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Households' immediate Responses to the 2009 American Samoa Earthquake and Tsunami

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ABSTRACT

This study used variables from the *Protective Action Decision Model* to guide data collection about 262 residents' responses to the 2009 Samoa M8.1 earthquake and tsunami. The results show that earthquake shaking, combined with knowledge that this can cause a tsunami, was the most common source of first awareness about a possible tsunami and that broadcast media were the most common first social sources of warnings. Radio was an important source of additional information, as were face-to-face contacts and phone calls. Contrary to previous research, few of the recommended elements of a warning message were communicated to those at risk and none of these message elements was significantly correlated with evacuation. Nonetheless, two thirds of coastal residents and half of inland residents began evacuations within 15 min after the earthquake. Those who had participated in earthquake hazard awareness meetings had higher risk perceptions but were no more likely to evacuate to higher ground or evacuate promptly. This study's results are broadly consistent with previous findings on disaster response but raise a number of unresolved questions about behavioral response to rapid onset disasters.

1. Introduction

The catastrophic impact of the 2004 Indian Ocean tsunami drew attention to the need for more effective preparedness and response to tsunami threat. A subsequent National Research Council assessment of the US National Tsunami Hazard Mitigation Program recommended that communities vulnerable to near-source tsunamis should conduct preparedness studies to determine if their risk area populations are able to recognize environmental cues of tsunami onset and should conduct modeling studies to determine if their risk area populations will be able to evacuate successfully before inundation [45]. Moreover, [29], p. 78) recommended that post-impact surveys be conducted to overcome the limitations of "past studies of tsunami warnings [that] have collected data from state and local emergency managers who reported on the aggregate behavior of the population at risk." They recommended that such surveys collect data from risk area residents on the information sources available to them; influences on evacuation behavior such as decision making, timing, and logistics; and household demographic information.

An earthquake and tsunami that struck American Samoa in 2009 provides an excellent opportunity to address these issues because it was the first near-source tsunami to affect US soil since a 1975 earthquake and tsunami in Hawaii. Although one would expect many findings from existing research on disaster response —especially the extensive research on hurricane evacuation—to apply to the Samoan tsunami, there are some reasons why there might be differences. First, the seconds or minutes of forewarning for a near-source tsunami is much less than the days of forewarning for the hurricanes that have been the foundation of most recent reviews of disaster response research [44]. Second, a pedestrian evacuation is feasible for a tsunami striking a mountainous island whereas only a vehicular evacuation is feasible for a hurricane striking the US coastal plain. Third, American Samoa is 92% Pacific Islander—a demographic group that does not appear to have been studied in any research addressed in recent reviews on evacuation [21,51,53,6]. Indeed, as will be described later, the Samoan population differs significantly from the mainland population in terms of many demographic characteristics that might affect warning dissemination and evacuation. Thus, the response to the 2009 American Samoa earthquake and tsunami has the potential to significantly expand scientific knowledge of disaster response.

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1.1. Theoretical foundation

Past research on household response to disasters has identified many activities in which people engage when they respond to imminent threats from earthquakes, floods, hurricanes, tornadoes, and volcanic eruptions [21,51]. One model, the *Protective Action Decision Model* (PADM) emphasizes the need for researchers to collect data about information sources; information channel access and preference; warning message content; perceptions of the threat, protective actions, and stakeholders; facilitating and inhibiting conditions; and behavioral responses such as information seeking, protective action, and emotion-focused coping [28]. The research on which the PADM is based has identified people's major information sources as environmental cues (sights, sounds, or smells that indicate disaster onset), social cues (observations of businesses closing and people evacuating) and social warnings from authorities, news media, and peers [7]. These social sources are differentiated in terms of their expertise, trustworthiness, and responsibility for providing protection [1]. Broadcast media (radio and TV) are extremely common warning sources in slow onset disasters such as hurricanes but peers are common first sources in very rapid onset hazards such as flash floods [48,49].

Warning messages are most likely to produce appropriate protective actions if they describe the threat, affected (and safe) areas, protective action recommendations, and sources to contact for additional information and assistance ([27], chapter 5). Such information produces situational risk perceptions that can be characterized in term of expectations about casualties, damage, and disruption to the community in general and to one's family in particular [16]. Depending on their perceptions of the information sources, the hazard, and alternative actions, people either continue normal activities, actively seek (or passively await) additional information, or prepare for and take protective action. However, people's search for additional information, attempts at family unification, and preparation for evacuation usually delay the initiation of protective actions such as evacuation. People's choices of response actions can be frustrated by situational inhibitors (e.g., the lack of a reliable vehicle in which to evacuate) or enhanced by situational facilitators (e.g., the availability of neighbors who have room in their cars) that arise from their physical, social, and household contexts. People who evacuate are most likely to spend their time away from home with peers, somewhat less likely to stay in hotels or motels, and least likely to stay in public shelters [40,56].

Although there is substantial support for this model, its generalizability to other cultures might be limited by the fact that so many of the supporting studies have been conducted in the United States. Accordingly, this model should be considered a tentative framework for examining household responses to tsunamis in American Samoa.

1.2. Research on household response to Tsunamis

There are relatively few studies of household response to tsunamis and most of them have focused on the receipt of information about tsunami onset—especially the interpretation of, and response to, environmental cues—as well as the receipt of warnings from social sources.

1.2.1. Environmental cues

There are many anecdotal accounts of individuals who correctly interpreted shoreline recession as evidence of a tsunami, took appropriate protective actions, and warned others to do so also [18,32,34]. The Iemura et al. [17] qualitative study of Indonesian respondents reported that most of them experienced strong or very strong earthquake shaking, which led 43% of them to run inland before a tsunami arrived and the remainder to evacuate after seeing a tsunami wave. Another qualitative study by Bird, Chagué-Goff and Gero [4] reported that some tsunami victims in Thailand, India, Sri Lanka, Indonesia and the Maldives were aware of the hazard and ran to high ground when the shoreline receded, whereas others climbed trees or evacuated to sturdy buildings. However, this study also found that other victims did not know how to respond because they were completely unaware of tsunami hazard. Informants reported that some of their peers did not believe warnings they received from others and that some people went to the shore to verify the warnings. A quantitative survey by Gregg et al. [13] found that 24% of their sample of tsunami victims in Thailand felt ground shaking but few attributed the shaking to an earthquake and none expected a tsunami.

More recent studies have reported similar results. [58] found that 23% of their 2011 Japanese tsunami interviewees correctly interpreted the implication of severe earthquake shaking and 17% observed a tsunami wave. Esteban et al. [9] found that many coastal residents they interviewed after the 2010 Chilean and Indonesian tsunamis also evacuated on the basis of earthquake shaking. Other studies have reported that mild ground shaking can be an ambiguous cue. For example, Mori et al. [41] reported that their Javanese respondents felt an earthquake but the intensity of the shaking was so low that they felt little need to evacuate. Later shoreline recession that exposed 5–10 m of beach appeared to have a greater effect on decisions to evacuate.

One way to learn the correct interpretation of environmental cues is a formal training program about earthquakes and tsunamis. A small sample of qualitative interviews conducted after the 2009 Samoa tsunami concluded that many people who lacked training did not know an earthquake could cause a tsunami so they failed to respond appropriately to ground shaking [8]. Another way to learn the correct interpretation of environmental cues is transmission of indigenous knowledge based upon a community's past experience. Gaillard et al. [12] studied Indonesian residents' responses to the 2004 Indian Ocean tsunami. The authors concluded that one community's oral history of their ancestors' failure to evacuate from an earlier tsunami that killed 400–1800 residents, coupled with a continuous residence in the area over the years, produced a high level of adaptive response. Two other communities, both of which had many recent immigrants, lacked a tradition of tsunami awareness and had lower levels of adaptive responses. Fritz and Kalligeris [11] reported similar findings regarding oral transmission of knowledge about tsunami hazard in the Solomon Islands.

1.2.2. Social warnings

One way to disseminate warnings of a near-source tsunami is to sound sirens, but these can fail to perform adequately when needed [29]. Moreover, some studies indicate that few people can interpret these alerts correctly even when they do hear them. For example, 95% of respondents reported hearing sirens that were activated before wave arrival of the 1960 Hilo tsunami [19]. However, 10% interpreted the siren only as an “alert” or “warning” that had no specific behavioral implications. Another 24% interpreted it as a preliminary signal to prepare for an evacuation, 29% interpreted it as an evacuation signal, 15% interpreted it as a signal to await further information or make preparations, and 22% ascribed meanings that the researchers were unable to interpret. Consequently, 15% continued normal routines, 45% waited for further information, and only 32% evacuated. Confusion about how people should respond to sirens has continued to the present. The Gregg et al. [14] study of coastal residents on the islands of Hawai'i, Maui, O'ahu and Kaua'i reported that 77% of Hawaiian residents knew how frequently sirens were tested (monthly) but only 7% of them could correctly state what to do when they heard