

Direct and vicarious experience of volcanic hazards: implications for risk perception and adjustment adoption

Introduction

While the direct effect of volcanic hazard activity is generally immutable, some of the emergent social, economic and physical consequences are amenable to reduction through the adoption of risk reduction behaviour and adjustments (e.g. storing food and drinking water, purchasing insurance). Consequently, determining the precursors of these reduction activities is an important issue. A key focus in this area has been on risk perception and its implications for reduction. Despite the intuitive appeal of their being a link between perceived risk and adjustment adoption, this may not always be justified, even when a hazard is well understood (Burger & Palmer 1992; Lindell & Whitney 2000; Mulilis & Duval 1995).

Two issues that affect interpretation of data in this context are the timing of its assessment and the nature of personal hazard experience. Hazards can be experienced directly or vicariously (e.g. where individuals are aware of hazard activity in other parts of the country but are not themselves directly affected). Although little work has been done to test this possibility for infrequently occurring natural hazards, some authors have suggested that vicarious experience can influence risk perception (Sjöberg 2000). Others have argued that only direct experience is influential (Lindell & Perry 1992). Assessing the capabilities of indirect or vicarious experience is important for several reasons. For example, because volcanic ash fall can, depending on meteorological conditions, affect communities that are some distance from the source of the hazard, indirect or vicarious experience could provide a valuable means of generating awareness of the kinds of effects that people need to prepare for. The rarity of hazard activity and the fact that most hazard education occurs during periods of hazard quiescence makes it important to test whether vicarious hazard experience or risk communication initiatives can positively influence risk perception and adjustment in a manner that increases resilience to hazard effects.

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While resilient capacity must also be developed at community and institutional levels, understanding the mechanisms that underpin individual adjustment adoption is important in areas vulnerable to potentially destructive earthquake and volcanic hazards. The potential disruption to utilities and social institutions from hazard activity means that residents in affected areas must be capable of meeting essential needs for several days. High levels of personal and household adjustment adoption is also required to minimise damage and costs (e.g. insurance) resulting from hazard activity (e.g. minor shaking or ashfall) capable of, for example, toppling furniture, disrupting hot water systems, or blocking air conditioning units. These initiatives also aim to encourage insurance adoption to reduce subsequent financial demands on households from repairing or replacing items destroyed or damaged.

This paper compares the role of direct and vicarious hazard experience on risk perception and adjustment adoption. It focuses on the role of the 1995 Ruapehu eruption, but also draws upon a study of the effectiveness of a public information campaign (the Auckland survey). Risk perception and preparedness were examined before the campaign was conducted and then again some 6 weeks afterwards (Ballantyne, Paton, Johnston, Kozuch & Daly 2000). Although focusing on volcanic hazards, the findings have more general implications for under-

standing the dynamics of personal risk perception and adjustment adoption.

Longitudinal assessment of hazard impact

Several studies have measured perceptions of volcanic hazards and risk either during periods of quiescence at a volcano (D'Ercole, Rancon & Lesales 1995; Johnston & Houghton 1995; Perry 1990; Ponter, Doorman & Feist 1993) or after a volcanic crisis (Kartez 1982; Saarinen & Sell 1985; Yoshii 1992). While such studies provide valuable information, the lack of pre-event data makes it difficult to assess the specific role of experience in forging beliefs about risk or changing behaviour. For example, when relying on post-event comparisons, particularly when data is derived from self-report public surveys, findings could be biased by over-representation of those with appropriate beliefs or who engage in appropriate behaviour to start with. While longitudinal analysis does not eliminate this potential sampling bias, it does provide a more objective basis for assessing the specific influence of an event on beliefs and behaviour.

A survey of hazard perceptions was conducted in two communities prior to the 1995 eruption (Johnston 1997). By comparing post-event responses with similar data obtained prior to the eruption it was possible to more objectively determine the specific influence of this event on hazard knowledge, risk perception, and preparedness. By conducting this analysis in two communities (one of which was not directly affected) it was possible to explore the implications of both direct and vicarious experience for these parameters.

Because communities can be vulnerable to several hazards, a core facet of contemporary emergency management is the need for intervention to be applicable with across all hazards. Consequently, a salient issue for emergency managers concerns the generalisability of hazard beliefs. If people group similar classes of experience together, experience of one hazard (e.g. volcanic eruption) could lead to improvements in hazard beliefs and preparedness for other salient hazards (e.g. earthquakes)

(Sjöberg 2000; Spedden 1998). By examining perception of risk attributed to a range of hazards, it was also possible to examine the efficacy of this process.

Contrasting communities

The characteristics and hazard experience of the communities discussed in this paper, Hastings and Whakatane, are described in *Table 1*. Comparisons between the two communities should be treated cautiously because they are subject to different magnitudes and frequency of hazards. They do, however, have broadly similar hazard histories and both have experienced impacts from historic earthquake and volcanic hazard activity.

The major difference between these communities, from the perspective of this paper, concerned the fact that Hastings was exposed to ash fall from the 1995 eruption, while Whakatane was not. This difference was used to frame questions regarding the influence of direct and vicarious experience respectively on residents threat knowledge and perceptions of risk from volcanic hazards, and how each type of experience influenced hazard adjustment adoption.

Awareness, risk and preparation

Eruption activity occurred over an 8-9 week period. Such sustained activity provided a substantial period of time within which information could be obtained, beliefs tested, and adjustments adopted. In order to attribute risk to a hazard, awareness of hazard activity and its threat potential is an essential precursor. Threat knowledge and risk perception have been linked to hazard salience, level of past activity and contact with hazard information sources (Lindell 1994; Lindell & Whitney 2000; Perry & Lindell 1990). These factors were used to guide the selection of the variables discussed here. Both towns have a history of vulnerability to volcanic hazards and have experienced damage and ash fall (*Table 1*) from historic eruptions (Johnston 1997), allowing the inference of a comparable degree of hazard salience. Both had comparable levels of access to media coverage (regarding ash fall and its effects) of the eruption and to information from local emergency management offices (*Table 1*).

Threat knowledge was measured by assessing knowledge of local eruption history and, in particular, ash thickness. The importance of this information lies with its role as a guide to what could happen and what protective measures could be necessary. Risk perceptions were assessed in terms of the perceived threat

| | Hastings | Whakatane |
|--------------------------------------|--|---------------------------------|
| Population | 27,000 | 14,000 |
| Location from Ruapehu | 110km SE | 190km NE |
| Hazard history | | |
| Earthquake | 1931 (magnitude 7.2) 93 deaths | 1987 (magnitude 6.2) |
| Volcanic | Minor ash fall 1896 1948 1975 | 7-8cm ash 1886 100 deaths |
| 1995 Impact | 2mm ash | No ash |
| 1995 Information Sources | | |
| Authorities (e.g., Civil defence) | 11% | 26% |
| Newsmedia | 60% | 75% |

Table 1: The hazard histories and characteristics of the experience of the 1995 eruption of Ruapehu volcano in Hastings and Whakatane

| | | Hastings | | Whakatane | |
|-----------------|---------------|----------|----|-----------|----|
| | | N | % | N | % |
| Survey 1 | March 1995 | 216 | 48 | 203 | 45 |
| Survey 2 | November 1995 | 99 | 46 | 102 | 50 |

Table 2: The hazard histories and characteristics of the experience of the 1995 eruption of Ruapehu volcano in Hastings and Whakatane

of volcanic activity to personal safety and to daily life (i.e. residents perception of the likelihood of volcanic ash fall causing disruption to their work, leisure activities or property) (Lindell 1994). In order to examine the role of experience within an all-hazards framework (i.e. whether experience of the effects of one hazard influenced beliefs regarding others), perception of the risk attributed to earthquakes as a result of exposure to volcanic hazard effects was also examined.

Next, the influence of each type of experience on preparation was examined. The relationship between the above variables and adjustment adoption is more complex. While this link has been described in several studies (Perry & Lindell 1990), more recent studies have suggested caution in assuming this relationship (Lindell & Whitney 2000). Here, residents were asked if, in regard to any natural hazards, they had adopted adjustments such as purchasing insurance, planning evacuation routes, obtaining a battery powered radio, and having supplies of food and water. Respondents levels of perceived preparedness were also assessed.

Method

A survey assessing individuals' hazard knowledge, risk perceptions and actual and perceived preparedness was administered first in March 1995 and then again in November to establish the immediate influence of the 1995 Ruapehu eruption on these parameters.

The survey was initially distributed to 450 households in each centre. The rates of return of the questionnaire and the sample sizes are described in *Table 2*. Of those who completed the first survey 50% in Whakatane and 45% in Hastings completed the second.

Data were analysed using the ANU sign test. A significant proportion of the respondents did not change their mind between the two surveys and hence there are many tied observations.

There are many sign tests that deal with ties, but the sign test of Putter (1995) was recommended by Coakley and Heise (1996) after different procedures were reviewed and compared.

This test is the uniformly most powerful (UMP), and performs very well in most settings, even when the sample size is small.

Results

Threat knowledge

Threat knowledge was measured using the proportion of respondents indicating an accurate knowledge of ash fall from previous eruptions (Table 3). Prior to the 1995 eruption, 19% of Whakatane respondents identified the correct range. This dropped to 15% following the eruption (Table 3). The vicarious experience of Whakatane residents neither affected their knowledge of ash thickness nor encouraged the search for information about the nature or extent of hazard effects (despite their having more access to information from the media and emergency management agencies (Table 1). In contrast, the direct experience of Hastings residents resulted in a shift in hazard knowledge, increasing from 32% prior to the eruption to 93% after it (Table 3). Direct experience of ash fall stimulated the search for information about past activity and increased threat awareness.

Risk perception

Risk perception has been linked to direct and indirect hazard experience (Lindell & Whitney 2000; Sjöberg 2000). Risk perception was assessed by asking residents to rate the risk to personal safety and to daily life attributed to earthquake and volcanic hazards. The results are described in Tables 4 and 5 respectively. It can be inferred from these data that, for Whakatane residents, vicarious experience resulted in their perception of risk attributed to volcanic hazards remaining unchanged (Tables 4 & 5).

In Hastings, direct experience of this eruption increased the perceived risk to personal safety and daily life (Tables 4 & 5). Another interesting finding was the significant decrease in the risk to personal safety attributed to earthquake hazards (Table 4). Although failing to reach significance, a similar trend was evident with respect to the risk of disruption to daily life (Table 5). A similar trend was evident in Whakatane. These results reiterate those obtained for hazard knowledge. Direct experience is an essential precursor to a shift in risk perception. The compensatory decrease in the perception of risk attributed to earthquake hazards was unexpected.

An additional measure of risk examined here concerned community perceptions of volcanic threat to the economy and the environment. In addition to providing information on the salience of these issues, these data also provide an indication of the likely commitment to community-wide mitigation. Communities which

| Hastings | | Whakatane | |
|----------|------|-----------|------|
| Pre | Post | Pre | Post |
| 32 | 93 | 19 | 15 |

Table 3: Percentage of respondents with accurate knowledge of eruption history (ash thickness)

| Hazard | Hastings | | Whakatane | |
|-------------------|----------|----------------|-----------|------------------|
| | Pre | Post | Pre | Post |
| Volcanic eruption | 3.75 | 3.15 (p<0.000) | 2.74 | 2.75 (p= 0.896) |
| Earthquake | 1.76 | 1.92 (p<0.01) | 1.96 | 2.09 (p = 0.226) |

1= high risk — 5 = lowest risk

Table 4: Risk Perception: Perceived threat to personal safety

| Hazard | Hastings | | Whakatane | |
|-------------------|----------|----------------|-----------|------------------|
| | Pre | Post | Pre | Post |
| Volcanic eruption | 3.67 | 2.88 (p<0.000) | 2.49 | 2.46 (p = 0.352) |
| Earthquake | 1.87 | 2.03 (p=0.124) | 1.87 | 1.97 (p = 0.363) |

1= high disruption — 5 = low disruption

Table 5: Risk Perception: Perceived disruption to daily life

acknowledge a shared risk (e.g. loss of economic integrity) are more likely to engage in reduction activities dependent upon collective action for their success (Paton & Bishop 1996). When asked if they thought that the threat to the regional economy or environment from volcanic eruptions was over-rated, the risk attributed to volcanic hazards in Hastings increased significantly, but remained unchanged in Whakatane (Table 6).

Adjustment to volcanic hazards

Two measures of preparedness were used. One asked about actual measures adopted. The other asked respondents to indicate the perceived level of their, their community, and local government preparedness.

The proportion of respondents reporting the adoption of preparatory measures is described in Table 7. While no change was observed in Whakatane, the proportion of Hastings respondents adopting these measures dropped from 63% prior to the eruption to 53% following the 1995 eruption. From these data, it can be inferred that neither direct experience nor increased threat knowledge and risk perception automatically translate into

better preparedness. Additional factors are operating to influence the nature of this relationship.

This issue was further examined by asking respondents to rate their perceived preparedness as well as that of their community and local government (emergency management). In both Hastings and Whakatane perceived preparedness levels increased for all groups (Table 8). Despite a shift to better perceived preparedness, the absolute levels of the scores still indicate relatively low levels of perceived preparedness.

Discussion

Vicarious experience and risk perception

Both the communities studied here have been, and remain, objectively vulnerable to volcanic hazards. That Whakatane, in this instance, was spared any direct effects was more a function of fortuitous meteorological conditions. Despite this common vulnerability, it was only those individuals residing in the community that experienced consequences directly that positive shifts in threat knowledge and risk perception were evident. Vicarious experience of this eruption did not influence hazard awareness or risk perception.

| Hazard | Hastings | | Whakatane | |
|---|----------|----------------|-----------|------------------|
| | Pre | Post | Pre | Post |
| Volcanic eruption | 3.00 | 3.41 (p<0.000) | 3.29 | 3.27 (p = 0.704) |
| 1= strongly agree – 5 = strongly disagree | | | | |

Table 6: Risk perception: Do you think the volcanic threat to the region is overrated?

| Hastings | | Whakatane | |
|----------|------|-----------|------|
| Pre | Post | Pre | Post |
| 63 | 53 | 66 | 66 |

Table 7: Preparedness: Proportion undertaking protective measures (%)

| | Hastings | | Whakatane | |
|--|----------|----------------|-----------|------------------|
| | Pre | Post | Pre | Post |
| Personal | 3.24 | 2.94 (p<0.000) | 3.03 | 2.73 (p<0.000) |
| Community | 3.43 | 3.13 (p<0.000) | 3.17 | 3.04 (p<0.05) |
| Government | 2.60 | 2.19 (p<0.000) | 2.30 | 2.20 (p = 0.219) |
| 1= very prepared – 4 = not prepared at all | | | | |

Table 8: Perceived preparedness at personal, community and local government levels

The fact that vicarious experience of an actual eruption did not influence these beliefs raises questions about the effectiveness of risk communication initiatives undertaken during periods of hazard quiescence. It can be inferred from this that, during quiescent periods, hazard salience will be lower, lessening the likelihood of information or advice being attended to. This possibility was tested in the Auckland survey of the effectiveness of a volcanic hazard public information programme (Ballantyne, et al. 2000). The efficacy of this form of vicarious experience was assessed by comparing knowledge and beliefs of 405 respondents prior to and after the campaign. No significant change in awareness of volcanic threat (pre: $x=0.88$; post: $x=1.08$, $t = -2.02$, $p = 0.331$) or risk perception (pre: $x=1.62$; post: $x=1.57$, $t = 1.59$, $p = 0.119$) was found. Since most hazard education and reduction initiatives are conducted during quiescent periods alternative strategies for education and the encouragement of adjustment adoption are required.

Other findings from the Auckland survey are informative in the context of the present discussion. Not only did the

provision of information not result in the desired changes in hazard beliefs, it also resulted in some 28% of respondents reporting that they were *less* concerned about volcanic hazards, the opposite of what was intended. When faced with issues about which they have little knowledge, people may infer responsibility for protection to those they perceive as having the requisite expertise (in this case the agencies responsible for the public information campaign). Mulilis and Duval (1995) and Lindell and Whitney (2000) concluded that attributing responsibility for personal safety to others would result in a reduction in adjustment adoption.

A secondary objective of this paper concerned the examination of the potential for the experience of one hazard to positively influence beliefs regarding others. This possibility was based on the assumption that people group similar events (in this case, 'natural hazards') together so that decisions and beliefs regarding one member of this class are automatically applied to others (Spedden 1998). In Hastings the opposite was found. An increase in risk attributed to volcanic hazards was accompanied by a decrease

in risk attributed to earthquake hazards even though both are objectively salient hazards. A similar trend was evident in Whakatane.

While these data indicate that experience of one kind of hazard activity can have cross-over effects on beliefs regarding others, the nature of the relationship was contrary to expectations. From the data available, it is not possible to determine the duration of this effect. These data suggest that more research is required to elucidate the processes that underpin the issue of risk sensitivity (Sjöberg 2000), and its implications. For example, with respect to risk communication within an all-hazards framework, if the operation of a compensatory mechanism is confirmed, it will be necessary to frame communication in ways that does not link behaviour to a specific hazard. It also raises the possibility that community responsiveness to natural hazard issues will be sensitive to the salience of other societal events. For example, an increase in the salience of social 'hazards' such as crime, economic adversity, or unemployment, could lessen the perceived importance of natural hazard issues. While additional work is required to elucidate this issue, this possibility suggests that hazard reduction and readiness initiatives could benefit from inclusion within community development programmes.

Vicarious experience and adjustment adoption

In regard to the effect of direct and vicarious experience on adjustment adoption and perceived preparedness, the situation is more complex. In Hastings, despite improved hazard awareness and risk perception, the proportion of respondents making adjustments (given that the eruption continued for 8-9 weeks) such as planning evacuation routes, purchasing insurance, storing food, water, torch, radio and spare batteries dropped following the eruption. In Whakatane the proportion stayed the same. While having a substantial majority prepared may seem to indicate reasonable levels of preparedness, caution in the interpretation of these data is required.

The assessment of preparation in the Ruapehu study did not examine the validity of claims made by respondents. This is an important issue. For example, in the Auckland study, some 41% of respondents stated that they could describe the list of protective actions described in the Civil Defence pages of the Yellow Pages. When asked to do so, however, only 15% of them (i.e. only 6%

of the total sample) could actually recall them. While respondents had a better (though still poor overall) recognition of the existence of these actions, their ability to recall them was significantly poorer, suggesting that people tend to overestimate their knowledge and preparedness. This is likely to lessen their attentiveness to new information and reduce their perceived need to develop better preparedness. Anecdotal (e.g. from respondents actually checking their emergency supplies and finding that they did not possess items assumed to be present) and contradictory (e.g. the number of people keeping spare batteries for torches outnumbered those with torches) reports also suggest that people overestimate their preparedness. Self-reports regarding actual and perceived preparedness must be verified.

Despite both direct and vicarious experience resulting in respondents reporting positive shifts in perceived preparedness, the ratings obtained here suggest that this remains a problematic issue. Perceived personal and community preparedness was low both before and after the eruption (*Table 8*). While a significant improvement in perceived preparedness was observed in both communities, these data should be interpreted cautiously. Despite the increased threat knowledge and risk perception recorded in Hastings, a reduction in preparatory activities was observed. In Whakatane, an improvement in perceived preparedness was observed despite their not recording any change in other parameters. Taken together, these data are consistent with the operation of a 'normalisation' bias (Mileti & O'Brien 1993). This described how individuals infer from their ability to cope with an (objectively) minor impact the ability to cope with any future occurrence or assume that future events will not exercise an adverse effect upon them. The ensuing increase in perceived preparedness could result in their vulnerability to more exacting levels of hazard activity being increased.

A similar picture emerged from the Auckland survey. The provision of information on volcanic hazards and protective activities failed to influence adjustment adoption (pre: $x=0.34$; post: $x=0.37$, $t = -0.669$, $p = 0.447$). Nor was there any correlation between risk perception and adjustment adoption ($r = 0.007$, $p = 0.831$). Collectively, these data reinforce the need for caution in assuming a link between risk perception and preparation. This is an important issue given that most public education programmes operate on

the assumption that a better informed public will be a better prepared public.

Also of interest was the pattern of results in *Table 8*. Within each community, respondents rated local government preparation as greater than their own preparedness and theirs as greater than that of the community in general. These data raise several issues. For example, they are consistent with the operation of an unrealistic optimism bias (Weinstein & Klein, 1996; Sjöberg 2000) whereby respondents rate themselves as less vulnerable and more skilful than average. Individuals may be aware of possible shortcomings in preparedness within their community, but these attributions do not extend to themselves. While individuals may appreciate a need for risk reduction activities, they may be less likely, as a consequence of the influence of differential attributions regarding preparedness (i.e. they attributed greater existing preparedness to themselves), to act on warnings or participate in community activities presented in public information campaigns.

The perceived preparedness that community members attributed to local government emergency management agencies (*Table 8*) could also reflect a tendency of people, when dealing with hazard effects they feel they know little about, to transfer responsibility for safety to those perceived to have greater knowledge. Data concerning perceived preparedness should thus be viewed with caution and the possibility that it signals the delegation of responsibility for safety from themselves to emergency management agencies cannot be discounted. Further, if perceived personal responsibility for safety is low, adjustment adoption is likely to be correspondingly compromised (Mululis & Duval 1995).

Conclusion

A number of general conclusions can be drawn from this study. While direct experience of hazard effects heightened threat knowledge and risk perception, vicarious experience did not. If the occurrence of an actual eruption did not influence threat knowledge and risk perception in residents in a community with known vulnerability to volcanic hazards, the likely success of reduction and risk communication strategies undertaken during periods of hazard quiescence is low. This conclusion was reinforced by the results of the Auckland survey which was conducted under just these circumstances. These findings reiterate the need for caution in assuming

a direct relationship between risk perception and adjustment adoption.

The data discussed here illustrate the dynamic nature of the relationship between individuals, hazard activity, and readiness strategies. The social environment within which natural hazard reduction and readiness activities are conducted is not stable. Several mechanisms influence how people interpret experience, make decisions regarding responsibility for their protection, and develop preparedness beliefs and behaviour. These relationships must be understood and their contingent implications incorporated into planning agenda.

More work needs to be done to investigate how compensatory mechanisms link beliefs regarding different hazards and how these change with experience of specific hazards (given that even in areas vulnerable to diverse hazards, not all will be experienced at any one time). This issue has implications for strategies designed to promote all-hazards preparedness. One approach to countering this constraint would involve incorporating risk management activities with community development initiatives. While acknowledgement of the existence of a threat from a hazard remains a precursor, more research is required to articulate the processes that mediate between risk perception and behaviour change and adjustment adoption.

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A strategic research agenda for emergency management

One of the Strategies defined in the National Emergency Management Strategic Plan 2000-2005 is to: 'Facilitate and Set Priorities for Directed Emergency Management Research'. In April 2000 the National Emergency Management Executive Group (NEMEG) endorsed the development of a collaborative research program based on a cooperative centre incorporating RMIT, ANU and EMA. The *Risk and Community Safety Research Initiative* has been established (pending final agreement between the three parties) to develop that program.

One of the first tasks of the *Risk and Community Safety Research Initiative* is to establish an agenda of strategic research needs for Australian emergency management.

The *Initiative* is collecting ideas and suggestions about what the research agenda should contain. We would like you to tell us the research areas or topics you think are important, and to indicate the order of importance. Reasons for your choice would be appreciated.

A paper setting out some initial suggestions is available from the address below. The plan

is to have the agenda finalised by the end of February. It will then guide the work of the *Initiative* and be available to other research groups.

Possible research topics set out in the paper are (here the topics are in abbreviated form):

1. *Emergency management capability*: What is it now and what could it consist of? How do emergency services contribute to the development of sustainable communities?
2. *Value*: What is the value of emergency services? What sort of performance indicators should be used?
3. *Volunteers*: How do we best find, motivate, keep and value volunteers? Should emergency management try to become more or less dependent on volunteerism?
4. *Understanding communities*: Three elements: conceptualising community safety, vulnerability and resilience; community capacity, participation and policy; and what role should the private sector have?
5. *Information management*: How can an "information culture" be built? How can we

ensure that the information needed for risk management is available to those who need it?

6. *Risk assessment*: What is needed to help with implementation of the risk assessment process? How to cope with the ethical, legal and political aspects of risk assessment?
7. *Uncertainty*: How to deal with uncertainty in risk and emergency management?
8. *Institutional and legal change*: What sort of changes are likely and how can emergency management gain from them (eg privatisation)? How to clarify legal uncertainty where it interferes with information exchange?
9. *Essential services*: How to best assess and manage the vulnerability of essential services?
10. *Costs of disasters*: Making sure that the true costs of disasters are documented.

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