International Journal of Mass Emergencies and Disasters
August 2000, Vol. 18, No. 2, pp. 317–338

# Household Adoption of Seismic Hazard Adjustments: A Comparison of Residents in Two States*

**Michael K. Lindell**
**Carla S. Prater**
Hazard Reduction and Recovery Center
Texas A&M University
College Station, TX 77843-3137
USA
E-mail (Lindell): mlindell@taz.tamu.edu

*Residents of a high seismic hazard area were compared with those in a moderate seismic hazard area in terms of demographic characteristics, personal hazard experience, risk perception, hazard intrusiveness, and self-reported adoption of 16 hazard adjustments (preimpact actions to reduce danger to persons and property). The results show that the two locations differed substantially in hazard experience, somewhat less so in risk perceptions and hazard intrusiveness, and little in hazard adjustment. Multiple regression analyses supported a causal chain in which location and demographic characteristics cause hazard experience, hazard experience causes hazard intrusiveness, perceived risk causes hazard intrusiveness, and hazard intrusiveness causes the adoption of hazard adjustments.*

Earthquakes have the potential to cause deaths, casualties, property damage, and social and economic disruption, but these impacts could be reduced significantly if those at risk would adopt adjustments such as hazard mitigation and emergency preparedness. Shortly after the 1971 San Fernando earthquake, estimates of the percent of risk area residents undertaking *any* seismic adjustments ranged only from 18 percent (Endo and Neilsen 1979) to 31 percent (Jackson 1977, 1981; Jackson and Mukerjee 1974). Indeed, the level of adoption does not appear to be high even after three decades of major California earthquakes (Mileti and Darlington 1995, 1997; Mileti and Fitzpatrick 1992, 1993). Thus, research is needed to identify characteristics of individu-

* This work was supported by the National Science Foundation under grant BCS 9796297. None of the conclusions expressed here necessarily reflects views other than those of the authors. Correspondence should be sent to Lindell.

als and households that can reliably distinguish between those that do and those that don't adopt earthquake hazard adjustments.

## Literature Review

Lindell and Perry's (2000) review of 23 studies addressing household adjustment to seismic hazard reported that a number of different categories of variables had significant correlations with the adoption of seismic hazard adjustments. Demographic variables are relevant because they can be used to target the populations most likely to adopt these adjustments, while risk perceptions are relevant because they may suggest ways to tailor the content of messages disseminated in public education programs.

Another potential predictor of hazard adjustment is personal hazard experience. This includes property damage or injuries to oneself and one's family members. It also includes such impacts on friends, relatives, neighbors, or coworkers. Many studies of earthquake hazard adjustment have been conducted in California where seismic experience is homogeneously high; most of the remaining studies took place following the Iben Browning prediction in the Midwest where seismic experience is homogeneously low (Edwards 1993; Farley et al. 1993; Showalter 1993). As a result, none of the studies other than Jackson (1981) has been able to compare respondents who varied substantially in their level of hazard experience.

Hazard experience could be an important explanatory variable for risk perception and the adoption of hazard adjustments. Burton, Kates, and White (1978) contended that more recent, frequent, and intense impacts are more likely to cause risk area residents to adopt hazard adjustments. Consistent with this, Perry and Lindell (1990) found that the severity of damage experienced in the May 18, 1980, eruption was related to both perceived hazards vulnerability and the number of hazard adjustments adopted in the area around Mount St. Helens.

Moreover, a broader line of research has shown that attitudes formed in response to direct experience with an object are more accessible from memory and thus have more clarity, generate more confidence and certainty, and are more predictive of action related to that object (Fazio and Zanna 1981). The fact that they are more readily accessible suggests that they will come to mind more frequently and that this, too, will increase the level of action related to an object.

There is evidence that experience may not always have a positive influence on hazard perceptions and adjustments. Baker (1991) concluded that previous hurricane experience is not consistently related to hurricane evacuation across studies and even can have a negative effect in some cases. Palm (1995) reported that earthquake experience was inconsistently correlated with her respondents' seismic risk perceptions and was unrelated to earthquake insurance purchase. As both of these researchers have observed, conclusions about the effect of previous experience depends upon what questions researchers use to measure experience and risk perceptions. In particular, risk perceptions *of an event itself* can be measured in terms of characteristics of the event such as the probability and severity (Mulilis and Lippa 1990) and imminence (Mulilis and Duval 1995) of an earthquake.



By contrast, other research dating back to Jackson and Mukerjee (1974) suggests that the effect of experience depends upon an individual's personalization of the risk (Turner, Nigg, and Paz 1986). That is, risk perceptions of personal consequences can be measured in terms of the probability and cost of property damage (Kunreuther et al. 1978; Palm et al. 1990), personal injury or death, interference with work, and social disruption (Showalter 1993). People's beliefs about a hazard also can be measured in terms of the frequency with which these beliefs come to mind during the course of everyday activities. The term accessibility is used to refer to the ease with which events come to mind when prompted, but the frequency with which ideas appear spontaneously is more properly labeled intrusiveness. Hazard intrusiveness, which can be measured by frequency of thought about a hazard, has been found to rise in the immediate aftermath of an earthquake and gradually decrease (Pennebaker and Harber 1995). An equivalent construct, hazard concern (Dooley et al. 1992), displays similar behavior. Continuing high levels of intrusiveness can be thought of as a measure of chronic accessibility, which involves refreshing memory on a continuing basis. Thus, measures of hazard intrusiveness may provide additional information about the emotional intensity of risk area residents' cognitive representations of the seismic threat.

Although some researchers have focused on earthquake insurance purchases (e.g., Kunreuther et al. 1978), there has been an increasing emphasis on the development of multi-item hazard adjustment scales (Mileti and Darlington 1997; Mulilis, Duval, and Lippa 1990; Russell, Goltz, and Bourque 1995; Turner et al. 1986). One factor analysis of such scales found evidence that seismic hazard adjustments could be categorized into three groups—survival, planning, and hazard mitigation (Russell et al. 1995).

In summary, previous research on people's adoption of seismic hazard adjustments suggests the following hypotheses.

| | |
|---|---|
| *Hypothesis 1:* | Compared to residents in an area of moderate seismic risk, those in a high risk area will have significantly greater levels of personal hazard experience, perceived risk, hazard intrusiveness, and adoption of hazard adjustments. |
| *Hypothesis 2:* | These variables can be ordered in a simple causal chain in which (a) location and demographic characteristics cause hazard experience, (b) hazard experience causes hazard intrusiveness, (c) perceived risk causes hazard intrusiveness, and (d) hazard intrusiveness causes the adoption of hazard adjustments. |

## Method

### Respondents

Southern California and western Washington were selected as the high and moderate seismic hazard areas, respectively. Residents of southern California are in an area where 50 year peak accelerations could exceed 0.40 g (Palm 1995). Moreover, they have been affected by a number of major earthquakes in the three decades since the 1971 San Fernando earthquake and have been told repeatedly that it is only a matter of time until they will be hit by "the big one." By contrast, residents of western Washington are in an area where 50-year peak accelerations are likely to range from 0.20–0.40 g. They have experienced no significant earthquakes during the past 30 years and have been exposed to relatively little information about their seismic vulnerability.

Three cities were selected from southern California (Inglewood, Norwalk, and Santa Clarita) and another three cities were selected from western Washington (Bremerton, Edmonds, and Renton). These cities were selected because the *County and City Data Book* (U.S. Department of Commerce 1994) showed that they provide diversity with respect to household ethnicity, education, and income (see Table 1). Moreover, May and Birkland (1994) categorized Inglewood and Renton as leaders in community hazard adjustment, while Norwalk and Bremerton were categorized as laggards. Santa Clarita and Edmonds were not classified, but Santa Clarita was picked because it was affected by the 1994 Northridge earthquake. Edmonds was selected because it has education and income levels that approximate those of Santa Clarita. Six hundred addresses were randomly selected from each city, and a questionnaire was sent to each address. Those who did not respond within 10 days to the first questionnaire were sent a second questionnaire. This process was repeated through four questionnaires. A total of 561 in a sample of 1,800 responded for a gross response rate of 31 percent. However, 174 households were no longer at their original address or were otherwise undeliverable and were removed from the sample without replacement. This yields an adjusted response rate of 35 percent, which is somewhat low but within the 31–52 percent range obtained by Mileti and Fitzpatrick (1993).

There were few significant demographic differences in the characteristics of the two geographic groups of respondents. As indicated in Table 2, there were significant differences in ethnicity, with Californians more likely than Washingtonians to be Black or Hispanic and less likely to be White. However, comparison of Tables 1 and 2 indicates that respondents from each of the two geographic areas were relatively similar in terms of ethnicity to the populations from which they were drawn. Specifically, the respondent groups had approximately the same proportion of Blacks as the communities from which they were sampled. There was a somewhat lower proportion of Hispanics among the southern California respondents than in their communities, but the proportions of Whites in both geographical areas is roughly representative.

The California respondents also were more likely than the Washingtonians to have children under six years of age, but not children between six and eighteen years old. This is consistent with the characteristics of the underlying population, but comparison of Tables 1 and 2 indicates that families with children were over-represented among the respondents.

The Californians were not significantly different from the Washingtonians in sex and marital status. Neither were there significant differences in age or education ("less than high school" = 1, "high school" = 2, "some college/vocational school" = 3, "college graduate" = 4, and "graduate school" = 5). However, both groups of respondents over-represented males and older residents and had higher levels of education than the populations from which they were drawn. Specifically, 93 percent of the southern California respondents had at least a high school education, and 45 percent had a bachelor's degree or higher. Similarly, 99 percent of the western Washington respondents had at least a high school education and 43 percent had a bachelor's degree or higher. The two groups of respondents also had nonsignificant differ-

**Table 1. Demographic Characteristics of Study Sites**

| | Inglewood | Norwalk | Santa Clarita | Southern California | Bremerton | Edmonds | Renton | Western Washington |
|---|---|---|---|---|---|---|---|---|
| Age | 28.4 | 29.3 | 31.0 | 29.5 | 28.1 | 38.3 | 32.0 | 32.8 |
| Black (%) | 51.8 | 3.2 | 1.5 | 18.8 | 7.1 | 0.9 | 6.5 | 4.8 |
| Hispanic (%) | 38.5 | 47.9 | 13.4 | 33.3 | 4.8 | 2.0 | 3.0 | 3.3 |
| White (%) | 17.4 | 55.8 | 87.2 | 53.5 | 83.9 | 93.5 | 83.5 | 87.0 |
| Children < 5 (%) | 9.8 | 8.9 | 9.0 | 9.2 | 9.3 | 5.9 | 7.5 | 7.6 |
| Children: 5-17 (%) | 20.3 | 20.9 | 19.0 | 20.1 | 14.7 | 15.1 | 14.8 | 14.9 |
| High school (%) | 66.0 | 64.7 | 87.9 | 72.9 | 82.0 | 90.2 | 85.5 | 85.9 |
| Bachelor's (%) | 14.9 | 9.9 | 25.9 | 16.9 | 12.6 | 31.0 | 21.8 | 21.8 |
| Income ($1,000) | 32.0 | 40.4 | 53.0 | 41.8 | 26.4 | 48.4 | 39.0 | 37.9 |
| Home ownership | 36.3 | 65.0 | 75.7 | 59.0 | 39.1 | 67.0 | 48.5 | 51.5 |



**Table 2. Differences between States in Demographic Characteristics, Hazard Experience, Risk Perception, Hazard Intrusiveness, and Hazard Adjustment**

| | Southern California | Western Washington | |
|---|---|---|---|
| *Demographic Variables* | | | $\chi^2$ |
| 1. Sex (female) | 44% | 39% | 1.4 |
| 2. Black ethnicity | 13% | 1% | 39.0** |
| 3. Hispanic ethnicity | 20% | 1% | 57.2** |
| 4. White ethnicity | 52% | 87% | 80.6** |
| 5. Married | 74% | 70% | 1.3 |
| 6. Children under six | 24% | 13% | 11.1** |
| 7. Children between six and sixteen | 42% | 35% | 2.7 |
| 8. Home ownership (OWNER) | 88% | 88% | 0.0 |
| | | | $t$ |
| 9. Age | 48.8 | 50.8 | 1.6 |
| 10. Education | 3.33 | 3.38 | -0.5 |
| 11. Income | 3.90 | 3.92 | -0.2 |
| 12. Community tenure (TENURE) | 13.3 | 13.2 | 0.1 |
| *Hazard Experience* | | | $\chi^2$ |
| 1. Own property damage (OWNDAM) | 56% | 14% | 110.9** |
| 2. Family death/injury (OWNINJ) | 10% | 2% | 19.5** |
| 3. Friend/relative/neighbor/coworker property damage (KNOWDAM) | 73% | 27% | 114.2** |
| 4. Friend/relative/neighbor/coworker death or injury (KNOWINJ) | 26% | 6% | 45.6** |
| *Risk Perception* | | | $t$ |
| 1. Damage in own city (CITYDAM) | 3.6 | 3.2 | 3.3** |
| 2. Damage to own home (HOMEDAM) | 3.1 | 2.8 | 3.3** |
| 3. Injury to self or family (FAMINJ) | 2.5 | 2.4 | 1.1 |
| 4. Disruption to job (JOBDIS) | 2.8 | 2.5 | 2.8** |
| 5. Disruption to shopping and other activities (CITYDIS) | 3.1 | 2.8 | 2.7** |

Table 2. (continued)

| | Southern California | Western Washington | |
|---|---|---|---|
| *Hazard Intrusiveness* | | | t |
| 1. Frequency of thought (THINK) | 3.0 | 3.6 | 6.7** |
| 2. Frequency of discussion (TALK) | 3.6 | 4.0 | 5.2** |
| 3. Frequency of information seeking (SEEKINFO) | 3.9 | 4.2 | 3.6** |
| | | | t |
| *Hazard Adjustment* | 8.3 | 7.4 | 3.0* |

* $p<.05$, ** $p<.01$

ences in income ("less than $15,000" = 1, "$15,000–24,999" = 2, "$25,000–34,999" = 3, "$35,000–49,999" = 4, and "more than $50,000" = 5), home ownership, and community tenure. However, homeowners were over-represented among the respondents.

In summary, there is a modest amount of sample bias that could affect the estimates of means and proportions, but this is not expected to affect the tests of the two hypotheses because, when there is bias in any of the variables, the degree of bias is similar in both states. Moreover, any common bias in the mean (or proportion) for a variable will not affect the *differences between states* as tested in Hypothesis 1 because both means/proportions are equally biased (Lindell and Perry 2000). Correlation and regression coefficients (as tested in Hypothesis 2) are similarly resistant unless the bias is so great that the variances of the variables are severely attenuated.

## Measures

Locational differences were measured in two ways. First, differences in overall seismic vulnerability were measured by contrasting the two states—California and Washington. Second, differences in emergency management support were measured by establishing one dummy-coded variable for the two leader cities (Inglewood and Renton) and another dummy-coded variable for the two laggard cities (Norwalk and Bremerton).



Earthquake experience items were devised that addressed whether the respondent's property had been damaged in an earthquake and whether the respondent or an immediate family member had been injured in an earthquake. Other items asked whether the property of a friend, relative, neighbor, or coworker known personally had been damaged in an earthquake and whether a friend, relative, neighbor, or coworker the respondent knew personally had been injured in an earthquake.

The risk perception item referring to the event itself measured the expected likelihood that an earthquake occurring during the next ten years would cause major damage to property in the respondent's city. The risk personalization items asked the respondents to judge the likelihood of an earthquake occurring in the next ten years causing major damage to their homes, injury to themselves or members of their immediate family, job disruption that would prevent them from working, and disruption to their shopping and other daily activities.

The hazard intrusiveness items asked how often the respondent thought about, talked to others about, or gathered information about earthquakes. These three items were rated on a 1–5 rating scale, where the response categories were daily, weekly, monthly, yearly, and never.

Finally, the questionnaire asked whether the respondent had adopted each one of 16 different hazard mitigation and emergency preparedness measures. These items were drawn from previous scales of hazard adjustment (Lindell 1994; Mileti and Darlington 1997; Mulilis et al. 1990; Russell et al. 1995; Turner et al. 1986) and represented all three subscales of basic survival, planning, and hazard mitigation. The specific items are listed in Table 3.

# Results

## Tests of Hypothesis 1

As predicted by $H_1$, Californians differed significantly from Washingtonians in their earthquake experience (see Table 2). The former were significantly more likely to have experienced injuries themselves or within their immediate family or have had family property damaged in an earthquake. They also were more likely to have known a personal friend, relative, neighbor, or coworker who suffered injuries or property damage.

Also predicted by $H_1$ are the differences between states in seismic risk perceptions. When using a scale where 1 indicates "not at all likely" and 5 indicates "almost a certainty," Californians rated their risk significantly higher than did Washingtonians. This includes the risk of damage in their city, damage to their own home, disruption to their jobs, and disruption to shopping and other daily activities. However, the differences are not large (only .24–.29 standard deviation units). More remarkable is the fact that the difference between states in perceived risk of injury to themselves or members of their family is not significant. Moreover, differences between states also are found in the data on the intrusiveness of seismic hazard. Californians reported significantly higher frequency of thinking about, talking about, and getting information about earthquakes than did Washingtonians.

Finally, as predicted by $H_1$, there are significant, but small, differences between the two states in the adoption of seismic hazard adjustments. Californians adopted a significantly greater number of hazard adjustments than Washingtonians, but only about one hazard adjustment more. More specifically, the Californians had significantly higher levels of adjustment adoption on only four of the sixteen adjustments listed in the questionnaire (see Table 3). These are: keeping four gallons of water in plastic containers, strapping heavy furniture to walls, installing cabinet latches, and developing a household earthquake emergency plan. Californians actually were significantly less likely than Washingtonians to have a fire extinguisher. There were nonsignificant differences on all of the remaining adjustments.

### Tests of Hypothesis 2

**Correlational Analyses.** The hazard adjustment items were formed into a multi-item scale that had an acceptable reliability (Cronbach's $\alpha$ = .74), and this scale was correlated with location (e.g., state, leader, and laggard), demographic characteristics, hazard experience, risk perception, and hazard intrusiveness. Table 4 confirms the findings from Table 2 in showing that the state variable was significantly correlated with hazard experience, risk perception, and hazard intrusiveness. However, the leader and laggard variables had statistically significant correlations only with hazard experience, and the negative signs for the coefficients probably are an artifact of the inclusion of Santa Clarita in the reference group.

The demographic characteristics were significantly related to hazard experience, risk perceptions, hazard intrusiveness, and hazard adjustment. Of the correlations between demographic characteristics and hazard experience, 15 (34 percent) of 44 correlations were statistically significant. This substantially exceeds the number of significant correlations that would be expected by chance (44 x 5 percent = 2.2).



**Table 3. Differences between States in Hazard Adjustment Adoption**

| *Hazard Adjustments* | Southern California | Western Washington | $\chi^2$ |
|---|---|---|---|
| 1. Have a working transistor radio with spare batteries. | 81% | 82% | 0.2 |
| 2. Have at least 4 gallons of water in plastic containers. | 78% | 46% | 54.7** |
| 3. Have a complete first-aid kit. | 73% | 75% | 0.1 |
| 4. Have a 4 day supply of dehydrated or canned food for yourself and your family. | 69% | 72% | 0.5 |
| 5. Have a fire extinguisher. | 68% | 76% | 4.1* |
| 6. Have wrenches to operate utility shutoff valves and switches. | 90% | 90% | 0.0 |
| 7. Have strapped water heaters, tall furniture, and heavy objects to the building walls. | 66% | 34% | 55.9** |
| 8. Have installed latches to keep cabinets securely closed. | 33% | 15% | 24.7** |
| 9. Have developed a household earthquake emergency plan. | 51% | 35% | 14.6** |
| 10. Have learned where and how to shut off water, gas, and electric utilities. | 83% | 84% | 0.0 |
| 11. Have learned the location of nearby medical emergency centers. | 77% | 82% | 1.6 |
| 12. Have purchased earthquake insurance. | 39% | 33% | 2.4 |
| 13. Have contacted the Red Cross or government agencies for information about earthquake hazard. | 18% | 16% | 0.4 |
| 14. Have attended meetings to learn about earthquake hazard. | 27% | 22% | 2.0 |
| 15. Have joined a community organization dealing with earthquake emergency preparedness. | 9% | 5% | 3.8 |
| 16. Have written a letter to a newspaper or a governmental official supporting action about earthquake hazard. | 4% | 2% | 2.9 |

* $p<.05$, ** $p<.01$

Moreover, the absolute value of the correlations fell in the range $.00 \le r \le .18$, and the resulting average correlation was $\bar{r} = .07$.

The demographic characteristics had a similar pattern of statistically significant correlations with risk perceptions (24/55 = 44 percent, $.00 \le r \le .26$, $\bar{r} = .08$), hazard intrusiveness (9/33 = 27 percent, $.01 \le r \le .13$, $\bar{r} = .06$), and hazard adjustment (6/11 = 55 percent, $.05 \le r \le .30$, $\bar{r} = .13$). Income was the only demographic variable to have consistent relationships with earthquake experience, and it also is correlated with hazard

**Table 4. Variable Means, Standard Deviations, and Intercorrelations**

| Variable | M | SD | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Location* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1. State | .61 | .49 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2. Leader | .30 | .46 | 07 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3. Laggard | .33 | .47 | 03 | -46 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Demographic characteristics* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4. Age | 50.00 | 13.58 | 07 | 04 | 00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5. Sex | .41 | .49 | -05 | 06 | 00 | -11 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6. Black | .05 | .23 | -26 | 33 | -15 | 00 | 07 | | | | | | | | | | | | | | | | | | | | | | | | |
| 7. Hispanic | .08 | .27 | -32 | -02 | 15 | -05 | 00 | -07 | | | | | | | | | | | | | | | | | | | | | | | |
| 8. White | .70 | .46 | 36 | -21 | -03 | 06 | 02 | -37 | -46 | | | | | | | | | | | | | | | | | | | | | | |
| 9. Married | .68 | .47 | -04 | -11 | -05 | -05 | -29 | -15 | 05 | 06 | | | | | | | | | | | | | | | | | | | | | |
| 10. Children | .44 | .50 | -10 | -06 | 02 | -45 | 01 | -04 | 13 | -04 | 24 | | | | | | | | | | | | | | | | | | | | |
| 11. Education | 3.36 | 1.01 | 02 | 00 | -20 | -11 | -05 | 04 | -12 | 07 | 07 | -01 | | | | | | | | | | | | | | | | | | | |
| 12. Income | 3.91 | 1.17 | 01 | -05 | -22 | -21 | -13 | -02 | -25 | 18 | 35 | 12 | 35 | | | | | | | | | | | | | | | | | | |
| 13. Owner | .88 | .33 | 00 | -08 | -02 | 16 | -09 | -08 | -09 | 07 | 27 | 03 | 07 | 33 | | | | | | | | | | | | | | | | | |
| 14. Tenure | 13.24 | 11.24 | 01 | 03 | -06 | 56 | -07 | 01 | -02 | 03 | 04 | -27 | -16 | -13 | 26 | | | | | | | | | | | | | | | | |
| 15. *HazExper* | .94 | 1.16 | -49 | -10 | -18 | -11 | -02 | 08 | -01 | -02 | 13 | 10 | 14 | 21 | 10 | -05 | | | | | | | | | | | | | | | |
| 16. OwnDam | .31 | .46 | -44 | -10 | -17 | -06 | -04 | 10 | -03 | -04 | 10 | 03 | 07 | 17 | 08 | 01 | 85 | | | | | | | | | | | | | | |
| 17. OwnInj | .05 | .21 | -19 | -05 | -12 | -06 | 00 | -02 | -06 | 08 | 06 | 06 | 03 | 10 | 03 | -07 | 47 | 26 | | | | | | | | | | | | | |
| 18. KnowDam | .45 | .49 | -45 | -09 | -13 | -09 | -01 | 10 | 00 | -06 | 14 | 11 | 14 | 18 | 13 | -05 | 84 | 64 | 16 | | | | | | | | | | | | |
| 19. KnowInj | .14 | .34 | -29 | -06 | -13 | -11 | 00 | 02 | 02 | 01 | 06 | 08 | 11 | 10 | 03 | -08 | 71 | 41 | 39 | 41 | | | | | | | | | | | |
| 20. *RiskPercep* | 14.23 | 4.72 | -12 | -02 | 02 | -13 | 20 | 06 | 15 | -08 | -10 | 06 | 03 | -05 | -14 | -07 | 20 | 19 | 10 | 16 | 12 | | | | | | | | | | |
| 21. CityDam | 3.41 | 1.67 | -07 | -01 | 04 | 02 | 11 | 04 | 06 | -06 | -09 | -02 | 05 | -08 | -09 | 05 | 13 | 16 | 07 | 08 | 07 | 70 | | | | | | | | | |
| 22. HomeDam | 2.89 | 1.07 | -14 | -01 | 02 | -06 | 26 | 10 | 14 | -09 | -13 | 01 | -02 | -07 | -09 | 00 | 16 | 16 | 10 | 13 | 10 | 84 | 46 | | | | | | | | |
| 23. FamInj | 2.43 | .98 | -05 | -02 | 05 | -10 | 23 | 07 | 13 | -08 | -08 | 01 | -04 | -09 | -12 | -03 | 10 | 09 | 04 | 07 | 08 | 79 | 31 | 76 | | | | | | | |
| 24. JobDis | 2.63 | 1.16 | -12 | -01 | -03 | -19 | 12 | 03 | 15 | -07 | -05 | 12 | 03 | 02 | -14 | -17 | 23 | 18 | 11 | 23 | 11 | 74 | 26 | 52 | 56 | | | | | | |
| 25. CityDis | 2.98 | 1.12 | -12 | -02 | -01 | -12 | 16 | 02 | 11 | 00 | -04 | 06 | -03 | -03 | -13 | -07 | 19 | 17 | 12 | 14 | 14 | 83 | 41 | 65 | 62 | 65 | | | | | |



**Table 4 (continued): Variable Means, Standard Deviations, and Intercorrelations**

| Variable | M | SD | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26. *Intrusive* | 6.71 | 2.30 | -26 | -06 | 00 | -04 | 14 | -03 | 07 | -07 | 10 | 13 | 04 | 09 | 09 | -04 | 27 | 22 | 18 | 23 | 22 | 33 | 17 | 30 | 26 | 29 | 33 | | | | |
| 27. Think | 2.63 | .99 | -28 | -09 | 01 | -06 | 13 | -02 | 05 | -06 | 11 | 13 | 01 | 10 | 06 | -03 | 31 | 26 | 20 | 25 | 24 | 35 | 20 | 31 | 28 | 31 | 35 | 86 | | | |
| 28. Talk | 2.17 | .90 | -22 | -04 | -01 | -04 | 11 | -04 | 08 | -09 | 11 | 11 | 03 | 05 | 07 | -02 | 20 | 14 | 17 | 17 | 17 | 23 | 11 | 23 | 20 | 21 | 24 | 88 | 66 | | |
| 29. SeekInfo | 1.91 | .82 | -15 | 00 | 01 | 01 | 10 | -01 | 04 | -06 | 03 | 08 | 06 | 02 | 08 | -05 | 16 | 12 | 08 | 15 | 13 | 18 | 10 | 16 | 14 | 18 | 20 | 79 | 49 | 57 | |
| 30. HazAdjust | 8.04 | 2.90 | -15 | -08 | -08 | 06 | -10 | -05 | -06 | 07 | 30 | 11 | 14 | 25 | 20 | 05 | 37 | 31 | 18 | 32 | 24 | 08 | 03 | 06 | 05 | 11 | 11 | 41 | 36 | 34 | 33 |

adjustment. Women reported consistently higher levels of risk perception and hazard intrusiveness but lower levels of hazard adjustment. Hispanic ethnicity also was positively related to risk perception but not to hazard intrusiveness or hazard adjustment. Marital status and presence of children in the home both were correlated significantly with hazard intrusiveness and hazard adjustment. Finally, home ownership was negatively related to risk perception, unrelated to hazard intrusiveness, and positively related to hazard adjustment.

The hazard experience variables generally were significantly correlated with the risk perception (14/20 = 70 percent, $.04 \le r \le .22$, $\bar{r} = .11$), the hazard intrusiveness variables (11/12 = 92 percent, $.08 \le r \le .26$, $\bar{r} = .17$), and the hazard adjustment scale (4/4 = 100 percent, $.17 \le r \le .32$, $\bar{r} = .26$). Risk perception variables had significant correlations with hazard intrusiveness variables (15/15 = 100 percent, $.10 \le r \le .33$, $\bar{r} = .24$) and hazard adjustment (2/5 = 40 percent, $.03 \le r \le .11$, $\bar{r} = .07$), while hazard intrusiveness variables were significantly correlated with hazard adjustment (3/3 = 100 percent, $.31 \le r \le .33$, $\bar{r} = .32$).

In summary, the correlational analyses provide support for $H_2$ because they confirm the predictions that (a) location and demographic characteristics are correlated with hazard experience, (b) hazard experience is correlated with risk perception, (c) risk perception is correlated with hazard intrusiveness, and (d) hazard intrusiveness is correlated with hazard adjustment. However, there also was evidence of additional statistically significant correlations that were not predicted. Thus, regression analyses are needed to determine if the nonpredicted correlates add statistically significant increments to the prediction of each of the endogenous variables or can be rejected as spuriously correlated.

**Regression Analyses.** Because of their high intercorrelations, the hazard experience, risk perception, and hazard intrusiveness items each were formed into multi-item scales. These scales had adequate reliabilities: hazard experience, $\alpha = .71$; risk perception, $\alpha = .88$; and hazard intrusiveness variables, $\alpha = .80$. A series of multiple regression analyses were then used to test the causal chain proposed in $H_2$. As indicated in the first column of Table 5, hazard experience was predicted significantly by location and demographic characteristics. Moreover, as indicated in the second column, risk perception was predicted significantly by hazard experience and also by three demographic characteristics (sex, Hispanic ethnicity, and home ownership). Further, the third column indicates that hazard intrusiveness was predicted by risk perception but also by location and two demographic characteristics (sex and Black ethnicity). Finally, hazard adjustment was predicted



**Table 5. Regression Analysis Results**

| *Independent Variables* | Hazard Experience | Risk Perception | Hazard Intrusiveness | Hazard Adjustment |
|---|---|---|---|---|
| | *Dependent Variables* | | | |
| 1. State | −1.25** | .76 | -.86** | .13 |
| 2. Leader | −.26* | −.34 | .18 | .07 |
| 3. Laggard | −.42** | .22 | .25 | .11 |
| 4. Age | .00 | −.03 | .02 | .03** |
| 5. Sex | −.06 | 1.68** | .61** | -.31 |
| 6. Black | −.12 | 1.25 | -1.18* | -.21 |
| 7. Hispanic | −.47** | 2.77** | -.56 | -.38 |
| 8. White | .17* | .00 | -.31 | .18 |
| 9. Married | .08 | −.56 | .43 | 1.05** |
| 10. Children | .05 | .14 | .38 | .40 |
| 11. Education | .07 | .14 | .05 | .17 |
| 12. Income | .06 | .06 | .06 | .24* |
| 13. Home Ownership | .17 | −1.66** | .56 | .24 |
| 14. Community Tenure | .00 | .02 | -.01 | .00 |
| 15. Hazard Experience | | .94** | .23* | .64** |
| 16. Risk Perception | | | .13** | .00 |
| 17. Hazard Intrusiveness | | | | .38** |
| Adjusted $R^2$ = | .33 | .11 | .18 | .29 |
| $F$ | 19.89 | 5.48 | 8.60 | 14.28 |
| $df$ = | 14, 546 | 15, 545 | 16, 544 | 17, 543 |

$^*p < .05$; $^{**}p < .01$

by hazard intrusiveness, but it also was predicted by hazard experience and three demographic characteristics (age, marital status, and income). In summary, the results of these analyses partially support the causal chain proposed in $H_2$. Each of the predicted links in the chain was supported, but the regression analyses indicate that there are additional links as well. Thus, the hypothesized variables *partially*, rather than *completely*, mediate the links in the causal chain.

## Discussion

The results of this study support both of the hypotheses. With regard to $H_1$, residents of southern California had higher levels of hazard experience, risk perception, hazard intrusiveness, and hazard adjustment than residents of western Washington. Differences between states in hazard experience clearly reflect the occurrence of the 1994 Northridge earthquake and possibly the 1971 Sylmar earthquake as well. However, the differences between states in risk perception and hazard intrusiveness may be due to the risk communication efforts of local emergency managers as well as to personal hazard experience. No measures of exposure to seismic hazard communication messages were included in the questionnaire, so it is not possible to draw specific conclusions about the importance of this information source. It is possible that the weight that the state variable receives in predicting hazard intrusiveness might be a proxy for an effect of risk communication on hazard intrusiveness. Thus, the impact of risk communication may well be to keep hazard vulnerability on the community agenda (Birkland 1997; Prater and Lindell 2000) rather than to affect people's risk perceptions. Further research is needed to test this explanation.

There also was significant support for $H_2$, but the findings were more complex than for $H_1$ because of the presence of unpredicted correlates for the four dependent variables (hazard experience, risk perception, hazard intrusiveness, and hazard adjustment). As predicted, hazard experience was significantly predicted by residence in southern California. However, hazard experience was positively related to education and White ethnicity but negatively related to leader and laggard status and Hispanic ethnicity. These results reflect the social ecology of southern California; the political and demographic differences in hazard experience can be interpreted as spurious effects attributable to the impact of the Northridge earthquake on residents of Santa Clarita (who happen to be in the reference category on the leader and laggard variables as well as being highly educated and White).

Also consistent with $H_2$, risk perception was significantly predicted by hazard experience. However, sex and Hispanic ethnicity were positively related and home ownership was negatively related to risk perception. The finding that females and Hispanics perceive greater risks is consistent with the results of other studies of seismic hazard adjustment (see Lindell and Perry 2000). The greater risk perception among renters may reflect differences in the structural vulnerability of their homes (e.g., living in unreinforced masonry apartment buildings). This reasoning is supported by data from two questionnaire items in which respondents were asked to rate the relative vulnerability of the home and workplace in relation to the average structure. Renters rated both their home (M = 3.0) and workplace (M = 3.0) as average in vulnerability, but owners rated their homes (M = 2.6) as significantly less vulnerable than their workplaces (M = 2.8). The difference in the owners' ratings is significant ($t_{424} = -2.7, p < .01$). However, it is important to note that the equation predicting risk perception accounted for only a very small proportion of variance even though this variable had high reliability. Thus, additional factors must be identified that affect seismic risk perceptions.



Another prediction of $H_2$ confirmed by the data was the significant effect of risk perception on hazard intrusiveness. However, hazard experience also had a significant regression weight, suggesting that the former has an effect on hazard intrusiveness that is not mediated by risk perception. Moreover, residence in southern California also had a significant effect on hazard intrusiveness, which also is indicative of an unidentified mediating mechanism. This effect of location on hazard intrusiveness might be a proxy for locational differences in risk communication.

It also is noteworthy that Black ethnicity is negatively related to hazard intrusiveness, which may be due to lower levels of exposure to seismic hazard information in the mass media. Other studies indicate that Blacks may be less likely than Whites or Hispanics to use the mass media as sources of warning confirmation (Lindell and Perry 1992, Table 7.11) and routine environmental hazards information (Lindell and Perry 1992, Table 6.1). Further research is needed to determine if this is the mediating mechanism that accounts for the observed result.

Finally, hazard adjustment was, consistent with $H_2$, predicted by hazard intrusiveness. In addition, however, hazard experience, age, income, and marital status also had significant effects. The statistical significance of hazard intrusiveness confirms theoretical predictions that the frequency of thought, discussion, and information reception provides significant information about the chronic accessibility of the threat to risk area residents. This chronic accessibility appears to be important for pre-impact adjustments that, unlike warning response, do not have an imminent deadline for response. Chronic accessibility would be expected to overcome the tendency for the earthquake hazard to be "out of sight and out of mind" by providing frequent reminders that the threat must be addressed. The statistically significant effect of income is somewhat surprising because the hazard adjustments in Table 3 involve little or no cost. Nonetheless, the significant effect of income is consistent with theoretical predictions because money provides the resources to acquire any skilled labor, tools, and supplies that are needed to implement a hazard adjustment (Lindell and Perry 2000).

The statistical significance of hazard experience also is rather surprising because existing theory predicts that its effects on hazard adjustment would be completely mediated by risk perception and hazard intrusiveness. In fact, hazard experience has a higher average correlation with hazard adjustment ($\bar{r} = .24$) than with risk perception ($\bar{r} =.13$) or hazard intrusiveness ($\bar{r} = .17$), which would be expected to be its mediating mechanisms. This suggests that hazard experience affects hazard adjustment via additional mediating mechanisms that are unrelated to risk perception and hazard intrusiveness. Further research is needed to identify these mechanisms.

The effect of marital status also is rather difficult to explain. One possibility is that marriage is a proxy for additional vulnerability (via the significant correlations with children and homeownership) and additional resources to support the adoption of hazard adjustments (via the significant correlation with income). The hypothesized income effect would be especially powerful in dual income families. This explanation is intuitively appealing but requires confirmation with other data.

The source of the significant effect of age also is unclear. One might suppose that the observed effect arises from older residents being more likely to have experienced an earthquake, but this would produce a significant correlation of age with hazard experience—which was not found. Nor were there significant correlations of age with risk perception or hazard intrusiveness. One possible explanation for the observed effect is that increased age is a proxy for greater amounts of discretionary time and financial assets to allocate to hazard adjustment.

It is noteworthy that neither leader nor laggard status in jurisdictional seismic hazard mitigation (May and Birkland 1994) had a significant effect on household risk perception, hazard intrusiveness, or hazard adjustment. That is, governmental actions in one phase of emergency management (community-level land use and building construction regulations) did not generalize to other levels and phases of emergency management (household-level hazard adjustments). The absence of a pervasive effect throughout all four phases of seismic hazard management suggests that progress in seismic hazard reduction is issue-specific and requires favorable conditions (e.g., issue champions, clear policies, supportive bureaucracies, vocal constituencies—see Prater and Lindell 2000) for each phase.

Other noteworthy results involve the correlations of the risk perception variables with hazard adjustment. First, the judged likelihood of the event itself was just as highly correlated with hazard adjustment as were judgments of personal consequences of that event. This is contrary to the conclusions of some previous research that has contended that personalization is a crucial precondition for action (Turner et al. 1986). More significantly, the risk perception variables all had only marginally significant correlations (at best) with hazard adjustment. This result replicates the findings of Mileti and Darlington (1997) and Lindell and Whitney (2000) and suggests that judgments of the probability of personal consequences are peripheral to risk area residents' protection motivation. As noted above, hazard intrusiveness appears to be a more powerful psychological construct than risk perception in predicting hazard adjustment.



All studies have limitations, and this one is no exception. First, the response rate was low, and this raises questions about the generalizability of the results to those who did not respond. The respondents' demographic characteristics were compared to Census data for the study communities (U.S. Department of Commerce 1994). Although the respondents did not exactly mirror the population from which they were drawn, biases were found in only a few variables, and even those were not large. In any event, the biases tended to be similar in the two states, suggesting that there is no net effect on differences in means and proportions between states (i.e., the tests of $H_1$). Correlation and regression coefficients are similarly resistant to bias, suggesting that the tests of $H_2$ can be taken at face value.

Second, the cross-sectional nature of the study makes it difficult to make conclusive causal inferences because the temporal order of the variables cannot be determined unequivocally (James, Mulaik, and Brett 1982). Thus, future research should collect data at multiple points in time to assess the stability of self-reported hazard experience, risk perceptions, and hazard intrusiveness. In addition, this also would establish the temporal ordering of the variables needed to support greater confidence in causal inferences.

Notwithstanding these limitations, the study does have some significant implications for practitioners. First, these data emphasize the importance of frequent thought, discussion, and information receipt about seismic hazard. One way that emergency managers can increase hazard intrusiveness is by providing repeated messages about community hazard vulnerability and appropriate hazard adjustments. This suggestion is consistent with recommendations from studies of evacuation warnings, which have found that repetition is critically important for eliciting appropriate protective action (Fitzpatrick and Mileti 1991). Second, the significant correlation of income with hazard adjustment suggests that emergency managers should focus on the least expensive hazard adjustments and emphasize this low cost when speaking to members of their communities. Finally, the complex relationships among the demographic variables suggest that emergency managers get to know the residents of their communities to identify the ways in which potential implementation barriers affect different segments of the population. Frequent, personally delivered communications about inexpensive hazard adjustments that are targeted to specific segments of the risk area population may be the most effective means of reducing community vulnerability to earthquake hazard.

## References


Baker, Earl J. 1991. "Hurricane Evacuation Behavior." *International Journal of Mass Emergencies and Disaster* 9: 287–310.

Birkland, Thomas A. 1997. *After Disaster: Agenda Setting, Public Policy, and Focusing Events.* Washington, DC: Georgetown University Press.

Burton, Ian, Robert W. Kates, and Gilbert F. White. 1978. *The Environment as Hazard.* New York: Cambridge University Press.

Dooley, David, Ralph Catalano, Shiraz Mishra, and Seth Serxner. 1992. "Earthquake Preparedness: Predictors in a Community Survey." *Journal of Applied Social Psychology* 22: 451–470.

Edwards, Margie L. 1993. "Social Location and Self-protective Behavior: Implications for Earthquake Preparedness." *International Journal of Mass Emergencies and Disasters* 11: 293–304.

Endo, Russell and Joyce Neilsen. 1979. "Social Responses to Natural Hazard Predictions." *Western Sociological Review* 10: 59-69.

Farley, John E., Hugh D. Barlow, Marvin S. Finkelstein, and Larry Riley. 1993. "Earthquake Hysteria, Before and After: A Survey and Follow-up on Public Response to the Browning Forecast." *International Journal of Mass Emergencies and Disasters* 11: 305–322.

Fazio, Russell H. and Mark P. Zanna. 1981. "Direct Experience and Attitude-Behavior Consistency." Pp. 161–202 in *Advances in Experimental Social Psychology,* Volume 14, edited by Leonard Berkowitz. San Diego: Academic Press.

Fitzpatrick, Colleen and Dennis S. Mileti. 1991. "Motivating Public Evacuation." *International Journal of Mass Emergencies and Disasters* 9: 137–152.

Jackson, Edgar L. 1977. "Public Response to Earthquake Hazard." *California Geology* 30: 278-280.





———. 1981. "Response to Earthquake Hazard: The West Coast of North America." *Environment and Behavior* 13: 387–416.

Jackson, Edgar L. and Tapan Mukerjee. 1974. "Human Adjustment to the Earthquake Hazard of San Francisco, California." Pp. 160–166 in *Natural Hazards: Local, National and Global*, edited by Gilbert F. White. New York: Oxford University Press.

James, Lawrence R., Stanley A. Mulaik, and Jeanne M. Brett. 1982. *Causal Analysis: Assumptions, Models and Data.* Beverly Hills, CA: Sage.

Kunreuther, Howard, Ralph Ginsberg, Louis Miller, Philip Sagi, Paul Slovic, Bradley Borkan, and Norman Katz. 1978. *Disaster Insurance Protection: Public Policy Lessons.* New York: Wiley.

Lindell, Michael K. 1994. "Perceived Characteristics of Environmental Hazards." *International Journal of Mass Emergencies and Disasters* 12: 303-326.

Lindell, Michael K. and Perry, Ronald W. 1992. *Behavioral Foundations of Community Emergency Planning*. Washington, DC: Hemisphere Press.

———. 2000. "Household Adjustment to Earthquake Hazard: A Review of Research." *Environment and Behavior* 32: 590-630.

Lindell, Michael K. and David J. Whitney. 2000. "Correlates of Seismic Hazard Adjustment Adoption." *Risk Analysis* 20: 13-25.

May, Peter J. and Thomas A. Birkland. 1994. "Earthquake Risk Reduction: An Examination of Local Regulatory Efforts." *Environmental Management* 18: 923–937.

Mileti, Dennis S. and Joanne D. Darlington. 1995. "Societal Response to Revised Earthquake Probabilities in the San Francisco Bay Area." *International Journal of Mass Emergencies and Disasters* 11: 119–145.

———. 1997. "The Role of Searching in Shaping Reactions to Earthquake Risk Information." *Social Problems* 44: 89–103.

Mileti, Dennis S. and Colleen Fitzpatrick. 1992. "The Causal Sequence of Risk Communication in the Parkfield Earthquake Prediction Experiment." *Risk Analysis* 12: 393–400.

———. 1993. *The Great Earthquake Experiment: Risk Communication and Public Action.* Boulder CO: Westview Press.

Mulilis, John-Paul and T. Shelley Duval. 1995. "Negative Threat Appeals and Earthquake Preparedness: A Person-Relative-to-Event (PrE) Model of Coping with Threat." *Journal of Applied Social Psychology* 25: 1319–1339.

Mulilis, John-Paul, T. Shelley Duval, and Richard A. Lippa. 1990. "The

Effects of a Large Destructive Earthquake on Earthquake Preparedness as Assessed by an Earthquake Preparedness Scale." *Natural Hazards* 3: 357–371.

Mulilis, John-Paul and Richard A. Lippa. 1990. "Behavioral Change in Earthquake Preparedness Due to Negative Threat Appeals: A Test of Protection Motivation Theory." *Journal of Applied Social Psychology* 20: 619–638.

Palm, Risa. 1995. *Earthquake Insurance: A Longitudinal Study of California Homeowners*. Boulder, CO: Westview Press.

Palm, Risa., Michael Hodgson, R. Denise Blanchard, and Donald Lyons. 1990. *Earthquake Insurance in California*. Boulder, CO: Westview Press.

Pennebaker, James W. and Kent D. Harber. 1993. "A Social Stage Model of Collective Coping: The Loma Prieta Earthquake and the Persian Gulf War." *Journal of Social Issues* 49: 125–145.

Perry, Ronald W. and Michael K. Lindell. 1990. *Living with Mount St. Helens: Human Adjustment to Volcano Hazards*. Pullman, WA: Washington State University Press.

Prater, Carla S. and Michael K. Lindell. 2000. "The Politics of Hazard Mitigation." *Natural Hazards Review* 1: 73-82.

Russell, Lisa, James D. Goltz, and Linda B. Bourque. 1995. "Preparedness and Hazard Mitigation Actions Before and After Two Earthquakes." *Environment and Behavior* 27: 744–770.

Showalter, Pamela S. 1993. "Prognostication of Doom: An Earthquake Prediction's Effect on Four Small Communities." *International Journal of Mass Emergencies and Disasters* 11: 279–292.

Turner, Ralph H., Joanne M. Nigg, and Denise Heller Paz. 1986. *Waiting for Disaster: Earthquake Watch in California*. Berkeley, CA: University of California Press.

U.S. Department of Commerce. 1994. *County and City Data Book*. Washington, DC: U.S. Department of Commerce.