

Managing tsunami risk in coastal communities: Identifying predictors of preparedness

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Abstract

This paper discusses the testing of a model predicting tsunami preparedness. Using data collected from a community identified as facing a high risk from locally-generated tsunami, the model illustrates how people's beliefs about the efficacy of mitigation interact with social context factors (community participation, collective efficacy, empowerment, trust) to influence levels of tsunami preparedness. The implications of the findings for tsunami hazard education programs are discussed.

Introduction

On Sunday 30th September, 2007 at 15.49 (AEST), the Joint Australian Tsunami Warning Centre detected a large undersea earthquake south of New Zealand and identified a potential tsunami threat to the South East mainland coast of Australia and to Tasmania. If a tsunami had been generated, it could have affected places such as St Helens (Tasmania) from 17.30, Hobart from about 18.15, and Sydney from 18.15. It would, consequently, have provided members of these communities with warning periods of some 90 minutes (St. Helens) to three hours (Hobart and Sydney). Whilst, in this case, the tsunami only reached a height of some 30cm (at St. Helens, Tasmania), this event has highlighted the susceptibility of coastal communities on Australia's Eastern seaboard to tsunami hazards and underlines the value of current work being undertaken to manage tsunami risk.

A key objective in this context is encouraging people to prepare (e.g., organizing an emergency kit containing food, water and essential medicines, developing and practising family response and evacuation plans) in ways that enhance their ability to respond should a tsunami occur (Horikawa & Shuto, 1983; Weigel, 2006). Using the September 30th event as an example, warning times of 90 to 180 minutes would have been too short for the members of the communities identified above to

have, for example, accepted that they faced a threat, developed evacuation plans and practised evacuation routes. Consequently, risk management must focus on developing people's capability to respond promptly and appropriately in advance of hazard activity occurring. Achieving this objective is a task that faces several significant hurdles.

Firstly, even when the hazard (e.g., bushfires in Australia, earthquakes in New Zealand) occurs relatively frequently, levels of preparedness are generally low (Paton, Smith & Johnston, 2005; Paton, Kelly, Bürgelt & Doherty, 2006). Consequently, attempting to encourage preparedness for a hazard that is effectively (from a community perspective) unknown in Australia will be difficult. A second challenge concerns the design of the public education component of a risk management strategy.

Growing recognition that public education programs based on the dissemination (e.g., using mass media, pamphlets etc) of general information (Lindell & Whitney, 2000; Duval & Mulilis, 1999; Paton, McClure & Bürgelt, 2006; Smith, 1993) are ineffective has called attention to a need for alternative approaches to hazard education. Researching the issues that hazard education should address requires sufficient variance in levels of people's preparedness to allow systematic analysis of predictor variables (that are then used to inform the development of hazard education content). However, the low levels of variance in tsunami preparedness (which reflects the fact that the majority of people in at



Coogee Beach, Sydney. Tsunami warning.

risk communities in Australia will not have undertaken any tsunami preparedness) likely to occur in Australian communities characterised by low tsunami risk awareness makes it difficult to test models directly on Australian populations at this stage.

One way of responding to this challenge is to conduct research in communities in which a risk has been recognised, and use these data to inform the development of preparedness strategies in Australia. This approach is adopted here to describe an evidence-based approach to facilitating tsunami preparedness using a model developed from research into how people interpret information about infrequent, complex and threatening hazards, their consequences and the actions proposed to mitigate their risk. This work identified a need to accommodate two processes.

The first involves a need for any model to be able to differentiate between people who decide to prepare from those that decide not to prepare (Paton, Smith & Johnston, 2005). The second entails accommodating how people's social context influences how they construe risk and decide what to do about it (Paton et al., 2006). By integrating these perspectives, Paton (in press) developed a model that describes how these interpretive processes interact to predict levels of hazard preparedness. Full details of the rationale for the model can be found in Paton (in press). Examining tsunami preparedness provided an opportunity to test the model.

Modelling tsunami preparedness

The model first examines people's beliefs about the efficacy of protective actions. This was assessed using the construct of outcome expectancy (Paton, in press). Negative outcome expectancy reflects beliefs that

tsunami consequences are too catastrophic for personal action to make any difference to people's safety. If people hold this belief, no further action is likely. In contrast, positive outcome expectancy (the belief that preparation can increase personal safety) can motivate people to prepare. However, a distinction can be drawn between the belief that preparing can be effective and knowing how to prepare. Consequently, it can be hypothesised that if people hold positive outcome beliefs and possess the necessary knowledge and resources to prepare, they will act. If however, they need guidance to understand their circumstances and what they should do, people look first to other community members and subsequently to emergency management agencies.

Faced with complex and uncertain events, when they do not possess all the information they need themselves, people's perception of risk and how they might mitigate it, is influenced by information from others who share their interests and values (Earle, 2004; Lion et al., 2002; Paton et al., 2006; Paton & Bishop, 1996; Poortinga & Pidgeon, 2004). Because participating in community activities provides access to information from people that share one's interests, values and expectations, information from this source can assist understanding one's circumstances and deciding what to do. Consequently, a measure of 'community participation' (Eng & Parker, 1994) was included in the model. However, the infrequent nature of tsunami means that people may first have to determine what consequences they could face in order to identify the information they need to further their preparedness planning. Because it provides a means of assessing community members' ability to identify the information, resource and planning needs required to advance their tsunami preparedness, a measure of 'collective efficacy' (Zaccaro, Blair, Peterson & Zazanis, 1995) was incorporated in the model.



Unloading food aid at Gizo, Solomon Islands.

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Given that this process may identify new information and resource needs that cannot be met within existing community contexts, the degree to which these needs are met by expert sources has a salient role in the model.

It is the consistency between people's estimation of their needs and the resources provided by expert sources that helps people construct more accurate estimates of risk, reduces their uncertainty, and influences their trust in a source (Earle, 2004; Eng & Parker, 1994; Paton et al., 2006). People's willingness to take responsibility for their own safety is increased, and decisions to prepare more likely, if they believe that their relationship with formal agencies is fair and empowering (e.g., agencies are perceived as trustworthy, as acting in the interest of community members) (Lion et al., 2002; Paton & Bishop, 1996; Poortinga & Pidgeon, 2004). If this relationship is not perceived as fair, the consequence is a loss of trust in the agency (i.e., the source of information), reducing the likelihood that people will act on the information and prepare.

The significance of this community-agency relationship derives from the important role that trust plays when people must make decisions under conditions of uncertainty (Earle & Cvetkovich, 1995; Siegrist & Cvetkovich, 2000). The infrequent and complex nature of tsunamis means that community members have to deal with considerable uncertainty. As uncertainty increases, so does the importance people attribute to their general trust beliefs about, and their past experiences with, the sources of information they turn to or have to rely on (Siegrist & Cvetkovich, 2000; Sjöberg, 1999). The degree to which agencies empower community members will influence trust and thus the likelihood that people will act on information. Empowerment was assessed using a measure developed by Speer and Peterson (2000) and trust with a measure used in an earlier study of hazard preparedness (Paton et al., 2005).

Finally, the model argues that the relationship between trust and preparing is mediated by behavioural intentions. The intention measure assessed people's intention to acquire tsunami information, increase levels of tsunami preparedness, and work with community and emergency management agencies to develop response plans. Drawing upon the recommendations of Horikawa and Shuto (1983), the preparedness scale measures people's ability to respond promptly should a tsunami occur.

Because tsunami risk awareness in Australian communities is low, the consequent level of variance in preparedness (see above) could preclude testing the model (Paton, in press). Consequently, the model was tested on an Alaskan population, allowing data to be collected from communities identified (General Accounting Office, 2006) as being in areas of high risk for locally-generated tsunami (for which readiness

to respond is particularly important). The variables described above were compiled into a questionnaire. Analysis is based on response from 353 residents of Kodiak, Alaska obtained during February 2007.

Table 1: Proportion of 353 participants reporting the adoption of emergency response items.

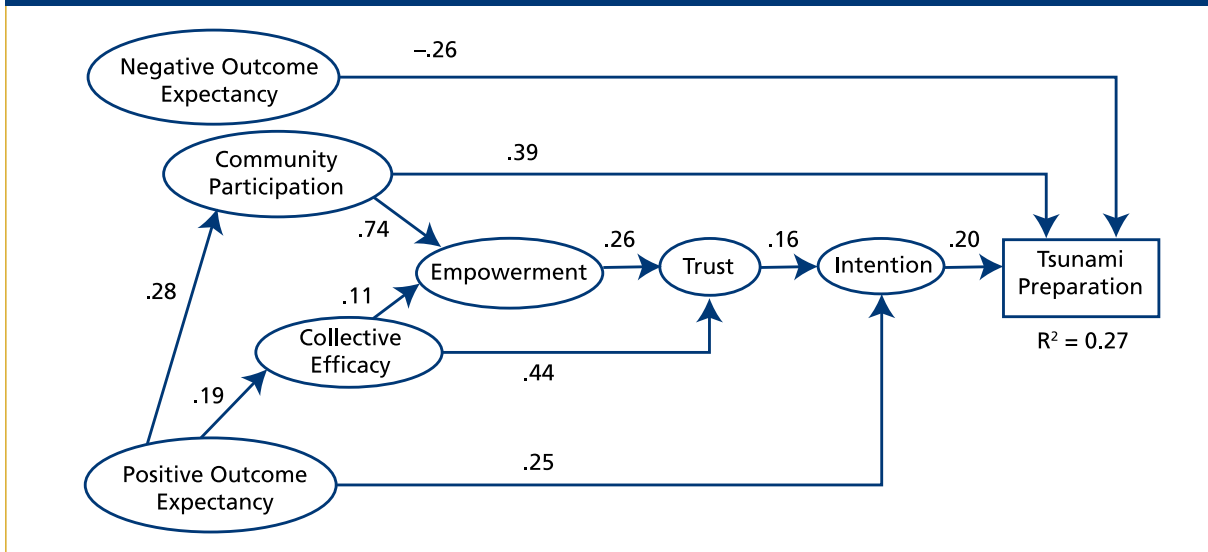
Emergency Response Item	% Adoption
Developed a family emergency response plan	34
Have a 3-day supply of non-perishable food and water	42
Have a back pack filled with supplies ready to take with me	30
Have a NOAA Weather Radio and working batteries	29
Prepared to respond to tsunamis in more places than my home	28
Participated in a tsunami evacuation drill	13

Results and analysis

Because it can estimate multiple and inter-related dependence relationships simultaneously, structural equation modelling allows statistics to be calculated to test the model as a whole and assess how well the data fit the hypothesised model (Goodness-of Fit). Data were analysed using the AMOS 6 structural equation modelling program.

The model (Figure 1) describes whether or not people prepare to respond to a tsunami as a causal sequence that commences with people's outcome expectancy beliefs and depicts a decision making process that flows from left to right. The numbers adjacent to each arrow indicate the strength of the path relationship. Table 1 indicates that levels of preparedness were present at low-moderate levels. Examination of the Goodness of Fit statistics ($\chi^2 = 19.19$, $df = 13$, $p=0.117$; $RMSEA = 0.037$, $90\% \text{ CI } 0.0 - 0.07$, $NFI = 0.99$, $GFI = 0.99$, $AGFI = .96$) indicate that the data are a good fit for the hypothesised model (Arbuckle, 2006) and that the model can account for differences in observed levels of preparedness. The model accounted for 27% of the variance in levels of preparing (Figure 1).

Figure 1. The results of the structural equation analysis of tsunami preparedness.



Discussion

As hypothesised, negative outcome expectancy (NOE) beliefs predicted that people will not prepare (Figure 1). For those holding NOE beliefs, preparedness information will be discounted or ignored because it is inconsistent with their existing belief that nothing can make a difference. Because NOE is independent of the factors that influence deciding to prepare, it is important to distinguish between people who decide not to prepare (i.e., who form NOE beliefs) from those who accept a need to prepare but need guidance in how to accomplish this (Paton et al., 2005). For the latter, this starts with the belief that preparing can enhance their safety.

Positive outcome expectancy (POE) had a direct influence on intentions (Figure 1). For some people, this belief (assuming they have sufficient knowledge, resources etc) is sufficient to motivate preparing. Others, however, need more information. The relationship between POE and both community participation and collective efficacy (Figure 1) provides support for the hypothesis that other community members influence whether people prepare (Earle, 2004; Lion et al., 2002). That community participation can guide people's preparedness is evident in the direct relationship between it and preparing (Figure 1). The finding that community participation and collective efficacy both predict empowerment supports the hypothesis that, under conditions of uncertainty, being able to identify resource needs influences the quality of the community-agency relationship.

The more citizens perceive themselves as being empowered (i.e., having their needs met through their relationship with emergency management agencies), the more likely they are to trust them (Figure 1) and to use the information provided to guide their decisions to

prepare for tsunami. Confirmation of the efficacy of the model allows its components to be used to offer evidence-based suggestions for public education strategies.

Implications for Public Education

If a tsunami occurs, people's survival will be influenced by the degree to which they are prepared to respond. As the data presented here attests, even in areas identified as high risk for locally-generated tsunami (Kodiak), levels of readiness to respond are relatively low. This underscores the challenge to encouraging the adoption of readiness measures in Australian communities in which low levels of tsunami risk awareness and acceptance are currently likely to prevail. However, by identifying predictors of tsunami preparedness, the model discussed here can inform the development of strategies for use with Australian communities. To facilitate preparedness, strategies must address information content (e.g., outcome expectancy), social context (community participation, problem solving) and community-agency relationship (empowerment, trust) factors.

Strategies must accommodate outcome expectancy beliefs. An important predictor of NOE (Paton et al., 2005; Paton et al., 2006) are control beliefs that result in some people assuming that because a tsunami is uncontrollable its consequences are also uncontrollable. Consequently, information provided should help people differentiate between uncontrollable causes and controllable consequences and emphasise how hazard consequences can be managed (Paton et al., 2006; Paton & Wright, 2008). It is particularly important that the media echo these sentiments. Another strategy involves framing messages in ways that invite people to consider what could be done to protect more vulnerable (e.g., children at school, residents in a home for the



Australian soldiers help local villagers.

elderly) members of society. By thinking about how they could assist those more vulnerable than themselves, people's NOE beliefs are more likely to break down (Paton et al., 2006).

Because NOE and POE make independent and opposite contributions to preparedness, reducing NOE will not, in itself, motivate preparing. That is, separate strategies are required to reduce NOE and increase POE beliefs. Consequently, strategies designed specifically to encourage the development of positive outcome expectancy beliefs must be developed.

POE beliefs are enhanced by information that not only identifies hazard consequences but also illustrates specifically how the recommended actions can mitigate the risk associated with each consequence (Paton et al., 2006). It may, however, be necessary to introduce recommendations gradually. Because presenting too much information at any one time can overwhelm people, strategies should start with relatively easily adopted items (e.g., preparing an emergency kit) and progressively introduce more complex actions (such as evacuation planning and rehearsing evacuation) over time. By presenting information on preparedness measures progressively over time, sustained adoption is more likely (Paton et al., 2006)

Because a distinction can be drawn between beliefs in the efficacy of preparing (i.e., POE beliefs) and knowing how to prepare, increasing the likelihood that people prepare involves encouraging community members to discuss hazard issues and identify the resources and information they need to deal with the consequences a tsunami would pose for them. This outcome could be encouraged by inviting representatives of community groups (e.g., community boards, Rotary, religious and ethnic groups etc.) to review tsunami scenarios and identify the implications and risk mitigation strategies appropriate for them (Paton, 2008). This increases the likelihood that the resources provided will be consistent with community beliefs, expectations and goals and be used to guide their preparedness. The effectiveness of these activities can be increased by working with community leaders and training them to facilitate (including, if necessary, developing problem solving competencies) community preparedness (Paton, 2008).

The effectiveness of such activities will, however, be a function of the extent to which the community-agency relationship is complementary and empowering.

One approach to empowering communities would involve emergency management agency representatives acting as consultants to communities (e.g., facilitators, resource providers, change agents, coordinators) rather than directing the change process in a top down manner (Paton & Bishop, 1996). By assimilating the needs and perspectives derived from community consultation, agencies are in a better position to provide the resources necessary to empower community groups and sustain self-help and resilience (Paton, 2008). Other approaches to promoting community empowerment can be found in Fetterman and Wandersman (2004).

Finally, by drawing a distinction between intentions and actual behaviour, the model draws attention to the existence of several factors that influence whether intentions are converted into actions that are difficult to influence through public education programs. These include people's beliefs regarding when a tsunami might occur (the further into the future this is believed to be, the less likely people are to convert intentions into action) and the physical costs (e.g., time, money, need to work with others etc) associated with implementation (Paton et al., 2005). Knowledge of these factors can inform the development of additional public education and community engagement content.

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