Research paper

Risk perception and volcanic hazard mitigation: Individual and social perspectives

Douglas Paton a,⁎, Leigh Smith b, Michele Daly c, David Johnston d

a School of Psychology, University of Tasmania, Locked Bag 1342, Launceston, Tasmania, Australia
b School of Psychology, Curtin University, Perth, Western Australia
c Kestrel Group, Auckland, New Zealand
d GNS Science, Avalon, New Zealand

Received 27 October 2006; accepted 11 December 2007
Available online 15 January 2008

Abstract

This paper discusses how people’s interpretation of their experience of volcanic hazards and public volcanic hazard education programs influences their risk perception and whether or not they adopt measures that can mitigate their risk. Drawing on four studies of volcanic risk perception and preparedness, the paper first examines why experiencing volcanic hazards need not necessarily motivate people to prepare for future volcanic crises. This work introduces how effective risk communication requires communities and civic agencies to play complementary roles in the risk management process. Next, the findings of a study evaluating the effectiveness of a public volcanic hazard education program introduce the important role that social interaction amongst community members plays in risk management. Building on the conclusions of these studies, a model that depicts preparing as a social process is developed and tested. The model predicts that it is the quality of the relationships between people, communities and civic agencies that determines whether people adopt measures that can reduce their risk from volcanic hazard consequences. The implications of the model for conceptualizing and delivering volcanic hazard public education programs in ways that accommodate these relationships is discussed.

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Keywords: volcanic hazards; risk perception; public education; community engagement

1. Introduction

On a global scale, volcanic hazards represent a significant threat to many communities. In her review of research from United States Geological Survey and Smithsonian Institute sources, Mayell (2002) describes how there are some 457 volcanoes with cities that house 1 million or more people located within 100 km of them. In communities whose proximity renders them susceptible to experiencing adverse impacts from volcanic processes, the active management of the associated risk is essential.

In this paper, risk is conceptualized as a product of a) the likelihood (probability) of a hazard event occurring, and b) the consequences of hazard activity (Hood and Jones, 1996). This definition represents risk perception as comprising two general components. The first concerns how people estimate the probability of volcanic hazard activity occurring, and how they interpret this likelihood information (Slovic, 2000). The second addresses the relationship between volcanic hazards and the consequences they can create when they interact with the environments in which people live. This paper focuses on the latter aspects of risk.

A focus on the consequences side of the risk equation is justified by its importance as a target for risk management initiatives. Although people are interested in knowing about the likelihood of hazard occurrence, it tends to be less salient than information on consequences and their management for their decision making about whether or not to prepare for hazard consequences (Mayer et al., 1995; Sjöberg, 1999; Lion et al., 2002; Paton et al., 2005). A key goal in risk communication is
encouraging people to adopt preparedness measures that reduce their risk by increasing their ability to manage hazard consequences.

For example, if people know to tape house windows or cover air conditioning units, they can reduce damage from ash inundation. Having face masks can reduce risk from inhaling ash. Similarly, having spare air filters for vehicles facilitates continued transportation availability, and knowing how to remove ash from households, roofs and vehicles limits property and infrastructure damage. People can increase their capacity to meet basic needs by storing food and water, and having a household volcanic emergency plan can ensure that families know what to do should an eruption occur.

These protective measures reduce the likelihood of injury, death and property damage and contribute to peoples’ capacity to cope with and adapt to volcanic hazard consequences during an eruption event. Their adoption thus increases people’s capacity to manage their risk. However, knowledge of one’s proximity to volcanic hazards or susceptibility to their consequences does not guarantee taking action to mitigate the associated risk. Levels of preparedness are often low, even when those at risk are aware of their circumstances (Ballantyne et al., 2000; Paton, 2006). Understanding why this is the case, and identifying alternative ways to increase people’s ability to mitigate their risk, is thus an important aspect of volcanic hazard risk management.

This paper discusses how people’s interpretation of their experience of both volcanic hazards and public education programs influences their risk perception and whether or not they adopt measures that can mitigate their risk. The content derives from four studies of volcanic risk perception and preparedness conducted by the authors (Johnston et al., 1999; Ballantyne et al., 2000; Paton et al., 2001; Paton, 2006). Understanding why this is the case, and identifying alternative ways to increase people’s ability to mitigate their risk, is thus an important aspect of volcanic hazard risk management.

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2. Understanding people’s beliefs about volcanic risk

People’s beliefs about volcanic hazards and what can be done to manage their consequences can be formed and maintained in several ways. One relates to hazard experience. Another involves informing people, usually via public hazard education programs, about the hazards they face and the measures and actions they can adopt to mitigate their risk.

That hazard experience can increase preparedness is evident from observation of communities that face regular exposure to volcanic hazard activity. For example, as a result of its proximity to Sakurajima volcano, the city of Kagoshima in Japan receives ashfall and ballistic debris on some 113 days per year. In response, the city has developed building codes, ash removal practices and community attitudes and preparedness that facilitate continuity of societal functions during periodic volcanic episodes (Johnston, 2004). Clearly, when a consistent need to confront hazard consequences prevails, mechanisms capable of actively managing risk can be established within the fabric of a community. There are, however, few places in which such regular occurrences can be relied upon to sustain this level of preparedness. This makes it pertinent to ask whether less frequent experience of volcanic hazard consequences can be similarly effective.

2.1. Risk perception and infrequent volcanic hazard experience

The 1995 eruption at Ruapehu volcano, New Zealand (Fig. 1) occurred in the midst of a research program investigating volcanic risk perception and preparedness. Ruapehu has a return period of some 50 years, with its previous major eruption occurring in 1945. Consequently, this eruption provided an opportunity to examine how infrequent experience of volcanic hazard consequences influenced risk perception and preparedness. A survey of risk perception and preparedness had been conducted in several communities susceptible to experiencing volcanic hazards prior to the 1995 Ruapehu eruption. During the eruption, one community surveyed before the eruption, Hastings (Fig. 1), received ash fall (Johnston et al., 1999). By re-surveying the same people (N=202) who responded to the initial survey, it was possible to assess how experiencing volcanic hazard consequences affected risk perception and preparedness. Full details are available in Johnston et al. (1999). Key findings and their implications for understanding volcanic risk perceptions are discussed here.

Fig. 1. The location of Ruapehu and the three study sites. Map courtesy of GNS Science.
Table 1
Comparison of risk perception and preparedness levels in Hastings, New Zealand before and after receiving ashfall from the 1995 eruption of Ruapehu volcano (1 = low, 5 = high)

<table>
<thead>
<tr>
<th></th>
<th>Hastings Pre 1995 eruption</th>
<th>Hastings Post 1995 eruption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk perception</td>
<td>1.25</td>
<td>1.85</td>
</tr>
<tr>
<td>Perceived preparedness</td>
<td>0.76</td>
<td>1.06</td>
</tr>
<tr>
<td>Preparation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean no. of items</td>
<td>3.7</td>
<td>2.8</td>
</tr>
<tr>
<td>Percentage adopting any preparations</td>
<td>63%</td>
<td>53%</td>
</tr>
</tbody>
</table>

Adapted from Johnston et al. (1999).

Direct experience of ashfall did increase the level of perceived risk people attributed to volcanic hazards (Table 1). Next, the implications of this experience for levels of preparation were assessed. Two variables, actual preparations and people’s perceived preparedness (their beliefs regarding their ability to deal with future eruptions) were examined (Table 1).

Despite their direct experience and their recording an increase in volcanic risk perception, a reduction in actual preparedness was evident (Table 1). Both the average number of preparation items adopted and the number of people adopting any preparedness measures dropped following the experience of ashfall in Hastings (Table 1). Overall, some 10% of the sample had abandoned any previous preparations they had undertaken. Interestingly, however, despite this reduction in levels of actual preparedness, comparison of pre- and post-event data revealed a significant increase in perceived preparedness (Table 1). People believed they would cope better with any future eruption. Given that a decrease in actual preparedness would adversely affect this capability, it thus becomes necessary to account for this apparent contradiction.

This pattern is consistent with the operation of the “normalisation bias” (Mileti and O’Brien, 1993). This describes how people infer from an ability to cope with (objectively) minor eruption consequences a capability to deal with any future occurrence. Since this eruption was people’s only experience of an infrequent event, it became their archetypal eruption. As such, it provided the foundation for how people would think about volcanic risk in the future. In circumstances like this, in which the experience fell short of what could be experienced, the operation of this bias can result in people overestimating their perceived preparedness (e.g., because they coped OK this time) and reducing future preparedness (because they do not consider what could happen). If communities base their risk judgements on events whose intensity is towards the lower level of what is possible, reducing levels of preparedness increases their future risk. Under these circumstances, people will be less able to deal with the more intense and/or more prolonged consequences that could occur.

These findings imply that agencies must engage with communities to understand people’s interpretation of their circumstances (which may be contrary to agency expectations). Only by engaging communities will agencies be able to determine how community interpretation influences their future risk management expectations. This provides a foundation for communities and agencies to work together to develop sustainable risk management strategies capable of catering for a more realistic range of possible consequences. This issue is discussed in more detail below.

The infrequent nature of eruptions means that volcanic hazard risk management typically occurs in the absence of any regular experience of the hazards that communities may be called upon to contend with. Under these circumstances, the principal method for imparting information about volcanic risk and encouraging preparedness involves public education programs delivered during periods of hazard quiescence. If, however, experience of volcanic hazards does not guarantee the adoption of protective actions, questions about the effectiveness of simply informing people about hazards and their mitigation must be asked.

2.2. Public education

Public education programs are often based on the assumption that providing the public with information (e.g., through the mass media or via the distribution of pamphlets) about hazard activity motivates people to prepare (Smith, 1993). This assumption is ill-founded. Despite the efforts of civic emergency management agencies to inform the public about hazards and how to deal with their consequences, the goal of ensuring sustained levels of volcanic hazard preparedness remains elusive (Ballantyne et al., 2000). By uncovering reasons why this approach can be ineffective, it will be possible to identify factors that need to be taken into account in order to motivate people to prepare. In this section, the findings of a study evaluating a public volcanic hazard education program are used to identify these factors.

2.3. Evaluating the effectiveness of public education

A telephone survey comparing risk perception and levels of preparedness was undertaken with 405 people in Auckland, New Zealand (Fig. 1) before and after a volcanic hazard public education program (Paton et al., 2006b). The public education program was designed and delivered independently of the evaluation research. The program was comprehensive in its coverage and content. It involved multi-media coverage of volcanic risk and preparedness activities and the distribution of pamphlets and volcanic hazard maps over a period of several weeks.

Following the program, although some 92% of respondents stated that they were aware of Auckland’s volcanic status, no change in either their risk perception or levels of preparedness were found (Table 2). Only 10% of the sample had adopted any of...
the recommended preparatory measures. Given the reliance on public education for facilitating more accurate risk perception, it is thus important to identify reasons for this lack of change.

2.4. Why is just providing information ineffective?

The data obtained from the evaluation process highlighted several areas from which explanation for these findings could be sought. One possibility is that people overestimate their existing levels of knowledge and preparedness.

In New Zealand, a list of actions to perform should a volcanic eruption occur is provided inside the cover of the Yellow Pages telephone directory. This information is thus generally available in most, if not all, households. It is a widely recognised source of information on hazard response actions. As a result, it provides a good context for testing people’s hazard knowledge.

People were first asked if they believed they could describe the list of protective actions for volcanic eruptions listed in the Yellow Pages. Some 41% of respondents stated that they thought that they could. Because these data were obtained over the telephone (i.e., people did not have cues about the answers in front of them and they were required to respond immediately so they did not have time to check), asking respondents to name these actions provided a good test of the relationship between people’s beliefs about their knowledge and their actual knowledge.

When asked to actually name the actions described in the Yellow Pages, only 6% could actually recall these items (Ballantyne et al., 2000). From this example, it can be inferred that people estimate their perceived preparedness on knowing where information could be obtained, but often assume that this equates to actual knowledge. The discrepancy between what people thought they knew and their actual knowledge (41% versus 6%) suggests that people can significantly overestimate their actual knowledge.

If people overestimate their knowledge or expertise, they will be less attentive to new information, less likely to perceive a need for any additional preparation, and less likely to alter the level of perceived risk they attribute to a hazard. Furthermore, this misconception can lead to people inappropriately overestimating their level of safety. People’s assumptions regarding their safety may have been further influenced by their interpretation of some of the content of the public education program.

Not only did this campaign not produce the desired change in risk perception, it also resulted in some 28% of respondents reporting their intention to reduce their levels of preparation in future (Ballantyne et al., 2000). This reflects the operation of an interpretive bias known as risk compensation (Adams, 1995). This construct describes how people maintain a balance between the perceived level of safety proffered by their environment and their perceived risk. Any positive shift in perceived environmental safety is accompanied by a reduction in their perceived risk. This could account for the stated intent to reduce levels of preparedness.

For example, people interpreted information contained in the public education program about civic and scientific agency monitoring of the volcano as making their environment safer than it was prior to their receiving this information (Ballantyne et al., 2000). If people perceive their environment as being safer, their level of perceived risk will decline, as will their perceived need to adopt protective measures. That is, people may go beyond the intention underlying the action of civil agencies (who assume that, at least, people will maintain levels of preparedness) and inadvertently interpret information in ways that lead them to believe that they can reduce their levels of preparedness, increasing their future risk as a consequence.

To counter this problem, civic agencies need to engage with community members to emphasise that they work in partnership with the community and that any structural and planned mitigation measures they implement complement, rather than replace, household actions. If they do not, people may effectively transfer responsibility for their safety to civic authorities (Ballantyne et al., 2000). This provides a further illustration of the need to incorporate the relationship between community members and civic agencies in the risk management process. Problems can also arise from people transferring risk from themselves to other members of their community.

In Auckland, people were asked to rate how prepared they believed themselves to be for a future volcanic eruption (Table 3). The same respondents were then asked to rate, relative to themselves, how prepared they believed other members of their community to be. When these scores were compared (Table 3), it was found that people consistently believed themselves to be better prepared relative to other members of their community (Ballantyne et al., 2000). Since not everyone can be better than average, what is happening? This pattern (Table 3) describes the phenomenon of unrealistic optimism bias (Burger and Palmer, 1992; Weinstein and Klein, 1996; Sjöberg, 2000). This is characterised by people perceiving themselves as less vulnerable or more skillful than the average person.

The operation of this bias means that even if people accept a need for greater preparedness, they assume this need applies to others but not to themselves. In so doing, people transfer risk to others within their community rather than accepting this risk themselves. If all members are making similarly biased assumptions about the distribution of risk within a community, no change in either the level of perceived risk or their level of preparedness is likely to occur.

This inappropriate assumption tends to go unchallenged when people are passive recipients (as is the case with mass media public education) of information about risk. It is only when risk issues are actively discussed with others that people confront their assumptions about how risk is distributed amongst community members and recognize that they need to act to manage their risk (Paton et al., 2006b). Encouraging discussion...

Table 3
Comparison of perceived preparedness for future volcanic crises in self and others in Auckland, New Zealand (1 = low, 5 = high)

<table>
<thead>
<tr>
<th></th>
<th>Perceived preparedness</th>
<th>Perceived preparedness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Self</td>
<td>Community</td>
</tr>
<tr>
<td>Auckland residents</td>
<td>2.98</td>
<td>2.68</td>
</tr>
</tbody>
</table>

Adapted from Ballantyne et al. (2000).
of risk amongst community members thus has an important role to play within the risk management process.

The finding that simply making volcanic hazard information available to people, irrespective of its quality, may not motivate people to prepare, is consistent with findings from research on other natural hazards (Burger and Palmer, 1992; Duval and Mullilis, 1999; Lindell and Whitney, 2000; Paton et al., 2005; Paton et al., 2006a). The remainder of this paper explores the hypothesis that this problem results from public education failing to accommodate the role of the social context in which information about complex, infrequently-occurring and uncertain volcanic events is received and interpreted.

Drawing on the findings introduced above, two facets of this social context are examined. Firstly, the discussion of unrealistic optimism suggests that discussion of hazard issues amongst community members makes an important contribution to how risk beliefs are formed and maintained. Secondly, the discussion of normalisation bias and risk compensation suggested that the relationship between communities and civic emergency planning agencies represents a significant component of this social context and must be accommodated if a comprehensive account of peoples’ risk management decisions is to be developed.

3. The social context

The findings discussed above illustrate how it is not information per se that determines whether people act to manage their risk. Rather, decisions to act are determined by how people interpret information (i.e., render it meaningful to them). Furthermore, people interpret information in the context of experiences, beliefs and expectations (Dake, 1992; Marris et al., 1998; Lion et al., 2002; Rippl, 2002) that are forged, changed and sustained through their social relationships (with other members of their community and/or representatives of civic and scientific agencies).

Peoples’ concept of environmental risk is thus influenced by others’ views, as are the choices they make regarding how they might confront risk (Paton and Bishop, 1996; Lion et al., 2002). Consequently, people turn to other members of their community to provide them with the information they need to reduce their uncertainty and guide their preparation. From this it can be inferred that a measure of community participation could help understand risk perception.

While providing access to collective knowledge, the infrequent and complex nature of volcanic hazards can place limits on how much people can find out from other community members. This increases the likelihood that people will have to rely, to some extent, on expert sources (e.g., emergency planners, scientists) for the information they require to manage their risk. However, to make an effective contribution to the risk management process, expert sources may be required to do more than make information available.

3.1. The relationship between people and emergency planning agencies

The quality of the relationship between people and civic agencies influences risk perception and decisions about whether or not to prepare for hazard consequences (Eng and Parker, 1994; Paton and Bishop, 1996; Tobin, 1999; Lion et al., 2002; Poortinga and Pidgeon, 2004; Paton, 2005). For example, the discussion of normalisation bias and risk compensation (see above) introduced a need for emergency planning agencies and communities to play complementary roles in the risk management process. Furthermore, levels of risk acceptance and people’s willingness to take responsibility for their own safety is increased, and decisions to prepare more likely, if people believe that their relationship with emergency planners is fair and empowering (e.g., agencies are perceived as trustworthy, as acting in the interest of community members) (Paton and Bishop, 1996; Paton, 2005). Support for the need to accommodate the relationship between communities and agencies was also evident from our studies of volcanic risk perception.

In Auckland, interview data revealed that the information provided by the public education program did not meet the needs and expectations of all residents (Ballantyne et al., 2000). One explanation for this derives from the fact that the ‘community’ is not a homogenous entity. The social context in which information is received is characterized by considerable demographic (e.g., age, ethnicity, family characteristics, socio-economic status) diversity. This diversity means that different groups have different needs and expectations. By presenting the public education program in a format (e.g., pamphlets, TV advertising) that could not cater for all needs, the perceived credibility of the information was compromised and trust in its source reduced (Ballantyne et al., 2000). Similar findings emerged from interviews with residents in the town of Ohakune (Fig. 1) following the 1995 eruption at Ruapehu volcano (Paton et al., 2001). When community members believed that information from civic and scientific sources failed to address their concerns, the consequence was a loss of trust in the sources of information.

The significance of these insights derive from the important role that trust plays in circumstances in which decisions are made under conditions of uncertainty (Coleman, 1990; Earle and Cvetkovich, 1995; Siegrist and Cvetkovich, 2000). When dealing with volcanic hazards, the infrequent and complex nature of volcanic hazard activity means all decision makers have to deal with risk and uncertainty. As uncertainty increases, so to does the importance that people attribute to their general trust beliefs about, and their past trust experiences with, the sources of information they turn to or have to rely on (Luhmann, 1979; Johnson-George and Swap, 1982; Sjöberg, 1999).

To acquire information on volcanic hazards, people often rely on sources (e.g., emergency planners) with whom they have a general relationship (e.g., as a result of these planners being officers of local councils), making general trust a significant issue (Siegrist and Cvetkovich, 2000) in this context. For example, people may not differentiate between emergency management and other council functions, but make judgements about trust with reference to their general dealings with the council over time (Ballantyne et al., 2000). To examine whether these issues could inform understanding of people’s preparedness decisions, a subsequent study (Paton, 2006) was undertaken. This study examined how community participation and
the inter-relationship between communities and civic agencies influenced decisions to prepare for volcanic hazards.

4. Risk perception, social trust and public education

To systematically examine how relationships between people, communities and civic agencies influence decisions about whether or not to act to reduce risk, a model developed by Kee and Knox (1970) and elaborated by Mayer et al. (1995) was used to provide a theoretical framework. This model describes how the relationship between personal, community, and societal factors and intentions to act (in this case, to prepare for volcanic hazard consequences) is mediated by trust (in this case, with regard to civic emergency planning agencies).

4.1. Area descriptions, measures and procedure

The first step was the identification of an area in which the model could be tested. The area selected was Auckland, New Zealand (Paton, 2006). Several factors make Auckland (Fig. 1) an appropriate place to examine how social processes influence perception of volcanic risk.

Auckland is built on a volcanic field that last erupted some 600 or so years ago. A return period of some 600–1000 years makes this scenario an appropriate one for assessing preparation. Uncertainty regarding the location of future eruptions and the potential for multiple distributed eruptions to occur simultaneously ensures that volcanic risk is comparable for all residents (Paton et al., 1999). This, in turn, makes being prepared for hazard consequences equally applicable to all residents (e.g., they cannot reason on grounds of their geographic position that they are not at risk). Furthermore, volcanic hazards present a diverse set of consequences (e.g., direct and indirect effects of ash etc) and mitigation options (e.g., securing home from ash inundation, vehicle maintenance etc) that people need to know about and be able to implement. The infrequent nature of hazard activity, the complexity of volcanic hazard consequences and their diverse implications for protective action increases citizens’ need to obtain information from expert (e.g., civic emergency management authorities) sources and to use this information to guide their risk management decisions. This combination of characteristics renders this volcanic scenario an appropriate one for investigating the social context in which people interpret risk and make decisions about whether or not to prepare.

4.1.1. Measures

Before the model can be tested, it was first necessary to operationalize the personal, community and societal elements of the model. This is done by selecting variables that can measure each element. The selection of variables was driven by the pragmatic goal of ensuring that they represented factors amenable to change through a risk management process.

The theoretical model proposes that an important variable at the personal level of analysis is peoples’ assessment of the costs and benefits associated with mitigating hazard consequences (Kee and Knox, 1970; Scott, 1980; Coleman, 1990; Yates and Stone, 1992). The construct of outcome expectancy was used here to assess this component.

Two outcome expectancy variables (Paton et al., 2005) were used. Positive outcome expectancy taps into beliefs that personal preparation can make a difference and add value to one’s life (benefit > cost). Negative outcomes expectancy taps into beliefs that hazards are too destructive for personal action to make a difference (cost > benefit). If people believe that the costs outweigh the benefits, no further action is likely. On the other hand, a belief that the benefits outweigh the costs will motivate people to prepare. People need specific knowledge and skills if they are to act on this belief. If people possess this knowledge themselves, this may be sufficient to guide their decision to formulate plans to act. However, because of the infrequent and complex nature of volcanic hazards, some people may not have this knowledge. Consequently, to acquire the information and resources they need to reduce their uncertainty and guide their actions, it is proposed that people look first to other community members and subsequently to civic emergency planning agencies.

The next issue concerned selecting variables to capture how interaction amongst community members and between communities and civic agencies contributes to defining the social context in which risk beliefs are forged and enacted. Variables were selected on the grounds of their potential to influence how people evaluate information under conditions of uncertainty.

Two community variables, community participation and articulating problems, were selected. Peoples’ concept of environmental risk is influenced by others’ views, as are the choices they make regarding how they might confront risk (Paton and Bishop, 1996; Lion et al., 2002). In particular, people typically turn to those they believe share their values when faced with deciding how they might deal with uncertainty (Earle, 2004; Poortinga and Pidgeon, 2004). Participating in activities with other community members provides access to information from others that will be consistent with one’s values and expectations. This makes assessing community participation an appropriate place to start. For this analysis, Eng and Parker’s (1994) measure of ‘community participation’ was used.

While community participation provides access to the collective knowledge and expertise within a community, this may not provide answers to all the issues people identify. Consequently, an additional step in the process may be required. The infrequent and complex nature of volcanic hazards, and people’s lack of direct experience of dealing with their consequences increases their need to rely, to some extent, on expert sources to acquire the information and resources they require to act. Under these circumstances, however, just knowing of a lack of or gaps in knowledge is not enough. If they are to interact effectively with civic agencies, community members must be able to articulate these needs into a set of communicable expectations that can help reduce their uncertainty.

When faced with uncertainty, decisions regarding the quality of information received derive from the degree to which it is consistent with the needs and expectations of those seeking it (Earle, 2004; Lion et al., 2004; Paton et al., 2006b). Being able to define information needs also facilitates more effective interaction...
with civic agencies. It is the consistency between people’s expectations and the information received that helps people construct more accurate estimates of risk, reduces uncertainty, and influences trust (Earle, 2004; Paton et al., 2006b). Community groups must be able to articulate their needs into a set of meaningful questions, the answers to which will reduce their uncertainty and provide direction for their actions. Eng and Parker’s (1994) measure of ‘articulating problems’ was used to assess this aspect of community functioning.

The final component concerns those variables that encapsulate the relationship between community members and civic agencies. Two variables, empowerment and trust, were proposed. According to Eng and Parker (1994), realizing the benefits of community problem-solving competence requires that civic agencies empower community members and provide them with the resources, including information, required to act on issues community members deem important. That is, participation/articulating problems and empowerment play complementary roles within the risk management process. A measure of empowerment developed by Speer and Peterson (2000) was used to assess the relationship between communities and civic agencies.

Finally, the theoretical model used here (Kee and Knox, 1970; Mayer et al., 1995) argues that trust mediates the relationship between personal and social factors and decisions to act to reduce risk (i.e., preparing). The measure of trust used was derived from an earlier study of earthquake preparedness (Paton et al., 2005).

The dependent variable was an intention to adopt protective measures. The inclusion of this measure was particularly important here. Levels of volcanic hazard knowledge and the adoption of protective actions were too low for them to be subjected to meaningful analysis (Paton, 2006). Intention represents a good predictor of likely future actions when dealing with uncertainty (Mayer et al., 1995; Paton et al., 2005). The variables described above were compiled into a questionnaire. This was administered in the form of a telephone survey to 297 Auckland residents during July 2005.

The model proposes that people’s decisions to prepare reflect the outcome of a sequence of activities. The process commences with deliberations about the costs and benefits of acting. If costs > benefits, it is hypothesised that no further action will be taken and people will not prepare. If people perceive that the benefits > costs, people will proceed to the next stage. This involves participating with others and articulating their needs and expectations into a set of questions, the answers to which reduce uncertainty and provide direction for effective risk management activities. Because all the information required may not be forthcoming from within a community, members then look to expert sources (e.g., civic emergency planners) for answers to these questions. Consequently, it is hypothesised that the relationship between community processes and deciding to prepare is mediated by the degree to which community groups perceive themselves being empowered (e.g., being provided with answers that reduce uncertainty and facilitate action) by these sources of information and by the level of trust they have in the source.

4.2. Results and analysis

The model describes preparing as a process which comprises variables that are linked in a causal sequence. As such, with the exception of the outcome expectancy variables that indicate the starting point of the process, the contribution of each of the remaining variables in the model is dependent on those preceding them (as indicated by the arrows linking the variables). Consequently, structural equation modelling was selected for the 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 to show how well the data fit the hypothesised model (Goodness-of-Fit).

The hypothesised relationships between personal, community and civic variables were analysed using the LISREL structural
equation modelling program. The findings are summarised in Fig. 2. The process commences with the variables (positive and negative outcome expectancy) on the left hand side of Fig. 2 and progresses sequentially to intentions to prepare. The arrows indicate the direction (commencing with outcome expectancy) of the causal relationships between variables identified by the analysis. The numbers adjacent to each arrow indicate the strength of the relationship (from 0 (no relationship) to 1). A minus sign indicates an inverse relationship between variables.

The analysis supports the validity of the model as a predictor of the role of social and societal influences on volcanic hazard preparedness. All paths shown are significant. The data provided a good fit for the model. The Goodness-of-Fit statistics are: \( \chi^2 = 9.02, \text{df}=11, p = 0.62 \), RMSEA = 0.052, NFI = 0.98, GFI = 0.99. These measures describe how well the data fit the hypothesised model (Goodness-of-Fit).

In structural equation modelling, the objective is to find non-significant differences between the predicted and actual model. This is measured by the Chi Squared \( \chi^2 \) statistic. The smaller the \( \chi^2 \) value, the better the fit of the actual model. The small value obtained here (9.02) indicates that the actual model is a close fit to the hypothesised model. This is supported by the other measures described here. The Goodness-of-Fit Index (GFI) can range from 0 (poor fit) to 1 (perfect fit). A value of 0.99 indicates a good fit. Acceptable fit is also indicated by a Root Mean Square Error of Approximation (RMSEA) value that falls between 0.05 and 0.08. The RMSEA value obtained here (0.052) falls within this range. Finally, the Normed Fit Index (NFI) provides an indication of the improvement (1-NFI) in fit that could be obtained. An NFI of 0.98 indicates a measure of improvement of 0.02, which is of little practical significance. The model accounted for 37% of the variance in intention to prepare for volcanic hazards. Overall, all measures of fit indicate that the model is a good fit to the data. The results support the utility of the model as a device to assist understanding decisions to prepare for volcanic hazard consequences.

5. Discussion and conclusion

5.1. Discussion

In this section, attention turns to discussing the components of the model and how they interact to influence decisions to prepare. The order in which each component of the model is discussed follows the sequence of relationships described in Fig. 2. It thus corresponds to the order in which each factor influences decisions about whether or not to prepare for volcanic hazard consequences.

5.1.1. Outcome expectancy

Peoples’ assessment of the costs and benefits of mitigating consequences was identified as a precursor of decision making under conditions of uncertainty (Kee and Knox, 1970; Coleman, 1990; Yates and Stone, 1992). As predicted, negative outcome expectancy (people believe that volcanic hazard consequences are so destructive or catastrophic as to render personal actions futile) predicted a reduction in the likelihood that people would formulate preparatory intentions (Fig. 2). It was also evident from its negative relationship with community participation (Fig. 2) that if people held this belief they were significantly less likely to discuss volcanic hazard issues with other community members. If people hold negative outcome expectancy beliefs, they are unlikely to act. It also means that risk management programs must neutralise this belief before commencing activities designed to increase preparedness (Paton et al., 2005; Paton et al., 2006b).

Positive outcome expectancy (i.e., people believe that the benefits of preparing for volcanic hazards outweigh the costs and perceive the desired outcomes as achievable) had a direct influence on intentions. This indicates that, for some people, a strong belief in the capacity of personal action to mitigate their risk is sufficient for them to take action. Others, however, need more information, and for this they turn to the members of their community. This is indicated by the relationship between positive outcome expectancy and both community participation and articulating problems (Fig. 2). In the absence of sufficient personal knowledge to manage one’s risk, positive beliefs regarding the efficacy of protective measures prompts people to interact with others to advance their risk management planning. It increases the likelihood that people will discuss hazard issues and formulate any gaps in knowledge in a way that provides the basis for constructive interaction with civic agencies.

5.1.2. Participation and articulating problems

Confirmation of the role of community participation in the model reflects the important contribution that social interaction with those that share similar beliefs and values has in forging and sustaining people’s risk perception and their risk management choices (Lion et al., 2002; Earle, 2004; Paton, 2005). This was evident in the small, but significant, direct relationship between participation and intentions (Fig. 2). Thus, in some cases, information from one’s community can provide sufficient clarity and guidance to support people making decisions to prepare. However, the strong relationship between participation and empowerment (Fig. 2) also supports the contention that, when faced with infrequent, complex events, communities may not always be in a position to meet the needs of members. When this happens, people look to civic agencies to fill gaps in their knowledge. The analysis also provided support for the hypothesis that ‘articulating problems’ would contribute to the risk management process.

Community participation provides the social context within which collective knowledge can be accessed and risk management needs formulated. However, if gaps in knowledge remain, being able to articulate these gaps into questions allows community members to represent their needs to external sources. It also plays an important role in their evaluating whether the response they get is meaningful and able to assist their risk management planning. It is the relationship between being able to articulate problems and getting meaningful (empowering) responses that ensures that information providers contribute to understanding and to motivating people to prepare (Eng and Parker, 1994; Siegrist and Cvetkovich, 2000; Earle, 2004; Paton et al., 2006b). This prediction was supported by the analysis,
particularly with regard to the direct effect that articulating problems had on both empowerment and trust (Fig. 2). The final prediction, that the relationship between participation and ability to articulate problems and preparedness would be mediated by empowerment and trust was supported (Fig. 2).

5.1.3. Linking community and civic agencies: empowerment and trust

Empowerment describes citizens’ capacity to gain mastery over their affairs and confront hazard issues while being supported in this regard by external sources. Empowerment strategies enhance social justice and facilitate the equitable distribution of resources (e.g., material, social, knowledge) (Eng and Parker, 1994; Paton and Bishop, 1996; Poortinga and Pidgeon, 2004) in ways that help people exercise some control over their risk management. The role of empowerment in the process was, as hypothesised, predicted by both community participation and articulating problems (Fig. 2). That is, preparing is more likely to occur when community members and civic agencies work together to facilitate community members ability to manage risk in ways that are consistent with the needs, values and expectations of the community (Eng and Parker, 1994; Paton, 2000; Paton and Bishop, 1996; Lion et al., 2002; Earle, 2004; Paton, 2005).

Finally, as predicted, trust mediated the relationship between empowerment and articulating problems and intention to prepare for volcanic hazards (Fig. 2). These relationships support the view that the more citizens perceive their needs as having been met through their relationship with civic agencies, the more likely they are to trust them and the information they provide, and to use the information to formulate plans to manage their risk by preparing for volcanic hazard consequences.

5.2. Conclusion

The research presented here illustrated why experience of volcanic hazard consequences or public education may not motivate people to manage their risk. These studies demonstrated that, firstly, when not engaging in hazard-related discussion with others, people tend to transfer risk to others in their community (see discussion on unrealistic optimism). From this it was hypothesised that an important aspect of any risk management strategy involves increasing community discussion (community participation) of hazard issues. Secondly, if civic agencies do not engage communities in ways that reinforce the need for agency and community action to be complementary (see discussion on risk compensation and normalisation bias), communities may overestimate the effectiveness of structural mitigation, reduce their efforts to manage their risk, and pass responsibility for their safety to civic agencies. This led to the hypothesis that the relationship between communities and civic agencies will play a role in risk management that is independent of the information they make available.

A theoretical model that integrated these perspectives was developed and tested. Analysis of this model confirmed that interaction between personal (positive and negative outcome expectancy), social (community participation, collective problem solving) and civic (empowerment, trust) factors predicted people’s decisions to prepare for volcanic hazard consequences. While people, communities and civic agencies make different contributions to this process, the model indicates that effective volcanic hazard risk management will only ensue when their roles are integrated. An important finding was that the relationship between civic emergency management agencies and communities is a significant component of the social context in which risk beliefs are forged and enacted, and one that involves more than just making information available.

Future work should address how to increase the amount of variance in preparation that the model can account for. The analysis revealed that tapping into existing community processes and relationships could account for 37% of the variance in intention to prepare. Currently, risk management programs are not geared to facilitating community discussion of hazard issues or developing community members’ ability to define and resolve their risk management problems. Nor are they designed to enhance the quality of the relationship (empowerment and trust) between communities and civic agencies. This suggests that integrating risk management and community development activities in ways that develop these competencies (e.g., discussion of hazards, problem solving) and relationships (e.g., empowering) will increase the degree to which the model predicts preparedness. When communities and emergency management agencies play complementary roles in the risk management process, community members levels of trust, satisfaction with communication, risk acceptance, willingness to take responsibility for their own safety, and commitment to prepare for volcanic hazard consequences will increase.

References


