QUICK RESPONSE REPORT

Psychological and Biological Stress Pathways and the Role of Protective Factors in Individuals Evacuated during the 2007 San Diego Wildfires

Inka Weissbecker
Elizabeth Lush
Meagan Martin
Sandra Sephton

University of Louisville
Louisville, Kentucky

Background

It is projected that the incidence of disasters and adverse weather conditions will continue to increase worldwide. Disasters can set into motion a cascading series of stressors including evacuation, separation from loved ones, loss of income and property, disruption of routines, and possible displacement, relocation, and rebuilding (Porter & Haslam, 2005; Ringold, Burke, & Glass).

Exposure to disaster can cause both psychological distress, such as Post-Traumatic Stress Disorder (PTSD), and disruption of biological stress response mechanisms (Ursano, 1997). Immediately following a traumatic event, most people experience some post-traumatic symptoms that can manifest as Acute Stress Disorder (American Psychiatric Association, 1994). If clinically significant symptoms persist longer than one month, the diagnosis of PTSD can be made. PTSD is characterized by intrusive and distressing thoughts regarding the event, avoidance of reminders of the event, and increased arousal and hypervigilance (Koopman, Classen, Cardena, & Spiegel, 1995). Research suggests that about 30% of adults suffer from chronic PTSD following a disaster, defined as still experiencing symptoms after three months (Koopman et al., 1995). PTSD can be very debilitating, disrupt functioning, and affect families and communities for years to come. Furthermore, affected individuals can suffer from significant anxiety and depression after the event (Koopman et al., 1995).

Traumatic events such as disasters can also affect biological stress-response mechanisms. The hypothalamic-pituitary-adrenal (HPA) axis is one of the two major endocrine stress-response systems that orchestrates response and recovery of the body during stress. The end product of HPA activation is the adrenal steroid, cortisol, which modulates aspects of immune function, glucose production, fat metabolism, peripheral circadian rhythms, and central nervous system functioning. Cortisol has a well-documented circadian rhythm, initiated by hypothalamic brain nuclei (Posener, Schildkraut, Samson, & Schatzberg, 1996), and characterized by high morning and low evening levels (Posener et al., 1996; Stone et al., 2001). Changes in this rhythm can occur with psychological stress and have been related to increased risk for illness and disease (Rosmond, Dallman and Bjorntorp 1998).

Several studies have reported trauma and PTSD to be related to cortisol dysregulation, but the mechanisms of this relationship are still unclear. Research has shown conflicting results, some reporting increased and others describing decreased cortisol levels after a traumatic event (Friedman & McEwen, 2002). In addition, it is not known which comes first, PTSD or neurobiological abnormalities (McKeever & Huff, 2003). On one hand, research suggests that psychological symptoms may over time alter HPA-axis function and result in cortisol dysregulation through repeated activation of stress response systems, along with subsequent changes in synaptic architecture and neurotransmitter receptors (Chrousos & Gold, 1998; Goenjian et al., 1996). On the other hand, it has been pointed out that endocrine abnormalities could also result in the later development of PTSD symptoms. Indeed, it has been shown that initial cortisol levels predict later PTSD symptoms (Delahanty, Nugenta, Christopher, & Walsh, 2005). Furthermore, findings linking PTSD symptoms and cortisol dysregulation are equivocal (Caffo, Forresi, & Lievers, 2005; Shea, Walsh, Macmillan, & Steiner, 2005): some showing increased versus decreased cortisol levels (Friedman & McEwen, 2002; La Greca, Silverman, Vernberg, & Roberts, 2002), blunted awakening cortisol responses and hypocortisolism (Chrousos & Gold, 1998; Irwin, Daniels, Smith, Bloom, & Weiner, 1987; Wessa,

Rohleder, Kirschbaum, & Flor, 2006; Yehuda, Teicher, Trestman, Levengood, & Siever, 1996) or other aberrant response patterns (Yehuda, McFarlane, & Shalev, 1998). Furthermore, it is important to consider factors that may protect individuals from maladaptive stress responses after disaster. Various studies suggest that social support can buffer the effects of stress (Cohen & Willis, 1985) and may mitigate the impact of disaster on mental health (Kilic et al., 2006). In addition, the ways individuals cope with a perceived loss of control during a stressful event such as a disaster may impact both psychological and biological health (D. H. Shapiro, Jr. & Astin, 1998).

Research Question

The aim of this study was to shed light on psychological and biological stress responses and their sequence during and after disaster. Another aim was to elucidate the role of social support and coping as factors that may relate to less severe stress reactions. No previous studies have assessed both psychological and biological stress responses immediately after a disaster and no research has examined stress reactions longitudinally.

Assessments from adults evacuated to Qualcomm Stadium during the 2007 California wildfires were collected at baseline (during the evacuation) and at three months follow-up. Measures included psychological stress (symptoms of PTSD, anxiety, and depression), biological stress responses (4-day diurnal salivary cortisol profiles) and protective factors (social support, coping).

Figure 1 summarizes the aims and hypotheses of the proposed study:

1. Describe psychological and biological stress responses at baseline and three months. It was hypothesized that participants would show higher psychological and biological stress responses at baseline compared to follow-up.

2. Examine pathways between psychological and biological stress responses. It was hypothesized that participants experiencing greater psychological stress reactions would also display more biological dysregulation at both baseline and follow-up.

3. Evaluate the impact of protective factors on psychological and biological stress responses. It was hypothesized that higher scores on protective factors at baseline (social support and coping) would predict lower psychological and biological stress responses at both baseline and follow-up.

The San Diego Wildfires of 2007

The San Diego Wildfires of 2007 were the largest in San Diego county history, with 7 separate fires burning simultaneously at the height of the disaster. Due to an ongoing drought and the Santa Ana winds, the fires began at 9:23 (PST), October 21, 2007, with the Harris Fire near the US/Mexico border. Approximately 13% of the land in San Diego County (369,000 acres) was consumed in these fires over the following 19 days. Most wildfires were contained by October 27 and the last fire was contained on November 9, 2007. At least 1,600 homes were destroyed, and total costs due to the fires are expected to surpass $1.5 billion. The wildfires occurred throughout the San Diego area and prompted the largest fire evacuation in history of the United States, with approximately 515,000 voluntary or mandatory evacuation notices.

In most cases, evacuation notices were distributed through two automated mass notification telephone systems, Reverse 911 and AlertSanDiego, which had been purchased after the 2003 wildfires. A phone hotline, 211 San Diego, provided non-emergency information such as road closures and shelter locations. In some rural areas, officials gave evacuation notices by going door to door. These automated notification systems were also used before official evacuations were deemed necessary. If time allowed, a preliminary message that instructed residents to prepare for a possible evacuation was also sent. After repopulation, information about water safety was also sent through these systems.

Forty-five shelters were opened during the San Diego wildfires, including two mega-shelters (Qualcomm Stadium and Del Mar Fairgrounds). Those who evacuated to Qualcomm Stadium slept in tents provided by volunteer organizations or in open-air cots. Most evacuees drove to the shelter locations, causing severe traffic congestion at the time of evacuation. Special needs populations and the elderly were provided with transportation (MSNBC, 2007). Those who did not go to shelters stayed with friends and family or went to hotels, although area hotels reached maximum capacity quickly (MSNBC, 2007). At the height of the wildfires, 10,000 people sought refuge in the Qualcomm Stadium, which closed on October 26 (Brady, 2007).

Research Design and Methods

Participants

Our research team recruited 40 participants over the age of 18 who had evacuated to Qualcomm Stadium. We approached 117 individuals about the study (47 males and 70 females, 40% and 60%, respectively). Twenty-six (22%) of those approached were not eligible for participation. Reasons for ineligibility included not being an evacuee (14, 54%) (12 volunteers, 1 media member, and 1 staff), being under 18 years of age (4, 15%), severe emotional stress or severe mental illness (4, 15%), poor comprehension of the English language (3, 12%), and cognitive impairment (1, 4%). Three individuals were approached that had already been recruited by another team member.

Of those eligible (88 total), 39 (45%) refused participation in the study. Reasons given included not being interested (9, 22%), time constraints (15, 39%), and response burden (15, 39%). A total of 49 (55% of total eligible) participants were recruited for the study and signed informed consent documents.

We obtained baseline questionnaire packets from 40 participants (85% out of total recruited). Participants who did not return packets could not be located and did not contact us to return questionnaires. Nine participants (18.4%) did not return baseline questionnaire packets.

Regarding collection of baseline cortisol data, all 40 participants had provided valid phone numbers. Our research team was able to reach 22 participants and left messages with 18 participants to remind them of sending back the cortisol data. Of those reached, 11 indicated they were working on cortisol data collection but cortisol data were never received. Out of 40 participants who completed the baseline questionnaire, 17 (42.5%) returned completed cortisol collection kits at baseline.

Regarding follow-up data, two participants requested that the follow-up data materials not be sent, one was out of the country for the duration of the follow-up period, and six had been contacted and indicated they had not received materials although the mailing address had been verified. Our research team left 18 messages with participants and nine phone numbers (22%) were invalid or disconnected at follow-up. For these participants, alternate contacts were also not reached (e.g., phone number not valid or phone messages not returned). Nine participants (22.5%) returned completed questionnaire and cortisol data at 3-months follow-up.

Procedure

The PI (IW) and two graduate students (EL and MM) traveled to Qualcomm Stadium in San Diego and remained at the site from Tuesday, October 23, to Thursday, October 25, 2007. Upon arrival at the site, the PI made contact with security staff members at Qualcomm Stadium, provided staff with the Quick Response activation letter and received permission to conduct this study. The PI and both graduate students camped at the stadium and collected data throughout the day and late evening hours (9:00am until 11:00pm).

All participants were recruited from benches or camp sites inside the stadium. Stadium areas were divided among research group members to minimize duplicate attempts at recruiting participants. Furthermore, participants who appeared to be in severe emotional distress (e.g., crying) were not recruited by our research team. Potential participants were approached by a member of our research group, who would introduce themselves and ask whether they were interested in possible participation in our study. If individuals indicated interest, the research group member would explain the study, determine eligibility, answer questions, and obtain informed consent, approved by the University of Louisville Institutional Review Board. The research group member then performed interview portions of the assessment and provided questionnaires, kits for collection of salivary cortisol data, instructions, and a self-addressed stamped envelope for return of the cortisol data.

Every effort was made to collect questionnaire data within a few hours of initial recruitment or on the same day. Most participants filled out questionnaires at their campsites or while seated in the stadium, which provided live television broadcasts of the wildfires. Participants received $10 gift cards of their choice (Target, Wal-Mart, or Ralph's) as a compensation for their time and effort in completing the questionnaires. During the two weeks following the questionnaire assessment, participants received reminder phone calls to encourage the return of the cortisol data.

Three months after initial data collection, participants received a follow-up questionnaire, cortisol collection kits, and a self-addressed stamped envelope for return of the data in the mail. Participants were also contacted via phone to remind them of returning the data to us. Upon completion of questionnaire and cortisol data, participants were mailed another $10 gift card of their choice.

Measures

Demographics. Questionnaires included basic demographic information including gender, age, marital status, education, household income, as well as employment, religious affiliation, and current medications and medical conditions.

Severity of Disaster Exposure. The exposure-related subscale of the Centers for Disease Control (CDC) Mental Health Disaster Screening Instrument (interview format) was used to assess severity and nature of exposure to the disaster including proximity, risk, and loss.

Psychological Stress Responses. The PTSD Symptom Scale (PDS (Foa, Cashman, Jaycox, & Perry, 1997)), the Beck Anxiety Inventory (BAI (A. Beck, Epstein, Brown, & Steer, 1988)) and the Beck Depression Inventory (BDI (A. T. Beck, Steer, & Garbin, 1988)) were used to assess psychological stress at baseline and at three months.

Biological Stress Responses: Diurnal Salivary Cortisol. The use of diurnal salivary cortisol profiles as an indication of HPA regulation has increased in recent years (Kraemer et al., 2006; Stone et al., 2001). Salivary cortisol provides an accurate assessment that correlates with free cortisol levels in blood with minimal intrusion to the subject. Collections were requested at waking and bedtime over four days. Collection kits included 8 pre-labeled collection tubes, or "salivette" devices (Walter Sarstedt Inc., Newton, North Carolina), which consisted of a small plastic holder with a cotton collection swab. Returned samples were centri-

fuged, aliquoted, and stored in Dr. Sephton's laboratory at –80° C until assay. The saliva samples provided data for calculation of the mean awakening cortisol level, mean evening level, diurnal mean level, day-to-day variability and the diurnal cortisol slope, a measure of diurnal rhythm (Kraemer et al., 2006). The slope of diurnal change in cortisol level estimates how each participant fits the normal (i.e., descending) profile (Kraemer et al., 2006).

Protective Factors. The Interpersonal Support Evaluation List (ISEL) was employed to assess availability of social contacts and resources (Cohen, Mermelstein, Kamarck, & Hoberman, 1985) and the Shapiro Control Inventory (D. H. Shapiro, Jr. & Astin, 1998) assessed coping.

Results

Sample Demographics

The mean age of participants was 42 years (SD = 14.14). Demographic characteristics of the sample are presented in Table 1.

Data Preparation and Cleaning

All questionnaire data were checked for univariate normality and the presence of outliers or data entry errors. Variables were normally distributed. Salivary cortisol was assessed using EIA techniques. Assay sensitivity was 0.007 ug/dL. The inter-assay CVs for the low and high controls were 10% and 9.7%, respectively. No baseline cortisol data points fell outside the range of 4 standard deviations from the mean. Two follow-up cortisol data points were outside the range of the assay and were deleted. Four cortisol follow-up data points were outside four SDs from the mean, though no reason (e.g., medication, medical illness) was present to warrant deletion of these data points and they were kept. None of the participants reported taking corticosteroids at either baseline or follow-up.

Severity of Exposure

Regarding exposure to the disaster, 68% of participants had been around the fires and had seen them, 21% had been around the areas of the fires and 4% had not been close to the fires. In addition, 34% felt that they had been at risk of being injured or killed, and 47% had been worried about family members being injured, killed, or missing.

Differential Attrition

Demographic and event characteristics (age, gender, ethnicity, marital status, education, household income, exposure to disaster) of participants who provided cortisol data via mailings at baseline (n=17) were compared to participants who did not mail back their cortisol samples at baseline (n= 23) and to those who did not mail back their data at follow-up (n=31). Independent samples t-tests showed that participants who returned baseline cortisol measures were older on average (M=48.5 vs. M=36.5, $p<.01$), had completed a higher education (M=3.5 vs. M=2.6, $p<.01$), had higher incomes (M=3.6 vs. M=2.3, $p<.05$), and were more likely to report that a close friend or family member had been injured, killed, or missing during the disaster (M=2.1 vs. M=1.8, $p<.05$). The same results emerged comparing participants who provided three-month follow-up data versus those who did not, with the exception that disaster exposure did not differ between both groups.

Analyses of Main Aims and Hypotheses

Descriptive statistics were used to examine psychological and biological stress responses for aim 1. In addition, paired samples t-tests were employed to compare stress responses at baseline vs. follow-up. Pearson Product Moment Correlations were performed to examine relationships of interest for aims 2, 3, and 4. No control variables were used for analyses of salivary cortisol due to the small sample size.

1) Describe psychological and biological stress responses at baseline and three months. It was hypothesized that participants would show higher psychological and biological stress responses at baseline compared to three months follow-up.

Psychological Stress

PTSD. During the evacuation, the majority of participants only experienced mild PTSD symptoms (22, 55%), followed by moderate (12, 30%), moderate-severe (5, 12.5%), and severe (1, 2.5%) symptoms (Mean= 10.4, SD= 10.9). At follow-up, none of the participants experienced more than mild symptoms (n=9, M=2.1, SD=1.5). A paired t-test analysis of those who provided data at both time points showed that PTSD symptoms did not differ significantly between baseline and follow-up (M= 4.2 vs. M= 2.1, $p=.27$).

Anxiety. During the evacuation, 20 participants (50%) experienced minimal anxiety, followed by mild anxiety (10, 25%), moderate anxiety (4, 10%), and severe anxiety (6, 15%) (Mean=11.1, SD=11.7, mild range). Reported norms for the BAI in healthy controls have ranged from 4.08 (Hoyer et al., 2002) to 13.41 (Osman et al., 1997). At follow-up, one participant reported mild anxiety while the rest of the participants (n=8) experienced only minimal anxiety (M=2.7, SD=3.4). A paired t-test analysis of those who provided data at both time points showed that anxiety symptoms were higher at baseline (M=5.3) than at follow-up (M=2.7, $p<.05$).

Depression. The majority of participants were classified as not experiencing significant depressive symptoms at base-

line (24, 60%). Ten participants were reporting moderate to severe depression (25%), followed by mild to moderate (6, 15%) depression (Mean=10.3, SD=8.7). At follow-up, all but one participant were classified as not having significant depressive symptoms (n=8), while one person was experiencing mild (n=1) symptoms (Mean=3.2, SD=3.5). Among those who provided data at both time points, symptoms of depression did not differ significantly between baseline and follow-up (M= 4.2 vs. M= 3.2, p=.29).

Diurnal Salivary Cortisol

Mean salivary cortisol values for all cortisol values at baseline (n=17) and follow-up (n=9) are presented in Table 2 and Figure 2. Paired samples t-tests showed that cortisol values did not differ significantly between baseline and follow-up.

2) Examine pathways between psychological and biological stress responses. It was hypothesized that participants experiencing greater psychological stress reactions would also display more biological dysregulation at both baseline and follow-up.

Pearson Product Moment correlations revealed no associations between psychological and biological indictors of stress at baseline. At the time of follow-up, symptoms of anxiety were related to lower cortisol levels at waking and to higher cortisol slope scores, indicating more flat or dysregulated diurnal slopes (see Table 3).

3) Evaluate the impact of protective factors on psychological and biological stress responses. It was hypothesized that higher scores on protective factors at baseline (social support and coping) would predict lower psychological and biological stress responses at both baseline and follow-up.

Results showed that during the evacuation, higher PTSD symptoms were correlated with lower self-esteem support (favorable self-comparison to others), appraisal support (having someone to talk to about problems), and tangible support (availability of instrumental aid). Similarly, higher anxiety symptoms related to less appraisal support, and tangible support, while more depressive symptoms correlated with lower self-esteem support, belonging support and tangible support. Furthermore, higher day-to-day variability of cortisol rhythms was associated with lower belonging support. Regarding coping, higher cortisol slope values indicating flat or dysregulated diurnal rhythms were associated with lower positive assertive coping. At follow-up, participants who reported more depressive symptoms also showed higher positive assertive coping. In addition, higher day-to-day variability was associated with lower tangible support. No other relationships reached significance (see Table 4).

Theoretical and Applied Significance of Findings and Conclusions

This study investigated psychological and biological stress responses during the evacuation and at the three-month follow-up after the 2007 California wildfires. We also investigated the role of protective factors such as social support and coping.

1. Indicators of psychological and biological stress responses

Results showed that the majority of participants did not experience significant psychological distress at the time of the evacuation or at follow-up. This finding of lower anxiety at follow-up is consistent with research suggesting that the majority of individuals affected by disaster do not develop significant and enduring psychopathology (Koopman et al., 1995). We also found that baseline and follow-up assessments of psychological and biological stress responses did not differ significantly. The only exception was anxiety, which was lower at follow-up. Compared to other disasters during which individuals may lose loved ones and suffer injuries and major trauma, the San Diego wildfires may have caused comparatively less psychological distress during evacuation. Many individuals had been instructed to leave their homes and were able to do so with time to prepare and to contact significant others. In addition, the major infrastructure was still in place and individuals had access to shelter, food, water, clothing, toiletries, and other items. The most significant stressor may have been the participants' uncertainty about their places of residence, which may be reflected in the higher anxiety scores at baseline versus follow-up.

2. Relationships between psychological and biological stress responses

Results showed no associations between psychological and biological indicators of stress at baseline. However, at the follow-up, symptoms of anxiety were related to lower cortisol levels at waking and to higher cortisol slope scores, indicating more flat or dysregulated diurnal rhythms. Other studies of anxiety and cortisol have provided mixed results, some reporting no association between diurnal salivary cortisol and anxiety in healthy participants (Kurina, Schneider, & Linda, 2004), while others observed associations between trait anxiety and a higher awakening response (Greaves-Lord et al., 2007), as well as elevated cortisol levels (e.g., van Eck, Berkhof, Nicolson, & Sulon, 1996). In contrast to other studies, we did not detect relationships between cortisol variables and PTSD symptoms (Caffo et al., 2005; Chrousos & Gold, 1998; Shea et al., 2005; Wessa et al., 2006; Yehuda et al., 1998). The relatively low levels of psychological distress at baseline and follow-up and the small sample size may have made it difficult to detect relationships among stress variables. In addition,

our research team refrained from recruiting participants who were visibly suffering from acute distress. Further studies are needed to elucidate such relationships in larger samples.

3. The role of social support and coping as protective factors

Our study showed that participants who experienced more psychological distress (PTSD, depression, and anxiety symptoms) during the evacuation also reported lower levels of social support. The strongest effects at baseline were observed with tangible support, which refers to the availability of practical instrumental support from others. Fewer significant relationships among those variables were observed at follow-up, which may be partly due to the smaller sample size. It could also be the case that social support has a more significant impact during times of high stress (Cohen & Willis, 1985; Koopman, Hermanson, Diamond, Angell, & Spiegel, 1998).

Furthermore, higher day-to-day variability of cortisol rhythms was associated with lower belonging support at baseline and with lower tangible support at follow-up. Little research to date has examined day-to-day variability of cortisol (Smyth et al., 1997), which may be an indicator of fluctuations in daily stress or a sign of cortisol dysregulation. Other studies have reported relationships between lower cortisol concentrations and higher levels of social support (Turner-Cobb, Sephton, Koopman, Blake-Mortimer, & Spiegel, 2000). It has been shown that social support may actually decrease cortisol levels during stressful situations (Thorsteinsson, James, & Gregg, 1998), although this effect may be gender-specific (Kirschbaum, Klauer, Filipp, & Hellhammer, 1995). Our findings seem consistent with a possible relationship between better social support and healthier stress response system functioning.

In sum, our findings underscore the importance of social support during disaster, which may alleviate psychological distress and support healthy stress response functioning. Our results are also consistent with the conservation of social resources theory (e.g., Hobfoll, Freedy, Lane, & Geller, 1990), which argues for the significance of social and personal resources during stressful life events. Interventions for individuals during the acute phase of disaster could specifically target and strengthen the communities' natural social support networks.

We also observed relationships between stress and coping. Shapiro et al. (D. Shapiro, Jr. et al., 1993) have suggested that there are several ways in which individuals cope with a perceived loss of control, which is often experienced during disaster. Four distinct ways of coping can be distinguished, which fall into the following four quadrants: positive assertive (active instrumental control), positive yielding (acceptance), negative assertive (overcontrol), and negative yielding (passivity, hopelessness) (D. H. Shapiro, Jr. & Astin, 1998). We found that higher cortisol slope values indicating flat or dysregulated diurnal rhythms were associated with lower positive assertive coping during the evacuation. These findings are consistent with the notion that positive modes of coping are related to better psychological and physical health (Astin et al., 1999; D. H. Shapiro, Jr. & Astin, 1998). Contrary to our hypotheses, depressive symptoms were associated with more positive assertive coping. However, it should be noted that it is difficult to draw conclusions given the small sample size.

4. Methodological Considerations

This study used a multi-modal assessment approach, including both self-report and biological measures that were collected at both the time of the disaster and three months after the event. To our knowledge, this is the first study that has taken such an approach. We found that most participants responded positively to our invitation to participate in this study, and many of them expressed interest in our research and in the ways we measured stress. Regarding baseline data collection, we had a very high response rate (85% of returned questionnaires). We attribute this to being able to distribute and subsequently collect the questionnaires while in the field, often making rounds at the stadium and keeping track of recruited participants' locations. Obtaining the cortisol data, which were mailed back to us after four days (n=17) and after three months (n=9), was more challenging. Our analyses showed that participants who returned follow-up data were older on average, had completed a higher education, and had higher incomes. Our participants who were recruited at Qualcomm Stadium may have been more likely to be of lower social economic status and to have fewer options and less financial resources during the evacuation. The fact that so many phone numbers (22%) were disconnected or changed at the three month follow-up may also be an indicator of uncertainty and instability in this population. It may also be the case that some of our participants had lost their homes and had to relocate. Furthermore, the collection of saliva samples over four days may have added response burden, making it less likely for participants to complete data collection. Future studies may consider reducing the number of samples to be collected and obtaining biological data while still in the field. Our relatively low sample size and the number of statistical analyses may have led to low power and spurious associations (type I error). However, it is important to note that this was an exploratory study, that most findings occurred in the expected direction, and that this is the first study to collect such data. Our research team plans to document findings from this study for conferences and peer-reviewed journal articles and to use these pilot data to apply for funding from national and international agencies.

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Natural Hazards Center
Institute of Behavioral Science
University of Colorado at Boulder
482 UCB
Boulder, CO 80309-0482

phone 303.492.6818
fax 303.492.2151

www.colorado.edu/hazards/