

**Societal Response to Revised Earthquake Probabilities
in the San Francisco Bay Area***

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Using data collected on the general public, health, safety and welfare agencies and organizations, and businesses in the San Francisco Bay Area we describe what people thought and did in response to receiving an informational newspaper insert about revised probabilities for the next damaging Bay Area earthquake. Our findings suggest that the insert was relatively successful in reaching all groups, that Bay Area residents are making earthquakes a permanent part of local culture, and sufficient knowledge may be in-hand with which to effectively and productively manage public earthquake predictions.

The quest for the technology to predict earthquakes arises from the hope that people may someday be able to be warned and then do things to protect themselves and their property before quakes strike. But the complexity of earthquake faults makes quake prediction difficult (Allen 1982). Current efforts to predict earthquakes involve estimating long, intermediate, and short term quake probabilities. Long term forecasting with 30-year time windows is fairly well developed, but intermediate and short term prediction (quakes within hours, days, weeks, months and a few years) capabilities

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...not as far advanced (Wallace, Davis and McNally 1984). Despite encouraging work, it is not yet possible for seismologists to "...provide a warning immediately before a major earthquake, when it would do the most good (Lindh 1990, p. 47)."

The societal impacts of forecasted earthquakes captured the attention of U.S. social scientists two decades ago. The earliest effort to estimate the societal impacts was by the Panel on Public Policy Implications of Earthquake Prediction in the National Research Council. The panel concluded that there was a significant need to study society's reaction to actual predictions as they were made (Turner, Nigg and Paz 1986), and research over the next two decades has answered this call. The purpose of this work is to describe societal — public, government, and business — response to revised earthquake probabilities in the San Francisco Bay Area following the 1989 Loma Prieta earthquake. But our work is just the latest in the two-decade-long effort to empirically document societal response to earthquake prediction (see Turner 1993).

The first empirical study of societal prediction response was of behavioral intentions in response to hypothetical quake prediction scenarios (Haas and Mileti 1976; Mileti, Hutton, and Sorensen 1981). The research gathered data on what organizational decision-makers and members of the public thought they might do in response to scientifically credible prediction were any to ever be issued. This research also investigated societal response to actual quake predictions in Wilmington, North Carolina and in Tokyo and Kawasaki, Japan. The findings of the study were grim. It was concluded that credible predictions of great earthquakes (with time, place, and magnitude specified) in a few months to a few years would create local social disruptions and economic losses of major proportions. These findings were then mirrored in a technology assessment of earthquake prediction performed by engineers at Stanford Research Institute (Weisbecker et al. 1977).

The first large-scale empirical social scientific research on an actual earthquake forecast in the United States began in early February of 1976. The U.S. Geological Survey (USGS) reported that a land uplift was detected along a portion of the San Andreas fault north of Los Angeles near the town of Palmdale. The USGS stated that the uplift was not fully understood, and that it may or may not be a precursor to an earthquake. But the media drew the public's attention to the discovery of the uplift along with news of a devastating earthquake in Guatemala. Scientists thought the threat serious enough to give a briefing to the Governor of California. "While acknowledging the uncertain meaning of the uplift, the California Seismic Safety

Commission officially declared on April 8 that 'the uplift should be considered a threat to public safety and welfare in the Los Angeles metropolitan area'" (Turner, Nigg and Paz 1986, p. 7).

News of the Palmdale Bulge led social scientists to assess societal reaction (Turner et al. 1978). The research demonstrated that there was little serious concern or individual or household preparedness for the earthquake despite the fact that nearly everyone believed that the quake was coming soon. The study also discovered that people who heard about the announcement from scientific sources took it more seriously than those who heard about it from nonscientific sources. The announcement induced the public to engage in a search for additional information (Turner et al. 1978), but it did not precipitate negative economic impacts, as prior work on societal reaction to prediction had suspected. Unfortunately, positive public reactions were not observed.

Then, in April of 1976, an individual university seismologist predicted that a 5.5 to 6.5 Richter magnitude earthquake would strike the San Fernando area north of Los Angeles sometime in the next 12 months. The prediction was widely covered by local newspapers. Even though the scientist was cautious to not label his forecast a prediction (but rather a hypothesis test) "...to the media and the public, this distinction was not evident" (Mileti, Hutton and Sorensen 1981, p. 33). The Los Angeles City Council moved within a week of the announcement to evaluate the legal implications of possible declining property values resulting from the prediction, and several insurance companies "...stopped or delayed selling new earthquake policies. One company canceled earthquake coverage on all its homeowners' policies that were in force" (Mileti, Hutton and Sorensen 1981, p. 33). The media deluged the public with information about the hypothesis test and earthquakes; and that year the City of Los Angeles drew up and adopted the first prediction response plan in the country.

Social scientists surveyed residents of the Los Angeles area to monitor trends in attitudes, perceptions and response to all the "prediction" information that was circulated (Turner 1983; Turner, Nigg and Paz 1986). They found that as time passed, people tended to notice or remember less and less information about earthquake hazards. This finding raised questions about the saturation point beyond which a public could not take in additional information, and about the relationship between information redundancy and a public's attention span. But these ideas have never been validated in subsequent studies. Most importantly, the researchers found that channels of information on which people relied changed over time and tended to rely on

observed as time passed. Public preparedness actions were also found to be a function of time; they increased when information was new, but decreased as time passed (Turner 1983).

In 1980, two American scientists, Brady and Spence, predicted an earthquake in Lima, Peru for the summer of 1981. The former scientist's affiliation with the U.S. Bureau of Mines and the latter's with the U.S. Geological Survey gave the prediction scientific credibility. Two assessments of the societal impacts of the prediction were conducted. Researchers Olson, Podesta and Nigg (1989) concluded that the prediction precipitated a fierce political controversy. And Echevarria, Norton and Norton (1986, p. 175) concluded that, "...over half of the population of Lima took some precautionary measures, that the total economic damage for the prediction was roughly \$50 million, and that the poorer groups in society bore a disproportionate share of the prediction costs."

Obviously, research up to this point in time on societal response to quake predictions were quite mixed since some found dramatic negative impacts, others found neither positive nor negative impacts, and yet others found increased public preparedness. An attempt to synthesize these apparently conflicting accounts of societal response was issued by Stallings (1982). He proposed major variables important to consider in determining whether or not a given group of people will believe an earthquake prediction. He focused on the probability that public statements about future earthquake events are believed and the prediction dissemination process. Stallings came to the following conclusions. People are more likely to believe scientific earthquake predictions when they overlap or converge with nonscientific forecasts. Belief in a prediction will vary along ethnic, social class, and age lines. Credibility is shaped by the general sense of trust that people have in government when prediction information is released by governmental authorities. In fatalistic cultures, predictions may be viewed as credible but preparedness actions do not necessarily follow. And,

...the nature of the prediction itself may have some influence on its credibility. Predictions may be stated either in terms of the likelihood of an earthquake in a certain place during a certain period of time, or of the absence of earthquakes above a certain magnitude in a region between two points in time. There is some indication that predictions of the former type (of the presence of some event) are inherently more credible than those of the latter type (of the absence of some event) (Stallings 1982, p. 65).

Stallings' insights opened the door for others to look across prediction events for discernable patterns on which to build a foundation for social theory and public policy, but his work was largely ignored at the time.

By the mid-1980s new physical scientists had arrived on the scene. They were young, enthusiastic, and inclined to simply speak their minds. This posture led to the issuance of a raft-full of a new sort of short-term predictions issued in the immediate aftermath of unpredicted earthquakes. This type of prediction is based on the idea that the odds of a larger quake are up after a smaller one has just happened. The most recent example of post-earthquake predictions of subsequent quakes comes from the 1989 Loma Prieta earthquake.

Public aftershock warnings were issued during the emergency and for two months thereafter. Public reaction was studied in detail (Mileti and O'Brien 1992). The researchers discovered that many people did many things to prepare for damaging aftershocks, but it was observed that those who had losses in the mainshock did the most to prepare for aftershocks, while those who had few or no mainshock losses did very little to get ready. They concluded that the public may be prone to a "normalization" bias in interpreting aftershock predictions: people interpret their risk to predicted aftershocks in line with mainshock experience and not in ways consistent to the actual risks which they may face.

Then in December, 1989 a quake prediction was made that may well be the most infamous to date. The USGS had been investigating the seismic characteristics of the central United States, and they estimated that there is a 13 to 65 percent chance that the New Madrid, Missouri fault will produce a major earthquake by the year 2000 (Edwards 1991). In December of 1989, Iben Browning, a climatologist and business consultant from New Mexico, aired a controversial prediction for a 6.5 to 7.5 magnitude earthquake on the New Madrid fault on December 3, 1990, give or take 48 hours and it was given focused media and public attention. The Browning prediction was also given credibility by a local earth scientist. The media issued what could be considered a public earthquake warning, and the prediction was extensively studied by social scientists.

Research concluded that the prediction was widely believed by the public (Farley et al. 1991), and that it was the media who played the key role in shaping peoples' perceptions (Atwood 1993). More than anything else, the 12 month long widespread news coverage of the prediction "...led to a heightened awareness of the problem of earthquakes in general and especially of the possibility of a major quake along the New Madrid Fault Line..." (Baldwin 1993, p. 351). In addition, the prediction prompted

people to take earthquake readiness actions, for example, purchasing earthquake insurance. It also prompted some organizations like schools and banks to change routine operating procedures on the day the earthquake was projected (Edwards 1991; Farley et al. 1991; Kennedy 1991). The public did not change its daily routines (Sylvester 1991), but some organizations did change their schedules on the day the earthquake was expected to occur (Farley et al. 1991).

A number of explanations have been offered about why this bogus prediction became salient to the public. First, Browning was strongly supported by the Director of the Center for Earthquake Studies at Southeast Missouri State University (Edwards 1991). "It is clear that up to half of the public did not see scientists as clearly rejecting the Browning forecast, despite the statements of both individual scientists and scientist groups to that effect" (Farley et al. 1991, p. 32). Second, the Loma Prieta earthquake occurred a year earlier, and this increased awareness of the quake threat throughout the American collective consciousness (Baldwin 1993, p.351). Third, local businesses helped to make the prediction salient when they took advantage of the situation to market quake-related products. Fourth, emergency management agencies also found "...an opportunity to place earthquake safety issues on the public agenda" (Edwards 1991, p. 19) and conducted campaigns to increase community hazard awareness and preparedness. Finally, less than three months before the predicted major quake, a Richter magnitude 4.6 quake hit in the region, and it was felt over a wide area and received considerable media attention (Baldwin 1993).

As the science of quake prediction is being advanced, societal research is keeping pace, and applications to enhance societal readiness are too numerous to mention. "As the ability of scientists to predict earthquakes improves, such forecasting capability will likely be put to even increased use" (Governor's Board of Inquiry 1990, p. 91). But societal response to the most scientifically approved and credible earthquake prediction to date — the Parkfield, California Earthquake Prediction Experiment — has yet to be described.

The Parkfield earthquake prediction was issued by the director of the U.S. Geological Survey in a public statement on April 5, 1985. The statement forecasted an earthquake of magnitude 5.5 to 6.0 in the next several years (1985–1993) with more than a 90% probability that it would happen, and the forecast also stated that there was potential for this quake to be magnitude 7. The release of this prediction was a major media event, and California's Office of Emergency Services eventually prepared and mailed a brochure describing the prediction and recommended actions to

the more than 122,000 central California households within the extended area at risk assuming a magnitude 7 earthquake.

Societal response research (Mileti and Fitzpatrick 1993) found that the prediction experiment greatly enhanced public preparedness for the impending quake, and no negative societal impacts were observed. It was also found that readiness actions were more likely among members of the public with recent damaging earthquake experience, whose friends and neighbors took preparedness and mitigation action, and who had taken protective action against earthquake risk prior to the prediction. Most important, the researchers found that the written brochure was the most significant factor to influence the risk that members of the public perceived and what they did to get ready. The brochure reached more people than other communication means; it was the most effective, understandable, and preferred vehicle for communicating predicted earthquake risk information.

The Event Studied

The current research investigated societal response to a earthquake "predictions" issued for the San Francisco Bay Area in the aftermath of the 1989 Loma Prieta earthquake. The National Earthquake Prediction Evaluation Council (NEPEC) began routine meetings in 1984 to review data from areas in the nation with earthquake prediction potential. In 1986 NEPEC asked the U.S. Geological Survey if it could review a quake forecast issued for southern California in the early 1980s. The Survey asked NEPEC to consider quake potential in both northern and southern California in the Spring of 1987. The Working Group on California Earthquake Probabilities was formed and issued its report in 1988. The report concluded that a 50% probability existed for a magnitude 7.0 or greater quake to occur in both northern and southern California in the next 30 years. But the October 1989 Loma Prieta earthquake led the Working Group to reconsider its conclusions. A subsequent report was issued in 1990. The total 30 year probability of one or more large earthquakes was set at 67% for the Bay Area.

Scientists, government officials and members of private disaster response organizations sought an effective way to inform citizens about the revised probabilities. Social scientists convinced these groups that a written document would be the most effective. A document was prepared to include in a Sunday edition of Bay Area newspapers. The insert "The Next Big Earthquake in the Bay Area May Come Sooner Than You Think" was distributed in several languages on September 9, 1990. Printed on slick bond paper using multiple colors, the 10 by 13 inch size, 24 page length contributed to the insert's magazine-like appearance. The document was divided

into about a dozen topical sections. Section titles at the top of pages were printed in bold lettering for easy reference. The insert also contained maps and pictures. For example, the centerfold map of the Bay Area illustrated the location of faults and ground conditions with different prospects for shaking or failing in a large quake. The document's appearance set it apart from the rest of the newspaper. The insert told: that a major quake is highly likely to happen soon and why, how much the ground will shake, what people could do to prepare, how to reduce damage, how to respond to short-term warnings, and where to get more information.

The general objective of our research was to discover the impact of the risk information communicated in the newspaper insert on what people and organizations thought and did to get ready for the next big Bay Area earthquake. But the Bay Area newspaper insert was not the only quake information to which the public had access. Other information was disseminated throughout the area on earthquake risk before, during, and after the distribution of the insert. Consequently, we sought to learn the impact of the insert in the context of all other available public earthquake information.

For example, in the 15 months prior to the October 1989 Loma Prieta earthquake, the San Francisco Chronicle ran 60 articles on the topic of earthquakes of which 11 addressed future quake risk in the Bay Area, the San Jose Mercury News had 32 quake-related articles of which 4 dealt with future risk, and three quake articles appeared in the Oakland Tribune but only one was on future Bay Area earthquake risk. No articles addressed mitigation and/or preparedness activities that the public could perform to ready for future damaging quakes.

The number of articles on earthquakes increased dramatically between October 1989 (one month following the Loma Prieta Earthquake) and September 1990 (the month that the newspaper insert was distributed). The San Francisco Chronicle published 776 earthquake articles, the Oakland Tribune published 380, and 302 were published by the San Jose Mercury News. The majority of San Francisco Chronicle articles dealt with the areas of aid and assistance (168), secondary economic impacts (126), infrastructure (104), earthquake policy and laws (96) and inhabitable structures (94). The same pattern was followed in the Oakland Tribune and the San Jose Mercury News. Surprisingly few articles appeared during this time period on earthquake preparedness and mitigation. For example, the San Francisco Chronicle published 20 articles on these topics, the San Jose Mercury News published 14, and 6 appeared in the Oakland Tribune.

An analysis of the newspaper articles that appeared between October 1990 (one month after the distribution of the newspaper insert), and June

1991 revealed a different pattern: the San Francisco Chronicle published 244 earthquake-related articles, the San Jose Mercury News published 174 articles, and 74 were published in the Oakland Tribune. Most of these articles were devoted to quake aid, secondary infrastructure impacts, and quake policy. Both the San Francisco Chronicle (46) and the San Jose Mercury News (52) increased the number of articles dealing with preparedness and mitigation activities.

Public information about earthquakes was also available from other sources. For example, the Bay Area Regional Earthquake Preparedness Project and the Association of Bay Area Governments both routinely disseminate public quake information; both groups distributed a wide array of published materials and made presentations at public and business meetings during the period covered by our study that included topics related to how to prepare for future earthquakes. Other agencies, such as the fire and police departments disseminated information that was more specific to their role, such as fire suppression and crowd control.

Other sources of earthquake information included the private sector. Some companies provided employees with information about the quake risk and what to do to prepare and how to mitigate future losses to their homes and their private offices at work. Additionally, non-profit organizations such as the Red Cross and the United Way disseminated public quake preparedness and mitigation information, and some Red Cross information was available in multiple languages.

Research Methods

Data about response to the risk information communicated in the insert was sought from varied societal levels and units of analysis. These included the public; businesses and corporations; and health, safety and welfare organizations and government agencies at the city, county, state and federal levels. Systematic data collection was preceded by qualitative field work to help inform our work, and a pretest of quantitative data collection instruments.

During the summer of 1991, we collected background data from throughout the Bay Area. Specific community leaders were interviewed and newspaper clippings and other publicly available earthquake risk and readiness information documents were collected. This information was inspected, collated, and summarized. It was used to help us frame the subsequent qualitative and quantitative questions we would ask once the study was formally underway.

General Public

Eight counties in the San Francisco Bay Area were selected to represent the population at risk to the next damaging earthquake in the area and the population of households we used to study public response. Residents of these counties were exposed to a range of different risk levels as described in the newspaper insert. High risk counties included Contra Costa and Alameda, moderate risk counties were Sonoma, San Francisco, Marin and San Mateo, while lower risk counties were Santa Clara and Santa Cruz. Addresses from the eight counties were pooled resulting in a total population of 581,068 households. A systematic random sample of addresses was used to provide a good degree of representativeness (Babbie 1990). The usefulness of information obtained in a sample is, however, dependent on the variation in the data which in turn is largely dependent on the number of observations included in the sample (Schaeffer, Mendenhall, and Ott 1986). We statistically judged that a minimum of 500-600 returned questionnaires would constitute an adequate sample size to provide desired variance for analyses.

We had just completed two other studies on the communication of risk information to the general public (see Fitzpatrick and Mileti 1990; Mileti and O'Brien 1992); consequently, we updated our measures but did not formally pretest the questionnaire; they were mailed to 1,309 households in January 1992 with two additional follow-up mailings sent to increase the number of responses in a quasi-"total design method" (Dillman 1978). Chinese and Spanish language versions of the questionnaire were created and crawlers at the top of each questionnaire indicated that it was available in these languages. A total of 806 usable questionnaires were returned giving the study a 61.6% response rate.

Organizations

We used a "nested" approach to determine which health, safety and welfare organizations and government agencies to include in the study. First, we drafted a questionnaire for use in the structured interviews. We pretested the instrument on organizational spokespersons in Santa Rosa, a community jolted by a quake several decades ago, but not included in our study. Through this process we eliminated the bad measures, refined good measures and reduced the number of questions needed to tap our concepts. Using the pretest responses to open-ended questions, we were able to determine the range of relevant items to include on the final lists used to measure the knowledge and action variables. Second, we interviewed all federal agencies in the Bay Area that had a role in setting earthquake policy,

managing land or public works, overseeing resources or public safety or that had a role in earthquake response. Third, we included all state agencies that met these same criteria. Next, we selected three counties to include in the research. The counties selected varied in terms of the risk they faced as described in the newspaper insert. These were high risk Alameda County, San Francisco — which the insert portrayed as having moderate risk, and lower risk Santa Clara County. We interviewed spokespersons from government agencies and private health, safety and welfare organizations in each county. Fifth, we interviewed similar organizations in the largest city (Oakland, San Francisco and San Jose) in each selected county. Almost 100 non-business interviews were performed during January, February and April of 1992.

We picked 54 businesses from the same geographical area used to study public response. Businesses were divided into eight categories: retailing, development, manufacturing, transportation, finance, health, service and high technology with small, medium and large-sized businesses selected from each category. The selected businesses were not selected statistically since random selection would have excluded some industry leaders and major employers. Our purposive sample guaranteed that major corporations would be studied and it also provided variation business type and size. Face-to-face interviews were conducted with the pretested interview schedule in the first two months of 1992.

Reported Effectiveness of the Insert

The insert was widely seen by the population to which it was distributed. Nearly three-quarters (74%) of our study's household respondents had heard about the next big Bay Area earthquake. A large proportion of the population (51%) had seen the newspaper insert. The insert reached sizeable proportions of the organizations we studied: 71% of the business and 84% of the health, safety and welfare organization and agency respondents reported they had seen the insert.

Almost everyone who got an insert read it. For example, 92% of the business respondents and 91% of the health, safety and welfare organization and agency spokespersons reported that they had read the insert on behalf of their organization. Of those who had seen the insert, 82% of the public, 97% of the businesses and 95% of the health, safety and welfare organization and agency respondents said they found it easy to understand. Only 44% of the public reported, however, that they were able to understand the centerfold map that color-coded the anticipated shaking in the next earthquake.

Table 1. What Respondents Remembered about the Parameters and Characteristics of the Next Bay Area Earthquake*

Parameters/Characteristics	(n)	% Who Remembered
Damage is greater in certain locations and buildings	(433)	54%
Damage is concentrated in areas of soft soils	(360)	45%
It has a 67% chance of happening in the next 30 years	(359)	45%
It will likely strike between San Jose and Santa Rosa	(352)	44%
It may be about magnitude 7	(351)	44%
Damage is concentrated in areas of moving faults	(273)	34%
Will cause much more damage than Loma Prieta	(320)	40%
Will be in a populated area	(270)	34%
Damage is concentrated where the ground settles or slides	(270)	34%
The Loma Prieta could be the first quake of a pair	(158)	20%
67% probability doesn't include that quakes can occur within a couple of years of each other	(144)	18%
Scientists agree about the next Bay Area earthquake	(89)	11%

*Respondents could report multiple answers.

About a third of the respondents from organizations who saw the insert (35% of businesses and 30% of health, safety and welfare organizations and agencies) and nearly one-quarter (23%) of the public reported that the brochure contained new information. Almost half (46%) of the businesses and about one-third (38%) of the health, safety and welfare organizations and agencies and the public (30%) reported the insert as useful for getting

ready for future quakes. Two-thirds of the organizations in our study (68% of businesses and 61% of the health, safety and welfare organizations and agencies) but less than half of the public (44%) kept the insert. About half of the organizations (49% of the businesses and 47% of the health, safety and welfare organizations and agencies) but only 6% of the public sought additional insert copies—perhaps because one copy was enough to share with family members, but not with other organization members.

Public Reaction

What People Remembered

Bay Area residents were selective in remembering information contained in the insert. But their selective recollections suggested that they are making earthquakes a permanent part of local culture. To the best of our knowledge, this is the first time that any study on a large urban population in the United States has been able to make this conclusion.

The insert informed citizens about a dozen different items concerning the next big earthquake (see Table 1). They were most likely to remember the quake's probability of occurrence (45%), its magnitude (44%), the location where it is likely to happen (44%) and the time horizon in which it is expected (45%). Residents were also likely to recall damage information that was also an obvious lesson in the recent Loma Prieta earthquake: how damage is related to location (54%) and soft soils (45%).

The time, place, magnitude and probability of occurrence of a future quake have long been the basic elements of a prediction required by the California and National Earthquake Prediction Evaluation Councils. No prior study of earthquake forecasts has documented a public so inclined to recall prediction parameters. This finding suggested that the Bay Area public found the basic parameters of the forecast salient, perhaps because they had learned about the general aspects of quake prediction science before the insert was ever issued.

The idea that earthquakes are becoming part of Bay Area culture was further reinforced when we examined what recommended safety actions in the insert people remembered (see Table 2). Past research documents that people are most inclined to recall recommendations that are easy, quick and inexpensive to perform. But we found that people were most likely to recall recommended actions that have been circulating for a long time which the insert repeated, and less likely to recall recommendations that are relatively new ideas. For example, 87% recalled advice to store emergency equipment; 85% remembered being advised to stockpile food and water; the recommendation to strap the water heater was recollected by 77% of the

Table 2. What Respondents Remembered about Actions Recommended in the Insert*

Recommended Actions	(n)	% Who Remembered
Store emergency equipment	(703)	87%
Stockpile food and water	(687)	85%
Strap water heater	(624)	77%
Put wrench by gas shut-off valve	(572)	71%
Bolt house to foundation	(528)	66%
Develop an earthquake plan	(504)	63%
Put latches on cabinets	(441)	55%
Store hazardous materials safely	(438)	54%
Rearrange breakable household items	(435)	54%
Look into earthquake insurance	(384)	48%
Purchase earthquake insurance	(378)	47%
Install flexible piping	(336)	42%
Pick an emergency contact person outside the area	(313)	39%
Inspect earthquake resistance of home	(311)	39%
Learn first aid	(309)	38%
Add lips to shelves	(288)	36%
Determine if live/work in vulnerable area	(258)	32%
Brace house walls	(247)	31%
Find out about school earthquake plans	(165)	26%
Learn how to put out fires	(155)	19%
Learn how to assist elderly and immobile people	(131)	16%
Learn how to rescue trapped people	(108)	13%

*Respondents could report multiple answers.

population; and 66% recalled advice to bolt their house to its foundation. Relatively few people, however, recalled advice based on new ideas such as learn how to rescue people who are trapped (13%) and only 16% remembered the recommendation about assisting elderly and immobile people.

What People Did

We asked people what they had done to prepare themselves for future earthquakes both before (because of their recent experience with the 1989 Loma Prieta earthquake) and after the insert was distributed. Their answers provided further support for the observation that earthquakes are becoming a fixed part of Bay Area culture (see Table 3). People were most likely to report that they did things that had been recommended for a long time. For example, 81% stored emergency equipment, 75% stockpiled food and water, 44% had put a wrench by the gas shut-off valve, and 24% had bolted their house to its foundation. Only a few people had completed some of the relatively new ideas recommended in the insert such as learn how to rescue trapped people (8%).

Reported citizen mitigation and preparedness activities in the Bay Area seemed plentiful (see Table 3). Regarding mitigation, for example, 52% of our sample reported that they had strapped their water heater; 24% said they bolted their house to its foundation; and 30% said they had installed flexible piping on their gas stove lines. These are high numbers when you consider that many Bay Area residents live in apartments without foundations to bolt or water heaters to strap, and many cook on electric stoves. Reported preparedness activities that were even higher: 81% stored emergency equipment; 75% stockpiled food and water; 32% learned first aid; and 32% picked an emergency contact person.

All of the mitigation and preparedness actions examined (see Table 3) had been performed by some members of the Bay Area public before the insert was distributed. But people participated in additional mitigation and preparedness activities after the insert was distributed. To illustrate this, 18% of the population had developed an earthquake plan before the insert was distributed, while 10% more did so after the insert was placed in area newspapers; 37% reported that they had strapped their water heater before insert distribution with 15% more reporting they did this after the insert's dissemination.

People listed four major reasons for not doing more to get ready for the next big Bay Area earthquake. Some 32% of our respondents reported the lack of money to do more; 30% said they were as ready as they were able to get; 25% said they simply didn't have the time to do more preparation;

and 24% thought it wouldn't help to do more to get ready. But one-quarter of the population (25%) reported that they intended to learn more about what to do; 28% expressed intentions to do more to make their homes safer in an earthquake; and 11% planned on buying earthquake insurance.

Table 3. Mitigation and Preparedness Actions Taken Before and After the Newspaper Insert*

Mitigation/Preparedness Action	Pre-Insert		Post-Insert		Total	
	(n)	%	(n)	%	(n)	%
Stored emergency equipment	(404)	50%	(248)	31%	(652)	81%
Stockpiled food and water	(357)	44%	(249)	31%	(606)	75%
Strapped water heater	(295)	37%	(122)	15%	(417)	52%
Stored hazardous materials safely	(231)	29%	(117)	15%	(348)	44%
Rearranged breakable items	(224)	28%	(143)	18%	(367)	46%
Put wrench by gas shut-off valve	(224)	28%	(127)	16%	(351)	44%
Bought earthquake insurance	(220)	27%	(103)	13%	(323)	40%
Learned first aid	(195)	24%	(66)	8%	(261)	32%
Installed flexible piping	(190)	24%	(46)	6%	(236)	30%
Picked emergency contact person	(165)	21%	(91)	11%	(256)	32%
Bolted house to foundation	(153)	19%	(40)	5%	(193)	24%
Developed earthquake plan	(148)	18%	(78)	10%	(226)	28%
Learned how to fight fires	(140)	17%	(51)	6%	(191)	23%
Put latches on cabinets	(84)	10%	(47)	6%	(131)	16%
Braced house walls	(74)	9%	(27)	3%	(101)	12%
Learned how to assist elderly/immobile	(72)	9%	(25)	3%	(97)	12%
Learned how to rescue trapped people	(49)	6%	(17)	2%	(66)	8%
Put lips on shelves	(37)	5%	(27)	3%	(64)	8%

*Respondents could report multiple answers.

The Risk People Perceived

Our respondents overwhelmingly viewed earthquakes as the most threatening hazard facing the Bay Area (80%). We measured perceived quake risk by asking people if they thought a damaging earthquake would occur in the short-term versus the long-term (see Table 4). Few people accepted the short-term risk of such an earthquake, but many did in the long-term. Only 18% of the population thought that such an earthquake would occur in the next couple years, while 48% thought it would occur in five or more years; only 10% accepted the idea of personal loss within two years, while 22% acknowledged such loss in five or more years.

Residents of the Bay Area seem to know more about quake prediction and to be doing more to prepare for future earthquakes than any population observed to date, yet few of these same citizens admitted that they faced significant losses in a big and damaging quake in the very near future. People may believe that they can control losses and injuries in future quakes by the actions they are taking now to get ready.

Organizational Response

The Risk Recognized

Organizational spokespersons perceived earthquake risk in the Bay Area very differently from the general public. More than one-half of all the organizational respondents included in the study believed that the earthquake risk they faced in the short-term was high. This view was taken by

Table 4. Short and Long-term Risk Perceptions of a Damaging Bay Area Earthquake

Response	In the Next Couple of Years an Earthquake:				Five or More Years From Now an Earthquake:			
	Will Occur		Will Cause Injury/Damage to Self, Family, Home		Will Occur		Will Cause Injury/Damage to Self, Family, Home	
	(n)	%	(n)	%	(n)	%	(n)	%
Yes	(147)	18	(77)	10	(385)	48	(176)	22
Don't know	(545)	68	(554)	69	(379)	47	(523)	65
No	(114)	14	(175)	22	(42)	5	(107)	13
Total	(806)	100	(806)	101*	(806)	100	(806)	100

* = Due to rounding.

56% of businesses and corporations, 56% of the health, safety and welfare organizations and agencies in the City and County of San Francisco, 55% of the federal agencies interviewed, 50% of Santa Clara County and the City of San Jose health, safety and welfare organizations and agencies, 40% of the state agencies in the areas at risk, and 39% of the Alameda County and City of Oakland health, safety and welfare organizations and agencies.

Preparedness Actions

We asked spokespersons in the organizations studied about varied preparedness actions that enhanced preparedness for their own in-house staff or their organization's ability to perform its role as part of community response to future quake disasters.

The actions we asked about included planning, training, conducting drills and/or exercises, stockpiling emergency supplies, and informing the public about quake preparedness. The activities respondents told us about were varied in terms of how they might actually affect overall preparedness: both minor (for example, adding a few extra bottles of water to those already kept by water coolers) and major preparedness actions (for example, bringing an existing emergency plan up to the state-of-the-art) were reported.

We gathered information about preparedness activities that occurred both after the Loma Prieta earthquake, but before the distribution of the newspaper insert and after the insert's release. The lack of preparedness activity in either period does not necessarily mean that an organization is not well prepared since adequate preparedness could have been in place before the Loma Prieta quake. Additionally, the presence of preparedness activities in either time period does not mean that the organization is adequately prepared.

We found emergency preparedness actions after the Loma Prieta quake and after the distribution of the insert across all types of organizations in the Bay Area. For example, although most organizations had some sort of emergency earthquake plan in place before the Loma Prieta quake, we found a number of organizations adopted their first quake-specific plan after the earthquake and just as many adopted their first plan after the insert's distribution (see Table 5). Many of the organizations with emergency plans before the Loma Prieta quake engaged in some attempt to update them after the earthquake, after the insert was distributed and in many cases during both periods (see Table 6), but then many government agencies routinely update plans annually.

We also observed that many organizations held their first quake-related drill and/or provided some type of training to employees after the Loma

Prieta quake and/or after the insert's distribution (see Table 5). For example, 32% of the businesses studied held drills for their employees for the first time after the insert was distributed, and 20% provided some type of training for their employees for the first time during the same period.

Table 5. Initial Emergency Preparedness Activities Taken by Organization*

Organizations	(n)	Plan		Drill		Training	
		1	2	1	2	1	2
Alameda County/ Oakland	(23)	19%	0%	19%	40%	10%	10%
Santa Clara County/ San Jose	(22)	14%	0%	9%	73%	5%	9%
San Francisco City & County	(18)	0%	0%	11%	44%	0%	22%
Business	(54)	11%	9%	9%	32%	15%	20%
State	(14)	0%	7%	8%	46%	15%	0%
Federal	(11)	9%	18%	9%	46%	9%	0%

*Where 1 = post Loma Prieta but pre-insert and 2 = post insert.

Table 6. Updating Existing Emergency Plans by Organizations*

Organizations	(n)	Plan	
		1	2
Alameda County/Oakland	(23)	24%	29%
Santa Clara County/San Jose	(22)	64%	41%
San Francisco City & County	(18)	33%	39%
Business	(54)	26%	30%
State	(14)	14%	64%
Federal	(11)	18%	36%

*Where 1 = post Loma Prieta but pre-insert and 2 = post insert.

Among those organizations that held drills and/or training prior to the Loma Prieta earthquake, a marked increase was seen in the number of drills performed and attempts to provide some sort of employee training in organizations after the insert was distributed (see Table 7). Except for state agencies, an increase in stockpiling some sort of emergency supplies or adding to existing stockpiles was observed in all types of organizations (see Table 7).

First attempts by organizations to inform the public about earthquake risk and how to get ready were observed after the Loma Prieta quake as well as after the insert was disseminated (see Table 8).

Mitigation Actions

Structural assessment, rehabilitation, and mitigation followed a common pattern for organizations (see Table 9). Although these activities occurred before the Loma Prieta quake in almost all organizational categories, the earthquake obviously increased the number of structural assessments performed to determine quake damage. Structural assessments after the quake were particularly frequent in Oakland/Alameda County (62%) and San Francisco (78%), where quake damage was relatively high. In some cases structural rehabilitation and mitigation followed assessments that revealed damage needing repair. Possible constraints to structural rehabilitation and

Table 7. Emergency Preparedness Activities Taken by Organizations*

Organizations	(n)	Drill		Training		Stockpile	
		1	2	1	2	1	2
Alameda County/ Oakland	(23)	43%	48%	20%	20%	23%	5%
Santa Clara County/ San Jose	(22)	64%	73%	50%	63%	5%	14%
San Francisco City & County	(18)	55%	72%	26%	38%	12%	18%
Business	(54)	43%	54%	36%	41%	15%	17%
State	(14)	46%	46%	47%	54%	0%	0%
Federal	(11)	46%	64%	27%	45%	0%	36%

*Where 1 = post Loma Prieta but pre-insert and 2 = post insert.

mitigative actions were the availability of voter approved funds needed to engage in these sorts of activities by local government organizations.

Eight businesses and 24 of the health, safety and welfare organizations and agencies in our study had vacated a building due to the earthquake hazard. In some cases, different agencies vacated the same structure. Some of this occurred before the Loma Prieta earthquake (2 businesses, 1 state and 3 local government agencies); the rest was in response to Loma Prieta damage (see Table 9). One corporation we studied vacated their headquarters in downtown San Francisco after Loma Prieta for mitigation purposes not related to experienced damage.

Actions to make sure that hazardous materials were stored safely followed their own pattern (see Table 9). Most activities to store hazardous material occurred before the quake, likely in response to policy requiring action.

We found that purchased insurance was not a viable action for health, safety and welfare organizations and agencies because many of them in our study are government agencies (see Table 9). Only one agency in our study reported holding some type of purchased earthquake insurance. On the other hand, 23% of the businesses we interviewed had bought earthquake insurance prior to the Loma Prieta earthquake. This figure dropped by more than half after the earthquake and it remained there even after the distribution of the insert. It is possible that the level of damage experienced after Loma Prieta led some businesses to conclude that purchased quake insurance did not make good economic sense.

Table 8. First Attempts to Inform the Public by Organizations*

Organizations	(n)	Informing the Public	
		1	2
Alameda County/Oakland	(23)	5%	5%
Santa Clara County/San Jose	(22)	5%	0%
San Francisco City & County	(18)	11%	6%
Business	(54)	6%	6%
State	(14)	14%	7%
Federal	(11)	9%	9%

*Where 1 = post Loma Prieta but pre-insert and 2 = post insert.

Table 9. Mitigation Activities Taken by Organizations*

Organizations	(n)	Hazard Material Storage			Insurance			Contents Protection		
		1	2	3	1	2	3	1	2	3
Alameda County/ Oakland	(23)	38%	5%	14%	0%	0%	0%	10%	57%	19%
Santa Clara County/ San Jose	(22)	32%	18%	5%	5%	5%	5%	41%	64%	27%
San Francisco City & County	(18)	28%	11%	0%	0%	0%	0%	11%	39%	22%
Business	(54)	38%	11%	9%	23%	11%	11%	32%	47%	30%
State	(14)	57%	7%	0%	0%	0%	0%	29%	43%	29%
Federal	(11)	20%	0%	0%	0%	0%	0%	10%	50%	30%

*Where 1 = pre Loma Prieta, 2 = post Loma Prieta but pre-insert, and 3 = post insert.

Organizations	(n)	Structural Assessment			Structural Rehabilitation			Structural Mitigation		
		1	2	3	1	2	3	1	2	3
Alameda County/ Oakland	(23)	10%	62%	0%	5%	24%	19%	5%	33%	19%
Santa Clara County/ San Jose	(22)	41%	45%	0%	27%	18%	9%	18%	27%	9%
San Francisco City & County	(18)	22%	78%	28%	22%	33%	39%	17%	39%	39%
Business	(54)	38%	55%	15%	25%	17%	13%	23%	17%	17%
State	(14)	23%	31%	15%	21%	7%	0%	0%	21%	0%
Federal	(11)	40%	40%	10%	40%	10%	0%	20%	0%	10%

*Where 1 = pre Loma Prieta, 2 = post Loma Prieta but pre-insert, and 3 = post insert.

Finally, many mitigation actions that involve the contents of buildings do not require voter approval, changes in policy, or the outcome of structural assessments to be performed. We found that all types of organizations did more things to make the contents of their buildings safer both after the Loma Prieta quake and after the insert was distributed than they had ever done in the past (see Table 9). For example, more than half of the organizations in Oakland/Alameda County (57%) and San Jose/Santa Clara County (64%), and 47% of businesses and 50% of federal agencies did things to building contents in order to reduce future losses. More organizations engaged in such activities after the insert's dissemination than at any point before the Loma Prieta quake.

Conclusions

Prior research has reported mixed findings regarding societal response to earthquake predictions, but these conclusions must be placed in their appropriate context. It would be inaccurate and inappropriate to infer — as some have attempted to do — that past descriptive findings about societal prediction response would help to describe societal response to future predictions. Past research conclusions include that credible predictions would elicit large social and economic disruptions (e.g., Olson, Podesta and Nigg 1989; Weisbecker et al. 1977; Haas and Mileti 1976), neither positive nor negative societal impacts (e.g., Turner, Nigg and Paz 1986; Turner et al. 1978), and positive without negative impacts (e.g. Mileti and O'Brien 1992; Mileti and Fitzpatrick 1993).

We found a great deal of evidence in this study on which to conclude that the public, businesses and government agencies in the San Francisco Bay Area responded to the revised quake probabilities with positive actions that increased both preparedness and mitigation actions, and few if any negative social or economic impacts were observed. But our study of societal prediction response was performed in a setting in which public prediction information was well-managed. Variation in past societal response findings was likely due to variation in the way that society managed prior prediction information.

The conclusions of past research regarding how prediction information impacts societal response have also been varied. For example, scientific sources are taken more seriously than those that are less scientific (Turner et al. 1978), scientific predictions are more salient for the public when they overlap or converge with nonscientific forecasts (Stallings 1982), people reach a saturation point regarding prediction information beyond which their attention span decreases (Turner, Nigg and Paz 1986; Turner 1983),

the channels of information that people find most useful change over time (Turner, Nigg and Paz 1986), and the greater the number of channels used the more likely that people will believe the communicated information (Mileti and Fitzpatrick 1993).

Our findings indicate that the conclusions made by past research investigations may have held in the information contexts investigated, but that a good deal more has been learned regarding the effective management of public quake prediction information. A brief account follows.

Inform the public, local government and businesses with a written document in appropriate languages. A newspaper insert works well to reach most organizations, and a direct mail brochure is much more expensive but only slightly more effective in reaching the public. The document should come from official government sources and scientists and should explain clearly and specifically what the risk and probability are, where and when the quake is going to happen, what the effects will be, what people should do before, during and after the quake, and where to get more information about it and what to do.

We also learned that detailed risk maps based on geological and seismological considerations alone are not well understood by the public. Future maps could be made more user friendly to enhance public understanding. It may be helpful to code risk on maps intended for public consumption on the basis of boundaries familiar to the public, for example, political boundaries. More detailed maps could be made available to the public on request and to earthquake professionals that need more information.

The order in which information is presented in a document like a newspaper insert is important. The most important information for the public to get is what people should do, how to do it, encouragement to talk thing over with others and instructions on how to get additional information. These topics should come first in the document. Earthquake science information, although interesting to the public, would be best placed in an appendix or at the end of the document. This may be particularly important when targeting people like those in the Bay Area who are already well-aware of the earthquake hazard.

A modular approach should be used in preparing future documents since it could be easier for the public to use. Put all the information about a particular topic in the same place. For example, tell people where they can get more information about how to perform a recommended action on the same page where that action is described instead of at the end of the document.

But as important as written documents are to spark positive readiness actions, written documents are not enough. Capture the attention of organizational decision makers, spark their interest, and get them to begin considering that they should do something to reduce their risk. People need to seek out additional information on their own, and talk with their friends and neighbors about it. Organizations need to do pretty much the same thing before they take action. This information seeking process permits both people and organizations to induce ideas about the risk they face and what they should do to get ready. People and organizations may simply need to feel that taking some protective action is their own idea. Public and organizational earthquake readiness actions result from this process, not merely from receiving a newspaper insert or hearing scientists or officials talking in the media.

A written document must be supplemented with information that confirms the importance of the risk and the need to do something about it. People who make decisions for organizations and members of the general public need to get the message several times, from different sources and through as many different channels as possible. Go to the media with as much consistent supplemental information as you can. Also, position supplemental information in the local community for the public to use during this process, such as brochures, slides shows, coloring books, film strips, and additional advice on emergency preparedness and mitigation actions.

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