Volcanic Hazards: Risk Perception and Preparedness

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Drawing upon research conducted in New Zealand, this paper discusses some conceptual and methodological issues involved with understanding and promoting risk reduction. Conceptual issues include the implications of the distinction between objective and public risk assessment and assumptions made regarding the relationship between risk perception and preparation. Methodological issues focus on the need for longitudinal analysis.

While volcanic activity per se is not amenable to reduction, several emergent social, economic and physical effects are. For example, taping house windows or covering air conditioning units can reduce damage from ash, storing food and water ensures that essential needs can be met, and insurance can reduce subsequent financial demands on households from repairing or replacing items destroyed or damaged. Despite the intuitive appeal of preparation being driven by perceived risk, this assumption may not be justified (Lindell & Whitney, 2000). This paper draws upon recent New Zealand research to discuss some conceptual and methodological issues involved with understanding and promoting risk reduction.

Risk: Public and Expert Assessments

Objectively, risk can be summarised as a function of the interaction between hazard effects and vulnerability to these effects. For example, in the areas surrounding Ruapehu, risk is increasing (Johnston et al., 2000). Even if the probability and intensity of eruption effects remains constant, continuing population growth and economic development in the surrounding area increases vulnerability, and consequently, risk. Public perceptions may not, however, mirror this process. For example, in Ohakune, volcanic risk perception following the 1995/96 Ruapehu eruptions was determined by the relationship between hazard effects and economic disruption and was not evenly distributed throughout the community. (Paton, Millar & Johnston., 2000). Risk perception is a highly interpretive and dynamic process (Hurnan & McClure, 1997; Lindell & Whitney, 2000; Sjöberg, 2000).

Risk reduction strategies tend to reflect objective risk assessment. The inference that public judgements about risk are made in a similar way, and using similar data, has fuelled the assumption that providing the public with information about hazard activity will automatically lead to their becoming better prepared (Paton et al, 2000; Smith, 1996). This need not be the case (Paton, 2000). For example, in Wellington, despite earthquake hazard awareness levels of some 97%, only 48% stored water or food, and fewer had a radio (22%), an emergency plan (11%), or a first aid kit (9%). In Auckland, despite volcanic hazard awareness of 92%, only 10% stored food and water, 9% had a first aid kit, and only 7% reported having a radio. While public education programmes may be successful in promoting awareness, additional interpretive processes influence whether a threat is accepted and whether the person acts to reduce this risk.

Risk Perception & Preparation

The measurement of risk perception, and the identification of the information used when making such judgements, is complex. For example, people differ in regard to their prior knowledge, misconceptions, beliefs and experience of hazard activity, and the manner in which their knowledge and beliefs were acquired (e.g., from direct experience, reading information from emergency management agencies, or from watching television). Given the lack of a common baseline, cross sectional surveys will not elucidate people's decision making regarding hazards and risk. In this paper, studies comparing risk perceptions and preparedness before and after the experience of volcanic activity, or exposure to a volcanic hazard public education campaign, are used to examine risk perception and to outline an alternative

approach to promoting preparation.

The locations discussed here (Hastings, Whakatane, Auckland) are vulnerable to volcanic hazards and have experienced damage and ash fall from historic eruptions. They thus provide a useful context in which to assess risk perception. In the studies discussed here, risk perception was assessed in terms of the perceived threat to personal safety (Lindell, 1994). Actual preparations adopted and perceived preparedness were also examined (Johnston et al., 1999).

The systematic assessment of risk communication should include examination of the efficacy of the media used to influence perceptions. Both direct and indirect (e.g., where people who are potentially vulnerable to hazard effects read about or see on television hazard effects affecting others) experience have been proposed as effective media for facilitating risk perceptions (Lindell & Perry, 1992; Sjöberg, 2000). Public education campaigns are, given the rarity of hazard activity, a common medium for attempting to influence risk perception. The efficacy of each is examined here.

Experience, Risk Perception and Preparation

A survey of perceived risk had been conducted in Hastings and Whakatane prior to the 1995 Ruapehu eruption. During the eruption, Hastings received ash fall but Whakatane did not (Johnston et al., 1999). It was possible to take advantage of this difference to assess the implications of direct and indirect experience for risk perception and preparation. Key findings of this analysis are summarised here. Full details of the methodology and analysis can be found in Johnston et al. (1999).

The data in Table 1 indicate that only direct experience exercised a positive influence on risk perception. Next, the implications of experience on preparation was assessed. Two variables, actual preparations (Table 2) and individuals' perceptions of their, and their community's, preparedness (Table 3) were examined.

Despite their direct experience and increased risk perception, a reduction in actual preparedness was evident in Hastings. Although perceived personal and community preparedness was low before and after the eruption, both direct and indirect experience produced positive shifts in perceived preparedness. These data raise questions regarding the manner in which the need for preparedness is perceived and how people attribute this need to themselves versus other members of their community.

Table 1. Risk Perception: Perceived threat to personal safety

	Hastings		Whakatane	
	Pre	Post	Pre	Post
Hazard				
Volcanic eruption	3.75	3.15	2.74	2.75
	(p<0.000)		(p= 0.896)	

1= high risk - 5 = lowest risk

Despite the objective vulnerability of both communities (e.g., Whakatane was spared direct effects only as a consequence of fortuitous wind direction), only direct experience resulted in a positive shift in risk perception. Direct experience did not, however, result in better preparedness. Given the lack of influence of indirect experience, the effectiveness of public information campaigns conducted during periods of hazard quiescence, when hazard salience will be lower, is open to question. This issue was examined in Auckland by comparing the beliefs and preparedness of 405 respondents prior to and after a volcanic hazard public information campaign.

The data in table 4 suggest that this concern is justified. Nor was their any correlation between risk perception and preparation ($r = 0.007$, $p = 0.831$). Further, not only did this campaign not produce the desired changes in hazard beliefs, it also resulted in some 28% of respondents reporting a reduced need for preparation. Faced with issues about which they have little understanding, people may infer responsibility for protection to those perceived as possessing the requisite expertise (i.e., the agencies responsible for the public information campaign), reducing the perceived need for personal preparedness. There is thus little to be gained by providing information to people unless they can render it meaningful. The latter represents a significant challenge for risk communication, particularly when dealing with infrequently occurring hazards. Diversity in peoples' interpretation of risk information helps account for the failure to find a direct link between risk perception and preparation.

Interpreting risk information

Risk perception is influenced by the data selected to construct beliefs. For example, despite assessments being made against a backdrop of continuing volcanic activity, economic factors represented more powerful determinants of risk perception amongst Ohakune residents (Paton et al., 2000). Using HSCL-21 scores as an indicator of perceived risk, mean scores dropped from 55 in July to 47 in September ($t = -10.66$, $p < 0.0001$, $df = 30$) following a successful ski season. It thus becomes important to ask how people select the information used to construct risk beliefs. Once identified, information can be tailored to meet community needs. For example, information on ash threat will be attended to more readily if framed in terms of safeguarding economic activity against disruption.

In Ohakune economic activity (e.g., agriculture versus winter sports) influenced both the interpretation of volcanic

Table 2. Preparedness: Proportion undertaking protective measures

Hastings		Whakatane	
Pre	Post	Pre	Post
63%	53%	66%	66%

Table 3. Perceived preparedness at personal and community levels

	Hastings		Whakatane	
	Pre	Post	Pre	Post
Personal	3.24	2.94	3.03	2.73
	($p<0.000$)		($p<0.000$)	
Community	3.43	3.13	3.17	3.04
	($p<0.000$)		($p<0.05$)	

1= very prepared - 4 = not prepared at all

Table 4. Risk perception and preparedness in Auckland

	Auckland	
	Pre	Post
Hazard Volcanic eruption		
Risk Perception	1.62	1.57
	($t = 1.59$; $p=0.119$)	
Preparation	0.34	0.37
	($t = -0.669$;$p=0.447$)	

1= low - 5 = high

hazard effects and the perceived need for mitigation (Paton et al., 2000). Those employed in agriculture were not affected and were reluctant to support mitigation measures to deal with a problem they did not perceive to exist. This may have further lessened the level of risk attributed to volcanic hazards (Lindell & Whitney, 2000). Risk was thus not evenly distributed amongst members of this community.

Assumptions that vulnerability and perceived risk will be similar amongst all community members may thus not always be justified. Group differences in risk perception must be defined and their implications accommodated. If this is not done, important relationships may be obscured and variance in the dependent variable (e.g., risk) will be restricted, introducing a downward bias into correlation coefficients (Lindell & Whitney, 2000). This is an important issue for public education campaigns which assume homogeneity in, for example, community risk perception, goals and needs. This assumption is unrealistic (Ballantyne et al., 2000; Paton et al., 2000). While pursuing understanding of risk perception remains an important research goal, the complexity of this process, and the diversity of beliefs likely to prevail at any given time, renders a reliance on public hazard information programmes insufficient as a basis for promoting and maintaining preparedness. Care must also be taken with regard to the interpretation of self-reports of preparation.

For example, in Auckland, while some 41% of respondents stated that they could describe the list of protective actions described in the Civil Defence pages of the Yellow Pages, only 6% could actually recall them. If people overestimate existing knowledge, they will be less attentive to new information, less likely to perceive a need for preparation, and may reduce the risk they attribute to a hazard. Self-reports regarding actual and perceived preparedness should be treated cautiously and must be verified.

In Hastings a decrease in actual preparedness was accompanied by increased perceived preparedness. This pattern is consistent with the "normalisation bias" (Mileti & O'Brien, 1993). This describes how people infer from an ability to cope with an (objectively) minor impact (with this event becoming the prototypical eruption used to make judgements about all volcanic issues) a capability to deal with any future occurrence. This attributional bias can result in their overestimating their perceived preparedness and/or underestimating the risk attributed to volcanic hazards.

In both Hastings and Whakatane, the tendency to perceive personal preparedness as being better than that of others in the community is consistent with the unrealistic optimism bias (Burger & Palmer, 1992, Weinstein & Klein, 1996; Sjöberg, 2000) where people perceive themselves as less vulnerable or more skilful than average. While aware of shortcomings in preparedness, if people attribute this to others they are less likely to attend to information, act on warnings, or prepare.

Risk Perception and preparedness

Consistent with other studies (Burger & Palmer, 1992; Johnston et al., 1999; Lindell & Whitney, 2000; Duval & Mulilis, 1999; Paton, et al., 2000), the data discussed here suggest that, even when a hazard is well understood, the link between perceived risk and preparedness is tenuous and mediated by additional factors. The next step is to identify these factors.

In Ohakune, self-efficacy (Beta = -0.24, $p< 0.05$) and problem-focused coping (Beta = -0.23, $p<0.05$) predicted psychological resilience to volcanic hazard effects using a linear regression model (Paton et al., 2000). Self-efficacy has been implicated as a determinant of preparation in the Theory of Planned Behaviour (Ajzen, 1991; Bennett & Murphy, 1997; Paton et al., in press). A prominent role for self-efficacy and problem-focused coping as predictors of preparation is also evident in the Person-Relative-to-Event model (Duval & Mulilis, 1999; Lindell & Whitney, 2000). This provides a starting point for exploring the relationship between risk perception and preparation (Paton et al., in press).

In this model, while the perception of a threat triggers the process, risk reduction behaviour is a function of outcome expectancies, self-efficacy, coping style, past experience and community norms. The starting point of this process, accepting a level of risk from hazard activity, is itself a complex process. For example, risk perception is influenced by peoples' experience and interpretation of hazard information and the sources of information they deem

most appropriate for their decision making. Consequently, people within the same community may not perceive risk in the same way as their neighbours.

Further complexity arises because, irrespective of the level of perceived risk, people are unlikely to act if hazard effects are perceived as insurmountable (low outcome expectancy) or if they do not perceive themselves as having the competence to act (low self efficacy). Preparation could also be undermined by resource inadequacies (e.g., lack of skill, time, money) or if people transfer responsibility (low perceived responsibility) from themselves to others (Duval & Mulilis, 1999; Lindell & Whitney, 2000; Paton et al., in press). Alternatively, the process could be disrupted if prior experience lessened the threat attributed to a hazard or its consequences. Preparation is also more likely if appropriate attitudes and behaviour are supported by the social and structural environment (Tobin, 1999).

According to this model, for risk reduction behaviour to occur, strategies must aim to develop accurate and shared risk perceptions and the outcome expectancies, efficacy, responsibility and social context necessary to facilitate the adoption of appropriate risk reducing behaviour. One way in which this can be accomplished is through community empowerment (Eng & Parker, 1994; Paton & Bishop, 1996; Paton et al., in press). Community participation in problem definition and resolution will facilitate the development of personal responsibility, self efficacy, and problem focused coping and will help counter inappropriate expectations generated by previous hazard experience.

Changes in hazard environments, periodic hazard activity, and changes within and between communities over time in prevailing beliefs and levels of preparedness necessitates these issues being conceptualised within a longitudinal framework. Multi-wave, longitudinal designs should be used for research and modeling risk perception and resilience processes at individual and community levels, and the methods used must be capable of dealing with the complexities of change data.

Longitudinal research

Golembiewski, Billingsly & Jaeger (1976) proposed three types of change - alpha, beta and gamma. When individuals are observed on more than one occasion changes in self-rating measures may occur as a result of events in the intervening period, from unreliable aspects of the measures, or because respondents have formed different relations to, or perceptions of, the items they rate. Researchers need to assess whether changes in measures across time reflect real change.

From the perspective of a structural measurement model an alpha - change occurs when an increase or a decrease in the score from a multi-item scale directly reflects a corresponding change in the latent construct. A beta - change occurs where an increase or decrease in the score signals a recalibration of the scale by respondents. When the structural relations of the items to the latent construct(s) alter, a gamma - change has occurred. It follows from this conception of the response patterns of groups to multi-item scales that not only differences in magnitude of responses are important, but also the manner in which groups structure the item set in relation to the latent constructs (Paton & Smith, 1999).

In addition to the structural-means analysis approach to assessing change and the use of structural equation modelling for path analysis, other techniques are also now available for the analysis of longitudinal data. Structural equation modelling has been extended to the analysis of multilevel models such as those advocated here (McArdle & Hamagami, 1996; Little & Schnabel, 2000). Pitts, West & Tein (1997) have addressed the methodological and analytical issues pertaining to questions about the stability of processes over time.

In dealing with change in communities we ought to be interested in who changes in addition to the question of how change occurs. Determining the perseverance of types of individual over time (e.g. those who remain unaware of protective behaviours) represent a form of survival analysis and can be analysed in terms of survival rates (Velicer, Martin & Collins, 1996). Data analytic techniques, such as Cox regression (Luke, 1993) can determine the factors that differentiate those who change from those who do not change. However, in many instances the data generated in the kind of research germane to issues we describe here is categorical in nature – people either do or do not adopt specific preparations. The growth of logit and probit models has facilitated the analysis of categorical data. The problem of modelling change over time with multi-wave categorical data has been extensively addressed in Hagenaars's (1990) book on log-linear panel, trend and cohort analysis.

Willett (1989) argued that the reliability of change measurement can be considerably improved by using more than two waves of observations. A further problem in longitudinal research is that not all of the relevant events occur or peak simultaneously (Cohen, 1991). Studies involving only two observation points gamble that observations are made when their relations are optimal. In general this is unlikely. It is better to collect data on more than two occasions, with one or more groups being followed through a sequence of events and studied in parallel (e.g., comparison designs), or as lagged cohorts. These advances enhance the ability of researchers to untangle the complex web of interacting factors that affect the development of risk perception and preparation. Designs such as the Solomon four-group design (Braver & Braver, 1988) and the control construct design (McKillip, 1992) can overcome some of the threats (e.g., sample mobility or attrition) to validity of the simple pretest-posttest design.

Conclusion

Promoting resilience through encouraging individual preparation is a complex process. Diversity in the data accessed and the fact that several cognitive mechanisms influence the meaning attributed to it helps explain why the expected relationship between risk perception and preparation has proved tenuous, irrespective of the media used to promote risk perception and preparation. A major challenge for risk communication is ensuring that the

information provided is meaningful to recipients and motivates risk acceptance and the adoption and maintenance of risk reduction behaviour. A need to promote these outcomes during periods of quiescence for infrequently occurring hazards suggests that risk communication should focus on the immediate benefits of preparation. Attention should also be directed to developing valid measures of the constructs described here. Once modelled using appropriate longitudinal methodology and analysis, the effectiveness of the interventions derived from this process can be facilitated by integrating risk management and community empowerment initiatives.

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