CHRONIC HAZARD: WEIGHING RISK AGAINST THE EFFECTS OF EMERGENCY EVACUATION FROM POPOCATEPETL, MEXICO

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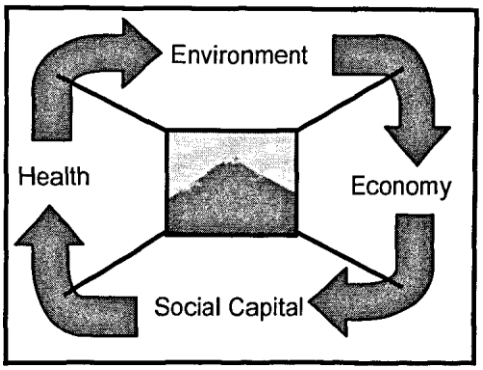
1. INTRODUCTION

The global disasters of recent years have drawn worldwide attention to the number of people living in high-risk hazard zones that expose them to landslides, floods, earthquakes, and volcanic eruptions. More than half the world's population, 3.4 billion people, live in disaster- prone areas (Dilley et al., 2005), and many reside in chronically hazardous conditions. These populations are a concern for planners, policy-makers and researchers who seek to understand why people continue to live in such areas, or why they will not move away when they know the risks. Explanations include: it is their home; their economic well-being is dependent on the place; their history and family are close by; or they cannot leave (Norris et al., 2005; Tobin and Whiteford, 2002; Whiteford and Tobin, 2004; Wisner et al., 2004). The question is not really why people continue to live in highly hazardous zones, but how they mitigate the dangers associated that situation, One response, of course, is evacuation during disasters, but this presents many challenges that are inextricably linked not only with the geophysical environment but also with socio-economic vulnerabilities and social support networks of the people concerned. This paper addresses just one component, evacuation activities of people living on the slopes of the active volcano Popocatépetl, Mexico, with a view to understanding the factors that impinge upon individuals' and families' evacuation responses in chronic hazard environments, particularly the extent to which younger and older people are dependent on others, and the extent to which older people may have developed a greater rootedness to the location and thus are less willingness to leave.

2. THEORETICAL FRAMEWORK

The long-term goal of this research is to explore how chronic exposure to hazards impacts the ability of people living in such communities to recover or maintain well-being. The Cascade of Impacts framework (Figure 1) identifies four sets of variables--environment, economics, health, and social capital/social networks--that have cumulative and cascading effects on peoples' ability to mitigate or effectively adapt to chronic disasters.

FIGURE 1
CASCADE OF IMPACTS



How these four parameters interact will determine the coping mechanism and ultimately survival of at-risk communities. For example, contrasting experiences regarding friends and family direct attention to the structure of social relations of eruption survivors within the larger society (Tobin et al., 2005) In Ecuador, people living on the slopes of an volcano expressed the hopelessness of their situation stating "Everyone is poor, we have nothing left, nothing to share," while others said, "This disaster has pulled us all together. We take care of each other." In other work in Mexico, we found that these sentiments were mirrored by disaster victims in Guadalajara (sewer explosion) and Acapulco (Hurricane Paulina).

3. LITERATURE REVIEW

3.1 EVACUATION CONCERNS

Evacuating at-risk populations from disasters is a common mitigation strategy, especially for volcanoes where loss of life and property are significantly reduced if action is timely. There appear to be four conditions that facilitate favorable responses of individuals to warnings: 1) recipients believe the warning message accurately describes a pending threat, 2) recipients believe that not taking action places them at high personal risk, 3) individuals believe in the effectiveness of the protective action and have a plan for implementing it, and 4) the household (family) must be assembled to evacuate as a unit or missing family members must be known to be out of danger (Lindell and Perry, 1992, 137).

Awareness, preparation and resources are of fundamental importance for success of evacuation. How these factors operate in practice is complex; the nuances of individual traits in association with local conditions influence behavioral responses. Response to any warning message is closely related to perception of risk (Tobin and Montz, 1997), although in the case of volcanoes this can be a multifaceted problem because of the many secondary effects of the hazard. While these events can be destructive, they also provide growing reminders of the volcano threat, and research has shown that visual evidence, like ash deposits and minor eruptions, can enhance hazard perception and elicit a better response to warnings (Lindell and Perry 1992). On the other hand, if a volcano has been dormant for some time, it may be difficult to initiate an effective evacuation when the threat of disaster is imminent. Mileti et al. (1991) in Colombia in 1985, and Newhall and Punongbayan (1996) in the Philippines, showed that limited local experience with volcanic hazards was associated with poor perception of the risk, which led to inappropriate responses.

Other factors also affected responses to warnings about lahars on Mt. Pinatubo volcano in the Philippines. In the balance between staying or leaving, the weight must fall more heavily on the fear of staying to counteract the fear of leaving. Reasons for staying are multiple and include the degree to which a family's source of livelihood was tied to its home and nearby farmland (economy), the perceived vulnerability to lahars (environment), the ease with which the family could move from the risk area includes social capital and health), and the comfort available in a prospective shelter (includes health) (Cola, 1996). It was also noted that the decision to respond to a warning was "swifter if the family was together (Cola, 1996: 147)." Janda (1996: 107) discussed response to lahar warnings for the area around Mt. Pinatubo volcano in the Philippines, and commented that the credibility of evacuation warning messages, prompted by Pinatubo's lahars, was diminished because of an excess of false alarms during the early stages of the hazard management process. In addition, decision-making can have political and electoral consequences for leaders as the social system changes.

The manner of evacuation creates problems, and policies that guide forced and/or voluntary evacuations have been identified as increasing vulnerability among already disenfranchised and poor populations. A culture of preparedness must be developed in which people actually plan for the eventuality of an evacuation and believe in the efficacy of that for protection. Whiteford and Tobin (2004) assert that forced evacuation is particularly detrimental for vulnerable populations because it divides communities, uses fear tactics to initiate the evacuation, and often unfairly targets the poor without means of securing homes and resources and whose families may be separated during the actual evacuation because of transportation limitations and job insecurity (Tobin and Whiteford, 2002; Whiteford et al., 2002; Whiteford and Tobin, 2004). The effectiveness of evacuation measures, therefore--as with all forecasting and warning decisions--depends upon a trade-off between reducing risk exposure through evacuation vs. the concomitant increase in social, economic, and political disruption. It is this area that needs to be addressed more fully by hazard researchers.

And, finally, other factors, such as cultural and religious beliefs (Blong, 1984), desire for the family to be together (Whiteford and Tobin, 2004) fear that property left behind will be stolen (Lindell and Perry, 1992), and close ties to family income sources (e.g., farmland and animals) in the home location (Cola, 1996) also contribute to a willingness or reluctance to evacuate. Indeed, a strong attachment to place is closely correlated with a reluctance to evacuate. According to Cola (1996: 148), "Those who evacuated longed for the community that had nurtured them and had provided them with a sense of security produced by generations of patterned interactions."

4. RESEARCH SITE

To examine risk perception and emergency response in a chronic hazard environment, research was undertaken in a small community directly affected by the active stratovolcano, Popocatépetl in Mexico (Figure 2). Popocatépetl, at 5,426 meters, is the second highest volcano in Mexico, and is located 70 kilometers southeast of downtown Mexico City and 45 kilometers southwest of the city of Puebla. The volcano is active although eruptions over the last few hundred years have been mild (Volcano World, 2005). In 1994, Popocatépetl entered a new active period, depositing ash over a wide area; nineteen villages (about 75,000 people) were evacuated at that time (NASA, 2005; Volcano World, 2005). The volcano continues to erupt with increasing frequency and there was another evacuation in December 2000. As of April 2007, the alert level around the

volcano is at yellow and access is restricted within a radius of 12 kilometers from the crater (CENAPRED, 2005). Lahars from snowmelt and ash falls remain serious threats. The research site is a town of roughly 4000 people in 800 households; it is located in the municipality of Atlixco, to the southeast of the volcano's crater. This town is one of the closer settlements to the cone and to its threat, because it lies in the area most likely to be hit by ash falls, lithic projectiles and pyroclastic flows.

FIGURE 1 IS OMITTED FROM THIS FORMATTED DOCUMENT

4. METHODS

A multiple methods approach was used to examine the response to chronic hazard conditions in the community. First, a series of focus groups was conducted to obtain in-depth information on risk perception and emergency response. A pilot study was initiated to guide subsequent questions then five other focus groups were formed with people selected randomly from those who receive welfare services through the local clinic, which is approximately 60 percent of the village. Groups were separated by sex with most comprised primarily of women and a later focus group, conducted with the town council, was comprised entirely of men. A total of 76 residents, 21 men and 55 women, participated. Second, a structured questionnaire survey was conducted of 146 households from November 2006 through April 2007. This entailed face-to- face interviews with questions focusing on household demographic characteristics, education levels, occupations, and their experiences with emergency evacuation procedures. The households were selected using a random sample to achieve a spatial distribution across the community. It should be noted that this is part of an ongoing project that examines the role of social networks in emergency responses and recovery.

5. RESULTS AND DISCUSSION

5.1 DEMOGRAPHIC CHARACTERISTICS

The demographic characteristics of households, broken down by age, are shown in Table I . In the random sample of 146 households, excluding people who were not currently living in the households, there were 685 people. Many respondents mentioned family members residing in the United States and a few elsewhere in Mexico. While representative data have not been collected on migration, it is likely that most households have someone living in the United States, or elsewhere in Mexico, primarily the former, a pattern seen in much of Mexico. In terms of the cascade of Impacts, such activity undoubtedly supports the community economically, but it suggests a high degree of social vulnerability during times of crisis. Most of the population had been born in the town and worked as farmers/peasants around the area, although 25 percent had worked at some time outside the community, many in the United States.

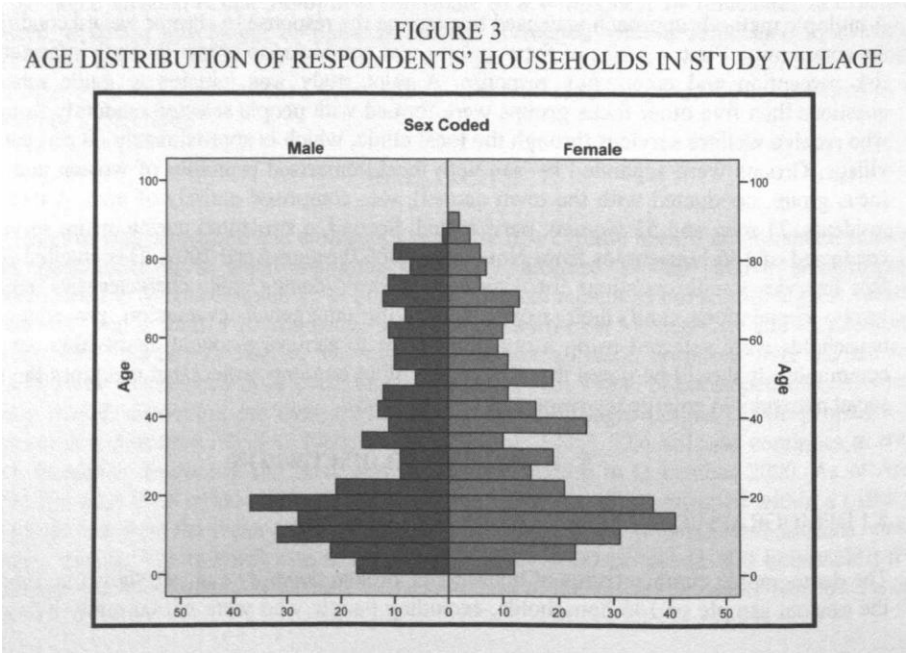
TABLE 1
SUMMARY DEMOGRAPHIC STATISTICS BY AGE (% by age category)*

Age Years	Male	Born in village	Married /Union	Education <5 years	Peasant worker	Worked outside village	Speaks Nahuatl
0-9	51	98	-	98	-	-	1
10-19	25	92	1	12	20	7	9
20-29	40	99	39	8	68	53	10
30-39	47	99	73	8	78	56	27
40-49	35	98	90	14	88	48	67
50-59	41	100	86	49	98	31	98
60-69	49	98	78	88	92	16	96
70-99	51	100	75	96	93	28	100
Total	39	97	42	39	55	25	39

* N varies between 605 and 622 depending on missing data

When all the data for particular variables are considered, then education, working outside, and speaking Nahuatl are all significantly different by age (at the 99 percent confidence level) using a Chi-Square test. The elderly generally have less formal education while the younger are less likely to speak the traditional language. Furthermore, the demographic structure of the community, with many working-age males missing, may create problems later, since they will not be available to aid during times of crisis (Figure 3).

FIGURE 3
AGE DISTRIBUTION OF RESPONDENTS' HOUSEHOLDS IN STUDY VILLAGE



Overwhelmingly, respondents stressed that the volcano does not impact them negatively but more often expressed that it is a part of them and they are accustomed to it. One respondent indicated the volcano is alive, "It has the right to smoke," while another stated that "It gives us life and we give it life." The volcano is seen as part of community life and the overall perceived risk is generally minimized. Many villagers, for example, reported hearing eruptions and falling rocks and others reported seeing the volcano "throw ash," "launch columns of smoke" and

"shake the earth" but that nothing bad had come to pass from this. Some went so far as to suggest that rather than a risk, the volcano "defends" them from storms and rains by blocking the rains, keeping the collected precipitation in gullies and not in settled areas, and sending the storms elsewhere. The common term used in this regard was that when storm clouds gather the volcano "sneezes and the clouds disappear." Some indicated the ash was not a problem because it fell far from their community. It should be noted that this is true some of the time when winds are blowing from a southerly or southeasterly direction, but on many occasions ash has fallen in the town. Few expressed explicit concern that predictions of future eruptions were accurate.

These environmental cues may also have other influences on perception. For instance, some respondents reported that harvests had declined especially in the hills and that fertilizer was now needed to increase crop yields particularly for fruit trees such as avocadoes. Others stated that water and food (left out for animals) is sometimes contaminated with ash, although the animals are fine and no one has become ill from it. This contrasts somewhat with comments from the community mayor who stated that many people became sick with stomach problems after the 1994 eruption because of the ash fall. Others reported losing stock animals and pets due to not being able to feed their animals after being evacuated. Another woman reported that "We breathe the ash." These different perceptions of the experiences exemplify various levels of tolerance.

In hazard terms, this denial of risk equates with classic cognitive dissonance models common in hazard zones throughout the world. In reality, residents are aware of the volcano and its activities, but dealing with the vicissitudes of daily life must take precedence over the unknown schedule of the volcano. A way to cope with the threat, is to minimize its existence. Another typical coping mechanism is to prescribe regular patterns to environmental hazards, like eruptions, to make the risk knowable. Popocatépetl is thusly described as becoming dangerous "every hundred years" or as active only in December or at night. Inevitably, many also place their faith in a perceived higher power; many respondents reported that Don Gregorio Popocatépetl, the "old man who lives on the volcano," looks after them, while others stated that God protects them, "God does not want to lose the town." The failure to believe they are at great risk if they stay, counteracts the authorities' belief that evacuation may be necessary sometime.

5.3 EVACUATIONS

There have been two official evacuations of the village since the volcano became active again, one in December 2000 and another in 1994. When just pre-2001 population statistics are considered (N = 622), that is those born prior to the second or most recent evacuation, an examination of the data shows that 35 percent of the population has never evacuated the town during an emergency (Table 2). Altogether, 211 people evacuated the community once and 164 both times. In 1994, the prime relocation site was Puebla (two hours northeast), with 43 percent of evacuees moving there, while in 2000, 61 percent went to Matamoros (two hours south), also In the state of Puebla. Most residents moved to official evacuation shelters set up by the government while others went to family and friends. It should be recognized, however, that these data do not include evacuations by people who have died since 1994, hence the corrected percentages might vary from those reported here.

TABLE 2
TIMES EVACUATED (%) (N=605)

Age in Years	Never Evacuated	Evacuated Once	Evacuated Twice
0-9	50	38	13
10-19	25	49	26
20-29	40	29	31
30-39	47	30	23
40-49	35	26	46
50-59	41	34	25
60-69	49	26	26
70-99	51	25	25
Total	38	35	26

There is a significant difference in evacuation responses based on age ($p = 0.001$ Chi-Square = 25.72). Again using pre 2001 birth data, it is the younger groups, with the exception of the children and the very old, those over 80 years of age, who are most likely to evacuate (Table 3). The elderly were particularly critical of evacuation strategies; one respondent stating "I was born here, I'll die here," others cited the need to care for their animals--a major form of economic savings--as a reason for not leaving. For this group, their ongoing experience of the volcano had a negative effect on emergency response; the elderly had seen the volcano active before, but because nothing had happened they were most reluctant to evacuate. Several women reported that, while no one had died because of the volcano, "You can wind up dead in any place and it is better if it is on your own land, in your town or with your family," and "There is danger everywhere" as reasons for not leaving. Others were fearful of looting and of people taking their land.

TABLE 3
EVACUATION BY AGE (N)

Age in Years	Never Evacuated	Evacuated at Least Once
0-9	20	20
10-19	43	131
20-29	31	46
30-39	36	41
40-49	20	38
50-59	24	35
60-69	25	26
70-99	35	34
Total	234	371

Focus groups revealed that, according to parents, many small children were terrified of the eruptions and experienced nightmares. Indeed, most women in the focus groups said they only evacuated for the sake of their children. Those individuals in the 10 to 19 year age group would have been between 3 and 12 years old in 2000, old enough to be frightened but not old enough to understand relative risks or measured ways to deal with the problems.

Overall, the evacuation was regarded as successful by those who left. The army had supplied buses and cars and the government provided shelters in safe communities such as Puebla and Matamoros. Several individuals complained about the food in the shelters, but generally

residents were favorable towards the evacuation strategy. The army also remained behind in the community to further monitor the village and also to attempt to feed animals. In fact, there seems to be a positive perception of the army by the towns' folk, something also observed by the authors in the Guadalajara sewer explosion. Organization and emergency preparation has also continued with the setting up of a Civil Protection Group, seven people chosen by the town, to aid in rapid evacuation and to remind people to not climb the volcano when the level of volcanic activity is high. In addition, children are educated in school about the volcano and school brigades have been formed to help. A culture of preparedness is clearly an objective of the authorities.

There was no significant difference in evacuation based on sex of respondent, although slightly more females than males evacuated at least once (64 percent of females compared to 58 percent of males). At times, the women evacuated only for the sake of their children while men continued to work in the fields and tend to the animals. There was a significant difference in evacuation based on occupation; students were far more likely to evacuate than others ($p = 0.001$, Chi-Square = 16.14) (Table 4). This is supported by the focus group data. Those working in the fields stated a need to tend the land and feed the animals. In fact, many men, even when evacuated, returned frequently to deal with these tasks. Significantly different evacuation rates were also based on education, with higher levels of education corresponding to a greater likelihood of evacuation ($p = 0.008$, Chi-Square 11.8) (Table 5). Education levels also correspond to age, younger people were much more likely to have a formal education than older people. However, the age/school-based difference does suggest that education helps encourage favorable responses to evacuation in Mexico, where obedience is emphasized in schools and home.

TABLE 4
EVACUATION AND OCCUPATION
(%) (N=610)

Primary Occupation	Never Evacuated	Evacuated at least Once
Peasant	44	56
Student	26	74
Laborer	40	60
Other	39	61
Total	38	62

TABLE 5
EVACUATION AND EDUCATION
(%) (N=616)

Education Years	Never Evacuated	Evacuated at least Once
0-1	42	58
2-4	51	49
5-8	34	66
9 or more	33	67
Total	38	62

There was a significant difference in the spatial pattern of evacuation (Table 6). Those families in the southeast of the town were much more likely to evacuate than families from other areas, while those villagers living in the southwest were most likely to stay ($p = 0.002$, Chi-Square = 14.37). The southwest section has the highest average age which suggests that there are fewer young children and more old people there; these people may not be as dependent on others for evacuation decisions and may be more economically dependent on life in the community. It is also possible that they have lived through many years of eruptions and worry less — further research is necessary to explore these findings.

TABLE 6
EVACUATION BY VILLAGE AREA

Village Section	Never Evacuated	Evacuated at least Once
Southeast	46	118
Southwest	61	63
Northwest	68	95
Northeast	62	104
Total	237	380

Possibly influencing risk perception is another environmental feature, the deep barranca (ravine) that dissects the community. Many residents believe this feature protects the town during emergencies funneling lava down the ravine and not through the village. This is not necessarily true and it certainly does little to protect against pyroclastic flows or heavy ash falls. It could be argued that the barranca is creating a false sense of security akin somewhat to that found with many human-made mitigation measures.

6. CONCLUSIONS AND APPLICATIONS

The Mexican Government has a long history of intervention and aid to disaster victims. The populace has come to expect aid and when aid does not materialize, it becomes a national and local political issue. Mexico's one-party rule ended in 2000, but some say the serious opposition began with the 1985 earthquake in Mexico City where the Institutional Revolutionary Party was criticized for not helping and, thus, lost prestige. At that time, the Mexican government got serious about disaster mitigation and the army got more involved.

In the case of Popocatépetl, the government's "Por Si Acaso" (Just in Case) program is an effort to prepare the area for evacuation and recovery if the volcano's activities should require it. Continual exposure to chronic disasters, however, changes behavior; some people leave the area, others are forced by family or economics to stay, while others choose to remain in the area to be close to their land, animals or home.

The chronic hazardous conditions around Popocatépetl threaten the long-term well-being of residents and overall community sustainability. These traits are not unique, but reflect classic patterns of risk perception and evacuation that have been identified elsewhere, including in other parts of Mexico. Unfortunately, there is no simple solution; disasters after all result from the complex interplay of geophysical processes and the web of social, economic and political forces. The system itself is dynamic varying not only spatially but also temporally to further challenge mitigation policies. Thus, it is argued that all components of the Cascade of Impacts model must be addressed, if emergency managers are to implement successful evacuation strategies. Such mitigation strategies should be planned locally, promote a clear understanding of the reality and specific nature of the risk, ensure that families are brought together and evacuated as a unit, and provide for animals left behind. In this way, those living in chronically hazardous environments may be protected from the vagaries of the volcano while maintaining community sustainability.

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