order to have a better understanding of how they were able to physically handle objects, they were asked of their ability to push, carry, or pick up different sizes and weights of objects (table 2). This table suggests that the interviewees were able to perform the task of "pushing" easier than "carrying" or "picking-up." In addition to physical abilities, the perception of one's disability level is a motivational variable for emergency response to disaster situations (Vash, 1981). The respondents were asked to indicate their level of disability. This question was asked on a rating scale from zero (nothing at all) to

Table 1. *Ability of the respondents to perform some tasks in daily living (nonearthquake) situations*

Question	Number responding Yes	No
Do you require assistance of others to move from one location to another?	4	29
Do you require the use of walking aids?	30	3
Do you require assistance to get out of a bed or chair?	14	19
Can you walk up or down stairs?	10	23
Can you open and close doors by yourself?	26	7
Can you open and close taps or valves firmly?	20	13
Can you turn on/off light switches?	28	5

Table 2. *Percent respondents who believed they were able to perform the required object manipulations during an earthquake*

[Examples for different object categories: small (S), flashlight; medium (M), medicine box; large (L), coffee table; large/heavy (L/H), couch]

Question	Object Category			
	S	M	L	L/H
Which items can you pickup from the floor?	62	59	48	Not included
Which items can you carry from one place to another?	83	79	47	Not included
Which items can you push from one place to another?	Not included	85	80	46

ten (bed ridden). This scale was anchored at interval distances (Borg, 1982). About one-half of the respondents (17 persons) described their disability as less than severe. About 36 percent (12 persons) were severely disabled, and the remaining 12 percent (4 persons) were very severely disabled and bedridden. Their perception were later matched against their actual medical conditions. It was found that the respondents had a fairly accurate perception of their loss of function.

We were also interested in knowing whether the respondents received critical assistance from others during the event. About 40 percent of the interviewees (13 persons) reported that they were living alone at the time of the earthquake. About 45 percent (15 persons) lived with one other person, and the remainder lived with two or more persons. Of those who lived alone, only four persons stated that they relied on neighbors or others for assistance in emergencies. Nonetheless, about one-half of the interviewees (17 persons) reported that they were alone at the onset of earthquake shaking on October 17, and no one else came to their assistance during the 10 to 15 seconds of shaking. This indicates that these individuals basically acted on their own, rather than with assistance from others, during and immediately after impact. Similarly, the study by Tierney and others (1988) suggested that disabled individuals living in institutional environments are slower to respond on their own and expect to receive assistance from others.

ENVIRONMENTAL FEATURES

Elements of the environment play an important role in the cognitive and decisionmaking processes of human beings (Vicente, 1990). Many earthquake injuries occur when occupants attempt to handle the objects inside a room or try to exit the building while objects are falling. The type of room, interior design and layout, type and size of contents vary enormously from one structure to another. About 45 percent of the respondents (15 persons) described their living units as houses and another 42 percent as apartments or condominiums. Therefore, the results of this research are mostly related to residential dwellings. Nonetheless, there were similarities and differences between these spaces in terms of contents and nonstructural elements. In general, houses had more floor space and appeared to have more elaborate interior design. The apartment designs ranged from a simple one bedroom (with the kitchen opening into the living room) to a large two bedroom (with separate kitchen area). It is important to mention that during the course of interviews, it became evident that most respondents had customized their living spaces according to their specific needs. Recent advances in rehabilitation engineering have made it possible to modify and adapt living and work environments to accommodate a wide variety of disabilities under a variety of environmental and work-space design considerations (Mital and Karwowski, 1988; Rahimi and Malzahn, 1984).

In a study by Howell and Epp (1978), it was stressed that knowledge about a building's contents and the arrangement of items inside living spaces is necessary for the efficient use of living quarters by the elderly. The design of interior spaces and nonstructural elements was also stressed by Raschko (1982) as an important factor in the safety of disabled occupants. These design concerns may become even more critical for the safety of disabled occupants during earthquakes. As mentioned before, surrounding objects in a room become hazard sources during and immediately after a strong earthquake. The room location and the surrounding objects recalled by the interviewees are listed in table 3. The objects ranged from a small book to a large refrigerator. An evaluation of the degree of hazard caused by these objects during the earthquake will be presented later. In addition, we felt that in order for the occupants to be aware of the potential hazards caused by these objects, they needed to be observant and know the location of these objects before the shaking. The interviewees were asked about their degree of familiarity with their immediate surroundings. About 85 percent of the people (28 persons) indicated that they were very familiar with their surroundings and the arrangements within them at the time of shaking.

Table 3. *Type of environment (respondent location) and contents at the onset of earthquake*

[Data were not communicated or completed for respondent 8]

Respondent	Environment type	Items located in immediate environment
1	Institute bedroom	TV, closet, plants, hospital bed
2	Institute four bed ward	Hospital beds, night-stand, curtains
3	Living room	TV, wheelchair, frames, flower pot, refrigerator, couch, dining table, microwave, wall clock, phone
4	Bedroom	TV
5	Living room	TV, VCR, cabinet, lamp, frames, shelves, books
6	Living room	TV, table, music system, speakers, couch, drawing table
7	Living room	China clock, antique dish, planter, large shelves, desk
9	Computer room	Desk, books piled high, cabinets, boxes, computer, phone
10	Eating area	Tables, potted plants, lights
11	Living room	Books, shelves, couch, music system, speakers, TV
12	Living room	Couches, music system, speakers, fish tank, table, coffee
13	Kitchen	Refrigerator, spice rack, cabinets, food tins, fan, oven
14	Office meeting room	Table, chairs, book shelves, music system, speakers
15	Kitchen	Dishes, table, chairs, refrigerator, cabinets, phone
16	Bedroom	Miniatures, statues, frames, books, table clock, TV
17	Bakery patio	Books, tables, chairs, potted plants, coffee cup
18	Parking lot	Power lines, newspaper stand, phone lines, bakery patio
19	Office	Computer terminals, keyboards, shelves, desk, motor
20	Living room	Drawing tables, dinning table, chairs, computer, overhead
21	Bedroom	Computer, book shelves, bed, table lamps, desk, phone
22	Garage	Washing machine, car, shelves with tools
23	Bedroom	Computer, TV, bed, table, bookshelves mounted, table
24	Classroom	Desks, tables, chairs, one wall entirely glass
25	Street, in front of house	Overhead power cables, trees, chimney, automobiles
26	Bathroom	Wheelchair, tub, shower seat , overhead lamp
27	Living room	Table, TV, VCR, rocking chair, books, shelves, couches
28	Office	Desk, type-writer, entertainment center on wheels, potted
29	Computer room	Long tables, computer terminals, IBM tape drive, VAX
30	Bathroom	Door, toilet, potty chair, hanging ceramic magazine rack
31	Doctor's office	Desk, table, coffee table, computer, table lamps, frames, on floor
32	Dining room	Table, chairs, phone stand, TV
33	Outside patio	Table, Kayak, tools, shelves
34	Back bedroom	Music system, speakers, computer, printer, desk, couch

ACTIVITIES AND HAZARD EXPOSURE

ACTIONS TAKEN DURING EARTHQUAKE

It has been clearly documented that because building occupants do not remain stationary, they become sources of hazards during earthquakes (for example, Ohta and Ohashi, 1980; Archea, 1990). Also, the safety of occupants, including persons with disabilities, is likely to depend on how they react during and immediately after impact and on what self-protection measures they are able to carry out. In order to obtain a better understanding of how interviewees behaved and how safe they were during the earthquake, they were asked to report their actions sequentially. This section of the questionnaire began with questions related to the disabled persons' body positions and their first reactions and continued with detailed descriptions of their activities until the moment that they finally felt they were out of danger from the initial shock. The remainder of this paper attempts to relate the disabled persons' physical activities to the corresponding degree of hazard exposure during the earthquake. (A set of single-paragraph summaries of the activity sequences for each respondent during the earthquake is available upon request.)

The location and body position of a disabled person at impact may be the most important factor in terms of ability to react to potentially hazardous situations. For example, it is known that in a residential fire situation, a person was not able to escape the danger because he was in his bathroom taking a bath (Levin, 1987). In our sample, a majority of the respondents (94 percent, 31 persons) were in either standing (and walking) or sitting positions as opposed to kneeling, reclining, or lying. Twenty-four respondents were regular wheelchair users at the time of the event. The respondents' readiness to take necessary action became more important considering the fact that about 52 percent of the respondents (16 persons) were alone at the onset of shaking. Help from others was not available for these people during the shaking. It must be noted that behavior of disabled occupants during an earthquake may have differed if other people were present in the room. Single-person versus multiple-person behavior was not addressed in this research. However, there is a need to study the behavior of disabled persons in a group-interactive environment.

The initial reactions of the respondents were organized and are listed in table 4. These actions were taken by the occupants at the onset of shaking. Analysis of the respondents' initial reaction is an important part of this study since these actions constitute the bases from which the subsequent behavior patterns can be evaluated. Based on the frequencies shown in table 4, 10 respondents (out of 33) initiated "active" mode of behavior (classification provided by Tierney and others, 1988). Labeled as "initial movement," these actions included moving under a door frame or overhead beam, standing up, sitting on the edge of a couch, and others. Initiation of such actions are considered to be an important part of a strategy for self-protection and safe behavior during earthquakes. "Holding on" to something was the second highest category. About one-third of the respondents (9 out of 33) held onto an object to counteract the forces of shaking. Most of the respondents in this category held onto an object to prevent from falling (one respondent held onto a spice rack to prevent it from falling on him). Approximately 33 percent of the respondents in this category held onto their wheelchair without initiating any active behavior at the onset of the earthquake. The third highest category of initial reactions was classed as "stayed put." In this category, eight respondents did not move much, even though they had the opportunity to do so. Some of the respondents did not realize the severity of the earthquake and thus did not react to the initial shaking, whereas others chose to stay in the same location. Nine percent (3 respondents) reported an unconscious automatic nonresponse to the onset of the shaking (classed as "instinctive behavior"). These are the most extreme cases of passive behavior which was detrimental to the self-protective needs of the building occupants. Finally, only three respondents were engaged in only "observing" the events within their surroundings at the onset of shaking.

MODE OF BEHAVIOR VERSUS FEELING OF VULNERABILITY OR SAFETY

As mentioned before, an active mode of behavior involves an individual's attempt to actively enhance personal safety, given the nature of the individual's disability and the

Table 4. *Respondents' first reactions and their reasons*

First reaction	Frequency	Reasons for actions
Initial movement:		
- under door frame	3	- to avoid falling debris and glass - prior education
- under overhead beam	1	- to be safe, prior knowledge
- under desk	1	- was told to do so
- toward exit door	1	- wanted to get out (did not succeed)
- into hallway	1	- to be safe, prior knowledge
- by turning wheelchair	1	- to face away from glass windows
- stood up	1	- did not know what else to do
- sat on edge of couch	1	- to get away from glass windows
Held onto:		
- couch/wheelchair	5	- shaking was intense - to stop from falling over, due to low balance control - did not know what to do - looking at plaster falling from ceiling - was bouncing out of control
- table	1	- afraid of falling
- spice rack	1	- was falling on respondent
- bathroom handrails	1	- to stop from falling over
- wheelchair wheels	1	- to stay in chair
Stayed put:		
- did not move much	5	- did not realize how bad the earthquake was - quake was mild - was not initially worried, had a pre-notion that morning - location was safe - to get a hug from doctor
- in car	1	- did not know how to react
- on phone	1	- to comfort friend on the line, and pass on last message
- yelled for help,	1	- unable to get out of bed on his own
Instinctive behavior:		
- started spasm	2	- automatic nervous reaction to stress
- froze	1	- seeing and hearing others panic caused this reaction
Observation:		
	3	- turned wheelchair out of curiosity to see what was happening to the space around - to get an estimate of earthquake intensity - looking for phone to call daughter

surrounding hazards encountered. For example, a number of respondents initiated physical actions that placed them in a location of perceived safety. Also, some respondents made every attempt to hold onto an object to prevent their falling. In contrast, in the passive mode, some respondents took no self-protective action in response to the earthquake. To allow for this dichotomy, the survey questionnaire contained an action sequence format based on a scenario analysis developed by Keating and Loftus (1984). This format led each of the respondents through a series of time-phased steps from the onset of shaking until the time when the respondents felt out of danger. Based on the active/passive analysis, the sample was split almost equally between persons who reported responding in an active manner and those who remained passive during the shaking. It is interesting to note that Arnold and others (1982) found that only 37 percent of the building occupants (disabled and able-bodied) stayed put during an earthquake in the Imperial County, California. Also, Archea and Kobayashi (1984) found that during the period of strong motion of an earthquake in Urakawa, Japan, respondents even increased their risk of injury by attempting to move about and to protect their personal belongings. No mention of respondents' disability was made in the Japanese sample.

A thorough investigation of occupant behavior must also include some aspects of the respondents' cognitive and emotional states. For example, one wheelchair-confined person indicated that he remained in his wheelchair during the entire period of shaking and did not attempt to move at all. When asked about his feeling of vulnerability, he responded that he felt "safe." His apparent lack of active behavior appeared to be mediated by a perception of safety based on variables related to his surroundings and personal traits. On the other hand, another respondent who held tight to her wheelchair during the shaking reported feeling very vulnerable. Her explanation was that even if she wanted to move to a safer location, she decided not to do so fearing she might fall out of her chair. To reflect this categorization on the entire sample of the disabled respondents, their active or passive behavior was cross-tabulated with their feeling of vulnerability. A nonparametric correlational analysis was conducted to explore this relationship. A resultant phi coefficient of –0.34 in table 5 indicates that interviewees who reported feeling safe during the shaking were likely to also report remaining in a passive state during the shaking (12 out of 33 persons). On the other hand, those who reported feeling vulnerable were more likely to have taken some action (10 out of 33 persons).

An important result emerges from table 5: passive behavior among the disabled respondents does not necessarily reflect a psychological feeling of vulnerability or fear. It is more probable that this passive behavior stemmed from inability to perform activities which required physical strength than from psychological motivations required for such physical exertions. It is interesting to note that this result is consistent with the notion of "body-mind" system presented by Vash (1981). She explained that there seems to exist a distinction between physical performance limitations (disability) and psychological underpinnings of human behavior. Contrary to our findings, McDaniel (1976) believed that the principle of somatopsychology produces a degree of "devaluation" and "spread" for disabled persons. Devaluation refers to the attitude of reduced self-esteem and self-confidence which culminates in a feeling of helplessness and dependency. Eventually, this feeling may not remain confined to the actual limits of the impairment; instead, disabled individuals may come to view themselves as being excessively incapacitated, even in situations where they are clearly able to function independently.

This perceived lack of ability to actively respond may also be related to the individual's degree of control over the outcome of the natural hazard. DeMan and Simpson-Housley (1987) and Lehman and Taylor (1987) suggested that human psychological response to a perceived or on-going natural hazard is mediated by the degree of physical and psychological uncontrollability for the event occurrence. Occupants are motivated to avoid uncertainty in hazardous circumstances. Human beings tend to deal with such uncertainty by denying that potentially hazardous situations exist (Hale and Glendon, 1987). Psychological tests were not performed to assess the motivational variables for respon-

Table 5. *Relationship between respondents' perceived vulnerability and type of behavior during the earthquake*

[Table shows total number of respondents with percentage of total respondents inside parentheses. The phi correlation coefficient for cell frequencies is -0.34, significance level is 0.05]

Activity	Vulnerability		
	Vulnerable	Safe	Total
Passive	4(12.1)	12(36.4)	16(48.5)
Active	10(30.3)	7(21.2)	17(51.5)
Total	14(42.4)	19(57.6)	33(100)

dents' reactions. However, research in fire hazard mitigation has indicated that through education and training, disabled people can be successfully trained to overcome such obstacles (Levin and Nelson, 1981; Jones and others, 1984; MacEachron and Krauss, 1985; Pauls and Juillet, 1989).

HAZARDS CAUSED BY BUILDING CONTENTS

None of the respondents were injured during the earthquake. During the shaking, a number of items fell and broke close to the respondents (for example, dishes, picture frames, books, light fixture, table lamps, computer terminal). Table 6 contains a list of fallen and broken items. About 67 percent (22 persons) reported items fallen or broken near them. They were also asked if these items affected their decision to take (or not to take) any safety action. Of those who experienced fallen and broken items, about 68 percent (15 persons) responded that the broken items did not affect their decisions to take (or not to take) any action. Therefore, it is quite possible that for these 15 respondents, there was no feeling of being exposed to imminent danger and thus there was no need for immediate reaction or response. One person, however, was caught between a spice rack and a refrigerator while attempting to take an item from the refrigerator. For those whose actions were affected by these fallen and broken items, there was a definite problem of increased blocking and difficulty of maneuvering (with or without wheelchair). It was difficult to further evaluate the nature of these barriers without reenactment (simulation) of the individual cases. In this study, the items in table 6 were found to be potentially barrier producing. It is conceivable that in an earthquake of higher magnitude, these items could act as projectiles and barriers, adding to the degree of danger.

A BEHAVIOR RISK ANALYSIS

In order to gain a comprehensive picture of how exposed the disabled persons were to hazards caused by the earthquake, a quantitative analysis of disabled respondents' activities was performed. This approach is a modification of a methodology developed by Yin (1989). For this analysis, a list of independent action categories (with a generic format) during and immediately after an earthquake was generated (table 7). The explanation for each action category shows the activity type, content, and potential hazards to the respondents. For example, if the initial reaction to an earthquake was to enter into an involuntary passive mode (for example, unable to comprehend the situation), the person was exposed to a higher risk. An "importance multiplier" was assigned to each item of this list. This importance multiplier is an independent rating (from 1 to 5) for the degree of correlation (dependency) between the action item and hazard exposure. In table 7, the highest correlation exists for "decision for next action," with a rating of five. In other words, in terms of overall exposure to hazards during an earthquake, it is extremely important to make a correct decision for action after observing one's location in a structure and the surrounding hazards.

The next step was to evaluate the actions performed by each respondent across all the categories listed in table 7. In order to perform this evaluation objectively, a "hazard weighting factor" was constructed for these actions (table 8). As described in table 8, the hazard weighting factor is

Table 6. *Objects fallen/broken and their effects on respondents' decisions*

[Data were not communicated or completed for respondent 8]

Respondent	Fallen/broken items	Effects of items on actions
1	None	–
2	None	–
3	Figurine from television, potted plant	None
4	None	–
5	Wine glasses, pottery items, potted plants	None
6	Lamp shade, records, tapes	None
7	China clock, lamps, antique dish, vase, everything on book shelf	None
9	Window panes, dry wall	None
10	None	–
11	Copper enamel plate	Conceived serious and made respondent move to hallway and outside; perceived duration of shaking as long
12	Small picture frames	None
13	Tin food, dishes	None
14	None	–
15	Dishes, glassware, lamps, books, figurines	Front door was jammed, required a hammer to open it, broken glass may have flattened the wheelchair tires
16	Frames, book shelves, figurines	Books blocked the main door, could not go anywhere
17	None	–
18	None	–
19	None	–
20	Two frames	None
21	None	–
22	One dish	None
23	Books, figurines, table lamp	Moved backwards to avoid falling book
24	None	–
25	Concrete pedestal, water cooler, books, paintings, sculptures, glassware, closet, sliding doors knocked open to a 30 degree angle	Front door was blocked by plants and water cooler, debris on floor prevented easy maneuvering
26	Heat lamp dislodged and was hanging by cord, most items from shelves and closet, table lamp, books, figurines, glass items	Did not venture into kitchen due to broken glass and having air-filled tires on wheelchair
27	Books, video tapes, records	None (went under doorway immediately, things could have been worse if he had waited a bit longer)
28	Wall plaque	None
29	Large computer terminal	Crashing sound led to feeling of panic and closing of eyes
30	Water dispenser, potted plant, tin food	None
31	Lamp, books	None
32	None	–
33	Chimney	None
34	Paintings, magazine rack, pencil holder	None

Table 7. *Generic activities (physical and mental) and their explanations for occupant risk analysis*

Actions list (importance multiplier *)	Explanation
Initial reaction (4)	Examines occupant's immediate reaction to earthquake. This could be physical, conscious, or involuntary action. It indicates whether the occupant is in a position to take any action to avoid a hazardous situation. Regardless of the occupant's location, if the initial reaction is involuntary the individual is in a high-risk exposure situation.
Observing the surroundings (3)	Respondent's degree of hazard awareness and observation of surrounding items, which could range from thorough (that is, complete and objective) to none at all. This activity is not as closely linked to hazard exposure as the initial reaction, or the next activity of decisionmaking.
Decision for next action (5)	Decision processes are examined as a planning tool for a series of actions. A typical decision is to move or stay put after the initial observation. This is normally a conscious decision with a defined objective in mind. It is critical that an occupant does not make a risky decision that might place him/her in an injury-producing situation.
Protective actions (4)	Occupants take a series of protective actions regardless of decisions made previously. These actions could range from being safe to risky with respect to potential hazards faced at that moment. Actions taken during the shaking period are responsible for occupant injury.
Interaction with obstacles (4)	Encounter and interaction with obstacles during the shaking period in an attempt to perform a task. Occupants may be involved in situations ranging from no obstacles/no difficulty to major obstacles with difficulty.
Reaching desired goal (4)	Whether the occupants reached their desired (stated) goal during the shaking period. Not reaching a desired goal may leave a person vulnerable to earthquake hazards.
Protective actions after shaking (3)	Occupants actions after the period of shaking may place them in a low- or high-risk situation. Potential hazards may be loose or dislocated objects, or dangers from aftershocks.
Interaction with objects (2)	Unlike events during shaking, occupants have more time to interact with objects encountered in their paths after shaking has stopped. Range of difficulty for encounters and interactions may remain the same as before.
Reaching desired goal (2)	The degree to which occupants have accomplished what they wanted to do after the shaking has stopped. Occupants may expose themselves to more hazards by setting low-priority goals and performing unnecessary activity in a hazardous building immediately after an earthquake.

*Importance multiplier is a measure of the dependence between each item in the list and the occupant's exposure to potential hazards.

Table 8. *Occupant risk analysis weighting factors*

Action list	Hazard weighting factor *		
	-1	0	1
Initial reaction	Controlled motion	Partially controlled	Involuntary motion
Observing the surroundings	Complete and objective	Partially observant	None
Decision for next action	Safe	Somewhat safe	Hazardous
Protective actions during shaking	Safe	Somewhat safe	Hazardous
Interaction with obstacles	No obstacles/ no difficulty	Some obstacles/ some difficulty	Major difficulty
Reaching desired goal	Reached	Partially reached	Not reached
Protective actions after shaking stopped	Safe	Somewhat safe	Hazardous
Interaction with objects	No obstacles/ no difficulty	Some obstacles/ some difficulty	Major difficulty
Reaching desired goal	Reached	Partially reached	Not reached

* Hazard is defined as conditions that can cause injury, illness, or death to occupants.

minus 1 if the action performed by the person is a safe one. A factor of zero (neutral) is assigned to an action which is partially safe or does not contribute to a higher degree of hazard exposure. And a factor of 1 is assigned to an action that significantly increases the potential for hazard exposure. Numerical calculations were performed as follows. The initial reaction of each respondent was determined by our interview records. For example, let us assume that a person's reaction was to move a wheelchair under an overhead beam away from a glass window. This reaction was given a hazard weighting factor of minus 1. Similarly, hazard weighting factors were assigned to the remaining action sequences for this person. The resulting nine numerical values were then multiplied by their corresponding importance multipliers. Then, these values were summed giving the final numerical score of hazard exposure for each individual. The theoretical range of minimum to maximum possible total scores for each respondent was from minus 31 to plus 31 (larger positive numbers denote increasing hazard exposures). The summed total score for each of the 33 respondents was calculated and shown in figure 1.

The total scores for our sample ranged from minus 28 to plus 28. A majority of the respondents (26 persons) fell in the negative score region, indicating overall safe performance of their action sequences. From the seven respondents having positive scores, only two persons had scores significantly above 20—indication of exposure to potential hazards in the earthquake. The behavior of the person with the highest score is explained in detail.

Respondent 1, score=plus 28. The respondent was in his chair watching television. The initial reaction for this person was an involuntary spasm. The spasm left him vulnerable to the danger from falling heavy objects in a nearby closet, television falling and blocking access, and overhead ceiling fixtures. He was unable to control his wheelchair during the entire period of shaking until he received help from the outside. During the initial seconds of the shaking, he was unable to observe his surroundings and look for potential hazards. In addition, he did not recall making any judgment or decision to alter his situation. He, therefore, stayed in the same body position and location throughout the en-

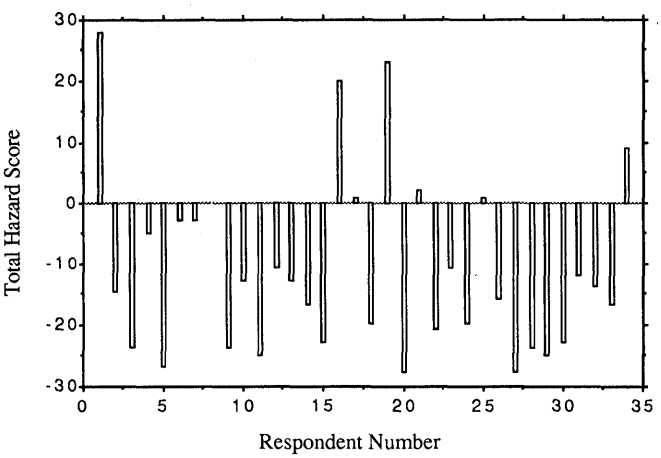

Figure 1. Bar graph indicating the total hazard exposure scores for 33 physically disabled occupants during the Loma Prieta earthquake. Note: Data were not communicated or completed for respondent 8.

tire shaking period. His major effort during the event was to control his spasms. He also tried to retrieve his mouth piece (a control device for wheelchair) that had shifted from its position. He was unsuccessful in both of these goals. This respondent was in this state until the institution staff made their rounds to insure that everyone was safe.

In contrast, to show the behavioral profiles of occupants, the activities of the person with the lowest score is also elaborated.

Respondent 20, score=minus 28. The respondent was working at his computer terminal at the onset of shaking. All of his actions during the shaking period were based on conscious and controlled thought processes. His initial reaction was to pull away from the terminal where there were heavy book shelves and a number of breakable items. He then made a thorough observation of his surroundings and moved under the main overhead beam. Once the shaking stopped, he headed for the main door and remained outside for awhile. His only possible hazardous activity was that he returned indoors to check the apartment for personal items while the potential for aftershocks existed.

From our analysis of the 33 respondents, it appears that a consistent application of this methodology can provide a quantitative profile of occupant behavior in relation to earthquake hazard exposure inside buildings. Using the quantitative three-level weighting factor, this method is capable of accurately categorizing the respondents' action sequences in reference to a predetermined independent variable such as hazard exposure, age, gender, type of disability, type of interior design, or prior earthquake experience. However, a disadvantage of this method is the difficulty by which the degree of detail for actions needs to be predefined. For example, in the list of generic actions, the last action item was classed as "reaching the desired goal." In our sample, some respondents were able to specifically mention whether they were successful in performing what they specifically wanted to do during the period of shaking. In other cases, however, this item needed to be later inferred by the evaluator after long explanations were given by the respondents. Also, a certain degree of subjectivity is applied in assigning the weighting scores. For example, a person moving under a doorway may be assigned a safe score only if there is no door swinging violently by the shaking forces. Nevertheless, this technique allows us to combine a subjective evaluation of human interactions (including environmental variables inside a room) with an objective assessment of hazard exposure. Further refinement of this technique would be able to incorporate into a single chart factors that are difficult to quantify such as position and location of dangerous objects, type and weight of objects, height and projectile potential of items in proximity to the occupant, and organization of household items in relation to the interior design of the room.

CONCLUSIONS

It was noted that a significant portion of the public living in earthquake-prone regions is disabled. Like other victims, disabled persons may require assistance in a major earthquake. However, little is known at the present time about what the special needs of this population may be. For example, while some writers (see Pollander and Rund, 1989) state that simple and efficient training for self-protection and search and rescue procedures are needed to better assist disabled persons, others might argue that their needs in this regard are no different from those of the general population. Regardless, a significant emphasis has been placed on special populations in the U.S. Decade for Natural Disaster Reduction (National Research Council, 1991): (1) to take an inventory of special-need groups and conduct hazard and risk assessments for vulnerable populations, (2) to educate and prepare elderly, disabled, and special needs groups by providing proper information and risk communication, and (3) to mitigate hazards by structural measures, nonstructural measures, and training programs.

The literature suggests that the risk of earthquake-related death or injury inside residential buildings is multifaceted and complex. A number of factors may influence mortality and morbidity outcomes in earthquake situations. Focusing on the Loma Prieta earthquake, our study attempted to assess how exposed were disabled persons to potential hazards inside their dwellings and what they did to protect themselves during the shaking. This study involved a small sample of persons with physical disabilities affecting motor coordination and the functional loss of upper and lower extremities, who were living in mostly independent residential settings. The earthquake was of moderate to high intensity and did not cause any complete or partial collapse of structures in which respondents were located. Any generalization from this study, therefore, must take into account a large number of variables not considered in this study.

There have been some clear indications that residential occupants show considerable variation in their actions during earthquake shaking (Ohashi and Ohta, 1984; Alexander, 1990). In the current study, results from the action-content analysis showed that the initial reaction at the onset of the shaking was critical to the individual's overall hazard exposure. Also, the decision actions that followed appeared to be significantly influenced by the initial reaction of the occupants. An example from our sample illustrates this point clearly. A respondent was in his wheelchair (battery-powered with inflatable tires) reading a book when he became aware of the seriousness of the event. He thought of moving toward the hallway to exit. He immediately reconsidered this move knowing the potential dangers of the broken items in the hallway. The

broken glass objects may have ruptured the wheelchair tires rendering him immobile during and after the earthquake—-a potential trapping hazard.

The idea that physically disabled individuals are more restricted than able-bodied persons, in the type and extent of activities they can initiate during and after earthquake impact, seems intuitive. However, our results appear to support the notion that the apparent lack of activity of disabled persons does not positively correlate with their feeling of vulnerability (fear of danger) during the shaking period. We noted that, of those who felt vulnerable (14 out of 33), more than two-thirds took active measures to protect themselves. In contrast, those who reported feeling little or no fear were more likely to remain passive during the shaking period. The self-protective actions of disabled persons appear to be closely related to their feeling (perception) of safety; those who feel safe apparently do not feel compelled to do anything more during earthquake impact to protect themselves. This finding seems to parallel to that of Goltz and others (1991) that an increasing level of fear "contributes to a definition of the situation as threatening to self and others and triggers certain learned responses which are survival-oriented." Our study also supports a position taken by some investigators that disabled persons have a psychological advantage for adapting to an altered built environment, since they negotiate with altered and sometimes difficult physical and environmental limitations on a daily basis (Parr, 1987; Tierney and others 1988). Also, the respondents appeared to be very aware of their environmental make-up and were highly adapted to their disability (adaptive response) in relation to critical activities needed for their daily task performances. Given the dichotomy of the respondents' behaviors, it cannot be stipulated whether a passive or active mode of behavior provides a safer framework for dealing with earthquake hazards.

Although there have been some rare cases where panic and flight were reported in earthquakes (see Alexander, 1990), accounts of irrational behavior among the affected populations are less evident in the United States. In order to provide some data as to the nature of behavior exhibited in our sample, a more detailed analysis of their actions was conducted. Based on our action-content analysis, the majority of the respondents' sequence of activities included logical patterns of behavior during the shaking period. Only two respondents recalled entering into a state of uncontrolled spasmodic behavior. Based on our small sample observations, it is therefore suggested that disabled persons go through a somewhat logical and controlled behavioral process, perhaps more than previously expected. Similar results were obtained from a study of the Whittier Narrows earthquake in 1987, where the majority of the respondents (able-bodied) did not remain in place, yet they did not exhibit any irrational behavior (Goltz and others, 1991).

In comparison to general population, this pattern of mostly logical and controlled behavior of our sample is similar to that expressed by Ohta and Ohashi (1980) for an "able-bodied" sample. In their sample, the highest frequency of time-sequenced behavior was "action-movement-stand by" classification. In terms of application for this result, this may be another support for the importance of prior earthquake training and preparedness. Being prepared for appropriate occupant behavior, regardless of disability, would help occupants to behave more rationally and safely during an earthquake. A difficulty is the communication of such risks for earthquake preparedness among the disabled population. As Mileti and others (1990) explain, in order to take preventive and protective actions in earthquakes, the occupants must come to "own" the risk information. Only after they own the earthquake risk information do they take the advice they were given to prepare for it and to mitigate its effects. The practicality of earthquake preparedness recommendations should be in the direction of giving advice on things that can be done quickly without a significant amount of effort involved. It is equally important that such guidelines be based on empirical evidence targeted for this segment of the population rather than on speculation or generalization from the overall population. For example, advice such as moving under a sturdy table during the shaking period, may not be applicable to a T4 quadriplegic because of the fear of not being able to move back into the wheelchair.

The results from this study also show that physically disabled persons may have less opportunity to access their personal items and emergency medical supplies after the shaking has stopped. A majority of the respondents who went back to their residences were unsuccessful in reaching and collecting what they needed. Planning and preparedness documents for disabled people should reflect alternative means by which the personal items and emergency supplies can be accessed. Also, the previously suggested "buddy system" (for example, a roommate or a neighbor helping the disabled individual) would not be effective if the occupant is living independently. Additionally, another observation from our sample was that many of the hazardous items were clustered around the beds or rest-chairs. Obviously, these small items were positioned for convenience. Yet, from our observations, no attempt was made to either secure these items or reduce their injury-producing potential in time of a severe earthquake.

Finally, it appears that the majority of respondents in our sample were not exposed to a high degree of danger during the earthquake. One field study on occupant behavior in earthquakes clearly suggests that injuries are more likely to occur when people try to leave the building or move around during earthquake shaking (Archea and Kobayashi, 1984). If our findings are generalizable, mobility limitations would not necessarily make disabled individuals more vulnerable to injury. Furthermore, it may be that,

since disabled persons must cope with the physical environment on a daily basis, they will in fact be more adaptable to hazards in an altered environment than able-bodied persons.

In light of the limitations of this study, our reported findings need to be reevaluated on much larger samples, comparing (different types of) disabled and able-bodied persons, and in both field studies and more controlled settings. Another factor not considered in this study is the fact that people with different types of disabilities may react differently at the onset of earthquakes. Also, studying behavior of disabled people in group settings (with potential expectation of help from others) would further add to our understanding of the needs of disabled individuals in earthquake situations. It is hoped that comparative studies in behavioral responses of "special populations" would eventually contribute to our understanding of how the general population can be further protected against the damaging effects of earthquakes.

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PUBLIC RESPONSE

EARTHQUAKE PREPAREDNESS BEHAVIOR OF STUDENTS AND NONSTUDENTS

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CONTENTS

ABSTRACT

Individual earthquake preparedness and perceived difficulty of becoming prepared for earthquakes were assessed for two separate populations both before and after the Loma Prieta earthquake. One of the populations consisted of University of Southern California undergraduate students, and the other population was composed of employees (nonstudents) of a Long Beach, California, business firm. Results indicated that prior to the earthquake, nonstudents were more prepared than students. However, both groups perceived that preparing for earthquakes was equally difficult. Moreover, following the earthquake, both groups indicated an initial increase in preparedness behavior and a decrease in perceived difficulty of preparation. A comparison of these results with results obtained from similar studies appears to indicate that higher levels of damage due to earthquakes, in concert with other factors, can lead to increased perceived earthquake threat, which in turn can lead to increased attempts to cope with such events, resulting in increased earthquake preparedness.

INTRODUCTION

Over the past few years, earthquake preparedness behavior has become a topic of increasing worldwide importance (see Drabek, 1986; Morton, 1990; Quarantelli, 1989, for bibliographic reviews). Owing to the occurrence of large and numerous earthquakes, California in particular has become a recent focus of this topic as evidenced by several studies describing the effects of earthquakes in California (in particular, the 5.9 magnitude Whittier Narrows earthquake of October 1, 1987, the 4.8 magnitude Whittier Narrows earthquake of February 11, 1988, and the 5.5 magnitude Upland earthquake of February 28, 1990) on individual earthquake preparedness behavior (Mulilis and Duval, 1990a, b; Mulilis and Duval, 1991b; Mulilis and others, 1990). A somewhat unique aspect of these studies is that they were all of a pre-post nature; that is, levels of both earthquake preparedness and perceived difficulty of preparing for earthquakes were assessed both before and after the earthquakes occurred, thus allowing for the direct examination of the effects of the earthquakes on these variables.

One of the few shortcomings of the above studies is that they were all conducted on a single type of population (undergraduate university students). The present study was designed to investigate the effects of the Loma Prieta earthquake on earthquake preparedness behavior, and at the same time, to attempt to overcome this single-population limitation by using two separate populations (students and nonstudents). Thus, direct comparisons of the effect of the same earthquake on earthquake preparedness behavior between two different populations could be made. On the basis of the results of the above studies, it was expected that the Loma Prieta earthquake would lead to increased earthquake preparedness and decreased perceived difficulty in preparing for earthquakes. Furthermore, the present study was designed to allow for a comparison of obtained results with the findings of the above studies to give a more complete understanding of the effects of earthquakes on earthquake preparedness behavior.

EARTHQUAKE PREPAREDNESS SCALE

The earthquake preparedness scale used in the present study was the MLEPS (Mulilis Lippa Earthquake Prepared-

ness Scale; Mulilis, 1985; Mulilis and Lippa, 1985; Mulilis and others, 1990), which was developed for use in assessing the earthquake preparedness and perceived difficulty in preparing for earthquakes of individuals and small businesses. The MLEPS is a multiact behavioral scale consisting of 27 preparedness items (for example, "Do you have an operating flashlight?", "Are your cabinets securely fastened with latches?", "Do you know the location of a medical emergency center in your neighborhood?") to which respondents answer "yes", "no", or "unsure" to each item.

The 27 items of the MLEPS represent standard suggestions appearing in earthquake preparedness brochures and books that are specifically and clearly related to earthquake preparedness. These items not only measure how prepared one is over a wide range of preparedness, but also assess individual behavioral involvement in earthquake preparedness. Thus, the MLEPS is essentially a behavioral scale, and as such, the items in the scale have high face validity. Although behavioral in nature, the scale also allows for the consideration of an assessment of an individual's "cognitive preparedness." Turner and others (1986) have stressed the importance of "cognitive preparedness," indicating that by being aware of the availability of items in a household (even though the items had not been newly acquired), individuals were in more of a position to use them.

In addition to assessing level of preparedness, the MLEPS also assesses the difficulty in obtaining or performing each item on a scale of 1 (least difficult) to 5 (most difficult). The MLEPS has been used in a number of recent earthquake preparedness investigations (see Mulilis, 1985; Mulilis, 1991; Mulilis and Duval, 1987; Mulilis and Duval, 1990a, b; Mulilis and Duval, 1991a, b; Mulilis and others, 1990; Mulilis and Lippa, 1990).

While Turner and others (1986) developed a 16-item "checklist of suggestions" for use in a study of the earthquake potential of the "Palmdale Bulge," the MLEPS measures more aspects of earthquake preparedness than the checklist and to the authors' knowledge, is the only preparedness scale that addresses the issue of difficulty in preparing for earthquakes. Furthermore, the major focus of the response format of the Turner and others (1986) checklist seems to involve reasons for carrying out/not carrying out preparedness actions. The present study, on the other hand, was more concerned with the overall extent to which a person was prepared for earthquakes and how difficult that person perceived preparing for earthquakes to be. Consequently, the MLEPS was used in the present investigation.

POPULATIONS ASSESSED

Two separate populations of subjects participated in the current investigation: students and nonstudents. Both of these populations were drawn from the greater Los Angeles area, approximately 488 km south of the epicenter of the Loma Prieta earthquake. Although not considered geographically local to Los Angeles, the Loma Prieta earthquake was widely felt throughout the Los Angeles area, produced immense destruction in the San Francisco Bay area, and received extensive and prolonged media coverage in the Los Angeles area. Thus, the direct effects of this earthquake were widely communicated in a credible manner to an area of similar earthquake risk and had many of the major components that have long been known to affect attitudes and behavior (see McGuire, 1969, 1985; Petty and Caccioppo, 1986; Fazzio, 1986; Ajzen, 1987; Chaiken and Stranger, 1987). Thus, the occurrence of this earthquake had the potential to influence attitudes and behaviors about earthquake preparedness and perceived difficulty of preparation for individuals living in the Los Angeles area, and any changes in preparedness behavior of the populations studied in the present investigation which were attributed to the Loma Prieta earthquake could be considered the result of this "nearby" (in a psychological sense) earthquake.

The first population included in the present study consisted of undergraduate students enrolled in an introductory psychology course at the University of Southern California. Students volunteered for this study to obtain additional course credit. On September 20, 1989, all students enrolled in the course (approximately 410 students) were given a "survey packet" to complete for extra course credit. Approximately 71 percent of the students (292) returned the completed survey packet on September 25, 1989, three weeks prior to the Loma Prieta earthquake. The MLEPS was included in this survey packet.

After the earthquake, four separate groups of subjects were randomly sampled from the 292 students who had completed the survey packet. The MLEPS was then administered to each of these groups (once per group) at four different time periods after the earthquake (the day after, one week after, three weeks after, and six weeks after). A total of 99 subjects (four separate groups ranging in size from 17 to 35 subjects) completed the MLEPS after the earthquake. Demographic characteristics and relevant earthquake information of students who completed the pre-earthquake survey packets and subjects in the four groups who completed the MLEPS after the earthquake are presented in table 1. Since the number and characteristics for males and females were similar for all groups, these data are collapsed across gender.

The following points can be noted from an investigation of table 1:

(1) Demographic characteristics of the groups tested both before and after the earthquake were similar.

(2) The student status of the four groups is evidenced by the large percentage of all groups who lived in dormitories.

(3) Even though the number of months since an earthquake was experienced (following the Loma Prieta earthquake) decreased for each of the groups tested the mean

Table 1.—*Characteristics of the student groups*

Variable	Time relative to the Loma Prieta earthquake				
	3 weeks before	1 day after	1 week after	3 weeks after	6 weeks after
Number	292	26	21	17	35
Mean age	18.6	19.0	18.9	19.3	19.1
Mean years lived in California	9.6	9.4	12.1	10.5	9.2
Largest earthquake felt (mean Richter)	M=4.3	M=4.7	M=4.9	M=4.7	M=4.6
Months since felt this earthquake	76.2	44.1	43.4	48.0	33.3
Most recent earthquake felt (mean Richter)	M=3.1	M=4.1	M=4.1	M=3.9	M=3.8
Months since felt this earthquake	59.7	37.0	24.4	31.5	19.3
Residence (pct.):					
With parents	12.7	23.1	19.0	17.6	8.6
With relatives	0.6	3.8	0.0	0.0	0.0
Fraternity/sorority	6.2	0.0	9.5	5.9	0.0
Dorms	41.8	30.8	28.6	47.1	51.4
Rent	38.4	42.3	42.9	29.4	40.0
Own	0.3	0.0	0.0	0.0	0.0

Table 2.—*Characteristics of the nonstudent groups*

Number	18
Mean age	32.9
Mean years lived in California	22.2
Residence (pct.):	
With parents	11.1
With relatives	0.0
Fraternity/sorority	0.0
Dorms	0.0
Rent	33.3
Own	55.6

Variable	Time relative to the Loma Prieta earthquake	
	1 1/2 weeks before	1 day after
Largest earthquake felt (mean Richter)	M=6.2	M=6.0
Months since felt this earthquake	111.0	121.0
Most recent earthquake felt (mean Richter)	M=4.4	M=4.6
Months since felt this earthquake	13.1	11.4

reported values for all such groups were much greater than the actual time that had passed since the occurrence of this earthquake, indicating that these subjects probably did not actually experience any seismic effects of the Loma Prieta event.

The second population included in the present study consisted of employees of a business firm in Long Beach, California (approximately 34 km from the University of Southern California). Subjects from this population volunteered for this study as part of the firm's earthquake preparedness program, which had been in existence for approximately 1 year prior to the present investigation. These subjects were randomly selected from a pool of approximately 40 employees and asked to complete the MLEPS as part of this program. All subjects in this population who were thus approached agreed to participate in this study.

At the time of the Loma Prieta earthquake the firm employed approximately 40 employees. On October 6, 1989 (approximately 1 1/2 weeks before the earthquake), 18 employees (45 percent) completed the MLEPS. On October 10, 1989 (one day after the earthquake) these same 18 employees again completed the MLEPS. Demographic characteristics and relevant data concerning subjects' experience involving the occurrence of earthquakes are presented in table 2. Because the number and characteristics of males and females were similar, these data were collapsed across gender.

The following points are clear from an investigation of table 2:

(1) The largest percentage of this group owned their dwellings.

(2) The nonstudent status of the population is evidenced by the fact that no one in this group indicated that they lived in either dormitories or fraternity/sorority houses. In addition, higher mean ages were reported by this group compared with the mean ages for the groups in the student population (see table 1).

(3) Again, as with the student population, even though the number of months since an earthquake was experienced decreased, the mean reported value of this group was much greater than the actual time which had passed since the occurrence of the Loma Prieta earthquake, indicating that these subjects did not actually experience any seismic effects of this earthquake.

The following differences between the student and nonstudent populations can be noted from a comparison of tables 1 and 2:

(1) The nonstudent group reported higher mean values of age, years lived in California, the largest magnitude earthquake which they had felt, and the most recent magnitude earthquake which they felt, indicating that this population may have had more "earthquake experience" than the student population.

(2) The nonstudent group reported a lower mean time since they felt an earthquake, indicating that this population may be more cognizant or aware of the occurrence of the Loma Prieta earthquake and (or) of the occurrence of earthquakes in general.

RESULTS

Results of the present study are present in table 3 in terms of mean levels of earthquake preparedness and perceived difficulty in preparing for earthquakes as a function of time relative to the Loma Prieta earthquake. Differences between males and females were minor and inconsistent.

Table 3.—*Effects of the Loma Prieta earthquake on earthquake preparedness behavior*

Population	Time relative to Loma Prieta earthquake	Mean levels of preparedness	Mean levels of difficulty
Students	3 weeks before	46.9	61.8
	1 day after	47.1	54.1
	1 week after	47.9	57.1
	3 weeks after	46.9	59.1
	6 weeks after	48.1	56.7
Nonstudents	1 1/2 weeks before	55.8	61.8
	1 day after	57.6	50.7

Consequently, all analyses and comparisons were made collapsing the data across gender.

The following points can be noted from an inspection of table 3:

(1) Pre-earthquake levels of preparedness were significantly higher for nonstudents than for students (m=55.8 vs. m=46.9, $t(308)$=3.69, p<0.001). Since there was a much higher percentage of homeowners in the pre-earthquake nonstudent group than in the pre-earthquake student group (55.6 vs. 0.3 percent), these results are consistent with results of Turner and others (1986), who found that owner-occupied households had higher rates of earthquake preparedness than did other types of households. Alternatively, the higher pre-earthquake preparedness levels of nonstudents could be attributed to differences in age or earthquake experience between the two groups. Interestingly enough, pre-earthquake levels of perceived difficulty in preparing for earthquakes were the same for both students and nonstudents ($t(308)$<1, *n.s.*).

(2) Levels of perceived difficulty in preparing for earthquakes one day after the earthquake decreased from pre-earthquake levels for both students and nonstudents. This decrease in perceived difficulty was significantly lower than pre-earthquake levels for students (m=61.8 vs. m=54.1, $t(316)$=2.14, p=0.033) and approached significance for nonstudents (m=61.8 vs. m=50.7, $t(37)$=1.72, p=0.093). This initial decrease in perceived difficulty observed following the 7.1 magnitude Loma Prieta earthquake was consistent with the initial decrease in perceived difficulty observed in students following the 5.9 magnitude Whittier Narrows earthquake of October 1, 1987 (Mulilis and Duval, 1990a; Mulilis and others, 1990).

(3) The initial decrease in perceived difficulty one day after the earthquake was greater for nonstudents than for students (m=61.8 to m=50.7 vs. m=61.8 to m=54.1), although the difference in levels of perceived difficulty between the two groups one day after the earthquake was not significant (m=50.7 vs. m=54.1, $t(45)$=0.68, p=0.499).

(4) Following the initial post-earthquake decrease, subsequent levels of perceived difficulty of preparation for students exhibited a distinct pattern. These levels continually increased through week three following the earthquake, then deceased through week six following the earthquake. This decrease at week six reached levels that approached a significant difference from pre-earthquake levels (m=56.7 vs. m=61.8, $t(325)$=1.62, p=0.105). The distinct pattern in perceived difficulty of preparation following the 7.1 magnitude Loma Prieta earthquake was consistent with the distinct, although somewhat different, pattern of post-earthquake levels of perceived difficulty that was observed in students following the 5.9 magnitude Whittier Narrows earthquake of October 1, 1987 (Mulilis and Duval, 1990a; Mulilis and others, 1990); however, it was in contrast to the random fluctuations in perceived difficulty that were observed in students following both the 4.8 magnitude Whittier Narrows earthquake of February 11, 1988 (Mulilis and Duval, 1990b) and the 5.5 magnitude Upland earthquake of February 28, 1990 (Mulilis and Duval, 1991b).

(5) Levels of earthquake preparedness one day after the earthquake increased from pre-earthquake levels for both populations, although these increases did not reach levels of significance for either students (m=46.9 vs. m=47.1, $t(316)$=0.08, p=0.938) or nonstudents (m=55.8 vs. m=57.6, $t(37)$=0.62, p=0.541). This initial increase in preparedness observed in both students and nonstudents following the 7.1 magnitude Loma Prieta earthquake was consistent with the significant initial increases in preparedness observed in students following the 5.9 magnitude Whittier Narrows earthquake of October 1, 1987 (Mulilis and Duval, 1990a; Mulilis and others, 1990).

(6) As was the case for pre-earthquake levels of preparedness, initial levels of preparedness one day following the earthquake were significantly greater for nonstudents than for students (m=57.6 vs. m=47.1, $t(45)$=3.91, p<0.001). Since there was a much higher percentage of homeowners in the post-earthquake nonstudent group than in the post-earthquake student group one day after the earthquake (38.1 vs. 0.0 percent), these results are again consistent with results of Turner and others (1986), who found that owner-occupied households had higher rates of earthquake preparedness than did other types of households, although again, these results could be attributed to differences in age or earthquake experience between the two groups.

(7) Following the initial post-earthquake increase, subsequent levels of preparedness for students exhibited a distinct pattern. These levels increased through week one following the earthquake, then decreased to pre-earthquake levels at week three following the earthquake, and then subsequently increased through week six following the earthquake. This distinct pattern of post-earthquake preparedness levels observed in students following the 7.1 magnitude Loma Prieta earthquake was consistent with the distinct pattern of post-earthquake levels of preparedness observed in students following the 5.9 magnitude Whittier Narrows earthquake of October 1, 1987 (Mulilis and Duval, 1990a; Mulilis and others, 1990); however, it was in

contrast to the random fluctuations in post-earthquake levels of preparedness observed in students following both the 4.8 magnitude Whittier Narrows earthquake of February 11, 1988 (Mulilis and Duval, 1990b) and 5.5 magnitude Upland earthquake of February 28, 1990 (Mulilis and Duval, 1991b).

DISCUSSION

The above results appear to indicate that the 7.1 magnitude Loma Prieta earthquake affected the earthquake preparedness behavior of both student and nonstudent populations in a similar manner (initial significant decreases in perceived difficulty in preparing for earthquakes and initial increases in earthquake preparedness) and that these changes in earthquake preparedness behavior were similar to significant changes observed in the preparedness behavior of students following the 5.9 magnitude Whittier Narrows earthquake of October 1, 1987 (Mulilis and Duval, 1990a; Mulilis and others, 1990). Although post-earthquake levels of perceived difficulty of preparation were significantly lower than pre-earthquake levels for subjects after both the 7.1 magnitude Loma Prieta and 1987 5.9 magnitude Whittier Narrows earthquakes, post-earthquake levels of earthquake preparedness were significantly higher than pre-earthquake levels only for the 1987 5.9 magnitude Whittier Narrows earthquake. The fact that post-earthquake increases in earthquake preparedness following the 7.1 magnitude Loma Prieta earthquake did not reach significance may have been due to the greater epicentral distance of this earthquake from Los Angeles than the 1987 5.9 magnitude Whittier Narrows earthquake (approximately 488 km vs. approximately 15 km).

Furthermore, post-earthquake levels of earthquake preparedness and perceived difficulty of preparation observed in student groups after the 7.1 magnitude Loma Prieta earthquake exhibited distinct patterns that were similar to the distinct patterns observed for these variables in students following the 1987 5.9 magnitude Whittier Narrows earthquake (Mulilis and Duval, 1990a; Mulilis and others 1990) but distinctly different from the random fluctuations in these variables observed in students following both the 1988 4.8 magnitude Whittier Narrows earthquake (Mulilis and Duval, 1990b) and the 1990 5.5 magnitude Upland earthquake (Mulilis and Duval, 1991b). Slight differences in the patterns of earthquake preparedness and perceived difficulty of preparation observed in subjects following the 7.1 magnitude Loma Prieta and 1987 5.9 magnitude Whittier Narrows earthquakes may have been due to the greater epicentral distance of the Loma Prieta earthquake from Los Angeles, and (or) the larger and more numerous aftershocks produced by the Loma Prieta earthquake.

Thus, although the student populations in the studies of the above four earthquakes had similar pre-earthquake levels of earthquake preparedness and perceived difficulty of preparation (Mulilis and Duval, 1991a) and the demographic characteristics of these populations were similar (Mulilis and Duval, 1991a), levels of earthquake preparedness and perceived difficulty of preparation had quite different patterns after these earthquakes. These differences were observed despite the fact that data from all four earthquakes were collected in the same location and under similar circumstances.

Differences in the impact of the four earthquakes on earthquake preparedness might be explained by important seismological differences between the earthquakes. Both the 1987 5.9 magnitude Whittier Narrows and 7.1 magnitude Loma Prieta earthquakes occurred at deeper focal depths, had greater Richter magnitudes, higher maximum surface accelerations, larger maximum modified Mercalli intensities, and were followed by larger and more numerous aftershocks than either the 1988 4.8 magnitude Whittier Narrows or 1990 5.5 magnitude Upland earthquakes (see Mulilis and Duval, 1991a). These seismological differences between the four earthquakes, in turn, resulted in greater damage from the 7.1 magnitude Loma Prieta and 1987 5.9 magnitude Whittier Narrows earthquakes than either of the other two earthquakes (Davis, oral commun., 1991; Earthquake Engineering Research Institute, 1989, 1990; Federal Emergency Management Agency, 1987; Fiore and Bucy, 1988; Jephcott, 1990; Tierney, 1988; U.S. Geological Survey, 1989; Ward and Page, 1989; table 4 provides a comparison of deaths, injuries, and property damage caused by these four earthquakes). We suggest that this greater level of damage from the 7.1 magnitude Loma Prieta and 1987 5.9 magnitude Whittier Narrows earthquakes, in concert with other factors such as level of media coverage, distance from the epicenter, extent to which socially significant others were affected by earthquakes, and so forth, may have increased subjects' perceived threat due to earthquakes. As indicated by Lazarus (1966) and Lazarus and Folkman (1984), increased perceived threat can lead to increased attempts to cope with the threatening event. In the present case, increased coping attempts could lead to increased earthquake preparedness behavior. In fact, laboratory studies by Mulilis and Duval (unpub. data, 1992) have found that increasing the perceived threat value of earthquakes does lead to increased earthquake preparedness behavior, but only under certain conditions. Thus, subjects may have increased their attempts to cope with earthquakes after the more threatening 7.1 magnitude Loma Prieta and 1987 5.9 magnitude Whittier Narrows earthquakes, which may have been manifested in increased earthquake preparedness behavior, whereas the less threatening 1990 5.5 magnitude Upland and 1988 4.8 magnitude Whittier Narrows earthquakes induced no such changes in subjects' coping attempts and consequently no increases in their earthquake preparedness behavior (Mulilis and Du-

Table 4.—*Damaging effects of the case-study earthquakes*

Variable	Earthquake			
	4.8 Whittier Narrows	5.5 Upland	5.9 Whittier Narrows	7.1 Loma Prieta
Deaths	1 (heart attack)	none	3	62
Injuries	32 (minor)	35 (minor)	932	3,757
Property damage (millions of dollars)	minor	10	350	6,000
Summary of damage	little	some	much	great

Table 5.—*Effect of earthquake damage on earthquake preparedness behavior*

Earthquake	Earthquake			
	4.8 Whittier Narrows	5.5 Upland	5.9 Whittier Narrows	7.1 Loma Prieta
Epicentral distance from Los Angeles (km)	15	68	15	488
Damage	little	some	much	great
Effect on preparedness	no	no	yes	some
Effect on difficulty	no	no	yes	yes

val, 1990a, b, 1991; Mulilis and others, 1990; table 5 summarizes the effects of earthquake damage on earthquake preparedness behavior for these four earthquakes). Further research is needed to clarify this hypothesized explanation of changes in earthquake preparedness behavior after earthquakes.

CONCLUSIONS

Levels of earthquake preparedness and perceived difficulty in preparing for earthquakes were obtained from groups of both students and nonstudents in the greater Los Angeles area both before and after the Loma Prieta earthquake. Results of analyses on these data indicated that levels of earthquake preparedness observed in the nonstudent groups were significantly greater than levels of earthquake preparedness observed in student groups both before and after the Loma Prieta earthquake. Furthermore, levels of earthquake preparedness observed in both student and nonstudent groups prior to the Loma Prieta earthquake increased after the occurrence of the earthquake. These increases in earthquake preparedness after the 7.1 magnitude Loma Prieta earthquake, although not significant, were consistent with similar increases in earthquake preparedness after the 1987 5.9 magnitude Whittier Narrows earthquake. Furthermore, although differences in perceived difficulty of preparation between student and nonstudent groups were not significantly different either before or after the earthquake, comparisons of pre- and post-earthquake data revealed a significant decrease in perceived difficulty of preparation after the earthquake for the student groups, and a decrease in perceived difficulty of preparation which approached significance for the nonstudent group. These decreases were consistent with significant decreases in perceived difficulty of preparation observed in student groups following the 1987 5.9 magnitude Whittier Narrows earthquake. Additionally, post-earthquake levels of both earthquake preparedness and perceived difficulty in preparing for earthquakes observed in the student groups showed a distinct pattern after the 7.1 magnitude Loma Prieta earthquake. These results were consistent with distinct patterns of these variables observed in similar student groups after the damaging 1987 5.9 magnitude Whittier Narrows earthquake, and in contrast to random fluctuations in these variables observed in similar student groups following lower magnitude, less damaging California earthquakes. It was hypothesized that the level of damage caused by an earthquake, in concert with other factors, is a critical variable in determining induced perceived threat due to earthquakes, which under certain conditions can lead to increased attempts to cope with threatening earthquakes, resulting in increased earthquake preparedness behavior.

Questions for further research include: (1) What variables associated with earthquakes lead to changes in induced perceived threat due to earthquakes? (2) How can perceived threat due to earthquakes be measured effectively? (3) Under what conditions does perceived threat due to earthquakes lead to increased attempts to cope with threatening earthquakes and subsequent increased earthquake preparedness behavior?

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